

5.0 ENVIRONMENTAL CONSEQUENCES

5.1 INTRODUCTION

Pursuant to the requirements of NEPA regulations at 40 CFR 1502.16 and *Minnesota Rules*, part 4410.2300, this chapter describes the potential environmental consequences of the NorthMet Project Proposed Action and Land Exchange Proposed Action on the affected environment as described in Chapter 4.

As defined in 40 CFR 1508.8, the chapter addresses the following types of effects:

- direct effects, which are caused by the action and occur at the same time and place; and
- indirect effects, which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth-inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems.

Evaluation criteria and analysis methodology are identified where applicable for each resource topic. Environmental effects were determined based on qualitative and/or quantitative assessment.

As listed in Table 5.1-1, this chapter follows the same structure and order of resource topics as Chapter 4. Section 5.2 describes the environmental consequences of the NorthMet Project Proposed Action and the NorthMet Project No Action Alternative. Section 5.3 describes the environmental consequences of the Land Exchange Proposed Action, Land Exchange Alternative B, and Land Exchange No Action Alternative.

Table 5.1-1 Resource Topic Areas Discussed in Chapter 5

Resource Topic	NorthMet Project Proposed Action	Land Exchange Proposed Action
Land Use	5.2.1	5.3.1
Water Resources	5.2.2	5.3.2
Wetlands	5.2.3	5.3.3
Vegetation	5.2.4	5.3.4
Wildlife	5.2.5	5.3.5
Aquatic Species	5.2.6	5.3.6
Air Quality	5.2.7	5.3.7
Noise and Vibration	5.2.8	5.3.8
Cultural Resources	5.2.9	5.3.9
Socioeconomics	5.2.10	5.3.10
Recreation and Visual Resources	5.2.11	5.3.11
Wilderness and Special Designation Areas	5.2.12	5.3.12
Hazardous Materials	5.2.13	5.3.13
Geotechnical Stability	5.2.14	5.3.14

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5.2 NORTHMET PROJECT PROPOSED ACTION

5.2.1 Land Use

This section evaluates the NorthMet Project Proposed Action against existing and applicable land use plans. The specific focus is on the consistency of the NorthMet Project Proposed Action with accepted plans, zoning ordinances, or land use agency management plans. It also addresses the legacy contamination and how it would be affected by proposed activities.

Summary

Components of the NorthMet Project Proposed Action are subject to the requirements of local comprehensive land use plans or the Superior National Forest Plan. In all cases, the NorthMet Project Proposed Action activities are consistent with the formally adopted plans. The NorthMet Project Proposed Action would decrease the amount of land available for public access and use, and would decrease portions of the 1854 Ceded Territory available for use by the Bands. Given the historic use of the federal lands within the Mine Site for mineral exploration and ongoing restrictions on public access (see Section 4.2.11), the NorthMet Project Proposed Action would result in little or no change in actual public use of these lands.

5.2.1.1 Methodology and Evaluation Criteria

The USFS uses the management area framework to broadly define the desired conditions and activities on lands within national forests. Land use outside the Superior National Forest is governed by local zoning and comprehensive plans. The management area designations applicable to the Mine Site and portions of the Transportation and Utility Corridor, as defined in the Forest Plan, are described in Section 4.2.1, as are zoning designations for land outside of the Superior National Forest.

The NorthMet Project Proposed Action is evaluated against the following evaluation criteria:

- compatibility of proposed land use with existing land use, land use plans, zoning ordinances, 1854 Treaty obligations, and adjacent USFS management areas;
- anticipated outcomes related to identified contaminated lands; and
- the degree to which past, ongoing, or planned investigation and remediation actions at legacy contamination sites would be affected by disturbance associated with the NorthMet Project Proposed Action.

5.2.1.2 NorthMet Project Proposed Action

5.2.1.2.1 Consistency with Zoning and Comprehensive Plans

The NorthMet Project area lies within the Mineral Mining zoning districts of the cities of Babbitt and Hoyt Lakes (Arrowhead 2011; Hoyt Lakes Planning Commission 2010), and an industrial use district of St. Louis County (St. Louis County 2011). Therefore, the NorthMet Project area is compatible with the zoning ordinance and draft revised Comprehensive Land Use Plan and would not require an amendment of the respective zoning ordinances or Comprehensive Land Use Plans (Arrowhead 2011; City of Babbitt 1996). Both the county and municipal zoning districts surrounding the Plant Site are designated for industrial or mining use; the NorthMet

Project area is compatible with these designations and would not require amendments to current land uses. Privately owned parcels adjacent to the Mine Site fall under the same or similar zoning and land use designations; therefore, the NorthMet Project Proposed Action would not have the potential to conflict with surrounding land uses.

5.2.1.2.2 Consistency with Superior National Forest Plan

The Mine Site is located within the Superior National Forest and on lands designated as a General Forest-Longer Rotation Management Area (USFS 2011a). In such areas, the USFS allows exploration, development, and processing of mineral resources under conditions where activities are consistent with sound environmental management so as to contribute to economic growth. In addition to managing project development, the USFS also requires preparation of associated reclamation plans to ensure the long term protection and restoration of the natural resources (USFS 2004b). The NorthMet Project Proposed Action would be consistent with these policies.

The NorthMet Project Proposed Action would represent a reactivation of the use of road and rail line for mining, which would be compatible with existing corridor land uses. Under the NorthMet Project Proposed Action, Dunka Road would remain private for mine operation use. Superior National Forest lands to the east, south, and southwest of the Transportation and Utility Corridor are accessible by forest roads and are not dependent on Dunka Road for access (see Figure 4.3.1-1), although Forest Road 113 connects Dunka Road to CR 110 near Skibo, Minnesota. The NorthMet Project Proposed Action represents no anticipated change in the level of public access to either of these adjacent Superior National Forest parcels.

5.2.1.2.3 Areas of Concern

Upon the purchase of a portion of the site, PolyMet became responsible for 29 AOCs (see legacy contamination discussion in Section 4.2.1.4.2). Of these, five have already been closed or have received a No Further Action letter from the MPCA (see Table 4.2.1-2). Additional investigation would be required to determine whether the remaining AOCs require further action. The NorthMet Project Proposed Action offers no direct resolution for the 33 AOCs that are designated as the responsibility of parties other than PolyMet (see Table 4.2.1-2). The MPCA VIC program would be utilized to facilitate and oversee remediation activity for any remaining potential historical releases on the 29 AOCs under the NorthMet Project Proposed Action.

5.2.1.3 NorthMet Project No Action Alternative

The NorthMet Project No Action Alternative would not result in any change in land management at the Mine Site or Transportation and Utility Corridor. Land at the Plant Site would continue to be managed in accordance with the existing closure plan and Consent Decree. The existing 1854 Treaty obligations for the Mine Site and Plant Site would remain unchanged.

5.2.2 Water Resources

This section is organized into a description of the criteria used for evaluating NorthMet Project Proposed Action-related effects, the methodologies used to predict these effects, and then a discussion of the effects resulting from the NorthMet Project Proposed Action. A summary of the primary effects of the NorthMet Project Proposed Action on water resources is provided below.

Summary

The NorthMet Project Proposed Action would be located in an historic mining area, known as the Mesabi Iron Range, and in the vicinity of other past, present, and proposed mining projects. Although the Mine Site would be on an undeveloped site, PolyMet proposes to reuse many of the former LTVSMC facilities at the brownfield Plant Site. While reusing the existing LTVSMC Tailings Basin offers environmental benefits (e.g., reducing wetland effects, addressing legacy water quality issues), it does create some challenges because the existing LTVSMC Tailings Basin is not lined and currently releases seepage with elevated concentrations of sulfate, TDS, and hardness, among other constituents. Many of the engineering controls proposed by PolyMet at the Plant Site are related to managing seepage from both the existing LTVSMC tailings and the additional NorthMet tailings.

The NorthMet Project Proposed Action would have the potential to affect groundwater and surface water hydrology and quality in both the Partridge River and Embarrass River watersheds. These two rivers are both tributaries to the St. Louis River and within the Lake Superior Basin. They are not located within the Hudson Bay Basin and do not drain to, nor would affect, the water quality of the BWCAW.

The NorthMet Project Proposed Action would represent the first copper-nickel-PGE mine in Minnesota, with the ore and waste rock containing various amounts of sulfide minerals. Sulfide minerals, when exposed to oxygen and water, have the potential to release soluble metals and sulfate and produce acid mine drainage. The sulfide sulfur (S) concentrations of the NorthMet waste rock would be relatively low compared to many other mines with sulfide-bearing rock around the world. The NorthMet waste rock is predicted to average 0.15 percent sulfide S, while concentrations in other mines with sulfide-bearing rock range as high as 40 percent (Minesite Drainage Assessment Group 2013). The host silicate minerals in the NorthMet deposit would help neutralize some acid generated by the sulfide minerals, such that the Category 1 Stockpile and the Tailings Basin are predicted to remain at neutral pH. Where the pore water pH remains near-neutral, metal mobility can be limited as some metals released by oxidation are removed from solution by adsorption or co-precipitation. The Category 2, 3, and 4 waste rock has sulfide S concentrations that could produce acid drainage if exposed to oxygen, but is proposed for subaqueous disposal in the East Pit (after temporary surface storage in a geomembrane-lined stockpile), where oxidation would be significantly limited and acid drainage would not occur.

The sulfate released from the NorthMet waste rock and tailings is especially important because there are waters supporting the production of wild rice that are downstream from both the Mine Site and Tailings Basin. Research indicates that elevated sulfate concentrations affect the growth and viability of wild rice. The MPCA has established a 10-mg/L sulfate standard for stream segments designated as waters used for the production of wild rice. If the sulfate concentration in wild rice water already exceeds 10 mg/L, the MPCA standard requires that proposed activities

cannot cause or add to an exceedance of the standard. In MPCA-recommended wild rice waters along the Partridge and Embarrass rivers, the sulfate concentration already exceeds 10 mg/L, so it must be demonstrated that the NorthMet Project Proposed Action would have an acceptably high probability of not increasing sulfate concentrations in these areas.

Since the issuance of the DEIS, PolyMet has significantly modified its proposed design by incorporating engineering controls at both the Mine Site and Tailings Basin to better address water resource issues, which are generally described below. At the Mine Site, the more reactive types of waste rock (Category 2/3 and 4) and some of the less reactive Category 1 waste rock is now proposed for subaqueous disposal in the East Pit to limit oxidation of sulfide minerals and associated release of soluble metals. The majority of the less-reactive Category 1 waste rock would be permanently stored at the surface, but would be covered by a geomembrane with a vegetated soil cover (to reduce infiltration) and surrounded by a groundwater containment structure that would collect more than 90 percent of the facility seepage for treatment; the remainder would migrate to the West Pit via groundwater. The containment structure consists of a trench with permeable backfill and piping that would nearly completely surround the Category 1 Stockpile. A WWTF using chemical precipitation and filtration would treat internal waste streams during mine operations and reclamation (up to year 40). After operations, the WWTF would be converted to a RO facility to treat West Pit lake water and Category 1 Stockpile water during closure. The treated water would be discharged to the West Pit Outlet Creek that flows into the Partridge River.

At the Tailings Basin, PolyMet proposes a groundwater containment system that would capture at least 90 percent of seepage from the Tailings Basin and either return it to the tailings pond for reuse or treat it for discharge. In closure, all of the captured seepage would be delivered to the WWTP for treatment prior to discharge to surface water. The main containment system would consist of a slurry wall keyed into bedrock and an upstream collection trench with permeable backfill and piping on the northeast, north and west sides of the Tailings Basin. Containment is not proposed on the east side of the Tailings Basin due to outcropping bedrock that effectively limits seepage migration in this direction. A seepage collection system on the south side of the Tailings Basin, where seepage is limited by bedrock and quickly becomes surface seepage, would consist of ponds and pumps to collect visible seeps and return it to the Tailings Pond. PolyMet proposes a bentonite amendment on the side slopes (installed as they are constructed during operations) and the beaches and pond (installed at closure) of the Tailings Basin to reduce oxygen flux and water percolation into the tailings, thereby reducing oxidation of sulfide minerals and associated release of soluble metals in water seeping from the facility (PolyMet 2013g; 2013m). A WWTP using RO technology that would provide mechanical treatment of the captured Tailings Basin seepage during operations and closure, and tailings pond water in closure. The treated effluent would be used to augment flow in several Embarrass River tributary streams and Second Creek in the Partridge River Watershed that would otherwise experience reduced flow because of the groundwater containment system. Additional water for flow augmentation in the nearby tributaries would be pumped from Colby Lake at periods during mine operations and reclamation.

During closure, the WWTF and the WWTP (both mechanical treatment facilities) would continue operating until monitoring and pilot-testing demonstrated that a transition could be made to non-mechanical systems, which may consist of constructed wetlands, permeable reactive barriers (PRBs), permeable sorptive barriers (PSBs), and/or other technologies to be

identified. Based on the results of field demonstrations, non-mechanical treatment systems would be implemented only when monitoring at key mine facilities indicated that the water quality and flow rates were amenable for these measures. In this SDEIS, non-mechanical treatment systems are not described in detail because the NorthMet Project Proposed Action is based on mechanical treatment only. However, implementation of non-mechanical systems is considered a long-term goal for closure.

The objective of closure is to provide mechanical or non-mechanical treatment for as long as necessary to meet regulatory standards at applicable groundwater and surface water compliance points. Both mechanical and non-mechanical treatment would require periodic maintenance and monitoring activities. Mechanical water treatment is part of the modeled NorthMet Project Proposed Action for the duration of the simulations (200 years at the Mine Site, and 500 years at the Plant Site). The duration of the simulations was determined based on capturing the highest predicted concentrations of the modeled NorthMet Project Proposed Action. It is uncertain how long the NorthMet Project Proposed Action would require water treatment, but it is expected to be long term; actual treatment requirements would be based on measured, rather than modeled, NorthMet Project water quality performance, as determined through monitoring requirements. PolyMet would be held accountable for maintenance and monitoring required under any permit and would not be released until all conditions have been met.

Several groundwater, surface water, and water quality models (MODFLOW, XP-SWMM, and GoldSim, respectively) were used to predict the hydrologic and water quality effects of the NorthMet Project Proposed Action. The water quality model, which was run at monthly time steps for 200 years for the Mine Site and 500 years for the Plant Site, performs probabilistic simulations, taking into account the uncertainty around many of the model input assumptions with the output taking the form of a cumulative probability distribution. The Co-lead Agencies have selected the 90th percentile probability (P90) as its evaluation threshold in determining whether the model results meet established evaluation criteria (i.e., there is at least a 90 percent probability that a constituent would not exceed the water quality evaluation criteria).

With the proposed design modifications and engineering controls, the water quality model predicts that the NorthMet Project Proposed Action would not cause or increase the magnitude of an exceedance of the groundwater and surface water quality evaluation criteria at the P90 level for any of 28 solutes at 29 groundwater or surface water evaluation locations within the Partridge River and Embarrass River watersheds, with two exceptions:

- Aluminum – Water quality model results predict that aluminum concentrations would increase the existing surface water exceedances at Unnamed Creek (PM-11), Trimble Creek (TC-1 and PM-19), and Mud Lake Creek (MLC-2 and MLC-3). This increase in aluminum concentrations is a side effect of the NorthMet Project Proposed Action due to the reduction in low aluminum concentration Tailings Basin seepage (approximately 5 to 20 µg/L) reaching these tributaries as a result of the proposed groundwater containment system, which would result in an increase in the proportion of non-contact stormwater runoff with higher natural aluminum concentrations (approximately 70 to 150 µg/L). In other words, the capture of the seepage would result in less dilution, which would increase the proportion of non-contact stormwater runoff with higher natural aluminum concentrations reaching the streams. The greatest increases in aluminum concentrations for all of these evaluation locations would occur during reclamation when water from Colby Lake with high aluminum concentrations (approximately 70 to 160 µg/L) would be used for flow augmentation. Therefore, the

increase in the magnitude of the aluminum exceedance at these Plant Site evaluation locations is not attributable to process water from the NorthMet Project Proposed Action (i.e., is attributable to non-contact stormwater runoff and Colby Lake water).

- Lead – Water quality model results predict an exceedance of the lead surface water evaluation criterion in Unnamed Creek (PM-11) and Trimble Creek (TC-1 and PM-19) north of the Tailings Basin. These exceedances are a side effect of the NorthMet Project Proposed Action due the reduction in surface water hardness that results from the capture and removal of dissolved solids by the WWTP and the associated decrease in the hardness-based lead evaluation criterion. The WWTP effluent would meet the water quality evaluation criteria, but exceedances would infrequently occur when stormwater runoff mixes with the WWTP effluent and lowers hardness more than it dilutes lead concentrations.

For MPCA-recommended wild rice waters, the engineering controls would prevent an increase in sulfate concentrations in the Partridge River and would decrease sulfate concentrations in the Embarrass River. The proposed engineering controls would provide a high degree of reliability and flexibility to ensure that the evaluation criteria would continue to be met in the future, where nearly all contact/process water at the NorthMet Project area would be treated at the WWTF or the WWTP before release to the environment. At the Mine Site, only about 10 gpm of untreated water would be released during closure (all related to groundwater seepage), which represents less than 5 percent of total Mine Site water releases. At the Tailings Basin, only about 21 gpm of untreated water would be released during closure (all Tailings Basin seepage that bypasses the groundwater containment system), which represents less than 1 percent of total Tailings Basin water releases. The NorthMet Project Proposed Action is also not predicted to result in any significant changes to groundwater and surface water flows when compared to existing conditions.

Many of the lakes and rivers in the NorthMet Project area are classified as “impaired waters” by the MPCA because of elevated mercury in fish. There are several factors that cause elevated mercury in fish, including the increased availability of methylmercury, which could be caused by elevated inorganic mercury concentrations, and/or the increased efficiency of mercury methylation, which could be caused by a number of factors including enriched sulfate concentrations. The NorthMet Project area is located within the Lake Superior Basin, so it is subject to the Great Lakes Initiative mercury water quality standard of 1.3 ng/L. The NorthMet ore and waste rock contain trace amounts of mercury, but mass balance modeling and analog data from other natural lakes and mine pit lakes in northeastern Minnesota suggest that the mercury concentration in the West Pit Lake, the source of the only surface water discharge at the Mine Site, would stabilize at approximately 0.9 ng/L. There would also be mercury in the tailings, although about 92 percent of the mercury in the ore is predicted to remain in the ore concentrate and the mercury concentration in seepage from the Tailings Basin is expected to be less than the standard. The WWTF and the WWTP would be designed to meet the 1.3 ng/L mercury standard for its effluent. Overall, the NorthMet Project Proposed Action is predicted to increase mercury loadings in the Embarrass River, but decrease mercury loadings in the Partridge River. The net effect of these changes would be an overall reduction in mercury loadings to the downstream St. Louis River.

PolyMet would be required by its permits to monitor effects on hydrology and water quality in order to refine modeling to help predict future conditions. In the event that the monitoring identifies the potential for any water quality exceedances, PolyMet has proposed an Adaptive

Water Management Plan (AWMP) that identifies additional measures the firm could take if necessary to prevent any exceedances of water quality standards.

5.2.2.1 Evaluation Criteria

In general, water resource evaluation criteria focus on groundwater and surface water hydrology and water quality and are defined as thresholds or changes in the existing physical/chemical/biological environment with the goal of protecting overall water body health.

5.2.2.1.1 Groundwater

This section discusses evaluation criteria for the effects of the NorthMet Project Proposed Action on groundwater hydrology (primarily groundwater levels) and water quality.

Hydrogeologic Evaluation Criteria

There are no state or federal regulatory standards for the maximum allowable change in groundwater levels. It is recognized that groundwater drawdown would occur surrounding the mine pits and groundwater elevations may decrease near the Tailings Basin as a result of proposed engineering controls, but these changes are not necessarily positive or negative in and of themselves. The significance of any changes in groundwater levels is evaluated in terms of its effects on other resources (e.g., wetlands) and these potential effects are discussed in those appropriate resource sections. The magnitude of any changes in groundwater levels are quantified in this section.

Water Quality Evaluation Criteria

Groundwater quality is variable and is a reflection of the land and parent material. Based on host rock mineralogy and the results of geochemistry analyses, 28 solutes were selected as potentially being affected by the NorthMet Project Proposed Action and for inclusion in water quality modeling, including:

- | | | |
|--------------|-------------|-------------|
| • Alkalinity | • Antimony | • Lead |
| • Calcium | • Arsenic | • Manganese |
| • Chloride | • Barium | • Nickel |
| • Fluoride | • Beryllium | • Selenium |
| • Hardness | • Boron | • Silver |
| • Sulfate | • Cadmium | • Thallium |
| • Magnesium | • Chromium | • Vanadium |
| • Potassium | • Cobalt | • Zinc |
| • Sodium | • Copper | |
| • Aluminum | • Iron | |

This suite of directly modeled solutes does not include TDS. However, TDS can be estimated by summing its constituent concentrations that were directly modeled, including calcium, chloride, fluoride, magnesium, potassium, sulfate, and a portion of alkalinity.

This SDEIS assesses effects by comparing predicted NorthMet Project Proposed Action-related water quality with both existing water quality (as characterized by groundwater quality monitoring) and applicable Minnesota groundwater quality standards, which are based on Minnesota water use classifications (*Minnesota Rules* 7060, 7050, and 7052). Groundwater quality standards are USEPA primary MCLs (pMCL), USEPA sMCL, and MDH HRLs. The groundwater quality evaluation criteria, for the purposes of this SDEIS, are defined as the strictest (i.e., lowest) concentration among the USEPA pMCLs, USEPA sMCLs, and the MDH HRLs, with the following exceptions:

- Human health-based primary drinking water standards for copper and lead are “at the tap” values applicable to treated water systems and not to “in situ” groundwater values (see Note 3 to Table 5.2.2-2). *Minnesota Rules* addressing the water quality standards applicable to Class 1 waters used for domestic consumption specifically state that the primary drinking water standards for copper and lead do not apply to Class 1 surface waters or groundwater. The SDEIS uses the USEPA sMCL of 1,000 µg/L as the groundwater evaluation criteria for copper. Modeling predictions for lead are presented, but without a groundwater evaluation criterion for lead because there is not an sMCL or an HRL for lead.
- Natural (unaffected) groundwater concentrations for aluminum and iron at the Mine Site and Plant Site are greater than secondary drinking water standards. The concentrations for these two solutes in groundwater are heavily influenced by processes not readily captured in water quality models (e.g., site-specific redox reactions). Furthermore, these sMCLs were established by the USEPA as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, and can be removed from groundwater with simple readily available treatment technologies, and are not enforced by the USEPA. For example, concentrations above the aluminum sMCL (200 µg/L) may result in colored water and concentrations above the iron sMCL (300 µg/L) may result in rusty color, metallic taste, and reddish or orange staining.
- Natural (unaffected) groundwater concentrations for beryllium, manganese, and thallium (bedrock unit only) at the Mine Site and beryllium and manganese at the Plant Site are greater than secondary drinking water standards and/or the HRL (see Table 5.2.2-2). These elevated concentrations are consistent with concentrations seen elsewhere in the Iron Range and northeast Minnesota. *Minnesota Rules*, part 7060.0600, subpart 8, states that “where the background level of natural origin is reasonably definable and is higher than the accepted standard for potable water and the hydrology and extent of the aquifer are known, the natural level may be used as the standard.”

The evaluation criteria for these solutes were set at either: (1) the 95 percent Upper Prediction Limit, (2) the second-highest value when there was a limited number of measured concentrations above the detection limit, or (3) half the detection limit when there were no detected concentrations pursuant to USEPA guidance (USEPA 2009b) (see Table 5.2.2-1).

Table 5.2.2-1 Beryllium, Manganese, and Thallium Evaluation Criteria

	Units	USEPA pMCL	USEPA sMCL	HRL	# samples	Range	Mean	Recommended Evaluation Criteria
Mine Site		Surficial						
Beryllium	µg/L	4	--	0.08	176	ND–1.6	0.23	0.45 ⁽³⁾
Manganese	µg/L	--	50	100	167	ND–1,900	294	964 ⁽¹⁾⁽²⁾
Mine Site		Bedrock						
Beryllium	µg/L	4	--	0.08	35	ND–0.2	<0.2	0.2 ⁽³⁾
Manganese	µg/L	--	50	100	35	ND–383	98	279 ⁽¹⁾⁽²⁾
Thallium	µg/L	2	--	0.6	35	ND (0.2–2.0)	<2	1.0 ⁽⁴⁾
Plant Site		Surficial						
Beryllium	µg/L	4	--	0.08	28	ND–2.72	0.31	0.49 ⁽³⁾
Manganese	µg/L	--	50	100	28	4.3–2,140	291	1,506 ⁽¹⁾

Source: Barr 2013h.

ND = Non-detect

¹ 95 percent Upper Prediction Limit (UPL) used as evaluation criteria.

² Kaplan-Meier Method used to determine UPL.

³ Second-highest detected concentration used as evaluation criteria.

⁴ One half of the highest detection limit used as evaluation criteria.

Table 5.2.2-2 presents the pMCL, sMCL, HRL, and the evaluation criteria used in this EIS.

**Table 5.2.2-2 Groundwater Evaluation Criteria Applicable to the NorthMet Project
Proposed Action**

Solute	Units	USEPA pMCL	MDH HRL	USEPA sMCL	SDEIS Evaluation Criteria
General Parameters					
Alkalinity	mg/L	--	--	--	--
Calcium	mg/L	--	--	--	--
Chloride	mg/L	--	--	250	250
Fluoride	mg/L	4	--	2	2
Hardness	mg/L	--	--	--	--
Magnesium	mg/L	--	--	--	--
Potassium	mg/L	--	--	--	--
Sodium	mg/L	--	--	--	--
Sulfate	mg/L	--	--	250	250
Total Dissolved Solids	mg/L	--	--	500	500
Metals					
Aluminum	µg/L	--	--	50-200 ⁽⁴⁾	-- ⁴
Antimony	µg/L	6	6	--	6
Arsenic	µg/L	10	--	--	10
Barium	µg/L	2,000	2,000	--	2,000
Beryllium	µg/L	4	0.08	--	0.45/0.2/0.49 ⁽¹⁾
Boron	µg/L	--	1,000 ⁽²⁾	--	1,000
Cadmium	µg/L	5	4	--	4
Chromium	µg/L	100	--	--	100
Cobalt	µg/L	--	--	--	--

Solute	Units	USEPA pMCL	MDH HRL	USEPA sMCL	SDEIS Evaluation Criteria
Copper ³	µg/L	-- ³	--	1,000	1,000
Iron	µg/L	--	--	300 ⁽⁴⁾	-- ⁴
Lead ³	µg/L	-- ³	--	--	--
Manganese	µg/L	--	100	50	964/279/1506 ⁽¹⁾
Nickel (soluble salts) ⁵	µg/L	--	100	--	100
Selenium	µg/L	50	30	--	30
Silver	µg/L	--	30	100	30
Thallium (salts) ⁵	µg/L	2	0.6	--	0.6/1.0 ⁽¹⁾
Vanadium	µg/L	--	50	--	50
Zinc	µg/L	--	2,000	5,000	2,000

Source: pMCLs (40 CFR 141), sMCLs (40 CFR 143), and HRLs (*Minnesota Rules*, part 4717.7500).

¹ Beryllium, manganese, and thallium (Mine Site bedrock unit only). The evaluation criteria differ by location based on background water quality (see Table 5.2.2-1 above). Criteria are based on dissolved concentrations unless otherwise noted (see Appendix 1 of MPCA 2006d).

² Boron. See MDH guidance: www.health.state.mn.us/divs/eh/risk/guidance/gw/boron.html.

³ Lead and copper. Lead and copper enter drinking water primarily through plumbing materials. In 1991, the USEPA published the Lead and Copper Rule (<http://www.epa.gov/safewater/lcrr/index.html>). This rule requires water systems to monitor drinking water at customer taps. The 1,300-µg/L copper concentration and 15-µg/L lead concentration represent action levels that, when exceeded at 10 percent of customer taps, require the water system to take additional actions to control corrosion. Therefore, these values reflect concentrations at the customer tap. Additionally, *Minnesota Rules*, part 7050.0221, subpart 1B, states that the primary drinking water standards for copper and lead are not applicable to Class 1 groundwaters.

⁴ Aluminum and iron. These parameters were excluded from groundwater evaluation criteria due to baseline USEPA sMCL standard exceedances in the Iron Range and Northeast Minnesota and because these concentrations are heavily influenced by processes not captured in the proposed models (e.g., site-specific redox reactions). Further, standards for these parameters were established for management of aesthetic conditions in treated drinking water and are readily removed from groundwater with simple readily available treatment technologies. This policy was adopted by the Co-lead Agencies in the NorthMet EIS Groundwater Impact Assessment Planning Final Summary Memo (June 27, 2011).

⁵ Nickel and thallium. The MDH HRL is based on the salt form of this parameter. It is conservatively assumed, for purposes of the SDEIS, that the salt form is equivalent to the total concentrations of this parameter.

These groundwater quality evaluation criteria are assessed at the following evaluation locations (see Figures 5.2.2-4 and 5.2.2-6):

- Partridge River Watershed:
 - Surficial Aquifer
 - East Pit and Category 2/3 Flowpath – at the Partridge River
 - Ore Surge Pile Flowpath – at the Partridge River
 - WWTF Flowpath – at the property boundary
 - Overburden Storage and Laydown Area Flowpath – at the property boundary
 - West Pit Flowpath – at the property boundary

- Bedrock
 - East Pit Bedrock Flowpath – at the property boundary
 - West Pit Bedrock Flowpath toward SW-004 – at the property boundary
 - West Pit Bedrock Flowpath toward SW-004a – at the property boundary
- Embarrass River Watershed (all surficial aquifer, see Section 5.2.2.2.3):
 - North Flowpath – at the north property boundary
 - Northwest Flowpath – at the northwest property boundary
 - West Flowpath – at the west property boundary

5.2.2.1.2 Surface Waters

This section discusses evaluation criteria for the effects of the NorthMet Project Proposed Action on surface water hydrology and quality.

Hydrologic Alteration of Streams and Lakes Evaluation Criteria

Hydrologic evaluation criteria include a comparison of proposed hydrologic changes with both existing natural conditions and historic hydrologic alterations from permitted mining practices, an assessment of present and predicted channel stability, and review of any appropriate physical or biological stream data. Evaluation criteria for streamflows in the Partridge River Watershed and changes in lake or reservoir levels in the NorthMet Project area are those developed by (Richter et al.1996; 1998) related to alteration of hydrology. The main parameters recommended for this “range of variability” approach include:

- annual mean daily flow by month;
- annual mean daily flow by month;
- annual maximum 1-day, 3-day, 7-day, 30-day, and 90-day flows;
- annual minimum 1-day, 3-day, 7-day, 30-day, and 90-day flows;
- number of high pulses (i.e., the number of times per year the mean daily flow increases above the 75th percentile of all simulated mean daily flows);
- number of low pulses (i.e., the number of times per year the mean daily flow falls below the 25th percentile of all simulated mean daily flows);
- duration of high pulses (i.e., the number of days per year with mean flows above the 75th percentile of all simulated daily mean flows);
- duration of low pulses (i.e., the number of days per year with mean flows below the 25th percentile of all simulated daily mean flows);
- mean duration of high pulses (i.e., the ratio of duration of high pulses to number of high pulses);

- mean duration of low pulses (i.e., the ratio of duration of low pulses to number of low pulses); and
- discernible trends in the annual mean, annual maximum, and annual minimum lake levels in Colby Lake and Whitewater Reservoir.

The magnitude of deviation from existing conditions, based on XP-SWMM modeling, in the mean values of the hydrologic parameters helps determine the degree of potential effect on stream ecology. These values are not expressed as compliance standards, but would assist in monitoring effects and recommending potential mitigation measures as appropriate.

The MDNR has recommended that maintaining surface flows within about plus or minus 20 percent of existing conditions in mining-affected streams should be a management objective where reasonably practical in order to maintain existing aquatic ecology.

Water Quality Evaluation Criteria

This SDEIS assesses effects on water by comparing the predicted water quality under the NorthMet Project Proposed Action against evaluation criteria based on the State of Minnesota water quality standards and use classifications (*Minnesota Rules* 7050 and 7052). Applicable use classifications of the primary surface waters potentially affected by the NorthMet Project Proposed Action are described in Section 4.2.2 and are summarized in Table 5.2.2-3.

Table 5.2.2-3 Applicable Use Classifications of the Primary Surface Waters in the NorthMet Project Area

Watershed	Stream Name	Domestic Consumption	Aquatic Life and Recreation		Industrial Consumption		Agriculture and Wildlife		Aesthetic Enjoyment	Other uses	
		1B	2A	2B	2Bd	3B	3C	4A	4B	5	6
Partridge	Partridge River			X			X	X	X	X	X
Partridge	West Pit Outlet Creek			X			X	X	X	X	X ¹
Partridge	Wetlegs Creek			X			X	X	X	X	X
Partridge	Longnose Creek			X			X	X	X	X	X
Partridge	Wyman Creek	X	X			X	X	X	X	X	X
Partridge	Colby Lake	X			X		X	X	X	X	X
Embarrass	Embarrass River			X			X	X	X	X	X
Embarrass	Trimble Creek			X			X	X	X	X	X
Embarrass	Mud Lake Creek			X			X	X	X	X	X
Embarrass	Second Creek			X			X	X	X	X	X
Embarrass	Unnamed Creek			X			X	X	X	X	X

¹ The WWTF would discharge to the West Pit Outlet Creek.

In *Minnesota Rules* part 7050.0221, the USEPA primary and secondary drinking water standards are adopted for Class 1B waters (i.e., those treated with simple chlorination for domestic consumption). The USEPA primary drinking water standards (40 CFR 141) set mandatory MCLs for drinking water contaminants to protect the public from consuming water that presents a risk to human health. The USEPA has also established secondary drinking water standards (40 CFR 143) for 15 contaminants that are intended to assist public water systems in managing their drinking water for aesthetic considerations such as taste, color, and odor. These contaminants are not considered a risk to human health.

The same suite of solutes was modeled for surface waters as described above for groundwater. As mentioned above, TDS concentrations were not directly modeled, but can be estimated indirectly by summing its constituents that were directly modeled.

Because the NorthMet Project area is located in the Lake Superior Basin, the Great Lakes Initiative (Lake Superior) water quality standards also apply (*Minnesota Rules* chapter 7052). These Lake Superior standards can differ from the water quality standards for the same parameters in *Minnesota Rules* chapter 7050. Where different, the 7052 standards supersede the 7050 standards, even if the 7052 rules are less stringent. For parameters not listed in chapter 7052, the standards from chapter 7050 apply.

Surface water standards are “in-stream” standards applicable at the surface water in question, which includes the Partridge River and its tributaries for the Mine Site, Transportation and Utility Corridor, and the Plant Site, and the Embarrass River and its tributaries for the majority of the Tailings Basin.

Applicable surface water quality evaluation criteria, for the purposes of this SDEIS, are listed by use classification in Table 5.2.2-4, with the strictest (i.e., lowest) concentration from the applicable water use classifications applying.

It should be noted that the water quality standards for metals are expressed as total metal in the table, but are applied as dissolved metal criteria for application to surface waters (*Minnesota Rules*, part 7050.0220). For the majority of metals, the ratio of the total metal criteria to the dissolved metal criteria is sufficiently close to one such that the total standard is adequately representative of the applicable criteria.

Table 5.2.2-4 Surface Water Quality Evaluation Criteria Applicable to the NorthMet Project Proposed Action

Parameter	Units	Class 1B pMCL	Class 1B sMCL	Class 2Bd ³	Class 2B ³	Class 3B ⁴	Class 3C ⁴	Class 4A ⁵	Class 4B ⁵	Class 5	Class 6
General											
Alkalinity	mg/L	--	--	--	--	--	--	--	--	--	--
Calcium	mg/L	--	--	--	--	--	--	--	--	--	--
Chloride	mg/L	--	250	230	230	100	250	--	--	--	--
Fluoride	mg/L	4	2	--	--	--	--	--	--	--	--
Hardness	mg/L	--	--	--	--	250	500	--	--	--	--
Magnesium	mg/L	--	--	--	--	--	--	--	--	--	--
pH	s.u.	--	6.5-8.5	6.5-9.0	6.5-9.0	6.0-9.0	6.0-9.0	6.0-8.5	6.0-9.0	6.0-9.0	--
Potassium	mg/L	--	--	--	--	--	--	--	--	--	--
Sodium	mg/L	--	--	--	--	--	--	--	--	--	--
Sulfate	mg/L	--	250	--	--	--	--	10 ⁽²⁾	--	--	--
TDS	mg/L	--	500	--	--	--	--	700	--	--	--
Metals Total⁷											
Aluminum	µg/L	--	50-200	125	125	--	--	--	--	--	--
Antimony	µg/L	6	--	5.5	31	--	--	--	--	--	--
Arsenic	µg/L	10	--	2.0 ⁽¹⁾	53 ⁽¹⁾	--	--	--	--	--	--
Barium	µg/L	2,000	--	--	--	--	--	--	--	--	--
Beryllium	µg/L	4.0	--	--	--	--	--	--	--	--	--
Boron	µg/L	--	--	--	--	--	--	500	--	--	--
Cadmium ⁶	µg/L	5	--	2.5 ⁽¹⁾	2.5 ⁽¹⁾	--	--	--	--	--	--
Chromium (III) ⁶	µg/L	100	--	86	86	--	--	--	--	--	--
Cobalt	µg/L	--	--	2.8	5.0	--	--	--	--	--	--
Copper ⁶	µg/L	-- ⁸	1,000	9.3 ⁽¹⁾	9.3 ⁽¹⁾	--	--	--	--	--	--
Iron	µg/L	--	300	--	--	--	--	--	--	--	--
Lead ⁶	µg/L	-- ⁸	--	3.2	3.2	--	--	--	--	--	--
Manganese	µg/L	--	50	--	--	--	--	--	--	--	--
Mercury	ng/L	2,000	--	1.3	1.3 ⁽¹⁾	--	--	--	--	--	--
Nickel ⁶	µg/L	--	--	52 ⁽¹⁾	52 ⁽¹⁾	--	--	--	--	--	--
Selenium	µg/L	50	--	5.0 ⁽¹⁾	5.0 ⁽¹⁾	--	--	--	--	--	--
Silver ⁶	µg/L	--	100	1.0	1.0	--	--	--	--	--	--
Thallium	µg/L	2	--	0.28	0.56	--	--	--	--	--	--
Vanadium	µg/L	--	--	--	--	--	--	--	--	--	--
Zinc ⁶	µg/L	--	5,000	120 ⁽¹⁾	120 ⁽¹⁾	--	--	--	--	--	--

Source: *Minnesota Rules*, chapters 7050 and 7052; USEPA pMCL (40 CFR 141); sMCL (40 CFR 143).

All values represent total concentration unless otherwise noted.

- ¹ Based on *Minnesota Rules*, part 7052.0100, *Water Quality Standards Applicable to Lake Superior Basin*, which supersedes standards listed in *Minnesota Rules*, part 7050.0140.
- ² The quality of Class 4A waters of the state shall be such as to permit their use for irrigation without significant damage or adverse effects upon any crops or vegetation usually grown in the waters or area... The following standards shall be used as a guide in determining the suitability of the waters for such uses... Sulfates (SO₄) - 10 mg/L, applicable to water used for production of wild rice during periods when the rice may be susceptible to damage by high sulfate levels.
- ³ *Minnesota Rules*, parts 7050.0222 and 7052.0100.
- ⁴ *Minnesota Rules*, part 7050.0223.
- ⁵ *Minnesota Rules*, part 7050.0224.
- ⁶ Water quality standard for this metal is hardness dependent. The listed value assumes a hardness of 100 mg/L.
- ⁷ Standards for metals are expressed as total metals, but must be implemented as dissolved metal standards. Factors for converting total to dissolved metals are listed in *Minnesota Rules*, parts 7050.0222 and 7052.0360.
- ⁸ Lead and copper enter drinking water primarily through plumbing materials. In 1991, USEPA published the Lead and Copper Rule (<http://www.epa.gov/safewater/lcrr/index.html>). This rule requires water systems to monitor drinking water at customer taps. The 1,300-µg/L copper concentration and 15-µg/L lead concentration represent action levels that, when exceeded at 10 percent of customer taps, require the water system to take additional actions to control corrosion. Therefore, these values reflect concentrations at the customer tap. Additionally, *Minnesota Rules*, part 7050.0221, subpart 1B, states that the primary drinking water standards for copper and lead are not applicable to Class 1 surface waters.

Surface Water Quality Evaluation Locations

These surface water evaluation criteria are assessed at the following surface water evaluation locations (see Figures 4.2.2-8 and 4.2.2-15):

- Partridge River Watershed
 - Partridge River – at SW-002, SW-003, SW-004, SW-004a, SW-004b, SW-005, and SW-006; and
 - Colby Lake.
- Embarrass River Watershed
 - Embarrass River – at PM-12, PM-12.2, PM-12.3, PM-12.4, and PM-13 (note that model results for evaluation locations PM-12.3 and PM-12.4 did not show anything different so are not discussed further in the SDEIS);
 - Mud Lake Creek – at MLC-2 and MLC-3;
 - Trimble Creek – at TC-1 and PM-19; and
 - Unnamed Creek – at PM-11.

Relationship of Hardness to Evaluation Locations

There are six metals whose chronic water quality standards are based on hardness concentrations: cadmium, chromium (III), copper, lead, nickel, and zinc. The water quality standards for these metals vary with the hardness concentration. Calcium and magnesium ions that contribute to water hardness generally lower metals toxicity (i.e., as hardness concentration increases, the water quality standard for these metals also increases).

Within the water quality modeling, estimated concentrations for these six metals are compared to hardness-based standards at each model evaluation location and each model time step to determine compliance with the evaluation criteria. Hardness-based standards are calculated differently at different evaluation locations for the reasons described below:

- Headwater release locations – These include model evaluation locations that periodically have little or no flow, and where releases from NorthMet Project Proposed Action-related sources may represent a significant portion of the total flow. At these locations in the Partridge River and Embarrass River watersheds, the instantaneous modeled hardness of the discharge at each time step is used to calculate the hardness-based metal standard.
- Non-headwater release locations – These include model evaluation locations where there is perennial flow and where releases from NorthMet Project Proposed Action-related sources contribute a variable percentage of the total streamflow. At these locations, the median hardness measured (not modeled) in the receiving stream is used to calculate the hardness-based metal standard.
- Non-release locations with perennial flow – These include model evaluation locations that are downstream of locations that receive NorthMet Project Proposed Action-related releases. At these locations, the instantaneous modeled hardness in the receiving stream is used to calculate the hardness-based metal standard.

Downstream Water Quality Standards

Releases are also analyzed in the SDEIS relative to downstream waterbodies and their associated evaluation criteria because they may have more stringent water quality standards. For example, the Fond du Lac Band has promulgated water quality standards that are protective of specific, designated, or beneficial uses for waterbodies on the Fond du Lac Reservation, which is located approximately 70 miles downstream of the NorthMet Project area on the St. Louis River. These standards were approved by the USEPA in December 2001. They apply to all waters, including wetlands, within the Reservation. The Fond du Lac water quality standards include determination of designated or beneficial uses, narrative and numeric criteria to support or sustain those uses, and anti-degradation provisions.

Based upon results of Fond du Lac Band water quality monitoring, as well as additional resource investigations, the Reservation's reach of the St. Louis River is attaining all of its beneficial uses and meeting all applicable water quality standards with the exception of mercury. In-stream mercury concentrations in the St. Louis River, measured by the Fond du Lac Band, have been below the Great Lakes Initiative Chronic Wildlife Standard of 1.3 ng/L, but exceed the Fond du Lac Band's human health chronic standard of 0.77 ng/L. For this reason, the Fond du Lac Band is especially concerned about any new or expanded discharges to the St. Louis River upstream of the Reservation that may adversely affect mercury bioaccumulation in fish in the St. Louis River (Schuldt, Pers. Comm., March 6, 2012).

Mercury Evaluation Criteria

Mercury numeric standards are based on total (particulate plus dissolved) concentrations. For the Lake Superior Basin, in which the NorthMet Project area is located, the Class 2B (aquatic life and recreation) numeric chronic standard for mercury in the water column protective of wildlife is 1.3 ng/L, which is the most stringent applicable standard (with the exception of the downstream standard at the Fond du Lac Reservation).

There is a relationship, only partially understood, between sulfate concentration and the conversion of inorganic mercury by sulfate-reducing bacteria into methylmercury. Methylmercury is much more of a problem than inorganic mercury, in that it can accumulate to concentrations of concern in the aquatic food chain, it is more bioavailable than inorganic mercury, and it can bioaccumulate in fish, wildlife, and humans. Currently, there is no State of Minnesota surface water quality standard for methylmercury, or for sulfate in the context of its potential for effect on methylmercury concentrations. However, the State of Minnesota has a fish tissue water quality standard for mercury of 0.2 milligram per kilogram (mg/kg), which was amended in *Minnesota Rules*, chapter 7050, in 2008. In 2006, the MPCA also developed a *Strategy to Address Indirect Effects of Elevated Sulfate on Methylmercury Production and Phosphorus Availability*, which identifies policies and review procedures for evaluating the potential of proposed projects to produce methylmercury. This strategy includes recommendations to avoid or minimize the discharge of water with elevated sulfate concentrations to methylmercury "high-risk" situations (MPCA 2006).

The *Minnesota Rules* fish tissue standard for mercury of 0.2 mg/kg is lower than the USEPA criterion of 0.3 mg/kg (wet weight, per USEPA criteria) to adjust for the higher per capita consumption of wild-caught fish in Minnesota. Based on the results of scientific investigations, this criterion assumes that all fish tissue mercury is in the methylmercury form.

Research suggests that total mercury concentrations in streams and methylmercury content in fish are roughly proportional within individual watersheds (USGS 2010), such that, for example, a 5 percent increase in total mercury in water would be expected to result in about a 5 percent increase in mercury content in fish within that watershed.

Waters Used for the Production of Wild Rice Evaluation Criteria

Minnesota Rules, part 7050.0224, defines the Class 4A water quality standards for the Agriculture and Wildlife Use Classification, which includes a 10 mg/L sulfate standard “applicable to water used for production of wild rice during periods when the rice may be susceptible to damage by high sulfate levels.” Application of this standard is therefore dependent on the identification of specific waters used for the production of wild rice and a determination of the period when rice may be susceptible to damage by high sulfate levels.

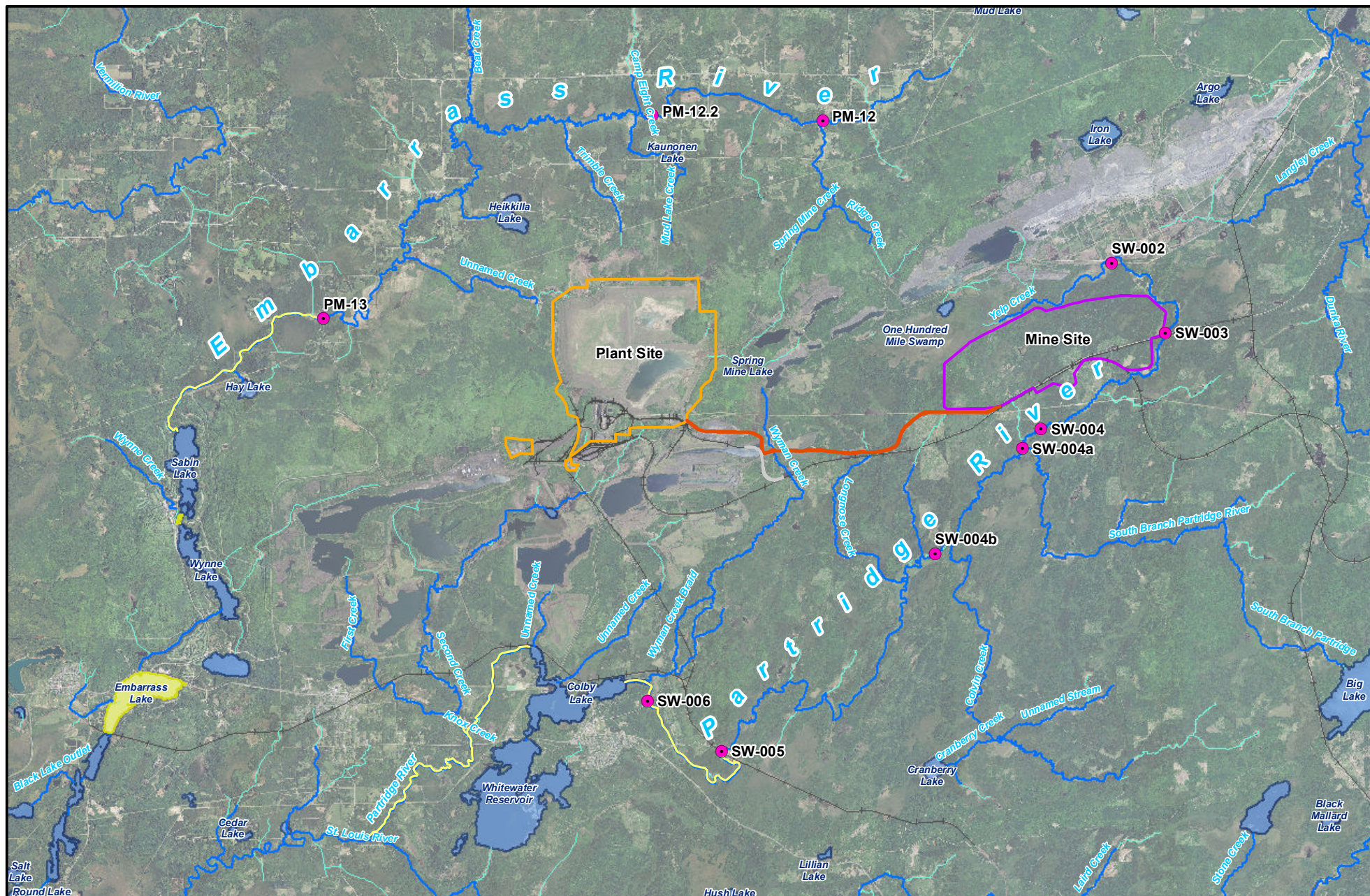
When evaluating any facility or project with potential effects on wild rice production, the MPCA considers all available information to determine on a case-by-case basis which surface waters are used for the production of wild rice (MPCA 2006). For the NorthMet Project Proposed Action, the MPCA considered available non-regulatory (i.e., not promulgated by rule) lists of wild rice beds assembled by the MDNR, the 1854 Treaty Authority and the Wild Rice Management Workgroup (a coalition of federal, state, and tribal resource managers and other wild rice stakeholders), and the results of site-specific wild rice field surveys conducted in 2009, 2010, and 2011 in the Partridge and Embarrass rivers.

To date within the NorthMet Project area, MPCA (2012a) has reached a draft staff recommendation that the following are “waters used for the production of wild rice (see Figure 5.2.2-1):

- Within the Embarrass River Watershed:
 - that segment of the Embarrass River from MN Highway 135 bridge to the inlet to Sabin Lake;
 - the northernmost tip of Wynne Lake (Embarrass River inlet); and
 - Embarrass Lake north of the railroad crossing.
- Within the Partridge River Watershed:
 - that portion of Upper Partridge River from river mile approximately 22, just upstream of the railroad bridge near Allen Junction, to the inlet to Colby Lake;
 - that portion of Lower Partridge River from the outlet of Colby Lake to its confluence with the St. Louis River; and
 - that portion of Second Creek from First Creek to the confluence with Partridge River.

Further recommendations of wild rice waters by the MPCA are possible if new information becomes available.

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- | | | | |
|--|---|--|-------------------------------------|
| | MPCA Staff-Recommended Wild Rice Water | | Mine Site |
| | MPCA Staff-Recommended Wild Rice Water | | Plant Site |
| | MDNR Designated PWI Stream/River | | Transportation and Utility Corridor |
| | Non MDNR Designated PWI Stream/River | | Railroad Connection |
| | MDNR Designated PWI Lake/Wetland | | Existing Railroad |
| | Partridge River or Embarras River Evaluation Location | | |

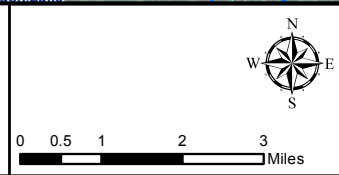


Figure 5.2.2-1
MPCA Staff-Recommended Wild Rice Waters
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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The MPCA also reached a draft staff recommendation (MPCA 2012b; ERM 2012), based on research findings and currently available information applicable to the Partridge River system, that the period when wild rice may be susceptible to damage by high sulfate levels (and thus, when the 10 mg/L sulfate water quality standard would be applicable) be defined as April 1 to August 31. This recommendation was primarily based on nutrient uptake during critical growth stages of wild rice plant growing in Minnesota, as well as MPCA permitting/environmental review precedents. MPCA staff will consider additional information that may become available in the future and reserves the right to modify their recommendation accordingly. PolyMet is not seeking application of the seasonal component of this standard for the NorthMet Proposed Action as currently proposed and evaluated in this SDEIS. During closure, PolyMet has indicated a desire to transition to non-mechanical treatment once pilot-testing and modeling indicate water quality standards could be met, which potentially could include application of the wild rice seasonal standard, but these are beyond the scope of this SDEIS.

5.2.2.2 Methodology

There have been substantial changes to the methodology used for predicting NorthMet Project Proposed Action effects on groundwater and surface flow and quality since the DEIS. Terminology necessary to understand the differences between the DEIS and SDEIS impact assessment methodologies is provided in Table 5.2.2-5. For example, the DEIS evaluated water quality at the Mine Site using three deterministic cases (i.e., low-, medium-, and high-flow conditions), in an attempt to capture uncertainty associated with some of the input values. This was supplemented by limited uncertainty analysis to help assess whether the deterministic modeling produced conservative values. The uncertainty analysis in the DEIS indicated mixed results regarding the conservatism of the deterministic modeling.

Table 5.2.2-5 Definition of Terminology used in this SDEIS

Term	Definition
Uncertainty	Incomplete knowledge of a process, quantity, value, or outcome, which can be quantified as a cumulative probability distribution.
Variability	There is no single correct absolute value; values vary in time and/or space.
Deterministic Simulation	Prediction is made based on a model for which all input parameters are represented as single values; i.e., no uncertainty is applied to the inputs. The model results are expressed as a set of fixed outcomes.
Probabilistic Simulation	Prediction is made based on a model that incorporates the uncertainty of model inputs; i.e., the cumulative probability distributions of input parameters are incorporated into the calculations. The model results are expressed as a set of cumulative probability distributions.

For the SDEIS, a probabilistic modeling approach was used for predicting NorthMet Project Proposed Action effects on water resources. Probabilistic modeling is a statistical method that estimates the probability of a given outcome occurring. It is designed to account for uncertainties, unlike deterministic modeling, where all inputs are known or estimated, and, when modeled, always produce a single result, without accounting for uncertainty. The probabilistic approach not only enables prediction of effects on groundwater and surface water from the NorthMet Project Proposed Action, but it also helps quantify the probability of the effects occurring and characterize the uncertainty around the predictions. Table 5.2.2-6 compares the modeling approach used in the DEIS with the approach used in the SDEIS:

Table 5.2.2-6 Comparison of DEIS and SDEIS Modeling Approaches

Previous DEIS	Current SDEIS
Stand-alone model components	Linked source-to-evaluation location
Discrete points in time with interpolation	Continuous through time until or near steady-state conditions reached
Deterministic with three cases	Probabilistic, including uncertainty and variability
Separate uncertainty analysis of select components	Fully integrated uncertainty analysis of entire model

The effects of the NorthMet Project Proposed Action on groundwater and surface water quality within the Partridge River Watershed were evaluated using MODFLOW for groundwater hydrologic modeling, XP-SWMM for surface water hydrologic modeling, and GoldSim for water quality modeling. Detailed descriptions of how these models were applied to the Mine Site are provided in the Mine Site Water Modeling Data Package (PolyMet 2013i) and Mine Site Water Modeling Work Plan (Barr 2012d). At the Plant Site, the modeling consisted of MODFLOW, GoldSim, and a spreadsheet compilation of streamflows for different watersheds based on Embarrass River stream gauging data. Detailed descriptions of how these models were applied to the Plant Site are provided in the Plant Site Water Modeling Data Package (PolyMet 2013j) and Plant Site Water Modeling Work Plan (Barr 2012e). Each of the three model types is summarized below.

5.2.2.2.1 Groundwater Hydrologic Modeling

Regional and site-scale modeling of groundwater flow systems was performed using MODFLOW, a public-domain, numerical, finite-difference groundwater flow model that can simulate three-dimensional saturated flow in heterogeneous media (McDonald and Harbaugh 1988). Input to the model included delineation of the areal and vertical extent of geologic materials, hydrologic characteristics of those materials (e.g., hydraulic conductivity), meteoric recharge, and alignment of hydrologic boundaries (e.g., perennial stream channels). MODFLOW provided estimates of hydraulic head distributions, groundwater flows/directions in the surficial aquifer and bedrock units, and baseflow releases to perennial streams. By adjusting hydraulic conductivity and recharge inputs, the MODFLOW models were calibrated to measured hydraulic heads in monitoring wells and estimated baseflows in the Partridge and Embarrass rivers.

Based on MODFLOW results and other site characterization data, groundwater flowpaths were delineated at the Mine Site and Plant Site for modeling of groundwater flow and solute transport from mine facilities to groundwater evaluation locations and locations where groundwater releases to surface water. The semi-analytical flowpath models were programmed into the Mine Site and Plant Site water quality models.

Mine Site

For the DEIS, a Regional (large-scale) MODFLOW model was developed to evaluate aerially distributed recharge, hydraulic head distributions, and groundwater flow directions (Barr 2007d). The regional model contained two layers—one for the surficial (unconsolidated) aquifer and one for bedrock. The model boundary conditions were mostly regional drainage divides (treated as no-flow boundaries) and perennial streams (treated as prescribed head boundaries). Revisions to the XP-SWMM model since the DEIS resulted in different baseflow estimates for the Partridge River. By varying areal recharge, the regional model was roughly calibrated to measured

hydraulic heads and the revised XP-SWMM baseflows. An important calibration constraint was that the predicted hydraulic head in the surficial aquifer would not be above ground surface.

To evaluate groundwater flowpaths and the hydraulic effects of Mine Site features in more detail, a site (local-scale) MODFLOW model of the Mine Site was developed that was essentially an internal “window” within the regional model. The Site MODFLOW model contained eight layers—one for the surficial aquifer and seven for bedrock. Where not coincident with perennial streams or drainage divides, the prescribed head conditions along the external boundaries of the Site model were taken from the head distributions predicted by the regional model. The footprints and vertical extent of the mine features were modified from the DEIS model to reflect the current Mine Plan. The aerial extent of the Site MODFLOW model and simulated hydrologic features are shown on Figure 5.2.2-2 and Figure 5.2.2-3.

Revisions to the XP-SWMM model since the DEIS resulted in different surface water baseflow estimates for the Partridge River. Using the revised XP-SWMM baseflow estimates, the Site MODFLOW model was calibrated using target baseflow values of 0.41, 0.51, and 0.92 cfs at SW-002, SW-003, and SW-004, respectively. This calibration was performed by varying hydraulic conductivity and stream conductance values, but not aerial recharge. In addition, groundwater elevations measured at Mine Site monitoring wells MW-1 through MW-18 were included as calibration targets. The automated-inverse modeling code PEST (Watermark 2005) was used to complete the model calibration, which involved varying the horizontal and vertical hydraulic conductivities of the different geologic subunits and the conductance of river cells representing the Partridge River to achieve a best fit between predicted and measured hydraulic heads and target baseflows. The automated PEST calibration used field-measured hydraulic conductivities to help constrain the range of allowed hydraulic conductivities in the model. Information on calibration of the Site MODFLOW model is provided in PolyMet (2013i).

The calibrated Site MODFLOW model provided optimized values for the horizontal and vertical hydraulic conductivities of different subunits of the surficial aquifer and bedrock, which are summarized in Table 5.2.2-7. For the surficial aquifer in the Site MODFLOW model, the meteoric recharge flux was 1.8 in/yr for glacial drift and 0.36 in/yr for wetland deposits.

Table 5.2.2-7 Mine Site Hydraulic Conductivities Based on Calibration of the Site MODFLOW Model and Field Testing

Major Unit	Subunit	Horizontal Hydraulic Conductivity			Vertical Hydraulic Conductivity
		Minimum	Mean	Maximum	
		ft/day	ft/day	ft/day	ft/day
Surficial Materials	Glacial drift	0.095	17.4	164	0.0028
	Wetland deposits	0.017	5.6	143	0.0028
Bedrock	Giants Range Batholith	(a)	0.026	(a)	0.0026
	Biwabik Iron Fm.	(a)	1.2	(a)	0.12
	Upper Virginia Fm.	(a)	0.072	(a)	0.0072
	Duluth Complex	(a)	0.00049	(a)	0.000049
	Lower Virginia Fm.	(a)	0.019	(a)	0.0019

(a) Single-value calibration values were developed for bedrock units; min/max values were not evaluated.

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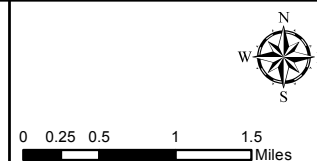
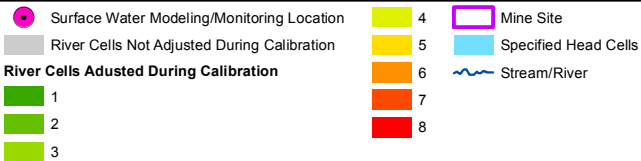
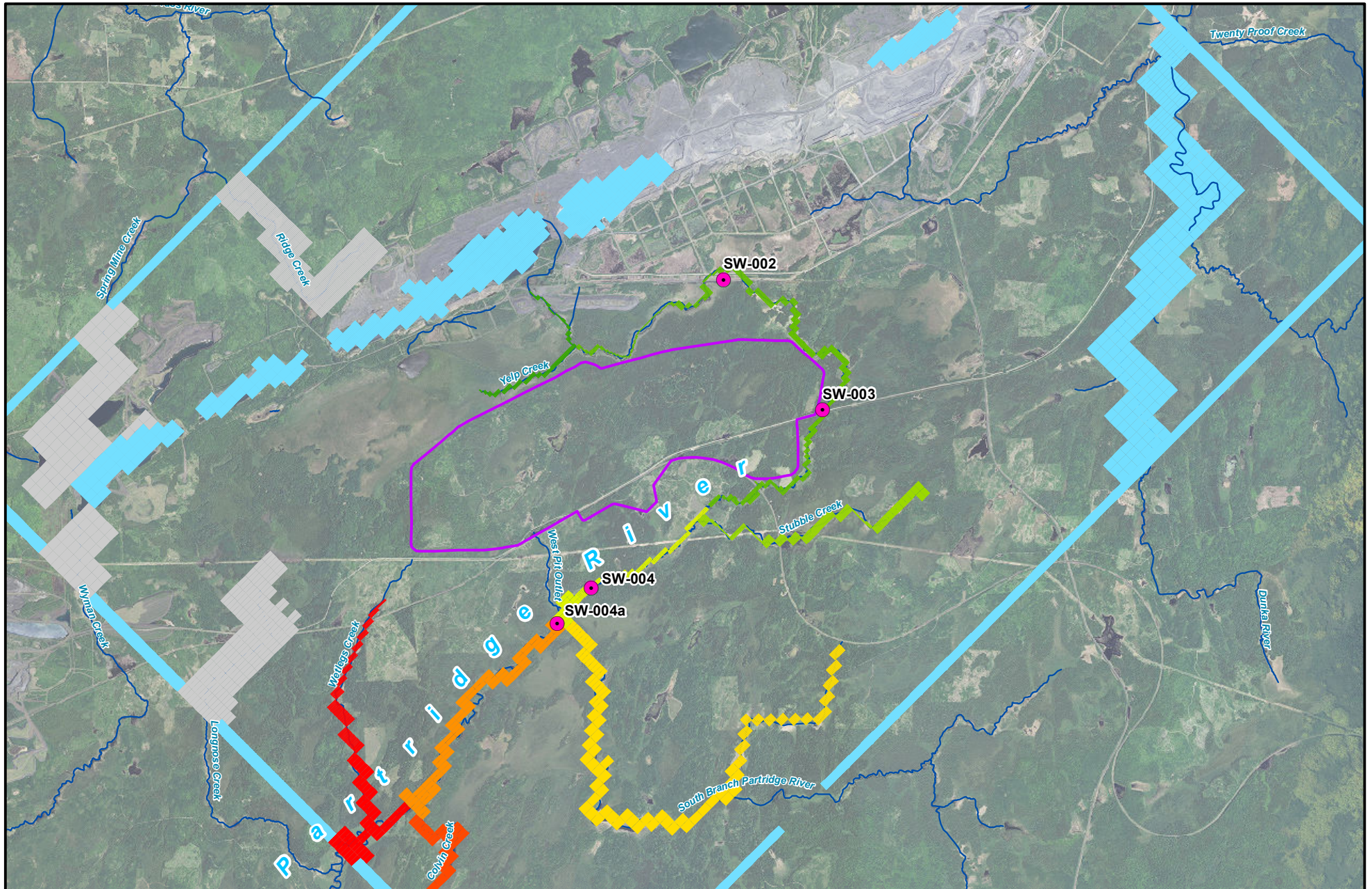
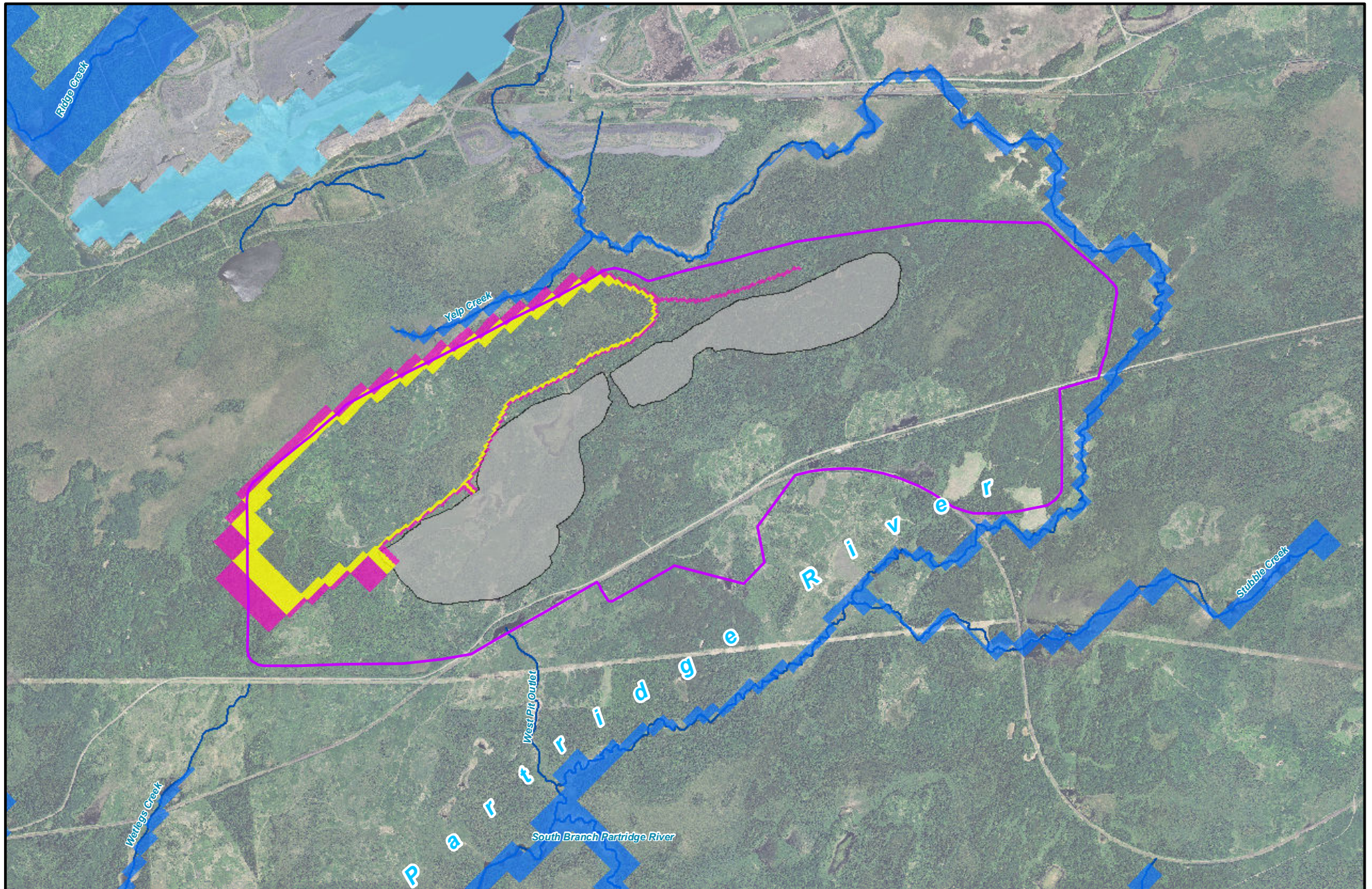









Figure 5.2.2-2
Mine Site MODFLOW Model - River Reaches
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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- | | |
|--|--|
|  Specified Head Cell |  Mine Site |
|  River Cell |  Mine Pit |
|  Low-K Cell Representing Soil Barrier or Cutoff Wall |  Stream/River |
|  Drain Cell Representing Category 1 Drainage Collection System | |

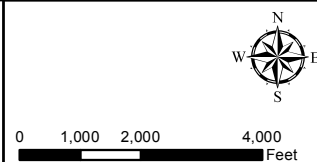


Figure 5.2.2-3
Mine Site MODFLOW Model - Groundwater Containment System Features
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

November 2013

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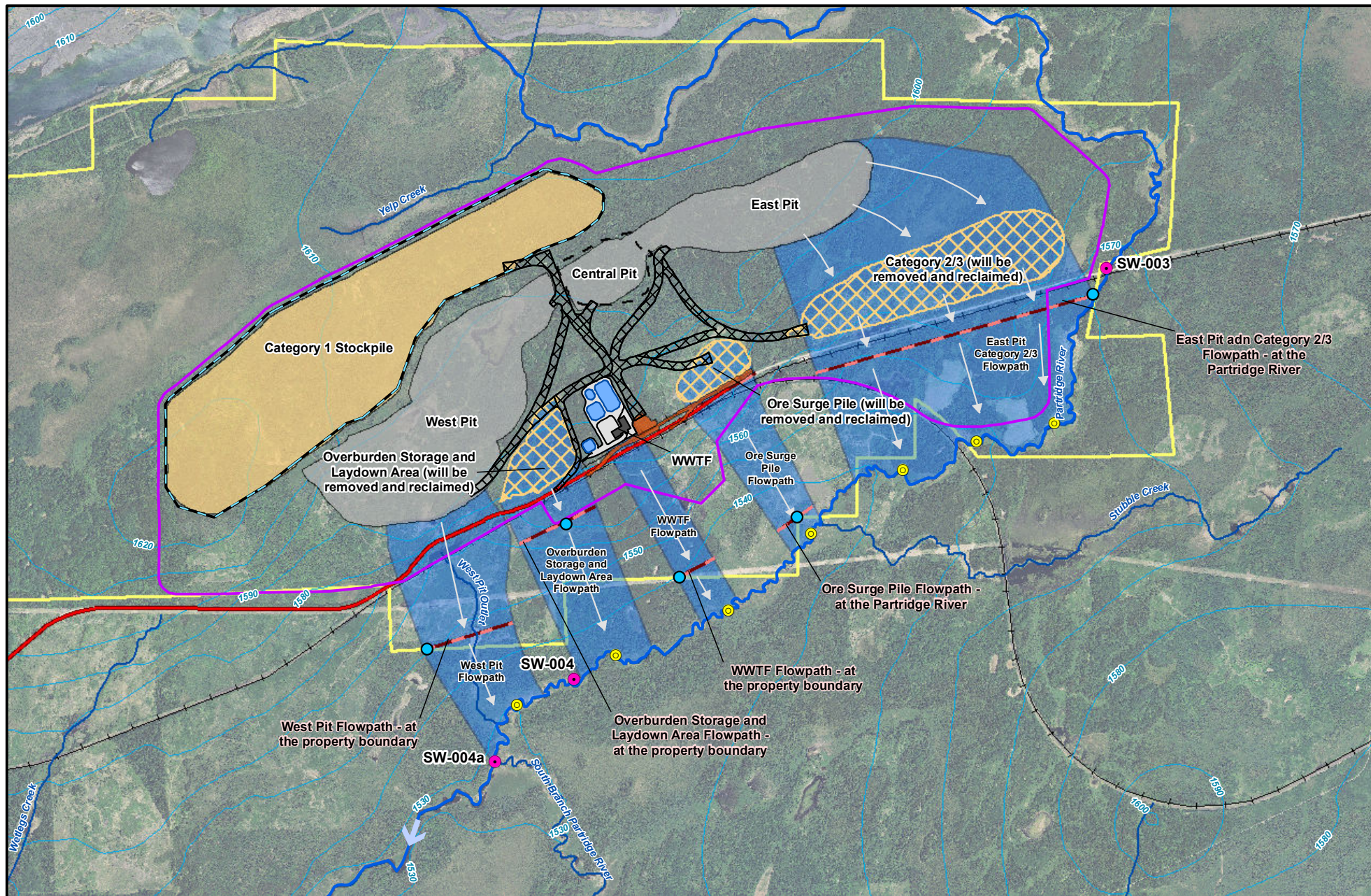
Figure 5.2.2-4 shows surficial groundwater flowpaths with the potential to transport mine-affected groundwater from identified source areas to designated evaluation locations. The hydrologic characteristics of each surficial flowpath are summarized in Table 5.2.2-8. Due to the generally low hydraulic conductivity of bedrock, independent calculations indicate that groundwater transport in bedrock is minimal and does not affect solute concentrations at the evaluation locations.

Bedrock flowpaths and evaluation locations were also evaluated, but because the bedrock (primarily the Duluth Complex) is highly competent with very low hydraulic conductivities (see Table 5.2.2-7), very little groundwater transport occurs within the bedrock flowpaths and travel times to evaluation locations are predicted to be in the thousands of years.

Concerns have been raised that fractures or faults may exist at the Mine Site that could function as high-permeability conduits for groundwater over long distances through the bedrock. Such features have been identified elsewhere on the Canadian Shield. Most of these features, however, have been associated with tectonic events occurring more than 1.6 billion years ago. These events would not be relevant to the Duluth Complex as they predate its emplacement, which occurred during the Mid-Continent Rift approximately 1.1 billion years ago. A few studies have identified the presence of fracturing and faults in the Duluth Complex, but these features were believed to have formed during emplacement of the Duluth Complex and are unlikely to transmit water and, where fractures were found, they were largely filled with gouge (Foose and Cooper 1979; 1981), or relate to an unusual cleavage pattern known to occur in one location west of Duluth, about 70 miles from the Mine Site (Foster and Huddelston 1986).

Although the presence of fractures at the Mine Site cannot be completely ruled out, site specific data, such as boring logs, indicate the bedrock appears competent, only rarely encountered deep fractures near the surface, and hydrogeologic investigations have indicated that the bulk hydraulic conductivity of bedrock at the Mine Site is very low. See Section 4.2.2.2.1 for additional information.

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<ul style="list-style-type: none"> Surficial Aquifer Head Contour (m) at Closure Groundwater Flowpath Surface Water Evaluation Location Groundwater Discharge to Surface Water Groundwater Evaluation Locations Extent of Future PolyMet Lands 	<ul style="list-style-type: none"> Groundwater Containment System Permanent Stockpiles Removed and Reclaimed Stockpile Removed Stockpile Surface Water Flow 	<ul style="list-style-type: none"> Mine Site Haul Road Mine Pit Groundwater Flow Dunka Road Stream/River 	<p>This PSDEIS document is a Co-lead</p> <p>US Army Corps of Engineers St. Paul District</p>		<p>Figure 5.2.2-4 Mine Site Surficial Groundwater Flowpaths NorthMet Mining Project and Land Exchange SDEIS Minnesota</p>
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Table 5.2.2-8 Mine Site Surficial Groundwater Flowpaths used in GoldSim Based on Deterministic Run with P50 Inputs

Description	Units	Solute Source to Groundwater					
		West Pit	Overburden Storage and Laydown Area	WWTF	Ore Surge Pile	Category 2/3 ⁽⁸⁾	East Pit ⁸
Groundwater flow rate from contaminant source into the upgradient portion flowpath	gpm	6.09 ⁽¹⁾	14.0 ⁽⁴⁾	0.0135 ⁽⁵⁾	0.00116 ⁽⁵⁾	0.0194 ⁽⁵⁾	3.75 ⁽¹⁾
Net meteoric recharge flux	in/yr	0.828	0.993	0.647	0.903	0.910	0.910
Flowpath width	meters	665	550	240	430	1440	1440
Flowpath total length	meters	1,505	1,600	1,730	1,415	2,120	2,120
Recharge flow rate into flowpath	gpm	10.58	11.16	3.43	7.01	35.47	35.47
Groundwater release rate into Partridge River	gpm	16.7	22.56 [11.1 ⁽²⁾]	3.4	7.0	35.5	39.3
Flowpath thickness	meters	5	5	5	5	5	5
Aquifer porosity	(--)	0.30	0.30	0.30	0.30	0.30	0.30
Solute source begin time	mine year	33 ⁽⁶⁾	0	0	0	0	21 ⁽⁷⁾
Solute source end time	mine year	Continuous	20	35	21	20	Continuous
Distance from contaminant source to groundwater evaluation location	meters	860	235	910	1,085	140	1,345
Sharp front contaminant arrival time at groundwater evaluation location (based on contaminant source begin time)	mine year	65	6 ⁽³⁾	75	90	12	90
Distance from contaminant source to Partridge River (surface water release)	meters	1,505	1,225	1,310	1,185	955	2,120
Sharp front contaminant arrival time at Partridge River (based on contaminant source begin time)	mine year	90	17 ⁽³⁾	95	90	30	110

Source: Barr 2013f; ERM 2013.

¹ Pit water into groundwater flowpath.

² After source removed at 21 years.

³ Concentration decrease for most solutes.

⁴ Infiltration of meteoric water (top of facility).

⁵ Liner leakage (bottom of facility).

⁶ Beginning in year 33, the West Pit water level would rise above the top of bedrock and begin to release pit lake water into the West Pit Surficial (groundwater) Flowpath. The West Pit would flood at about year 40.

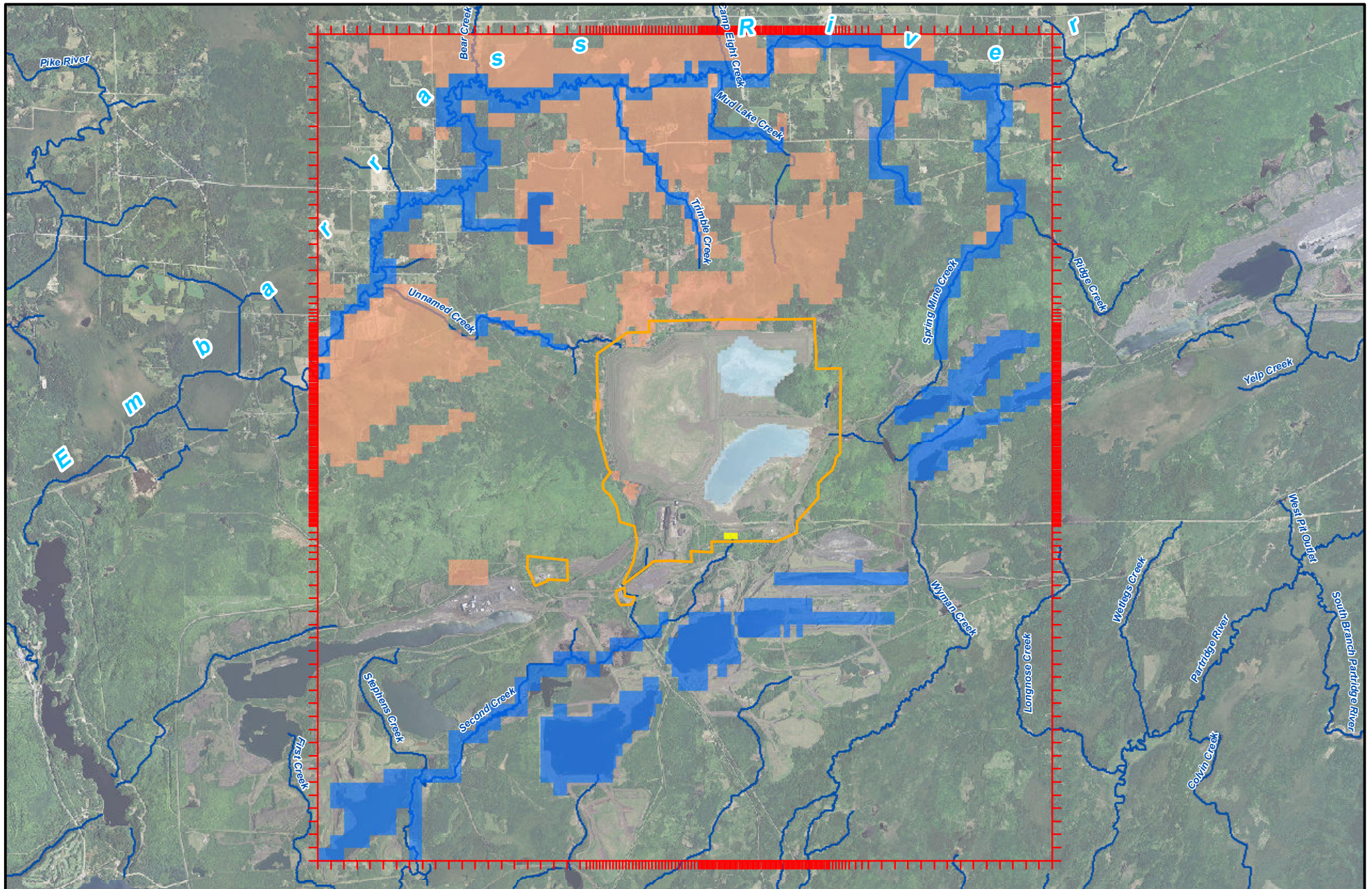
⁷ Beginning in year 21, the water level in the East Pit saturated backfill would rise above the top of bedrock and begin to release pit water into the East Pit Cat 2/3 Surficial (groundwater) Flowpath. The East Pit would flood at about year 22.

⁸ East Pit and Category 2/3 Stockpile deliver affected water to the same flowpath at different times. This flowpath is referred to as the "East Pit Cat 2/3 Surficial Flowpath."

Plant Site

The Plant Site MODFLOW model (existing conditions model) was constructed with two layers (the Project model had additional layers) and simulated groundwater flow in tailings materials, the underlying surficial groundwater system, and in bedrock outcrops. The aerial extent of the Plant Site MODFLOW model and simulated hydrologic features are shown on Figure 5.2.2-5. The model was used to estimate:

- hydraulic conductivities of natural surficial materials, tailings, and bedrock;
- aerial recharge;
- specific yield; and
- distribution of tailings seepage to different segments of the Tailings Basin perimeter.



- Plant Site
- Constant Head Cell Layer 1
- Constant Head Cell Layer 2
- River Cell - Layer 2
- Drain Cell - Layer 2
- Model Grid

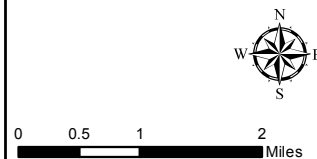


Figure 5.2.2-5
Plant Site MODFLOW Model - Extent
and Boundary Conditions
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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Model calibration was performed by varying input hydraulic conductivities, specific yields, and recharge so that model-predicted hydraulic heads were a reasonable match to water levels measured in monitoring wells. An initial steady-state calibration was performed using operational and water-level data from early 2002 to simulate groundwater mounding conditions near the end of LTVSMC operations. Then, a transient calibration was performed to simulate the observed dissipation of the groundwater mound from 2002 to 2011. A description of the MODFLOW model and calibration process is provided in the Plant Site Water Modeling Data Package (Barr 2013i, Attachment A). The MODFLOW-calibrated hydraulic parameters for different geologic units and tailings types are summarized in Table 5.2.2-9 and Table 5.2.2-10.

Table 5.2.2-9 Plant Site Hydraulic Conductivity and Specific Yield Based on MODFLOW Calibration

Model Zone	Hydraulic conductivity		Specific yield ⁽¹⁾ (---)
	Horizontal (ft/day)	Vertical (ft/day)	
Cell 2W fine tailings	0.312	0.0158	0.024
Cell 2W coarse tailings	3.33	0.0535	0.010
Cell 2W embankments	3.33	0.0535	0.010
Cell 1E fine tailings	0.0779	0.0500	0.10
Cell 1E coarse tailings	6.81	0.802	0.010
Cell 2E fine tailings	0.247	0.200	0.054
Cell 2E coarse tailings	6.35	0.702	0.10
Cell 2E embankments	6.35	0.702	0.10
Surficial deposits	71.3	28.5	0.0002
Bedrock outcrops	0.0493	0.0207	0.20

Sources: Barr 2013i; Barr 2013j.

¹ Value represents storage coefficient. Specific yield not estimated by MODFLOW model for this material type.

Table 5.2.2-10 Plant Site Recharge Based on MODFLOW Calibration

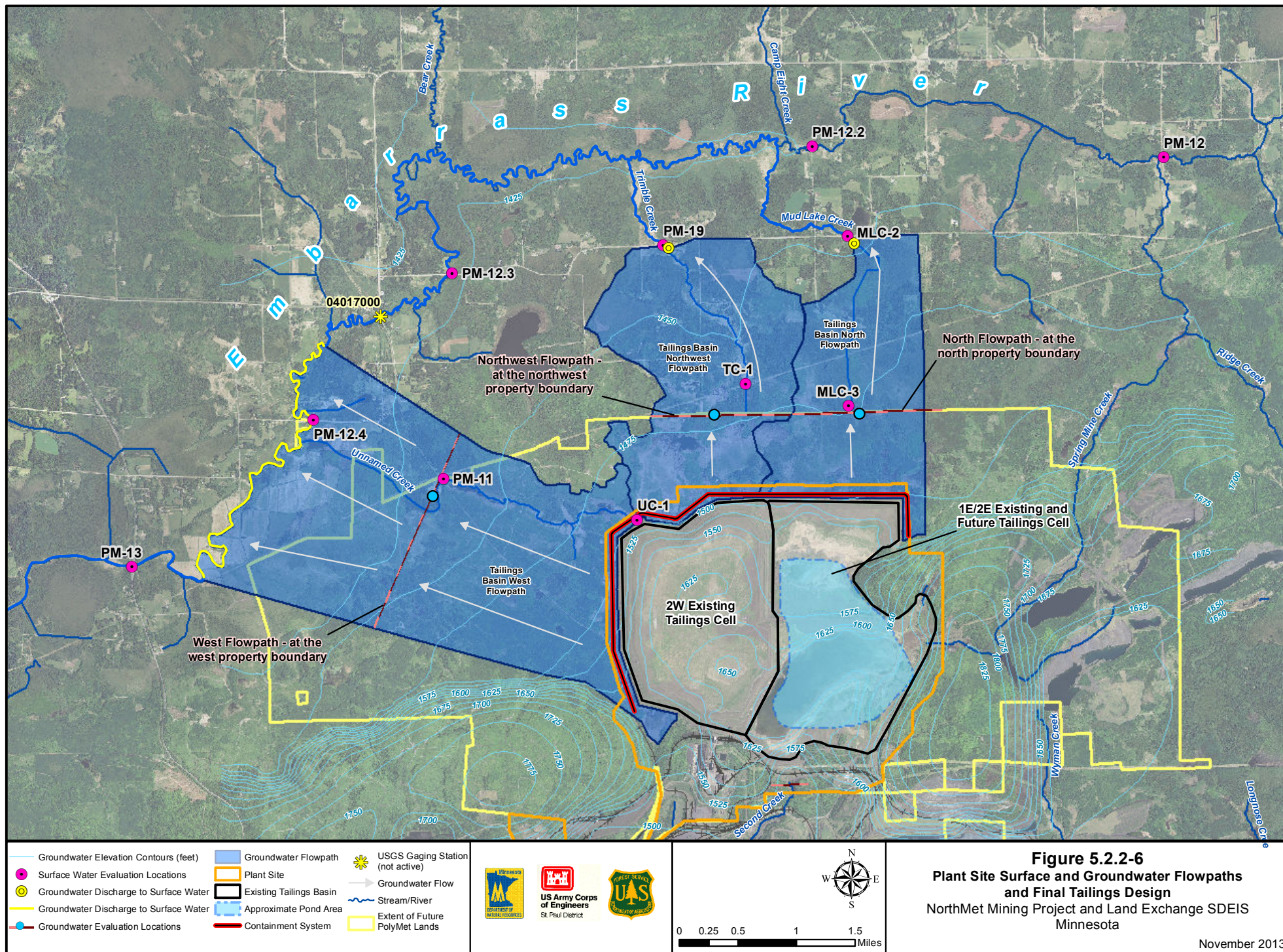
Model Zone	Recharge	
	Steady-State Calibration (in/yr)	Transient Calibration (in/yr)
Exterior dams	6.0	6.0
Cell 2W interior slopes	12.0	11.0
Cell 2W interior tailings	26.1	18.0
1E and 2E fine tailings	1.0	1.0
1E and 2E coarse tailings	6.0	6.0
Surficial deposits	6.0	6.0
Bedrock outcrops	1.0	1.0

Sources: Barr 2013i; Barr 2013j.

After calibration was completed, the Plant Site MODFLOW model was used to evaluate groundwater conditions associated with the NorthMet Project Proposed Action. These predictive simulations evaluated the growth/decay of the groundwater mound below the Tailings Basin and the distribution of groundwater flows from subareas of the Tailings Basin to the north, northwest, west, and south toes of the Tailings Basin.

Figure 5.2.2-6 shows surficial groundwater flowpaths that have the potential to transport Tailings Basin-affected groundwater from contaminant source areas to the Embarrass River or its

tributaries. Also shown are the groundwater evaluation locations (property boundary) used to assess compliance with evaluation criteria. The hydrologic characteristics of each surficial flowpath are estimated based on a combination of MODFLOW results and site characterization information. Deterministic model inputs include length, average width, saturated thickness, hydraulic gradient (essentially ground slope), and effective porosity. Uncertain inputs are hydraulic conductivity and net meteoric recharge.



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Summary information for the groundwater flowpaths is provided in Table 5.2.2-11. Based on deterministic inputs and 50th percentile probability (P50) values for uncertain inputs including hydraulic conductivity and recharge; the estimated total release rate of flowpath groundwater into the Embarrass River or its tributaries would be approximately 306 gpm for all project phases (operation, reclamation, and closure).

Table 5.2.2-11 Plant Site Groundwater Flowpaths Based on Deterministic and P50 Inputs¹

Description	Units	Surficial Aquifer Pathway		
		West	Northwest	North
Groundwater flow rate approaching containment system	gpm	102.5	51.2	40.7
Containment system capture efficiency ²	%	90	90	90
Groundwater flow rate bypassing containment system	gpm	10.2	5.1	4.1
Net meteoric recharge flux	in/yr	0.765	0.765	0.765
Flowpath width	m	2,920	2,090	1,920
Total distance from containment system to location of groundwater release to surface water	m	5,331	3,645	3,191
Recharge flow rate to flowpath downgradient of containment system	gpm	152.1	74.4	59.8
Groundwater release to surface water (Embarrass River or its tributaries)	gpm	162.3 (Embarrass River)	79.5 (Trimble Creek)	63.9 (Mud Lake Creek)
Flowpath thickness	m	7	7	7
Aquifer porosity	(--)	0.30	0.30	0.30
Distance from containment system to groundwater evaluation location	m	3023	1250	1132
Sharp-front contaminant arrival time at groundwater evaluation location	yr	242	193	197
Sharp-front contaminant arrival time at the location of groundwater release to surface water	yr	298	296	298

¹ Source: ERM 2013.

² Input capture efficiency; engineering evaluation indicates that actual capture efficiency would be greater than 90% (PolyMet 2013f).

5.2.2.2.2 Surface Water Hydrologic Modeling

This section describes the methods used to model surface water hydrology in the Partridge River and Embarrass River watersheds. The Plant Site represents a very small portion of the natural (pre-LTVSMC Tailings Basin) Second Creek Watershed and, as a consequence, Second Creek was not included in the surface water hydrologic modeling. However, the loss of natural watershed flow to the headwaters of Second Creek is addressed as an impact.

Partridge River Watershed

Surface water flow within the Partridge River Watershed was modeled using the XP-SWMM model, which is a public-domain watershed hydrology model that estimates stormwater runoff, streamflow, and groundwater-controlled base flow for a network of streams. Input to the model includes subdrainage delineation, ground conditions, stream channel alignments, and a rainfall database. XP-SWMM estimates monthly average streamflow rates at different locations along the Partridge River and its important tributaries. To improve the results, the model inputs (mainly stormwater runoff parameters) were adjusted so that flow estimates were calibrated to available

measured flow rates in the Partridge River. A description of the XP-SWMM model for the Mine Site is provided in the Mine Site Water Modeling Data Package (PolyMet 2013j). A summary of the model results for seven Partridge River monitoring stations (see Figure 4.2.2-8) is provided in Table 5.2.2-12.

Table 5.2.2-12 Mine Site Surface Water Flows for Existing Conditions Based on XP-SWMM Model Results Adjusted to Match USGS Stream Gaging Data

Stream	Station	Baseflow ¹	10-Year Low ²	Average Annual 1-Day Minimum	Annual Daily Mean	Average Annual 1-day Maximum	10-Year High ²
		Cfs	cfs	cfs	cfs	cfs	cfs
Partridge River	SW-002	0.4	0.4	0.4	6.1	82	118
	SW-003	0.5	0.5	0.5	7.4	93	132
	SW-004	0.9	0.7	0.9	14	156	215
	SW-004a	2.4	1.7	2.1	38	468	678
	SW-004b	3.8	2.8	3.4	58	631	895
	PM-4/SW-005	4.9	3.6	4.3	75	737	1,081
	SW-006	5.3	3.9	4.7	79	761	1,127

Source: PolyMet 2013j.

¹ Average annual 30-day minimum.

² 10-year values are based on individual model year flow statistics not published in Attachment G of PolyMet 2013i. Values in Attachment G represent averages of 10-year model period.

Embarrass River Watershed

Flow characteristics for different reaches of the Embarrass River and selected tributaries were estimated by extrapolating flows from USGS gaging station 04017000 (located just downstream of PM-12.3) on a unit-area basis. A summary of the flow results for different stations on Embarrass River, Mud Lake Creek, Trimble Creek, and Unnamed Creek is provided in Table 5.2.2-13.

Table 5.2.2-13 Plant Site Surface Water Flows for Existing Conditions including Tailings Basin Seepage and Flowpath Release Based on Embarrass River Stream Gauging Results Applied to Contributing Watersheds

Stream	Station	Estimated Baseflow Cfs	20-Year Annual Low Flow Cfs	Average Annual Low Flow cfs	Average Annual Flow cfs	Average Annual High Flow cfs	20-Year Annual High Flow cfs
Embarrass River	PM-12	0.9	0.2	0.7	14	145	370
	PM-12.2	1.6	0.4	1.4	26	268	684
	PM-12.3	7.1	4.2	6.6	65	644	1,638
	PM-12.4	7.6	4.3	7.0	73	731	1,860
	PM-13	9.4	5.6	8.7	83	824	2,096
Mud Lake Creek	MCL-3	0.5	0.5	0.5	1.5	11	28
	MLC-2	0.7	0.6	0.7	3.2	28	70
Trimble Creek	TC-1	2.7	2.6	2.7	4.2	19	45
	PM-19	2.9	2.8	2.9	5.6	33	80
Unnamed Creek	PM-11	1.1	1.0	1.1	3.4	27	67

Source: Barr, Pers. Comm., March 8, 2013.

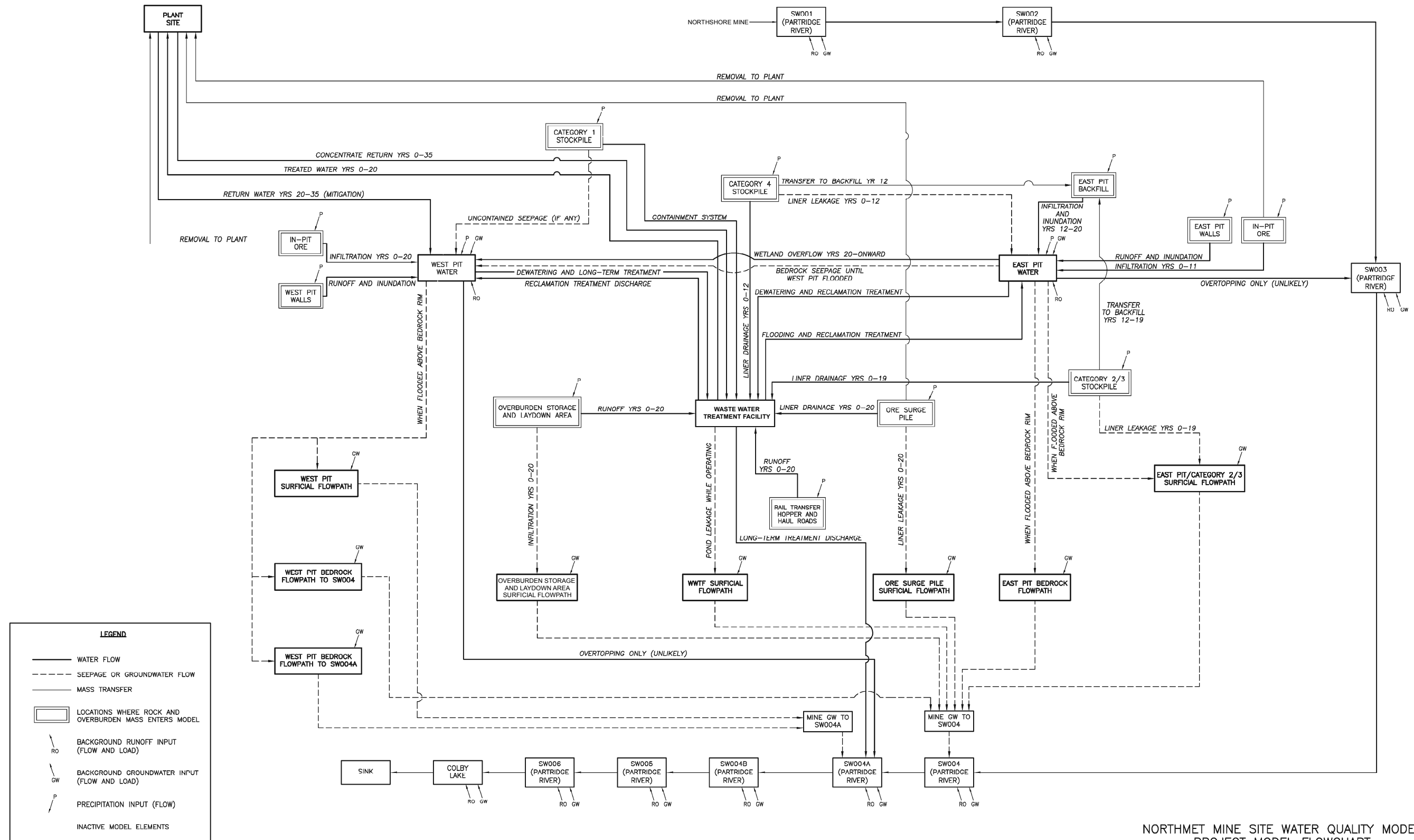
5.2.2.2.3 Water Quality Modeling (GoldSim)

GoldSim is a commercially available “systems” model that allows for probabilistic simulations and was used by PolyMet to simulate time-varying surface water and groundwater quality. GoldSim was programmed with a suite of complex algorithms to estimate the release of contaminants from mine facilities (i.e., “sources”) and their transport to groundwater and surface water evaluation locations. An overview of the modeling of contaminant release and transport in GoldSim is provided below. The sections below provide a geochemistry overview of the waste rock and tailings, and describe the methodology used to estimate contaminant release and transport at the Mine Site (Partridge River Watershed) and Tailings Basin (Embarrass River Watershed).

Mine Site (Partridge River Watershed)

This section describes the geochemistry of the NorthMet Deposit waste rock and the factors affecting contaminant release and transport from the various contaminant sources at the Mine Site. An overall flowchart of the Mine Site GoldSim model is provided as Figure 5.2.2-7.

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NORTHMET MINE SITE WATER QUALITY MODEL
PROJECT MODEL FLOWCHART
GOLDSIM MODEL VERSION 5



Figure 5.2.2-7
Mine Site GoldSim Flow Chart
NorthMet Mining Project and Land Exchange SDEIS
Minnesota

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NorthMet Waste Rock Geochemistry

The mechanism most responsible for the release of solutes from waste rock is oxidation of sulfide minerals, primarily pyrrhotite ($\text{Fe}_{(1-x)}\text{S}$) in NorthMet Deposit rock. The sulfide-oxidation reaction produces sulfuric acid, and releases soluble metals (e.g., cobalt, copper, iron, and nickel) that were bound in sulfide minerals. Secondary effects include leaching of some metals (primarily nickel and chromium) from silicate minerals, particularly where acidic pore waters increase silicate solubility. Mine-related blasting and excavation dramatically increases the surface area and porosity of the rock, which allows rapid introduction of atmospheric oxygen and flushing of solutes by water. Within the pit walls, the blasting effects are limited in terms of lateral extent and do not have much effect on solute transport in bedrock. Where the pore water pH remains near-neutral, metal mobility can be limited as some constituents released by oxidation are removed from solution by adsorption, co-precipitation, or solubility-controlled precipitation of secondary minerals. The onset of acidic pore water is also problematic, as these conditions cause the rate of sulfide oxidation to increase and the concentration of metals to increase as precipitates dissolve.

Key environmental characteristics of the NorthMet waste rock include the following:

- most of the waste rock and pit wall rock would contain some sulfide sulfur, mainly as mineral pyrrhotite ($\text{Fe}_{(1-x)}\text{S}$), which can produce acid leachate and soluble metals when it oxidizes;
- there are essentially no acid-neutralizing carbonate minerals in NorthMet waste rock, but silicate minerals—including plagioclase feldspar ($[\text{Na,Ca}][\text{Si,Al}]_4\text{O}_8$), olivine ($[\text{Mg,Fe}]_2\text{SiO}_4$), and pyroxenes (e.g., diopside, $\text{MgCaSi}_2\text{O}_6$)—neutralize some acid, which would delay acid onset in some rock and would prevent entirely the onset of acidic conditions in rock with less than 0.12 percent sulfur;
- in rock with less than 0.12 percent sulfur (S), the oxidation rate is slow enough that all acid produced during weathering would be completely neutralized by reaction with silicate minerals, so this low-sulfur rock (classified at Category 1 waste rock in the NorthMet Project Proposed Action) is predicted to never generate acidic leachate;
- sulfide-bearing rock from the NorthMet Project Proposed Action may oxidize for several years before producing acidic leachate;
- the rate of sulfide mineral oxidation in excavated NorthMet waste rock would be approximately proportional to the total sulfur content of the material, and the rate could increase several fold if the pore water were to become acidic;
- chemical reactions, including mineral precipitation and surface adsorption, would limit the concentration of many contaminants in non-acidic waste-rock effluent and thus would reduce the rate at which contaminants were released; and
- if the pore-water pH were to shift from neutral to acidic, then the rate of sulfide mineral oxidation and associated release of some metal cations (e.g., nickel and copper) would increase dramatically (e.g., average increase in oxidation upon onset of acidic conditions is a factor of 8.2 relative to non-acidic conditions [Table 8.4 in PolyMet 2013]).

The environmental classification of NorthMet waste rock is based primarily on the sulfur concentration, and the distribution of sulfur through the deposit is based on spatial interpolation between 19,661 analyses of rock samples collected as part of the exploration drilling (SRK 2007a). Rates of oxidation and contaminant release are based on 102 “humidity cell” tests, which measured solute concentrations in leachate as rocks were subjected to over 4 years of simulated weathering cycles. These include tests on 85 waste rock samples of Category 1 through Category 4 waste rock and ore from the NorthMet Deposit that include samples from each type of waste (PolyMet 2013l, Attachment A, Table 2). Estimates for changes in oxidation rates and solute release during long-term weathering were supplemented with 17 independent tests conducted by the MDNR on rock from a similar proximal deposit (the Dunka Blast Hole). These tests on Dunka rock used smaller fragment size rock (termed “MNDNR Reactors”), and results were used to refine estimates of oxidation-rate changes during weathering (PolyMet 2013l, Attachment A, Table 3). Total leachable metal concentrations are based on 61 analyses of metals extracted from waste rock by acidic digestions (SRK 2007b). For constituents that are assumed to be released in proportion to dissolution of another constituent (e.g., copper and zinc were always modeled as being released in proportion to sulfide sulfur oxidation), the concentration ratios were estimated using the average total constituent concentrations measured in all available assayed samples of either Category 1, Category 2/3, or Category 4 waste rock; ore, or Category 4 Virginia Formation (i.e., approximately 18,800 total whole-rock analyses, see Large Table 5 and Section 8.1.2.3 in PolyMet 2013l). Finally, the concentration of metals in mineral phases was based on electron microprobe analysis, which measured the concentration of metals in 630 individual mineral grains (74 oxides, 268 sulfides, and 288 silicates [SRK 2007b; SRK 2007c]).

These environmental characteristics have been used to classify NorthMet waste rock into the following four environmental categories (PolyMet 2013l, Figure 4-8):

- Category 1: Sulfide S range = 0.01 to 0.12 percent, would not produce acidic leachate.
- Category 2/3: Sulfide S range = 0.13 to 0.60 percent, could produce acidic leachate if allowed to weather for several years.
- Category 4 (Duluth Complex): Sulfide S range = 0.63 to 3.05 percent, would produce acidic leachate if allowed to weather for several years.
- Category 4 (Virginia formation): Sulfide S range = 0.4 to 5.0 percent, would produce acidic leachate immediately upon weathering.

Ore would behave similar to Category 4 Duluth complex waste rock, but, other than residual ore in pit wall rock, would not remain on the surface for any extended periods. Ore would be moving in and out of the Ore Surge Pile (a lined facility) throughout the life of the mine.

The sulfide S concentration of the NorthMet waste rock is relatively low compared to many other mines with sulfide-bearing rock around the world. Data from the International Kinetic Database, which includes humidity cell test results from 71 mines, shows sulfide S concentrations ranging as high as 40 percent, with an average of 3.6 percent (see Figure 5.2.2-8) (Mine Site Drainage Assessment Group 2013). In comparison, most (70 percent) of the NorthMet waste rock would be the low-sulfur, non-acid-generating Category 1 material (i.e., average sulfur would equal 0.06 percent, and range from 0.01 to 0.12 percent). The average mass-weighted sulfur content in all NorthMet waste rock is 0.15 percent. The only NorthMet waste rock that would contain greater on average than 1 percent sulfide is the Virginia

Formation, which has an average sulfide S concentration of 2.43 percent, but would only comprise about 1.8 percent of the total NorthMet Deposit waste rock. It should be noted, however, that not all sulfide sulfur has the same potential for release.

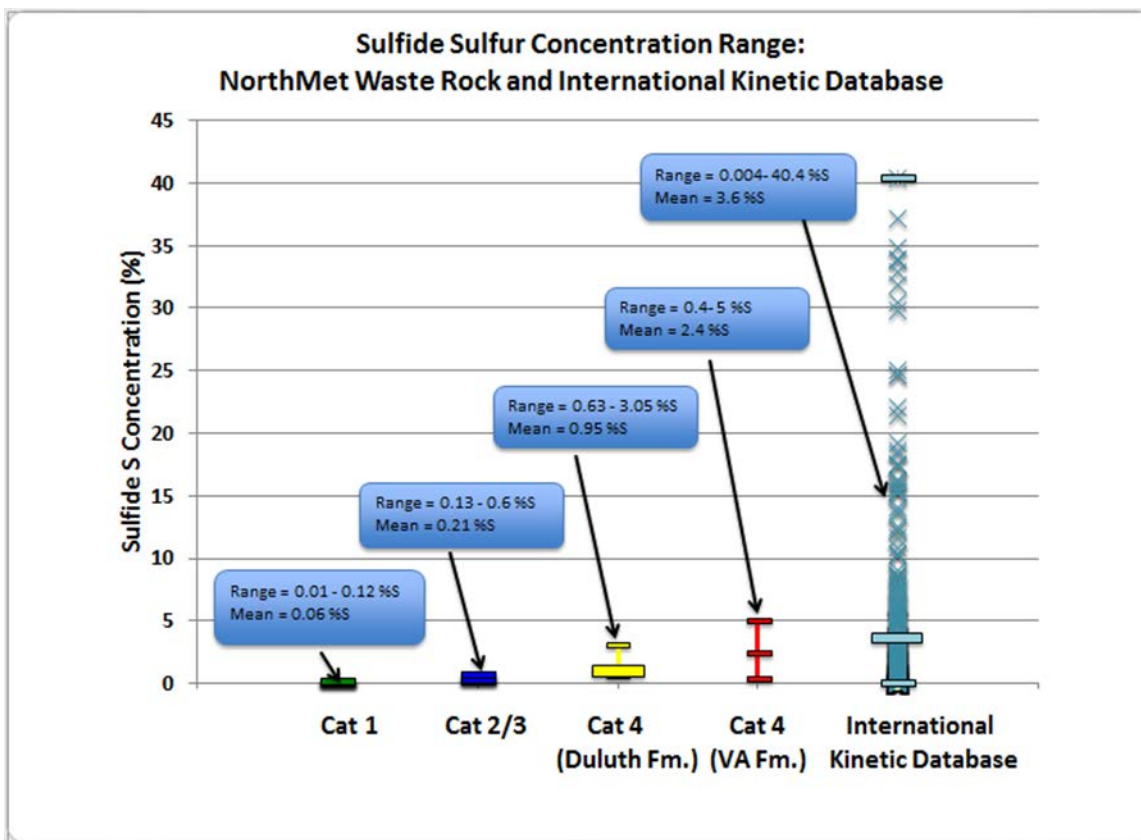


Figure 5.2.2-8 Comparison of NorthMet Project Waste Rock Sulfide Sulfur Concentrations with Other Mines

Constituent Release from Waste Rock

The GoldSim model simulates constituent release from waste rock based on simplifying assumptions that either extrapolate from conditions observed under field-scale weathering of similar rock (Category 1 waste rock) or in laboratory tests (Category 2, 3, and 4 waste rock, and ore) in order to provide quantitative estimates of loading that are then combined with hydrologic estimates to predict solute concentrations. The predictive models assume that the entire mass of waste rock in each of the stockpiles is oxygenated and is thus capable of reacting with air (some waste rock stockpiles can have zones with lower than atmospheric oxygen concentrations, so this assumption tends toward producing higher rates of pollutant release than may exist). Field oxidation rates are then estimated by scaling from lab rates to account for effects of temperature (oxidation is slower at the lower on-site temperatures), differences in pH (potential acidification), fragment size (waste rock fragments would be larger than rock tested in the lab, and would thus react more slowly), pore-water pH (oxidation rates in NorthMet rock are assumed to increase when pore water becomes acidic), and the fraction of rock flushed by percolating water (some fraction of waste rock under field conditions is hydraulically isolated). For the Category 1 waste

rock (i.e., the waste rock with the lowest sulfide sulfur content, but which would remain stored permanently on the surface after closure), instead of using lab tests, the rate of oxidation and constituent release was estimated from studies of seepage release measured in Dunka Mine rock, which is a nearby source of waste rock with similar chemical composition that has been monitored under field conditions. The rate of contaminant release is modeled as a load rate (e.g., mg contaminant per month), estimated as the product of the mass of the waste (kg waste) and the rate of contaminants are released (mg contaminant per kg waste per month).

This transport simulation assumes that solutes released by oxidation can dissolve when contacted by rain and snowmelt percolating through the waste rock, and dissolved constituents are flushed immediately through the rock. Where the concentration of contaminants in percolating water is not limited, the entire load released over a time step can dissolve in any available water. In this case, decreasing the water flow would still collect the entire contaminant load, producing a more concentrated leachate, but the same solute load rate. In most NorthMet waste rock, however, contaminant concentrations are limited by “concentration caps”—empirical upper-concentration values. These concentration caps are estimated in part using measured behavior of laboratory tests on waste rock from the NorthMet Deposit, but rely heavily on concentrations of dissolved constituents measured in effluent from field-scale facilities of similar waste rock (including rock from the Amax and Dunka mine deposits in Minnesota, and the Whistle and Vangorda mines in Canada (PolyMet 2013l). When solute concentrations are capped in modeling, then solute loads are proportional to flow rate, so that reduced flow rates would result in a proportional reduction in solute load to the environment. The Category 1 Stockpile is the clearest example of this effect, because solutes would be released over time by oxidation, but the pore water would maintain at a near-neutral pH, where many solutes have limited solubility. The effect of concentration caps in the Category 1 Stockpile would be further enhanced in long-term closure, when a proposed geomembrane cover would reduce infiltration, producing a proportional reduction in the load rate of those solutes at their pore-water concentration caps. The GoldSim model tracks the total mass of these capped solutes, so that constituents removed from solution to meet concentration caps are retained in the model for later release when solute concentrations would otherwise decrease below the concentration caps. In contrast, for the more acid-generating materials, including the ore and Category 4 waste rock, concentration caps are much higher or may not attain the cap value, and load to the environment is more closely related to the rate of solute release regardless of water flow rate through the waste.

Detailed descriptions of the assumptions and algorithms used to estimate solute release from mine-related facilities is provided in the Waste Characterization Data Package (PolyMet 2013l).

Contaminant Transport in Groundwater from Waste Rock

Once contaminants are released, they are assumed to travel with flowing water. Any water that leaks through the stockpile liners or seeps from the mine pits would move in the same direction and rate as groundwater, although accounting for some dispersion, and ultimately emerging in surface water. At the Mine Site, five surficial groundwater flowpaths were identified, as described previously. Groundwater flow rates and flow directions in the model were taken directly from the MODFLOW results or were programmed to be consistent with the MODFLOW results. Time-varying surface water flow rates were taken either from the XP-SWMM results or were estimated from stream gauging data.

Affected waters entering the groundwater Bedrock Flowpaths were also programmed into GoldSim. However, due to the very low bulk hydraulic conductivity of bedrock, groundwater flow rates in these flowpaths were not large enough to affect water quality at the groundwater and surface water evaluation locations.

Some solutes, however, travel through the aquifer at a slower rate than the flowing water. This effect, called “attenuation,” is caused by the adsorption (often also referred to as sorption) of solutes onto the mineral surfaces in the aquifer. Table 5.2.2-14 defines fate and transport mechanism terminology in this SDEIS.

Table 5.2.2-14 Definition of Fate and Transport Mechanism Terminology used in this SDEIS

Term	Definition
Adsorption (Sorption)	The process by which ions of a solute are attracted to and accumulate at the interface between a solid phase and an aqueous phase.
Attenuation	The gradual loss in intensity of solute transport through an aquifer caused by adsorption of solutes onto the mineral surfaces in the aquifer.
Constituent-loading	The mass of a constituent or solute that is carried in water.
Mechanical Dispersion	The process whereby solutes are mechanically mixed during advective transport caused by the velocity variations at the microscopic level.
Metal Partition Coefficient (K_d)	The ratio of the sorbed metal concentration (expressed in milligrams of metal per kilograms of sorbing material) to the dissolved metal concentration (expressed in milligrams of metal per liter of solution) at equilibrium.
Plume	The downstream extension or spread of contaminated surface water.
Groundwater Plume	The downgradient extension or spread of contaminated groundwater within the pore spaces or fractures of soil or rock.

In the NorthMet Project Proposed Action GoldSim water quality model, four solutes are assumed to be attenuated by adsorption in the aquifer: arsenic, antimony, copper, and nickel. The metal partition coefficient (K_d) is the ratio of the sorbed metal concentration (expressed in mg metal per kg sorbing material) to the dissolved metal concentration (expressed in mg metal per L of solution) at equilibrium. Higher K_d values represent higher sorption capacity of the aquifer, and thus slower migration of a solute in groundwater.

Literature values are available for estimating metal partition coefficients (USEPA 1996; 2005). These values have been adopted by MPCA as part of its risk-based guidance for State Superfund and VIC program sites (MPCA 1998). In addition, PolyMet conducted site-specific sorption testing on soil samples collected from the most permeable zone of two borings at the Mine Site. Batch sorption tests were conducted in the laboratory generally using standard ASTM procedures (Barr 2009h). Table 5.2.2-15 presents the USEPA literature values, the results of the site-specific sorption testing, and the K_d values accepted for use in groundwater modeling. The lower K_d values for antimony reflect greater uncertainty regarding antimony sorption in the scientific literature and site-specific testing.

Table 5.2.2-15 Comparison of Site-specific and Literature Sorption Values¹ at the Mine Site

Parameter	USEPA K _d Screening Value Used in DEIS	Site-specific Sorption (K _d) Values ¹			K _d used in GoldSim Model	Associated Retardation Factor used in GoldSim Model ²
	(L/kg)	Boring RS-22 (L/kg)	Boring RS- 24 (L/kg)	Average (L/kg)	(L/kg)	(---)
Antimony	45	1.6	22	12	1.3, 1.6, 6.1 ⁽³⁾	7.5, 9.0, 31 ⁽³⁾
Arsenic	25	>52	590	~320	25 ⁽⁴⁾	126 ⁽⁴⁾
Copper	22	1,047	463	755	22 ⁽⁴⁾	111 ⁽⁴⁾
Nickel	16	73	40	56	16 ⁽⁴⁾	81 ⁽⁴⁾

¹ Modified from: Barr 2009h.

² Assuming porosity of 0.3 and dry bulk density of 1,500 kg/m³.

³ Uncertain input with triangular distribution. Minimum, mode, and maximum values, respectively.

⁴ Deterministic value.

The attenuation effect resulting from sorption is significant enough that arsenic, copper, and nickel are not predicted to travel from source areas to any evaluation locations or the Partridge River within the 200-year model simulation period (Barr 2013f). Analytical calculations suggest that the travel times for these solutes would be on the order of thousands of years.

Antimony, which is modeled with lower K_d values, reaches the groundwater evaluation location in the East Pit Category 2/3 Surficial Flowpath at about 150 years, but the predicted concentration increase is very small. GoldSim predicts that antimony would not reach any other evaluation or Partridge River locations along any of the other flowpaths within the 200-year model simulation period. PolyMet conducted a separate 1,000-year model simulation for antimony in the West Pit Surficial Flowpath. The results of this longer simulation indicated that the maximum antimony concentration in groundwater at the groundwater evaluation location would be 3.5 µg/L, below the evaluation criterion of 6.0 µg/L, and this would not occur until approximately year 450 (see Figure 5.2.2-9).

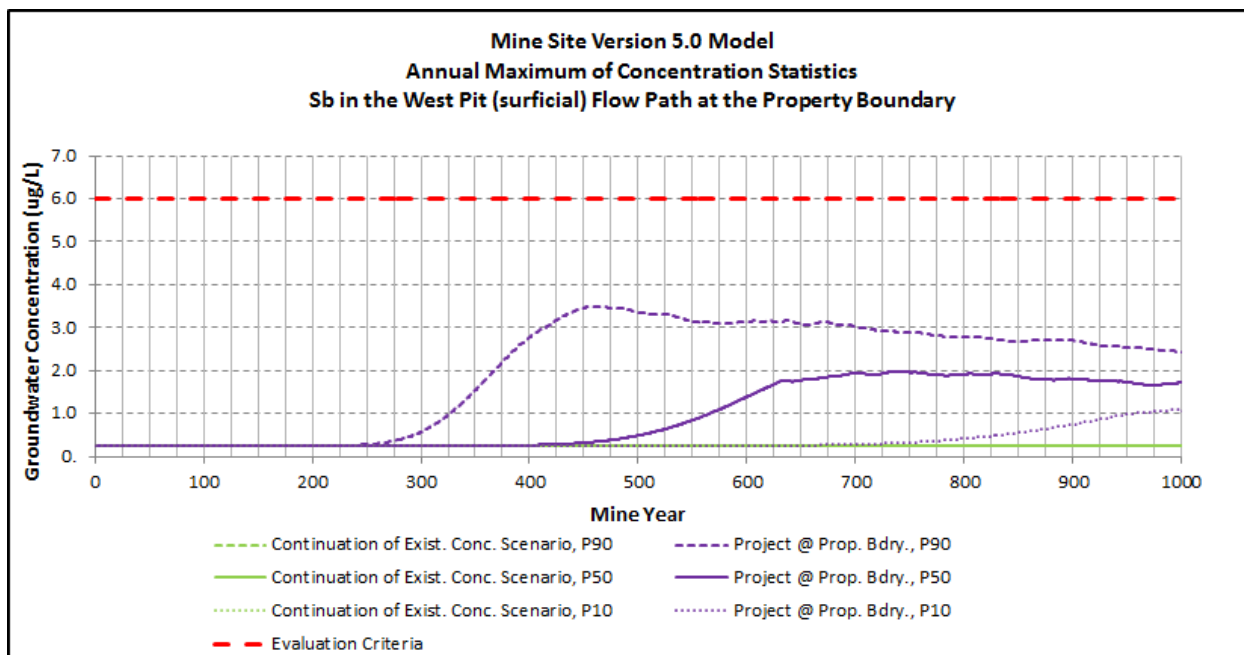


Figure 5.2.2-9 Antimony Concentrations in the West Pit Surficial Flowpath at the Groundwater Evaluation Location for a 1,000-Year Model Run

Tailings Basin (Embarrass River Watershed)

The GoldSim software has been programmed to incorporate surface water flow, contaminant release from tailings, groundwater transport of bypass from the containment system to the Embarrass River system, water transfers between mine facilities, and discharge of WWTP-treated effluent to the Embarrass River system. An overall flowchart of the GoldSim model is provided as Figure 5.2.2-10. This section describes the geochemistry of the NorthMet Project Proposed Action tailings and the factors affecting contaminant release and transport from the Tailings Basin.

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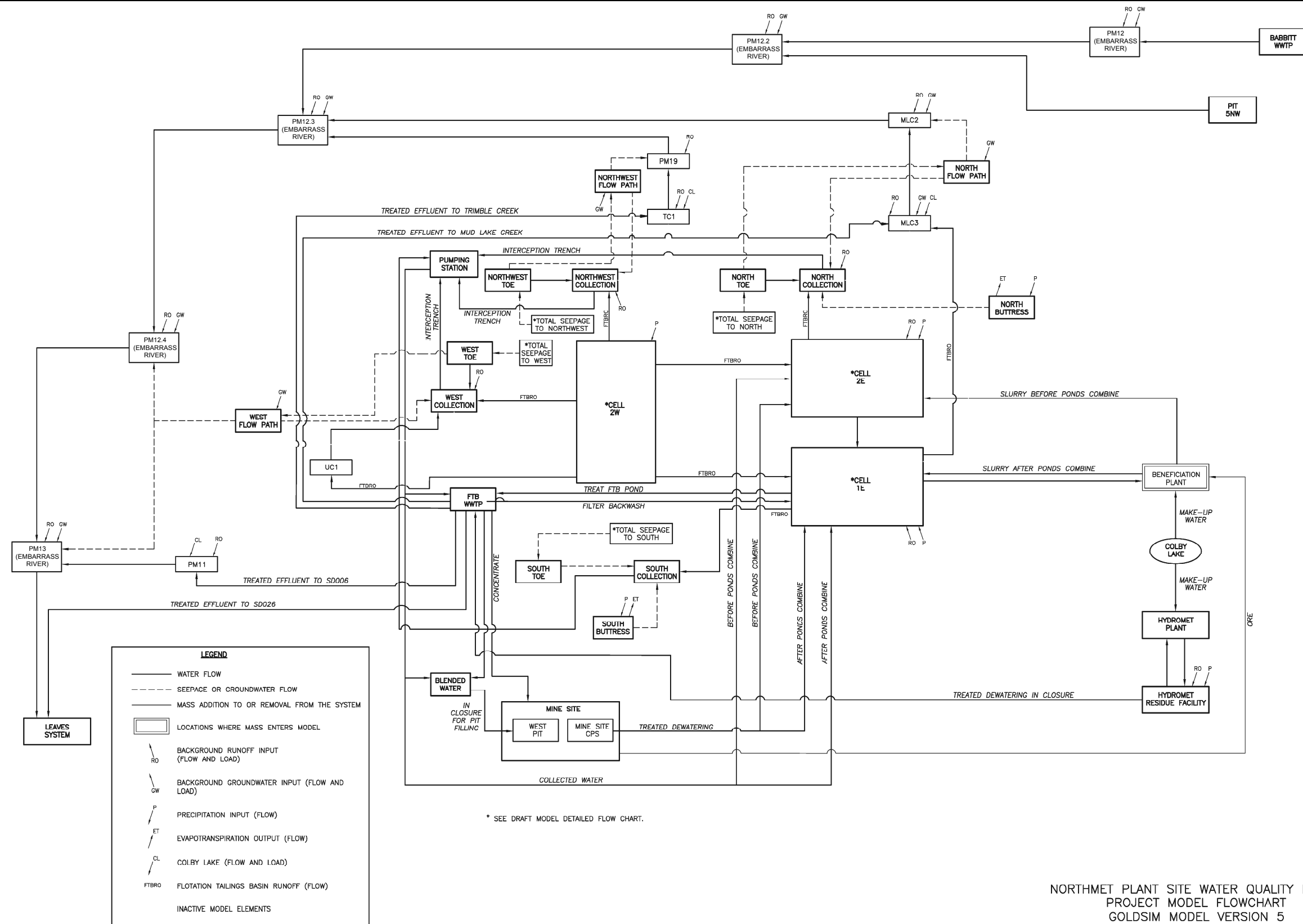


Figure 5.2.2-10
Plant Site GoldSim Flow Chart
NorthMet Mining Project and Land Exchange SDEIS
Minnesota

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NorthMet Tailings Geochemistry

The NorthMet Project Proposed Action tailings are predicted to have less than 0.12 percent sulfur, which kinetic tests demonstrate is low enough that it would never produce acidic leachate (PolyMet 2013l). The bulk sulfide flotation process used in handling the ore would maintain the sulfide S below 0.12 percent in the tailings discharged to the Tailings Basin.

The assumptions regarding the environmental behavior of the flotation tailings are based on 21 humidity cells (14 for coarse tailings and seven for fine tailings) generated in the pilot-plant processing tests conducted to refine the metal recovery process. The tailings samples were analyzed to determine concentrations of total metals, acid-generating sulfur, and acid-neutralizing carbonate carbon, and were then subjected to humidity cell testing (PolyMet 2013l, Attachment E, Table 1). The estimates of tailings effects on water quality presented in this SDEIS are based largely on the results from these humidity cell tests at the point when they had run continuously for between 90 and 300 weeks (PolyMet 2013l).

Tailings samples subjected to humidity cell tests included a range of sulfide S concentrations (0.06 to 0.14 percent S) and size fractions selected to represent the ranges expected under various depositional environments in the Tailings Basin (PolyMet 2013l):

- dam material (greater than 0.152 mm),
- beach (0.076 to 0.152 mm), and
- fine sands (less than 0.076 mm).

Results of the humidity cell tests on pilot-plant tailings had similar results to Category 1 waste rock, with sulfate release rates increasing roughly in proportion to total sulfur, and declining sulfate production over time as the sulfide minerals are consumed (PolyMet 2013l, Attachment E, Figure 5). The GoldSim model estimates the moisture content in the tailings and dams materials through time, and uses this to estimate the quantity of tailings oxidizing, the oxidation rate of sulfide minerals, and the associated release of solutes.

The predicted concentration of contaminants in tailings seepage is limited by “concentration caps.” Concentration caps are empirical upper-concentration values based primarily on measured effluent from field-scale waste rock facilities that are chemically similar to the NorthMet Deposit. For solutes modeled at their concentration caps, the load leaving the tailings would be proportional to water flow; but the GoldSim model tracks the mass of contaminants stored in the tailings, so reductions in predicted seepage loading due to concentration cap limits are balanced by a longer total duration of contaminant release.

The pH of effluent from oxidizing tailings ranges between 6 and approximately 8.3, though the pH in effluent from tailings with sulfur similar to that of the Tailings Basin (sulfur approximately 0.12 percent) is generally above 7 (PolyMet 2013l). In most samples of tailings subjected to humidity cell testing, decreases in pH are associated with increases in the concentrations of some metal cations, such as nickel. By the end of the longest humidity cell tests (300 weeks), the pH in most tailings effluent was increasing, suggesting that the pH would not become acidic. Under oxygenated conditions at room temperature, oxidation of the tailings releases about 5 mg SO₄ per kg tailings per week (see Tables 1-13 and 1-14 in Barr 2013l), and the range in most tests is between approximately 2 and 8 mg SO₄ per kg tailings per week (PolyMet 2013l, Attachment E).

Finally, acid base accounting and humidity cell tests were also conducted on the existing LTVSMC tailings, which would underlie the NorthMet Project Proposed Action tailings. These were produced from a separate deposit and contain enough carbonate minerals to be net-neutralizing, so are a low risk of producing acidic leachate. Concentrations of specific carbonate minerals in the LTVSMC tailings, based on X-ray diffraction analyses on 16 samples, included from 0.1 to 1 percent calcite (CaCO_3), from 2 to 7 percent ankerite ($\text{Ca}(\text{Fe}^{2+}, \text{Mg}, \text{Mn})(\text{CO}_3)_2$), between 2 and 8 percent siderite (FeCO_3 ; Table 5-1 in SRK 2007c).

Leachate from humidity cell tests produced stable pH (between 7.3 and 8.1) and stable release rates for the primary constituents of concern, which were used as the basis of predicting solute release under field conditions (PolyMet 2013l, Attachment E). Unlike the proposed Tailings Basin, which does not yet exist, the LTVSMC tailings have been in place for years, so the model estimates for effluent release from the LTVSMC tailings are constrained by measured solute concentrations in the receiving waters (e.g., wells GW001 and GW012 for release to the north, GW006 for release to the northwest, and GW007 for release to the west; Figure 4.2.2-13). The initial model extrapolation of laboratory constituent-release rates measured on LTVSMC tailings overestimated the concentrations of sulfate and several other constituents relative to field measurements, even when the release rates were adjusted for scale factors (primarily oxygen concentration in pore gas temperature; Section 10.2.1 in PolyMet 2013l). This discrepancy was rectified in part by applying an empirical “correction factor,” which reduced the modeled sulfate release from the LTVSMC tailings by factors of approximately 2 to 4 (see Figures 10-4 and 10-5 in PolyMet 2013l). Even after reducing sulfate release rates to match observed concentrations downgradient of the tailings, the water quality model overestimated the concentrations of several solutes, including many metals. In response, the LTVSMC tailings model was further adjusted by applying empirical “calibration factors” to all remaining constituents that were also overestimated relative to observed concentrations. These calibration factors (listed in Table 1-21 in Barr 2012e) reduced the concentration of 11 constituents by greater than 90 percent relative to the uncorrected model estimates, including reduction by greater than 99 percent the predicted concentration of seven constituents. The fact that measured solute release rates need to be corrected down an order of magnitude for the model to match observed constituent concentrations in downgradient waters suggests that there are additional attenuation effects that are not completely accounted for in the NorthMet water quality model.

Pathways within the tailings, from the surface and through the unsaturated and saturated tailings areas, were estimated using groundwater flow models, and these pathways were used to route the solutes released by oxidation in the tailings.

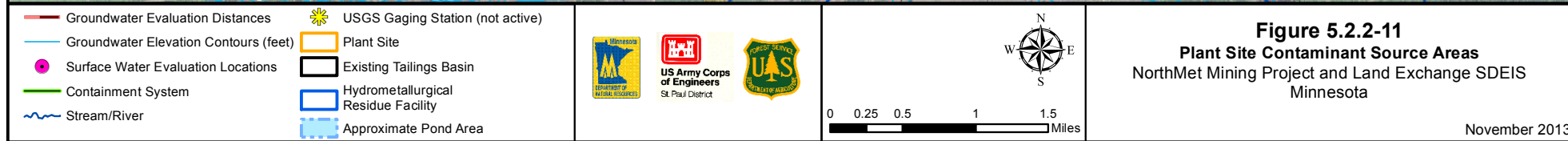
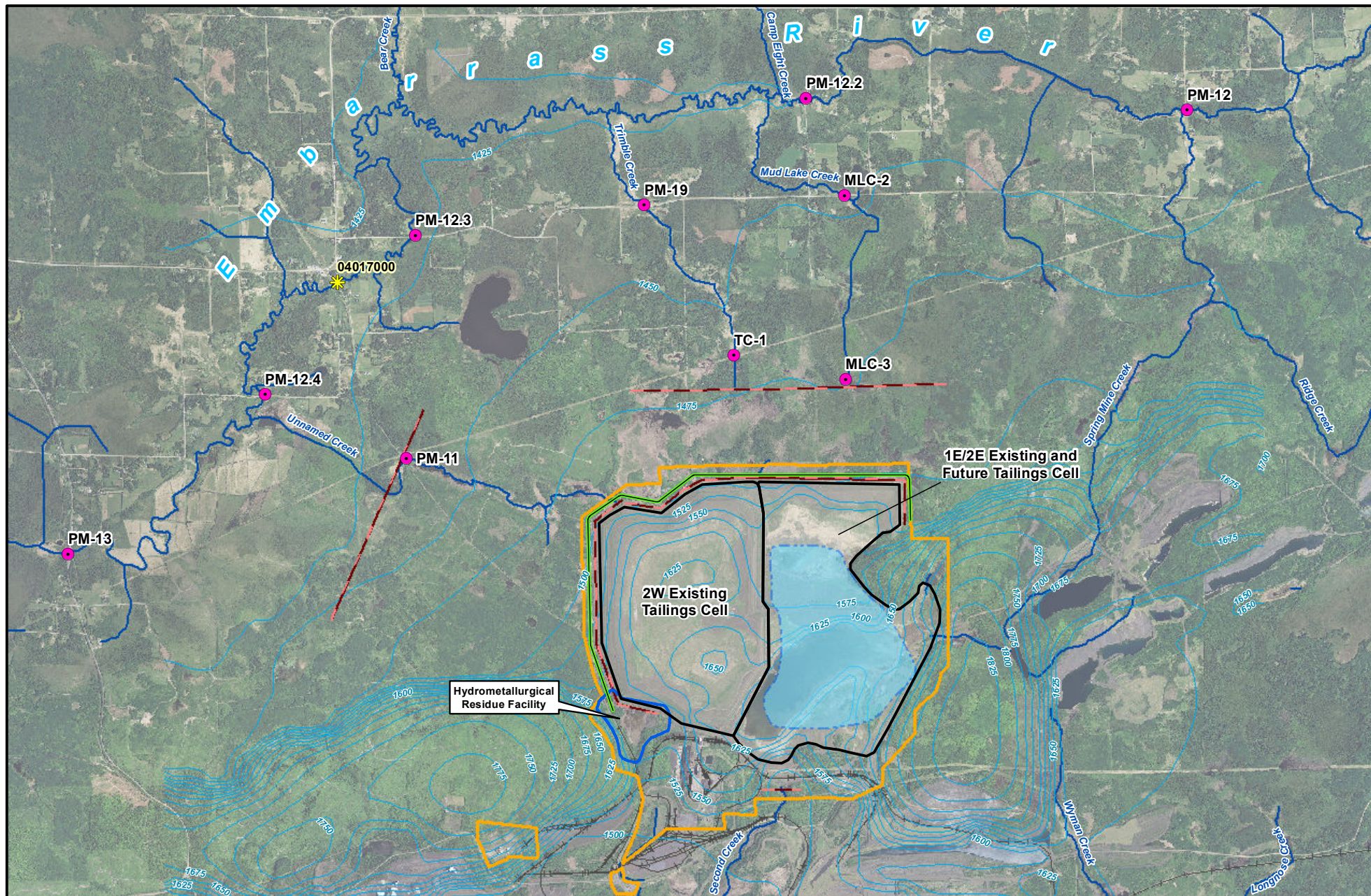
Contaminant Release from the Tailings Basin

Figure 5.2.2-11 is a base map of the Plant Site showing the tailings facilities that have the potential to be contaminant sources to groundwater and surface water, including Cell 2W, Cell 1E/2E, and a Tailings Basin pond of varying surface area that would continue to exist on top of Cell 1E/2E. The current tailings in Cell 2W and Cell 1E/2E are referred to as LTVSMC tailings and new tailings that would be generated by the NorthMet Project Proposed Action are referred to as NorthMet tailings.

GoldSim is programmed with algorithms for estimating the release of solutes from the tailings sources areas. For the NorthMet Project Proposed Action, a groundwater and surface water containment system would be constructed at the beginning of operations along the northeastern,

northern, and western perimeters of the Tailings Basin to intercept affected water seeping from the facility. The physical and material characteristics of each source area are summarized in Table 5.2.2-16. In GoldSim, the overall Tailings Basin is divided into subareas that are described in Table 5.2.2-17. For each subarea, the contaminant release is associated with a particular material including different types of LTVSMC tailings and NorthMet tailings. The contaminant release rate in each subarea is based on characteristics of the underlying material and the rate of atmospheric oxygen diffusion into the tailings. The proposed bentonite amendments to surface material during operations and closure are intended to reduce oxygen diffusion into the subsurface and thereby decrease contaminant release rates from the underlying materials. Using the GoldSim model for existing conditions, the contaminant release parameters for LTVSMC tailings were calibrated to measured water quality in current tailings seepage and groundwater. NorthMet Project Proposed Action contaminant release parameters are based on a combination of laboratory tests and water quality observations at similar tailings facilities in northern Minnesota. The time-varying chemistry of the tailings pond water is computed during the GoldSim simulation based on evaporation and mixing of rainwater, stormwater runoff, and NorthMet Project Proposed Action-related water transfers to and from the other mining facilities.

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Table 5.2.2-16 Tailings Basin Facilities

Facility	Engineered Features	Chemical Mechanisms
2W	Existing LTVSMC Tailings Basin; would not be used for NorthMet Project Proposed Action. Soil surface has natural vegetation to reduce infiltration. Groundwater containment system would collect groundwater and surface seepage.	Sulfide oxidation and associated release of sulfate and metals.
1E/2E	Existing LTVSMC Tailings Basin that would receive new NorthMet tailings generated by NorthMet Project Proposed Action. Groundwater containment system would collect groundwater and surface seepage. During operations, new dams built on top of 1E/2E are amended with bentonite. During closure, surface soils would be amended with bentonite and vegetated to reduce infiltration and oxygen entry.	Sulfide oxidation and associated release of sulfate and metals.
Pond	During closure, pond bottom would be amended with bentonite to reduce seepage.	Seepage of pond water and its associated water quality and dissolved oxygen.

Source: PolyMet 2013f.

Table 5.2.2-17 Tailings Basin Solute Source Subareas used in GoldSim for Closure

Source Area	Tailings Basin Sub-area	Tailings Material Assumed to Control Solute Release	Bentonite-Amended	Area (acre)	Recharge ¹ (in/yr)	Bottom Seepage ⁶ (gpm)	Basis for Solute Release Calculations
1E/2E	North Dam banks (outer slopes)	LTVSMC bulk (other)	Operations and closure	249.0	6.07	78.1	Calibration ²
	East Dam banks (outer slopes)	LTVSMC bulk (other)	Operations and closure	40.0	6.07	12.5	Calibration ²
	South Dam banks (outer slopes)	LTVSMC bulk (other)	Operations and closure	91.0	6.07	28.5	Calibration ²
	North Beach	35% NorthMet fine, 65% NorthMet coarse	Closure Only	90.2	6.07	28.3	Lab/other sites ³
	East Beach	35% NorthMet fine, 65% NorthMet coarse	Closure Only	45.6	6.07	14.3	Lab/other sites ³
	South Beach	35% NorthMet fine, 65% NorthMet coarse	Closure Only	103.1	6.07	32.3	Lab/other sites ³
	Closure Beach	35% NorthMet fine, 65% NorthMet coarse	Closure Only	188.6	6.07	59.2	Lab/other sites ³
	1E coarse	LTVSMC coarse	none	3.4	2.68	0.5	Calibration ²
	1E fine ⁵	LTVSMC fine		0.0			
	2E coarse ⁵	LTVSMC coarse		0.0			

Source Area	Tailings Basin Sub-area	Tailings Material Assumed to Control Solute Release	Bentonite-Amended	Area (acre)	Recharge ¹ (in/yr)	Bottom Seepage ⁶ (gpm)	Basis for Solute Release Calculations
	2E fine ⁵	LTVSMC fine		0.0			
	2E other	LTVSMC coarse	none	75.3	5.50	21.4	Calibration ²
	North Buttress banks	Category 1 waste rock	none	115.0	13.24	78.7	Lab / other sites ³
Pond	Pond	NA	Closure (after 30 years)	905.3	6.50	304.0	Computed ⁴
2W	2W coarse	LTVSMC coarse	none	220.1	13.27	150.9	Calibration ²
	2W fine	LTVSMC fine	none	748.1	15.93	615.7	Calibration ²
	2W banks	LTVSMC coarse	none	339.2	7.82	137.0	Calibration ²
	South Buttress banks	Category 1 waste rock	none	15.0	13.27	10.3	Lab/other sites ³
Total				3,229		1,572	

Source: PolyMet 2013f; PolyMet 2013l.

¹ Net infiltration of meteoric water. Based on a percentage of P50 annual rainfall (27.82 in/yr).

² Calibrated to water quality of existing affected seepage and groundwater.

³ Laboratory humidity cell tests and water quality at similar mine sites.

⁴ Pond contaminant concentrations computed during GoldSim simulation.

⁵ Does not exist in closure.

⁶ Bottom seepage assumed equal to recharge multiplied by associated area.

Contaminant Transport from the Tailings Basin

At the Plant Site, most groundwater flow occurs in an unconfined surficial groundwater system composed of unconsolidated sands, silts, and clays, and has a saturated thickness on the order of 7 meters. Below the surficial groundwater system is a low-permeability fractured bedrock unit consisting of several rock types. Groundwater flow rates in the bedrock unit are much less than flow in the overlying surficial groundwater system. As at the Mine Site, once most of the contaminants are released, they are assumed to travel in the same direction and rate as groundwater (accounting for some dispersion) and ultimately reach surface water. Groundwater flow rates and flow directions in the model were taken directly from the MODFLOW results or were programmed to be consistent with the MODFLOW results. Unlike the Mine Site, however, PolyMet proposes a containment system along the northern and western perimeters of the Tailings Basin to intercept surficial groundwater and surface water seeping from the Tailings Basin. Design and performance modeling of the containment system predict that it would achieve greater than 90 percent capture of upstream groundwater in the surficial (unconsolidated) unit (PolyMet 2013f). In GoldSim, the containment system is conservatively assumed to be 90 percent efficient, which means that 10 percent of the approaching groundwater bypasses the system and continues to migrate toward the Embarrass River via the surficial groundwater flowpaths. This affected groundwater migrates in the flowpaths to the north, northwest, and west, and concentrations change progressively at the evaluation locations. The affected groundwater reaches and releases directly into the Embarrass River (West Flowpath) or into its tributaries (Northwest and North flowpaths). Due to the very low hydraulic conductivity of the bedrock and

because the slurry trench would be keyed into bedrock, the GoldSim model assumes that groundwater bypass via bedrock is negligible compared to that occurring in the surficial unit.

Calculation of average groundwater seepage velocity and solute travel time are standard methods used in groundwater hydrology and have been applied to numerous field sites. These are considered index values that provide the investigator with a general idea of how fast solutes in groundwater migrates and when the arrival of a solute plume should be expected. There are many mechanisms that are not considered in these simple calculations including the effects of aquifer heterogeneity, mechanical dispersion, and geochemical reactions. Despite this, the calculations are useful for preliminary site characterization and checking the results of more complicated solute transport models.

Table 5.2.2-11 provides estimates of contaminant travel times to the evaluation locations and the Embarrass River either directly or via surface tributaries based on best-estimate impact values. Contaminant arrival would be gradual due to dispersion in the aquifer, and this process is accounted for in the GoldSim algorithms. As shown, travel times at the evaluation locations range from 190 to 240 years, and arrival at the Embarrass River or its tributaries takes about 300 years. These theoretical arrival times apply to all constituents except antimony, arsenic, copper, and nickel, which are attenuated via adsorption as was similarly assumed at the Mine Site. The transport time for these solutes is predicted to be greater than 500 years.

Detailed descriptions of the assumptions and algorithms used to estimate solute release from the Tailings Basin are provided in the Waste Characterization Data Package (PolyMet 2013l).

GoldSim Model Operations and Output

Within the GoldSim program are utilities for performing probabilistic simulations based on the uncertainty of inputs. For this method, selected “uncertain” inputs are entered into the program as probability functions rather than single fixed values. The probability functions are based on the variability of measured data, professional judgment, or both. Figure 5.2.2-12 is an example of the cumulative probability function of a hypothetical input. Point A on the figure indicates that there is a 10 percent probability that the true input value is less than or equal to 14.1. Point B (median) indicates a 50 percent probability that the true input is less than or equal to 22.2, and Point C indicates a 90 percent probability that the true input is less than or equal to 30.3. At the beginning of a model run, GoldSim selects a random probability number between zero and 100 percent for each uncertain input and uses the associated cumulative probability distribution to determine the numerical input value. If for example, the program-selected random probability is 38.1 percent, the input value for the hypothetical input on Figure 5.2.2-12 would be 20.3 (Point D). For some inputs, such as annual rainfall, the random sampling is performed at the beginning of each simulation year as the program progresses through time. With the resulting suite of inputs, a single transient model run is performed (referred to as a “realization”) and the results are saved. The process of statistical sampling is then repeated using new random probabilities and the next realization is run.

The GoldSim model uses a Monte Carlo simulation approach, where the model is run 500 times, with each realization based on unique suite of statistically sampled inputs. At the end of the Monte Carlo simulation, the multiple model run results are compiled. Consider, for example, a model estimate of contaminant concentration at a particular evaluation location at year 100. The GoldSim model will provide 500 numerical values for this result, one for each realization. This

suite of resulting values is ordered and used to construct a cumulative frequency plot (see Figure 5.2.2-13), which is interpreted in a manner similar to the input plots. On Figure 5.2.2-13, for example, it is concluded that there is a 90 percent probability that the concentration at year 100 would be less than or equal to 120.8 (Point C). For results that change over time, a convenient way to present the probabilistic results is to prepare a time-series plot showing the 10, 50, and 90 percent probability results, as shown on Figure 5.2.2-14. For example, consider point C on the 90 percent probability line on this plot. At a simulation time of 100 years, the value on the curve is 120.8, indicating a 90 percent probability that the true result would be less than or equal to 120.8, which is consistent with Point C on the 100-year frequency plot shown on Figure 5.2.2-13.

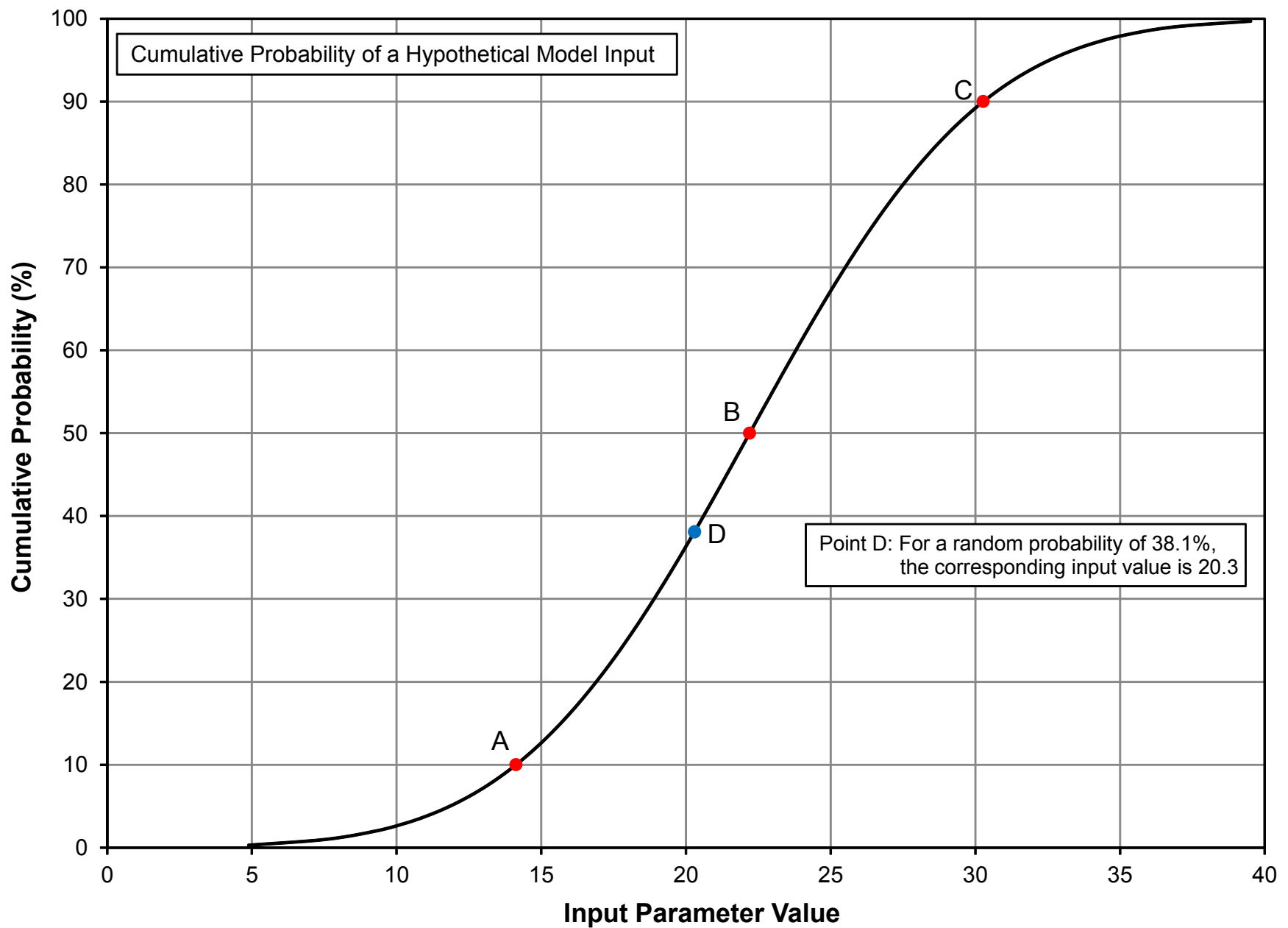


Figure 5.2.2-12
Cumulative Probability of a Hypothetical Model Input
NorthMet Mining Project and Land Exchange SDEIS
Minnesota

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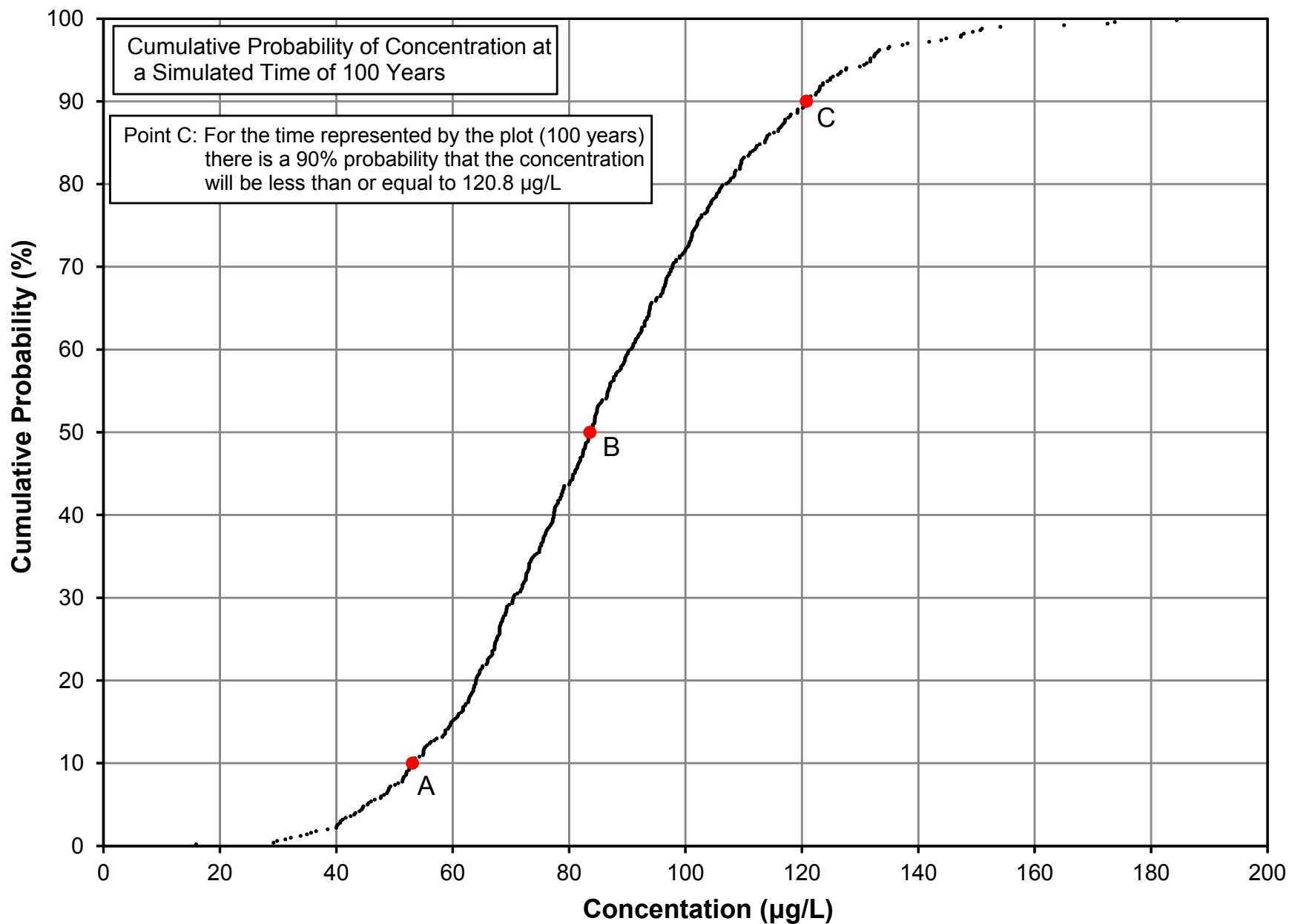


Figure 5.2.2-13
Cumulative Probability of Concentration
at a Simulated Time
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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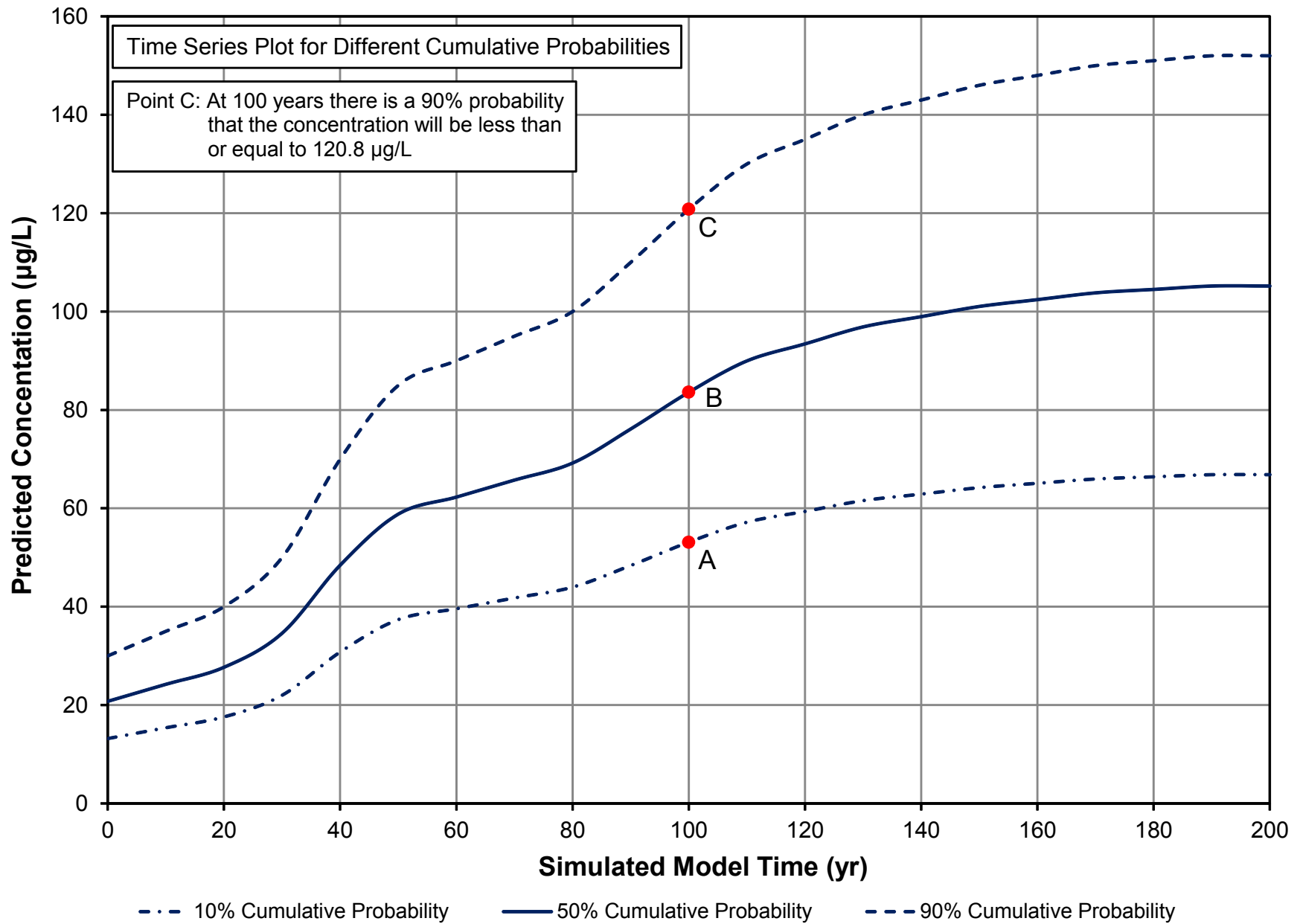


Figure 5.2.2-14
Time Series Plot for Different Cumulative Probabilities
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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Application of Evaluation Criteria to Probabilistic Modeling Results

PolyMet uses the GoldSim probabilistic model to estimate potential effects from the NorthMet Project Proposed Action on groundwater and surface water quality. The output of the probabilistic model is not a single value for a particular solute concentration at a specific evaluation location and time. Instead, the output is expressed as a cumulative frequency distribution of predicted concentrations. This can be used to assess the probability that the NorthMet Project Proposed Action would exceed any water quality evaluation criteria (see Figures 5.2.2-12 through 5.2.2-14).

The predicted 90th-percentile probability concentration of a solute (referred to herein as the P90 value) is used as the threshold for determining if the evaluation criteria at evaluation locations would be exceeded. In other words, if the modeled P90 value was exactly equal to the evaluation criterion, there is a 90 percent probability that the actual concentration would be below the criterion. This threshold does not mean that water quality criteria would be exceeded the other 10 percent of the time. In fact, if the P90 value is below the evaluation criteria, it means that the water quality evaluation criteria would never be exceeded, with a 90 percent probability. For many solutes, none of the simulations exceeded the water quality evaluation criteria

Using cobalt in surface water at SW-004a as an example, GoldSim conducts 500 simulations of a 200-year period with monthly time steps, for a total of 2,400 water quality predictions (200 years times 12 months per year) for cobalt at SW-004a. The predicted concentrations range from 0.15 to 6.66 µg/L. The P90 value for cobalt at SW-004a is 1.88 µg/L because 90 percent (or 2,160 out of 2,400 results) of the simulations were at or below this value. The evaluation criterion for cobalt is 5 µg/L. Since the P90 value is less than the evaluation criteria, cobalt at SW-004a is considered to meet the evaluation criteria. In the case of cobalt at SW-004a, only 1 of the 2,400 simulations results actually exceeded the evaluation criteria.

This P90 threshold generally equates to a reasonable worst-case scenario and has been adopted for other mining NEPA documents where probabilistic modeling was used (e.g., Idaho Cobalt Project [USFS 2009b]). For comparison, the 50th percentile probability (P50) equates to the median value, while the 10th percentile probability (P10) equates to a reasonable best-case scenario from a water quality perspective. Regarding the selection of the P90 threshold, the Co-lead Agencies also retain the flexibility to modify this evaluation criteria based on consideration of low-flow modeling analyses, site-specific factors, and model predictions in consideration of applicable permitting regulations and guidance.

It should be noted that the use of the P90 criterion for determining whether or not evaluation criteria are being met is not equivalent to how water quality-based effluent limits (WQBELs) would be developed for NPDES permitting. Appropriate WQBELs would be derived based on water quality standards and implemented in the permit. Discharges would be evaluated during the NPDES permitting stage and WQBELs applied according to 40 CFR 122.44(d).

Continuation of Existing Conditions Scenario

The overall analysis of NorthMet Project Proposed Action effects on water quality also takes into consideration the extent to which predicted water quality for the NorthMet Project Proposed Action compares with existing conditions. There are some ecological processes, however, that most water quality models do not fully capture, which limits the ability to simply compare the predicted effects of the NorthMet Project Proposed Action from water quality models with

existing water quality for some constituents. These include sulfate reduction between the LTVSMC Tailings Basin and the Embarrass River and site-specific redox reactions. For this reason, a Continuation of Existing Conditions Scenario was modeled within GoldSim.

For this reason, a Continuation of Existing Conditions Scenario was modeled within GoldSim. This scenario draws from the same existing condition hydrologic and water quality dataset in GoldSim that was used for modeling the NorthMet Project Proposed Action, but never introduces any NorthMet mine features or activities. The Continuation of Existing Conditions Scenario was otherwise modeled in GoldSim the same way as the NorthMet Project Proposed Action, using 500 Monte Carlo simulations for the same model durations and the results were displayed in the same probabilistic manner.

This Continuation of Existing Conditions Scenario model was intended to represent conditions in the absence of the NorthMet Project Proposed Action. Modeling both the NorthMet Project Proposed Action and Continuation of Existing Conditions Scenario in the same way allows for a direct comparison of predicted water quality model results and facilitates an assessment of the extent to which implementation of the NorthMet Project Proposed Action would result in changes in existing water quality.

It is important to note, however, that this modeled Continuation of Existing Conditions Scenario is not the same as the No Action Alternative, which is described in Section 5.2.2.4. The Continuation of Existing Conditions Scenario assumes no changes in baseline conditions (i.e., not only no NorthMet Project Proposed Action, but also no other mining or other development projects or changes in the climatic or water quality conditions within the Partridge and Embarrass River watersheds). For example, the Continuation of Existing Conditions Scenario model does not include future expected additional mitigation at the existing LTVSMC Tailings Basin, because these mitigation measures have not yet been determined, nor does it try to account for climate change. The No Action Alternative, on the other hand, is not static and anticipates for other predictable changes in the NorthMet Project area, such as other planned projects, required mitigation, and climate change.

Comparison of Proposed Action with the Continuation of Existing Conditions Scenario

The analysis of the model results that follows (see Section 5.2.2.3) compares predicted solute concentrations for both the NorthMet Project Proposed Action and Continuation of Existing Conditions Scenario to applicable groundwater and surface water evaluation criteria. These comparisons are made at each of the Mine Site and Plant Site groundwater and surface water evaluation locations (combined total of eight groundwater and 18 surface water evaluation locations) using the GoldSim P90 probabilistic results. Based on solute transport times, the Mine Site was modeled in monthly time steps for 200 years (i.e., 2,400 individual monthly time steps) and the Plant Site for 500 years (i.e., 6,000 individual monthly time steps). Because of the large quantity of model results (i.e., either 2,400 or 6,000 individual predicted concentrations for each solute at each evaluation location), the following analysis typically focuses on what is referred to as the “maximum P90 value” for each solute, which is the highest P90 value from among the 2,400 Mine Site and 6,000 Plant Site monthly P90 values (i.e., the highest single monthly P90 values over the 200 to 500 years of the model).

5.2.2.3 NorthMet Project Proposed Action

This section discusses the potential environmental consequences of the NorthMet Project Proposed Action on groundwater and surface water levels and quality at both the Mine Site and Plant Site (Tailings Basin) and the Transportation and Utility Corridor.

5.2.2.3.1 NorthMet Project Proposed Action Water Budget Overview

This section briefly describes the water budget under the NorthMet Project Proposed Action at the Mine Site and Plant Site. Under the NorthMet Project Proposed Action, the following water sources would have to be managed:

- stormwater runoff on mine facilities (e.g., waste rock stockpiles, mine pits, Tailings Basin);
- seepage from mine facilities;
- groundwater entering the mine pits;
- process plant makeup water withdrawn from Colby Lake;
- stream augmentation water withdrawn from Colby Lake; and
- discharge from the WWTF and WWTP.

An overall water process flow diagram, shown on Figures 5.2.2-7 and 5.2.2-10, illustrates the principal NorthMet Project Proposed Action components and their relationship to surface water and groundwater resources.

Operations (Year 0 to 20)

Mine Site

During operations (years 0 to 20), water management at the Mine Site would include pit dewatering, the WWTF, stormwater dikes and ditches, the stockpile liners, and the Category 1 Stockpile cover and groundwater containment system. Water from the waste rock stockpiles, Ore Surge Pile, mine pits, and ancillary mine features would be collected at the WWTF and treated using chemical precipitation.

During operations, the effluent from the WWTF and stormwater runoff from the Overburden Storage and Laydown Area would be pumped via the Central Pumping Station and the Treated Water Pipeline to the Tailings Basin for use as processing plant makeup water or used to supplement flooding during backfilling of the East Pit. Reuse of the Mine Site process water at the Plant Site would eliminate the need to discharge any process water to surface waters at the Mine Site during operations. The Category 1 Stockpile would be covered by a geomembrane with a vegetated soil cover and surrounded by a groundwater containment structure. Filtered sludge from the chemical precipitation process would be sent off site for disposal or stored at the Hydrometallurgical Residue Facility. The reject concentrate stream from the WWTP would be transported to the WWTF via rail tank cars where it would be added to the West Equalization Basin.

In year 11, after East Pit mining would be completed, the pit would be backfilled using Category 2/3 and 4 waste rock from the temporary waste rock stockpiles and from ongoing operations. The East Pit would be flooded with groundwater, in-pit runoff, direct precipitation, and treated

process water from the WWTF to limit the oxidation of the sulfide minerals in the pit walls and backfilled waste rock and reducing the amount of metals leaching to the pit water. The pipeline between the WWTF and the East Pit would be left in place during backfilling to manage the water elevation in the East Pit. During periods of high precipitation or during spring snowmelt, dewatering of the East Pit (to the WWTF and ultimately to the Tailings Basin) may be required to allow placement of the waste rock.

Plant Site

During operations, the primary source of process water at the Plant Site would be the Tailings Basin pond, which would mostly contain return water from the flotation process, treated water from the Mine Site WWTF, and water collected from the Tailings Basin containment system. Direct precipitation and stormwater runoff from the process areas at the Plant Site would also be directed to the Tailings Basin pond. If necessary, additional makeup water would be provided by pumping from Colby Lake. Leakage from the Hydrometallurgical Residue Facility would be collected by the leakage collection component of the double-liner system and returned to the Hydrometallurgical Residue Facility flotation pond. During periods of excess process water, Tailings Basin pond water would be sent to the WWTP for treatment and discharge to surface water. To provide water for stream augmentation, a portion of the water collected by the containment system would be sent to the WWTP, treated, and discharged as augmentation water to tributaries flowing into the Embarrass River. Reject concentrate from the WWTP RO system would be sent to the Mine Site WWTF for treatment by chemical precipitation.

Containment systems would be installed to collect water seeping from the Tailings Basin and the existing LTVSMC Tailings Basin via surface and surficial groundwater flow. During operations, this water would be returned to the Tailings Basin pond for reuse to the extent possible, with any excess treated at the WWTP and discharged at permitted locations for stream augmentation via Partridge River tributaries. Loss of flow to Second Creek caused by seepage collection on the south side of the Tailings Basin would be augmented with WWTP effluent at a minimum 80 percent of the existing seepage rate (see Section 5.2.2.3.3). The 80 percent rate is used because seepage from the south side of Tailings Basin is likely higher than the flow contribution to Second Creek that would occur from the Basin footprint for natural ground conditions (i.e., if the Tailings Basin were not present).

The purpose of the WWTP would be to treat water for discharge to the environment when the NorthMet Project Proposed Action had excess water that could not be stored in the Tailings Basin. The WWTP would be constructed south of the Tailings Basin near the coarse crusher and would include an RO unit designed to achieve less than 9 mg/L sulfate in effluent, as well as all other applicable water quality standards. WWTP effluent remaining after flow augmentation to Second Creek would be discharged to the three Embarrass River tributaries (Unnamed, Trimble, and Mud Lake creeks), as partial fulfillment of required augmentation to maintain downstream hydrology and wetland function (Barr 2013a).

Reclamation (Years 20 to 40)

Mine Site

Once backfilling of the East Pit is complete, the backfill would continue to saturate and the pore water would be sent to the WWTF for treatment and returned to the pit to improve the pore water quality. When the backfill water level rises above the top of bedrock, it would release into the East Pit – Category 2/3 Surficial Flowpath. The affected groundwater in this flowpath would migrate slowly towards the Partridge River. After complete saturation of the backfill, a wetland would be established at the surface of the pit and water levels would be maintained by a gravity overflow structure to the West Pit.

West Pit reclamation would commence when mining activity ceases. Primary dewatering systems would no longer be operated, and the West Pit would begin to flood naturally with groundwater, precipitation, and surface runoff from the tributary watershed. Flooding would be accelerated by delivery of treated water from both the Mine Site WWTF and the Plant Site WWTP. With the addition of water pumped from the Plant Site, West Pit flooding is projected to be completed by approximately year 40. When the West Pit water level rises above the top of bedrock, there would be a release of pit lake water into the West Pit Surficial Flowpath. The affected groundwater in this flowpath would migrate slowly towards the Partridge River.

Reject concentrate from the Plant Site WWTP RO system would be treated at the Mine Site WWTF and the resulting filtered sludge would be taken off site for disposal.

Plant Site

Plant Site reclamation would include building and structure demolition and equipment removal, Tailings Basin reclamation, and Hydrometallurgical Residue Facility reclamation.

During Tailings Basin reclamation, the pond bottom and beaches would be covered with a bentonite layer to reduce the downward percolation from the pond, which would reduce the amount of water collected by the Tailings Basin groundwater containment system. Most of the side slopes and top (non-ponded) surfaces of the Tailings Basin would be amended with bentonite to reduce meteoric infiltration and oxygen diffusion into the tailings, with the intent of reducing sulfide oxidation and associated release of soluble sulfate and metals. The LTVSMC portion of the Tailings Basin would be revegetated to reduce meteoric infiltration.

Water management would include maintenance of the pond and wetland within the reclaimed Tailings Basin, stormwater management, and continued operation of the WWTP and the groundwater containment systems. A wetland would be constructed on the pond perimeter.

After bentonite amendment of tailings surfaces, establishment of the wetland, and continued water treatment, the tailings pond water quality would improve over time. The pond and wetland would continue to lose water via seepage, but at a reduced rate as compared to operations. The reject concentrate stream from the WWTP would be transported to the WWTF via rail tank cars where it would be added to the West Equalization Basin.

Containment systems would continue to operate, although seepage rates would be progressively reduced. The collected seepage would be pumped to the WWTP. During most of this period, the WWTP effluent would be used to flood the West Pit, while Embarrass River augmentation water

would come exclusively from Colby Lake (Barr 2013a). The WWTP and the containment system would be periodically inspected to ensure continuing integrity.

Reclamation of the Hydrometallurgical Residue Facility would include removal of ponded water from the cell surface, removal of pore water from the residue, construction of the cell cover system, and establishment of vegetation and stormwater runoff controls. Once the Hydrometallurgical Residue Facility is reclaimed, the volume of water draining from the facility would decline and ultimately cease if the cover system were effective. The facility would only require periodic pumping of any remaining drainage to the WWTP and inspection of the reclaimed cell to verify integrity of the reclamation systems.

Closure (After Year 40)

Mine Site

Shortly before closure, the WWTF would be converted to a multistage RO system with a distillation crystallizer to eliminate the liquid reject stream. The moist waste solids from this system would be disposed of off site. Pilot-testing has indicated that treated effluent from this system would have sulfate concentrations less than 9 mg/L and meet water quality discharge standards for all regulated solutes. Effluent from the WWTF RO system would be discharged to tributaries feeding the Partridge River.

Water levels in the East Pit would generally be controlled by passive wetland overflow to the West Pit. Depending on seasonal weather conditions, there could be occasional pumped flows from the wetland to the WWTF or of treated effluent from the WWTF to the wetland to further control the water levels (PolyMet 2013g). In any event, saturated backfill in the East Pit would continue to release groundwater to the East Pit – Category 2/3 Surficial Flowpath.

After refill, the West Pit water level would be controlled by pumping to the WWTF to prevent surface water overflow from the pit lake. However, release of pit lake water to the West Pit Surficial Flowpath would continue. The WWTF would also receive low flow rates from the Category 1 Stockpile groundwater containment system. The WWTF effluent would be discharged into a tributary channel that flows into the Partridge River at the location shown on Figure 5.2.2-15.

During closure, other water management systems would be modified. Perimeter dikes that would be no longer needed to provide access or separation from the areas outside the Mine Site would be removed (see Figure 5.2.2-16). The dike located north of the East Pit would remain in place to minimize mixing of the Partridge River flows with the East Pit water and prevent gully development on the northern side of the pit in the segments not protected by ditches (see Figure 5.2.2-15). In addition, the dike located north of the Category 1 Stockpile would remain in place to allow access to groundwater monitoring locations. The Category 1 Stockpile would be inspected on a regular basis and portions of the geomembrane liner and soil cover would be replaced if necessary.

Surface runoff would be routed away from the mine pits using a combination of existing and new ditches (see Figure 5.2.2-15). Some portions of the pit rim dikes may be left in place, if needed to prevent an uncontrolled flow to or from the pits and potential erosion of the pits walls. A more detailed evaluation of this requirement would be conducted prior to mine closure.

Stormwater pond outlet control structures would remain in place as necessary to manage water resource effects. The outlet control structure on the stormwater pond located immediately north of the East Pit and the Category 1 Stockpile would remain in place to minimize the mixing of the Partridge River flows with the East Pit water and prevent gully development on the northern side of the pit. The outlet control structures on the two stormwater ponds next to Dunka Road would remain in place to direct water under the road and the railroad to a tributary to the Partridge River along natural drainage paths. As a requirement of the NPDES/SDS stormwater permit and/or Reclamation Plan for the facility, discharges from these outlet control structures would be monitored as necessary to ensure that stormwater runoff to the Partridge River would meet water quality discharge limits. For modeling purposes, it is assumed that the water quality of this stormwater runoff is the same as the non-contact water for other portions of the watershed.

The WWTF would continue to operate during long-term closure, treating excess water from the West Pit and discharging the effluent to the small Partridge River tributary. The typical discharge rate from the WWTF is predicted to be 285 gpm. The water balance model predicts periodic temporary higher treatment/discharge rates to account for conditions when the freeboard in the pit becomes too small. By pumping pit lake water to the WWTF, the pit water level would be managed to always provide sufficient freeboard to absorb extreme precipitation events without overflowing. The estimated discharge for this condition is 570 gpm. In the water balance model, the occasional switch to the “high” treatment flow pushes the long-term average discharge rate to 290 gpm.

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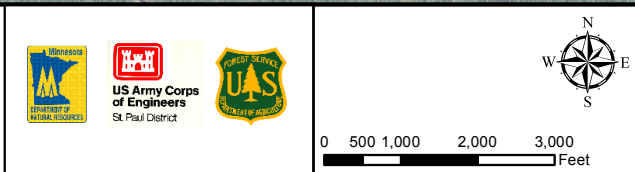
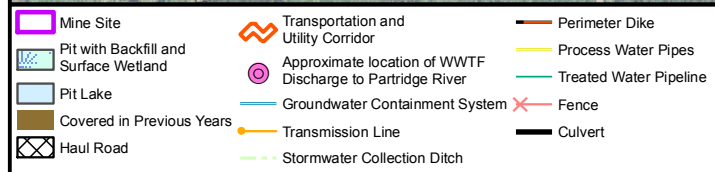
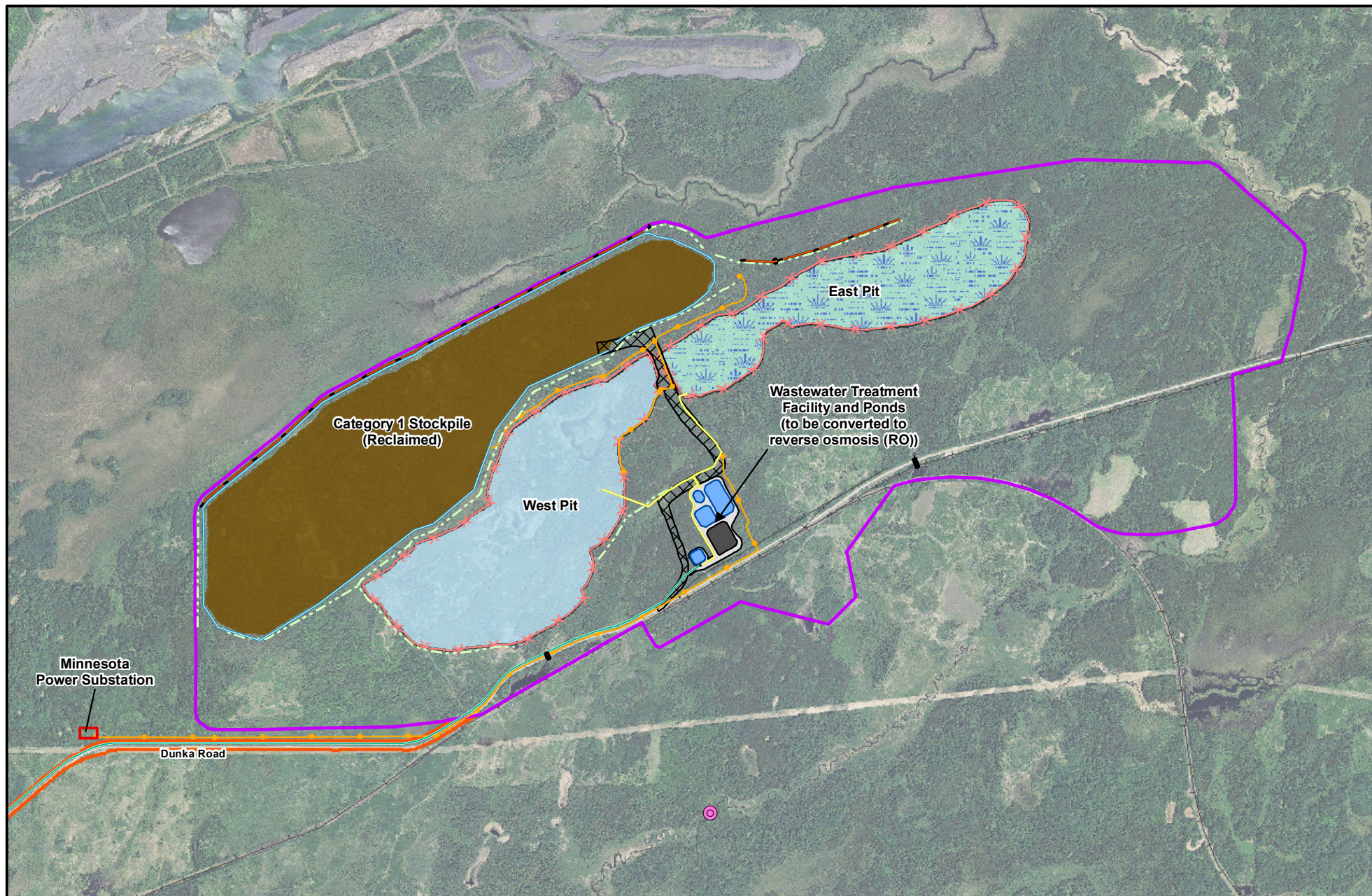


Figure 5.2.2-15
Mine Site Plan - Long Term Closure
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

November 2013

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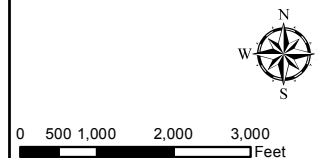
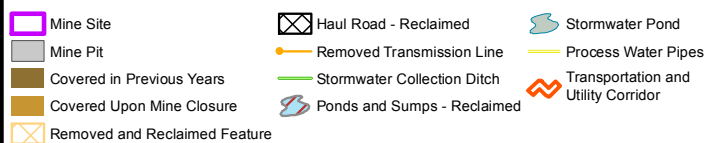
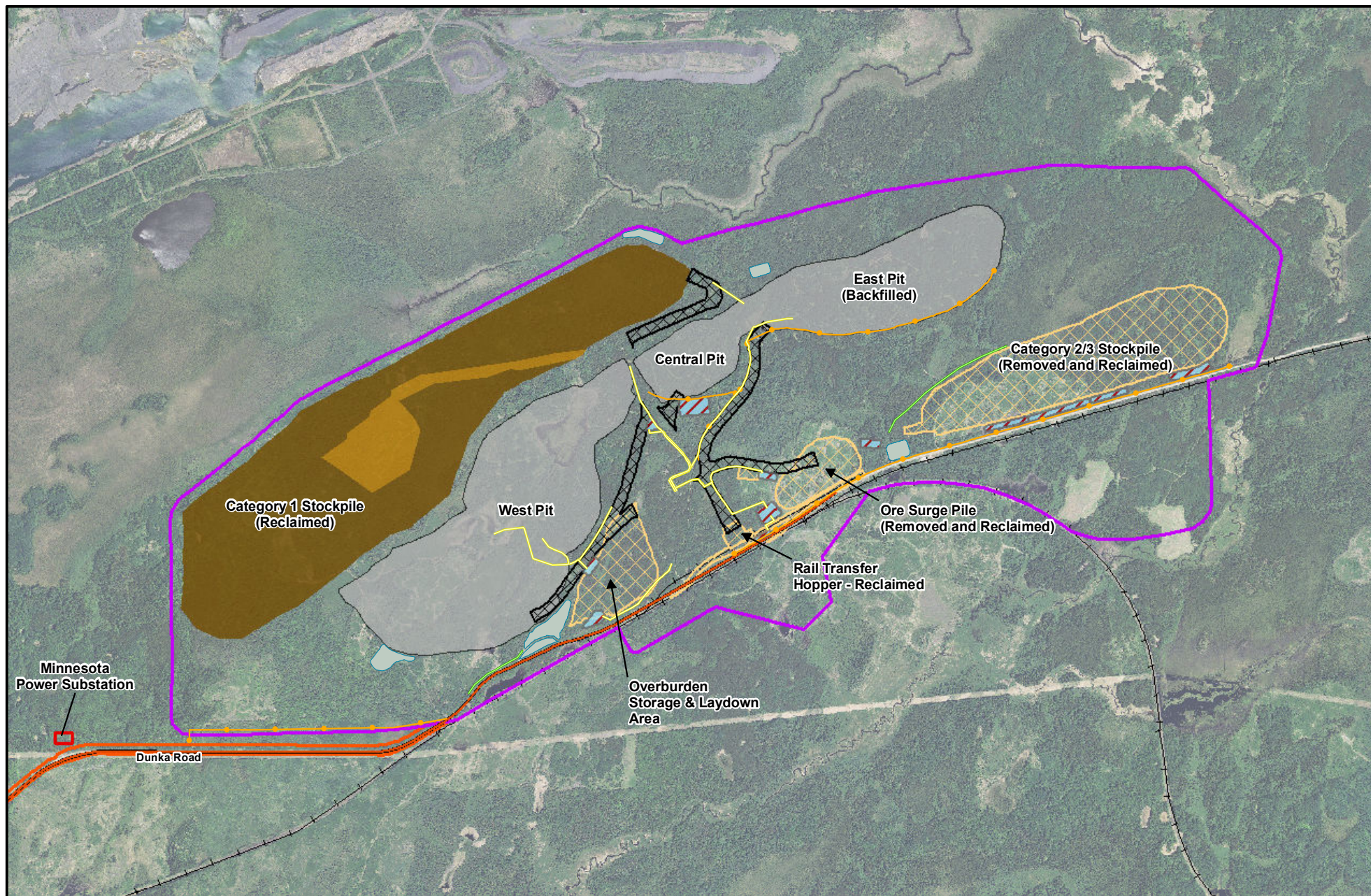


Figure 5.2.2-16
Features to be Removed/Reclaimed at Mine Closure
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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Plant Site

At the beginning of closure, the WWTP RO system would be modified for multistage operation and use of the distillation crystallization unit to eliminate the liquid reject stream. The moist waste solids from this system would be disposed of off site. Pilot-testing has indicated that treated effluent from this system would have sulfate concentrations less than 9 mg/L and meet water quality discharge standards for all regulated constituents.

During long-term closure, the WWTP would continue to treat water collected by the Tailings Basin containment systems. Some of the treated effluent would be used for flow augmentation to Unnamed Creek, Mud Lake Creek, Trimble Creek, and Second Creek. It is predicted that Colby Lake water would no longer be needed for augmentation (Barr 2013a). Tailings seepage bypassing the containment system (approximately 19.4 gpm) would continue to enter the North, Northwest, and West Surficial flowpaths, and migrate slowly toward the Embarrass River.

Long-term Closure Objectives

The ultimate water objective of long-term closure is to transition from the mechanical treatment provided by the WWTF and WWTP to non-mechanical treatment. Transitions to the non-mechanical treatment systems would begin after the performance of the non-mechanical treatment methods have been proven. At the Mine Site, non-mechanical treatment systems would be considered for long-term treatment of water from the Category 1 Stockpile groundwater containment system and West Pit overflow. At the Plant Site, non-mechanical treatment would be considered for tailings seepage collected by the Tailings Basin containment systems. Descriptions of possible non-mechanical systems are presented in PolyMet 2013g.

Long-term monitoring of the Hydrometallurgical Residue Facility would continue. Water collected by the leak detection system (if any) would be sent to the WWTP for treatment. Monitoring would continue and mitigation measures would be undertaken if there was any indication of potential solute releases to groundwater or surface water.

Surface water and groundwater would be monitored as required by relevant permits. The long-term closure activities would continue until monitoring indicated that the site water quality had met the stipulated permit conditions for discontinuing these activities.

5.2.2.3.2 Partridge River Watershed

This section discusses the potential environmental consequences of the NorthMet Project Proposed Action on groundwater and surface water hydrology and quality within the Partridge River Watershed, which includes all of the Mine Site, Transportation and Utility Corridor, and processing plant. A small portion of the Tailings Basin discharges via a surface seep to the headwaters of Second Creek. This seepage, however, is collected and pumped back to the existing LTVSMC Tailings Basin pursuant to the Cliffs Erie Consent Decree, and would continue to be pumped back under the NorthMet Project Proposed Action, so is not considered further in this discussion. WWTP effluent would be used to augment flow to Second Creek at a minimum 80 percent of the existing seepage rate.

Effects on Groundwater Hydrology

This section discusses the effects of the NorthMet Project Proposed Action on groundwater hydrology, specifically groundwater levels at the Mine Site. The NorthMet Project Proposed

Action would not result in any measureable effects on groundwater levels along the Transportation and Utility Corridor (other than as a result of the West Pit dewatering, which is discussed as part of the Mine Site) or at the processing plant.

The NorthMet Project Proposed Action would affect groundwater levels at the Mine Site during operations by dewatering the active mine pits and pumping water to the Plant Site (years 0 to 11) or to the East Pit and Tailings Basin (years 11 to 20). During years 20 to 40, water from the Plant Site would be pumped to the West Pit to accelerate flooding and help return groundwater levels to near pre-mining conditions.

Inflow to Mine Pits

The expected rate of groundwater inflow to the East Pit and West Pit during operations was estimated from MODFLOW modeling, similar to that performed for the DEIS. The model was updated in several ways, including the following:

- MODFLOW model was recalibrated using target baseflows of 0.41 cfs at SW-002, 0.51 cfs at SW-003, and 0.92 cfs at SW-004 to reflect revisions from the XP-SWMM model; and
- groundwater elevations at monitoring wells MW-1 through MW-18 were included as targets in the updated calibration.

These updated estimates of groundwater inflow rates to the pits were used to develop the overall water balance for the probabilistic model. Table 5.2.2-18 shows the MODFLOW-predicted inflows to the pit (years 1 to 20) as well as outflows during closure once the pits have flooded.

Table 5.2.2-18 Groundwater Inflows and Outflows at the Mine Pits Based on MODFLOW Results

Year	West Pit		Central Pit		East Pit	
	Inflow gpm	Outflow gpm	Inflow gpm	Outflow gpm	Inflow gpm	Outflow gpm
1	0	0	0	0	80	0
2	50	0	0	0	70	0
3	40	0	0	0	80	0
4	30	0	0	0	90	0
5	30	0	0	0	150	0
6	40	0	0	0	140	0
7	40	0	0	0	140	0
8	40	0	0	0	160	0
9	30	0	0	0	230	0
10	30	0	0	0	240	0
11	100	0	20	0	320	0
12	70	0	10	0	280	0
13	60	0	10	0	240	0
14	50	0	10	0	240	0
15	50	0	10	0	240	0
16	50	0	10	0	200	0
17	50	0	10	0	140	0
18	40	0	10	0	100	0
19	40	0	10	0	60	0
20	50	0	10	0	10	0
Long-term Closure	West Pit ¹		Combined East-Central Pit ²			
	Inflow gpm	Outflow gpm	Inflow gpm		Outflow Gpm	
	40	<10	30		<10	

¹ Open pit lake with water-surface elevation at approximately 1,576 ft amsl.

² Combine pits backfilled and resaturated with water-level elevation at approximately 1,592 ft amsl.

Extent of Pit Drawdown

Understanding the extent of groundwater drawdown, especially in the surficial material surrounding the NorthMet Project Proposed Action mine pits, is important in order to assess the potential effects on nearby surface water features such as wetlands. However, the complex mix of bedrock, glacial till, and wetland soils at the Mine Site makes it difficult to accurately quantify drawdown at any specific location. Site characterization data and MODFLOW calibration results indicate that the bulk hydraulic conductivity of bedrock is much lower than the bulk hydraulic conductivity of surficial materials. As a consequence, the bedrock tends to be saturated and overlain by a thin surficial aquifer that controls the local groundwater flow system. In a dewatering situation, the lower-permeability bedrock tends to remain saturated because it is subject to downward leakage from the overlying higher-permeability surficial aquifer (as long as the surficial aquifer contains groundwater). Unsaturated conditions in bedrock may occur very close to the pit wall, but not at moderate or large distances from the pit. Blasting during the mining operation is controlled to maintain pit wall integrity for safety considerations. Fractures and impacts to hydraulic conductivity due to blasting would only be affected very locally. In a dewatering situation, the lower-permeability bedrock tends to remain saturated because it is

subject to leakage from the overlying higher-permeability surficial aquifer. Water table drawdown in the surficial aquifer near the mine pits would be limited because it would be subject to meteoric recharge and has a saturated thickness on the order of only 14 ft.

Monitoring well response to pit dewatering at the Canisteo Pit, located approximately 65 miles west of the NorthMet Project area in similar surficial geology, indicated extreme aquifer heterogeneity. Modeling of aquifer response at the Canisteo site using MODFLOW resulted in differences between simulated and measured water levels ranging from +28 ft to -4 ft (reference USGS Report 02-4198). The model clearly could not accurately estimate water level changes of a few feet or less as would be desirable for assessing potential effects on nearby surface water features such as wetlands. Therefore, it was concluded that it was not reasonable to attempt to quantify drawdown at the Mine Site using the MODFLOW model.

In lieu of using MODFLOW to estimate pit drawdown at the Mine Site, an analog approach was developed using available well data from the Canisteo Pit, which is the only mine pit within the Mesabi Iron Range that has an associated water balance study with well data that could be used to assess potential drawdown effects. Sixteen Canisteo wells were used for the analog evaluation; an additional shallow well near Kinney, Minnesota, adjacent to Minntac's West Pit, and one deep bedrock well, also near Kinney, were also used for the evaluation. A comparison of the hydrogeologic conditions at the Canisteo Mine Pit, the Kinney area wells, and the Mine Site concluded that the geologic and hydrogeologic settings of the Mine Site are relatively similar to the Canisteo and Minntac sites (Barr 2011h).

The Canisteo Pit is not as deep as the proposed NorthMet mine pits. However, the glacial till at the Canisteo site ranges from 50 to 100 ft thick, while the surficial deposits at the Mine Site average only about 14 ft thick. Also, the underlying bedrock at the Canisteo site is composed exclusively of the Biwabik Iron Formation, which generally has a higher hydraulic conductivity than the Duluth Complex and Virginia Formation that underlie surficial deposits at the Mine Site. Despite the difference in pit depths, it is interpreted that there is potential for greater drawdown at the Canisteo site compared to the Mine Site. Overall, the Canisteo data are believed to provide a reasonably conservative estimate of the maximum extent of surficial groundwater drawdown that would result from the proposed PolyMet mine pits.

Several years of well water level data were used to measure response to the changing Canisteo Pit water level, and response to the approaching, dewatered Minntac West Pit (ERM and MDNR 2011).

The following were conclusions of the analog study:

- three wells within 700 ft of the Canisteo Pit showed a strong response to the rising pit water;
- six wells within 900 to 2,625 ft from the pit showed a measurable, but weak, response to the rising pit water;
- seven wells within 660 to 3,500 ft showed no response to the rising water;
- the deep bedrock well near Kinney started to show an apparent, progressive water level drop when the dewatered Minntac West Pit approached within about 1,000 ft of the well; and
- the shallow well near Kinney did not show any measurable water level drop from June 2000 through March 2003 (when data collection stopped for safety reasons), during which time the dewatered Minntac West Pit had advanced to within 900 ft of the well.

As can be seen by the above conclusions, an important finding of the analog evaluation was that there was no clear, systematic relationship between the proximity of wells to mine pits and effects on water levels.

Given the analog evaluation conclusions, the following guidelines for potentially measurable drawdown were developed at the Mine Site:

- 0 to 1,000 ft from the pit rim: groundwater drawdown from pit dewatering may occur and may be measurable;
- 1,000 to 1,700 ft from the pit rim: groundwater drawdown from pit dewatering may occur, but may be difficult to distinguish from natural variations in background water levels;
- 1,700 to 3,200-plus ft from the pit rim: groundwater drawdown from pit dewatering may occur, but would likely only occur under certain hydrogeologic conditions, and may not be discernible from natural variability; and
- beyond 3,200 ft from the pit: no effects expected.

These guidelines are intended to help define zones of potential groundwater drawdown that could be used to estimate potential indirect effects on nearby surface water features and wetlands (see Section 5.2.3 for further discussion of this analog approach). They could also be used to design a monitoring program to quantify actual effects, which could trigger appropriate mitigation measures if warranted. Contingency mitigation options are discussed in the Water Management Plan for the Mine Site (PolyMet 2013i). These guidelines have been expanded considerably since the original analog study (see Section 5.2.3).

There are few surface waterbodies within the 0 to 1,000 ft or the 1,000 to 1,700 ft zones, where groundwater drawdown may occur and would potentially be distinguishable from natural variations that could be affected by pit drawdown. The West Pit Outlet Creek is located within these zones and would be affected by the WWTF discharge and other NorthMet Project Proposed Action activities, as well. Yelp Creek and the headwaters of the Partridge River are located to the north of the mine pits, but beyond the 0 to 1,000 ft zone. The proposed Category 1 Stockpile groundwater containment system, which is tied into bedrock, would minimize effects of pit drawdown on these waterbodies.

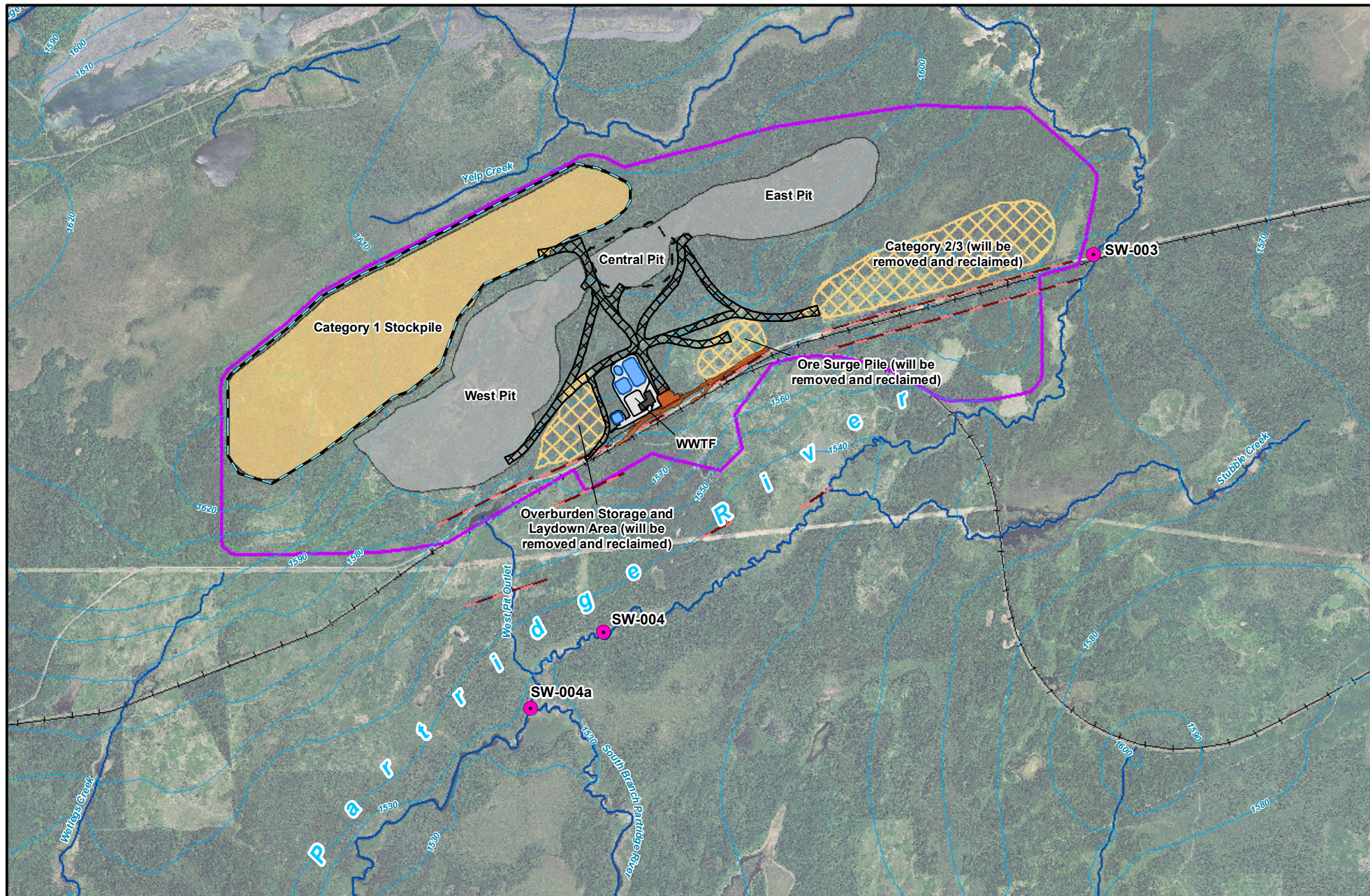
Note that these guidelines would apply during mine operations and reclamation, but groundwater drawdown associated with the mine pits should decline and essentially cease as the pits flood. The actual steady-state water level in the East Pit would be established by an outlet structure (invert at elevation 1,592 ft amsl) that would route surface overflows into the West Pit. The water level in the West Pit would be controlled by operation of the WWTF. Long-term change in on-site surficial aquifer groundwater levels (i.e., permanent drawdown) would be due to the fixing of head boundaries to lower surface water levels controlled by pumped discharge by the WWTF relative to existing conditions. There would be a permanent drawdown of a maximum of about 20 ft immediately surrounding the West Pit lake, resulting from a closure groundwater elevation of 1,579 ft versus existing groundwater elevation of approximately 1,600 ft, and about 10 ft immediately surrounding the East Pit, resulting from a closure groundwater elevation of 1,592 ft versus existing groundwater elevation of approximately 1,600 ft.

Effects on Groundwater Quality in the Surficial Aquifer

The NorthMet Project Proposed Action could affect groundwater quality at the Mine Site by leaching metals, sulfate, and other solutes from exposed waste rock, overburden, and ore. Groundwater would serve as the primary pathway for transporting untreated water from mine facilities to the Partridge River.

Potential Sources of Groundwater Contamination and Proposed Engineered Controls

The potential sources of groundwater contamination from the NorthMet Project Proposed Action within the Partridge River Watershed include the waste rock stockpiles, the Overburden Storage and Laydown Area, the Ore Surge Pile, the WWTF, and the mine pits (see Figure 5.2.2-17). Each of these sources is briefly described below and key features are summarized in Table 5.2.2-19. Note that the Category 2/3 Stockpile, the Overburden Storage and Laydown Area, the Ore Surge Pile, and the WWTF equalization basins, which are the source of affected groundwater at this facility, would only exist during mine operations and would cease being a source after approximately year 20. Most seepage from the Category 1 Stockpile would be captured and any seepage not captured would enter the West Pit, so the long-term effect of the Category 1 Stockpile is addressed as part of the West Pit water. The mine pits and Category 1 Stockpile would be the only facilities that would remain with the potential to behave as long-term sources of contamination. It is assumed that any uncollected seepage from the Category 4 Stockpile liner system would follow the hydraulic gradient to the East Pit, where it would be collected as part of the pit dewatering system and pumped to the WWTF for treatment.



- | | |
|---|---------------------------------|
| Groundwater Evaluation Locations | Mine Site |
| Surficial Aquifer Head Contour (m) at Closure | Haul Road |
| Groundwater Containment System | Mine Pit |
| Surface Water Modeling/Monitoring Location | Permanent Stockpile |
| Stream/River | Removed and Reclaimed Stockpile |
| | Removed Stockpile |

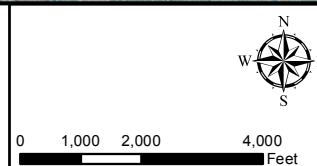


Figure 5.2.2-17
Mine Site Contaminant Source Areas
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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Table 5.2.2-19 Mine Site Solute Source Areas used in GoldSim

Source Area	Active Source Period (mine years)	Engineered Features	Chemical Mechanisms
Category 1 Stockpile	0+	Geomembrane cover; perimeter groundwater containment system. Permanent mine feature.	Most solutes released from Category 1 Stockpile material at concentration caps. Seepage collected by containment system would be sent to the WWTF or the West Pit. Seepage not collected by containment system would migrate as groundwater to West Pit.
Category 2/3 Stockpile	0-20	Geomembrane liner with seepage collection. Solid material would be sent to East Pit as backfill. Would be removed during reclamation.	Oxidation of Category 2/3 Stockpile material. Seepage collected above liner sent to WWTF. Seepage through liner would enter the underlying groundwater system.
Category 4 Stockpile	0-20	Geomembrane liner with seepage collection. Solid material sent to East Pit as backfill. Would be removed during reclamation.	Oxidation of Category 4 Stockpile material. Seepage would migrate as groundwater to the East Pit.
West Pit	Pit lake: 20+ Flow to groundwater flowpaths: 33+ ⁽¹⁾	Dewatered during mining, followed by flooding. Water level would reach top of bedrock at year 33. Maximum flooding would occur at about year 40, after which water level would be controlled by pumping to the WWTF.	Oxidation of wall rock prior to flooding. Would receive affected water from East Pit. Receives treated (or blended) water from Plant Site WWTP during flooding period (20-33 years). Would receive treated water from Mine Site WWTF. Beginning in year 33, the West Pit water level would rise above the top of bedrock and begin to release pit lake water into the West Pit surficial groundwater flowpath.
East Pit	Flow to groundwater flowpath: 21+ ⁽¹⁾ Flow to West Pit: 22+ ⁽¹⁾	Would merge with the Central Pit. Dewatered during mining. All Category 2, 3, and 4 waste rock, and some Category 1 waste rock, would be used as backfill. Water level in saturated backfill would reach top of bedrock at year 21. Maximum refill would occur at year 22, after which water level in saturated backfill would be controlled by overflow through a wetland to the West Pit.	Oxidation of wall rock prior to backfill saturation. Solute release from unsaturated and saturated backfill. Beginning in year 21, the water level in the East Pit saturated backfill would rise above the top of bedrock and begin release of pit water into the East Pit Cat 2/3 Surficial (groundwater) Flowpath. The East Pit would reach maximum refill at about year 22.
Overburden Storage and Laydown Area	0-20	Unlined facility, but with collection system for surface runoff. Would be removed during reclamation.	Leaching of overburden materials. Seepage would enter underlying groundwater system.

Source Area	Active Source Period (mine years)	Engineered Features	Chemical Mechanisms
WWTF Basins	0-35	Precipitation/filtration treatment plant using equalization basins with geomembrane liners. Would be removed during reclamation when water treatment plant converted to RO.	Receives water from West Pit (including East Pit overflow), Category 1 Stockpile, Category 2/3 Stockpile, Overburden Storage and Laydown Area, and Ore Surge Pile. Would receive reject concentrate from Plant Site WWTP. Seepage collected above liner would be sent to WWTF. Seepage through liner would enter the underlying groundwater system.
Ore Surge Pile	0-21	Geomembrane liner with seepage collection. Would be removed during reclamation.	Oxidation of ore. Seepage collected above liner would be sent to WWTF. Seepage through liner would enter the underlying groundwater system.

Source: PolyMet 2013g.

¹ Based on deterministic GoldSim run with P50 inputs.

All of these potential solute sources would be located at the Mine Site. The only potential solute sources along the Transportation and Utility Corridor or at the processing plant (both within the Partridge River Watershed) would be from spills, as there would be no surface stockpiles of waste rock, ore, or other potential solute sources in these areas. As mentioned previously, the South seep from the Tailings Basin at the headwaters of Second Creek is currently, and would continue to be, collected and pumped back to the Tailings Basin pond.

No effects on groundwater quality along the Transportation and Utility Corridor are anticipated during construction or closure as part of the NorthMet Project Proposed Action. There is the potential, however, for ore spillage from rail cars in transport from the Mine Site to the processing plant during operations. Based on observations at other mining operations using similar side-dump rail cars, it is assumed that spillage could occur along the first 1,000 meters of rail from the Rail Transfer Hopper (PolyMet 2013l). It is estimated that 55.7 kg ore per m² track could spill from rail cars within the first 1,000 meters of the Transportation and Utility Corridor over the 20-year life of the NorthMet Project Proposed Action. This is equivalent to 1.25 inches of spilled material over a 2,000-m² area. Rainfall contacting the spilled ore material has the potential to release solutes, but with the small volume of ore and dilution from other sources, water quality is expected to meet the evaluation criteria (PolyMet 2013l).

In order to guard against possible adverse effects from spilled ore, monitoring and mitigation activities would be developed. Water quality monitoring is recommended downgradient from the rail line on the Partridge River tributary streams to check for any deteriorations of water quality over time from ore spillage, and, if detected, adaptive water management measures would be implemented.

Waste Rock Stockpiles

The NorthMet Project Proposed Action would generate about 308 million tons of waste rock over the 20 years of mine operations. This waste rock would be managed according to its geochemical properties. Four categories of waste rock were defined generally based on its sulfur content as summarized in Table 5.2.2-20.

Table 5.2.2-20 Summary of Waste Rock Stockpile Properties

Waste Rock Categorization	Sulfur Content (%S)¹	Approximate % of Waste Rock Total Mass⁴	Max Footprint (acres)	Stockpile Duration	Bottom Liner System	Cover System
Category 1	$\%S \leq 0.12$	70%	526	Permanent	No liner system; a groundwater containment system would collect water for pumping to the WWTF.	3-ft engineered system consisting of geomembrane and overlying vegetated soil cover.
Category 2	$0.12 < \%S \leq 0.31$	24%	180 ⁽³⁾	Temporary	12-inch compacted (1 x 10-5 cm/s) subgrade overlaid by 80-mil LLDPE geomembrane, covered by a 24-inch overliner drainage layer.	Stockpile would be completely removed and reclaimed.
Category 3	$0.31 < \%S \leq 0.6$	3%	180 ⁽³⁾	Temporary	12-inch compacted (1 x 10-5 cm/s) subgrade overlaid by 80-mil LLDPE geomembrane, covered by a 24-inch overliner drainage layer.	Stockpile would be completely removed and reclaimed.
Category 4 ⁽²⁾	$0.6 < \%S$	3%	57	Temporary	12-inch compacted (1 x 10-6 cm/s) subgrade overlaid by 80-mil LLDPE geomembrane, covered by a 24-inch overliner drainage layer.	Stockpile would be completely removed and reclaimed.

Source: PolyMet 2013c.

¹ In general, the higher the rock's sulfur content, the higher its potential for generating acid rock drainage or leaching heavy metals.

² Includes all Virginia formation rock.

³ Max footprint is total for Category 2/3 waste rock.

⁴ Approximately 29% of waste rock that ultimately fills the East Pit (mostly Category 2 and 3) would be sent to the pit without prior stockpiling.

As Table 5.2.2-20 above indicates, the Category 1 Stockpile would be permanent. It would not have a liner, but would be surrounded by a groundwater containment system consisting of a cutoff wall (i.e., low-permeability hydraulic barrier) and a subsurface drain that would collect nearly all (approximately 93 percent) of the seepage from the stockpile. This stockpile would be progressively reclaimed with an engineered geomembrane cover system constructed from year 14 through 21. A maximum of 7 percent of seepage is estimated to bypass the containment system, but would flow as groundwater to the West Pit, where it would be collected and pumped to the WWTF for treatment. During reclamation and closure, the estimated bottom seepage from the Category 1 Stockpile would be about 3 gpm.

The Category 2/3 and 4 stockpiles would both be removed during reclamation, and therefore would not require a cover. Each of these stockpiles, however, would be constructed with a liner system including a compacted subgrade, an underdrain, an impermeable geomembrane liner, an overliner drainage layer, and a drainage/leachate collection system. Drainage from these stockpiles would be collected on the liner and routed to a lined sump for pumping to the WWTF for treatment. Once mining of the East Pit is completed (approximately year 11), the Category 2/3 and Category 4 waste rock would be backfilled into the East Pit, the liner system would be removed, and the footprints of these stockpiles reclaimed. The GoldSim modeling assumes, however, that some leachate seeps through tears/flaws in the Category 2/3 Stockpile geomembrane liner, reaches the groundwater table, and follows what is referred to as the Category 2/3 Stockpile and East Pit Flowpath, ultimately discharging to the Partridge River. Some leachate from the Category 4 Stockpile is also assumed to seep through the liner system, but given its location adjacent to the East Pit, it is assumed that any uncollected seepage would follow the hydraulic gradient to the East Pit, where it would be collected as part of the pit dewatering system and pumped to the WWTF for treatment.

Overburden and Overburden Storage and Laydown Area

The NorthMet Project Proposed Action would strip overburden as needed for mine development, thereby minimizing the amount of exposed bedrock at any one time. About 32 percent of the overburden would be stripped in the first 2 years of the mine life, with the balance being removed by the end of year 11. Overburden present at the Mine Site is categorized into three types: unsaturated overburden, saturated overburden, and peat (organic soils). Each type of overburden would be managed in accordance with its characteristics.

Saturated overburden is the material that has been below the normal water table and not exposed regularly to oxygen, so it is still potentially reactive if exposed to oxygen. Some of this material would be used for construction purposes, but only for applications where it would be placed below the water table or where any water contacting it would be collected and appropriately treated. Saturated overburden not used for construction purposes would be commingled with waste rock and placed in the temporary Category 2/3 or 4 stockpiles with a geomembrane liner.

Unsaturated overburden is above the normal water table, and waste characterization studies indicate that it has been exposed to oxygen for a sufficiently long period of time that it is now non-reactive. This material would be used for construction purposes. To the extent that unsaturated overburden exceeded immediate construction needs, it would be temporarily stored in the unlined Overburden Storage and Laydown Area. Peat would also be used for reclamation purposes, as appropriate, and any excess would be temporarily stored along with the unsaturated

overburden in the unlined Overburden Storage and Laydown Area for future use during reclamation. Surface runoff from the Overburden Storage and Laydown Area is considered “process water,” and would be captured in an unlined pond (Pond PW-OSLA) and monitored for quality. If the Overburden Storage and Laydown Area water were of acceptable quality, it would be pumped to the Central Pumping Station and discharged to the East Pit Category or the Tailings Basin, where the destination would be based on variable project demand over time. If water in Pond PW-OSLA required treatment, it would be pumped to the WWTF for treatment prior to delivery to the Central Pumping Station.

Since the Overburden Storage and Laydown Area would be unlined, the GoldSim model assumes meteoric water would seep into the groundwater below the Overburden Storage and Laydown Area and follow what is referred to as the Overburden Storage and Laydown Area Flowpath ultimately discharging to the Partridge River. During operations, the estimated bottom seepage from the Overburden Storage and Laydown Area would be about 14 gpm. The water quality of this seepage was estimated based on the results of the Meteoric Water Mobility Procedures test for peat and unsaturated overburden (PolyMet 2013l).

Ore Surge Pile

An Ore Surge Pile would be constructed near the Rail Transfer Hopper to allow for temporary storage of ore and a steady flow and uniform grade of ore to the processing plant. Ore would flow into and out of this pile during the life of the mine as needed to meet plant operations. The Ore Surge Pile would have a liner system identical in design to that for the Category 4 Stockpile. Drainage from the Ore Surge Pile would be collected on the liner and routed to a lined sump for pumping to the WWTF for treatment. The Ore Surge Pile, including the liner system, would be removed at the completion of mining activities and reclaimed.

The GoldSim modeling assumes, however, that a small volume of leachate would seep through tears/flaws in the geomembrane liner, reaches the groundwater table, and follows what is referred to as the Ore Surge Pile Flowpath, ultimately discharging to the Partridge River.

East Pit

During mining, the East Pit would be dewatered. In approximately year 10, mining of the East Pit would be completed and backfilling would begin with stockpiled Category 2/3 and 4 waste rock, and fresh waste rock (all categories) from the West Pit. During backfilling, natural groundwater inflow to the pit would saturate the backfill. The pore water in the initially saturated backfill would have relatively high solute concentrations (see Figure 5.2.2-18 for a representative example based on sulfate), but once submerged, oxygen transport would be limited and there would be a systematic decrease in oxidation and associated dissolution of sulfide minerals. Additional concentration reduction would occur by cycling the East Pit backfill pore water through the WWTP.

Once the saturated water level in the backfill reaches the top of bedrock along the pit rim (approximate elevation of 1,577 ft at year 21), some backfill pore water would begin to flow from the pit into the surficial aquifer. The quality of the aquifer inflow would reflect the quality of the pit water over time. This groundwater inflow would migrate south through the East Pit Category 2/3 Surficial Flowpath and ultimately release to the Partridge River. Since both the Category 2/3 Stockpile and the East Pit would share the same flowpath, the flowpath would experience two concentration peaks, the first representing the arrival of solutes from the

Category 2/3 Stockpile, which would reach the Partridge River around year 30 and would peak around year 55, and the second from the arrival of aquifer inflow from the East Pit, which would reach the Partridge River around year 115 and peak around year 160. For cobalt, Figure 5.2.2-19 shows the dual peak that would occur in the East Pit Cat 2/3 Surficial Flowpath at the Partridge River and compares this response with peaks that would occur in the other surficial flowpaths.

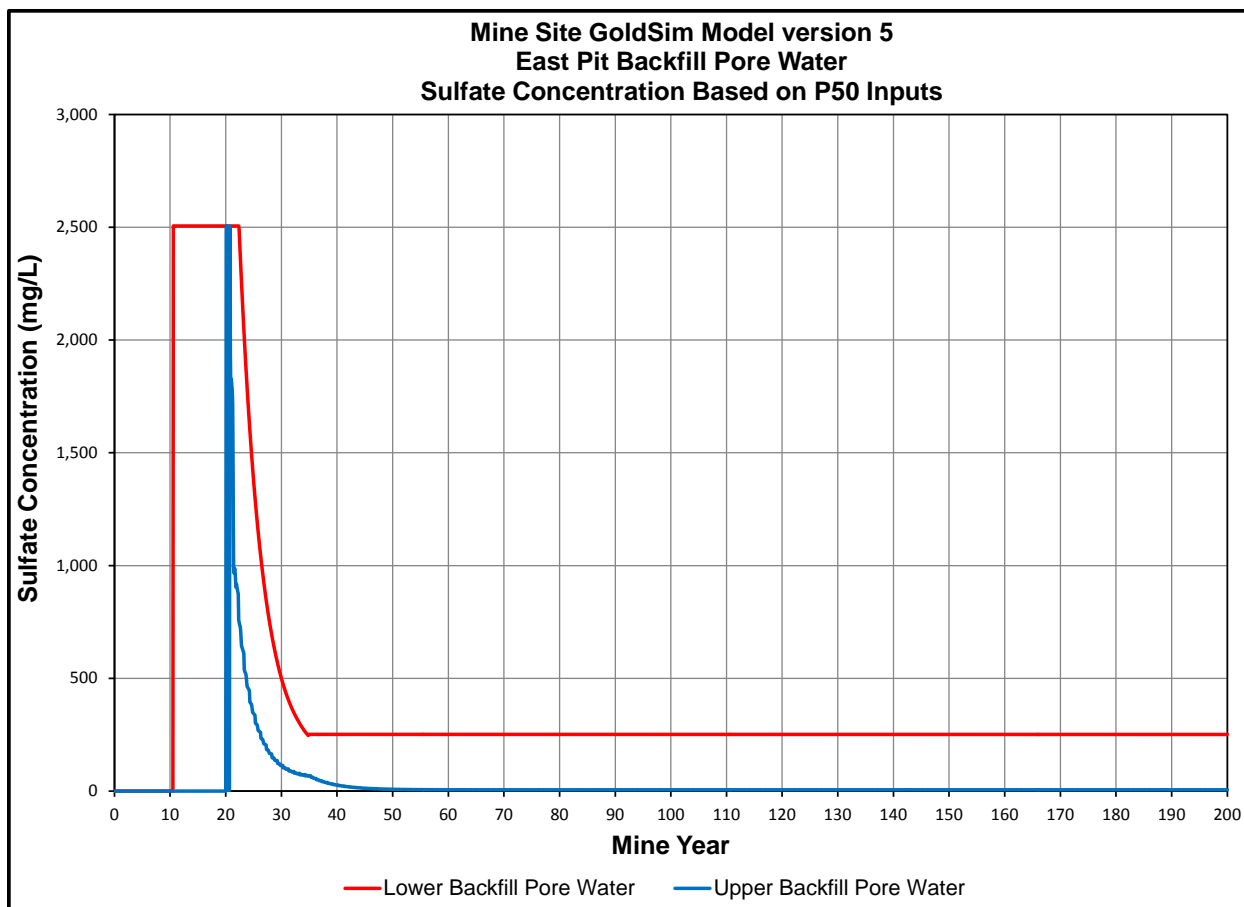


Figure 5.2.2-18 *Sulfate Concentrations in East Pit Backfill Based on GoldSim Deterministic Run with P50 Inputs*

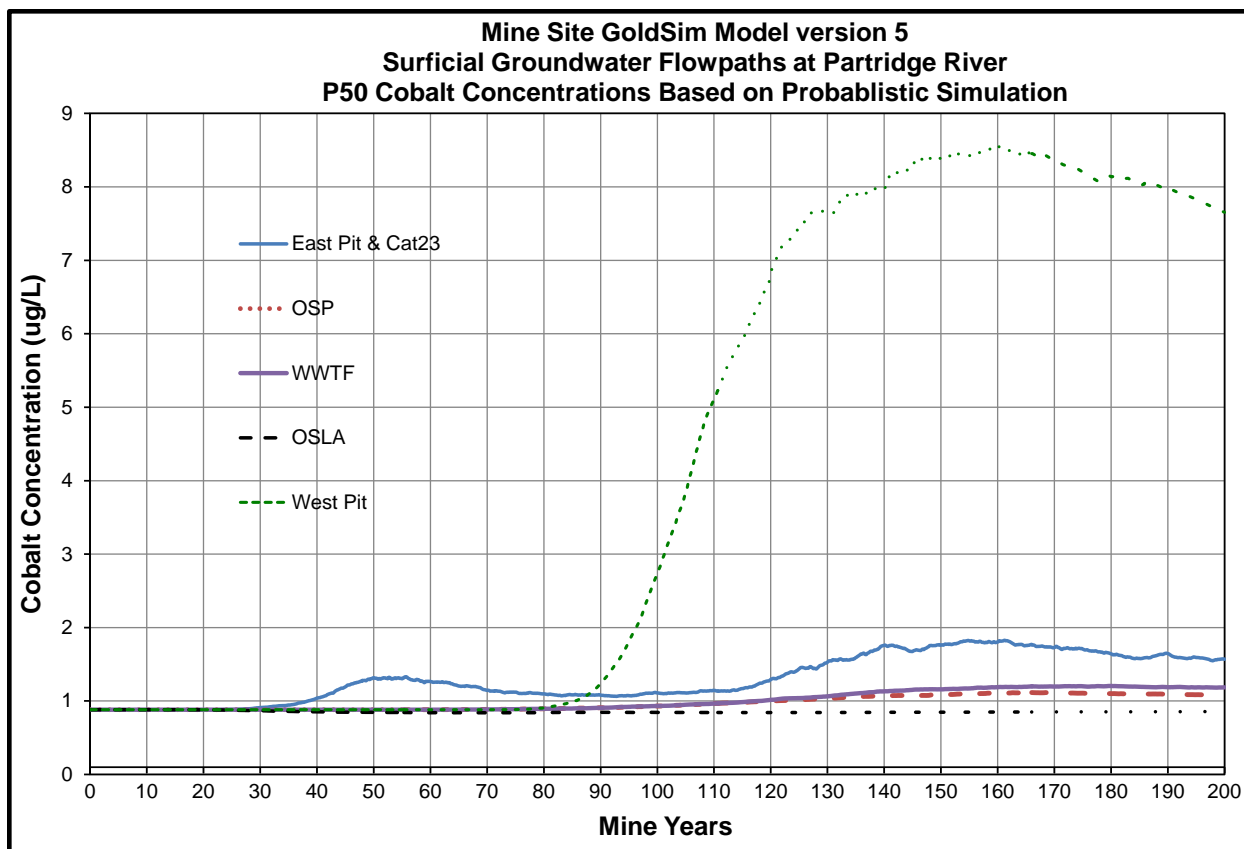


Figure 5.2.2-19 *P50 Cobalt Concentrations in Surficial Groundwater Flowpaths at the Partridge River Based on GoldSim Probabilistic Simulation*

West Pit

Flooding of the West Pit would begin after the completion of mining in year 21. The water in the West Pit is expected to contain dissolved oxygen with initial concentrations as high as 15 mg/L. This oxygen would be initially reactive with the pit wall rock, but the reactivity would decrease over time as the material exposed to water oxidizes. Groundwater flow in bedrock (although very minimal) would be towards the pit, so the only mechanism for oxygen to reach unoxidized rock beyond the pit wall would be diffusion, and this would limit the rate of wall rock chemical reactions.

Once the water in the flooded pit reached the top of bedrock along the pit rim (approximate elevation 1,550 ft at year 33), some of the pit lake water would begin to flow into the surficial aquifer. The quality of this aquifer inflow would reflect the quality of the pit lake water, which would gradually improve over time due to cycling through the WWTF. The groundwater inflow would migrate south along West Pit Surficial Flowpath and ultimately release to the Partridge River. The initial arrival of West Pit solutes at the Partridge River would occur at about year 90, and peak concentrations in groundwater discharging to the river would occur at about year 160.

Wastewater Treatment Facility

The WWTF would treat influent water from a variety of sources (e.g., pit dewatering, stockpile leachate collection, contact surface water). The only potential source of groundwater contamination at the WWTF would be influent leaking from the two equalization basins and effluent leaking from the Central Pumping Station. The equalization basin would have a geomembrane liner system and would be designed to have a minimum of 3 feet of freeboard, in accordance with the MPCA guidance (Meyer et al. 2009). Leakage from these basins through the liner system is calculated differently than for the waste rock stockpile liner systems in that these systems are intended to store water and do not have positive drainage. Therefore, the hydraulic pressure on the liners would be greater, and, in turn, more water would be expected to leak on a per-acre basis (i.e., approximately 5 gallons per acre per day) (PolyMet 2013i). The total volume of leakage from the equalization basins, however, would be less than from the stockpiles, as the footprint of the equalization basins would be much less. This leakage would reach the groundwater table and follow what is referred to as the WWTF Flowpath ultimately to the Partridge River.

Groundwater Transport and Evaluation Locations

Solutes from each source area described above would be transported by groundwater along its associated flowpath (see Figure 5.2.2-4). Each of these flowpaths has a groundwater evaluation location where the GoldSim model predicts groundwater quality (see Figure 5-2.2-4). At each evaluation location, the predicted water quality for the NorthMet Project Proposed Action is compared with both the evaluation criteria and the water quality under the predicted Continuation of Existing Conditions Scenario. See Table 5.2.2-14 for a summary of solute fate and transport.

The time at which contaminants leached from the Mine Site would begin to affect water quality at the downgradient evaluation points depends on the following four variables:

- the time (i.e., year) when the source facility was constructed or began leaching contaminants;
- the rate at which contaminants move in groundwater (assumed to equal the groundwater flow rate for all constituents except the four attenuated contaminants (arsenic, antimony, copper, and nickel), which are assumed to migrate more slowly than the groundwater);
- the distance between the source and the evaluation point; and
- mechanical dispersion, which tends to spread out the solute plume.

Cobalt was generally used to illustrate groundwater transport at the Mine Site because it is not attenuated and would enter the surficial flowpaths at concentrations higher than baseline groundwater. As a consequence, the movement of solute fronts associated with this solute is readily discernible on concentration-versus-time and concentration-versus-distance plots for the modeled flowpaths. Transport of other non-attenuated solutes should be similar to cobalt, but the changes in concentrations are not as visually noticeable as it is for cobalt.

The estimated migration times for contaminant plumes to reach the evaluation locations are presented in Table 5.2.2-21.

Table 5.2.2-21 Solute Migration Times for Mine Site Groundwater Flowpaths

Surficial Groundwater Flowpath	Solute Source Times		Solute Migration Times to Groundwater Evaluation Location ¹		Solute Migration Times to SW Release or River ¹	
	Start Mine Year	Stop Mine Year	Initial Concentration Increase Mine Year	Peak Concentration ⁵ Mine Year	Initial Concentration Increase Mine Year	Peak Concentration ⁵ Mine Year
Mine Site – Category 2/3 Stockpile	0	21	12	30	30	55
Mine Site – East Pit	21 ⁽⁴⁾	Continuous	90	130	110	160
Mine Site – Ore Surge Pile	0	21	90	165	90	165
Mine Site – WWTF	0	37	75	150	95	175
Mine Site – Overburden Storage and Laydown Area	0	21	6 ⁽²⁾	20 ⁽³⁾	17 ⁽²⁾	70 ⁽³⁾
Mine Site – West Pit	33 ⁽⁴⁾	Continuous	65	125	90	160

Source: Barr 2013f.

¹ For all constituents except arsenic, copper, nickel, and antimony, which are modeled with adsorption coefficients that greatly increase solute migration times.

² Concentration decrease for most constituents.

³ Minimum concentration for most constituents.

⁴ Based on deterministic GoldSim run with P50 inputs. Time when pit water level would rise above the top of bedrock and begin to release pit water into the adjacent surficial (groundwater) flowpath.

⁵ All modeled peak concentrations are below evaluation criteria.

Table 5.2.2-21 indicates that all of the contaminant plumes would reach the Partridge River within the 200-year modeled duration.

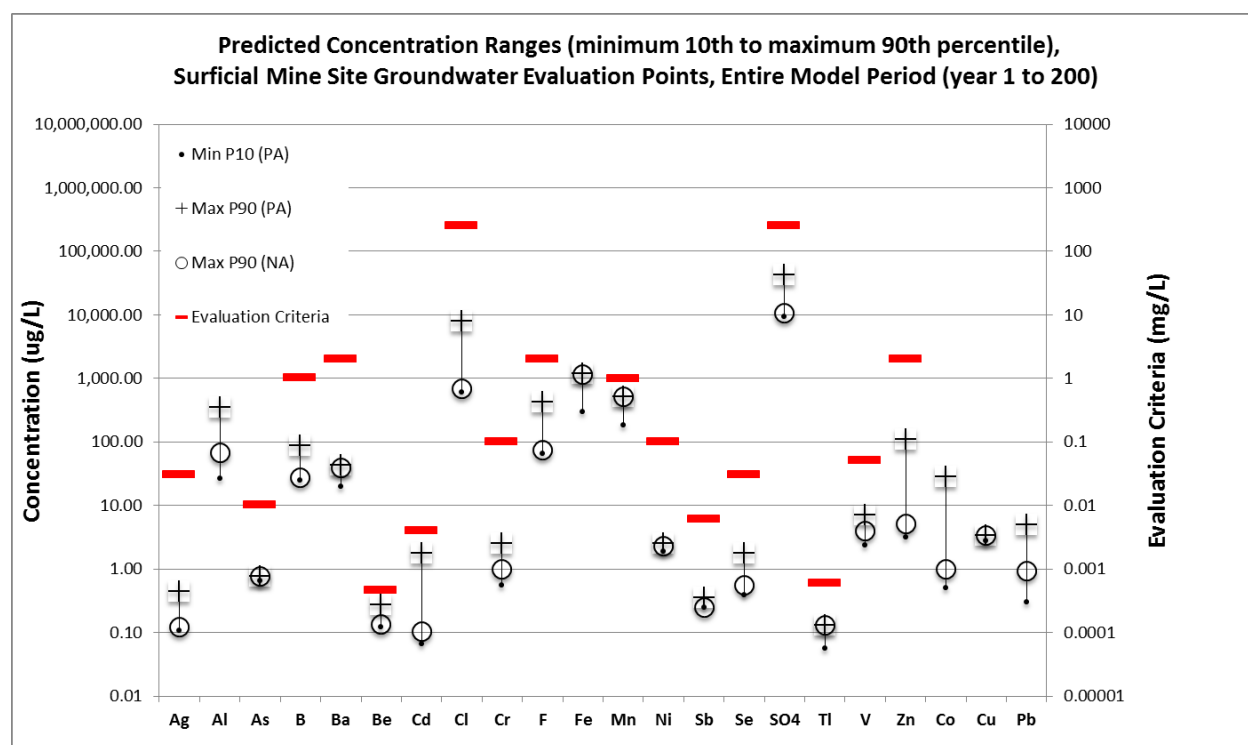
Surficial Groundwater Quality at the Evaluation Locations

The results of the GoldSim model were reviewed for all 28 solutes at the evaluation location at each of the five surficial flowpaths. A screening process was used to identify any constituents and locations that warranted a more robust examination because modeled concentrations were near water quality evaluation criteria. The screening process involved comparing the single-highest monthly P90 water quality prediction from among the 2,400 months covered by the simulation (i.e., 12 months times 200 years) for each constituent at each of the five evaluation locations. These NorthMet Project Proposed Action modeled values were compared with both the Continuation of Existing Conditions Scenario modeled values and the evaluation criteria discussed previously. Each contaminant that was identified as near the numerical evaluation criteria was then evaluated in more detail.

The screening of maximum P90 groundwater concentrations of all modeled solutes indicated that none of the solutes at any of the five flowpaths were predicted to ever exceed the evaluation criteria at the P90 level. These results are shown in Table 5.2.2-22, which lists the maximum P90 values for each modeled constituent. These results are illustrated, along with the maximum P90

concentrations for the Continuation of Existing Conditions Scenario and the range in NorthMet Project Proposed Action model concentrations (lowest P10 to the highest P90 value over 200-year simulation and across all groundwater model-reporting points), in Figure 5.2.2-20. The proportional increase in the concentrations of each solute (i.e., the ratio of the maximum P90 value under the NorthMet Project Proposed Action Scenario to the maximum P90 value under the Continuation of Existing Conditions Scenario) are listed in Table 5.2.2-23 and illustrated graphically in Figure 5.2.2-21. Note that if the values are the same, the relative change ratio would be 1; values greater than 1 indicate the ratio at which the NorthMet Project Proposed Action would result in an increase in solute concentrations relative to the Continuation of Existing Conditions Scenario model results.

When groundwater affected by mining reaches the Partridge River, the concentration of groundwater that discharges from the flowpath into the river would be a mixture of water that entered the upgradient end of the flowpath and meteoric recharge along the flowpath. For most constituents, the background solute concentration would be lower than the source concentration. This means there would be a reduction in concentration of these constituents by the time the groundwater arrived at the Partridge River because the groundwater leaving the Mine Site would mix with and be added to by other groundwater of lower constituent-loading, thus diluting the original groundwater before reaching the Partridge River (PolyMet 2013i).



Note: Groundwater evaluation criteria plotted are listed in Table 5.2.2-2.

Figure 5.2.2-20 *Predicted Maximum P90 Concentrations of Each Solute versus Evaluation Criteria, Mine Site Surficial Groundwater Evaluation Locations*

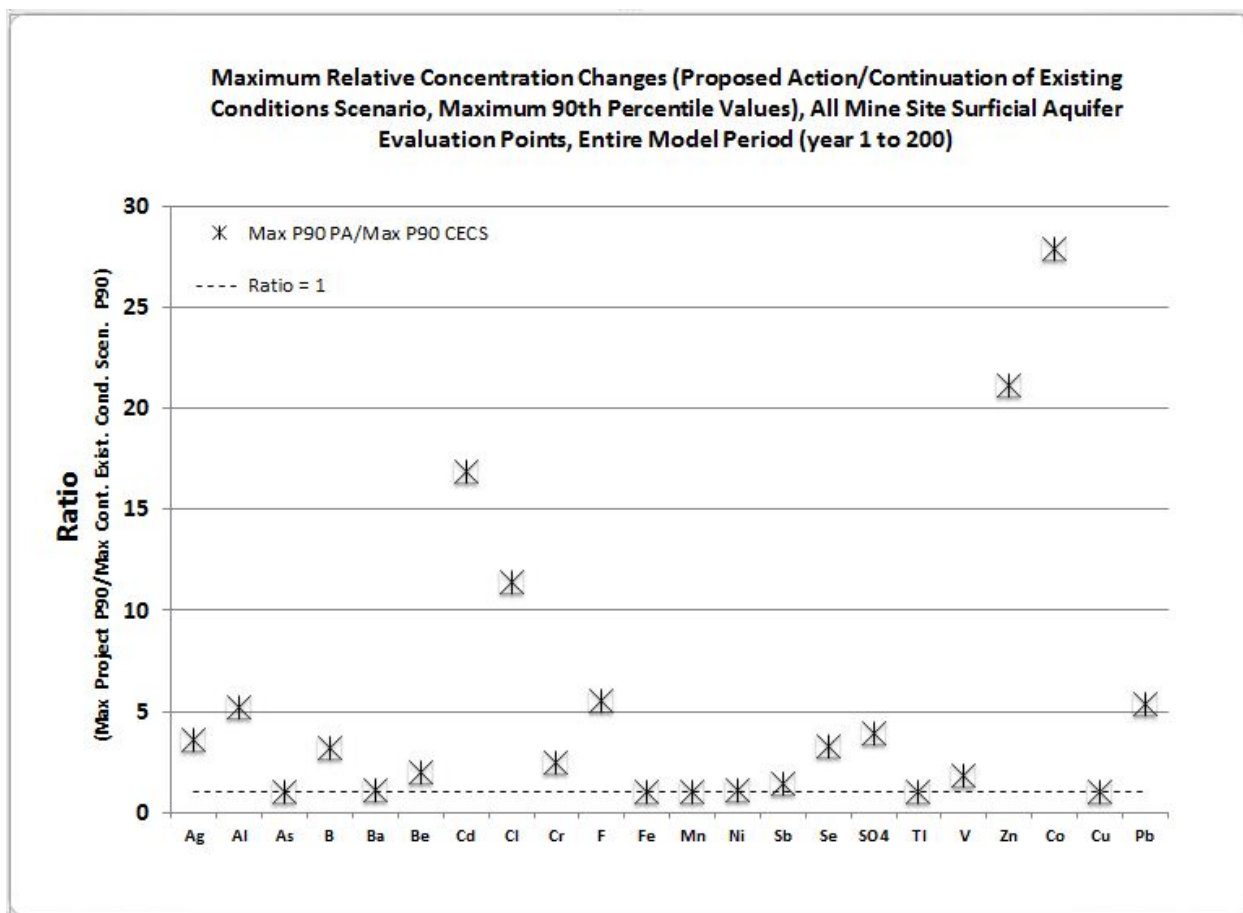


Figure 5.2.2-21 Maximum Relative Concentration Changes (NorthMet Project Proposed Action/Continuation of Existing Conditions Scenario), Maximum P90 Values, Over the 200-year Simulation Period at All Surficial Aquifer Evaluation Locations

Table 5.2.2-22 Mine Site Groundwater – Maximum P90 Solute Concentration Over Entire 200-Year Simulation Period Based on the GoldSim Probabilistic Model

Parameter	SDEIS Groundwater Evaluation Criterion			East Pit Category 2/3 Surficial Flowpath at Partridge River		Overburden Storage and Laydown Area Surficial Flowpath at Property Boundary ⁽¹⁾		Ore Surge Pile Surficial Flowpath at Partridge River ⁽¹⁾		WWTF Surficial Flowpath at Property Boundary ⁽¹⁾		West Pit Surficial Flowpath at Property Boundary ⁽¹⁾	
	Concen-tration	Units	Reference Table	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario
General													
Alkalinity	--	mg/L	5.2.2-2	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7
Calcium	--	mg/L	5.2.2-2	22.1	16.8	16.8	16.8	16.8	16.8	16.8	16.8	33.1	16.8
Chloride	250	mg/L	5.2.2-2	2.98	0.7	3.7	0.7	0.70	0.7	0.70	0.7	7.95	0.7
Fluoride	2	mg/L	5.2.2-2	0.13	0.08	0.42	0.08	0.08	0.08	0.08	0.08	0.17	0.08
Hardness	--	mg/L	5.2.2-2	90.1	72.3	72.3	72.3	72.4	72.3	72.6	72.3	148.5	72.3
Sulfate	250	mg/L	5.2.2-2	21.6	10.8	36.5	10.8	10.9	10.8	11.3	10.8	41.9	10.8
Magnesium	--	mg/L	5.2.2-2	8.5	7.4	7.4	7.4	7.4	7.4	7.5	7.4	16.0	7.4
Potassium	--	mg/L	5.2.2-2	4.4	1.8	2.6	1.8	1.8	1.8	1.9	1.8	7.2	1.8
Sodium	--	mg/L	5.2.2-2	13.5	5.6	16.1	5.6	5.6	5.6	5.7	5.6	25.4	5.6
TDS ⁽³⁾	500	mg/L	5.2.2-2	113	83.2	123	83.2	83.4	83.2	83.9	83.2	172	83.2
Metals													
Aluminum	--	µg/L	5.2.2-2	177	66.9	141	66.9	77.4	66.9	87.3	66.9	66.9	66.9
Antimony	6	µg/L	5.2.2-2	0.26	0.25	0.29	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Arsenic	10	µg/L	5.2.2-2	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77
Barium	2000	µg/L	5.2.2-2	41.7	39.4	39.4	39.4	39.4	39.4	39.4	39.4	39.6	39.4
Beryllium	0.45	µg/L	5.2.2-1 ⁽²⁾	0.16	0.13	0.16	0.13	0.13	0.13	0.13	0.13	0.27	0.13
Boron	1000	µg/L	5.2.2-2	33.1	27.3	87.3	27.3	27.3	27.3	27.3	27.3	65.7	27.3
Cadmium	4	µg/L	5.2.2-2	0.52	0.10	0.10	0.10	0.1	0.10	0.11	0.10	1.8	0.10
Chromium	100	µg/L	5.2.2-2	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.5	1.0
Cobalt	--	µg/L	5.2.2-2	7.6	1.0	1.0	1.0	1.8	1.0	1.9	1.0	28.0	1.0
Copper	1000	µg/L	5.2.2-2	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Iron	--	µg/L	5.2.2-2	1,157	1,140	1,140	1,140	1,143	1,140	1,148	1,140	1,140	1,140
Lead	--	µg/L	5.2.2-2	1.02	0.93	0.93	0.93	0.93	0.93	0.94	0.93	4.99	0.93
Manganese	964	µg/L	5.2.2-1 ⁽²⁾	514	509	509	509	510	509	510	509	509	509
Nickel	100	µg/L	5.2.2-2	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Selenium	30	µg/L	5.2.2-2	0.87	0.55	0.62	0.55	0.55	0.55	0.56	0.55	1.8	0.55
Silver	30	µg/L	5.2.2-2	0.13	0.12	0.44	0.12	0.12	0.12	0.12	0.12	0.16	0.12
Thallium	0.6	µg/L	5.2.2-2	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Vanadium	50	µg/L	5.2.2-2	4.5	3.9	3.9	3.9	3.9	3.9	3.9	3.9	7.1	3.9
Zinc	2000	µg/L	5.2.2-2	31.6	5.1	5.1	5.1	5.4	5.1	5.8	5.1	108	5.1

Source: Barr 2013f.

Notes: For each constituent at each location, the maximum solute concentration over the entire 200-year simulation period is recorded for each of 500 realizations of the Monte Carlo run. At the end of the Monte Carlo run, there is a list of 500 maximum concentration values for each constituent at each location. Each list is converted to a cumulative frequency distribution. Each value in this table is the 90th percentile concentration from the associated distribution.

¹ Groundwater evaluation criteria.

² Surficial groundwater.

³ TDS is calculated as the sum of 90th-percentile alkalinity, calcium, magnesium, sodium, potassium, chloride, sulfate, and fluoride using the formula provided in PolyMet (2013i, section 6.2.6.2).

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Table 5.2.2-23 *Maximum Relative Groundwater Concentration Change (NorthMet Project Proposed Action/Continuation of Existing Conditions Scenario, Maximum 90th Percentile values) for Mine Site Surficial Flowpaths¹*

Parameter	Units	East Pit-Category 2/3 Flowpath at the Property Boundary ²	East Pit-Category 2/3 Flowpath at the Partridge River	Overburden Storage and Laydown Area Flowpath at the Property Boundary ²	Overburden Storage and Laydown Area Flowpath at the Partridge River	Ore Surge Pile Flowpath at the Partridge River ²	WWTF Flowpath at the Property Boundary ²	WWTF Flowpath at the Partridge River	West Pit (Surficial) Flowpath at the Property Boundary ²	West Pit (Surficial) Flowpath at the Partridge River
General										
Alkalinity	Unitless	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Calcium	Unitless	1.6	1.3	1.0	1.0	1.0	1.0	1.0	2.0	1.7
Chloride	Unitless	6.4	4.3	5.3	2.4	1.0	1.0	1.0	11.4	8.5
Fluoride	Unitless	2.1	1.7	5.6	2.4	1.0	1.0	1.0	2.3	1.9
Hardness	Unitless	1.5	1.2	1.0	1.0	1.0	1.0	1.0	2.1	1.7
Magnesium	Unitless	1.3	1.1	1.0	1.0	1.0	1.0	1.0	2.2	1.8
Potassium	Unitless	3.2	2.4	1.4	1.1	1.0	1.0	1.0	3.9	3.1
Sodium	Unitless	3.3	2.4	2.9	1.5	1.0	1.0	1.0	4.5	3.5
Sulfate	Unitless	2.7	2.0	3.4	1.8	1.0	1.0	1.0	3.9	3.1
Metals										
Aluminum	Unitless	5.2	2.6	2.1	1.3	1.2	1.3	1.2	1.0	1.0
Antimony	Unitless	1.4	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0
Arsenic	Unitless	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Barium	Unitless	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Beryllium	Unitless	1.3	1.2	1.2	1.0	1.0	1.0	1.0	2.0	1.7
Boron	Unitless	1.3	1.2	3.2	1.8	1.0	1.0	1.0	2.4	2.0
Cadmium	Unitless	7.3	4.9	1.0	1.0	1.0	1.1	1.1	16.9	12.4
Chromium	Unitless	1.2	1.1	1.0	1.0	1.0	1.0	1.0	2.5	2.1
Cobalt	Unitless	11.9	7.6	1.0	1.0	1.7	1.9	1.7	27.9	19.9
Copper	Unitless	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Iron	Unitless	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Lead	Unitless	1.2	1.1	1.0	1.0	1.0	1.0	1.0	5.4	4.1
Manganese	Unitless	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Nickel	Unitless	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Selenium	Unitless	2.0	1.6	1.1	1.0	1.0	1.0	1.0	3.3	2.6
Silver	Unitless	1.2	1.1	3.6	1.8	1.0	1.0	1.0	1.3	1.2
Thallium	Unitless	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Vanadium	Unitless	1.2	1.1	1.0	1.0	1.0	1.0	1.0	1.8	1.6
Zinc	Unitless	9.3	6.2	1.0	1.0	1.0	1.1	1.1	21.1	15.5

¹ Source: Barr 2013f.

² Evaluation location.

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Effects on Bedrock Groundwater Quality

At the Mine Site, the only mine-related solute sources to bedrock groundwater are flooded backfill in the East Pit, ponded water in the West Pit, and seepage from the Category 1 Stockpile that flows into the West Pit.

Predicted water quality in the bedrock was reviewed, but the solute load had not yet reached the evaluation locations at the end of the 200-year model run because the estimated travel time for groundwater between the mine pits and the bedrock evaluation locations was so long (i.e., over 1,000 years). The effect of the NorthMet Project Proposed Action on bedrock groundwater is considered negligible because groundwater contribution to bedrock from the pits is predicted to be very small (less than 1 gpm from the East Pit and less than 1 gpm from the West Pit) and the contaminant load would be relatively low and would be expected to improve over time as the water quality in the pits improved.

Saline Groundwater

Saline groundwater is known to occur in bedrock across the Canadian Shield (Fritz and Frapre 1987; Morton and Ameal 1985). In general, the potential for encountering saline water increases with depth, such that briny groundwater (defined as TDS greater than 35,000 mg/L) may be nearly ubiquitous in bedrock at depths greater than approximately 3,000 ft throughout the Lake Superior Basin in northeastern Minnesota (Morton and Ameal 1985), including the Duluth Complex (Rouleau et al. 2003; Bottomley 1996). Brackish to saline groundwater is encountered sporadically in deep (greater than 1,000 ft) bedrock wells in northeastern Minnesota and on the Keweenaw Peninsula and in shallow (less than 300 ft) bedrock wells near Lake Superior (Morton and Ameal 1985). This elevated salinity at depth does not appear to be caused by the bedrock itself, as studies have found no particular relationship with rock type (Morton and Ameal 1985). One study concluded that these “brines” were likely formed by the evaporation of seawater during Devonian time about 359 to 419 million years ago (Bottomley 1996).

The concern for the NorthMet Project Proposed Action is whether excavation of the East Pit and West Pit could penetrate zones of saline or briny groundwater or otherwise draw these waters to the surface, thereby increasing the salinity of the West Pit water, which is proposed for treatment at the WWTF.

The closest wells to the NorthMet Project area that are known to have encountered saline groundwater are located 3.2 miles to the northeast of the East Pit at the former AMAX test shaft at depths of approximately 1,200 to 1,400 ft bgs (Barr 2012v). The maximum depths of the East Pit and West Pit, however, are approximately 630 and 696 ft bgs (elevations 800 to 900 ft amsl), respectively, and about 500 ft above the elevation where saline water was observed (i.e., elevations 200 to 400 ft amsl).

Bedrock groundwater sampling from the Mine Site also suggests that the pit excavations would not encounter saline groundwater. Sampling from two exploratory boreholes, a water supply well, and nine groundwater monitoring wells drilled at the Mine Site found a maximum chloride concentration of 15.7 mg/L (excluding a value of 93.1 mg/L from the initial sampling at Observation Well-3, where the maximum value detected in subsequent monitoring was 0.81 mg/L) (Barr 2012v).

Despite the absence of brine in current wells, the excavation and dewatering of the mine pits would likely draw water up from deeper bedrock below the pits, which could contain elevated chloride concentrations. Bedrock conductivity, however, is much lower than the surficial aquifer, and hydraulic analyses indicate that groundwater inflow to the West Pit would be dominated by water from the surficial aquifer, which is predicted to comprise 83 percent of groundwater inflow at end of mining and increase to 96 percent of inflow as the lake floods (PolyMet 2013i, Table 1-22b).

Regionally, the Federal Hardrock Mineral Prospecting Permits Project ROD recognizes this as a potential risk from exploration drilling (USFS 2012b), noting the possibility that “exploratory drilling could cause pockets of brackish (i.e., salty) groundwater to reach freshwater supplying drinking water wells.” This ROD concluded, in consultation with the MDH, that “this scenario is considered unlikely,” but “that the risk is not zero” (USFS 2012b).

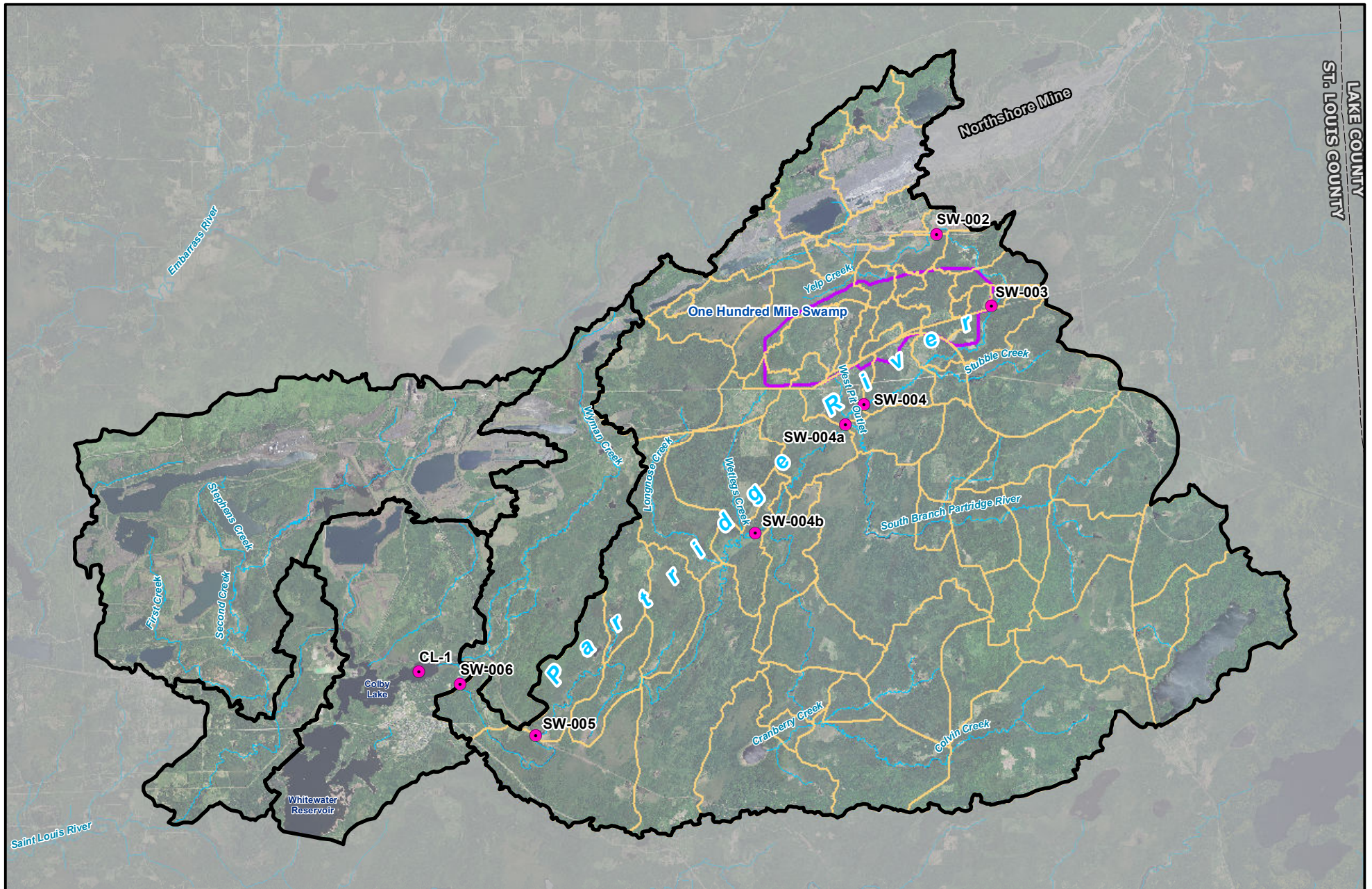
Given that bedrock groundwater monitoring from 12 wells ranging down to 600 ft bgs at the Mine Site did not reveal any elevated chloride concentrations, that the nearest known occurrence of saline water is 3.2 miles from the Mine Site, and that the proposed pit floors would be about 500 ft above the elevation where saline water is known to occur, the risk of encountering saline water is considered low. If encountered, bedrock groundwater inflow to the pits would only be a small component of total pit inflow, so any saline water would be quickly diluted. In addition, any groundwater inflow to the pit during construction would be collected as part of pit dewatering and pumped to the WWTF for treatment. Finally, the chances of a perpetual elevated saline condition is considered small because the pits would flood in closure, producing hydraulic head that inhibits groundwater upwelling.

Effects on Surface Water Hydrology in the Partridge River Watershed

This section describes the effects of the NorthMet Project Proposed Action on the surface water hydrology of the Partridge River and its tributaries (see Figure 5.2.2-22). The NorthMet Project Proposed Action could affect flows in the Partridge River and its tributaries by changing drainage areas (e.g., alteration or reduction in watershed area), reducing groundwater baseflow contributions during the dewatering and flooding of the East Pit and West Pit (i.e., years 1 to 40), and withdrawing water from Colby Lake occasionally for use as makeup water at the processing plant during operations (i.e., years 1 to 20) and for Embarrass River tributary streamflow augmentation during reclamation (i.e., years 20 to 40). Each of these potential effects is discussed below.

Changes in Drainage Area

The NorthMet Project Proposed Action would result in changes to drainage areas in some locations that would, in turn, affect streamflows. These changes would primarily include the capture and retention of contact water at the Mine Site and ultimately the use of this water to flood the mine pits. During mine operations and reclamation, surface water runoff from much of the Mine Site would be retained until the West Pit floods. Some of these changes in drainage area would only be temporary. This effective reduction in drainage area by the NorthMet Project Proposed Action would reduce both surface runoff (the major streamflow component) and surficial groundwater flow reaching the Partridge River. Table 5.2.2-24 shows the total watershed area and percent watershed area reduction at each surface water evaluation location for selected time periods.



- Model Evaluation Locations
- Partridge River Watersheds
- Upper Partridge River Subwatersheds
- Mine Site
- ~~~~~ Stream/River

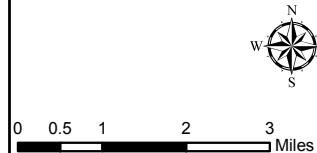


Figure 5.2.2-22
Partridge River Subwatersheds and
Surface Water Evaluation Locations
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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Table 5.2.2-24 Total Watershed Area (acres) and Percent Watershed Area Reduction for the Partridge River Resulting from the NorthMet Project Proposed Action

Location/ Year	SW-001 ⁽¹⁾	SW-002	SW-003	SW-004	SW-004a	SW-004b	SW-005	SW-006	Colby Lake
Year Zero ²	670	4,508	5,550	10,566	30,557	45,665	59,065	62,056	74,636
Year 11	670 0%	4,264 5.4%	5,301 4.5%	9,907 6.2%	29,041 5.0%	44,149 3.3%	57,549 2.6%	60,540 2.4%	73,120 2.0%
Year 20	670 0%	4,484 0.5%	5,521 0.5%	10,126 0.4%	29,504 3.4%	44,612 2.3%	58,012 1.8%	61,003 1.7%	73,583 1.4%
Year 40, Long term	670 0%	4,462 1.0%	5,504 0.8%	10,397 1.6%	29,903 2.1%	45,011 1.4%	58,411 1.1%	61,402 1.1%	73,982 0.9%

Source: Barr 2013a.

¹ Station SW-001 is upstream from the NorthMet Project area, and is thus unaffected by the NorthMet Project Proposed Action. Data from this station is used in the hydraulic modeling, but this SDEIS does not estimate water quality at this station.

² Year zero is also representative of the Continuation of Existing Conditions Scenario.

The maximum watershed area reduction for any modeled location along the Partridge River would be 6.2 percent at SW-004, during year 11 of operations. A maximum long-term watershed area reduction of 2.1 percent would occur at SW-004a. Other years during operation were not tabulated because they would be less than those occurring during year 11.

These proposed modifications to drainage areas were taken into consideration in the XP-SWMM modeling and are not expected to be significant.

XP-SWMM Modeling Results for the Partridge River

The water resources evaluation criteria (see Section 5.2.2.1) established 28 flow parameters, known as Richter Statistics, to be evaluated for the Partridge River. Section 5.2.2.1.6 discusses these parameters. The XP-SWMM model was run for the NorthMet Project Proposed Action and the Continuation of Existing Conditions scenarios for several selected years during operations while the West Pit would be flooding, and over the long term, to determine the changes to each parameter at each stream location. Given the relatively small watershed area changes (watershed area reductions would approximate flow reductions), only selected modeling results are presented here to demonstrate the range of potential hydrologic effects. Effects on Colby Lake were not evaluated with the XP-SWMM model; water level changes to Colby Lake and Whitewater Reservoir are addressed in a subsequent section. Table 5.2.2-25 summarizes the XP-SWMM results for selected flow parameters and stream locations.

Table 5.2.2-25 Modeled Percent Change in Selected Streamflow Parameters at Selected Locations in the Partridge River

Location/Flow Parameter	SW-002		SW-004		SW-004a		SW-006	
	Year 11	Long Term	Year 11	Long Term	Year 11	Long Term	Year 11	Long Term
Average Annual Flow	-4.9%	NC	-4.3%	NC	-4.4%	+1.0%	-1.7%	NC
Average Feb. Flow	-5.3%	NC	-4.5%	NC	-4.5%	6.5%	-1.8%	+3.7%
Average April Flow	-5.3%	NC	-4.7%	NC	-4.5%	NC	-2.0%	NC
Annual Max 3-day Flow	-4.6%	NC	-2.8%	-2.6%	-3.5%	NC	-2.1%	NC
Annual Min 3-day Flow	-6.7%	NC	-7.4%	-2.7%	-7.9%	+38.1%	-3.4%	+15.4%
Average 30-day Low Flow	-5.7%	-1.4%	-6.7%	-2.3%	-6.1%	+21.9%	-2.6%	+9.3%
Mean Duration of High Pulses	-1.8%	-1.8%	-2.4%	-1.6%	-2.9%	-2%	-1.3%	-1.3%
Mean Duration of Low Pulses	NC	NC	+3.2%	NC	NC	NC	-5.9%	-6.9%

Source: Barr 2012g.

NC: Indicates modeled change less than 1 percent.

It is apparent from Table 5.2.2-25 that virtually all effects on streamflow during the year of maximum watershed reduction (year 11) would be in the form in streamflow reductions. The largest modeled effect, about an 8 percent reduction, would occur during low-flow conditions. After the West Pit is filled with water, discharge from the WWTF to the West Pit Outlet Creek would more than compensate for the reduced low flows at some locations. The maximum modeled effect is at location SW-004a, just downstream of where the WWTF discharge would enter the Partridge River. Here, the annual minimum 3-day flow and average annual 30-day low flow would increase by about 38 and 22 percent, respectively. Although these percent increases would be relatively large compared to other alterations, the actual flow increases would be only 0.6 cfs. The NorthMet Project Proposed Action would have little effect on high flows, as evidenced by no change in the average April flow and the annual maximum 3-day flow.

Changes in hydrology can affect stream geomorphology. PolyMet conducted a Level I Geomorphic Survey of the Partridge River from its headwaters to Colby Lake (Barr 2005) to determine the stability of the river under existing conditions, evaluate its sensitivity to hydrologic change, and indicate how restoration may be approached if a portion of the stream becomes unstable. The Geomorphic Survey found the Upper Partridge River to be stable, with no evidence of erosion except in its headwaters (see Figure 4.2.2-8). Because its steep reaches are well-armored and the flatter reaches tend to have well-vegetated shorelines, the Partridge River is considered to be a robust stream. As indicated in Table 5.2.2-25, the NorthMet Project Proposed Action would reduce flow in the Upper Partridge River during mine operations by between 0 to 8 percent depending on evaluation location, with less of an effect (0 to 5 percent) on higher flows. Flows would return to nearly pre-NorthMet Project Proposed Action conditions during closure.

Considering that the Geomorphic Survey found the Upper Partridge River to be stable, that the NorthMet Project Proposed Action would not directly disturb the river banks, that large flows

(e.g., bankful flows, which are especially important in shaping geomorphic processes) would only be reduced by a maximum of 5 percent during operations (i.e., within the range of natural variability), and that streamflows would return to nearly pre-NorthMet Project Proposed Action conditions in closure, no erosion or significant geomorphic changes are expected in the Upper Partridge River.

Effects on the Hydrology of the Partridge River Tributary Streams

The NorthMet Project Proposed Action is not expected to have any measureable effects on surface water hydrology of the tributary streams along the Transportation and Utility Corridor. Baseline flow data collection and monitoring of the Partridge River tributary streams would be conducted for permitting.

Flow in the West Pit Outlet Creek would be modified, as it would incur reduced flows during operations as a result of the mine pits interrupting groundwater flow. Around year 40, when the West Pit is predicted to flood, the overflow would be collected, routed to the WWTF, and then discharged to the West Pit Outlet Creek. The XP-SWMM model estimates an average annual flow of 1.2 cfs at the approximate location of the WWTF discharge under existing conditions. The estimated average annual flow at this location in long-term closure is increased to 1.4 cfs (due to changes in upstream watershed areas and the addition of the WWTF discharge). The estimated 1-day maximum flow for the West Pit Outlet Creek at the location of the WWTF discharge is 24.1 cfs based on the XP-SWMM model results.

A geomorphic survey of the West Pit Outlet Creek between Dunka Road and the Partridge River found no evidence of erosion, downcutting, or channel widening. Baseflow was very low during the survey (November) and flow is expected to be more snowmelt and storm driven. The survey concluded that because the creek has a well-developed floodplain and substantial and continuous bank vegetation, it would be tolerant to moderate changes in hydrology (Barr 2013). As indicated above, the estimated change in flow is small (0.2 cfs), especially when considering the estimated 1-day flow is approximately 24 cfs. Therefore, a discharge of approximately 1.2 cfs should not result in any geomorphic effects on the creek.

Effects on Colby Lake and Whitewater Reservoir Water Levels

The effect of the NorthMet Project Proposed Action on water levels in Colby Lake is related to any changes in Partridge River inflow, as well as water withdrawals to provide water for process water makeup and Embarrass River tributary streamflow augmentation (see Section 5.2.2.3.3 for additional details regarding the proposed flow augmentation program).

The XP-SWMM modeling for SW-006, just upstream of Colby Lake, shows minor reductions in Partridge River low flows (i.e., 3 percent reduction in the 30-day low flow, which is equivalent to about a 0.15 cfs reduction). On an annual average basis, inflow to Colby Lake would be reduced a maximum of less than 2 percent, or about 1 cfs. Over the long term, inflow to Colby Lake would be increased about 0.5 cfs.

NorthMet Project Proposed Action makeup water demand from Colby Lake, including water pumped for augmentation to the Embarrass River tributary streams, would be a maximum average annual demand of about 2,030 gpm (4.5 cfs) during operations (for both process makeup water and stream augmentation) and about 1,600 gpm (3.6 cfs) during reclamation (all for stream augmentation); no water would be needed from Colby Lake during closure.

Therefore, the maximum combined effect of Partridge River flow reduction, plus pumping from Colby Lake for makeup water and flow augmentation, would be about 2,500 gpm (about 5.5 cfs). The NorthMet Project DEIS (October 2009) evaluated two potential Colby Lake withdrawal rates, 3,500 gpm and 5,000 gpm, for a previous NorthMet Project design. The model assumed transfer of water from Whitewater Reservoir in order to maintain water levels above the critical outflow elevation of 1,439 ft at all times in Colby Lake, which is required under MDNR Water Appropriation Permit 1949-0135.

At 3,500 gpm withdrawal and average flow conditions, the average Colby Lake drawdown was modeled at 0.03 ft, with an average annual water level fluctuation of about 3.6 ft, compared to 3.9 ft for zero withdrawal. Whitewater Reservoir would also be affected by water withdrawals, as it is used to help maintain water levels in Colby Lake. Under this 3,500 gpm withdrawal and average flow conditions scenario, drawdown on Whitewater Reservoir was predicted to be about 0.4 ft with a maximum annual fluctuation of about 4.2 ft, compared to about 2.9 ft for zero withdrawal. Environmental consequences of the drawdown on wetlands and aquatic resources are discussed in Sections 5.2.3 and 5.2.6, respectively.

It is reasonable to assume that the effects of PolyMet's proposed withdrawal of less than 3,500 gpm would be no worse on Colby Lake and Whitewater Reservoir water levels than this modeled 3,500 gpm withdrawal. These anticipated effects on water levels are well within the range experienced during the former LTVSMC taconite mining operations.

Effects on the Hydrology of the Lower Partridge River

Existing flow conditions in the Lower Partridge River can be estimated by examining the flow record (i.e., 1942 to 1982) at USGS gaging station 04016000, which was located approximately 1.5 miles downstream of Colby Lake. Historic hydrologic alterations to Partridge River watershed area caused by former LTVSMC operations are likely present in the USGS flow data, while alterations from the present Mesabi Nugget operations are not considered. Notwithstanding these effects, the historic flow records can be used to provide a reasonable estimate of NorthMet Project Proposed Action effects on the Lower Partridge River.

The record shows average monthly flows varying from about 17 cfs during January to about 333 cfs during April, with an average annual flow of about 112 cfs. As described above, the maximum effect of the NorthMet Project Proposed Action on streamflow into Colby Lake would be a net reduction in flow of about 5.5 cfs during operations, which would represent about a 5 percent decrease in the average annual flow at the gage site. The 5.5 cfs withdrawal cannot simply be subtracted from each month to estimate effects on low or high flows because of required transfer of water from Whitewater Reservoir when Colby Lake drops to elevation 1,439.0. Given this requirement to supplement low flows by transferring water from the reservoir, it is expected that effects on low flows at the gage station would be negligible. Effects on high flows would be less than on average flows, and would proportionately diminish as the flow increases. It should be noted that high flows downstream of Colby Lake would also be substantially reduced because of water transfers to the reservoir during high runoff periods, which reflects existing operating procedures. Therefore, the NorthMet Project Proposed Action is expected to have negligible effects on flow in the Lower Partridge River. It should be noted that during closure, once the West Pit floods, the hydrology of the Partridge River is expected to return to relatively normal conditions with a small net increase in flow of 0.5 cfs predicted.

Effects on the Hydrology of Second Creek

Second Creek is the only Lower Partridge River tributary stream that could be significantly affected by the NorthMet Project Proposed Action. Historically, seepage from the south side of the Tailings Basin entered the headwaters of Second Creek. In July 2011, a seepage collection system was installed, which returned most of the south-side seepage to the Tailings Pond and essentially eliminated the flow of Tailings Basin seepage into Second Creek. Under the NorthMet Project Proposed Action, seepage collection would continue indefinitely, capturing approximately 180 gpm, which would be pumped to the WWTP. As part of its streamflow augmentation plan (PolyMet 2013j), PolyMet would discharge a combination of WWTP effluent and/or Colby Lake water to the headwaters of Second Creek at a rate equal to a minimum of 80 percent of the capture flow rate, or at least 145 gpm, to compensate for interception of the south-side seepage. The effects of the NorthMet Project Proposed Action on Second Creek streamflow would be minimal.

Effects on Surface Water Quality

The NorthMet Project Proposed Action would affect the water quality of the Partridge River and its tributaries that drain the Mine Site, Transportation and Utility Corridor, and the processing plant area. PolyMet proposes to treat, reuse, and recycle water, resulting in no direct surface water discharges to the Partridge River until the West Pit were to overflow in approximately year 40, except for flow augmentation at Second Creek. Nevertheless, several potential pathways for surface water quality effects remain, including domestic wastewater, non-contact stormwater runoff, seepage from waste rock stockpiles and the pits, WWTF effluent after the West Pit fills, and stream augmentation flows into the headwaters of Second Creek near the processing plant area.

PolyMet proposes to manage domestic wastewater by providing portable facilities serviced by a supplier at the Mine Site and continuing use of existing septic systems at various buildings at the Plant Site (e.g., Administration Building, Area 1 and 2 shops, Tailings Basin Reporting Building). These portable facilities and septic systems would be designed to adequately manage the domestic wastewater requirements of the NorthMet Project Proposed Action, so this potential contaminant source is not discussed further.

The other predicted effects of the NorthMet Project Proposed Action on surface water quality in the Upper Partridge River, Colby Lake, and the Lower Partridge River are discussed below.

Effects on the Upper Partridge River

Water quality in the Upper Partridge River (upstream of Colby Lake) is already affected by discharges from the Northshore Mine. As mentioned above, PolyMet does not propose any surface water discharges to the Upper Partridge River until the West Pit floods around year 40. However, non-contact stormwater runoff, unrecoverable groundwater seepage from the five groundwater flowpaths (i.e., from the waste rock stockpiles, pits, Ore Surge Pile, WWTF, and Overburden Storage and Laydown Area), and the WWTF discharge would all serve as potential contaminant sources to the Upper Partridge River. Each of these potential contaminant sources is discussed below and then the predicted overall effect of these sources on water quality in the Upper Partridge River is evaluated.

Non-contact Stormwater Runoff

PolyMet proposes to collect non-contact stormwater runoff from undisturbed and reclaimed vegetated areas within the Mine Site and route it to the Partridge River via existing drainage patterns to the extent possible. Stormwater quality is not expected to differ significantly from existing conditions because it would not contact any reactive rock, but there would be the potential for increased suspended solids. PolyMet would provide sedimentation ponds at the outlet locations to manage suspended solids prior to discharge to surface waterbodies (see Figures 3.2-5, 3.2-6, 3.2-7, and 3.2-8). These sedimentation ponds should be adequate to manage suspended solids, but monitoring of the discharge is recommended as part of any NPDES/SDS permit (see Section 4.1.3.5 for a discussion of recommended monitoring measures).

Unrecovered Groundwater Seepage from Liner Leakage and Pit Seepage

The WWTF equalization basins, Ore Surge Pile, Category 2/3 Stockpile, and Category 4 Stockpile would all have compacted soil and geomembrane liners. Percolating water above the liner would be collected and pumped to the WWTF for treatment.

Some water is predicted to leak through the liners as a result of tears or defects in the geomembrane liners and this effect is included in the GoldSim model. The quantity of water leaking through the liners is determined by the liner design and effectiveness. The Hydrologic Evaluation of Landfill Performance model was used to help estimate liner leakage, including the use of uncertainty analysis for three key input variables (i.e., liner slope, subgrade permeability, and frequency of liner defects) (PolyMet 2013i).

The proposed liner system should be able to be installed in accordance with the proposed design if rigorous quality control measures are used in accordance with industry standards. Current construction practices and improvements in electrical leak detection surveys should be able to achieve the proposed design criteria (i.e., defects/acre, overliner slope, and subgrade permeability). Concerns regarding geomembrane liners primarily relate to the potential for differential settlement to cause tears and for it to degrade over time. These concerns are ameliorated, to a large extent, by the fact that all of the proposed liner systems would be temporary. The Ore Surge Pile and Category 2/3 and 4 stockpiles would be removed, including the liners, by year 20. The WWTF equalization basins would remain in use while the East Pit is being treated in closure until approximately year 35.

During reclamation and closure, small volumes of water are predicted to flow from the pits into the downgradient surficial groundwater. These untreated pit releases would include East Pit backfill pore water into the East Pit Category 2/3 Surficial Flowpath (beginning year 21) and West Pit lake water into the West Pit Surficial Flowpath (beginning year 33). These releases to surficial groundwater would continue in perpetuity. Groundwater in these flowpaths would flow downgradient and eventually reach the Partridge River.

Liner leakage from the Overburden Storage and Laydown Area, WWTF, Ore Surge Pile, and Category 2/3 Stockpile would also follow groundwater flowpaths that eventually reach the Partridge River, but would only be temporary sources. The leakage/seepage flow rates associated with these solute sources are generally low and are summarized in Table 5.2.2-26. For P50 inputs, depending on the flowpath, the initial concentration change in groundwater discharging to the Partridge River would occur at 17 to 110 years after the start of mining, and peak concentrations would occur in the range of 55 to 175 years (see Table 5.2.2-21). After peak

concentrations were achieved, the groundwater concentrations would gradually decrease over many tens to hundreds of years. Note that for the Overburden Storage and Laydown Area flowpath, most solutes would experience a decrease in concentration downgradient of the source. In summary, the contribution of solutes to the Partridge River from these groundwater seepage sources would vary considerably over time.

Table 5.2.2-26 Pit Outflow and Liner/Equalization Basin Leakage into Groundwater Flowpaths (Based on GoldSim Deterministic Run with P50 Inputs)

Contaminant Source	Flow Rate (gpm)	Duration of Source (Mine Years)	Mine Year when Solute Plume First Arrives at Partridge River
East Pit	3.75 ⁽¹⁾	21+	110
Category 2/3 Stockpile	0.0194	0-20	30
Ore Surge Pile	0.00116	0-21	90
WWTF Equalization Basins	0.0135	0-35	95
Overburden Storage and Laydown Area	14.0	0-20	17 ⁽²⁾
West Pit	6.09 ⁽¹⁾	33+	90

¹ Pit water into groundwater flowpath.

² Concentration decrease.

Category 1 Stockpile Seepage

The Category 1 Stockpile would have a permanent cover consisting of a geomembrane overlain by a compacted soil and growth medium, which would be installed progressively during operations and reclamation. During closure, the total seepage rate from the stockpile is estimated to be about 3 gpm. About 2.7 gpm of this seepage would be collected by the surrounding groundwater containment system and sent to the WWTF for treatment. About 0.3 gpm would pass below the containment system and migrate as groundwater into the West Pit. None of the seepage would flow directly into any of the surficial flowpaths.

Wastewater Treatment Facility Discharges

PolyMet proposes a WWTF at the Mine Site to treat affected water from the sources summarized in Table 5.2.2-27. This table presents the estimated average Mine Site process water flow rates by source for the WWTF's design year (i.e., maximum annual average flow year, which are years 14, 25, and 75 for operations, reclamation, and closure, respectively). Details regarding some of these WWTF influent sources are discussed below. The process water at the Mine Site would be combined into three waste streams for treatment at the WWTF. Construction water would be treated in a construction water stream and would only be needed through approximately year 11. Process water containing relatively high levels of metals and sulfate (drainage from the temporary Category 2/3 Stockpile and Category 4 Stockpile liners and the temporary Ore Surge Pile liner) would be stored in the West Equalization Basin and routed to the chemical precipitation treatment train. Process water containing relatively low concentrations of metals and sulfate (drainage from haul roads, the Rail Transfer Hopper, pit dewatering, and Category 1 Stockpile drainage) would be stored in the East Equalization Basin and routed to the membrane filtration treatment train. The WWTF effluent would flow by gravity to the Central Pumping Station pond to be blended with the Overburden Storage and Laydown Area runoff prior to being pumped through the Treated Water Pipeline for use at the Tailings Basin or used to

supplement flooding of the East Pit after approximately year 11 (PolyMet 2013e). Table 5.2.2-27 presents the estimated average Mine Site process water flow rates by source for the WWTF's design year (i.e., maximum annual average flow year, which are years 14, 25, and 75 for operations, reclamation, and closure, respectively).

Table 5.2.2-27 Mine Site Process Water Flows to the Wastewater Treatment Facility

Source	90 th Percentile Estimated Average Annual Flow (gpm)		
	Operations ²	Reclamation ³	Closure ⁴
East Pit	420	1,750 ⁽⁵⁾	--
Central Pit	60	--	--
West Pit	390	--	400 ⁽⁶⁾
Haul Roads and Rail Transfer Hopper	65	--	--
Category 1 Stockpile	385	10	n/a
Category 2/3 Stockpile	145	--	--
Ore Surge Pile	25	--	--
Category 4 Stockpile	0	--	--
WWTP Reject Concentrate	150	175	--
Total ¹	1,550	1,925	400

Source: PolyMet 2013g, Table 2-1.

¹ Flows are rounded to the nearest 5 gpm; column values do not sum to 90th percentile total value due to probabilistic modeling (P90 of totals is not equivalent to the total of the P90s).

² Estimates based on Reference (3) for year 14 (Design Year), 90th Percentile.

³ Estimates based on Reference (3) for year 25, 90th Percentile.

⁴ Estimates based on Reference (3) for year 75, 90th Percentile.

⁵ Flow value is total of East Pit and Central Pit.

⁶ Includes flow from Category 1 Stockpile.

Actual flow rates would vary both daily and seasonally throughout the 20 years of mine operations. Peak influent flows to the WWTF are anticipated to occur during spring snowmelt. Because influent flow rates to the WWTF would vary significantly over the life of the NorthMet Project Proposed Action and within any given year, the WWTF design includes two equalization basins that would store influent when flows exceed the WWTF's treatment capacity. The WWTF equalization basins are designed for the spring snowmelt, when the Mine Site would be at its maximum area. In the event of an extreme event (e.g., 100-year storm), excess water would remain in the mine pits, which essentially have unlimited storage capacity, with mine operations in the pits temporarily shut down (see Mine Site Water Management Plan). Even during an extreme event, no untreated water would be discharged to a natural water body.

The WWTF design for operations and reclamation includes chemical precipitation and membrane filtration. During mine operations, the treated effluent from the WWTF would be mixed with the runoff collected from the Overburden Storage and Laydown Area in the Central Pumping Station pond, where it is pumped either to the Tailings Basin pond (for reuse as process water at the Beneficiation Plant) or to help flood the East Pit (after mining would be completed in year 11). During mine reclamation, the WWTF is primarily used to treat the East Pit water to reduce the load from the backfilled waste rock, and the effluent is primarily returned to the East Pit.

During mine closure, the WWTF is primarily used to treat water from Category 1 Stockpile drainage and the flooded West Pit water. Since the West Pit would now be flooded, the WWTF would begin in closure to discharge effluent to the West Pit Outlet Creek, a natural water body intermittent stream that flows to the Partridge River just upstream of SW-004a. The treated effluent would need to meet applicable water quality standards. During long-term closure, the existing WWTF membrane system would be converted from a nano-filtration system to an RO system with an evaporator/spray dryer, or equivalent unit.

Table 5.2.2-28 presents the target WWTF effluent concentrations for the different mine phases. Pilot-testing of a WWTF with RO demonstrated that all of the target closure effluent concentrations could be achieved with the planned WWTF design (Barr 2013g).

Table 5.2.2-28 Wastewater Treatment Facility Preliminary Water Quality Targets

Parameter ¹	Targets			Basis
	Operations	Reclamation	Long-term Closure	
Metals/Inorganics (µg/L, except where noted)				
Aluminum	125	125	125	M.R. ⁽⁴⁾ 7050.0222 Class 2B (chronic standard)
Antimony	31	31	31	M.R. ⁽⁴⁾ 7050.0222 Class 2B (chronic standard)
Arsenic	10	10	10	Federal Standard (pMCLs)
Barium	2000	2000	2000	Minn. Groundwater (HRL, HBV ⁵ , or RAA)
Beryllium	4	4	4	Federal Standard (pMCLs)
Boron	500	500	500	M.R. ⁽⁴⁾ 7050.0224 Class 4A (chronic standard)
Cadmium ³	5.1	4.2	2.5	M.R. ⁽⁴⁾ 7052.0100 Class 2B (chronic standard)
Chromium ²	11	11	11	M.R. ⁽⁴⁾ 7052.0100 Class 2B (chronic standard)
Cobalt	5	5	5	M.R. ⁽⁴⁾ 7050.0222 Class 2B (chronic standard)
Copper ³	20	17	9.3	M.R. ⁽⁴⁾ 7052.0100 Class 2B (chronic standard)
Iron	300	300	300	Federal Standard (sMCLs)
Lead ³	10.2	7.7	3.2	M.R. ⁽⁴⁾ 7050.0222 Class 2B (chronic standard)
Manganese	50	50	50	Federal Standard (sMCLs)
Nickel ³	113	94	52	M.R. ⁽⁴⁾ 7052.0100 Class 2B (chronic standard)
Selenium	5	5	5	M.R. ⁽⁴⁾ 7052.0100 Class 2B (chronic standard)
Silver	1	1	1	M.R. ⁽⁴⁾ 7050.0222 Class 2B (chronic standard)
Thallium	0.56	0.56	0.56	M.R. ⁽⁴⁾ 7050.0222 Class 2B (chronic standard)
Zinc ³	260	216	120	M.R. ⁽⁴⁾ 7050.0222 Class 2B (chronic standard)
General Parameters (mg/L, except where noted)				
Chloride (mg/L)	230	230	230	M.R. 7050.0222 Class 2B (chronic standard)
Fluoride (mg/L)	2	2	2	Federal Standard (sMCLs)
Hardness (mg/L)	250	200	100	M.R. ⁽⁴⁾ 7050.0100 Class 2B (chronic standard)
Sodium	60% of cations	60% of cations	60% of cations	M.R. ⁽⁴⁾ 7050.0224 Class 4A (chronic standard)
Sulfate (mg/L)	250	150	9	Operations: Federal Standard (sMCLs) Long-term closure: M.R. 7050.0224 Class 4A

Source: PolyMet 2013g, Table 2-3; Barr 2013g, Table 3.

¹ The Process Water Quality Targets parameter list has been updated from RS29T to include only the parameters modeled in GoldSim.

² The Chromium (+6) standard of 11 µg/L is used rather than the total Chromium standard to be conservative.

³ Standard based on hardness.

⁴ *Minnesota Rules*.

⁵ Health-Based Value.

Comparison of Contaminant Sources

The GoldSim model enables the identification of “culpability,” or the relative contribution of various contaminant sources to the overall contaminant load at a specific evaluation location. Table 5.2.2-29 presents an illustrative example of the culpability analysis using two representative solutes of interest (copper and sulfate) at evaluation location SW004a during representative years for operations, reclamation, and closure periods. The culpability identifies 12 sources of copper and sulfate at this evaluation location. In addition to the nine NorthMet Project Proposed Action-related sources (i.e., five surficial aquifer flowpaths, three bedrock flowpaths, and the WWTF discharge), three non-NorthMet Project Proposed Action-related sources are identified (i.e., background groundwater, background surface water, and the Northshore Mine discharge).

Table 5.2.2-29 Culpability Analysis Using Copper and Sulfate at SW-004a

Contaminant Source	Copper Load (% of total)			Sulfate Load (% of total)		
	Operations Year 12	Reclaim Year 25	Closure Year 200	Operations Year 12	Reclaim Year 25	Closure Year 200
Background Groundwater	35.8%	37.2%	27.2%	16.2%	17.3%	15.7%
Non-contact Stormwater	52.6%	50.9%	39.1%	65.5%	63.5%	62.0%
Northshore Dewatering	9.2%	9.4%	6.8%	17.2%	18.1%	16.2%
East Pit Category 2/3 Surficial GW Flowpath ⁽¹⁾	1.1%	1.6%	1.1%	0.5%	0.7%	0.8%
Ore Surge Pile Surficial GW Flowpath ⁽¹⁾	0.2%	0.3%	0.2%	0.1%	0.1%	0.1%
WWTF Surficial GW Flowpath ⁽¹⁾	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%
Overburden Storage and Laydown Area Surficial GW Flowpath ⁽¹⁾	0.9%	0.5%	0.3%	0.4%	0.2%	0.2%
West Pit Surficial GW Flowpath ⁽¹⁾	0.0%	0.0%	0.4%	0.0%	0.0%	0.6%
East Pit Bedrock GW Flowpath	0.0%	~0.0%	~0.0%	0.0%	~0.0%	~0.0%
West Pit Bedrock GW Flowpath (two flowpaths)	0.0%	0.0%	~0.0%	0.0%	0.0%	~0.0%
WWTF discharge	0.0%	0.0%	24.7%	0.0%	0.0%	4.3%

Source: Barr 2013f.

GW = Groundwater.

¹ Includes NorthMet Project Proposed Action-related loading and loading associated with meteoric recharge.

As Table 5.2.2-29 indicates, the primary source of contaminant load for both copper and sulfate at SW-004a for operations, reclamation, and closure phases are the non-NorthMet Project Proposed Action-related sources (background groundwater, surface water, and Northshore Peter Mitchell Pit dewatering, although as a portion of overall copper discharge the WWTF discharge also represents a significant source of copper in closure).

Overall Effects on Upper Partridge River Water Quality

Results of the GoldSim water quality modeling were reviewed for all 28 constituents at all six Upper Partridge River evaluation locations (station SW-001, upstream of SW-002, is used in modeling hydraulic flow, but because it is upstream of the NorthMet Project area, water quality is not predicted at SW-001 and thus it is not an evaluation location [see Figure 5.2.2-1]). A screening process was used to identify any constituents and locations that warranted a more robust examination (see Table 5.2.2-30). The screening process involved comparing the single-highest monthly P90 water quality prediction from among the 2,400 months covered by the simulation (i.e., 12 months times 200 years, herein referred to as the “maximum P90”) for each constituent for each of the six evaluation locations. These NorthMet Project Proposed Action modeled values were compared with both the Continuation of Existing Conditions Scenario modeled values and the evaluation criteria identified in Section 5.2.2.1. If the maximum P90 concentration was near the evaluation criteria, the screening process identified it for further analysis.

Table 5.2.2-30 Mine Site Surface Water – Maximum P90 Solute Concentration Over Entire 200-Year Simulation Period Based on the GoldSim Probabilistic Model

			SW-002		SW-003		SW-004		SW-004a		SW-004b		SW-005 ⁽³⁾		SW-006 ⁽³⁾	
Parameter	Partridge Evaluation Criteria ¹	Units	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario
General																
Alkalinity	NA	mg/L	126.8	126.8	128.2	128.1	128.6	128.6	128.8	128.9	128.8	128.9	128.8	129.0	128.8	129.0
Calcium	NA	mg/L	30.0	30.0	30.0	30.0	30.1	30.1	30.2	30.2	30.2	30.2	30.2	30.2	30.2	30.2
Chloride	230	mg/L	21.8	21.8	22.0	22.0	22.5	22.5	22.8	22.8	22.8	22.9	22.9	23.0	22.9	22.9
Fluoride	NA	mg/L	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Hardness	500	mg/L	118.1	118.1	118.2	118.2	118.4	118.4	118.5	118.6	118.5	118.6	118.6	118.6	118.6	118.6
Magnesium	NA	mg/L	13.5	13.5	13.6	13.5	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7
Potassium	NA	mg/L	3.59	3.59	3.59	3.59	3.61	3.61	3.61	3.63	3.63	3.63	3.63	3.63	3.63	3.63
Sodium	NA	mg/L	17.7	17.7	17.7	17.7	18.0	17.9	18.9	18.2	18.3	18.2	18.3	18.2	18.3	18.2
Sulfate	NA / 10 ⁽²⁾	mg/L	20.9	20.9	20.6	20.6	20.9	19.5	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4
TDS	700	mg/L	183.8	183.8	184.6	184.4	186.2	184.7	186.1	185.5	185.5	185.6	185.6	185.7	185.6	185.6
Metals Total																
Aluminum	125	µg/L	165.4	165.4	165.8	165.6	169.1	168.9	171.7	173.5	173.4	173.7	173.7	173.9	173.7	173.9
Antimony	31	µg/L	1.66	1.66	1.66	1.66	1.66	1.66	3.97	1.67	3.1	1.67	2.27	1.67	2.09	1.67
Arsenic	53	µg/L	5.96	5.96	5.77	5.79	5.17	5.1	5.6	3.91	4.47	2.89	2.88	1.76	2.48	1.52
Barium	NA	µg/L	13.6	13.7	14.5	14.6	18.1	17.8	27.8	25.2	28.4	26.5	26.1	24.3	25.4	23.8
Beryllium	NA	µg/L	0.11	0.11	0.11	0.11	0.12	0.11	0.19	0.12	0.18	0.12	0.15	0.12	0.14	0.12
Boron	500	µg/L	174.5	174.4	175.8	175.6	177.8	177.8	179.6	179.7	180.0	179.9	180.1	180.3	180.3	180.2
Cadmium	1.3 - 2.7 ⁽¹⁾	µg/L	0.12	0.12	0.12	0.12	0.13	0.12	0.61	0.12	0.45	0.12	0.31	0.12	0.27	0.12
Chromium	11	µg/L	1.77	1.77	1.78	1.78	1.84	1.84	1.87	1.86	1.87	1.87	1.87	1.87	1.87	1.87
Cobalt	5	µg/L	0.58	0.58	0.59	0.59	1.1	0.63	2.18	0.74	1.81	0.76	1.37	0.72	1.25	0.71
Copper	4.2 - 10.5 ⁽¹⁾	µg/L	2.02	2.03	2.05	2.07	2.27	2.21	4.28	2.57	3.93	2.64	3.27	2.53	3.13	2.5
Iron	NA	µg/L	2,445	2,444	2,477	2,471	2,547	2,547	2,577	2,593	2,587	2,594	2,592	2,602	2,592	2,602
Lead	0.97 - 3.8 ⁽¹⁾	µg/L	0.44	0.44	0.45	0.45	0.53	0.51	1.28	0.64	1.14	0.66	0.91	0.6	0.85	0.58
Manganese	NA	µg/L	184.5	184.6	188.3	188.3	217.4	219.5	304.0	307.8	331.1	329.5	320.2	318.9	315.1	317.5
Nickel	23.6 – 58.7 ⁽¹⁾	µg/L	2.91	2.91	2.91	2.91	2.95	2.95	15.7	2.98	12.3	2.99	8.26	2.99	7.32	2.99
Selenium	5	µg/L	0.61	0.61	0.61	0.61	0.61	0.61	1.27	0.61	1.07	0.61	0.84	0.61	0.79	0.61
Silver	1	µg/L	0.12	0.12	0.12	0.12	0.12	0.12	0.14	0.12	0.13	0.12	0.13	0.12	0.13	0.12
Thallium	0.56	µg/L	0.27	0.27	0.26	0.26	0.25	0.24	0.22	0.21	0.18	0.18	0.13	0.13	0.12	0.12
Vanadium	NA	µg/L	5.39	5.39	5.4	5.39	5.41	5.41	6.07	5.43	5.61	5.43	5.44	5.43	5.44	5.43
Zinc	54.2 – 135 ⁽¹⁾	µg/L	26.0	26.0	26.3	26.3	27.1	27.1	33.5	27.4	28.5	27.6	27.7	27.5	27.7	27.5

Source: Barr 2013f.

Notes:

For each constituent at each location, the maximum solute concentration over the entire 200-year simulation period is recorded for each of 500 realizations of the Monte Carlo run. At the end of the Monte Carlo run, there is a list of 500 maximum concentration values for each constituent at each location. Each list is converted to a cumulative frequency distribution. Each value in this table is the 90th percentile concentration from the associated distribution.

¹ Hardness-based standard. Range applies to P10 and P90 variation in hardness. Exact numbers based on predicted hardness at evaluation location.

² Sulfate 10-mg/L wild rice standard applies at SW-005 and SW-006.

Bold value indicates exceedance of the evaluation criterion. For hardness-based standards, bold value indicates exceedance of stream standard for the predicted contemporaneous hardness value.

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The screening table clearly shows that the maximum P90 concentrations for the NorthMet Project Proposed Action are similar to the corresponding Continuation of Existing Conditions Scenario modeled values for most of the constituents. Some of the NorthMet Project Proposed Action maximum P90 values—such as those for antimony, arsenic, cadmium, cobalt, copper, lead, nickel, and selenium at SW-004a, SW-004b, SW-005, and SW-006—are noticeably higher than the Continuation of Existing Conditions Scenario maximum P90 values, but the NorthMet Project Proposed Action values all remain well below the applicable evaluation criteria.

Table 5.2.2-30 above also shows that the maximum P90 concentrations for the NorthMet Project Proposed Action do not exceed the applicable evaluation criteria for any of the constituents except aluminum (at all locations) and sulfate (at SW-005 and SW-006), for any time during the 200-year modeling period. A detailed evaluation of these two constituents is provided below.

Tables 5.2.2-31, 5.2.2-32, and 5.2.2-33 below compare the P10, P50, and P90 for NorthMet Project Proposed Action and the Continuation of Existing Conditions Scenario modeled concentrations for selected representative solutes of interest at representative years during mine operations, reclamation, and closure at SW-004a, which is the evaluation location where the NorthMet Project Proposed Action would have its greatest effects on water quality for most constituents. As these data show, the water quality is predicted to be essentially the same between the Continuation of Existing Conditions Scenario and the NorthMet Project Proposed Action modeled values for operations and reclamation. This result is not unexpected, as none of the groundwater contaminant loads would reach the Partridge River until year 34 at the earliest and there would be no surface water discharge from the NorthMet Project Proposed Action until year 40. By year 200 in closure, which reflects when effects would have peaked and would be decreasing, the WWTF would be discharging and all groundwater contaminant loads would have reached the Partridge River (except negligible contributions from the bedrock flowpaths). All of the constituents would meet water quality evaluation criteria. Although the NorthMet Project Proposed Action evaluation criteria focuses on the P90 values (e.g., a reasonable worst case), the most probable result would be closer to the P50 value, while the P10 value represents a reasonable best case in terms of modeled water quality effects from the NorthMet Project Proposed Action.

Table 5.2.2-31 Comparison of the P10, P50, and P90 Values for NorthMet Project Proposed Action and Continuance of Existing Conditions Modeled Concentrations at SW-004a for Selected Key Constituents, Year 12

Parameter	Partridge Evaluation Criteria	Units	P10		P50		P90	
			Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action
Sulfate	NA	mg/L	8.3	8.4	14.2	14.4	19.2	19.2
Aluminum	125	µg/L	41.3	41.6	74.6	74.6	169.6	169.5
Arsenic	53	µg/L	1.3	1.3	2.9	3.0	3.8	3.8
Copper ¹	9.5	µg/L	1.4	1.4	2.1	2.2	2.5	2.6
Lead ¹	3.3	µg/L	0.4	0.4	0.5	0.5	0.6	0.6
Nickel ¹	53	µg/L	1.3	1.4	1.7	1.7	2.9	2.9
Zinc ¹	122	µg/L	5.9	6.0	9.4	9.4	26.9	26.9

Source: Barr 2013f.

¹ Evaluation criteria based on average hardness of 102 mg/L at Station SW-004a.

Bold value indicates exceedance of the evaluation criterion. For hardness-based standards, bold value indicates exceedance of stream standard for the predicted contemporaneous hardness value.

Table 5.2.2-32 Comparison of the P10, P50, and P90 Values for Proposed Action and Continuation of Existing Conditions Scenario Concentrations at SW-004a for Selected Key Constituents, Year 25

Parameter	Partridge Evaluation Criteria	Units	P10		P50		P90	
			Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action
Sulfate	NA	mg/L	7.6	7.6	14.0	14.4	19.1	19.1
Aluminum	125	µg/L	41.4	42.3	74.2	74.2	166.7	166.7
Arsenic	53	µg/L	1.2	1.2	2.9	2.9	3.7	3.7
Copper ¹	9.5	µg/L	1.4	1.3	2.1	2.2	2.5	2.6
Lead ¹	3.3	µg/L	0.4	0.3	0.5	0.5	0.6	0.6
Nickel ¹	53	µg/L	1.2	1.2	1.7	1.7	2.9	2.9
Zinc ¹	122	µg/L	5.7	5.7	9.4	9.4	26.0	26.0

Source: Barr 2013f.

¹ Evaluation criteria based on average hardness of 102 mg/L at Station SW-004a.

Bold value indicates exceedance of the evaluation criterion. For hardness-based standards, bold value indicates exceedance of stream standard for the predicted contemporaneous hardness value.

Table 5.2.2-33 Comparison of the P10, P50, and P90 Values for Proposed Action and Continuation of Existing Conditions Scenario Concentrations at SW-004a for Selected Key Constituents, Year 200

Parameter	Partridge Evaluation Criteria	Units	P10		P50		P90	
			Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action
Sulfate	NA	mg/L	8.0	8.2	14.0	13.4	19.0	18.9
Aluminum	125	µg/L	41.5	37.3	74.7	73.6	166.8	165.6
Arsenic	53	µg/L	1.2	1.6	2.8	3.5	3.8	4.8
Copper ¹	9.5	µg/L	1.4	2.0	2.1	3.7	2.5	4.2
Lead ¹	3.3	µg/L	0.4	0.6	0.5	1.1	0.6	1.3
Nickel ¹	53	µg/L	1.3	5.0	1.7	11.6	2.9	15.0
Zinc ¹	122	µg/L	5.8	11.3	9.5	18.3	26.1	32.6

Source: Barr 2013f.

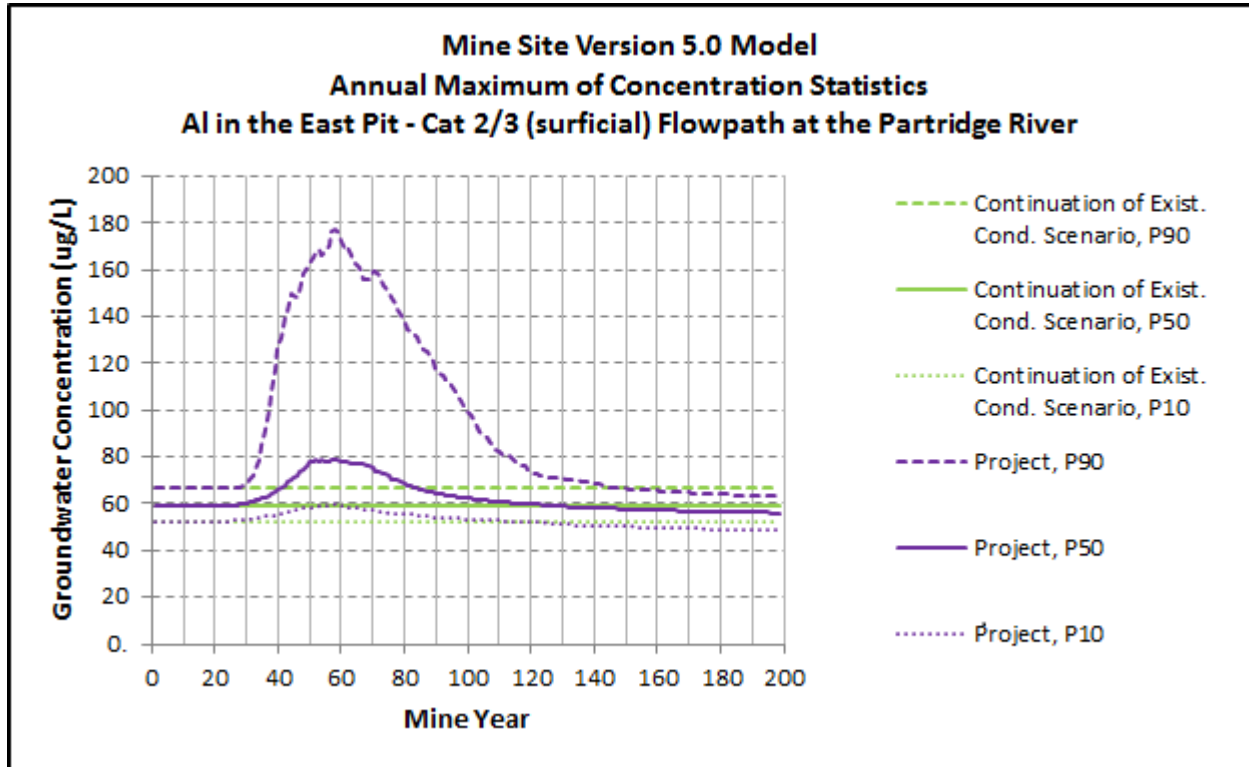
¹ Evaluation criteria based on average hardness of 102 mg/L at Station SW-004a.

Bold value indicates exceedance of the evaluation criterion. For hardness-based standards, bold value indicates exceedance of stream standard for the predicted contemporaneous hardness value.

Aluminum in the Partridge River

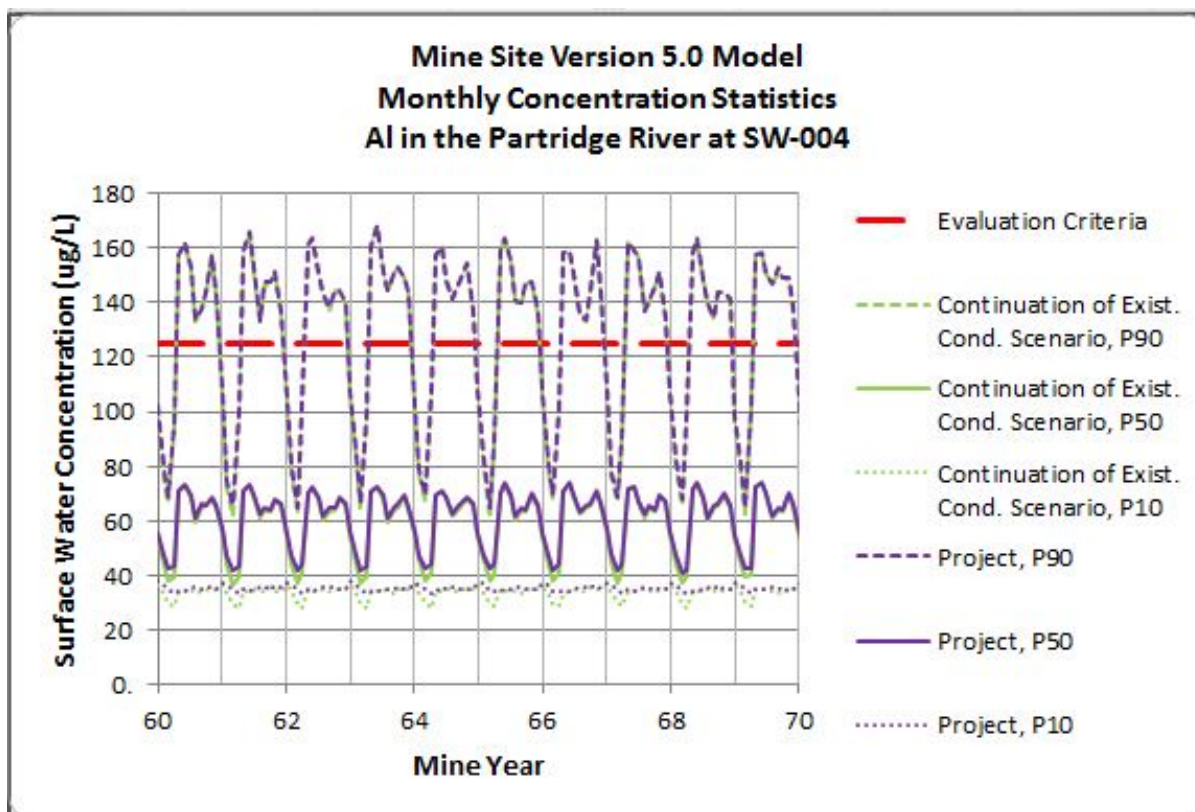
Model results indicate that the maximum P90 concentration of aluminum in the Partridge River for the modeled NorthMet Project Proposed Action would exceed the evaluation criterion (125 µg/L) in all six evaluation locations along the Upper Partridge River. Aluminum maximum P90 values for NorthMet Project Proposed Action conditions range from 165.4 to 173.7 µg/L at the various evaluation locations.

Potential sources of aluminum from the NorthMet Project Proposed Action include the East Pit – Category 2/3 Stockpile, the Ore Surge Pile, the WWTF Equalization Basins, the Overburden Storage and Laydown Area, and the West Pit. For each source, the primary constituent migration pathway would be transport in the surficial aquifer. Aluminum concentrations would remain consistently below the 125 µg/L surface water evaluation criterion in groundwater flowpaths from the WWTF Equalization Basins, the Ore Surge Pile, and the West Pit; and modeled aluminum concentrations in the West Pit flowpath would decrease below Continuation of Existing Conditions Scenario modeled levels in the long term (see Table 5.2.2-30). Groundwater from the East Pit – Category 2/3 Stockpile shows a “pulse” of aluminum concentration that would peak at about 175 µg/L at the Partridge River between years 25 and 125 (see Figure 5.2.2-23). Groundwater from the Overburden Storage and Laydown Area would show a similar, peak in groundwater aluminum, slightly above the 125 µg/L surface water evaluation criterion. Figure 5.2.2-24 shows the modeled, monthly aluminum concentration for years 60 to 70, which captures the pulse shown in Figure 5.2.2-23. Because the groundwater flow rate from the East Pit – Category 2/3 Stockpile would small (41 gpm or 0.09 cfs) compared to normal Partridge River streamflow, it would be diluted upon reaching the river at SW-004, the first surface water evaluation location downstream of the contribution of the East Pit – Category 2/3 Stockpile flowpath. As evidenced by the Continuation of Existing Conditions Scenario and the NorthMet Project Proposed Action modeled concentrations being coincident in Figure 5.2.2-24, effects from the NorthMet Project Proposed Action are not discernible.



Source: Barr 2013f.

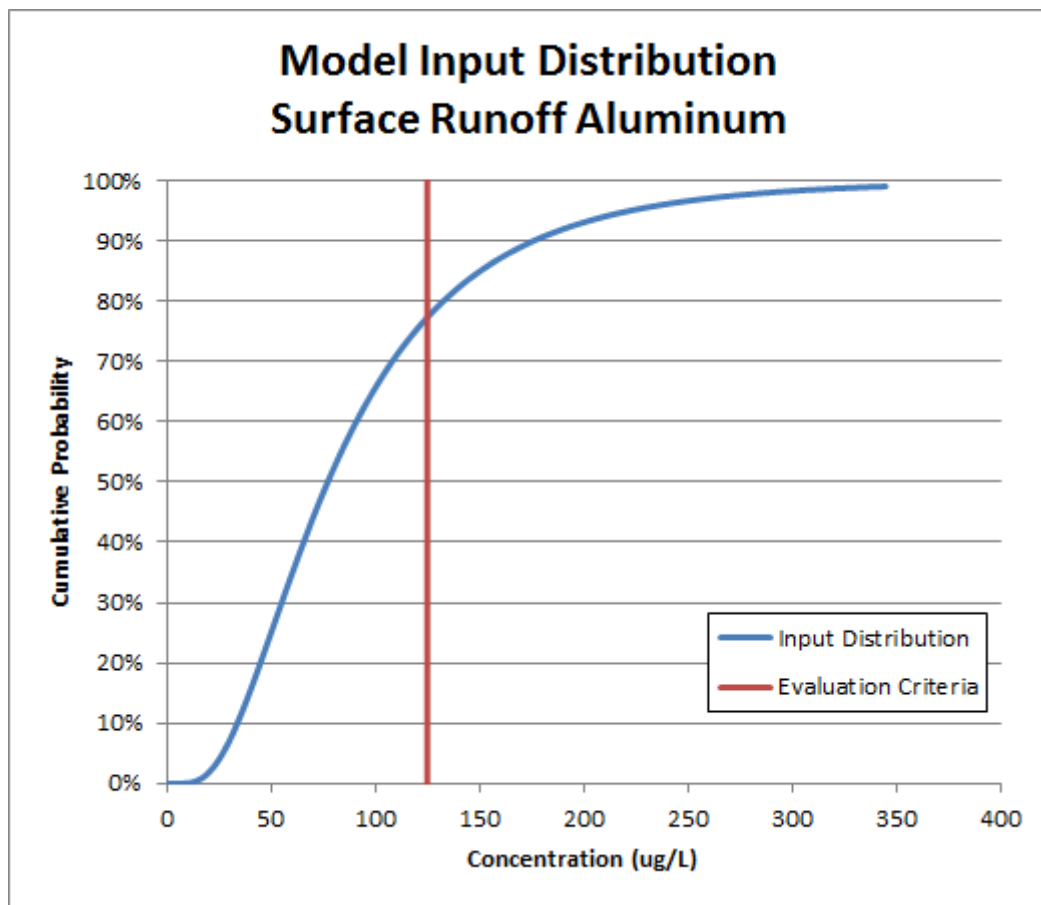
Figure 5.2.2-23 Annual Maximum Aluminum Concentrations Along the Groundwater Flowpath from the East Pit - Category 2/3 Stockpile



Source: Barr 2013f.

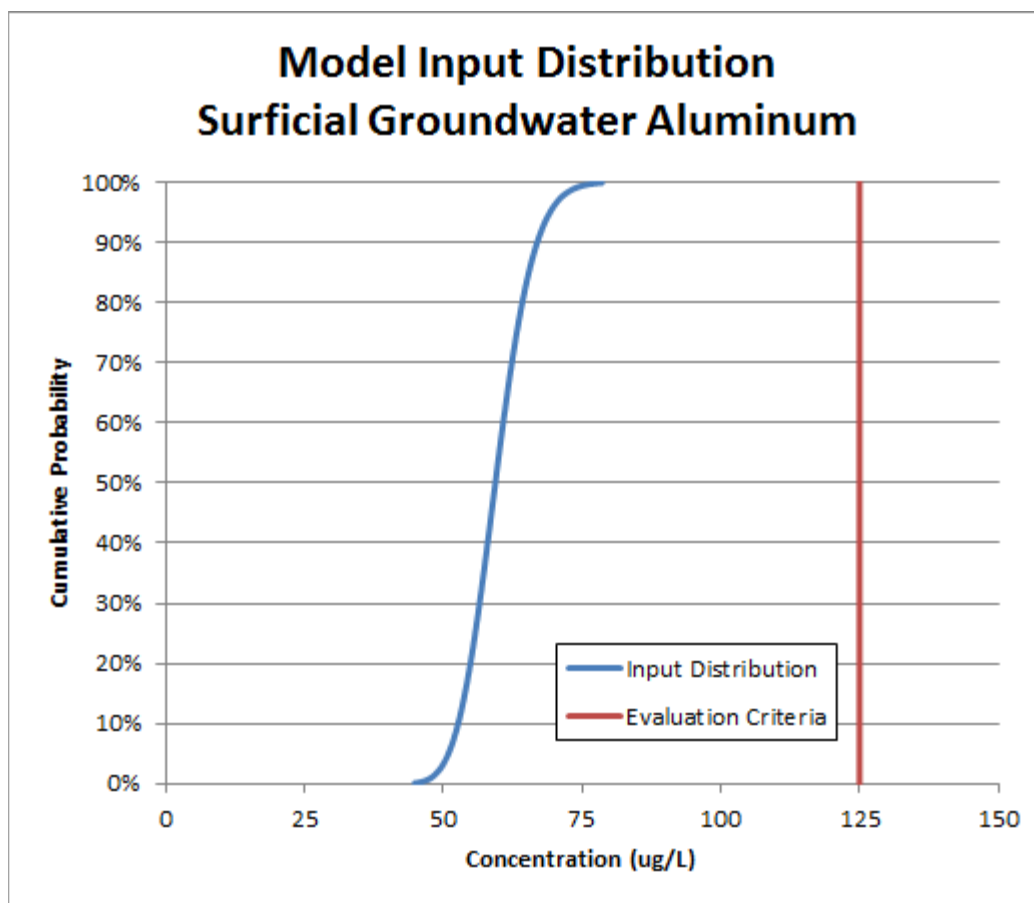
Figure 5.2.2-24 Monthly Aluminum Concentrations at SW-004

The modeled exceedances of the aluminum evaluation criteria typically occur between April and November, when surface runoff would contribute proportionately more to river flow than groundwater baseflow. The modeled spatial mean concentrations of aluminum in groundwater almost never exceed 125 $\mu\text{g/L}$, whereas concentrations of aluminum in background surface runoff (i.e., non-contact water) exceed the evaluation criterion approximately 20 percent of the time (or above 125 $\mu\text{g/L}$) (see Figures 5.2.2-25 and 5.2.2-26).



Note: Cumulative probability of non-exceedance

Figure 5.2.2-25 *Simulated Distribution of Aluminum Concentrations in Surface Runoff*



Note: Cumulative probability of non-exceedance

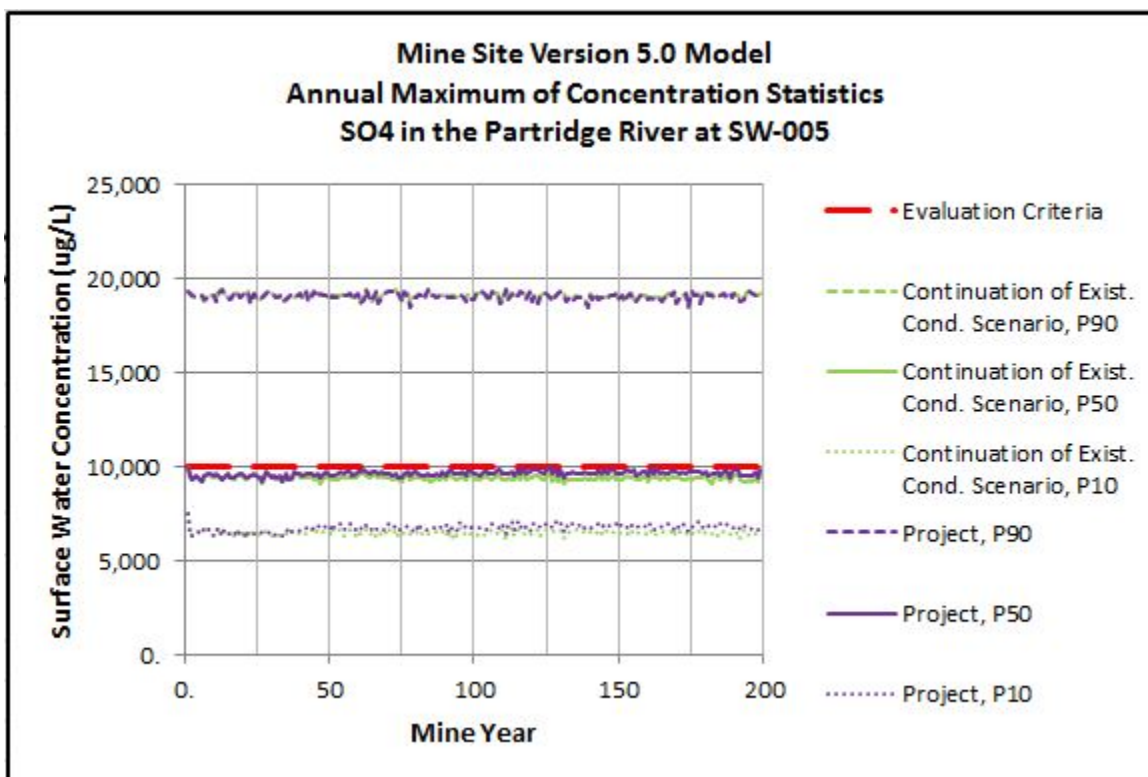
Figure 5.2.2-26 Simulated Distribution of Aluminum Concentrations in Groundwater

As Table 5.2.2-30 indicates, in comparing the modeled Continuation of Existing Conditions Scenario concentrations in the Upper Partridge River with the modeled NorthMet Project Proposed Action concentrations, the NorthMet Project Proposed Action would not cause concentrations of aluminum to measurably increase above the evaluation criteria at evaluation locations. Although aluminum concentrations in the Upper Partridge River would exceed evaluation criteria, the concentrations are predicted to be about the same as they would be under the Continuation of Existing Conditions Scenario. Therefore, it is predicted that the NorthMet Project Proposed Action would not cause the exceedances and would not have a measureable adverse effect on aluminum concentrations in the Upper Partridge River. Moreover, the modeled exceedances are attributable to background surface non-contact water, which is naturally high in aluminum.

Sulfate in the Partridge River

The MPCA has recommended that the lower portion of the Partridge River, including evaluation locations SW-005 and SW-006, as a water used for the production of wild rice, and it is therefore recommended to be subject to the 10-mg/L sulfate evaluation criterion.

As Table 5.2.2-30 indicates, the maximum P90 sulfate concentrations at SW-005 and SW-006 as a result of the NorthMet Project Proposed Action are predicted to be 19.4 mg/L, which would exceed the wild rice sulfate evaluation criteria. The Continuation of Existing Conditions Scenario model results also predict similar maximum P90 sulfate concentrations (see Figure 5.2.2-27). However, since the 10-mg/L standard applies at SW-005 and SW-006, a more robust discussion of sulfate modeling results at that location is provided to better define the magnitude and timing of NorthMet Project Proposed Action effects. It should be noted, however, that the median (P50) sulfate concentrations at SW-005 and SW-006 for the NorthMet Project Proposed Action for the 200-year modeling period would generally be slightly less than the 10-mg/L standard, and nearly identical to the Continuation of Existing Conditions Scenario model results. The analysis below focuses on SW-005, as the greatest NorthMet Project Proposed Action effects would occur at that location; effects from the NorthMet Project Proposed Action are further diluted at SW-006.



Source: Barr 2013f.

Figure 5.2.2-27 *Maximum Annual Sulfate Concentration Percentiles at SW-005*

The NorthMet Project Proposed Action would have negligible effect on sulfate concentrations at SW-005 during mine operations and reclamation (years 0 to 40), relative to Continuation of Existing Conditions Scenario model results, as there would be no discharge of WWTF effluent until year 40 and the contributions from groundwater flowpaths in most cases would not yet have reached the Partridge River.

The NorthMet Project Proposed Action would have greater potential to affect sulfate concentrations at SW-005 during closure (after year 75) for the following reasons:

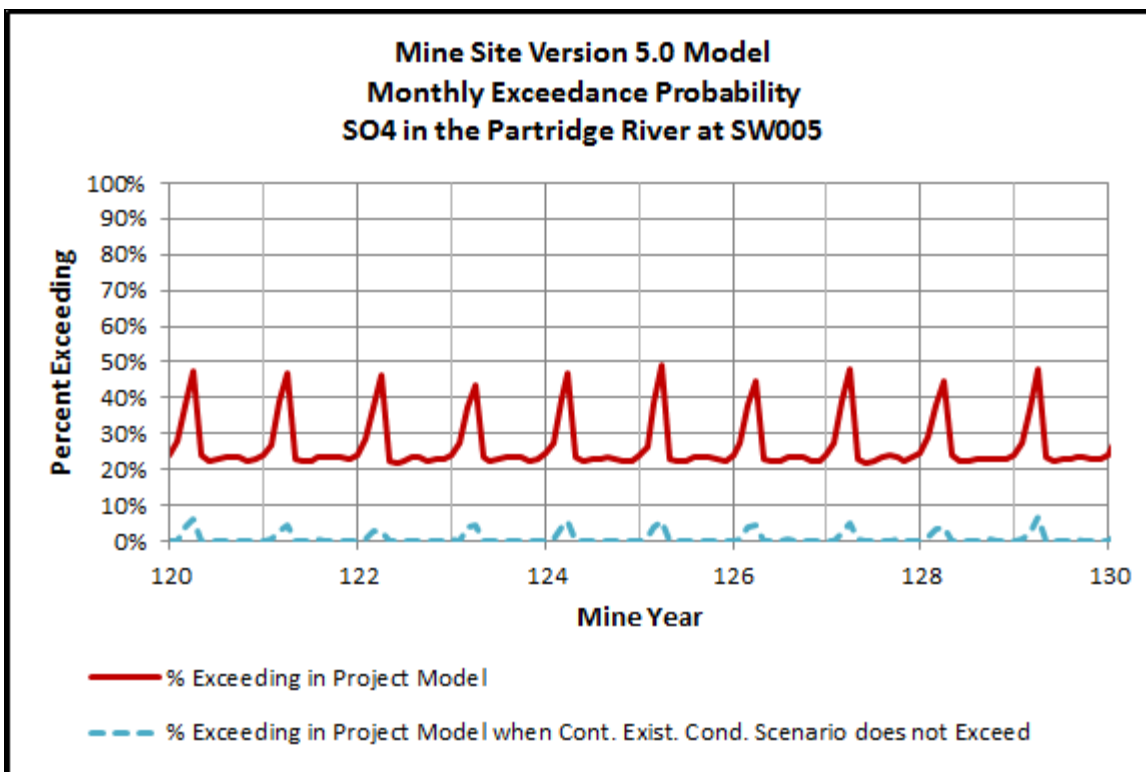
- increased sulfate contributions to the Partridge River from the Overburden Storage and Laydown Area surficial aquifer flowpath, which are predicted to range from 10 to 20 mg/L and would peak in terms of sulfate load contribution between approximately years 50 to 100;
- increased sulfate contributions to the Partridge River from the East Pit – Category 2/3 Stockpile surficial aquifer flowpath, which are predicted to range from 10 to 20 mg/L and would peak in terms of sulfate load contribution at approximately year 125; and
- increased sulfate concentrations to the Partridge River from the West Pit surficial aquifer flowpath, which are predicted to range from 10 to 35 mg/L and would peak in terms of sulfate load contribution at approximately year 125.

Collectively, these three sources of sulfate only total about 0.17 cfs (78 gpm) of flow, so represent only a small percentage (approximately 0.2 percent) of the average flow in the Partridge River (about 78 cfs at SW-005). These sources would have a proportionally greater effect on flow (and sulfate loadings) during low flows (average 30-day low flow of 4.9 cfs at SW-005, where 0.17 cfs represents 3.5 percent of the average 30-day low flow).

Other sources of sulfate loadings generally have sufficiently low concentrations that they tend to dilute loadings from these sources. For example, surface runoff is expected to have a median sulfate concentration of 3.6 mg/L (although it can occasionally be over 20 mg/L), and the WWTF, which would begin discharging approximately 300 gpm to the Partridge River upstream of SW-005 in year 40, would have a design effluent concentration of 9 mg/L sulfate. Background groundwater is expected to have a median sulfate concentration of 21.8 mg/L.

The net effect of these three groundwater sources to SW-005 is as follows:

- NorthMet Project Proposed Action effects on the frequency of sulfate exceedances of the evaluation criteria – the GoldSim model results indicate that the NorthMet Project Proposed Action would not increase the frequency of exceedances of the sulfate evaluation criteria (i.e., there is less than a 10 percent probability that the NorthMet Project Proposed Action would exceed the sulfate evaluation criteria for months when Continuation of Existing Conditions Scenario model results do not indicate exceedances). As the lower blue line on Figure 5.2.2-28 illustrates, the NorthMet Project Proposed Action would result in a maximum 6.6 percent increase in the probability the sulfate concentration would exceed the sulfate evaluation criteria for months when the Continuation of Existing Conditions Scenario model results do not indicate exceedances.

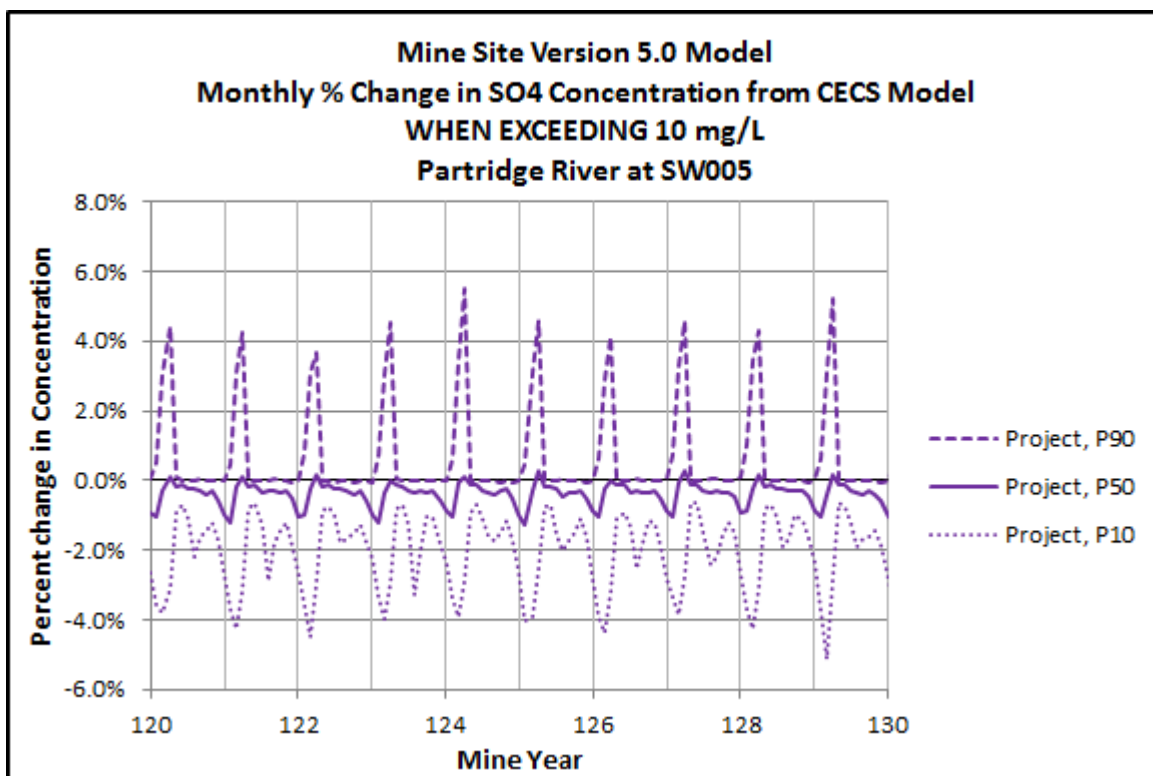


Source: Barr 2013f.

Figure 5.2.2-28 *Likelihood that Monthly Sulfate Concentration at SW-005 Would Exceed 10 mg/L, Mine Years 120 to 130*

- NorthMet Project Proposed Action effects on the magnitude of an exceedance – during months when the modeled sulfate concentration at SW-005 exceeded the 10 mg/L evaluation criteria, Figure 5.2.2-29 illustrates the modeled sulfate concentrations for the NorthMet Project Proposed Action in terms of percent change from the Continuation of Existing Conditions Scenario model results during years 120 to 130. As this figure demonstrates, sulfate concentrations in closure may increase or decrease on a monthly basis relative to Continuation of Existing Conditions Scenario. The NorthMet Project Proposed Action is more likely to decrease concentrations than increase concentrations (as evidenced by the P50 line being below zero for most months).

There is, however, a possibility that the NorthMet Project Proposed Action would increase the magnitude of exceedances of the sulfate evaluation criteria. These increases in magnitude, however, would be small (i.e., a maximum of 0.56 mg/L) and would be temporally limited to extreme low-flow periods, primarily after year 75 in closure, which would be when the peak of the sulfate load from the East Pit and West Pit flowpaths would reach the Partridge River.



Source: Barr 2013f.

Figure 5.2.2-29 Percent Change in Sulfate Concentration when Exceeding 10 mg/L, Mine Years 120 to 130

Due to the fact that these predicted increases in the magnitude of exceedances would be relatively small (i.e., less than a maximum of 0.56 mg/L), of short duration (i.e., only during extreme low-flow periods), and would primarily occur during a well-defined period (i.e., after year 75), there would be opportunities to monitor and tailor measures to lessen these effects.

Throughout the mine life, there would be ongoing monitoring of groundwater quality downgradient of mine features. If future modeling, informed by the results of the groundwater monitoring, predicted that the NorthMet Project Proposed Action had a likelihood that it would cause or increase exceedances of the applicable evaluation criteria for sulfate, then contingency measures could be implemented and adapted as necessary to decrease NorthMet Project Proposed Action effects on the Partridge River prior to an actual effect occurring (Barr 2013g). Possible contingency measures that could be implemented include the following:

- Modify the WWTF design to generate effluent with sulfate concentrations less than 9 mg/L, at least during low-flow conditions. Recent pilot-testing of the proposed RO unit resulted in average sulfate removal rates of 99.8 percent with average and maximum sulfate concentrations observed in the effluent of 3.7 and 6.9 mg/L, respectively, for the blended (RO and vibratory shear enhanced processing) streams, which is below the 9 mg/L value assumed for modeling purposes (Barr 2013g). Given that the WWTF would have an annual average discharge of approximately 300 gpm, as compared to about 78 gpm from the three groundwater sources of sulfate, a small decrease in the actual sulfate concentration in the WWTF effluent could offset the loading from the three groundwater sources.

- Increase the WWTF discharge. PolyMet could temporarily increase the volume of the WWTF (which is operating below its actual capacity) effluent discharge during low-flow conditions, which, at 9 mg/L or lower sulfate concentration, would help further dilute sulfate concentrations in waters supporting wild rice.
- Install groundwater containment facilities in the East Pit – Category 2/3, Overburden Storage and Laydown Area, and/or West Pit surficial flowpaths to capture groundwater with elevated sulfate that would otherwise release to the Partridge River. The collected water would be sent to the WWTF for treatment and then discharged to the river tributaries with sulfate concentrations less than or equal to 9 mg/L.
- Install non-mechanical treatment systems in the East Pit – Category 2/3, Overburden Storage and Laydown Area, and/or West Pit surficial flowpaths to reduce sulfate concentrations (in-situ) prior to release to the Partridge River.

Given that the predicted effect would be relatively small, of short duration each year, and primarily limited to specific mine years that are relatively far in the future, which allow for monitoring to determine if predicted effects would be likely to occur, and that contingency measures are available that could be implemented with a high level of confidence, there is a reasonable likelihood that measures could be implemented (if needed) to prevent increases in the magnitude of exceedances of the 10-mg/L sulfate standard in Partridge River recommended wild rice waters should they be predicted to occur. Thus, potential effects on water quality are unlikely, but would not be significant if they were to occur.

Effects on Surface Water Quality in the Upper Partridge River Tributary Streams

This section discusses the effects on surface water quality in the four Upper Partridge River tributary streams: West Pit Outlet Creek, Wetlegs Creek, Longnose Creek, and Wyman Creek. Surface water quality in these creeks would be affected by ore spillage during rail transport from the Mine Site to the processing plant.

Based on observations at other mining operations using similar side-dump rail cars, it is assumed that spillage could occur along the first 1,000 meters of rail from the Rail Transfer Hopper (PolyMet 2013l). The railway does not cross any streams along this stretch. It is estimated that 55.7 kg ore per m² track could spill from rail cars within the first 1,000 meters of the railway over the 20-year life of the NorthMet Project Proposed Action. This is equivalent to 1.25 inches of spilled material over a 2,000 m² area. Rainfall contacting the spilled ore would have the potential to release contaminants, but the relatively small volume of material and dilution from other sources are expected to result in surface water quality meeting the evaluation criteria (PolyMet 2013l). During closure, there may be residual effects on surface water quality from the spilled ore, although the small quantity of expected spilled material would become rapidly depleted of sulfide materials compared to the much larger waste rock stockpiles (PolyMet 2013l).

In order to guard against possible adverse effects from spilled ore, monitoring and mitigation activities would be developed (see Section 5.2.2.3.5). Water quality monitoring is recommended downstream from the rail line on the Partridge River tributary streams to check for any potential deteriorations of water quality over time from ore spillage, and, if detected, adaptive water management measures would be implemented.

The West Pit Outlet Creek would also receive effluent from the WWTF during closure, which is estimated at an average annual discharge of 1.2 cfs. The WWTF is designed to meet all surface water quality standards with its discharge.

Effects on Surface Water Quality in Colby Lake and Whitewater Reservoir

The GoldSim modeling indicates that the NorthMet Project Proposed Action would meet all evaluation criteria at the P90 level, except for aluminum, iron, and manganese, as indicated in Table 5.2.2-34. These three solutes with apparent exceedances in Colby Lake are discussed below. Arsenic is also discussed because of the more stringent water quality evaluation criteria for drinking water supplies.

Table 5.2.2-34 Maximum P90 Surface Water Concentrations for Colby Lake

Parameter	Colby Lake Evaluation Criteria	Units	Continuation of Existing Conditions Scenario (Max P90 Value)	NorthMet Project Proposed Action (Max P90 Value)	% Change from Continuation of Existing Conditions Scenario
General					
Alkalinity	NA	mg/L	128	128	NA
Calcium	NA	mg/L	30.1	30.1	NA
Chloride	230	mg/L	22.7	22.7	0%
Fluoride	4	mg/L	0.19	0.19	0%
Hardness	500	mg/L	118	118	-0.1%
Magnesium	NA	mg/L	13.7	13.7	0%
Potassium	NA	mg/L	3.60	3.6	0%
Sodium	NA	mg/L	18.3	18.3	0%
Sulfate	250	mg/L	19.4	19.4	0%
Metals Total					
Aluminum	125	µg/L	174	173	-0.3%
Antimony	5.5	µg/L	1.65	1.69	2.4%
Arsenic	2	µg/L	0.65	0.90	38.5%
Barium	2000	µg/L	12.7	13.3	4.7%
Beryllium	4	µg/L	0.10	0.11	10%
Boron	500	µg/L	179	179	-0.2%
Cadmium	5 ¹	µg/L	0.12	0.15	25%
Chromium	11	µg/L	1.86	1.87	0.5%
Cobalt	2.8	µg/L	0.56	0.68	21.4%
Copper	4.56 ¹	µg/L	2.09	2.25	7.7%
Iron	300	µg/L	2,590	2,575	-0.6%
Lead	1.08 ¹	µg/L	0.31	0.38	22.6%
Manganese	50	µg/L	241	238	-1.2%
Nickel	25.6 ¹	µg/L	2.98	3.94	32.2%
Selenium	5	µg/L	0.61	0.63	3.3%
Silver	1	µg/L	0.12	0.12	0%
Thallium	0.28	µg/L	0.05	0.05	0%
Vanadium	NA	µg/L	5.41	5.43	0.4%
Zinc	58.1 ¹	µg/L	27.5	27.6	0.4%

Source: Barr 2013f.

Note: Bold font indicated an exceedance of the evaluation criteria.

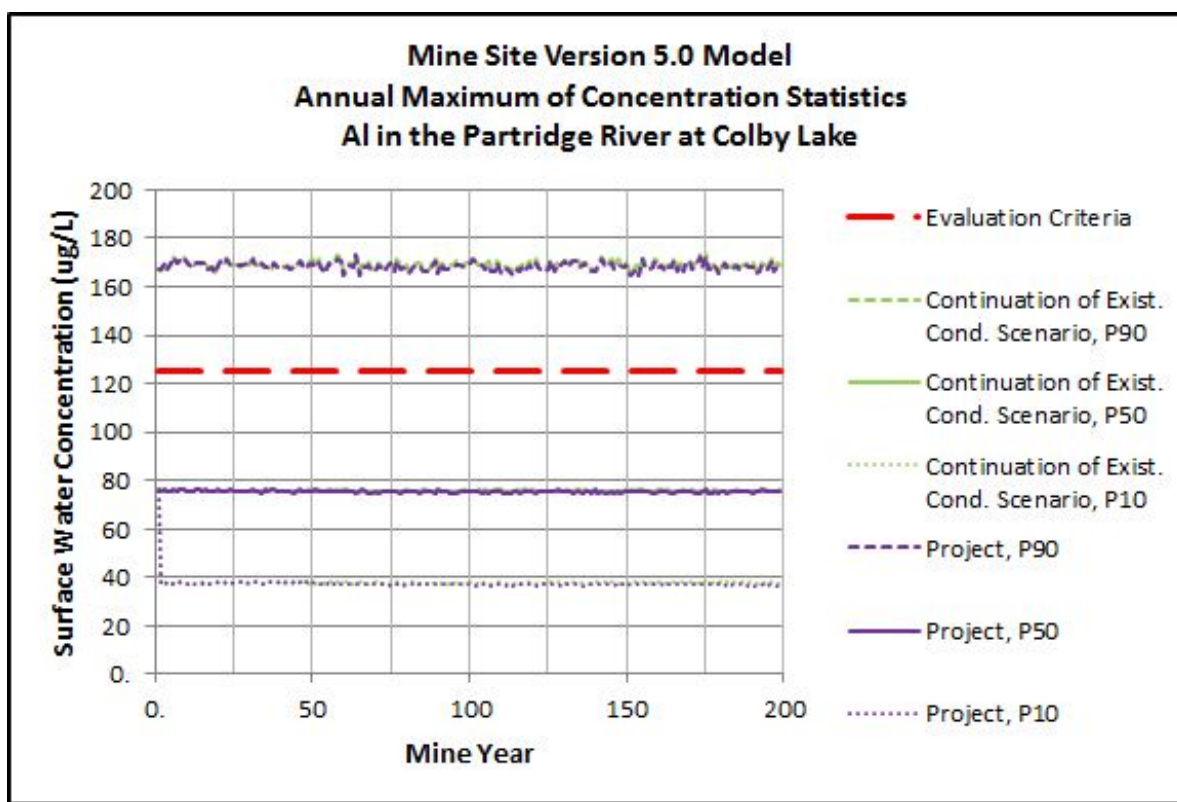
¹ Evaluation criterion is hardness-dependent and estimated using hardness at maximum solute P90 concentration.

Table 5.2.2-34 above shows the percent change from the Continuation of Existing Conditions Scenario model results. The percent change can appear quite large, but the absolute change is quite small, especially when compared with the evaluation criteria. A good example is nickel, which has a maximum P90 value that increases 32.2 percent, but the absolute increase is less

than 1 µg/L, and the NorthMet Project Proposed Action maximum P90 value (3.94 µg/L) is still well below the evaluation criteria (25.6 µg/L).

Aluminum

Model results indicate that the maximum P90 concentration of aluminum (173 µg/L) would exceed the evaluation criteria (125 µg/L) in Colby Lake, just as it is predicted along most of the Partridge River (see Figure 5.2.2-30).



Source: Barr 2013f.

Figure 5.2.2-30 Colby Lake Annual Maximum Aluminum Concentrations

The exceedances of the aluminum evaluation criterion would typically occur between April and November, when surface runoff would contribute proportionately more to river flow than groundwater baseflow. Concentrations of aluminum in background surface non-contact water would exceed the water quality standard approximately 20 percent of the time, whereas aluminum in groundwater would almost never exceed the evaluation criteria (see Figures 5.2.2-25 and 5.2.2-26).

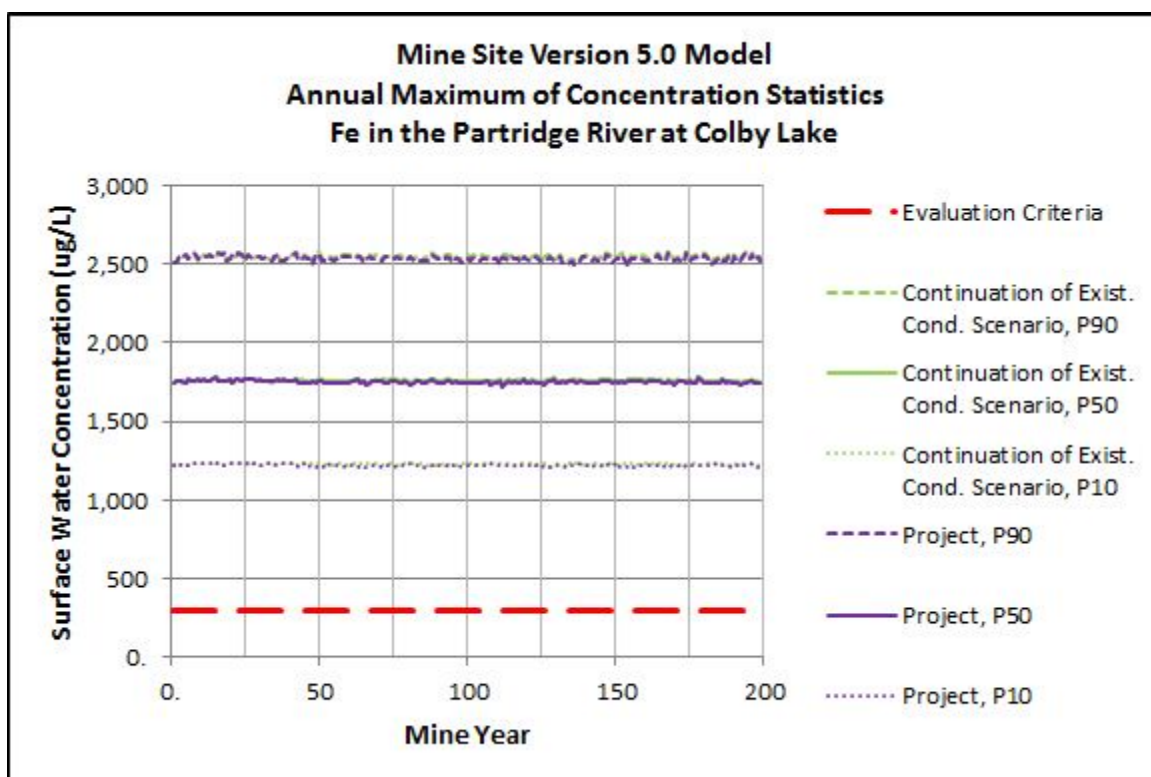
As Table 5.2.2-34 and Figure 5.2.2-30 indicate above, in comparing the Continuation of Existing Conditions Scenario concentrations in Colby Lake with the NorthMet Project Proposed Action concentrations, the NorthMet Project Proposed Action would not cause concentrations of aluminum to increase at evaluation locations and would actually cause aluminum concentrations to decrease slightly (from a maximum P90 concentration of 173.6 µg/L for the Continuation of

Existing Conditions Scenario to 170.0 µg/L for the NorthMet Project Proposed Action) due to changes in watershed configuration and the release of groundwater from the West Pit with relatively lower aluminum concentrations.

Further, aluminum has not been an issue for the City of Hoyt Lakes. In fact, the City treats the raw water from Colby Lake with alum, which probably adds aluminum to the water. The City is not required to monitor for aluminum, as there is no human health-based drinking water standard for aluminum.

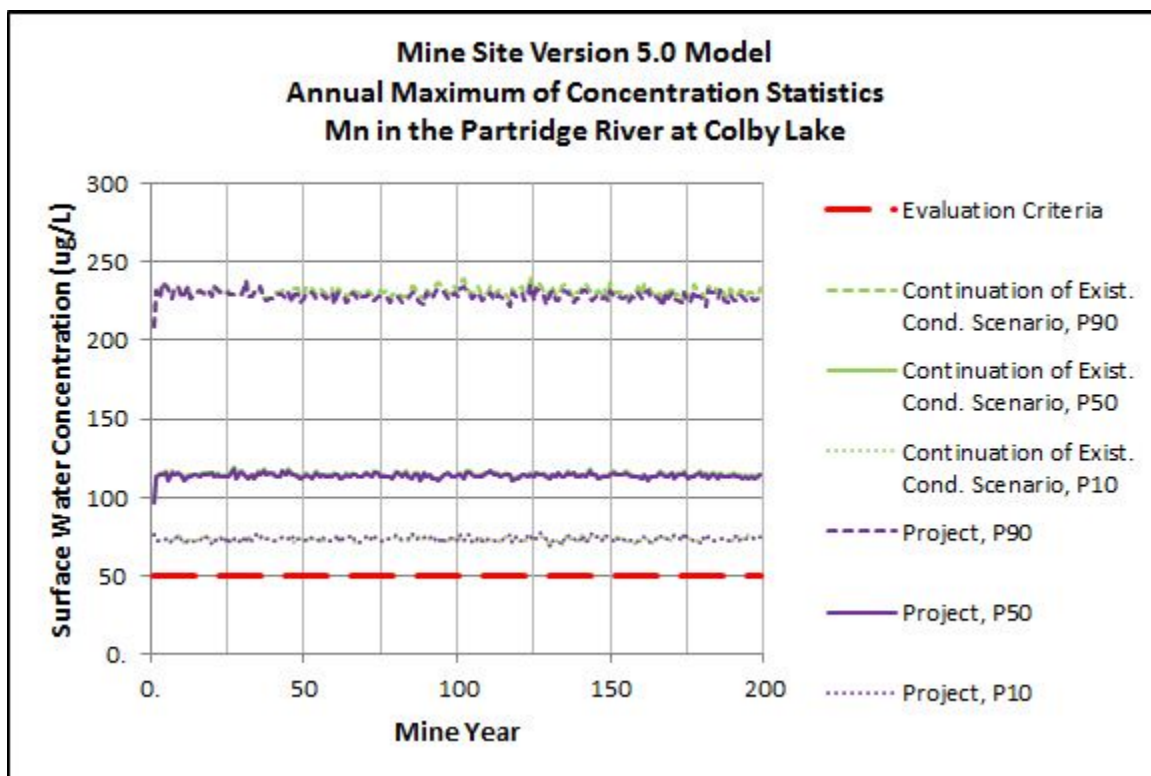
Iron and Manganese

Since Colby Lake is used as a drinking water source by the City of Hoyt Lakes, the USEPA sMCL evaluation criteria apply. The model results indicate that iron concentrations would exceed the 300 µg/L evaluation criterion and that manganese concentrations would exceed the 50 µg/L evaluation criterion, as shown in Figures 5.2.2-31 and 5.2.2-32 below.



Source: Barr 2013f.

Figure 5.2.2-31 **Colby Lake Annual Maximum Iron Concentration**



Source: Barr 2013f.

Figure 5.2.2-32 Colby Lake Annual Maximum Manganese Concentrations

Actual monitored background iron and manganese concentrations in Colby Lake, however, are naturally high and exceed their respective evaluation criteria. Over 90 percent of the background iron samples exceed the evaluation criteria (300 $\mu\text{g/L}$) and approximately 80 percent of the background manganese samples exceed the evaluation criteria (50 $\mu\text{g/L}$).

In comparing the Continuation of Existing Conditions Scenario predicted concentrations in Colby Lake with the NorthMet Project Proposed Action predicted concentrations, it appears that the NorthMet Project Proposed Action would cause a slight decrease in the long-term P90 concentrations for both iron and manganese due to changes in the watershed area, the lower iron concentration effluent from the WWTF (design maximum effluent concentration of 300 $\mu\text{g/L}$ for iron and 50 $\mu\text{g/L}$ for manganese), and the lower long-term seepage concentration from the West Pit lake (see Figures 5.2.2-33 and 5.2.2-34).

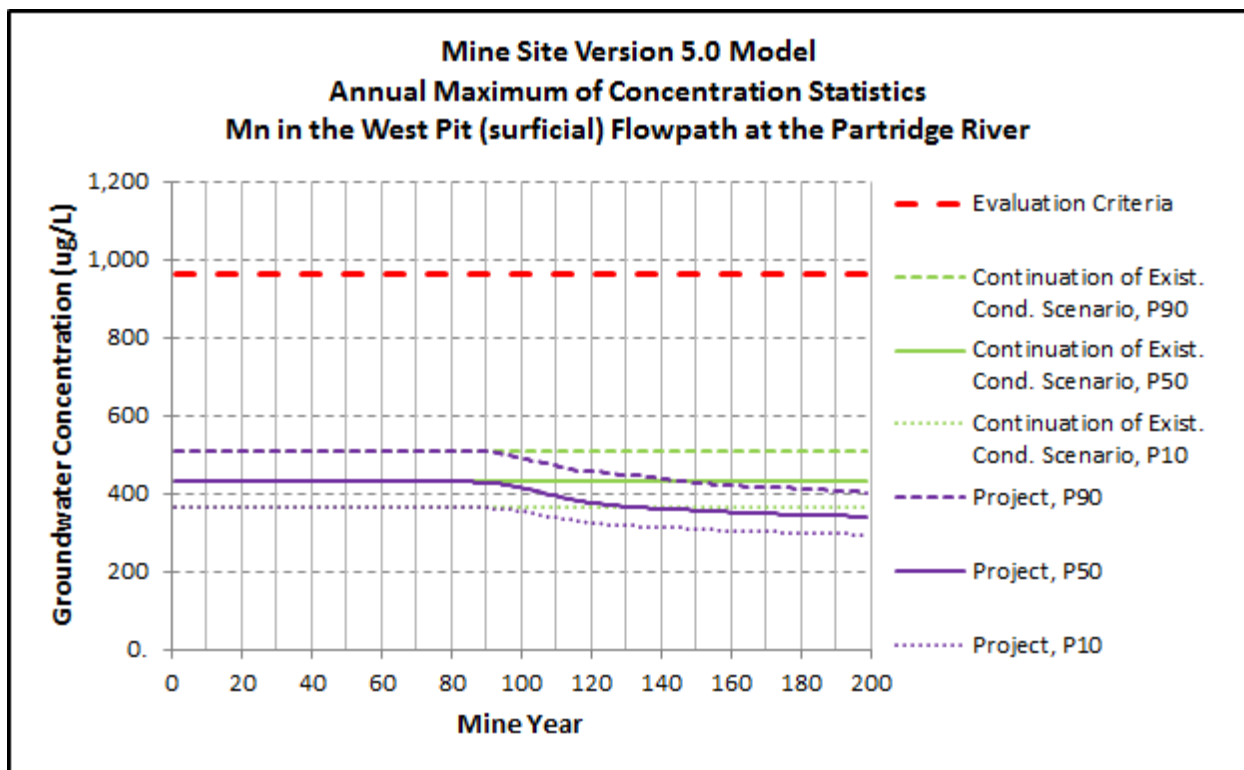


Figure 5.2.2-33 *Annual Maximum Manganese Concentration in the West Pit Flowpath*

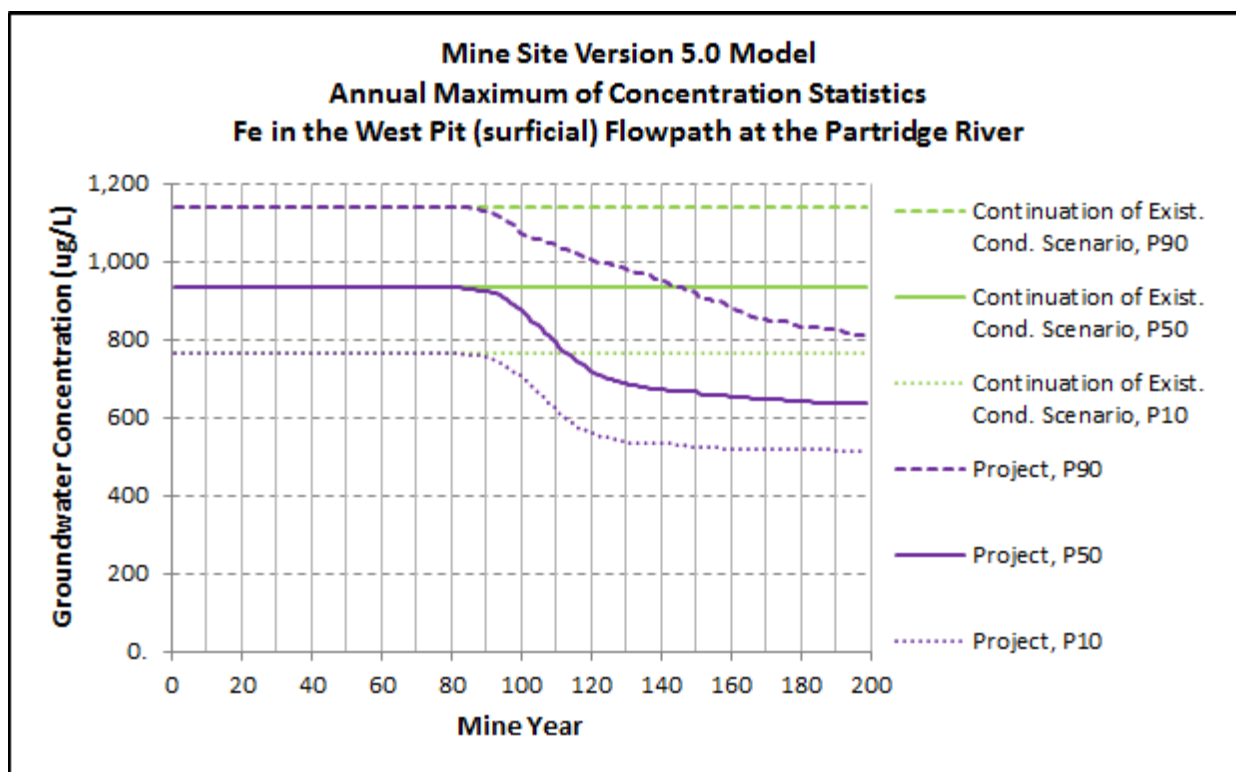
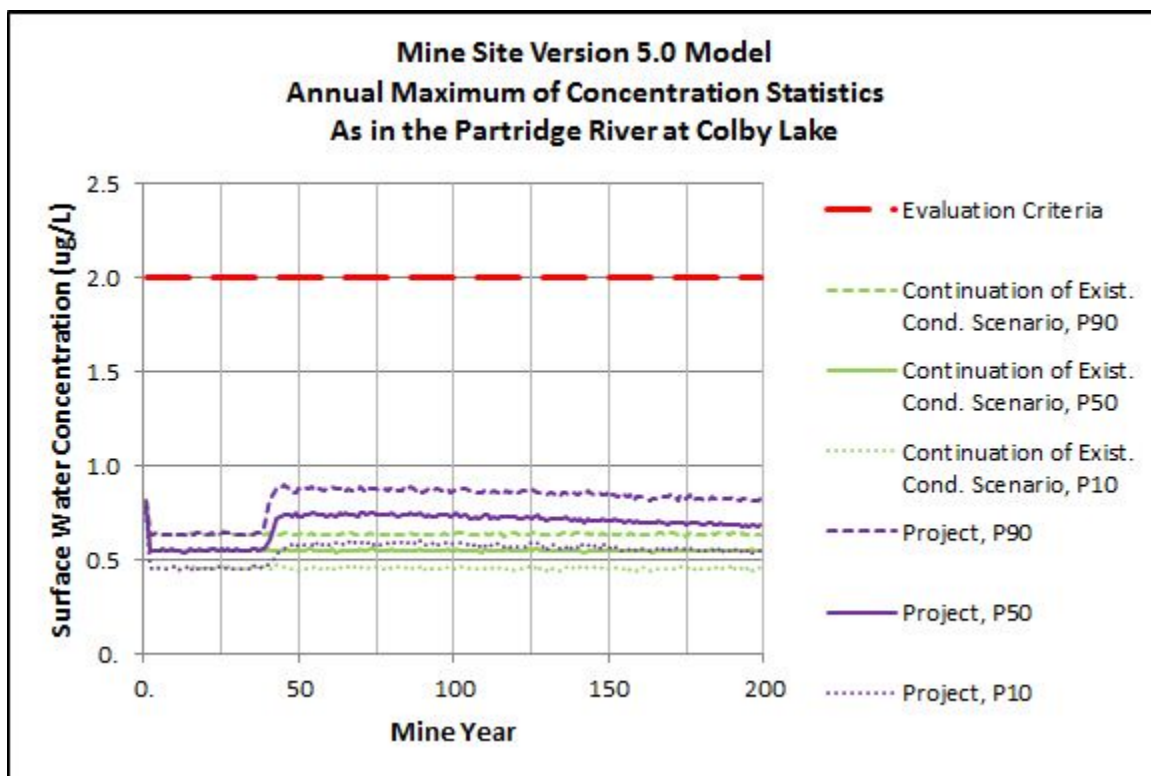


Figure 5.2.2-34 Annual Maximum Iron Concentration in the West Pit Flowpath

Therefore, although the NorthMet Project Proposed Action is predicted to result in exceedances of the iron and manganese evaluation criteria, the concentrations are not predicted to increase, and over the long term are predicted to slightly decrease under the Continuation of Existing Conditions Scenario. Further, iron and manganese are readily removed at drinking water treatment facilities prior to distribution to the community. The City of Hoyt Lakes, which uses Colby Lake as a water supply source, is able to remove nearly all iron at its water treatment plant, and iron is not considered an operations issue for the City. In the past, the City had some problems with manganese, but only during late summer under low oxygen levels, where manganese would be released from Colby Lake sediments. The City installed a higher water intake that is used during low-oxygen conditions, which has corrected this problem (Nelson, Pers. Comm., October 1, 2009).

Arsenic

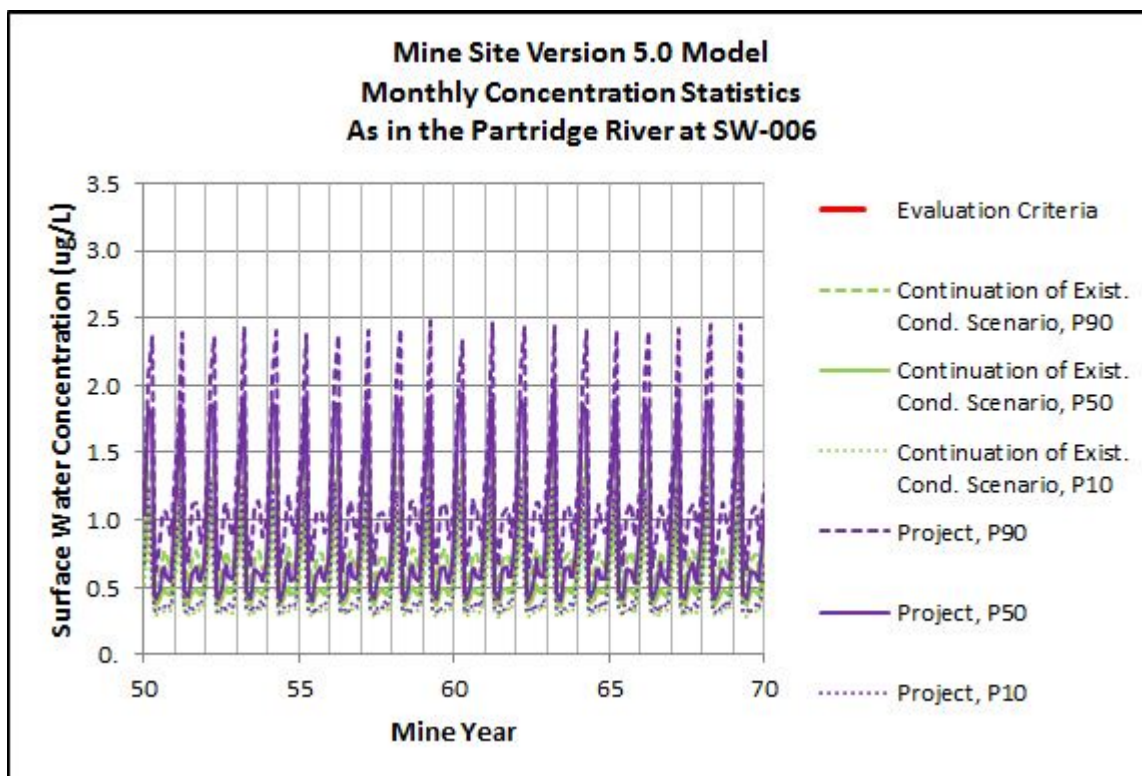
The water quality evaluation criterion for arsenic is 52 µg/L in the Partridge River, but drops to only 2 µg/L in Colby Lake because of its use as a drinking water source by the City of Hoyt Lakes. As Figure 5.2.2-35 indicates, the maximum P90 arsenic concentrations are predicted to be well below the evaluation criterion of 2.0 µg/L.



Source: Barr 2013f.

Figure 5.2.2-35 Colby Lake Annual Maximum Arsenic Concentrations

However, the predicted arsenic concentrations at the nearest evaluation location (SW-006) consistently show annual maximum P90 concentrations above 2 µg/L from year 40 onwards (i.e., when the West Pit would begin to overflow), with a predicted high concentration of 2.48 µg/L in year 59 (see Figure 5.2.2-36). These “elevated” concentrations at SW-006 (relative to the Colby Lake evaluation criteria) could raise concern for the potential of exceedances of the arsenic evaluation criterion in Colby Lake.



Source: Barr 2013f.

Figure 5.2.2-36 Partridge River SW-006 Annual Maximum Arsenic Concentrations

Closer review of the monthly predictions for arsenic concentrations at SW-006, however, show that these elevated concentrations above 2 $\mu\text{g/L}$ would only occur during the late winter, when Partridge River flows would be low (i.e., average flow at SW-006 in February and March of approximately 19 cfs) and would never occur for more than 2 consecutive months. Given that Colby Lake has a volume of approximately 5,000 acre ft, the residence time of these elevated arsenic concentrations during late winter flows would be over 4 months. Therefore, these low-flow/elevated concentrations of arsenic would essentially get blended with high-flow/lower concentrations of arsenic such that arsenic concentrations in Colby Lake are not predicted to exceed the 2 $\mu\text{g/L}$ evaluation criteria at the 90th percentile probability.

The primary NorthMet Project Proposed Action source of arsenic load to Colby Lake would be from the WWTF. PolyMet has assumed that effluent from the WWTF would have an arsenic concentration of 10 $\mu\text{g/L}$. In fact, the pilot-testing of the WWTP, using the same RO technology and greensand filter pretreatment as proposed for the WWTF, with influent arsenic concentrations similar to that expected as the West Pit, resulted in effluent arsenic concentrations of less than 1 $\mu\text{g/L}$ (Barr 2013g). The GoldSim model was re-run using a WWTF effluent concentration of 4 $\mu\text{g/L}$ (still well above the pilot-testing effluent concentration of less than 1 $\mu\text{g/L}$), which resulted in a maximum P90 concentration of arsenic at SW-006 of 1.87 $\mu\text{g/L}$, which is below the Colby Lake evaluation criteria of 2 $\mu\text{g/L}$. This arsenic concentration would be further diluted as it enters Colby Lake, and would therefore clearly meet the Colby Lake arsenic evaluation criterion (Barr 2013o).

Whitewater Reservoir

The NorthMet Project Proposed Action should have negligible effects on water quality in Whitewater Reservoir because only high Partridge River flows would be diverted into the reservoir from Colby Lake, which would coincide with the periods when any contaminants from the NorthMet Project Proposed Action would be diluted and because the water quality of Colby Lake is predicted to meet water quality standards, prior to dilution, except for the three parameters (i.e., aluminum, iron, and manganese) that are explained above.

Water Quality Effects in the Lower Partridge River

Although not specifically modeled, water quality in the Lower Partridge River would be expected to reflect the water quality condition of water flowing out of Colby Lake, which, as discussed above, is predicted under the NorthMet Project Proposed Action to meet all water quality evaluation criteria other than for aluminum, iron, and manganese, which are attributable to natural background conditions. The contaminant load in flow from Colby Lake attributable to the NorthMet Project Proposed Action would be further diluted downstream as the watershed area increases, and therefore would not be culpable for any exceedances of water quality evaluation criteria. The NorthMet Project Proposed Action would not result in any new surface water discharges (other than stormwater runoff from the processing plant area and Second Creek flow augmentation) or groundwater seepage that would affect the water quality of the Lower Partridge River that are not already reflected in predicted upstream water quality.

These contaminant loads from the NorthMet Project Proposed Action, however, could contribute to cumulative effects in combination with contaminant-loading from other projects. A review of the available surface water quality monitoring data for the Lower Partridge River indicates that the water quality of the Lower Partridge River is generally similar to that of Colby Lake except for significantly higher sulfate values (i.e., mean of 33.8 mg/L at Colby Lake versus 164 mg/L in the Lower Partridge River) at CR 110, which is significantly above the 10-mg/L evaluation criterion that is applicable to waters supporting the production of wild rice. The potential for the NorthMet Project Proposed Action to contribute to cumulative effects on sulfate concentrations in the Lower Partridge River, and further downstream in the St. Louis River, is discussed under Cumulative Effects (see Section 6.2.3.3).

Groundwater currently seeps from the existing LTVSMC Tailings Basin to the headwaters of Second Creek. Under the Cliffs Erie Consent Decree, this seepage is currently collected in a sump and pumped back to the Tailings Basin pond. Under the NorthMet Project Proposed Action, this seepage is predicted to continue during mine operations, reclamation, and closure. The NorthMet Project Proposed Action would install an engineered containment system south of the Tailings Basin designed to capture this seepage in closure (approximately 180 gpm), which would continue to be pumped to either the Tailings Pond or the WWTP. To mitigate the reduction of flow to Second Creek, under the NorthMet Project Proposed Action, WWTP effluent would be used to augment flow to Second Creek in closure at a flow rate equal to about 80 percent of the capture flow rate (or about 145 gpm). Since the effluent from the WWTP is designed to meet surface water quality standard, this discharge is not expected to cause any exceedance of water quality evaluation criteria.

NorthMet Project Proposed Action Solute Contribution Over Time

As discussed above, the NorthMet Project Proposed Action is predicted to meet all groundwater and surface water quality evaluation criteria at all evaluation locations for all mine phases (operations, reclamation, and closure). There is value, however, in understanding how the NorthMet Project Proposed Action would contribute to the solute load in the Partridge River over time.

The NorthMet Project Proposed Action would contribute solutes to the Partridge River from seven groundwater sources: Overburden Storage and Laydown Area, Ore Surge Pile, Category 2/3 Stockpile, WWTF equalization basins, East Pit, West Pit, and the Category 1 Stockpile (which provides seepage to the West Pit and the WWTF). As shown in Table 5.2.2-35, four of these sources are temporary and would not be present during closure. The loadings from these features would not occur after the feature is removed and the associated peak concentrations in groundwater reaching the Partridge River would occur before 200 years. The East Pit, West Pit, and Category 1 Stockpile are permanent features that would continue to provide solute-loading for a minimum of 200 years. Also contributing solutes to the Partridge River would be the WWTF effluent discharge, which would continue to operate during closure.

Table 5.2.2-35 Estimated Times for Affected Water to Reach the Partridge River

Source	Flow Rate from Source into Surficial GW Flowpath³ (gpm)	Time Period that Source is Active³ (Mine Year)	Time for Peak Loading at Partridge River⁴ (Mine Year)
Overburden Storage and Laydown Area	14.0	0 to 20	70 ⁽¹⁾
Ore Surge Pile	0.00116	0 to 21	165
Category 2/3 Stockpile	0.0194	0 to 20	55
WWTF leakage	0.0135	0 to 35	175
East Pit	3.75	21 onward	155
West Pit (receives seepage from Category 1 Stockpile)	6.09	33 onward	160
WWTF discharge ² (receives seepage from Category 1 Stockpile)	290	40 onward	40 onward

¹ For most constituents, source causes a concentration *decrease* in the flowpath; reported time is for *minimum* river loading.

² Discharge of WWTF effluent directly into the river.

³ Based on GoldSim deterministic run with P50 inputs.

⁴ Based on P50 results for GoldSim probabilistic run.

GW = Groundwater

The East Pit, Category 1 Stockpile, and the West Pit would be the only permanent mine features and would continue to contribute solute load to the surficial aquifer that eventually releases to the Partridge River. The small volume of seepage from the Category 1 Stockpile that would not be captured by the containment system would contribute solutes to the West Pit. This seepage would be expected to reduce in quantity over time as the Category 1 Stockpile geomembrane and vegetative cover is established, although concentrations are not expected to improve because most solutes are at their concentration caps.

The West Pit would also contribute solutes to the Partridge River via pit lake overflow. Under the NorthMet Project Proposed Action, the water levels and overflow would be controlled by water pumped to the WWTF for treatment. The WWTF is considered a long-term facility that would require ongoing care and maintenance.

The water quality of both mine pits, however, is predicted to improve over time as the pits become flooded, thereby effectively eliminating oxidation of the pit walls, the primary source of solutes, except for the upper few feet where water levels may fluctuate. Figures 5.2.2-37, 5.2.2-38, and 5.2.2-39 show how the water quality in the West Pit is predicted to improve over time for three representative solutes: cobalt, nickel, and sulfate. It is expected that eventually the solute concentrations in the pits would stabilize to more or less steady-state values, although the timeframe for this would likely be greater than 200 years as indicated by Figures 5.2.2-37 to 5.2.2-39, which show solute concentrations continuing to decrease at year 200, although still above water quality standards. These predicted improvements in water quality suggest that the WWTF may not need to operate permanently, but that at some point, non-mechanical treatment systems may be sufficient to meet water quality standards.

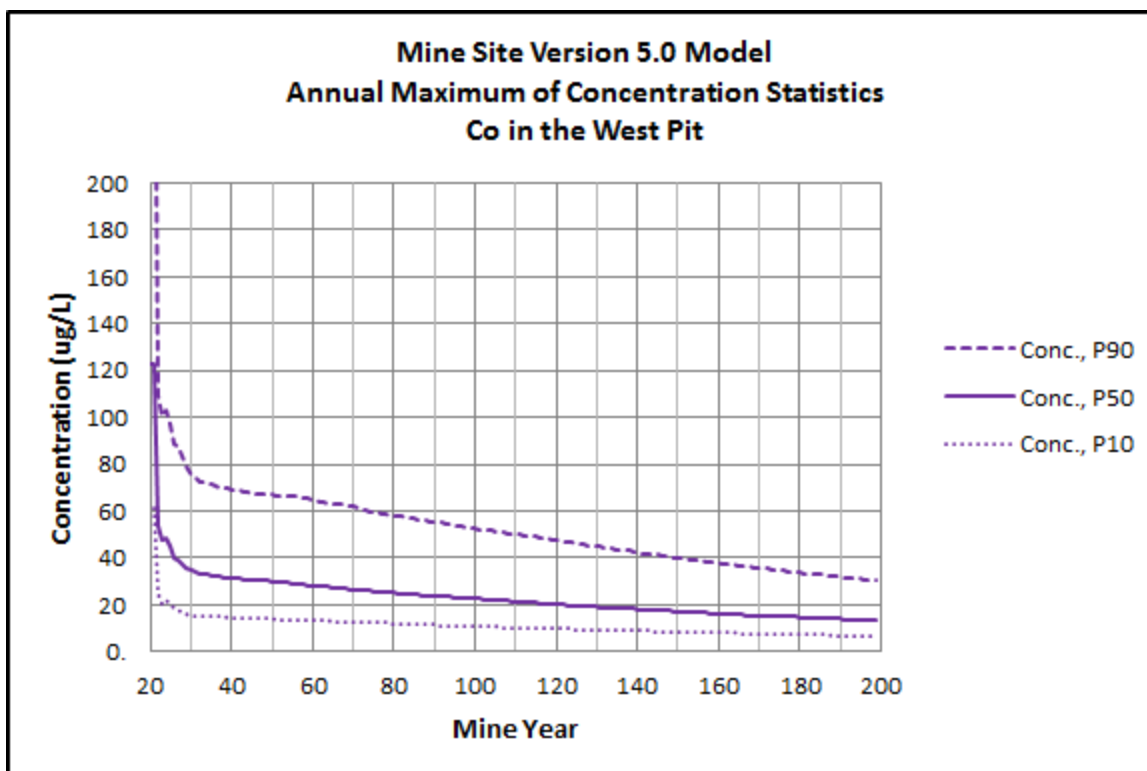


Figure 5.2.2-37 Maximum P90 Concentration of Cobalt in the West Pit over 200 Years

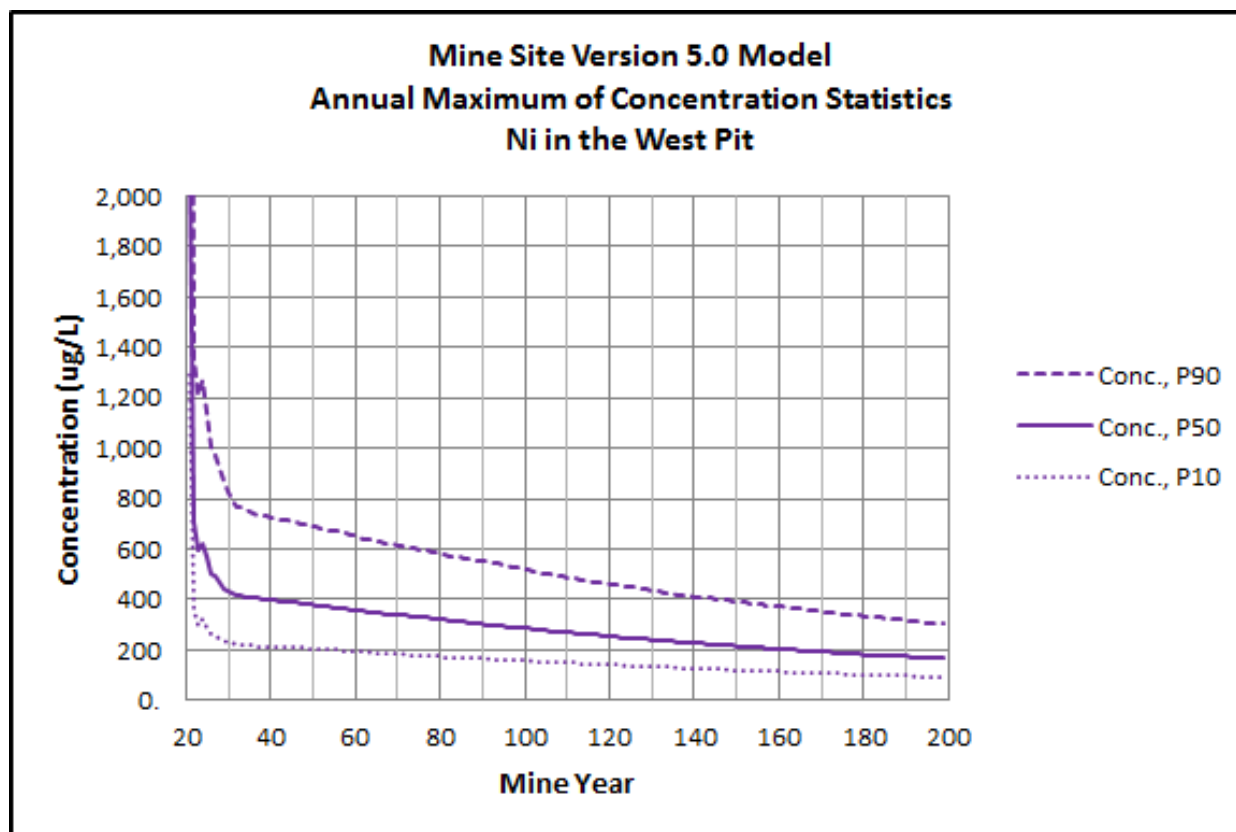


Figure 5.2.2-38 Maximum P90 Concentration of Nickel in the West Pit over 200 Years

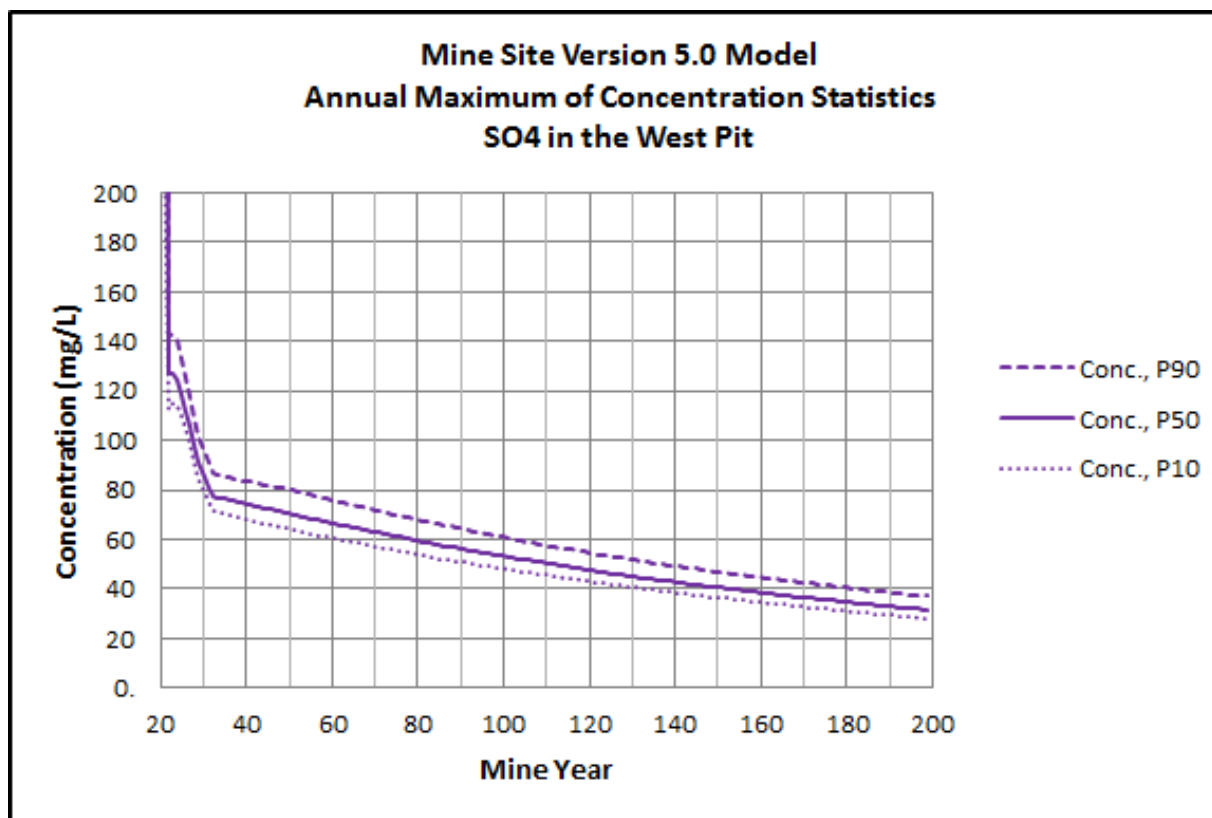


Figure 5.2.2-39 Maximum P90 Concentration of Sulfate in the West Pit over 200 Years

The only long-term sources of solutes from the NorthMet Project Proposed Action would be groundwater seepage from the East Pit and West Pit (which includes Category 1 Stockpile seepage), with a combined total flow rate of about 10 gpm and the WWTF effluent discharge of about 290 gpm.

5.2.2.3.3 Embarrass River Watershed

This section discusses environmental effects of the NorthMet Project Proposed Action on groundwater and surface water hydrology and quality within the Embarrass River watershed. The only solute-generating NorthMet Project Proposed Action features in the Embarrass River Watershed are the Tailings Basin, the WWTP and tributary streamflow augmentation, and the Hydrometallurgical Residue Facility.

The Hydrometallurgical Residue Facility would have a double geomembrane liner with a leachate collection system between the liners. The amount of water pumped from the leak collection system would be monitored on a long-term basis. If the amount of pumpage were to increase or if there were any other indications of increased leakage, appropriate repairs and mitigation measures would be undertaken. For these reason, it is assumed that the leakage from this facility into underlying groundwater or adjacent surface water would be negligible and this potential effect is not discussed further.

The groundwater and surface water in the Embarrass River Watershed could be affected by seepage from the Tailings Basin, flow augmentation, and WWTP effluent discharges. These

potential hydrologic and contaminant sources and their predicted effects on groundwater and surface water hydrology and quality are evaluated below.

Effects on Groundwater Hydrology

This section discusses the environmental consequences of the NorthMet Project Proposed Action on groundwater hydrology within the Embarrass River Watershed, specifically from the Tailings Basin and associated engineering controls. There are no other NorthMet Project area facilities within the Embarrass River Watershed that would affect groundwater hydrology.

As discussed in Section 4.2, PolyMet proposes to reuse the existing LTVSMC Tailings Basin. Seepage from the existing LTVSMC Tailings Basin has decreased since LTVSMC operations stopped in 2001, reaching a current steady state of approximately 2,020 gpm to the Embarrass River Watershed. Once the seepage reaches the toe of the Tailings Basin, it divides between flow that remains as groundwater (referred to as groundwater seepage) and flow that exceeds the hydraulic capacity of the aquifer and upwells to the surface (referred to as surface seepage). Under existing conditions, about 209 gpm of Tailings Basin seepage remains as groundwater and about 1,811 gpm upwells to the surface and ultimately contributes to surface water flow in several of the Embarrass River tributaries: Mud Lake Creek, Trimble Creek, and Unnamed Creek (PolyMet 2013j).

Groundwater seepage from the Tailings Basin flows in three flowpaths to the Embarrass River identified as the North, Northwest, and West flowpaths (see Figure 5.2.2-6). Little groundwater would flow to the east because of high bedrock elevations, and essentially all of the groundwater that flows south toward Second Creek in the Partridge River Watershed would be captured and pumped back into the Tailings Basin.

The addition of tailings and changes in water management due to the NorthMet Project Proposed Action would result in increased seepage from the Tailings Basin relative to existing legacy LTVSMC seepage. As Table 5.2.2-36 indicates, seepage is predicted to increase from the current approximately 2,020 gpm to approximately 3,380 gpm during operations. Most of this seepage would travel to the north, northwest, and west of the Tailings Basin and could affect groundwater levels in those areas.

Table 5.2.2-36 NorthMet Project Proposed Action Tailings Basin Seepage (gpm) During Operations

Flowpath	Continuation of Existing Conditions Scenario			NorthMet Project Proposed Action				Ground-water Flow Bypassing Containment System
	Tailings Basin Seepage	Ground-water Seepage	Surface Seepage	Tailings Basin Seepage	Ground-water Seepage	Surface Seepage	Containment System	
North Flowpath	870	44	826	1,990	44	1,946	1,986	4
Northwest Flowpath	610	55	555	770	55	715	764	6
West Flowpath	540	110	430	620	110	510	609	11
Total	2,020	209	1,811	3,380	209	3,171	3,359	21

Source: Barr 2013j.

The NorthMet Project Proposed Action would increase Tailings Basin seepage rates by 67 percent and increase surface seepage by about 75 percent. The hydraulic capacity of the surficial aquifer would not change. This increase in upwelling could have a significant effect on downgradient wetlands and waterways. Therefore, PolyMet proposed that the groundwater containment system would wrap around the northeast, north, and west sides of the Tailings Basin. This system is designed to capture 100 percent of the surface seepage and 100 percent of the groundwater seepage, but is modeled to collect 100 percent of surface seepage and 90 percent of the groundwater seepage to account for less-than-perfect construction of the cutoff wall at the bedrock. As Table 5.2.2-37 indicates, the net effect of the groundwater containment system would be to decrease groundwater seepage from the Tailings Basin downgradient of the containment system from approximately 209 to 21 gpm. This decrease in groundwater seepage would be mitigated by a proposed flow augmentation program, which is described later in this section.

As Table 5.2.2-37 below indicates, seepage from the Tailings Basin to the Embarrass River watershed is predicted to decrease from the estimated current rate of 2,020 gpm to about 1,320 gpm at closure under the NorthMet Project Proposed Action (about a 35 percent decrease). The groundwater containment system would remain in place, which would capture all but an estimated 21 gpm of Tailings Basin seepage. The decrease in groundwater seepage would not be expected to have a significant effect on groundwater or wetlands downgradient of the groundwater containment system because of the proposed flow augmentation, which would maintain hydrology within 20 percent of existing conditions. There would be sufficient natural recharge to maintain saturation in the surficial (unconsolidated) unit. The effects of the containment system on surface water hydrology are discussed later in this section.

Table 5.2.2-37 NorthMet Project Proposed Action Tailings Basin Seepage during Closure

Flowpath	Continuation of Existing Conditions Scenario			NorthMet Project Proposed Action				
	Tailings Basin Seepage ¹	Ground-water Seepage ¹	Surface Seepage ¹	Tailings Basin Seepage ¹	Ground-water Seepage ¹	Surface Seepage ¹	Containment System ¹	Ground-water Flow Bypassing Containment System ¹
North Flowpath	870	44	826	550	44	506	546	4
Northwest Flowpath	610	55	555	440	55	385	434	6
West Flowpath	540	110	430	330	110	220	319	11
Total	2,020	209	1,811	1,320	209	1,111	1,299	21

Source: Barr 2013j.

¹ All units are gpm.

Effects on Groundwater Quality

The NorthMet Project Proposed Action could affect surficial groundwater quality within the Embarrass River watershed by leaching metals, sulfate, and other solutes from the NorthMet Tailings Basin. Most seepage from the Tailings Basin would flow along the North, Northwest, and West flowpaths towards the Embarrass River and would affect downgradient groundwater quality. Several sources contribute solutes to the Tailings Basin, including both the existing LTVSMC tailings and NorthMet Project Proposed Action tailings themselves, Mine Site process water (which could be pumped to the Tailings Basin through year 11, and possibly through year 20 depending on the NorthMet Project Proposed Action water budget), Colby Lake makeup water, and a negligible amount of watershed runoff. The contribution from the Mine Site would be influenced by the predictions of stockpile leachate and mine pit water quality and the ability of the WWTF to achieve design effluent concentrations prior to pumping to the Tailings Basin. Groundwater would also be the primary pathway for transporting contaminants from the Tailings Basin and is thus a critical component in the model for estimating effects on surface water.

These solutes can be released from tailings by direct dissolution of minerals, but solutes of concern are primarily released by oxidation of sulfide minerals in the tailings. The oxidation rate in tailings, and thus the rate of solute release, is typically limited by the rate that atmospheric oxygen can diffuse into the facility. The diffusion of oxygen and the rate of oxidation and associated solute release would depend strongly on the porosity of the tailings and their moisture content, where higher moisture content corresponds to lower rates of oxygen diffusion and associated oxidation and contaminant release. Thus, the unsaturated tailings in the embankment and beach areas are expected to have higher oxidation rates than the saturated tailings below the pond.

Pilot-testing resulted in average sulfur concentrations in the NorthMet tailings of 0.12 percent, which is low enough to ensure that they would never produce acidic leachate as they weathered. Pore water metal concentrations could increase dramatically if pH were to decrease, especially for nickel and cobalt (SRK 2007c). The oxyanions (arsenic, antimony, and selenium), however, tend to have increasing solubility with higher pHs.

Testing of tailings containing 0.2 percent sulfur by the MDNR from the nearby Babbitt prospect within the Duluth Complex did not result in acidic leachate because silicate weathering was sufficient to neutralize the acid produced. Humidity cell test results for NorthMet Project Proposed Action tailings have tended to support the research by the MDNR and the results from the Babbitt Deposit (Day 2009). Leachate showed an initial decline in pH, but has subsequently remained between 6.0 and 7.8 with no trend toward lower pHs.

Solutes released by oxidation (primarily sulfate and metals) would be flushed from the tailings by percolating water. The rate of percolation would depend on the surface properties and precipitation. The seepage from the NorthMet Project Proposed Action tailings would pass through the underlying existing LTVSMC tailings (i.e., previous taconite tailings). These underlying tailings may attenuate metals leached from the NorthMet Project Proposed Action tailings, and/or may contribute additional solutes to seepage.

The Tailings Basin pond would primarily receive solute loadings from the tailings, treated Mine Site process water (primarily during years 1 to 11, and possibly through year 20, depending on the NorthMet Project Proposed Action water budget), and captured seepage from the groundwater containment system. The Tailings Basin pond, in turn, would become a primary source of contaminants as its water seeps into the tailings. Therefore, the composition of the Tailings Basin pond, which would be a permanent feature of the Tailings Basin, would be an important component in the quality of water that would be discharged from the Tailings Basin. Thus, PolyMet proposes to use the WWTP to treat the pond water during reclamation, and as necessary during closure, to maintain the design water level and prevent overflow. The presence of the pond in closure would provide benefits as it would create a saturated layer that would permanently reduce the oxygen flux and associated solute release in the underlying tailings.

Engineering Controls

PolyMet does not propose to line the Tailings Basin, nor is the existing LTVSMC Tailings Basin lined. In lieu of a liner, PolyMet proposes three engineering controls to reduce the release and transport of solutes from the Tailings Basin (see Figure 5.2.2-40):

- the Tailings Basin groundwater containment system;
- bentonite amendment of the tailings dam as it is constructed, and bentonite amendment of the Tailings Basin beach and pond during reclamation, to reduce subsequent oxygen flux and water percolation; and
- mechanical treatment of the Tailings Basin pond water and collected tailings seepage by the WWTP.

Tailings Basin Groundwater Containment System

The groundwater containment system would be installed prior to plant operations and would consist of a groundwater collection system along the outside perimeter of the Tailings Basin where seepage has the potential to enter the surficial aquifer (see Figure 3.2-28). The design includes a hydraulic barrier (cutoff wall) that would be keyed into bedrock, with a collection trench and drain pipe installed on the upgradient side (see Figure 3.2-29). The trench and piping would convey the collected seepage to two pumping stations, which would pump the seepage during operations to either the Tailings Basin pond for reuse, or any excess seepage to the

WWTP for treatment prior to discharge. The groundwater containment system would continue to operate during reclamation and closure, although in those phases, the seepage could not be reused as process water, but would be treated at the WWTP and used to accelerate filling of the West Pit (during reclamation) and for streamflow augmentation (during closure). Although it is designed to capture all of the Tailings Basin seepage, the groundwater containment system is assumed to capture 90 percent of the groundwater flow that approaches the system (PolyMet 2013g).

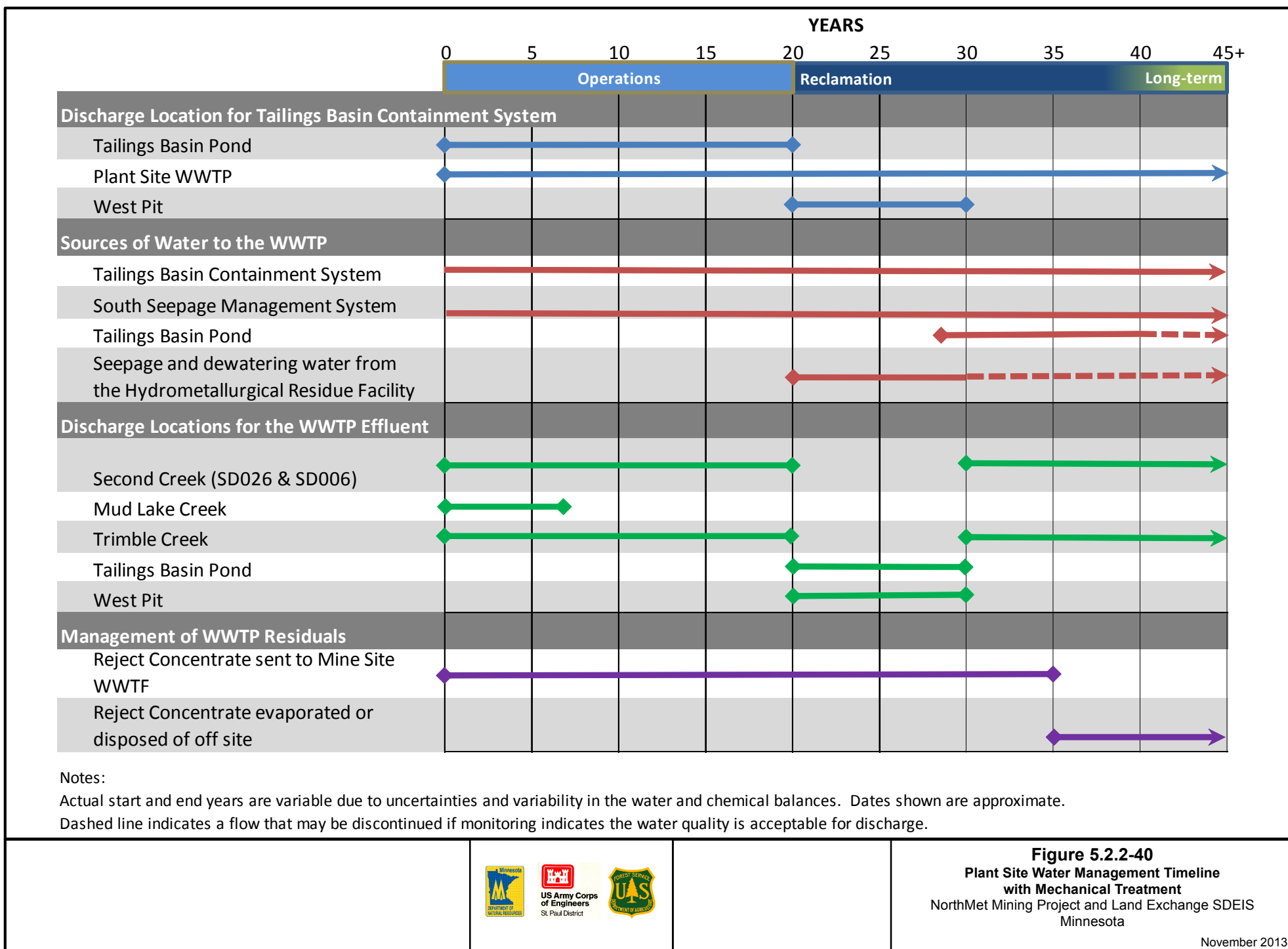
Wastewater Treatment Plant

PolyMet proposes a WWTP to treat water in the tailings pond and tailings seepage collected by the groundwater containment system. The WWTP would treat water throughout the entire mine life (operations, reclamation, and closure). The WWTP would essentially treat all Tailings Basin seepage except for the small quantity (i.e., 21 gpm on average) that would bypass the groundwater containment system. The WWTP would discharge treated effluent to augment streamflow during operations (about 1,574 gpm at representative year 10) and closure (2,020 gpm). During reclamation, the WWTP effluent would be pumped to the West Pit to accelerate flooding. The level of water treatment at the WWTP (including RO) would be designed to be sufficient to meet surface water evaluation criteria.

Bentonite-amended Tailings Cover

For the NorthMet Project Proposed Action during operations, PolyMet would cover the tailings dam embankments with a 12-inch-thick bentonite-amended soil layer, as allowed by construction activities. On top of the bentonite-amended layer would be an 18-inch-thick vegetated soil cover. After operations cease in year 20, PolyMet would place a similar two-layer cover on top of the dry tailings beaches. The objective of the cover system would be to 1) reduce infiltration of meteoric water and 2) maintain the bentonite layer at or above 90 percent saturation so that it would operate as a barrier for oxygen diffusion into the tailings.

PolyMet would also place a bentonite layer at the bottom of the tailings pond to reduce downward percolation of pond water into the tailings. The thickness and effective hydraulic conductivity of the bentonite layer would be designed to achieve a pond seepage flux of 6.5 in/yr or less.



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Groundwater Transport and Evaluation Locations

Groundwater seepage flow away from the Tailings Basin towards the Embarrass River is tracked in three groundwater surficial flowpaths: North, Northwest, West (see Figure 5.2.2-6). Within each flowpath is a groundwater evaluation location, coincident with the property boundary, along which predicted solute concentrations are compared to the groundwater evaluation criteria to assess potential effects. Because solute effects on surface water are of interest, the solute concentrations at locations where groundwater releases to surface water (generally at or close to the Embarrass River) are also tracked in the model because it helps to interpret the surface water chemistry in the Embarrass River and its tributary streams.

For the North, Northwest, and West Surficial flowpaths, the time at which contaminants leached from the Tailings Basin would begin to affect water quality at their respective evaluation locations depends on the following variables:

- Time at which affected water would seep past the Tailings Basin groundwater containment system. GoldSim conservatively assumes that 10 percent of the approaching groundwater would bypass the system and this would begin at time zero.
- The rate at which contaminants would move in groundwater would be the same as the groundwater seepage velocity downgradient of the containment system for all but four constituents (arsenic, antimony, copper, and nickel). Note that this velocity would increase in the downgradient direction due to meteoric recharge that would add flow to the groundwater system. Transport of the four attenuated constituents would be 10 to 100 times slower than the groundwater flow because of sorption.
- The distance between the location of solute release (Tailings Basin containment system) and the flowpath evaluation location.
- The effects of hydrodynamic dispersion, which tends to spread out the leading edge of the solute plume.

If the effects of hydrodynamic dispersion were neglected, a solute plume would migrate as a “sharp front” with an associated travel time to the evaluation location. Table 5.2.2-11 presents the calculated sharp-front travel times of non-attenuated constituents to the evaluation location in each flowpath based on deterministic and P50 inputs. Also listed are the sharp-front travel times to the location of groundwater release to surface water. Depending on the flowpath, sharp-front travel times to the evaluation locations would range from 193 to 242 years. Travel times to the locations of groundwater release to surface water would be about 300 years for each flowpath.

While the solute travel times provided in Table 5.2.2-11 are useful index values, the effects of dispersion and variable (probabilistic) inputs would need to be considered for a more detailed evaluation of solute effects on groundwater.

To ensure that the water quality modeling would identify the potential effects on groundwater and surface water, a 500-year GoldSim probabilistic (Monte Carlo) simulation was performed. Lead was used to illustrate groundwater transport at the Plant Site because it is not attenuated and would enter the surficial flowpaths at concentrations higher than baseline groundwater. As a consequence, the movement of solute fronts associated with this constituent is readily discernible on concentration-versus-time and concentration-versus-distance plots for the modeled flowpaths. Transport of other non-attenuated solutes should be similar to lead, but the change in

concentrations is not always as visually noticeable as it is for lead. Based on the GoldSim results, P90 lead concentrations at the evaluation locations and at locations where groundwater would release to surface water are shown on Figures 5.2.2-41a and 5.2.2-41b, respectively.

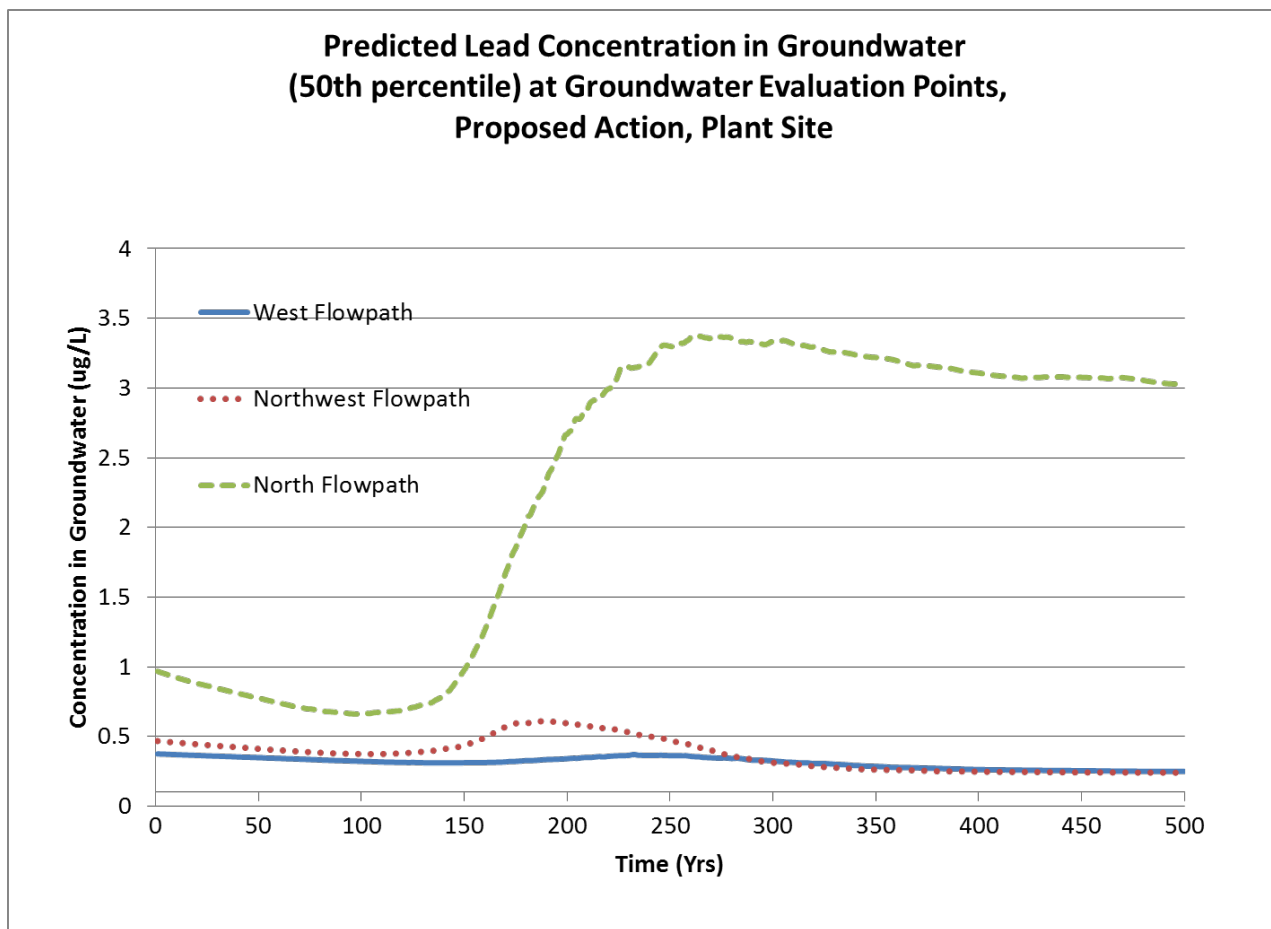


Figure 5.2.2-41a *Predicted P50 Lead Concentrations at the Evaluation Locations Based on the GoldSim Probabilistic Simulation for the Plant Site*

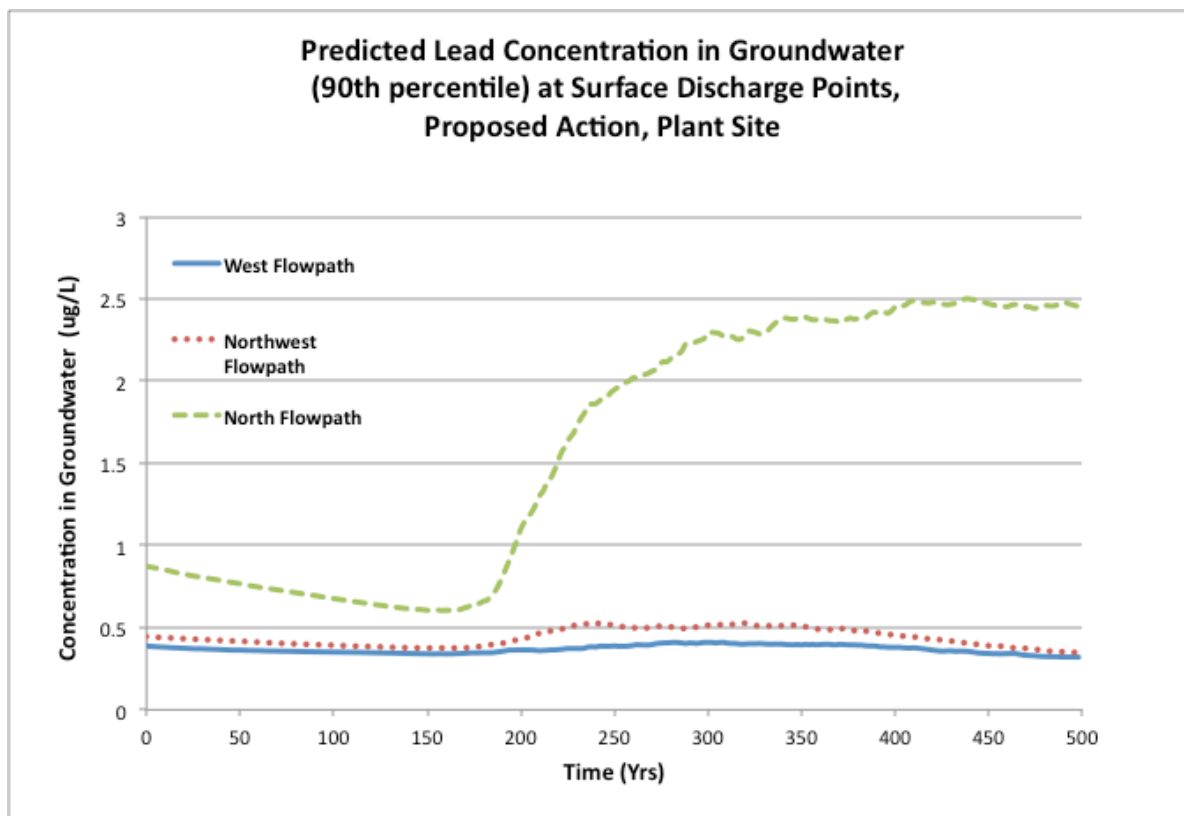


Figure 5.2.2-41b *Predicted P90 Lead Concentrations at the Locations of Groundwater Release to Surface Water Based on the GoldSim Probabilistic Simulation for the Plant Site*

Surficial Groundwater Quality at the Evaluation Locations

Results of a 500-year GoldSim water quality modeling simulation (provided by Barr Engineering) were reviewed for all 28 solutes at all three surficial flowpath evaluation locations. A screening process was used to identify any constituents and locations that warranted a more robust examination because of potential exceedances of water quality evaluation criteria. The screening process involved comparing the maximum P90 water quality prediction from among the 6,000 months covered by the simulation (i.e., 12 months times 500 years) for each constituent at each of the three evaluation locations. These NorthMet Project Proposed Action modeled values were compared with both Continuation of Existing Conditions Scenario modeled values and the evaluation criteria discussed previously. Each contaminant that was identified as exceeding the numerical evaluation criteria was then evaluated in more detail to understand the details and context of the potential exceedance.

The screening of maximum P90 groundwater concentrations of all modeled solutes indicated that across all three flowpaths, the NorthMet Project Proposed Action would not cause or increase the exceedances of the evaluation criterion for any solute at the maximum P90 level. Table 5.2.2-38 presents the maximum P90 values for the NorthMet Project Proposed Action and the Continuation of Existing Conditions Scenario in comparison with the evaluation criteria. Figure 5.2.2-42 illustrates the range of model predictions for each solute (minimum P10 to maximum

P90 values) over the 500-year simulation. Figure 5.2.2-43 illustrates the relative change between the NorthMet Project Proposed Action and Continuation of Existing Conditions Scenario maximum P90 values. If the values were the same, the relative change ratio would be 1; values greater than 1 indicate the ratio at which the NorthMet Project Proposed Action would result in an increase in solute concentrations relative to Continuation of Existing Conditions Scenario. Conversely, values less than 1 indicate the ratio at which the NorthMet Project Proposed Action would result in a decrease in solute concentrations relative to Continuation of Existing Conditions Scenario.

The only solute that would exceed an evaluation criterion is fluoride, along the North Flowpath, where the maximum P90 concentration of 3.1 mg/L would exceed the 2 mg/L sMCL, but would remain below the 4 mg/L pMCL. This exceedance would not be attributable to the NorthMet Project Proposed Action because the highest concentration would occur in the initial time step (year 1). Therefore, the NorthMet Project Proposed Action would not increase concentrations relative to the Continuation of Existing Conditions Scenario, and in fact, concentrations are predicted to decrease under the NorthMet Project Proposed Action. Although the GoldSim results do not show any exceedances of groundwater quality evaluation criteria, a more detailed discussion of TDS is warranted and provided below.

Table 5.2.2-38 *Maximum P90 Concentrations over 500-year Model Simulation Period at All Groundwater Evaluation Points along Modeled Flowpaths in the Plant Site Surficial Aquifer (NorthMet Project Proposed Action)*

Parameter	Ground-water Evaluation Criterion ¹		North Flowpath at Property Boundary		North Flowpath before MLC ²		Northwest Flowpath at Property		Northwest Flowpath before TC ¹		West Flowpath at Property		West Flowpath before Embarrass River	
		Units	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario
General														
Alkalinity	NA	mg/L	196	197	150	150	187	188	143	144	165	165	142	142
Calcium	NA	mg/L	39.3	39.4	34.8	34.9	62.5	63.0	47.9	48.1	58.1	58.1	49.6	49.6
Chloride	250	mg/L	18.2	18.3	13.9	14.0	18.2	18.5	13.8	14.0	16.1	16.2	13.5	13.7
Fluoride	2	mg/L	3.1	3.1	2.3	2.3	1.2	1.3	1.0	0.97	0.82	0.82	0.70	0.70
Hardness	NA	mg/L	294	295	216	216	501	505	328	331	436	437	341	342
Magnesium	NA	mg/L	47.7	47.9	31.3	31.5	84.1	84.7	50.8	51.5	70.9	71.1	53.0	53.1
Potassium	NA	mg/L	6.3	6.3	4.4	4.4	6.0	6.0	4.1	4.1	5.2	5.2	4.2	4.2
Sodium	NA	mg/L	36.7	36.9	21.9	22.0	31.5	31.6	19.3	19.3	24.1	24.2	18.2	18.2
Sulfate	250	mg/L	158	170	118	122	204	230	150	163	193	218	159	172
Metals														
Aluminum	NA	µg/L	78.7	45.2	86.4	62.4	78.6	45.5	87.2	62.2	84.1	54.2	78.6	62.5
Antimony	6	µg/L	0.32	0.31	0.33	0.33	0.28	0.28	0.31	0.30	0.30	0.29	0.30	0.30
Arsenic	10	µg/L	3.6	3.6	2.8	2.8	1.8	1.8	1.4	1.4	1.4	1.4	1.3	1.3
Barium	2000	µg/L	172.1	174	143.2	144	82.3	82.8	82.2	82.5	78.8	73.5	75.0	75.0
Beryllium ²	0.49	µg/L	0.30	0.24	0.30	0.26	0.30	0.24	0.30	0.26	0.30	0.25	0.30	0.25
Boron	1000	µg/L	262	268	200	204	355	376	266	278	329	337	274	277
Cadmium	4	µg/L	0.36	0.15	0.22	0.15	0.19	0.17	0.17	0.16	0.17	0.17	0.15	0.15
Chromium	100	µg/L	1.6	0.81	1.3	0.94	1.2	0.85	1.2	0.98	1.1	0.92	1.1	0.97
Cobalt	NA	µg/L	4.4	1.6	1.7	1.1	1.6	2.9	1.2	1.9	1.6	2.7	1.3	2.1
Copper	NA	µg/L	2.7	2.7	3.2	3.2	2.9	2.9	3.3	3.3	3.1	3.1	3.4	3.4
Iron	NA	µg/L	1,149	1,350	852	946	2,436	2,803	1,782	1,968	2,389	2,729	1,958	2,147
Lead	NA	µg/L	5.8	1.1	2.5	0.87	1.1	0.56	0.53	0.46	0.58	0.46	0.41	0.40
Manganese ²	1,506	µg/L	759	522	722	575	1,033	1,197	925	977	1,043	1,165	962	1,026
Nickel	100	µg/L	4.3	4.2	5.1	5.0	4.9	4.8	5.5	5.5	5.3	5.2	5.5	5.5
Selenium	30	µg/L	1.3	0.81	1.2	0.95	1.1	0.80	1.1	0.93	1.1	0.87	1.1	0.88
Silver	30	µg/L	0.09	0.11	0.08	0.09	0.07	0.11	0.07	0.09	0.07	0.10	0.07	0.09
Thallium ²	0.6	µg/L	0.17	0.19	0.17	0.18	0.17	0.18	0.17	0.17	0.17	0.18	0.16	0.17
Vanadium	50	µg/L	5.7	5.0	5.7	5.3	5.2	3.7	5.5	4.6	5.3	4.0	5.4	4.4
Zinc	2000	µg/L	32.4	16.5	25.9	18.9	22.7	13.4	22.5	17.1	21.6	15.0	21.0	16.7

Source: Barr 2013f.

¹ References for the groundwater evaluation criteria are summarized in Table 5.2.2-1; concentrations that exceed the evaluation criteria are in italics.
² Beryllium, manganese, and thallium (Mine Site bedrock unit only). The evaluation criterion differs by location based on background water quality (see Table 5.2.2-1).

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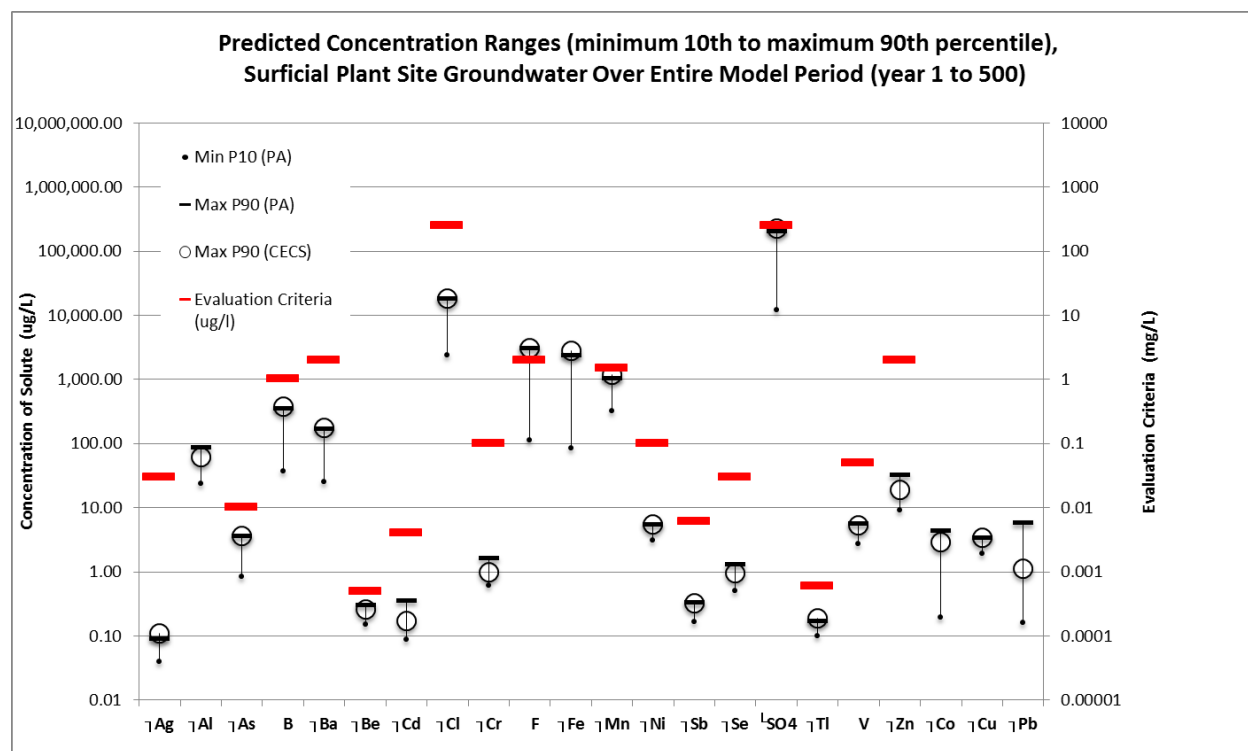


Figure 5.2.2-42 *Predicted Groundwater Concentration Ranges (Minimum 10th to Maximum 90th Percentile) at All Plant Site Surficial Groundwater Evaluation Locations Based on the GoldSim Probabilistic Model*

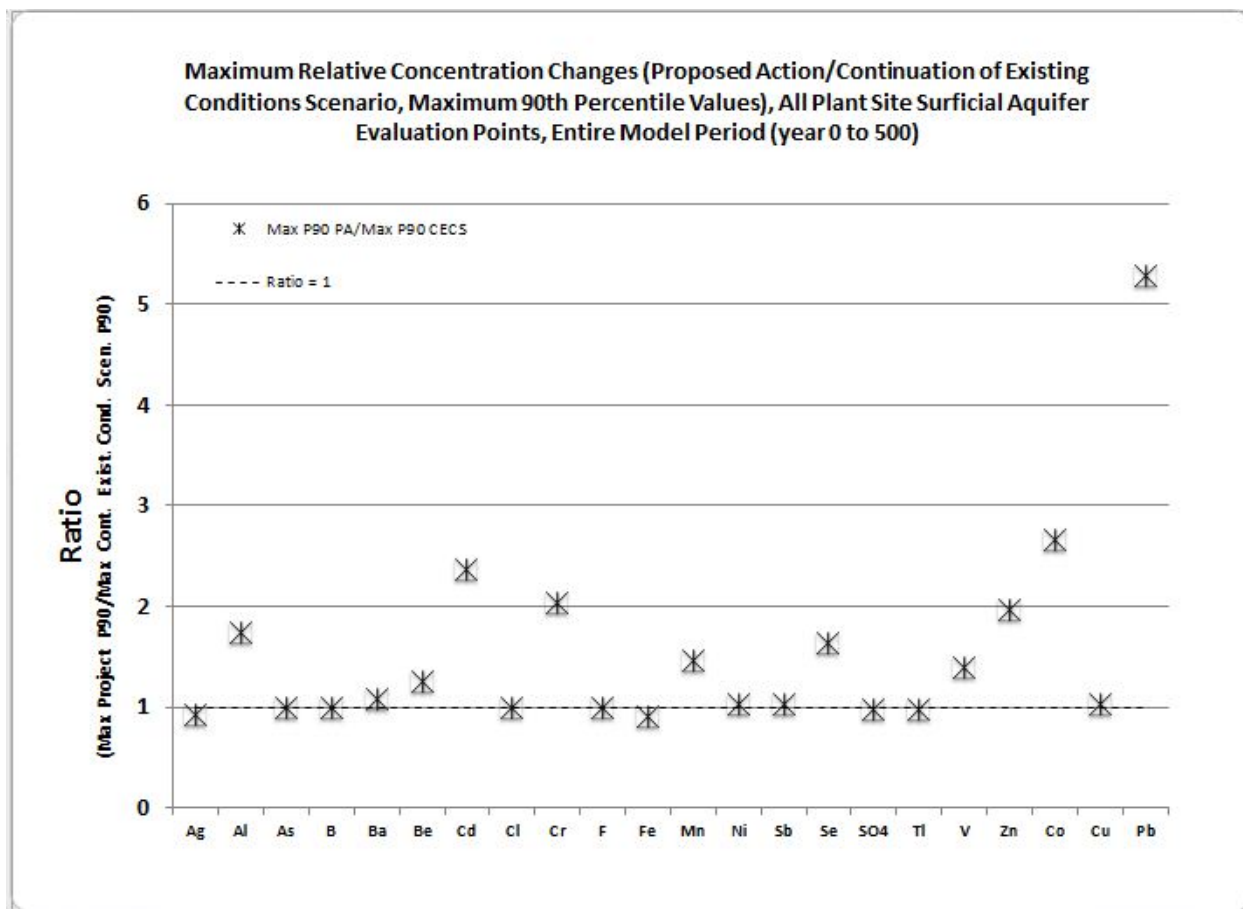


Figure 5.2.2-43 **Maximum Relative Concentration Changes (NorthMet Project Proposed Action/Continuation of Existing Conditions Scenario) at Surficial Aquifer Evaluation Locations, Entire Model Period**

Total Dissolved Solids

The water quality evaluation criteria include TDS for groundwater (500 mg/L, Table 5.2.2-2), but the NorthMet Project Proposed Action water-quality model did not directly model TDS. TDS can be indirectly estimated by summing instantaneous concentrations of each of the eight constituents that comprise TDS (i.e., alkalinity, calcium, chloride, fluoride, magnesium, potassium, sodium, and sulfate). PolyMet conducted modified simulations that calculated P90 values for TDS at each model time step based on the sum of the concentrations of these major ions predicted in the GoldSim Plant Site model. This analysis shows that estimated TDS concentrations would initially exceed the evaluation criteria for all three Tailings Basin flowpaths (e.g., see Figure 5.2.2-44 for the West Flowpath).

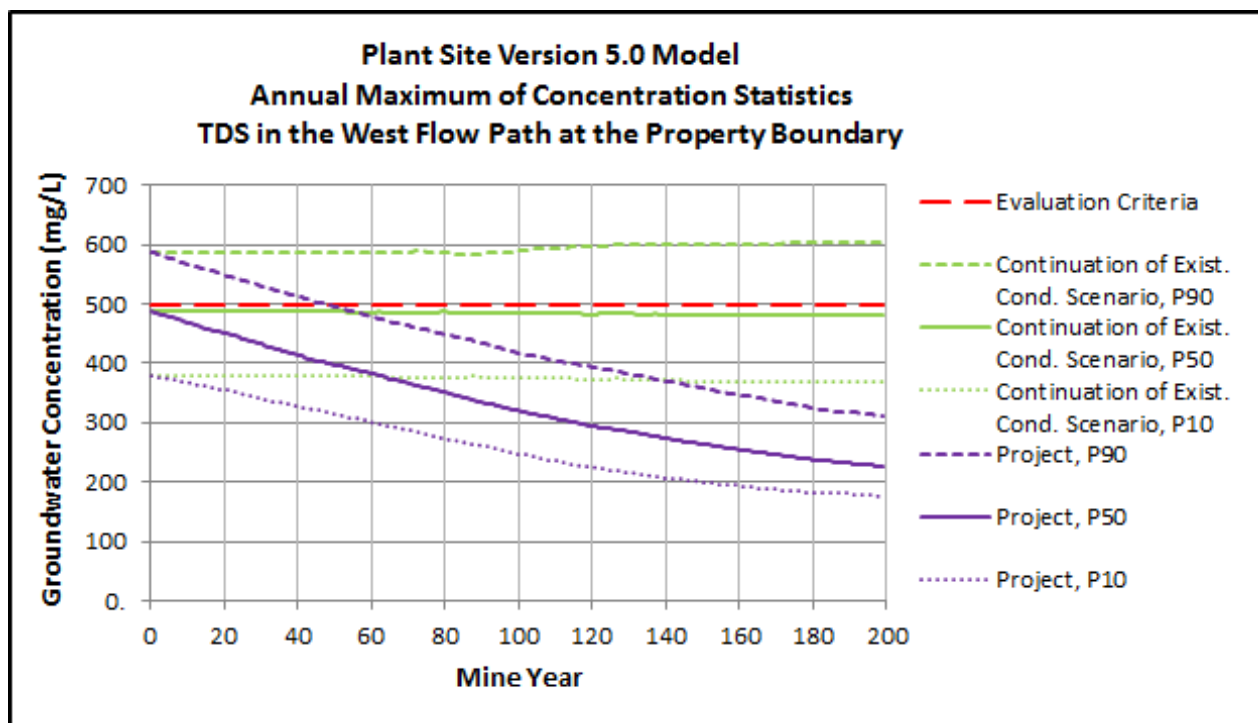


Figure 5.2.2-44 *Total Dissolved Solids Estimates in the West Flowpath at the Property Boundary*

Upon closer examination, however, it is clear that the exceedances only occur in the early model years (years 0 to approximately 55) and are a result of elevated baseline TDS concentrations that are also reflected in the Continuation of Existing Conditions Scenario model predictions for all three flowpaths. In each case, the predicted TDS concentrations would decrease from year 0 such that all three flowpaths are predicted to eventually meet the P90 TDS evaluation criteria (i.e., year 10 for the North Flowpath, year 50 for the West Flowpath, and year 55 for the Northwest Flowpath). This decrease in TDS concentrations over time would be attributable to the NorthMet Project Proposed Action groundwater containment system, which would be designed to capture at least 90 percent of the groundwater flowing from the Tailings Basin, including existing seepage from the existing LTVSMC tailings that are responsible for the baseline TDS exceedances.

The NorthMet Project Proposed Action would not cause or increase an exceedance of the evaluation criteria and is predicted to reduce TDS concentrations and eventually meet groundwater evaluation criteria.

Effects on Surface Water Hydrology in the Embarrass River Watershed

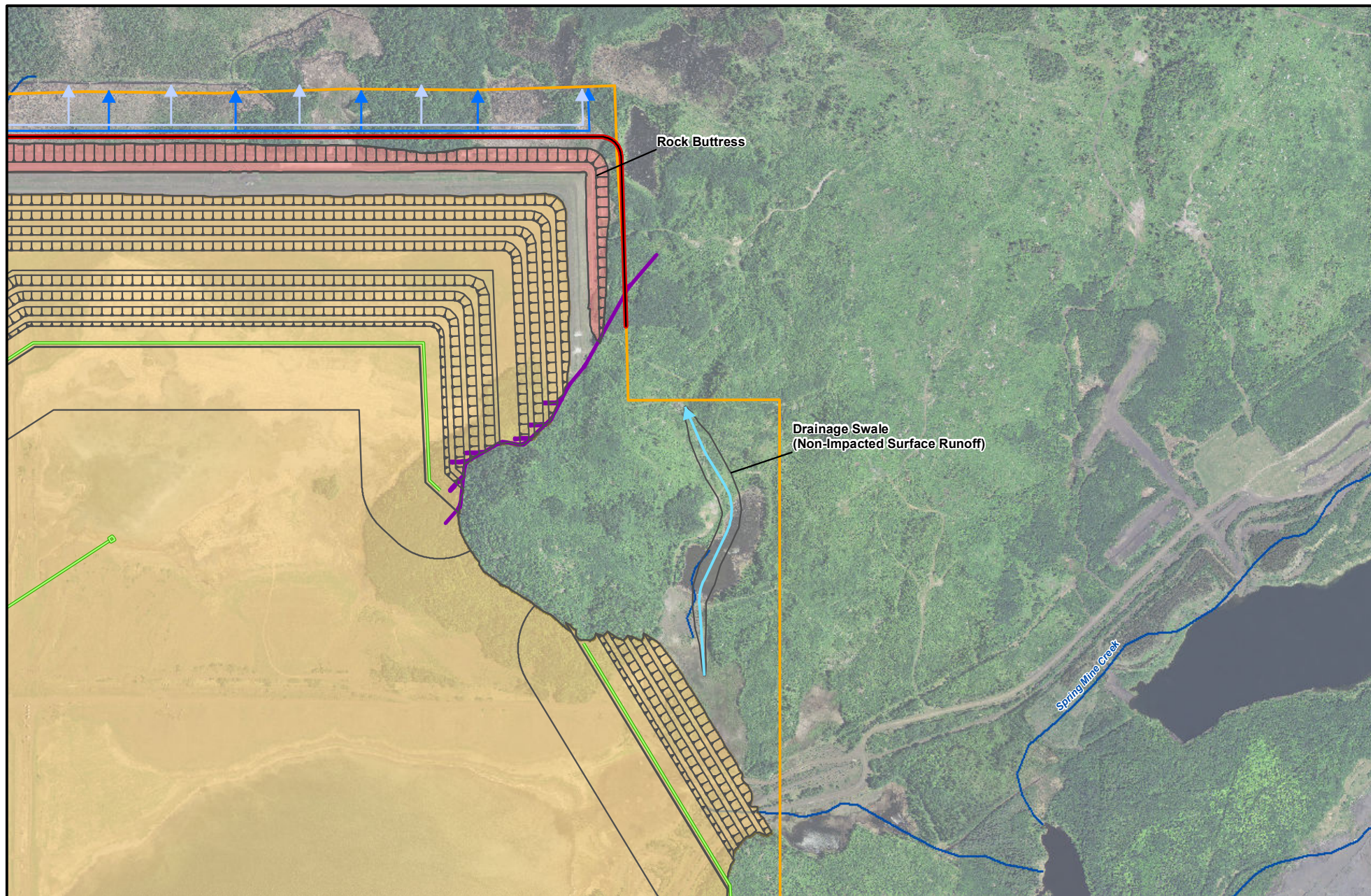
This section describes the effects of the NorthMet Project Proposed Action on the surface water hydrology of the Embarrass River and its tributaries. The effects of the NorthMet Project Proposed Action on surface water hydrology, especially in the three tributary streams draining the Tailings Basin (i.e., Mud Lake Creek, Trimble Creek, and Unnamed Creek) are complex, as some project features/engineering controls would tend to increase flows while others would decrease flows and change over time. For example, during mine operations, the NorthMet Project Proposed Action would increase seepage from the Tailings Basin as a result of tailings deposition, but most of this seepage would be captured by the groundwater containment system; this reduction in flow would, in turn, be mitigated by the proposed Embarrass River tributary streamflow augmentation. The NorthMet Project Proposed Action would also slightly modify some watershed areas within the Embarrass River, which would affect streamflows. These NorthMet Project Proposed Action effects on surface water hydrology are described in more detail below.

Mud Lake Creek Watershed Alteration

The Tailings Basin has a contributing watershed immediately to the east of Cell 1E that drains into the cell. In year 7 of mine operations, the East Dam would be constructed to enable tailings deposition into Cell 1E. At that time, the watershed that currently drains into Cell 1E would be rerouted via a constructed drainage swale to drain to the headwaters of Mud Lake Creek. After year 7, there would be no need for augmentation to Mud Lake Creek because of the additional runoff water resulting from the swale diversion. Figure 5.2.2-45 shows the approximate location of the drainage swale. Construction of the swale diversion would increase the Mud Lake Creek Watershed area at MLC-3 from 1.34 mi² to 2.24 mi².

Effects on Embarrass River Tributary Streamflow

The NorthMet Project Proposed Action includes construction of the groundwater containment system along the northern and western sides of the Tailing Basin, which would capture virtually all of the Tailings Basin seepage presently flowing in those directions to restore water quality. Seepage and local runoff captured by these systems would be pumped back into the Tailings Basin or to the WWTP. As indicated in Table 5.2.2-39, the groundwater containment system, during the operations phase, would reduce average annual flow (relative to existing conditions) in Mud Lake Creek (i.e., North Flowpath) by 37 percent, in Trimble Creek (i.e., Northwest Flowpath) by 65 percent, and in Unnamed Creek (i.e., West Flowpath) by 46 percent. The MDNR has recommended that maintaining surface flows within about plus or minus 20 percent of existing conditions in mining-affected streams should be a management objective, where reasonably practical, in order to maintain existing aquatic ecology.



- | | |
|------------------------------|-----------------------------------|
| Plant Site | Containment System |
| Drainage Flow Direction | Tailings Basin Emergency Overflow |
| Tailings Pipeline | Tailings Basin |
| Treated Water Discharge Pipe | Rock Buttress |
| Colby Lake Transfer | |



0 250 500 1,000 1,500
Feet



Figure 5.2.2-45
Mud Lake Creek Headwaters Diversion
NorthMet Mining Project and Land Exchange SDEIS
Minnesota

November 2013

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Table 5.2.2-39 Annual Average Flow Conditions in the Tributaries

	Mud Lake Creek (MLC-3) (gpm)	Trimble Creek (TC-1) (gpm)	Unnamed Creek (PM-11) (gpm)
Current Tailings Basin seepage flow rate to watershed ¹	1480		540
Seepage split to groundwater ²	44	55	110
Seepage split to the tributaries ³	207	1174	430
Current annual average flow rate contribution from the watershed ⁴	458	714	750
Current annual average surface water flow rate ⁵	665	1888	1180
Proposed annual average surface water flow rate ⁶	418	665	640
% reduction from current to proposed conditions	37	65	46

Source: Barr 2013a, Table 1.

¹ Average annual seepage to the toes of the Tailings Basin (splits into items 2 and 3).

² Average aquifer capacity at the upstream end of each flowpath (Barr 2013i, Table 1).

³ Flow (seepage – aquifer capacity) that reports to each tributary. Note that 75 percent of the seepage from the north bank (870 gpm) of Cell 2E that *does not* stay in the aquifer, but actual reports to Trimble Creek because of the location of the watershed divide.

⁴ Watershed area includes both the undisturbed watershed areas and the outer banks of the Tailings Basin.

⁵ Sum of lines 3 and 4.

⁶ Determined from P50 results of the GoldSim probabilistic model.

PolyMet has proposed to augment flow by distributing treated effluent from the WWTP among these three tributary streams to maintain average annual flow to within 20 percent of existing conditions. When necessary, augmentation water would also be supplied from Colby Lake using a separate dedicated pipeline. Table 5.2.2-40 shows the minimum required and maximum allowable (plus or minus 20 percent of existing average annual tributary streamflow) augmentation that would be discharged on an average annual basis from the WWTP and Colby Lake to each of the three tributaries. The discharge locations would be downstream of the groundwater containment system. Multiple spigot points would be used distribute flow to Mud Lake Creek and Trimble Creek so as to minimize effects on nearby wetlands, whereas augmentation flow to Unnamed Creek would be via a single discharge near the current SD006 discharge.

Table 5.2.2-40 Determination of Combined Flow Requirement from the WWTP and Colby Lake

	Mud Lake Creek (MLC-3)⁵ (gpm)	Trimble Creek (TC-1) (gpm)	Unnamed Creek (PM-11) (gpm)	Second Creek (SD026)⁶ (gpm)
Total annual average surface flow ¹	665	1,888	1,180	500
Expected future contribution from the watershed ²	439 / 734	599	664	0
Minimum requirement from WWTP/Colby Lake ³	93 / 0	911	280	400
Maximum allowable from WWTP/Colby Lake ⁴	359 / 64	1,667	752	600

Source: Barr 2013a, Table 2.

¹ Equivalent to line 5 of Table 5.2.2-37.

² The future contribution from the watershed would decrease because the containment system, which would be away from the toes of the Tailings Basin, would remove watershed area and any runoff from the outer banks of the Tailings Basin.

³ 80 percent of the existing total annual average surface flow, less the expected future watershed contribution.

⁴ 120 percent of the existing total annual average surface flow, less the expected future watershed contribution.

⁵ X / Y values: X indicates the flow values before the drainage swale is in place; Y indicates the flow values after the watershed area to Mud Lake Creek is increased (from 1.34 to 2.24 mi²) because of the construction of the drainage swale at time greater than 7 years.

⁶ Second Creek, although discharging to the Partridge River, is included in this table show so as to show the total augmentation flow requirements.

The total flow required from the WWTP effluent and/or Colby Lake prior to construction of the Mud Lake Creek drainage swale would be between 1,684 and 3,378 gpm on an average annual basis (plus or minus 20 percent of the current total annual average surface flow, less the expected future watershed contribution, summed for all tributaries).

Table 5.2.2-41 shows the amount of water that is anticipated to be pumped for augmentation to each tributary, from the two sources, for operations, reclamation, and long-term closure. During operations, WWTP effluent would be the primary source of augmentation water. There would be times, however, when there would not be sufficient WWTP effluent available to meet the minimum flow requirement in the tributaries, and water would be transferred from Colby Lake on an as-needed basis. During reclamation, all WWTP effluent would be used to help flood the West Pit; therefore, during this phase, all augmentation water would come from Colby Lake (approximately 1,600 gpm). In closure, it is expected that effluent from the WWTP alone (estimated at approximately 2,000 gpm) would be sufficient to meet the minimum flow augmentation requirements of the tributaries without requiring additional water from Colby Lake.

Table 5.2.2-41 Augmentation Flows and Sources to Tributaries for Various Time Periods

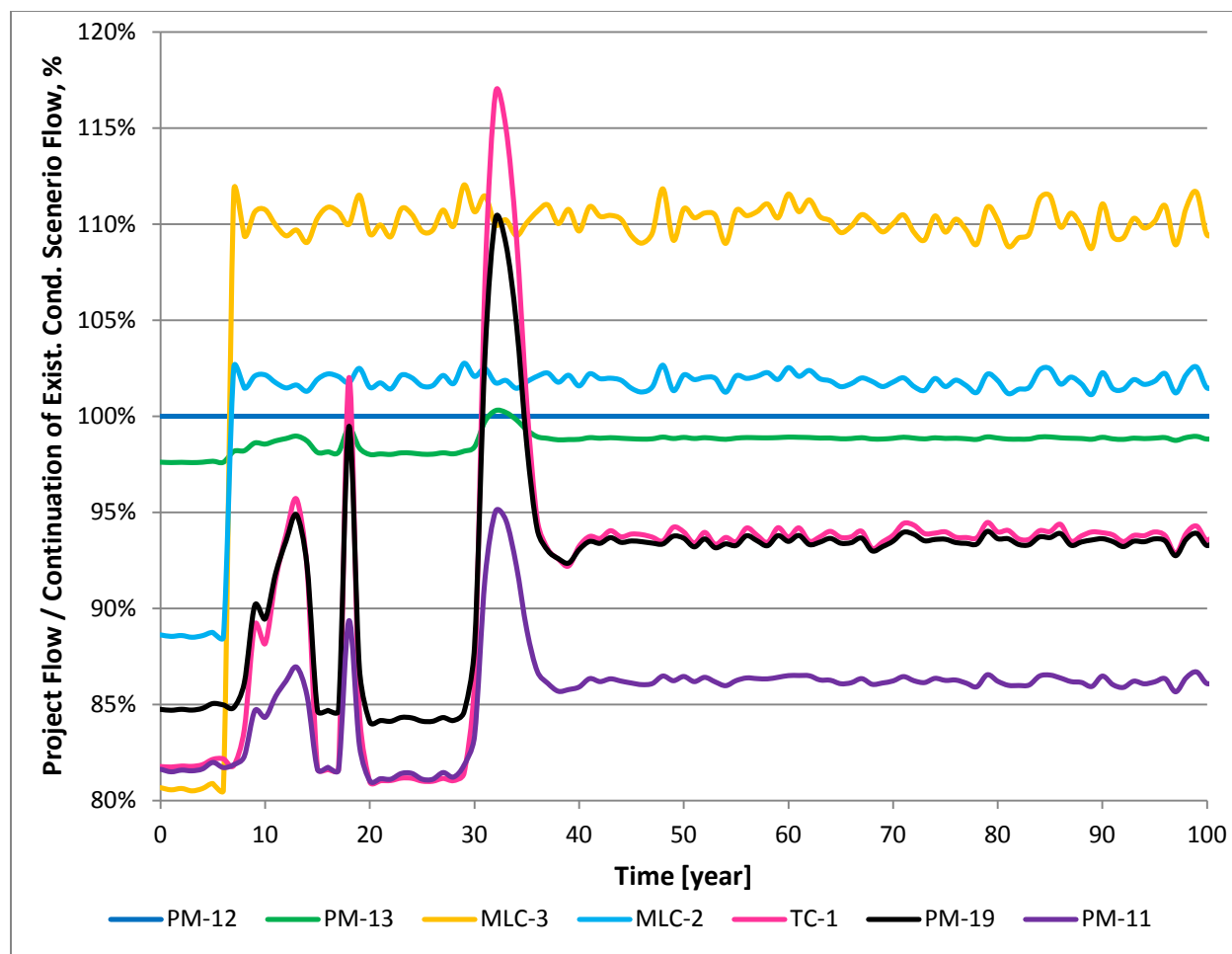
	Mud Lake Creek (MLC-3) ^{1,2}		Trimble Creek (TC-1) ²		Unnamed Creek (PM-11) ²		Second Creek (SD026) ²	
	WWTP	Colby Lake	WWTP	Colby Lake	WWTP	Colby Lake	WWTP	Colby Lake
Minimum Req'd	93		911		280		400	
Operations	28	66	571	399	122	176	251	175
Reclamation	0	0	0	916	0	282	0	402
Closure	0	0	1136	0	349	0	499	0

Source: Computed from Barr 2013a, Tables 3, 4, 5, and 6.

¹ Augmentation required only during first 7 years of operation; thereafter, watershed diversion from swale would contribute slightly more flow than existing conditions.

² All units are gpm.

Figure 5.2.2-46 shows the predicted effectiveness of the proposed flow augmentation in maintaining annual average Embarrass River tributary streamflow within 20 percent of the Continuation of Existing Conditions Scenario. The graph only shows up to year 100 because the results are steady beyond that point.



Source: PolyMet 2013j, Figure 6-75.

Figure 5.2.2-46 *Average Annual Embarrass River and Tributary Flows in the NorthMet Project Proposed Action Model (Percent of Continuation of Existing Conditions Scenario)*

Hydrologic fluctuations throughout operations and reclamation (first 40 years) would be due to changes in the available amount of WWTP effluent, and changing the augmentation water source between the WWTP and Colby Lake. At no time, however, would flows change by more than the 20 percent threshold of Continuation of Existing Conditions Scenario. The maximum expected change in average annual flow during this time period would occur at TC-1, varying from about -19 percent to +17 percent. The maximum combination of tributary hydrologic effects on average annual flow at Embarrass River location PM-13 would be about -2.5 percent. In the long term, Mud Lake Creek would experience an increase in flow of about 10 percent at MLC-3 and 2 percent at MLC-2; Trimble Creek at TC-1 and PM-19 would have reduced flows of about -7 percent. The Embarrass River at PM-13 would experience reduced flows of about 2 percent of average annual flow (2.1 cfs) during operations and 1 percent of average annual flow (0.9 cfs) during closure.

Effects on Surface Water Quality

As shown on Figure 5.2.2-6, Embarrass River tributaries that would be affected by mine facilities include Unnamed Creek, Trimble Creek, and Mud Lake Creek. These tributaries currently receive Tailings Basin seepage with its associated water quality. Because the tributaries discharge into the Embarrass River, their flow rates and water quality affect Embarrass River concentrations (e.g., at PM-13).

Under the NorthMet Project Proposed Action, the Tailings Basin containment system would capture nearly all the tailings seepage and send it to the WWTP for treatment. Then, augmentation water would be distributed to the tributaries to compensate for the collected (intercepted) seepage. During operations, a blend of WWTP effluent and Colby Lake water would be used for augmentation. During most of reclamation, all the augmentation water would come from Colby Lake, and during closure, all the augmentation water would come from the WWTP. These augmentations generally apply to the three creeks; however, Mud Lake Creek would be realigned during year 7, whereby it would receive additional storm runoff, thus eliminating the need for subsequent augmentation.

Results of the GoldSim water quality modeling were reviewed for all 28 solutes at five tributary stream (i.e., MLC-2, MLC-3, TC-1, PM-19, and PM-11) and five Embarrass River (i.e., PM-12, PM-12.2, PM-12.3, PM12.4, and PM-13) evaluation locations. Model results for the NorthMet Project Proposed Action and Continuation of Existing Conditions Scenario are essentially identical at stations PM-12 and PM-12.2, the two stations that are upstream of the NorthMet Project area and thus would not be affected by the NorthMet Project Proposed Action (see Table 5.2.2-43).

A screening process was used to identify any constituents and locations that warranted a more robust examination because of potential exceedances of water quality evaluation criteria (see Table 5.2.2-40 for the Embarrass River tributary streams evaluation locations and Table 5.2.2-41 for the Embarrass River mainstem evaluation locations). The screening process involved comparing the single-highest monthly P90 water quality prediction from among the 6,000 months covered by the simulation (i.e., 12 months times 500 years) for each constituent for each of the eight evaluation locations. If the maximum P90 concentration exceeded the evaluation criteria, the screening process identified it for further analysis.

Tables 5.2.2-42 and 5.2.2-43 show that the maximum P90 concentrations for the NorthMet Project Proposed Action would not exceed the applicable evaluation criteria, with the two following exceptions:

- The aluminum criterion would be exceeded at all locations for both the Continuation of Existing Conditions Scenario and the NorthMet Project Proposed Action; and
- The lead criterion would be exceeded at Unnamed Creek (PM-11) and at Trimble Creek (TC-1 and PM-19) for the NorthMet Project Proposed Action. More detailed discussions of these two constituents are provided in subsequent subsections of this SDEIS. Sulfate is also discussed because waters recommended for wild rice production are found approximately 10 miles downstream of the Tailings Basin.

Tables 5.2.2-44, 5.2.2-45, and 5.2.2-46 below compare the P10, P50, and P90 modeled concentrations for the NorthMet Project Proposed Action and the Continuation of Existing Conditions Scenario for selected key constituents at representative years during mine operations, reclamation, and closure at PM-13, which is the most downstream evaluation location that would capture all NorthMet Project Proposed Action-related contaminant loadings. As these data show, the sulfate concentrations would decrease for the NorthMet Project Proposed Action relative to the Continuation of Existing Conditions Scenario across all three probability values and all three mine phases. This trend would be attributable to higher sulfate concentrations in the current Tailings Basin seepage (assumed to flow into the streams under Continuation of Existing Conditions Scenario) compared to lower concentrations in the WWTP effluent and Colby Lake water, which would be used for stream augmentation under the NorthMet Project Proposed Action (see Table 5.2.2-47).

Comparison of GoldSim-predicted Continuation of Existing Conditions Scenario and NorthMet Project Proposed Action conditions at PM-13 for arsenic, copper, lead, nickel, and zinc is summarized as follows:

- Operations (year 12): NorthMet Project Proposed Action concentrations would all be higher than Continuation of Existing Conditions Scenario concentrations.
- Reclamation (year 24): NorthMet Project Proposed Action concentrations would be similar to or slightly lower than Continuation of Existing Conditions Scenario concentrations, except for copper, which would have slightly higher concentrations.
- Closure (year 200): NorthMet Project Proposed Action concentrations would all be higher than Continuation of Existing Conditions Scenario concentrations.

The reason for increased PM-13 concentrations for these metals during the operations and closure phases is that WWTF effluent would mostly be used for augmentation during operations and solely used for augmentation during closure. As shown in Table 5.2.2-47, the concentrations of these metals in the WWTP effluent would be significantly higher than concentrations in the current Tailings Basin seepage (assumed for Continuation of Existing Conditions Scenario). As a consequence, there would be a significant increase in solute loading to Embarrass River surface water during operations and closure when compared to Continuation of Existing Conditions Scenario.

During reclamation, Colby Lake water would be used exclusively for augmentation and Table 5.2.2-47 shows that the metal concentrations in this augmentation source would be lower than WWTP effluent concentrations and closer to concentrations in the current Tailings Basin seepage. Thus, during reclamation, the solute loading to the surface water would be more similar to Continuation of Existing Conditions Scenario loading associated with the Tailings Basin.

Table 5.2.2-42 Plant Site Tributary Surface Water – Maximum P90 Solute Concentration Over Entire 500-Year Simulation Period Based on GoldSim Probabilistic Model

Parameter	Stream Standard	Units	MLC-2		MLC-3		TC-1		PM-19		UC-1		PM-11	
			NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario
General														
Alkalinity	NA	mg/L	143	267	83.8	299	100	311	106	301	--	323	100	300
Calcium	NA	mg/L	34.3	47.4	31.0	51.5	35.1	79.3	36.9	77.9	--	118	35.1	110
Chloride	230	mg/L	10.4	19.2	10.3	22	7.0	23.5	8.0	22.5	--	24.4	9.0	22.8
Fluoride	NA	mg/L	1.1	3.3	0.19	3.8	0.13	2.9	0.16	2.7	--	1.2	0.16	1.1
Hardness	500	mg/L	208	430	110	508	116	784	139	760	--	1,165	110	1,080
Magnesium	NA	mg/L	30.7	77.1	10.4	92.7	11.6	145	16.0	140	--	216	10.9	199
Potassium	NA	mg/L	4.1	9.1	1.4	10.5	0.94	11.4	1.4	10.9	--	12.2	0.94	11.3
Sodium	NA	mg/L	22.2	59.7	4.1	69.8	3.3	70.2	5.6	66.9	--	66.6	3.2	61.3
Sulfate	NA	mg/L	59.9	180	44.4	221	59.8	278	61.1	265	--	360	53.5	330
Metals Total											--			
Aluminum	125	µg/L	173	155.5	175.9	144.4	151.1	112.5	151.5	126.8	--	20.7	160.8	142.8
Antimony	31	µg/L	1.5	0.31	2.8	0.31	19.3	0.31	18.5	0.31	--	0.33	18.8	0.31
Arsenic	53	µg/L	3.5	3.78	5.9	4.5	10	3.8	9.8	3.6	--	2.61	10	2.4
Barium	NA	µg/L	91.8	176.6	39.6	197.6	7	149.9	13.3	143.7	--	68.8	7.0	63.7
Beryllium	NA	µg/L	0.25	0.22	0.2	0.2	0.4	0.21	0.39	0.21	--	0.23	0.4	0.21
Boron	500	µg/L	119	276.7	154.4	326.9	385.1	419.2	357.4	403.4	--	540.2	367.4	500.2
Cadmium	1.4 – 9.0 ⁽¹⁾	µg/L	0.2	0.15	0.31	0.15	2	0.16	1.9	0.16	--	0.19	2.0	0.18
Chromium	11	µg/L	2.3	2.11	2.7	2.0	8.0	1.5	7.8	1.8	--	0.73	8.0	2.0
Cobalt	5	µg/L	1.8	1.8	3.1	2.21	5	3.2	4.9	3.1	--	4.65	5	4.3
Copper	5.0 – 38.4 ⁽¹⁾	µg/L	4.3	2.62	5.8	2.6	9	3.3	8.9	3.22	--	4.45	9	4.1
Iron	NA	µg/L	3,674	3,416	3,792	3,298	2,665	3,116	2,959	3,202	--	4,540	3,319	4,238
Lead	1.3 – 26.2 ⁽¹⁾	µg/L	1.3	1.16	1.9	1.3	3	1.07	2.9	1.02	--	0.63	3	0.69
Manganese	NA	µg/L	568	486	370	471	142	967	188	956	--	1683	128	1556
Nickel	29.1 – 212 ⁽¹⁾	µg/L	15.6	4.14	29.4	4.1	50	5.5	49	5.4	--	7.92	50	7.2
Selenium	5	µg/L	1.3	1.23	1.3	1.2	5	0.9	4.9	1.0	--	0.65	5.0	1.1
Silver	1	µg/L	0.13	0.13	0.15	0.13	0.22	0.13	0.21	0.13	--	0.14	0.21	0.14
Thallium	0.56	µg/L	0.26	0.25	0.26	0.24	0.24	0.22	0.23	0.22	--	0.21	0.24	0.23
Vanadium	NA	µg/L	5.6	5.4	6.0	5.4	9.6	5.0	9.4	5.2	--	1.8	9.6	5.2
Zinc	66.9 – 221 ⁽¹⁾	µg/L	21.5	17.9	25.7	17	100	13.8	97.9	15.3	--	7.21	100	15.4

Source: PolyMet 2013j.

For each constituent at each location, the maximum solute concentration over the entire 500-year simulation period is recorded for each of 500 realizations of the Monte Carlo run. At the end of the Monte Carlo run, there is a list of 500 maximum concentration values for each constituent at each location. Each list is converted to a cumulative frequency distribution. Each value in this table is the 90th percentile concentration from the associated distribution.

¹ Hardness-based standard. Range applies to P10 and P90 variation in Hardness. Exact numbers based on predicted hardness at evaluation location.

Bold value indicates exceedance of the evaluation criterion. For hardness-based standards, bold value indicates exceedance of stream standard for the predicted contemporaneous hardness value.

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Table 5.2.2-43 Plant Site Embarrass River Surface Water – Maximum P90 Solute Concentration

Parameter	Stream Standard	Units	PM-12		PM-12.2		PM-13	
			NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario
General								
Alkalinity	NA	mg/L	85.8	85.8	91	91	97.3	179
Calcium	NA	mg/L	24.7	24.7	45	45	35.7	54.5
Chloride	230	mg/L	10.1	10.1	9.8	9.8	9.9	12.2
Fluoride	NA	mg/L	0.19	0.19	0.19	0.19	0.19	1.2
Hardness	500	mg/L	101	101	524	524	237	487
Magnesium	NA	mg/L	10.3	10.3	101	101	38.5	86.5
Potassium	NA	mg/L	1.6	1.6	21.3	21.3	7.4	9.6
Sodium	NA	mg/L	4.4	4.4	37.7	37.7	14.7	37.1
Sulfate ²	NA	mg/L	9.3	9.3	418	418	139	202
Metals Total								
Aluminum	125	µg/L	174.2	174.2	163.8	163.8	166.7	165.6
Antimony	31	µg/L	0.32	0.32	0.3	0.3	7.8	0.29
Arsenic	53	µg/L	1.0	1.0	1.1	1.1	5.3	1.8
Barium	NA	µg/L	49	49	37.6	37.6	37	83.1
Beryllium	NA	µg/L	0.2	0.2	0.18	0.18	0.28	0.2
Boron	500	µg/L	27.1	27.1	77.1	77.1	136.4	212.7
Cadmium	1.4 – 9.03 ⁽¹⁾	µg/L	0.13	0.13	0.12	0.12	0.95	0.13
Chromium	11	µg/L	2.3	2.3	2.2	2.2	4.0	2.2
Cobalt	5	µg/L	0.91	0.91	0.88	0.88	2.6	1.6
Copper	5.018 – 38.4 ⁽¹⁾	µg/L	2.8	2.8	2.6	2.6	5.7	2.7
Iron	NA	µg/L	3,697	3,697	3,485	3,485	3,537	3,586
Lead	1.32 – 26.2 ⁽¹⁾	µg/L	0.76	0.76	0.72	0.72	1.6	0.75
Manganese	NA	µg/L	445	445	561	561	406	716
Nickel	29.1 – 211.6 ⁽¹⁾	µg/L	4.0	4.0	4.0	4.0	26.4	4.5
Selenium	5	µg/L	1.3	1.3	1.3	1.3	2.7	1.3
Silver	1	µg/L	0.13	0.13	0.13	0.13	0.14	0.13
Thallium	0.56	µg/L	0.26	0.26	0.25	0.25	0.25	0.25
Vanadium	NA	µg/L	5.6	5.6	5.7	5.7	7.2	5.4
Zinc	66.9 – 221.2 ⁽¹⁾	µg/L	18.6	18.6	17.5	17.5	55.9	17.8

Source: PolyMet 2013j.

For each constituent at each location, the maximum solute concentration over the entire 500-year simulation period is recorded for each of 500 realizations of the Monte Carlo run. At the end of the Monte Carlo run, there is a list of 500 maximum concentration values for each constituent at each location. Each list is converted to a cumulative frequency distribution. Each value in this table is the 90th percentile concentration from the associated distribution.

¹ Hardness-based standard. Range applies to P10 and P90 variation in hardness. Exact numbers based on predicted hardness at evaluation location.

² Sulfate 10-mg/L wild rice standard applies at PM-13.

Bold value indicates exceedance of the evaluation criterion. For hardness-based standards, bold value indicates exceedance of stream standard for the predicted contemporaneous hardness value.

Table 5.2.2-44 Comparison of the P10, P50, and P90 Values for NorthMet Project Proposed Action and Continuation of Existing Conditions Scenario Modeled Concentrations at PM-13 for Selected Key Constituents, Operations (Year 12)

Parameter	Partridge Evaluation Criteria	Units	P10		P50		P90	
			Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action
Sulfate	NA	mg/L	151	68.4	169	96.6	188	129
Arsenic	53	µg/L	1.4	2.7	1.6	3.5	1.7	4.3
Copper ¹	8.9	µg/L	1.6	3.2	2.0	4.0	2.5	4.9
Lead ¹	3.0	µg/L	0.4	0.8	0.5	1.0	0.6	1.3
Nickel ¹	49.9	µg/L	2.8	12.2	3.4	16.7	4.0	21.0
Zinc ¹	114	µg/L	9.8	29.4	11.7	38.2	15.5	46.2

Source: PolyMet 2013j.

¹ Hardness-based standard. Evaluation criteria based on average hardness of 95 mg/L at PM-13.

Table 5.2.2-45 Comparison of the P10, P50, and P90 Values for NorthMet Project Proposed Action and Continuation of Existing Conditions Scenario Modeled Concentrations at PM-13 for Selected Key Constituents, Reclamation (Year 24)

Parameter	Partridge Evaluation Criteria	Units	P10		P50		P90	
			Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action
Sulfate	NA	mg/L	148	83.0	167	106	191	139
Arsenic	53	µg/L	1.4	1.0	1.6	1.0	1.8	1.0
Copper ¹	8.9	µg/L	1.6	1.8	2.0	2.2	2.5	2.7
Lead ¹	3.0	µg/L	0.4	0.2	0.5	0.3	0.6	0.6
Nickel ¹	49.9	µg/L	2.7	2.5	3.3	3.0	4.0	3.6
Zinc ¹	114	µg/L	9.8	8.6	11.6	10.6	17.7	17.8

Source: PolyMet 2013j.

¹ Hardness-based standard. Evaluation criteria based on average hardness of 95 mg/L at PM-13.

Table 5.2.2-46 Comparison of the P10, P50, and P90 Values for NorthMet Project Proposed Action and Continuation of Existing Conditions Scenario Modeled Concentrations at PM-13 for Selected Key Constituents, Closure (Year 200)

Parameter	Partridge Evaluation Criteria	Units	P10		P50		P90	
			Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario	NorthMet Project Proposed Action
Sulfate	NA	mg/L	140	69.6	167	97.7	197	129
Arsenic	53	µg/L	1.4	2.5	1.5	3.0	1.8	3.6
Copper ¹	8.9	µg/L	1.5	3.0	1.92	3.7	2.7	4.5
Lead ¹	3.0	µg/L	0.4	0.7	0.5	0.9	0.6	1.1
Nickel ¹	49.9	µg/L	2.5	10.9	3.2	14.2	4.5	17.6
Zinc ¹	114	µg/L	9.9	10.5	11.6	13.4	16.0	18.4

Source: Barr 2013j.

¹ Hardness-based standard. Evaluation criteria based on average hardness of 95 mg/L at PM-13.

As Table 5.2.2-46 illustrates, the WWTP water quality target concentrations are predicted to be above the modeled Continuation of Existing Conditions Scenario P50 values at PM-13 (shown in Tables 5.2.2-44, 5.2.2-45, and 5.2.2-46) for all selected, key constituents except sulfate. Consequently, when the WWTP effluent is used for augmentation, concentrations of these constituents would increase at PM-13. As Tables 5.2.2-44, 5.2.2-45, and 5.2.2-46 show, the metal concentrations at PM-13 are predicted to decrease, while sulfate concentrations are predicted to increase during reclamation relative to operations or closure. This is attributable to the fact that Colby Lake water (with higher sulfate and lower metal concentrations relative to the WWTP effluent) would comprise all of the flow augmentation during this phase, as the WWTP effluent would be used to help flood the West Pit during this phase.

Table 5.2.2-47 Comparison of Wastewater Treatment Plant Effluent and Colby Lake Water Quality

Parameter	Unit	Current Average Tailings Basin Seepage Concentrations used in GoldSim for Continuation of Existing Conditions Scenario ¹	Plant Site WWTP Effluent Concentrations used in GoldSim for NorthMet Project Proposed Action ²	Colby Lake Average Water Quality used in GoldSim for NorthMet Project Proposed Action ²
Sulfate	mg/L	240	9	33.8
Arsenic	µg/L	2.8	10	0.75
Copper	µg/L	1.9	9	2.7
Lead	µg/L	0.8	3	0.25
Nickel	µg/L	3.3	50	2.1
Zinc	µg/L	7.9	100	3

Source: PolyMet 2013g; Barr 2013.

Notes:

¹ For Continuation of Existing Conditions Scenario, tributaries would receive Tailings Basin seepage with current concentrations.

² During operations, tributary augmentation would be a combination of WWTP effluent and Colby Lake water.
During reclamation, tributary augmentation would almost all be Colby Lake water.
During closure, tributary augmentation would all be WWTP effluent.

Despite these predicted increases in concentrations at PM-13, all of these constituents would meet water quality evaluation criteria (see Table 5.2.2-44). Although the NorthMet Project Proposed Action evaluation criteria focuses on the P90 values (e.g., a reasonable worst case), the most probable result would be closer to the P50 value, while the P10 value represents a reasonable best case in terms of modeled water quality effects from the NorthMet Project Proposed Action.

Aluminum in Surface Waters of the Embarrass River Watershed

As shown in Tables 5.2.2-42 and 5.2.2-43, a review of model results over the 500-year simulation period indicates that the maximum P90 aluminum concentrations at most of the evaluation locations for both the NorthMet Project Proposed Action and Continuation of Existing Conditions Scenario would exceed the evaluation criterion of 125 µg/L. For example, Embarrass River location PM-12, which is upstream of any NorthMet Project Proposed Action effects, would have a maximum P90 concentration of 173.8 µg/L. Concentrations of aluminum under Continuation of Existing Conditions Scenario at tributary locations MLC-2, MLC-3, TC-1, PM-19, and PM-11 would be lower than at PM-12, averaging about 136 µg/L, but still above the

evaluation criterion. Concentrations for NorthMet Project Proposed Action conditions in the tributaries would increase over Continuation of Existing Conditions Scenario by an average of about 10 to 25 percent, which results in a corresponding increase in the Embarrass River at PM-13 of up to a maximum of less than 1 percent. The causes of these increases are discussed below.

Aluminum concentrations in the various Plant Site water sources would be as follows:

- Ambient groundwater – 50 to 90 µg/L;
- Ambient surface water – 70 to 150 µg/L (30 percent probability of exceeding the evaluation criterion of 125 µg/L); and
- Tailings Basin seepage – 5 to 20 µg/L.

Under the Continuation of Existing Conditions Scenario, the relatively low aluminum concentration in LTVSMC Tailings Basin seepage (5-20 µg/L), which would constitute about 30 percent of total flow to the Embarrass River tributary streams (see Table 5.2.2-42), would mix with ambient groundwater and surface water having aluminum concentrations in the range of 50 to 150 µg/L. Due to the dilution effect caused by the Tailings Basin seepage, the aluminum concentrations in the affected waters (after mixing) would be lower than concentrations in the ambient waters. The overall effect of the Tailings Basin seepage would be to cause downgradient groundwater and downstream surface water to have lower aluminum concentrations than would occur if the Tailings Basin did not exist. This dilution effect is demonstrated by the increase in measured aluminum concentrations from upstream tributary locations (UC-1, TC-1, and MLC-3) to downstream locations (PM-11, PM-19, and MLC-2), where upstream locations would average less than 100 µg/L compared to downstream locations averaging about 142 µg/L. This is because the upstream locations would have a higher mixing ratio of Tailings Basin seepage to ambient water so the dilution effect would be more significant. At downstream locations, the mixing ratio of Tailings Basin seepage to ambient water would be smaller, so there would be less dilution effect and the aluminum concentrations would be closer to ambient conditions.

Under NorthMet Project Proposed Action conditions, more than 90 percent of the Tailings Basin seepage would be captured by the containment system, pumped to the WWTP, and discharged to tributary streams. The GoldSim model assumes that the RO system of the WWTP could treat aluminum concentrations down to 125 µg/L, which is the chronic surface water standard under *Minnesota Rules* 7050. However, if the influent aluminum concentration were less than 125 µg/L standard, the GoldSim model assumes that the effluent concentration would be equal to the influent concentration. Because most of the WWTP influent comes from low-concentration tailings seepage, the average aluminum concentration in the WWTP influent and effluent would be about 10 mg/L (based on P50 inputs), and there would be little variation during the 500-year simulation period. Because the WWTP effluent would be dilutive with regard to aluminum, concentrations in the Embarrass River tributary streams may increase or decrease depending on the flow rates at each discharge point. In this case, a lower WWTP discharge rate would lead to higher aluminum concentrations (reduced dilution) and vice versa. In the Embarrass River, the ratio of WWTP discharge to streamflow would be small, so the aluminum concentrations would not be much affected by the WWTP effluent.

For groundwater, the NorthMet Project Proposed Action would prevent more than 90 percent of the Tailings Basin seepage with low aluminum concentrations from mixing with ambient

groundwater having higher aluminum concentrations. Consequently it is predicted that groundwater in the surficial flowpaths would experience an increase in aluminum concentration compared to Continuation of Existing Conditions Scenario. This increase would not result from an increase in load, but rather a decrease in the dilution effect of mixing low-concentration Tailings Basin water with ambient groundwater.

At certain times during operations and reclamation, Colby Lake water would be used to augment flow in the tributary streams. The aluminum concentration in Colby Lake water ranges from about 70 to 160 µg/L, which is higher than the Tailings Basin seepage (5 to 20 µg/L). With regard to aluminum, the effect of using Colby Lake water for augmentation is to increase concentrations in surface water downstream of the Tailings Basin compared to Continuation of Existing Conditions Scenario. This is because the higher concentration Colby Lake water would replace some or all of the lower-concentration Tailings Basin seepage that currently releases to surface water. A mix of WWTP and Colby Lake water would be used during operations (first 20 years), all Colby Lake water would be used during filling of the West Pit (years 21 to 37), and all WWTP effluent would be used during long-term closure (after 37 years).

For different mining phases, the relative effects of these different sources of water on the maximum P90 aluminum concentrations in the Embarrass River tributary streams and mainstem (PM-13) are shown in Table 5.2.2-48. For the NorthMet Project Proposed Action, there would be little change in Embarrass River aluminum when compared to Continuation of Existing Conditions Scenario because the River concentration would be controlled by ambient water quality. For operations and reclamation, the aluminum concentrations would be higher in TC-1 and PM-11 because some or all augmentation water would be derived from higher-concentration Colby Lake water. For closure, aluminum concentrations at TC-2 and PM-11 would be similar to the Continuation of Existing Conditions Scenario concentrations because all augmentation water would come from the WWTP, which would have an effluent concentration similar to the Tailings Basin seepage. The higher concentrations at MLC-3 during operations, reclamation, and closure would result from construction of the Mud Lake Creek diversion in mine year 7 (see Figure 5.2.2-45), which would greatly reduce WWTP augmentation to Mud Lake Creek and replace it with stormwater runoff from the tailings embankment and undisturbed watershed, which is assumed to have higher-concentration ambient water quality. Compared to Continuation of Existing Conditions Scenario, the loss of dilution from low-concentration Tailings Basin seepage would result in higher aluminum concentrations in Mud Lake Creek for the NorthMet Project Proposed Action.

Table 5.2.2-48 Maximum P90 Aluminum Concentrations (µg/L) for Embarrass River Tributaries and Embarrass River for Various Conditions

Location	Continuation of Existing Conditions	NorthMet Proposed Action Conditions		
	Scenario Conditions ¹	Operations (Years 1–20)	Reclamation (Years 21–40)	Closure (After Year 40)
MLC-3	139-144	168	171	176
TC-1	106-113	148	151	112
PM-11	137-143	157	161	150
PM-13	159-166	161	163	163

Source: PolyMet 2013j.

¹ P90 values vary slightly depending on time period.

After completion of the Mud Lake Creek diversion in year 7 (see Figure 5.2.2-45), the aluminum concentration in Mud Lake Creek would not change appreciably for the NorthMet Project Proposed Action because there would be no augmentation and the stream water quality would be controlled by unaffected stormwater runoff from the tailings embankment and natural runoff from the undisturbed watershed. Aluminum in the other two tributaries would reach maximum concentrations during reclamation when all WWTP effluent would be pumped to the Mine Site to help fill the West Pit. As a result, 100 percent of stream augmentation water would come from Colby Lake with relatively high aluminum concentrations. In the long term, when only WWTP effluent would be used for augmentation, the maximum P90 values for Trimble Creek, Unnamed Creek, and the Embarrass River would all decrease. The reason the concentrations would not decrease even more, considering that Colby Lake water would no longer be used, is that the seepage rate from the Tailings Basin would be decreasing once operations ceased, resulting in reduced WWTP flows, and therefore less water available to dilute ambient groundwater and surface water with higher aluminum concentrations. During closure for the NorthMet Project Proposed Action, aluminum concentrations at TC-1 would increase less than 1 percent over Continuation of Existing Conditions Scenario and the value at PM-11 would increase less than 5 percent. The net effect of these tributary changes on Embarrass River at PM-13 would be less than a 1 percent increase in aluminum concentration.

In summary, these predicted increases in aluminum would be the result of diverting low-concentration Tailings Basin seepage, which would dilute the higher-concentration ambient groundwater and surface water under the Continuation of Existing Conditions Scenario, and replace it, at least partially, with higher-concentration Colby Lake water.

Lead in Surface Water at the Tailings Basin

Model results for the Plant Site indicate that the NorthMet Project Proposed Action may exceed the surface water evaluation criterion for lead in Unnamed Creek and Trimble Creek.

The existing LTVSMC Tailings Basin seepage is relatively high in hardness and associated solutes such as calcium, magnesium, potassium, and sodium, as shown by Continuation of Existing Conditions Scenario P90 hardness values for the tributaries (MLC-2, MLC-3, TC-1, and PM-11) consistently being well above 400 mg/L (see Table 5.2.2.41). In comparison, the P90 hardness value at PM-12, upstream of any NorthMet Project Proposed Action effects, would be 101.1 mg/L.

The surface water evaluation criterion for lead is hardness-based. Because hardness is very high in the tributaries under existing conditions as a result of seepage from the existing LTVSMC Tailings Basin, the water quality evaluation criterion for lead is also quite high. Under the NorthMet Project Proposed Action, most seepage from the Tailings Basin would be collected, treated by the WWTP, and released to Unnamed Creek, Trimble Creek, Mud Lake Creek, and Second Creek with significantly less (over 50 percent less) hardness. This, in turn, would significantly decrease the hardness in the tributaries, which would cause the hardness-based water quality evaluation criterion to be lower in the tributaries than under existing conditions. Among the six constituents with hardness-based evaluation criteria (cadmium, chromium (III), copper, lead, nickel, and zinc), lead is the only one predicted to exceed its water quality evaluation criteria.

The modeled exceedances in these tributaries, however, would primarily be caused by natural conditions, not by the NorthMet Project Proposed Action. The primary sources of water to these surface water evaluation locations would be non-contact water (groundwater and surface runoff) and the NorthMet Project Proposed Action (i.e., seepage from the Tailings Basin, WWTP effluent).

- Natural background groundwater – Lead groundwater concentrations (0.15 to 0.4 µg/L) would be well below what would be the surface water quality evaluation criterion over the range of estimated hardness (3.0 to 5.3 µg/L for lead). Therefore, the predicted exceedances in lead would not be attributable to background groundwater concentrations.
- Natural background surface runoff – Natural runoff from undisturbed portions of the watersheds is estimated to occasionally exceed the surface water evaluation criterion for lead (i.e., at any given time, there would be approximately a 10 percent chance that the lead surface runoff concentration would exceed the associated lead evaluation criterion).
- Seepage from the Tailings Basin – Most (greater than 90 percent) seepage from the Tailings Basin would be collected via the groundwater containment system, treated by the WWTP, and discharged to these four tributaries in compliance with the lead evaluation criterion over the estimated range of hardness.
- NorthMet Project Proposed Action WWTP effluent would comply with the lead evaluation criterion over the estimated range of hardness.

Therefore, these predicted exceedances of the evaluation criteria would be primarily attributable to surface runoff, especially during high flows when surface runoff would dominate flow at the surface water evaluation locations. In fact, the modeling indicates that by directing the WWTP discharge and Colby Lake water to these tributaries, as proposed by PolyMet, there would be a lower probability of an exceedance than if only natural runoff and unaffected groundwater were to reach these tributaries.

In summary, the containment system under the NorthMet Project Proposed Action would capture virtually all of the high-hardness seepage from the Tailings Basin, which would cause the hardness-based lead water quality evaluation criterion in the tributaries to significantly decrease. The capture and treatment of existing high-hardness seepage (affected by the existing LTVSMC Tailings Basin seepage), combined with the probability of elevated lead concentrations in natural surface runoff, causes the NorthMet Project Proposed Action model to show an increased frequency of exceedances of the lead evaluation criterion in surface water. However, the root cause of the exceedances would not be directly from NorthMet Project Proposed Action releases. The primary effect of the NorthMet Project Proposed Action would be that its features would cause the surface water concentrations (both hardness and lead) to move closer to background concentrations, described by a significantly lower lead standard and naturally occurring lead exceedances, rather than the existing (Tailings Basin-affected) conditions in surface water. The increased frequency of exceedances would be attributable to the relatively high concentrations of lead in natural surface runoff combined with lower lead water quality evaluation criteria because of lowered hardness.

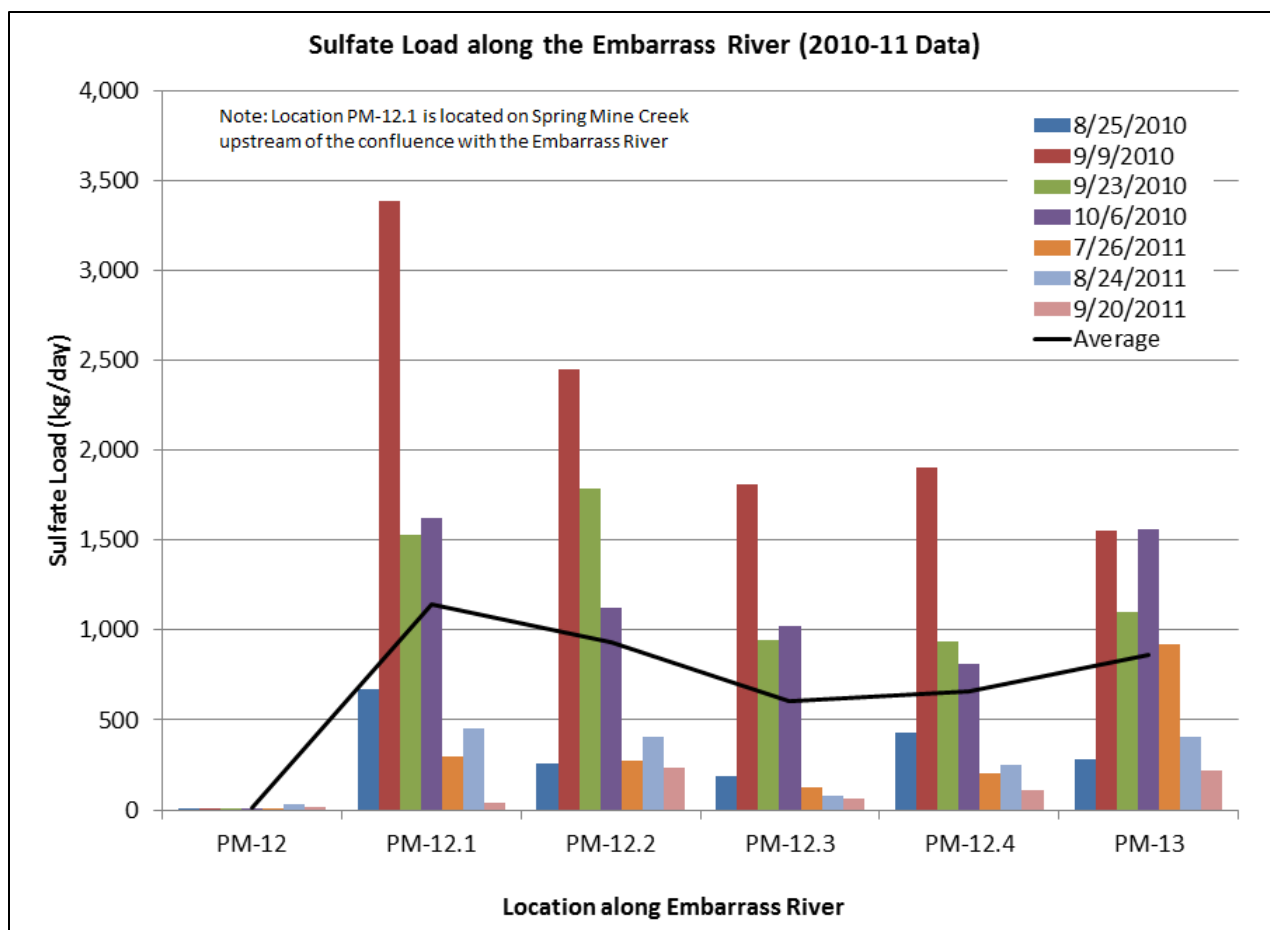
Sulfate in Surface Water in the Embarrass River

The effect of the NorthMet Project Proposed Action on sulfate concentrations in the Embarrass River Watershed is of concern because MPCA has recommended waters within and downstream from Embarrass Lake, the northernmost tip of Wynne Lake, and the segment of the Embarrass River from Sabin Lake to the Highway 135 bridge, as waters used for the production of wild rice (see Figure 5.2.2-1). The MPCA has developed the following supplemental water quality criteria for sulfate at the Plant Site because of this recommendation (MPCA 2011d):

- No increase in sulfate-loading from existing conditions would occur at PM-11 (Unnamed Creek), PM-19 (Trimble Creek), and MLC-2 (Mud Lake Creek);
- The concentration of sulfate in the Embarrass River at PM-13 would decrease from existing condition; and
- No statistically significant increase in sulfate would occur in the Embarrass River from upstream of the facility (e.g., PM-12.2) to downstream of the facility (e.g., PM-13).

Sulfate concentrations in the MPCA-recommended wild rice waters that extend from PM-13 downstream to where the river enters Sabin Lake already exceed the 10-mg/L evaluation criterion. Seepage from the existing LTVSMC Tailings Basin, which averages about 228 mg/L, contributes to these elevated sulfate concentrations.

Although the sulfate load from the existing LTVSMC Tailings Basin is relatively high, not all of this sulfate actually reaches the Embarrass River. Concurrent monitoring at multiple locations along the Embarrass River has documented decreasing sulfate loads, which suggest biological sulfate reduction or losses. For example, the average sulfate load in the Embarrass River between PM-12.3 and PM-13 currently increases by approximately 200 kg/day (see Figure 5.2.2-47), but this is much less than the approximately 3,120 kg/day currently estimated to be seeping from the existing LTVSMC Tailings Basin towards the Embarrass River (sum of the loads leaving the northern, northwestern, and western toes of the Tailings Basin; see PolyMet 2013l). Concurrent monitoring of chloride clearly shows that Tailings Basin seepage is reaching the Embarrass River (see Figure 5.2.2-48). The GoldSim model does not capture these sulfate reductions, resulting in overestimation of existing and future sulfate concentrations. Therefore, consistency with the evaluation criteria was assessed by comparing the predicted sulfate concentrations for the NorthMet Project Proposed Action with the Continuation of Existing Conditions Scenario model results at key evaluation locations like PM-13, which is the most downstream evaluation location and captures all NorthMet Project Proposed Action-related solute loadings.



Source: Barr 2013j.

Figure 5.2.2-47 *Sulfate Load Calculated Along the Embarrass River (2010-2011)*

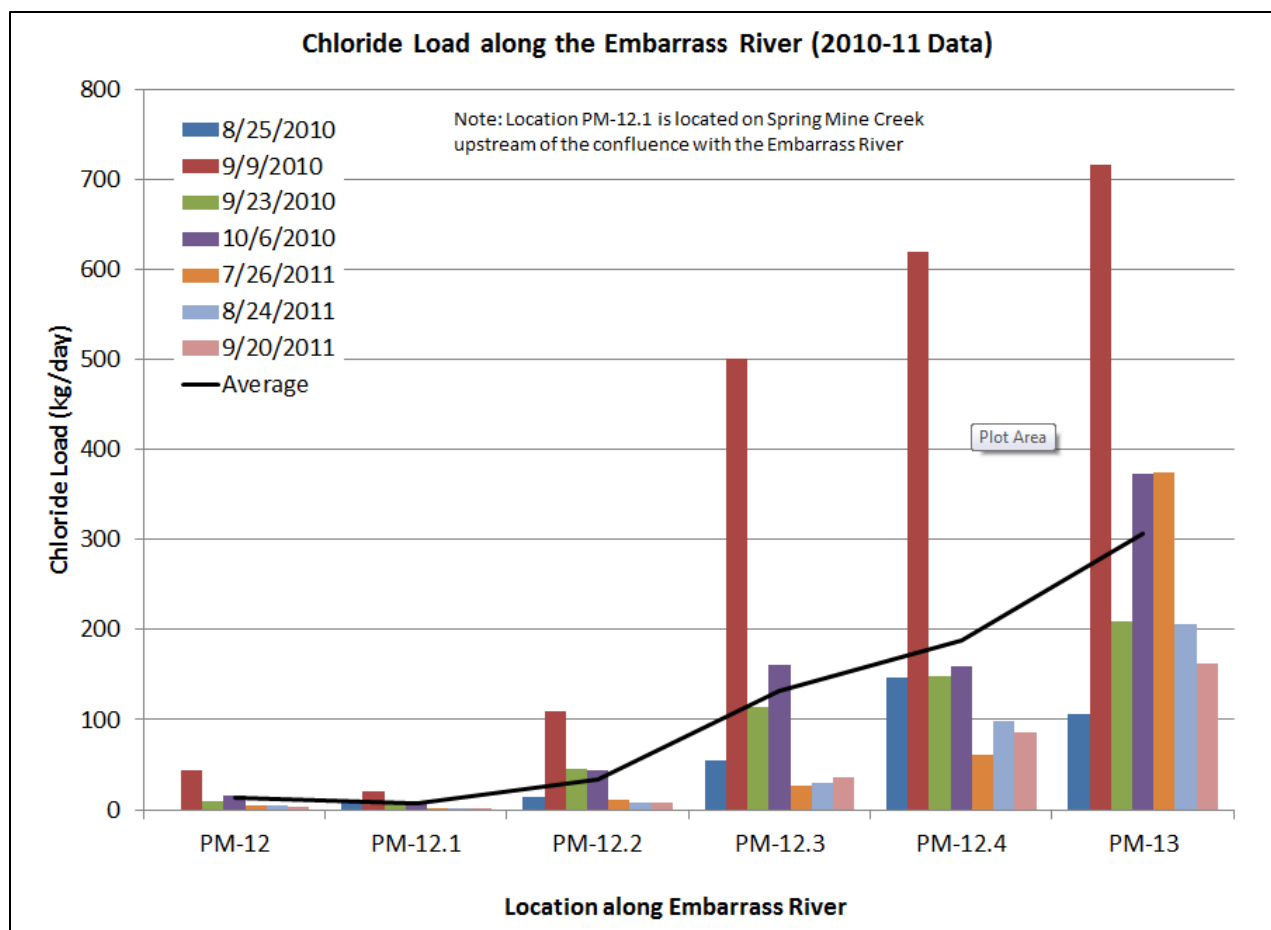


Figure 5.2.2-48 Chloride Load Calculated Along the Embarrass River (2010-2011)

As Figure 5.2.2-49 shows, the maximum P90 sulfate concentration at PM-13 for the NorthMet Project Proposed Action is predicted to be consistently less than the Continuation of Existing Conditions Scenario modeled concentrations. This reduction in sulfate loadings is attributable to the proposed engineering controls that would collect and treat most seepage from the groundwater containment system and provide a bentonite-amended Tailings Basin cover at closure.

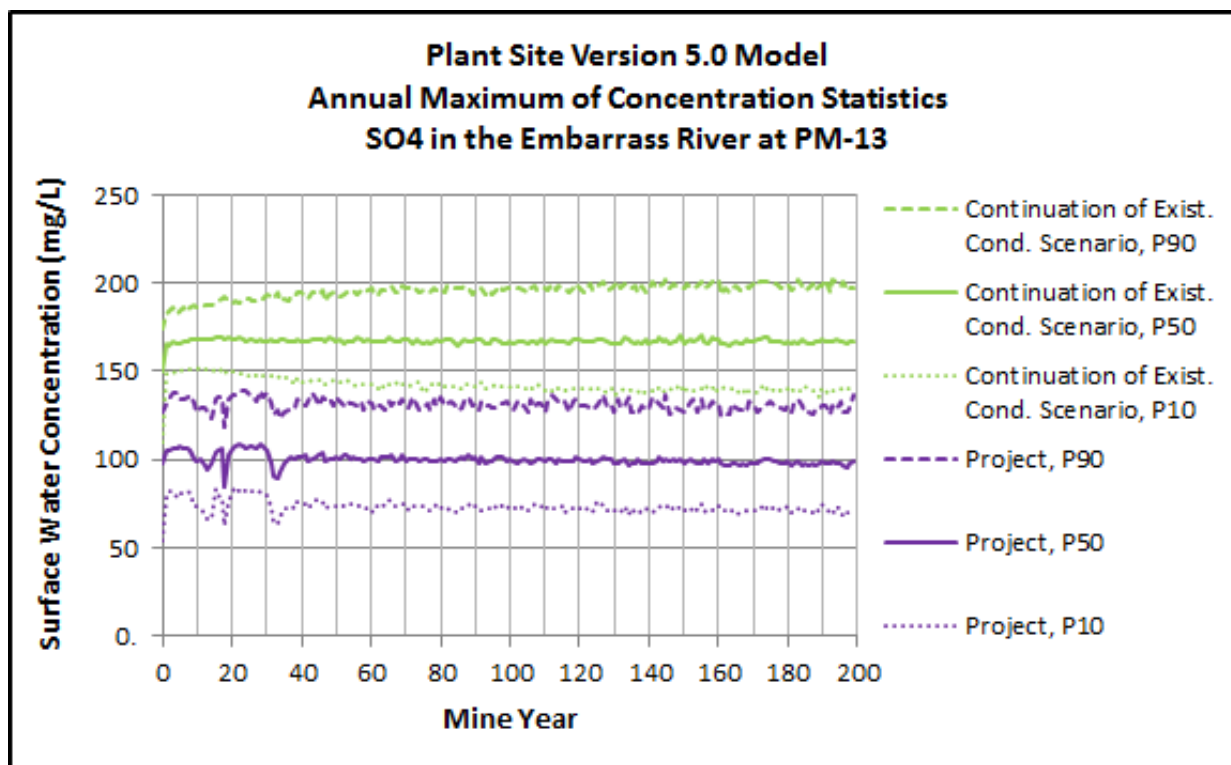


Figure 5.2.2-49 Annual Maximum Sulfate Concentrations in the Embarrass River at PM-13

Consistency with the supplemental MPCA evaluation criteria is discussed below. This was assessed by comparing the predicted sulfate concentrations for the NorthMet Project Proposed Action with the Continuation of Existing Conditions Scenario model results at relevant evaluation locations.

Criterion 1: No increase in sulfate-loading from existing conditions would occur at PM-11 (Unnamed Creek), PM-19 (Trimble Creek), and MLC-2 (Mud Lake Creek)

Figures 5.2.2-50, 5.2.2-51, and 5.2.2-52 show the range of modeled P90 values for sulfate-loading at PM-11, PM-19, and MLC-2. The sulfate-loading at these three locations would be reduced, respectively, by about an order of magnitude, greater than an order of magnitude, and about 50 percent relative to the Continuation of Existing Conditions Scenario model results.

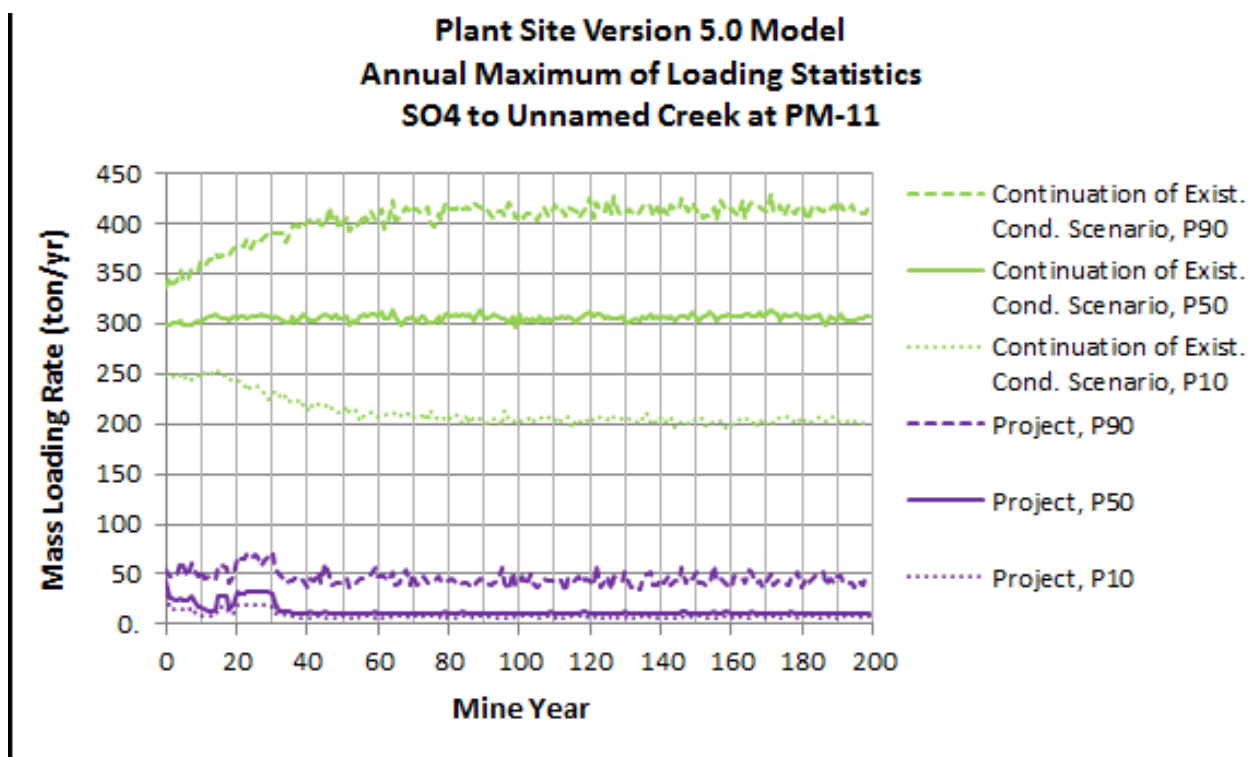


Figure 5.2.2-50 **Range of Annual Sulfate Loading Rates to PM-11; Continuation of Existing Conditions Scenario vs. NorthMet Project Proposed Action (Barr 2013f)**

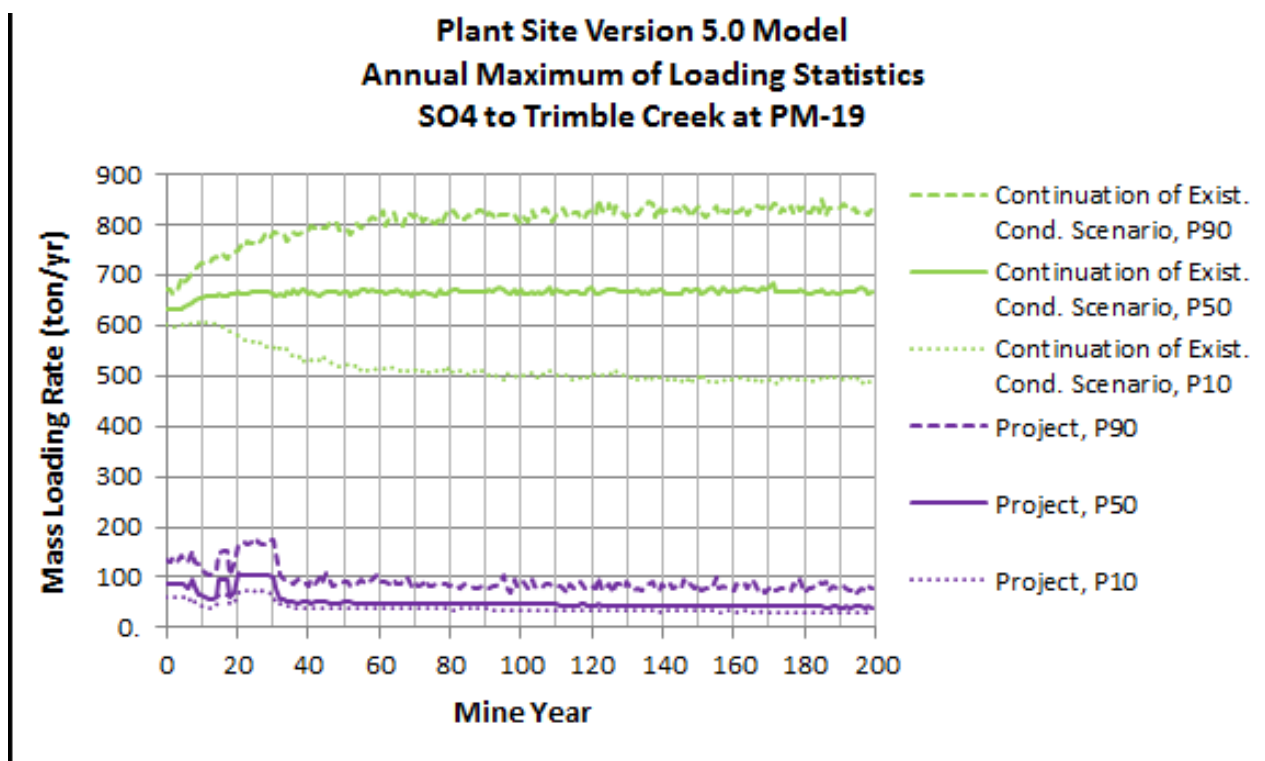


Figure 5.2.2-51 **Range of Annual Sulfate Loading Rates to PM-19; Continuation of Existing Conditions Scenario vs. NorthMet Project Proposed Action (Barr 2013f)**

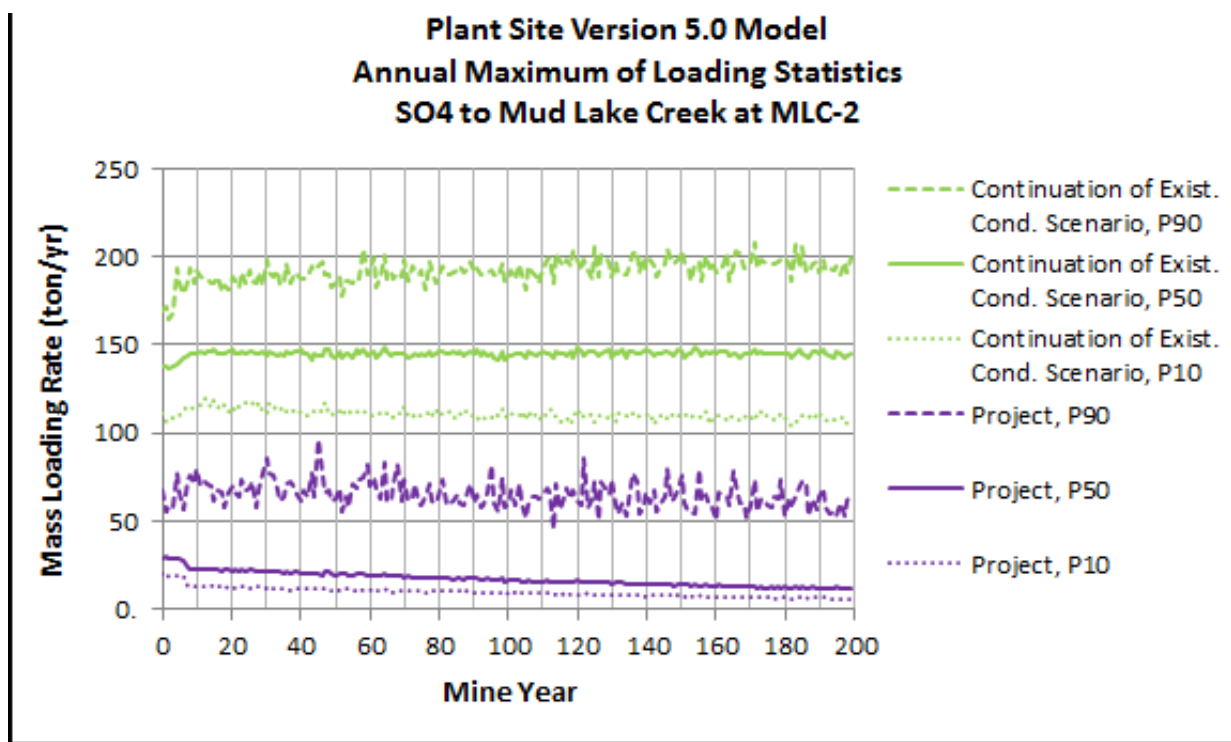


Figure 5.2.2-52 *Range of Annual Sulfate Loading Rates to MLC-2; Continuation of Existing Conditions Scenario vs. NorthMet Project Proposed Action (Barr 2013f)*

Criterion 2: The concentration of sulfate in the Embarrass River at PM-13 would decrease from existing condition

Figure 5.2.2-53 shows modeled Continuation of Existing Conditions Scenario and NorthMet Project Proposed Action maximum sulfate concentrations at PM-13. On average, sulfate concentrations would be reduced by more than 40 percent at PM-13 because of reduced loading discussed previously.

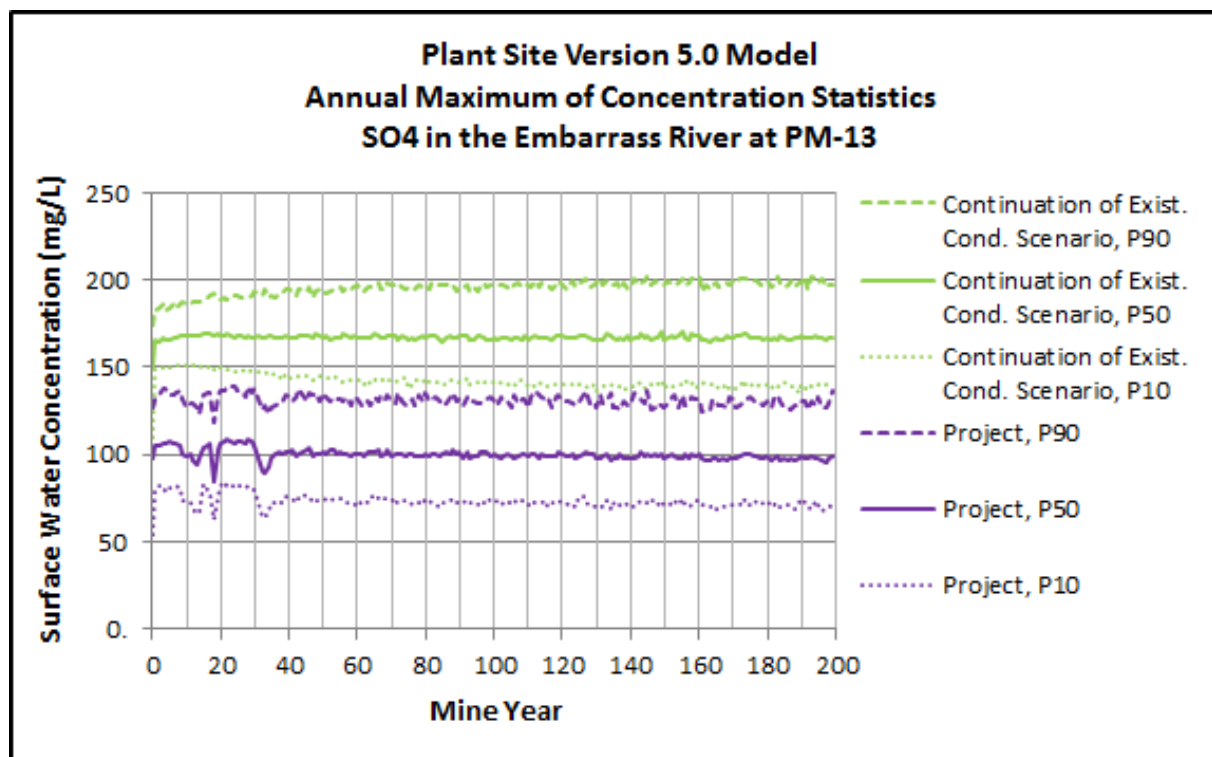
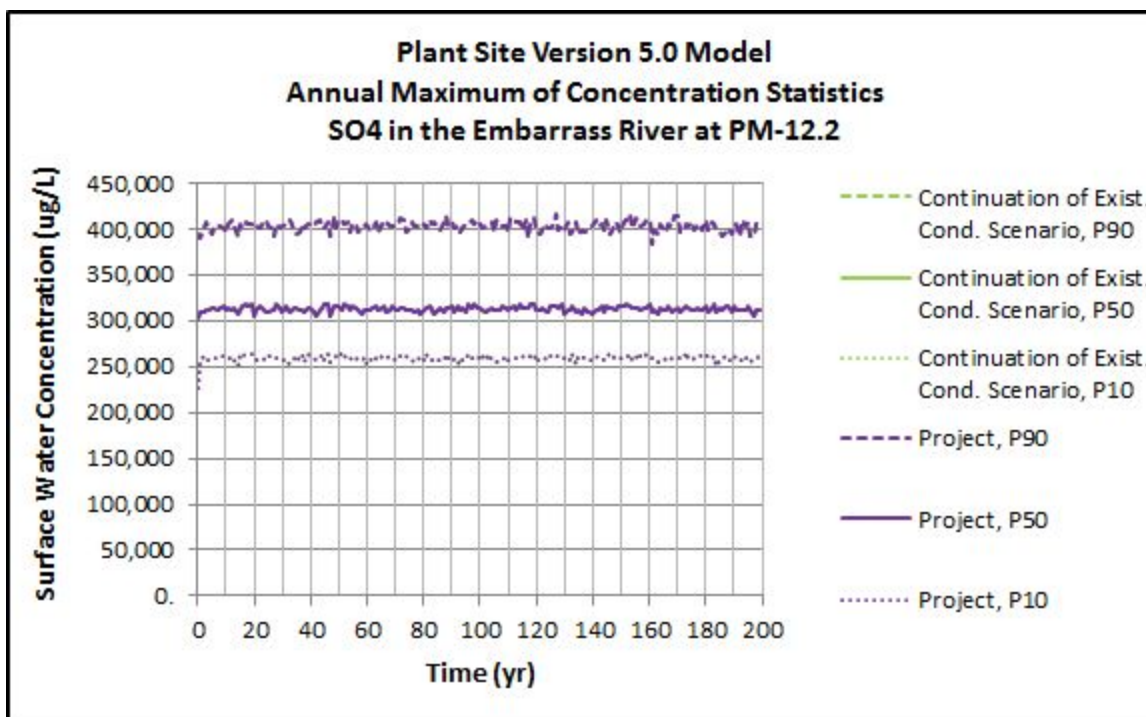


Figure 5.2.2-53 Annual Maximum Sulfate Concentrations at PM-13; Continuation of Existing Conditions Scenario vs. NorthMet Project Proposed Action (Barr 2013f)

Criterion 3: No statistically significant increase in sulfate would occur in the Embarrass River from upstream of the facility (e.g., PM-12.2) to downstream of the facility (e.g., PM-13)

Figure 5.2.2-54 shows the annual maximum sulfate concentration at PM-12.2. There are no planned NorthMet Project Proposed Action activities that would affect this location, so this figure serves as a basis for determining downstream sulfate reductions during NorthMet Project Proposed Action conditions. Figure 5.2.2-53 above shows both the Continuation of Existing Conditions Scenario and NorthMet Project Proposed Action maximum sulfate concentrations at PM-13. Under existing conditions, maximum sulfate concentration would be reduced from about 315 mg/L at PM-12.2 to about 170 mg/L at PM-13. Due to the reduction in sulfate-loading discussed previously, the maximum sulfate concentration at PM-13 is expected to decrease by more than 40 percent, to about 100 mg/L.



Note: Continuation of Existing Conditions Scenario values are identical to and hidden by the NorthMet Project Proposed Action values.

Figure 5.2.2-54 *Annual Maximum Sulfate Concentration at PM-12.2 (Barr 2013f)*

5.2.2.3.4 Mercury

Mercury can be released to surface water or groundwater through mobilization of mercury stored in rock, soil, peat, and vegetation. Methylmercury, which is an organic form of mercury, accumulates in fish and is toxic to humans and wildlife. Current scientific understanding of the factors and mechanisms affecting mercury methylation and bioaccumulation is limited. Mercury concentrations in fish sampled from downstream lakes presently trigger advice to limit fish consumption. An increase in mercury bioavailability would be counter to statewide efforts to reduce mercury concentrations in fish.

Mercury was not included in the GoldSim model, as insufficient data and a general lack of definitive understanding of mercury dynamics prevented modeling mercury like the other solutes. Regardless, the NorthMet Project Proposed Action would still need to demonstrate consistency with the mercury evaluation criteria (see Section 5.2.2.1).

This section discusses mercury from only a water-concentration perspective; the potential effects of the NorthMet Project Proposed Action on the bioaccumulation of methylmercury in fish are discussed in Section 5.2.6.

Direct Release of Mercury to the Partridge River Watershed

The NorthMet waste rock and ore contain trace amounts of mercury. Laboratory analysis of humidity cell leachates from waste rock samples found average total mercury concentrations between 5 and 7 ng/L, with concentrations unrelated to rock type or sulfur content (SRK 2007b).

Separate 36-day batch tests using local rainfall (12 ng/L total mercury) found that contact with Duluth Complex rock actually decreased total mercury concentrations to between 1.9 and 3.2 ng/L as a result of adsorption (SRK 2007b). Therefore, the data suggest that mercury present in rainfall or released by sulfide oxidation is typically adsorbed by other minerals present in the mine waste rock. For these reasons, mercury released from waste rock and ore at the Mine Site is not expected to be a constituent of concern in groundwater seepage. The primary NorthMet Project Proposed Action-related source of mercury to the Partridge River would be the WWTF discharge.

As discussed previously, there would be no surface water discharges to the Partridge River or its tributaries from the Mine Site until approximately year 40, when the West Pit would be flooded and the overflow would be directed to the WWTF for treatment and discharge. The WWTF discharge would be subject to the Great Lakes Initiative standard for mercury (1.3 ng/L). Mercury concentrations in the West Pit were estimated two ways: using analog data from other natural lakes and mine pit lakes in northeastern Minnesota, and using a mass balance approach.

The West Pit, like seepage/headwater lakes (e.g., lakes with no significant inflowing streams), would receive most of its water from precipitation and direct runoff from the surrounding watershed. Water balance modeling estimates that 70 percent of the West Pit inflow after reclamation would be from precipitation. Therefore, natural seepage/headwater lakes and existing mine pits in the vicinity of the NorthMet Project area can provide an analog for mercury concentrations that would occur in the West Pit at the time of overflow. Data from 16 mine pit lakes and five natural headwater/seepage lakes in northeastern Minnesota were evaluated. As Table 5.2.2-49 shows, despite the fact that the primary source of inflow to these lakes/pits was precipitation, which averages about 9.8 ng/L based on average volume-weighted mercury in precipitation as measured at the Marcell Experimental Forest deposition site in Itasca County (NADP 2013), only two of the lakes/pits had average total mercury concentrations above the Great Lakes standard of 1.3 ng/L (Pit 2W at 1.61 ng/L and Pit 9S at 1.87 ng/L).

Table 5.2.2-49 Total Mercury Concentration Data from Natural Lakes and Mine Pits in Northeastern Minnesota

Lakes/Pits	Number	Total Mercury Average Range	Individual Sample Range	Number with Avg Concentration >1.3 ng/L
Natural Lakes	5	0.43 – 1.25 ng/L	0.34 – 1.73	0
Pit Lakes	21	0.4 – 1.87 ng/L	0.5 – 2.55	2

Source: PolyMet 2013i.

A mass balance approach was also used to evaluate potential mercury concentrations in the West Pit. The mass balance took into consideration average inflows and estimated potential mercury inputs from precipitation, atmospheric dry deposition, groundwater inflow, Category 1 Stockpile drainage, other stormwater runoff within the Mine Site, supplemental water from the Plant Site WWTP, collected seepage from the Tailings Basin, and inflows from the East Pit (see Table 5.2.2-50). The mass balance also took into consideration the loss of mercury via burial (i.e., loss due to settling), evasion/volatilization, and outflow (i.e., pumping to the WWTF for treatment and discharge). The mass balance model conservatively assumed that mixing only occurred in the upper 30 ft of the water column, as this would limit the volume of water available to dilute the mercury-loading.

Table 5.2.2-50 Initial and Final Parameter Values for the Mercury Mass Balance

Parameter	Flow in Mine Year 45	Total Mercury Concentration or Flux
Wet and Dry Deposition	696 acre-ft/yr ⁽¹⁾	13 ng/L; 9,407 ng/m ² /yr ⁽¹⁾
Precipitation (based on monitoring data) ⁽¹⁾		
Atmospheric dry deposition	NA	3,093 ng/m ² /yr ⁽¹⁾
Total wet and dry deposition	NA	12,500 ng/m ² /yr ⁽¹⁾
Contained/Uncontained Category 1 Stockpile drainage	0.3 ac-ft/yr ⁽²⁾	13 ng/L
Watershed runoff (stormwater runoff from undisturbed or reclaimed/revegetated areas; includes the runoff from the Category 1 Stockpile)	30 ac-ft/yr ⁽²⁾	4 ng/L ⁽³⁾
Groundwater Inflow (shallow aquifer)	46 ac-ft/yr ⁽²⁾	3 ng/L ⁽³⁾
East Pit flow (from wetland)	239 ac-ft/yr ⁽²⁾	4 ng/L
Backfilled East Pit flow (groundwater) ("lower pore water seepage")	0 ⁽²⁾ (intermittent contribution; 0.02 to 0.15 ac-ft/yr)	4 ng/L
Treated Water: Mine Site WWTF	0 ⁽²⁾ (Up to 453 acre-ft/yr during pit flooding)	8 ng/L
Plant Site Water: Treated water from the WWTP and collected seepage water (untreated) from the groundwater containment system and South Seepage management system (supplemental water for pit flooding)	0 ⁽²⁾ (Up to 6,600 acre-ft/yr during pit flooding)	1.3 ng/L
West Pit Mercury Losses		
Burial	NA	92% of total load; 12.6 ng/m ² /yr ⁽⁴⁾
Evasion/Volatilization (~5% of atmospheric inputs)	NA	5% of atmospheric inputs ⁽⁵⁾
Outflows	490 acre-ft/yr ⁽²⁾	Varies with concentration of West Pit water column

Source: PolyMet 2013i, Table 6-25.

¹ Precipitation volume from monitoring stations within 30 miles of the NorthMet Project area; annual average Hg concentration from the National Atmospheric Deposition Program for the Fernberg Road Site (MN18) (2010-2011). Total atmospheric deposition is assumed to equal 12,500 nanograms per square meter per year (ng/m²/yr) (Swain et al. 1992). Dry deposition is set equal to the difference between total and wet deposition and represents about 25% of total deposition.

² Flow estimate from GoldSim Modeling results.

³ Estimate of Hg concentration based on NorthMet Project Proposed Action data.

⁴ Burial rate for mercury is lower (more conservative) than initial estimate according to the burial regression equation discussed in Section 6.6.2.3.7 of PolyMet 2013i.

⁵ Volatilization rate is estimated based on the low end of the range of values discussed in Section 6.6.2.3.7 of PolyMet 2013i.

Based on the input values from Table 5.2.2-50 above, the estimated average mercury concentration of the West Pit during flooding (years 20 to 40) would initially be approximately 0.3 ng/L, and after flooding (after year 40) would stabilize at approximately 0.9 ng/L.

It should be noted that the West Pit overflow would be treated by the WWTF using RO technology prior to discharge, and the RO process is known to remove mercury. Therefore, the actual mercury concentrations in the WWTF effluent discharge are expected to be less than the concentrations predicted for the West Pit lake (i.e., less than 0.9 ng/L), although an effluent mercury concentration of 1.3 ng/L was assumed for purposes of estimating mercury

concentrations in the WWTF discharge. Table 5.2.2-51 provides a summary of the initial mass balance results, with the largest input of mercury to the West Pit coming from atmospheric deposition (about 55 percent of total estimated inputs), and the largest loss of mercury attributed to burial (about 92 percent of total mercury inputs).

The Overburden Storage and Laydown Area would not be lined, but would have a compacted soil bottom. Stormwater runoff from the Overburden Storage and Laydown Area would be considered process water and would be collected and routed to the Tailings Basin for years 1 to 11, where much of the mercury would be sequestered in the tailings. In years 12 to 20, the Overburden Storage and Laydown Area stormwater runoff would be collected and routed to help flood the East Pit, where most of the remaining mercury would be sequestered (e.g., through settling and other processes within the pit). After year 20, the Overburden Storage and Laydown Area would not be used for overburden storage and would be closed and would no longer serve as a potential source of mercury. The potential for mercury release from peat decomposition in the Overburden Storage and Laydown Area is included in the mass balance as part of the Process Water input.

The NorthMet Project Proposed Action is predicted to result in a net decrease in mercury-loading to the Partridge River from 24.2 to 23.0 grams per year. This would primarily be a result of a decrease in natural runoff (with a total mercury concentration of 3.6 ng/L) and a proportional increase in water discharged from the West Pit via the WWTF (with a total mercury concentration of 1.3 ng/L).

Table 5.2.2-51 Summary of Estimated Mercury-Loading (Inputs)¹ and Losses (Outputs) for the West Pit Lake (Mine Year 20 to about Mine Year 40)

Parameters	Annual Average Load of Mercury (nanograms)	Percent of Summed Inputs	Comments
Inputs			
Atmospheric (wet + dry)	1.28E+10	56%	Dry deposition ~30% wet deposition
East Pit wetland overflow	5.15E+08	2%	Includes runoff from the East Pit and watershed to the East Pit
Process water (other than from the East Pit)	1.66E+09	7%	Includes runoff from the Category 1 Stockpile and the Overburden Storage and Laydown Area
Groundwater	2.74E+08	1%	Includes groundwater flow from undisturbed portions of the Mine Site + groundwater inflow from the East Pit + contained/uncontained Category 1 Stockpile drainage
WWTF	2.88E+09	13%	
Pumping from the Plant Site: WWTP and collected seepage from the Tailings Basin	4.80E+09	21%	
SUM	2.29E+10		
Outputs (Losses)			
Evasion/Volatilization	6.40E+08	3%	Loss from the water column

Parameters	Annual Average Load of Mercury (nanograms)	Percent of Summed Inputs	Comments
Burial	2.11E+10	92%	
Groundwater	NE		
Overflow (release)	1.38E+07	0.1%	
Removal by RO WWTF	NE		
SUM	2.17E+10		
NET (retention)			
Inputs – Outputs	1.18E+09		Net retention of Hg

Source: PolyMet 2013i, Table 6-26.

NE = Not estimated for this analysis.

¹ Reasonably conservative estimates of mercury concentrations and average annual flow estimates from GoldSim modeling were used to estimate mercury-loading.

Direct Release of Mercury to the Embarrass River Watershed from the Tailings Basin

The Plant Site would receive inputs of mercury from two primary sources: residual trace concentrations in the tailings and process consumables, with some minor contributions from Colby Lake makeup water and Mine Site process water, which would be pumped to the Tailings Basin pond through year 11 (and possibly through year 20, but is dependent on the NorthMet Project Proposed Action's water balance). Mercury would be released from the Tailings Basin via seepage, discharge from the WWTP, and volatilization from the Tailings Basin pond (this mechanism is discussed in Section 5.2.7, Air Quality). As with the Mine Site, mercury was not included in the GoldSim model, but quasi-analog and mass balance approaches were used to estimate future mercury concentrations.

Several studies have been conducted by state agencies regarding the release of mercury from taconite ore processing and tailings facilities. Berndt (2003) concluded that wet and dry deposition of mercury was the major source of dissolved mercury in taconite tailings pond water, rather than the actual tailings themselves. Further, Berndt found that taconite tailings appear to be a sink for mercury in full-scale actual tailings basins in northern Minnesota, at least similar to other media like soils, as evidenced by lower mercury concentrations in waters seeping from tailings basins (specifically at U.S. Steel's Minntac Mine and Northshore Mining's Northshore Mine) than in either precipitation input or pond water in the tailings basin. This finding is supported by surface and groundwater monitoring around the existing LTVSMC Tailings Basin, which found mercury concentrations consistent with baseline levels (see Table 4.1-31), generally averaging less than 2.0 ng/L. The overall average total mercury concentration at two discharge locations at the Tailings Basin (SD026 and SD004) over a 5-year period was 1.1 ng/L, indicating relatively low mercury concentrations in the existing LTVSMC Tailings Basin seepage. All monitoring results were well below average concentrations in precipitation, so most mercury appears to be sequestered in the LTVSMC tailings.

A mass balance model was developed to aid in estimating potential release of mercury from the Plant Site. All major inputs of mercury were included in the mass balance model. The major outputs of mercury include the hydrometallurgical residue, air emissions from the hydrometallurgical process, the tailings, and the ore concentrate. The vast majority of the mercury is predicted to remain in the concentrate, with only about 8 percent predicted to be sent to the Tailings Basin via the tailings and process water. Process and tailings water samples from a pilot study conducted with NorthMet ore were found to have mercury concentrations of 11.2

and 0.7 ng/L, respectively. Mercury loadings to the Tailings Basin are estimated to be 16.2 pounds per year (lbs/yr), with about 15.8 lbs/yr from solids and about 0.4 lbs/yr from process water. For comparison, this is significantly less than the 610 lbs/yr estimated average mercury-loading to the existing LTVSMC tailings basin during LTVSMC operations.

NTS (2006) conducted a bench study using NorthMet tailings to determine the rate of mercury adsorption by the tailings. The concentration of dissolved mercury in a treatment flask containing process water and NorthMet tailings decreased from 3.3 ng/L (at time 0) to 0.9 ng/L (at 480 minutes). Although the exact mechanisms behind the adsorption process are not yet clearly understood, the ability of NorthMet tailings to adsorb mercury, in combination with the proven ability of the underlying taconite tailings to adsorb mercury, is expected to result in an overall increase in the adsorption of mercury at the Tailings Basin with the addition of the NorthMet tailings.

In summary, the Tailings Basin is predicted to receive less mercury (about 2 to 3 percent) and less flow than the existing LTVSMC Tailings Basin historically received, while retaining the adsorption benefits of the LTVSMC tailings, as well as the demonstrated mercury adsorption capability of the NorthMet tailings. For these reasons, it is reasonable to conclude that the seepage from the NorthMet tailings should have similar or lower mercury concentrations as the LTVSMC tailings seepage, which has averaged about 1.1 ng/L. Therefore, the total mercury concentration in seepage from the Tailings Basin is expected to be less than the Great Lakes Initiative standard of 1.3 ng/L.

Most of the Tailings Basin seepage would be captured by the tailings containment system and pumped to the WWTP for treatment. The WWTP would also receive water from the Tailings Basin pond, as well as stormwater runoff from the basin. The discharge from the WWTP, like the discharge from the WWTF, would be subject to the Great Lakes Initiative standard of 1.3 ng/L. The estimated mercury concentration and flow rate for each of these influent streams is shown in Table 5.2.2-52. As this table shows, the combined influent streams are estimated to have a mercury concentration of 1.3 ng/L prior to treatment.

Table 5.2.2-52 Estimated Mercury Concentration of the Combined Inflows to the Plant Site WWTP

Stream	Flow Rate (gpm)	Mercury Concentration (ng/L)	Total Mercury Flow (ng/yr)
Seepage water	1,498	1.1	3.3E+09
Runoff (interacting with tailings)	294	1.1	6.4E+08
Runoff (not interacting with tailings)	72	3.5	5.0E+08
Tailings Basin pond dewatering	365	2.0	1.5E+09
Combined stream	2,229	1.3	5.9E+09

Source: Table 6-13, PolyMet 2013j.

The WWTP would use a greensand filtration process followed by RO technology. RO treatment plants are known to remove mercury, particularly when the influent to the RO system is pre-treated. Therefore, the total mercury concentration in the WWTP discharge is expected to meet the evaluation criteria of 1.3 ng/L.

The NorthMet Project Proposed Action is predicted to result in a net increase in mercury loadings to the Embarrass River of up to 0.6 grams per year (from 22.3 to 22.9 grams per year), about a 3 percent increase. This increase is primarily attributable to:

- the redirection of surface runoff in the vicinity of the East Dam from the Tailings Basin (where the seepage averages 1.1 ng/L) directly to Mud Lake Creek (with an assumed mercury concentration of 3.5 ng/L), and
- the Tailings Basin containment system, which would collect seepage from the Tailings Basin, with an estimated mercury concentration of 1.1 ng/L, and route it to the WWTP, which would discharge with an assumed mercury concentration of 1.3 ng/L, for a net increase of 0.2 ng/L of mercury as a result of wastewater treatment, which is a conservative assumption.

Enhanced Mercury Methylation

Virtually all dispersal of mercury in the environment (especially atmospheric dispersal) occurs in inorganic form (Fitzgerald and Clarkson 1991), but nearly all of the mercury accumulated in fish tissue (more than 95 percent) is organic methylmercury (Bloom 1992). Thus, methylation is a key step in bioaccumulation of mercury. Methylmercury is a product of the methylation of inorganic mercury by sulfate-reducing bacteria, a process that can be stimulated by increased sulfate concentrations in aquatic systems where sulfate is limiting (Gilmour et al. 1992; Krabbenhoft et al. 1998). Although, as described above, the NorthMet Project Proposed Action is expected to result in a negligible release of inorganic mercury to groundwater or surface waters and is predicted to meet the 1.3 ng/L discharge evaluation criteria, the potential effects of the NorthMet Project Proposed Action on mercury methylation must be evaluated.

There are several factors that appear to influence mercury methylation, including total available mercury, organic carbon, temperature, micronutrients required by sulfate-reducing bacteria, sulfate loadings (over the range for which sulfate may be a limiting factor for sulfate-reducing bacteria), and certain hydrologic conditions. The NorthMet Project Proposed Action is expected to have little or no effect on most of these things, but the effect on two of these, sulfate concentrations and hydrologic conditions, warrants further discussion. These two potential effects are discussed below.

Sulfate Loadings

Research indicates that sulfate-reducing bacteria are the primary mercury methylators in aquatic systems, especially in wetlands (Compeau and Bartha 1985). Biologically available sulfate is believed to be one of several limiting factors for the methylating bacteria (Jeremiason et al. 2006; Watras et al. 2006). Adding sulfate to aquatic systems where sulfate is limiting can therefore stimulate sulfate-reducing bacteria activity, leading to increased mercury methylation as the sulfate is consumed (Gilmour et al. 1992; Harmon et al. 2004; Branfireun et al. 1999; Branfireun et al. 2001). Recent research in northern Minnesota suggests that increased atmospheric sulfate-loading to a peatland can result in increased mercury methylation and export (Jeremiason et al. 2006), but other research suggests that this effect is not linear and diminishes at higher loads where sulfate may no longer be limiting (Mitchell et al. 2008). Heyes et al. (2000) reported a significant positive correlation between methylmercury and sulfate in a poor fen ($R^2 = 0.765$, $p = 0.005$) and in a bog ($R^2 = 0.865$, $p = 0.022$). However, the relationship between sulfate concentration and methylmercury production is complicated. Branfireun and Roulet (2002)

found a negative relationship between sulfate and methylmercury in a wetland, which they interpreted as showing that methylmercury production at that site was caused by the reduction of sulfate. However, water may also transport sulfate to other downstream locations where sulfate availability is rate limiting for methylmercury production.

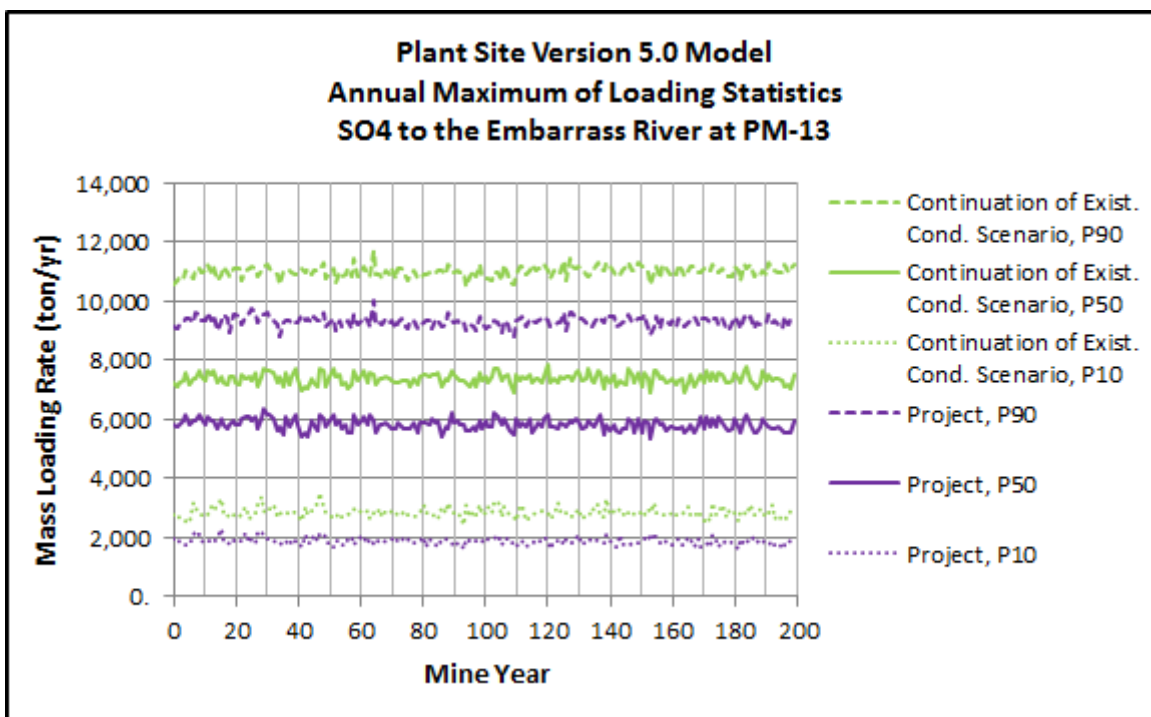
Many studies have shown that wetlands can be sinks for mercury and sources of methylmercury to surrounding watersheds (St. Louis et al. 1996). Galloway and Branfireun (2004) found that wetlands were an important site of sulfate reduction and methylmercury production. Balogh et al. (2004) and Balogh et al. (2006) concluded that increases in methylmercury in several Minnesota rivers during high-flow events was likely the result of methylmercury transport from surrounding wetlands to the main river channel. A recent study by the MDNR found little, if any, correlation between total mercury or methylmercury and sulfate concentrations in northeastern Minnesota streams (Berndt and Bavin 2012a; 2012b). Instead, the study found strong correlations between mercury and dissolved organic carbon concentrations and total wetland area. Overall, these studies suggest that most mercury methylation, at least in the St. Louis River Basin, primarily occurs within wetlands rather than in stream channels and the methylmercury is flushed to rivers from wetlands during storm events.

The MPCA recognizes the important role of sulfate in methylmercury production, as well as the uncertainties regarding site-specific relationships between sulfate discharges and water body impairment. The MPCA has set forth a strategy (MPCA 2006) for addressing the effects of sulfate on methylmercury production that encompasses technical, policy, and permitting issues. The strategy acknowledges that the technical basis does not exist to establish sulfate concentration limits. The strategy, however, sets forth steps the MPCA can take to improve the technical basis for controlling sulfate discharges and establishes guidance for considering potential sulfate effects during environmental review and NPDES permitting. The strategy focuses on avoiding “discharges,” which could include groundwater seepage, to “high-risk” situations. These high-risk areas include wetlands, low-sulfate water (less than 40 mg/L) where sulfate may be a limiting factor in the activity of sulfate-reducing bacteria, and waters that flow to a downstream lake that may stratify, all or most of which apply to the area downstream of the Tailings Basin and the WWTF discharge.

In response to this policy, as well as to comply with sulfate standards that apply to waters recommended as supporting the production of wild rice, PolyMet has proposed several significant changes to the NorthMet Project Proposed Action design from that proposed in the DEIS. These changes would significantly reduce sulfate loadings, and include a groundwater containment system around the Category 1 Stockpile and a WWTF to treat the West Pit overflow at the Mine Site, and a groundwater containment system around most of the Tailings Basin and a WWTP to treat tailings seepage at the Plant Site.

As a result of the design changes at the Mine Site, the NorthMet Project Proposed Action is predicted to increase the sulfate load by less than 2 percent in the Partridge River watershed, but maintain the same maximum P90 concentration (19.4 mg/L) as Continuation of Existing Conditions Scenario. Effluent from the WWTF would be discharged at 9 mg/L beginning when the West Pit is predicted to flood in year 40. Sulfate concentrations in this range would meet the state’s definition of low-sulfate water and would not be expected to promote mercury methylation.

As a result of the design changes at the Plant Site, the NorthMet Project is predicted to significantly decrease sulfate loadings to the wetlands north of the Tailings Basin and to the Embarrass River, primarily because the groundwater containment system would capture nearly all Tailings Basin seepage and ultimately route it to the WWTP, which would treat the seepage and discharge the effluent at a target concentration of 9 mg/L as part of the Embarrass River tributary streams flow augmentation. The net effect of these engineering controls would be a reduction in sulfate loadings relative to Continuation of Existing Conditions Scenario model results at PM-13 (see Figure 5.2.2-55).



Source: Barr 2013j.

Figure 5.2.2-55 *Range of Annual Sulfate Loading Rates to the Embarrass River at PM-13 – Continuation of Existing Conditions Scenario versus NorthMet Project Proposed Action*

Hydrologic Changes and Water Level Fluctuations

Methylation of environmental mercury by sulfate-reducing bacteria is also stimulated by drying and rewetting associated with hydrologic changes and water level fluctuations (Gilmour et al. 2004; Selch et al. 2007). Drying (and subsequent increase in exposure to oxygen) of substrate containing reduced sulfur species (sulfides and organic sulfur) oxidizes those species into sulfate, which is remobilized and available to sulfate-reducing bacteria upon rewetting of the substrate. This mechanism stimulates production of methylmercury in sediments exposed to wetting and drying cycles (Gilmour et al. 2004) and probably accounts for some of the elevated methylmercury concentrations observed in releases from wetlands during high-flow events (Balogh et al. 2006). Thus, hydrologic changes and water level fluctuations can stimulate mercury methylation and enhance bioaccumulation.

Mercury Summary

Based on the above analysis, the NorthMet Project Proposed Action would have negligible effects on hydrologic changes or water level fluctuations in the Partridge River and Embarrass River, would maintain relatively low sulfate loadings and concentrations to the Partridge River, would significantly reduce sulfate loadings to the Embarrass River, and would meet the Great Lakes Initiative mercury standard with its discharges. Overall, mercury loadings are predicted to increase slightly in the Embarrass River (3 percent) as a result of the NorthMet Project Proposed Action, but would be offset by a larger decrease (5 percent) in the Partridge River, resulting in a net decrease in overall mercury loadings (0.6 grams per year) to the St. Louis River as a result of the NorthMet Project Proposed Action.

5.2.2.3.5 Proposed and Recommended Mitigation Measures

PolyMet has either proposed or agreed to the following measures to avoid, minimize, or mitigate effects, which are considered part of the NorthMet Project Proposed Action (see Section 3.1). These measures include design changes since the DEIS, including fixed engineering controls and an overall Adaptive Water Management Plan (AWMP). PolyMet would be required by its permits to monitor effects on hydrology and water quality in order to refine modeling to help predict future conditions for consideration in permit renewals. In the event that the monitoring identifies the potential for any water quality exceedances, PolyMet has proposed features from the AWMP that identify additional measures the firm could take if necessary to prevent any exceedances of water quality standards.

NorthMet Project Proposed Action Design Changes

PolyMet has proposed several significant improvements to the design of the NorthMet Project Proposed Action for this SDEIS from the Proposed Action as described in the DEIS (October 2009), which would avoid or minimize effects on water resources. These include the following:

- Category 1 Stockpile liner – This was replaced with a groundwater containment system to capture additional seepage.
- Category 4 Stockpile Location – The location of the Category 4 Stockpile was shifted such that seepage would be captured in the Central Pit and East Pit and would minimize effects on surficial groundwater.

- Subaqueous Disposal of Reactive Waste Rock – Starting in year 11, when mining in the East Pit would cease, the temporary Category 2/3 and Category 4 stockpiles would be backfilled into the East Pit, and all future generated Category 2/3 and 4 waste rock would also be placed in the East Pit. Subaqueous disposal of the most-reactive waste rock would significantly reduce oxidation of the sulfide minerals.
- Saturated Overburden Management – saturated overburden, which is still potentially reactive, would be treated like waste rock and temporarily placed in the Category 2/3 and Category 4 stockpiles with a geomembrane liner and would ultimately be subaqueously disposed of in the East Pit.
- Expedited Flooding of the West Pit – Oxidation of the West Pit wall rock could be a significant source of loading for various constituents in the pit lake and ultimately affect its water quality. The longer the wall rock would be exposed to oxygen, the more oxidation of sulfide minerals would occur. PolyMet’s original proposal had estimated flooding to the West Pit in approximately 45 years; the current proposal estimates flooding to the West Pit in approximately 20 years.
- Ore Transport – PolyMet proposes to use side-dump rail ore cars that would minimize ore spillage (PolyMet 2013c).
- Tailings Basin – Vertical wells on north side of the Tailings Basin would be replaced with a Tailings Basin Seepage Containment System.
- Refined Hydrometallurgical Flowsheet – A single (rather two) autoclave would be fed with nickel concentrate and produce copper concentrate produced with beneficiation refinements. The production of hydrometallurgical residue would be cut approximately in half with this design change. Residual copper would be recovered by cementation (contacting the leach solution with copper concentrate) to further upgrade the copper concentrate and to further reduce the production of hydrometallurgical residue.
- Relocate and redesign Hydrometallurgical Residue Facility – The Hydrometallurgical Residue Facility would be moved from south end of Cell 2W to the Emergency Basin and would be provided a significantly enhanced the liner system.
- WWTP – A WWTP would be added at the Plant Site to treat Tailing Basin seepage through operations.

Fixed Engineering Controls

In addition to the design changes that avoid or minimize effects on water resources described above, PolyMet has proposed several fixed engineering controls that would minimize or mitigate effects on water resources from the NorthMet Project Proposed Action. These fixed engineering controls are not expected to be modified during the life of the NorthMet Project Proposed Action and would be included as part of the NorthMet Project Proposed Action’s financial assurance package. These fixed engineering controls include the following:

- Stormwater management, including ditches, dikes (including pit rim and north cutoff dikes), and sedimentation basins that would be used to separate and control stormwater and process waters.

- Process water management, including pipes, pumps, and process water ponds that would be used to separate and control stormwater and process waters.
- Temporary stockpiles (Category 2/3, Category 4, and Ore Surge Pile) would all have geomembrane liners, underdrain systems, sumps, and overflow ponds, for proper temporary storage of mine wastes and ore.
- Category 1 Stockpile groundwater containment system that would include a cutoff wall to collect seepage and drainage from the Category 1 Stockpile and convey it by gravity flow to collection sumps, where it would be pumped to the WWTF, enabling the capture and treatment of nearly all Category 1 Stockpile seepage.
- Treated Water Pipeline and Central Pumping Station to allow recycle of water for process at the Plant Site and zero liquid discharge during operations at the Mine Site.
- Haul Roads designed for collection of process water off road surfaces and separation of stormwater.
- Tailings Basin for the collection and control of NorthMet tailings and reuse/recycling of process water. The Tailings Basin would also include a bentonite amendment on its beaches (during reclamation) and embankment face (during operations) to reduce both water and oxygen intrusion into the tailings during reclamation. The tailings pond would also have a bentonite amendment, but this is discussed below as an adaptive engineering control.
- Tailings Basin seepage groundwater containment system for collection, control, and storage of Tailings Basin seepage on the western, northern, and northeastern sides of the existing LTVSMC Tailings Basin. Seepage and local runoff captured by this system would be pumped back into the Tailings Basin or to the Plant Site WWTP.
- Tailings Basin south surface seepage management system for collection and control of Tailings Basin seepage within the southeastern side. Seepage and local runoff captured by this system would be pumped back into the Tailings Basin.
- Hydrometallurgical Residue Facility for collection, control, and storage of hydrometallurgical residue and reuse and recycle of process water. This facility would have a double geomembrane liner with a leakage collection system that would return any leachate to the Hydrometallurgical Residue Facility pond.
- Colby Lake pumphouse, pipeline from Colby Lake, and Plant Site reservoir for augmentation of process water and streamflows.
- Streamflow augmentation system for flow augmentation in streams downgradient of the Tailings Basin from WWTP effluent and water transferred from Colby Lake in order to maintain streamflows within 20 percent of existing conditions.

Adaptive Water Management Plan

Adaptive management is a system of management practices, based on clearly defined outcomes and monitoring requirements, that assesses whether management actions are meeting the desired outcomes, and, if not, they are facilitating changes that would ensure the defined outcomes are met. In the case of the NorthMet Project Proposed Action, PolyMet has developed an AWMP, which includes adaptive engineering controls and contingency mitigation measures (PolyMet

2013g). Adaptive engineering controls may have their design, operation, or maintenance modified before or after their installation based on how actual water quality, as measured during monitoring, compares with GoldSim water quality predictions. Not all questions about changing water management can be answered using the current construct of GoldSim (i.e., transport time for constituent load in Category 1 stockpile). Certain assumptions were made that may not be applicable to all potential project feature modifications. If water quality were better or worse than predicted, these adaptive engineering controls would be adjusted accordingly, with the approval of the MDNR and MPCA. The adaptive engineering controls would be included as part of the financial assurance package and would include the following:

- WWTF – The WWTF is now proposed to be upgraded to a RO process during closure to manage sulfate concentrations in the effluent. The WWTF at the Mine Site is considered an adaptive engineering control because the operating configuration and requirements of the process units within the WWTF or the capacity of the WWTF could be modified to accommodate varying influent streams and discharge requirements. The plan for construction of the WWTF already envisions a phased build-out of the capacity in order to meet the Mine Site's maximum flow requirements (year 14). Therefore, these capacity expansions could be accelerated if necessary. The WWTF processes could be adapted depending on the actual water quality conditions encountered during the NorthMet Project Proposed Action phases and estimated by water quality monitoring and model updating. Treatment performance issues that could occur from changes in influent water quality could be addressed by making adjustments to operating conditions (PolyMet 2013g). In addition, the WWTF effluent, which would include calcium carbonate generated from the WWTF recarbonation/calcite precipitation system, would be used to help flood the East Pit, while also contributing some alkalinity to help maintain circumneutral pH in the pit water (PolyMet 2013g). Lime could also be added to the East Pit during waste rock backfilling if additional alkalinity were needed (PolyMet 2013i).
- Category 1 Stockpile Cover System – PolyMet proposes to install a geomembrane cover system, in lieu of the originally proposed evapotranspiration cover, to reduce the load of the constituents that would reach the West Pit via drainage from the Category 1 Stockpile. Construction of the Category 1 Stockpile cover system would be progressive, starting in year 14 and being fully constructed by the end of year 21. Under the NorthMet Project Proposed Action, the Category 1 Stockpile would be the only permanent waste rock stockpile. Water quality modeling indicates that, for many constituents, this stockpile would be the largest source of constituent load to the West Pit. The Category 1 Stockpile cover system would be the primary engineering control that limits constituent loading from the Category 1 Stockpile to the West Pit.

The design of the Category 1 Stockpile cover system could be adapted up to the point of construction, depending on the actual water quality conditions encountered during the NorthMet Project Proposed Action phases and estimated by water quality monitoring and model updating. Design options, which would need to be approved by the MPCA and MDNR, include:

- increased or decreased thickness of the geomembrane material to modify the potential for defects to be created during installation and to modify the life of the geomembrane;

- increased or decreased soil cover thickness above the geomembrane material to modify water storage capacity;
- increased or decreased soil hydraulic conductivity of the granular drainage layer above the geomembrane to modify lateral drainage capacity;
- increased or decreased uninterrupted slope length to modify lateral drainage capacity;
- modified soil type and/or thickness below the geomembrane to modify leakage rate through potential geomembrane defects;
- and/or including a geosynthetic clay liner below the geomembrane to modify leakage rate through potential geomembrane defects.

After installation of the cover system, post-installation adjustments, such as modifying vegetation density and erosion of the cover system, could be made if approved by the MPCA and MDNR (PolyMet 2013g).

- **WWTP** – The WWTP would treat Plant Site process water. It is considered an adaptive engineering control because the operating configuration and requirements of the process units within the WWTP or the capacity of the WWTP could be modified to accommodate varying influent streams and discharge requirements. Because the plan for construction of the WWTP envisions a phased build-out of the capacity that would be needed when the maximum flow were to occur, variations in quantity could easily be addressed by either accelerating or delaying the installation of the additional equipment that was planned for the expansion of the WWTP. The WWTP processes could be adapted depending on the actual water quality conditions encountered during the NorthMet Project Proposed Action phases and estimated by water quality monitoring and model updating. Treatment performance issues that could occur from changes in influent water quality could be addressed by making adjustments to operating conditions (PolyMet 2013g). Any design changes would need to be approved by the MPCA and MDNR.
- **Tailings Basin Pond Bottom Cover System** – PolyMet proposes to install a Tailings Basin pond bottom cover system during reclamation in order to reduce the diffusion of oxygen into the tailings. The Tailings Basin pond bottom cover system would consist of a bentonite amendment to the Tailings Basin pond bottom to reduce percolation. This system would provide an oxygen barrier above the NorthMet tailings to reduce oxidation and the resultant production of contaminants. In addition, the seepage through the tailings would be reduced, resulting in less flow being collected via the Tailings Basin groundwater containment system, and then treated.

Potential adaptive management actions for the Tailings Basin pond bottom cover system could trigger design modifications if the monitored quantity or quality of water collected by the groundwater containment system suggested that modifications were needed to meet water resource objectives. Prior to installation, the design of the pond bottom cover system could be adjusted to modify performance. Design options include: increasing or decreasing the thickness of the bentonite amendment, increasing or decreasing the percent of bentonite, and/or a combination of these options. After installation, the design of the installed pond bottom cover system could also be adjusted to modify performance by these same methods.

In addition, the bentonite amended layer could be excavated from portions of the pond bottom to modify performance. Any design modifications would need to be approved by the MPCA and MDNR (PolyMet 2013g).

Contingency Mitigation

Contingency mitigation measures are feasible options that could be undertaken should engineering controls be unable to ensure compliance with applicable water quality standards. These contingency measures were not included in the GoldSim modeling, as current model results at the P90 confidence level did not show these measures were needed to meet the evaluation criteria. If monitoring or refined modeling were to indicate that contingency mitigation would be needed, these measures would be employed as appropriate and approved by the MPCA and MDNR. The contingency mitigation measures would not be initially included in the financial assurance package, but, if required in the future, these measures would be added to the financial assurance package. These contingency mitigation measures would address the following situations (PolyMet 2013e and PolyMet 2013f):

- A pattern of overflows of the process water sumps or ponds developed – In all the process water sumps and ponds, there would be excess capacity designed as a safety factor ranging from approximately 30 to 270 percent of required capacity. Additional capacity could be developed by expanding the pond areas.
- Streams along the railroad corridor between the Mine Site and Plant Site showed degradation in water quality as a result of material spilled from the rail cars – Catchment areas could be developed adjacent to the tracks at stream crossings to minimize the amount of material that reaches the streams.
- Groundwater downgradient of lined infrastructure had compliance issues – Interception wells could collect groundwater flows affected by a leak from one of the liner systems. Because all liner systems at the Mine Site would be for temporary infrastructure (temporary stockpiles, temporary ponds, etc.), the interception wells would only be needed while the liner was in use or until the liner repair could be performed.
- West Pit water quality was not as expected – This could be addressed by reducing the contaminant load from the West Pit walls or the East Pit using methods such as low-permeability soil barriers or a PRB, adding water with lower concentrations of contaminants to the West Pit by routing additional stormwater to the West Pit, or treating the West Pit either by pumping West Pit water to the WWTF for treatment or treating the West Pit Lake in situ with iron salts, fertilizer, or other methods tailored to the contaminant.
- New surface seepage locations emerged as the Tailings Basin was developed – The groundwater containment system or the Tailings Basin south surface seepage management system could be expanded to collect seepage from any new seepage locations.
- Tailings Basin pond water quality was worse than expected – This could be addressed by several methods, including: reducing solute load delivered to the Tailings Basin pond by incorporating additional treatment at the Mine Site WWTF; sending all or a portion of the water from the groundwater containment system and Tailings Basin south surface seepage management systems to the WWTP for treatment before being returned to the Tailings Basin pond; sending pond water to the WWTP for treatment before being returned to the Tailings

Basin pond; or treating the Tailings Basin pond in situ with iron salts, fertilizer, or other methods tailored to the constituent of concern.

- Groundwater or surface water downgradient of the Tailings Basin has compliance issues – This could be addressed by several methods, including inspecting the containment system around the Tailings Basin for breaches and repaired or using interception wells to collect groundwater flows affected by a breach, or improving Tailings Basin pond water quality (see above).

Future Transition from Mechanical to Non-Mechanical Treatment Systems

The NorthMet Project Proposed Action would rely upon mechanical treatment to achieve water resource objectives as long as needed; however, the goal would be to transition to non-mechanical treatment—which would be a low-maintenance, low-energy treatment system—to ensure attainment of water resources objectives, including compliance with applicable groundwater and surface water standards, during the closure phase. Non-mechanical treatment systems, which are described below, would be designed and pilot-tested before being implemented to treat water from the Category 1 Stockpile groundwater containment system, the West Pit Overflow, the Tailings Basin groundwater containment system, and the Tailings Basin south seepage management system.

Category 1 Stockpile Groundwater Containment Non-mechanical Treatment System

PolyMet proposes to install a Category 1 Stockpile groundwater containment non-mechanical treatment system at the Mine Site to replace the mechanical treatment of the water collected by the containment system during the long-term closure phase of the NorthMet Project Proposed Action. The system would likely include two PRBs, which are flow-through treatment systems, for metal precipitation and solids removal. The PRBs would reduce constituent-loading through physical, chemical, and/or biological treatment processes including: biochemical reduction of sulfate to sulfide using sulfate-reducing bacteria, sorption to solid-phase surfaces such as iron oxides or organic matter, chemical precipitation to convert dissolved-phase constituents to solid-phase particles, and physical filtering of solid-phase particles. The PRBs would ideally be located where they could take advantage of gravity flow. The locations would be dependent on the final hydraulic plan for discharge from the Category 1 Stockpile groundwater containment system into the West Pit (PolyMet 2013g).

West Pit Overflow Non-mechanical Treatment System

PolyMet proposes to install a West Pit overflow non-mechanical treatment system at the Mine Site to replace mechanical treatment of the West Pit overflow water during the long-term closure phase of the NorthMet Project Proposed Action. It is expected to be a multi-stage system with a constructed wetland for metal (copper, cobalt, nickel, and lead) precipitation and solids removal, a PSB for metal sorption, and an aeration pond to provide time for water exiting the PSB to re-equilibrate with the atmosphere and to increase the concentration of dissolved oxygen before the water would be discharged. The West Pit overflow non-mechanical treatment system would be designed to discharge only during September and October in order to comply with the seasonal sulfate discharge criterion for wild rice downstream of the Mine Site (PolyMet 2013g).

Tailings Basin Non-mechanical Treatment System

PolyMet proposes to install a Tailings Basin non-mechanical treatment system to replace the mechanical treatment of the water draining through the Tailings Basin and collected in the Tailings Basin groundwater containment system and the south seepage management system during the long-term closure phase of the NorthMet Project Proposed Action. The Tailings Basin non-mechanical treatment system would consist of a constructed wetland for metals precipitation, sulfate load reduction, and solids removal and PSBs for polishing (i.e., additional removal of metals, if needed). It would be constructed by rebuilding the natural wetlands between the Tailings Basin and the containment system as a vertical, upflow constructed wetland system with PSB systems at the outer perimeter within the access road. The total flow for the Tailings Basin non-mechanical treatment system is expected to be 1,200 gpm, which would include flows at the northern, northwestern, western, and southern toes (PolyMet 2013g).

Tailings Basin Pond Overflow Post-mechanical Treatment Options

During the initial portion of the long-term closure period, Tailings Basin pond water would be pumped to the WWTP to prevent overflow. A monitoring program would document changes in pond water levels and water quality over time. One goal of the NorthMet Project Proposed Action during long-term closure would be to allow overflow of the tailings pond. This could only be done after demonstrating that water in the Tailings pond was stormwater and that it complied with applicable standards. The Tailings Basin closure overflow structure would be embedded into bedrock of the hillside east of Cell 2E during reclamation. This structure would likely be modified to serve as a stormwater overflow, which would allow water discharged to enter the Mud Lake Creek Watershed (PolyMet 2013g).

5.2.2.3.6 Monitoring

Monitoring would be a critical component for ensuring that the proposed adaptive management would be effective. The NorthMet Project Proposed Action includes a water quality and quantity monitoring plan that would be finalized in permitting and updated as required. Overviews of the water monitoring plans at the Mine Site and Plant Site, with recommended or potential monitoring locations and frequencies, are presented in Tables 5.2.2-53 and 5.2.2-54. The specifics of monitoring—including specific locations, frequencies, and parameters—would be finalized during the NPDES/SDS permitting process.

Partridge River Watershed

Water monitoring within the Partridge River Watershed would be used on a continual basis to document compliance with permit conditions, annually validate and update water models, and provide input to optimize operations of adaptive engineering controls. Depending on the component (i.e., water flow, elevation, or quality) monitoring frequency would range from continuously to quarterly (PolyMet 2013e). An overview of the water monitoring plan within the Partridge River Watershed, which would be finalized in permitting, is in Table 5.2.2-53.

Table 5.2.2-53 Overview of Monitoring Plans within the Partridge River Watershed

Monitoring Plan Component		Purpose	Summary	General Locations
Internal Process Water Streams	Pit water	Compare water balance with expected conditions. Define future pumping requirements and evaluate trends in pit water quality.	Flow monitoring and water quality sampling ¹	Stations installed to monitor flows and water quality from each pit sump
	Stockpile drainage	Compare water balance with expected conditions. Define future pumping requirements, and evaluate trends in stockpile drainage water quality.	Flow monitoring and water quality sampling ¹	Stations installed to monitor drainage from each stockpile underliner and each stockpile underlain and the two Category 1 Stockpile groundwater containment system sumps
	Overburden Storage and Laydown Area runoff	Compare water balance with expected conditions. Define future pumping requirements, and evaluate trends in Overburden Storage and Laydown Area water quality.	Flow monitoring and water quality sampling of the Overburden Storage and Laydown Area pond ¹	Stations installed to monitor flows and water quality from the Overburden Storage and Laydown Area pond
	Haul road runoff	Compare water balance with expected conditions. Define future pumping requirements, and evaluate trends in haul road water quality.	Flow monitoring and water quality sampling of the haul road ponds ¹	Stations installed to monitor flows and water quality from the haul road ponds
	Rail Transfer Hopper runoff	Compare water balance with expected conditions. Define future pumping requirements, and evaluate trends in Rail Transfer Hopper water quality.	Flow monitoring and water quality sampling of the Rail Transfer Hopper pond ¹	Stations installed to monitor flows and water quality from the Rail Transfer Hopper pond
	WWTF influents and effluents	Optimize the treatment operations and demonstrate acceptable effluent characteristics.	Flow monitoring and water quality sampling of the influent and effluent streams	Inlet and outlet of the WWTF
	Treated Water Pipeline flows	Compare water balance with expected conditions and evaluate trends in Treated Water Pipeline water quality.	Flow monitoring and water quality sampling at the inlet and outlet	Inlet and outlet of the Treated Water Pipeline
Stormwater	Stormwater	Evaluate trends in stormwater quality and compare water balance with expected conditions.	Flow monitoring and water quality sampling at pond outlets ¹	Stormwater pond outlets

Monitoring Plan	Component	Purpose	Summary	General Locations
Groundwater	Surficial aquifer	Evaluate groundwater level and water quality trends in the surficial aquifer.	33 sampling locations sampled approximately April, July, and October	Surficial aquifer monitoring wells installed downgradient of each stockpile and pit
	Bedrock	Evaluate groundwater level and water quality trends in the bedrock.	Number of wells are yet to be determined, with sampling approximately April, July, and October	Bedrock monitoring well locations are TBD
Wetlands	Wetlands	Evaluate water levels for potential effects of mining operations on wetlands and determine if potential indirect effects from the mining operations have occurred or if additional mitigation is needed.	Number of piezometers and sampling frequency TBD	Continuation of baseline monitoring program
Surface Water	Partridge River	Evaluate trends in surface water quality and flow.	Flow monitoring at/near SW-004a and SW-006, and sampling of water quality during non-frozen conditions	Partridge River
	Partridge River tributaries	Evaluate trends in surface water quality and flow.	Water quality and flow monitoring for all streams	Longnose Creek, Wetlegs Creek, Wyman Creek, West Pit Overflow Creek, and Second Creek
	Colby Lake and Whitewater Reservoir	Evaluate trends in water quality of Colby Lake and water levels for Colby Lake and Whitewater Reservoir.	Water quality and water level sampling at one location for each water body during non-frozen conditions	Colby Lake and Whitewater Reservoir

Source: PolyMet 2013e.

¹ Cumulative flow volume would be continuously measured, with values recorded on a monthly basis. Water quality monitoring would occur during non-frozen conditions.

Proper placement of waste rock and overburden in the appropriate stockpile and for ultimate disposal would be important to achieve the NorthMet Project Proposed Action's predicted water quality. PolyMet has developed a Rock and Overburden Management Plan for monitoring and testing of waste rock during mine operations. The USEPA, MDNR, and MPCA have agreed that they will review this Plan and include requirements for waste rock testing and monitoring to ensure it is properly categorized and managed during permitting.

The MDNR would require a Spilled Ore Plan as part of the Permit to Mine for monitoring the extent of spillage and identifying appropriate mitigation measures

Embarrass River Watershed

Water monitoring within the Embarrass River Watershed would be used on a continual basis to document compliance with permit conditions, annually validate and update water models, and provide input to optimize operations of adaptive engineering controls. Depending on the component (i.e., water flow, elevation, or quality) monitoring is proposed to occur continuously, monthly, or three times a year in the first month of non-freezing quarters (PolyMet 2013f). An overview of the water monitoring plan at the Plant Site, which would be finalized in permitting, is in Table 5.2.2-54.

Table 5.2.2-54 Overview of Monitoring Plans for the Embarrass River Watershed

Monitoring Plan Component		Purpose	Summary	General Locations
Internal Process Water Streams	Tailings Basin pond	Monitor pond water levels and trends in Tailings Basin pond water characteristics over time	Water level (WL) monitoring and water quality (WQ) monitoring	WL monitoring location TBD; WQ monitoring at pond barge
	Tailings Basin seepage	Evaluate seepage rate and trends in water quality characteristics over time	Flow monitoring and WQ samples from seepage collection systems	Groundwater containment system lift stations and Tailings Basin south surface seepage management system pump station
	Hydrometallurgical Residue Facility pond	Monitor water level to prevent overtopping the Hydrometallurgical Residue Facility dam and monitor water quality trends over time	WL monitoring and WQ monitoring.	WL monitoring location TBD; WQ monitoring at pond barge
	Hydrometallurgical Residue Facility leachate	Evaluate leachate quantity and characteristics over time	Flow monitoring and monitoring of leachate quality	Underdrain
	Continued existing waste streams	Continue existing WQ monitoring requirements as appropriate	Monitoring of flow and WQ during non-frozen conditions (April, July, and October)	Seep into Cell 1E
Stormwater	Stormwater	Monitor stormwater quality and quantity	Flow rate (during non-frozen conditions, April through October) and WQ monitoring	Stormwater control features
Surface Discharges	WWTP	Demonstrate acceptable effluent characteristics	Flow and WQ monitoring of WWTP effluent, and total flow monitoring at discharge locations	WWTP effluent

Monitoring Plan Component		Purpose	Summary	General Locations
Surface Water	Embarrass River and tributaries	Evaluate trends in surface water quality and flow	Flow monitoring at/near PM-13 and PM-12 and WQ sampling	Embarrass River, Mud Lake Creek, Trimble Creek, and Unnamed Creek
	Second Creek	Evaluate trends in surface water quality and flow	Flow and WQ sampling	Second Creek downstream of seepage barrier
	Colby Lake intake/discharges for augmentation	Evaluate water quantity use over time for plant use and to augment streamflow	Flow monitoring, total flow monitoring at discharge locations	Colby Lake intake/discharge system to Embarrass River tributaries and Second Creek
Groundwater	General	Evaluate groundwater quality and water level trends over time	Monitoring wells sampled during non-frozen conditions (April, July, and October)	Existing monitoring wells installed around the Tailings Basin

Source: PolyMet 2013f.

WQ = Water Quality; WL = Water Level

5.2.2.4 NorthMet Project No Action Alternative

Under the NorthMet Project No Action Alternative, the NorthMet Project Proposed Action would not occur and, therefore, the environmental effects associated with the NorthMet Project Proposed Action, as described in Section 5.2.2, would not occur. Although under the No Action Alternative, the NorthMet Project Proposed Action, including the proposed Tailings Basin seepage collection and water treatment engineering controls, would not occur, the No Action Alternative would not be static. Under the No Action Alternative, water quality would continue to be maintained by generally effective existing natural ecosystem functions. Under the NorthMet Project Proposed Action, these functions would be provided by the WWTP or WWTF (or alternative, if developed) and this reflects a substantial shift in how water quality is maintained.

In the Partridge River Watershed, there are actions occurring as part of the Cliffs Erie Consent Decree that would be expected to result in improvements to the water quality of Second Creek and the Lower Partridge River, but there are also other proposals for mining and mineral processing, and mitigative actions under other existing water quality permits, that could also affect the water quality of these waterbodies, but which cannot be predicted at this time.

In the Embarrass River Watershed, it is anticipated that the water quality of the existing LTVSMC Tailings Basin seepage would improve over time as a result of natural attenuation and/or possible additional mitigation measures at some point in the future pursuant to new permit requirements or other state or federal remediation requirements. Other actions are underway to improve the water quality of the Area 5NW Pit overflow, which contributes a high sulfate load to the Embarrass River. At this time, the exact nature, timing, and effectiveness of these measures are unknown and, therefore, not quantifiable in this SDEIS, but it is reasonable to expect that water quality within the Embarrass River could improve over time, absent other unforeseen activities that could affect water quality. In addition, climate change would be likely to affect the hydrology and, indirectly, the water quality, of the NorthMet Project area as the result of predicted increases in mean annual temperature and mean annual precipitation.

Therefore, there are several factors that could dynamically affect the hydrology and water quality of the Partridge and Embarrass River watersheds in the future, but in ways that cannot be quantified with any reasonable level of confidence at this time. It should be noted that PolyMet did analyze the effects of climate change on water quality and quantity estimates for the NorthMet Project Proposed Action by conducting a sensitivity analysis. As described in Section 5.2.2.3, the GoldSim model was used to evaluate the Continuation of Existing Conditions Scenario for comparison with the NorthMet Project Proposed Action. The Continuation of Existing Conditions Scenario represents future conditions without the NorthMet Project Proposed Action, including all proposed facilities, but is not synonymous with the No Action Alternative because it does not account for other foreseeable changes within the NorthMet Project area.

5.2.3 Wetlands

This section describes the potential environmental consequences of the NorthMet Proposed Action to wetland resources, including the potential direct and indirect effects. Discussions are also included on actions taken to avoid or mitigate wetland effects, proposed wetland mitigation options, and wetland monitoring plans.

Summary

The NorthMet Project Proposed Action would result in both direct and indirect effects on wetland resources at the Mine Site, along the Transportation and Utility Corridor, at the Plant Site, and around the Mine Site (Area 1) and north of the Plant Site (Area 2). This section describes these effects within each of these areas and provides a summary of the effects over the operational life of the facility.

Direct wetland effects would result from mining-related activities involving filling, excavation, a combination of filling and excavation, and installation of a containment system within the wetland boundary, and therefore these wetlands would be permanently lost. The NorthMet Project Proposed Action would directly affect 912.5 acres of wetlands located within the NorthMet Project area. The Mine Site would be subject to the majority of the direct wetland effects. The direct wetland effects within the entire NorthMet Project area would occur in the following wetland types: coniferous bog (56 percent), shrub swamp (12 percent), coniferous swamp (9 percent), shallow marsh (8 percent), deep marsh (8 percent), sedge/wet meadow (4 percent), hardwood swamp (1 percent), and open bog (1 percent). The majority of the direct effects would occur as a result of a combination of filling and excavation (65 percent).

Wetlands directly affected within the Mine Site would result in a combined effect area of 758.2 acres. These direct wetland effects would be caused by fill (10 percent), excavation (12 percent), or a combination of fill and excavation (78 percent). The Transportation and Utility Corridor would directly affect 7.2 acres of wetlands, all of which would be directly filled. Approximately 147.1 acres of wetlands within the Plant Site would be directly affected. These wetlands effects would be caused by fill (12 percent), excavation (31 percent), excavation and fill (less than 1 percent), and the containment system (58 percent).

Compensatory mitigation is required for the 912.5 acres of wetlands that would be directly affected. The overall wetland mitigation strategy for the NorthMet Project Proposed Action is to compensate for unavoidable wetland effects in-place, in-kind where possible and in-advance of effects when feasible. A combination of off- and on-site wetland mitigation projects would be implemented to fulfill the requirements for compensatory mitigation. PolyMet's current mitigation proposal includes the following:

- On-site mitigation totaling 101.8 acres of wetland restoration during reclamation; and
- Off-site mitigation including:
 - Aitkin Site – 810.2 acres of wetland restoration and 123.1 acres of upland buffer;
 - Hinckley Site – 313.0 acres of wetland restoration and 79.2 acres of upland buffer; and
 - Zim Site – 508.2 acres of wetland restoration and preservation and 22.7 acres of upland buffer.

USACE St. Paul wetland compensatory mitigation replacement ratios are based on three factors: in-place versus out-of-place, in-kind versus out-of-kind, and in-advance versus concurrent. The USACE St. Paul District's 2009 policy states a base compensation ratio of 1.5:1, and a minimum of 1:1, with a provision for a case-by-case determination of higher ratios to account for factors including difficult-to-replace and rare and/or exceptional wetlands/aquatic resources. Therefore, per the 2009 policy, the District Engineer may determine that a higher compensation ratio of 2:1 (or higher) would be required to offset losses of wetlands that would be difficult to replace and/or provide an exceptional level of functions. The USACE St. Paul District has not made a final determination of the compensation ratios that would be required for the NorthMet Project Proposed Action. The final decision on compensatory mitigation ratios will be determined at the time of the DA permit decision pursuant to Section 404 of the CWA based on current District guidance. PolyMet would ultimately need to satisfy both the federal and state mitigation requirements. The NorthMet Project Proposed Action is estimated to directly affect 912.5 acres. Depending on the location, type, and timing of compensatory mitigation, the minimum required amount of replacement wetlands for direct effects could range from 912.5 acres up to 1,825.0 acres (i.e., 1:1 up to 2:1 compensation ratios). In addition, compensatory mitigation for the 26.9 acres of wetland fragmentation would also be provided up front.

Off-site wetland compensation of 1,631.4 acres could provide 1,568.0 wetland mitigation credits. In addition, a total of 225.0 acres of upland buffer areas are proposed to be established with native vegetation around the wetland restoration areas. In accordance with USACE guidelines, credit for the upland buffer areas would be at a 4:1 ratio, resulting in an additional 56.3 credits. The total off-site mitigation could provide 1,624.2 wetland mitigation credits. Compensatory ratios determined in permitting may vary from these assumptions. The determination of final mitigation credits required to offset the effects of the proposed NorthMet Project Proposed Action would be determined during permitting.

Finally, establishment of 101.8 acres of wetland on-site would likely occur during reclamation of the Mine Site and this establishment is not included in the mitigation credits discussed above.

Potential indirect wetland effects from the NorthMet Project Proposed Action would result from one or more of the following six factors: 1) wetland fragmentation, 2) change in wetland hydrology resulting from changes in watershed area, 3) changes in wetland hydrology due to groundwater drawdown, 4) water quality changes related to deposition of dust, 5) water quality changes related to ore spillage along the Transportation and Utility Corridor, and 6) changes in water quality related to leakage from stockpiles/mine features and seepage from mine pits. The change in wetland hydrology from groundwater drawdown at the Mine Site was assessed by two different methodologies; therefore, total indirect wetland effects were provided based on both approaches. The NorthMet Project Proposed Action could indirectly affect up to either 7,350.7 acres of wetlands located within and around the NorthMet Project area, based on the method of wetlands crossing analog impact zones, or up to 6,498.1 acres of wetlands located within and around the NorthMet Project area, based on the method of wetlands within analog impact zones (PolyMet 2013k; PolyMet 2013q).

Regardless of the method used, wetland mitigation for potential indirect wetland effects would be determined by the agencies during permitting. If the NorthMet Project Proposed Action were to be permitted, wetland monitoring would be conducted to identify if future indirect effects to wetlands would occur. Wetland hydrology and vegetation would be monitored, and additional monitoring locations may be considered during permitting. A component of the monitoring plan

would be based on those wetlands that would have a high likelihood of indirect effects as a result of groundwater drawdown. If the monitoring were to determine that indirect wetland effects had occurred, additional compensation could be required if determined necessary by the permitting agencies. In the event that the wetland monitoring identified additional indirect effects, appropriate measures (i.e., adaptive management practices) would be implemented, such as hydrologic controls or additional compensatory mitigation. Permit conditions would likely include an adaptive management plan to account for any additional effects that may be identified in the annual monitoring and reporting.

5.2.3.1 Methodology and Evaluation Criteria

Wetland effects for the NorthMet Project Proposed Action include direct, indirect, and cumulative effects. As previously mentioned, a Wetland IAP Workgroup was formed, and based on this workgroup, effects were assessed using agency-prescribed methods as presented in the Wetland Analysis Work Plan (PolyMet 2011m) and using the wetland types and acreages identified in the report *NorthMet Project Wetland Data Package Version 7* (PolyMet 2013b). Methods used to evaluate direct and indirect effects are described below; cumulative effects are described in Chapter 6.

5.2.3.1.1 Direct Wetland Effects Methodology and Evaluation Criteria

Direct wetland effects for the NorthMet Project Proposed Action were determined through a GIS analysis of the areas that would be directly disturbed by mining features and operations, such as mine pits, stockpiles, and access roads. The area of analysis for the direct effects included the Mine Site, Transportation and Utility Corridor, and Plant Site.

Direct effects would result from mining-related activities such as filling or excavation of wetlands, and therefore, these wetlands would be permanently lost. Wetlands within the NorthMet Project area were identified using the Eggers and Reed (1997) community classification system, as described in Section 4.2.3. The analysis for the direct wetland effects included identification of wetland type, total wetland acreage, total acres of direct effect, type of direct effect (i.e., fill, excavation, etc.), and the quality of each wetland to be affected by the NorthMet Project Proposed Action.

5.2.3.1.2 Potential Indirect Wetland Effects Methodology and Evaluation Criteria

Wetlands that are not filled or excavated, but have a reduced function or value, would be considered indirectly affected. The most likely types of indirect effect on the functions and values of remaining wetlands at the Mine Site include wetland fragmentation from NorthMet Project area elements such as open pits, stockpiles, and haul roads; and indirect hydrological effects that may result in a conversion of one wetland type to another or the conversion of a wetland to an upland. Other indirect effects could result from changes in wetland watershed areas (during operation and post-closure); groundwater drawdown resulting from open pit mine dewatering; groundwater mounding/drawdown resulting from operation of the Tailings Basin, including groundwater seepage containment system; changes in streamflow near the Mine Site and Tailings Basin and associated effects on wetlands abutting the streams (during operation and post-closure); and changes in wetland water quality related to atmospheric deposition of dust and rail car spillage associated with the Mine Site and the Tailings Basin operations.

Potential indirect wetland effects from drawdown were estimated using the analog method. Various models, some of which were associated with impact analysis of other environmental resources such as air, groundwater, and surface water that affect wetland resources were also used in estimating potential indirect wetland effects.

Each analysis was completed using the same set of wetlands that were not directly affected; therefore, there are wetlands that may be potentially indirectly affected by more than one type of assessed source. The potential indirect wetland affects for each wetland cannot be summed across the analysis as this would likely result in double-counting of wetland acres. The results of the analyses and assessments identify areas to be monitored for wetland effects.

Wetland acreage by wetland type was calculated using GIS analysis with 500-ft radius increments beginning at the mine pits and continuing out to a total radius of 10,000 ft (for a total of 20 increments); and 500-ft radius increments beginning at the Plant Site and continuing out to the Embarrass River. The area of analysis for the indirect effects extended beyond the NorthMet Project area component boundaries and included Area 1 and Area 2, as identified in Section 4.2.3. The analysis did not include wetlands identified as directly affected. Additionally, wetlands in the Northshore Mine and areas directly north of the Northshore Mine have been excluded from the evaluation (PolyMet 2011m).

Noise and dust effects on wildlife that utilize the wetland habitat are discussed in Section 5.2.5 (Wildlife Section).

Additional description of the specific methods used to assess individual indirect effects is provided below.

Potential Indirect Wetland Effects Resulting from Wetland Fragmentation

For each wetland that would not be directly affected at the Mine Site, along the Transportation and Utility Corridor, or at the Plant Site, an estimate of indirect wetland effects (wetland acres by wetland type, and type of effect) from wetland fragmentation by NorthMet Project area features (e.g., open pits, stockpiles, haul roads) was determined based on an analysis of the various factors that may contribute to fragmentation such as change in the size of the wetland, the isolation of the wetland due to being surrounded by NorthMet Project area features, and the corresponding change in the function and values of the wetland (e.g., wildlife habitat). Fragmentation increases habitat edge effects (such as the introduction of non-native species), which are a function of habitat patch size and shape and the quality of adjacent landscapes.

Potential Indirect Wetland Effects Resulting from a Change in Watershed Area

For each wetland that would not be directly affected, but would have NorthMet Project area elements affect its watershed, an estimate of the change in watershed area (acreage and percent gain or loss) was calculated for the following conditions: pre-NorthMet Project Proposed Action, during operation when the maximum amount of watershed has been removed, and at long-term closure. For those non-directly affected wetlands that would have changed watershed areas (during operation and post-closure), an estimate of indirect wetland effects (wetland acres by wetland type and type of indirect effect) was calculated.

Potential Indirect Wetland Effects Resulting from Changes in Hydrology Due to Drawdown at the Mine Site

An estimate of indirect wetland effects (wetland acres by wetland type, and type of indirect effect) due to groundwater drawdown from open pit mine dewatering was determined using an analog model in which the degree of effect was correlated to the distance from the open pit mine (PolyMet 2011m). The analog approach was based on similar mine settings (e.g., within the glacial till in the region). The closer a wetland was to the pit where dewatering would occur, the greater the water table drawdown would be and the greater the potential for hydrologic effects on overlying wetlands. Wetlands were divided into zones based on distance from the open pit. The use of the impact zones may overestimate indirect effects on wetlands. The analog distances, referenced to the pit edge, were as follows:

1. 0 to 1,000 ft;
2. greater than 1,000 to 2,000 ft;
3. greater than 2,000 to 3,500 ft; and
4. greater than 3,500 to 10,000 ft (within the wetland evaluation area).

The following is a discussion of the justification for the use of the analog data based upon comparisons of the existing regional and site-specific geologic data (e.g., bedrock faults, bedrock joint systems, bedrock topography, glacial till hydraulic conductivities), site-specific engineering controls (e.g., Category 1 Stockpile groundwater containment system), and the geologic settings of the analog information sites and the Mine Site (PolyMet 2011m; PolyMet 2013b). Analog data were used instead of a model such as MODFLOW since MODFLOW could not practically be used to estimate potential indirect wetland effects, due to complex mixes of bedrock, glacial till, and wetland soils at the Mine Site and therefore could not be used to accurately assess the potential effect of pit dewatering on wetlands (PolyMet 2013b).

The Mine Site contains localized heterogeneous vertical and horizontal hydraulic conductivities within each soil unit, which also makes the MODFLOW model less effective. Hydraulic conductivities between the different deposits range from 0.00026 to 31 ft/day (PolyMet 2013b). Because there is such a wide range in hydraulic conductivity within the natural geologic formations at the Mine Site, each model layer would contain widely variable hydraulic conductivities. Thus, it was not feasible to model the expected effects of mine dewatering on wetlands in a meaningful way. Prior to conducting the analysis to identify indirect wetland effects resulting from changes in hydrology, bog wetlands within and surrounding the Mine Site were reclassified as either ombrotrophic or minerotrophic. This distinction is important because ombrotrophic bogs would likely not be affected by groundwater drawdowns associated with proposed mining operations, whereas more minerotrophic bogs would have a higher likelihood of being affected (Eggers 2011a).

A discussion of potential indirect wetland hydrology drawdown effects at the Mine Site, including conversion to other wetland community types, a change in vegetation without a change in community type, conversion to uplands, or other effects is provided below in Section 5.2.3.2.2. These effects were categorized by applying the Eggers and Reed (1997) wetland classification system to each wetland type based on wetland sensitivity class tables for falling groundwater tables that were developed for a previously proposed mine project in Wisconsin (PolyMet 2013b).

Potential Indirect Wetland Effects Resulting from Changes in Hydrology at the Plant Site

Potential indirect wetland effects from hydrological changes were evaluated based on estimates of groundwater upwelling and resulting surface water flow in wetlands and/or groundwater drawdown near the water containment system that would surround the Plant Site. An estimate of potential indirect wetland effects (wetland acres by wetland type, and type of effect) from hydrologic changes resulting from the containment system was determined as follows:

1. The amount of Plant Site groundwater seepage water that would evade the containment system and discharge to surface water features, including wetlands, downgradient of the Tailings Basin was quantified. The quantity of seepage evading the containment system was confirmed using MODFLOW and incorporated into the GoldSim model as a deterministic value.
2. All wetlands (type, acreage) within the surficial aquifer groundwater flowpaths downgradient of the Plant Site were identified within the boundaries used in the water quality modeling (as shown in the Groundwater IAP Summary document [MDNR 2011q]).
3. Using the wetlands identified in step 2, wetlands were categorized into minerotrophic (groundwater-fed) and ombrotrophic (precipitation-fed) wetlands using guidance in the Corps Memorandum (CEMVP-OP-R) *Distinguishing Between Bogs That Are Entirely Precipitation Driven Versus Those with Some Degree of Mineral Inputs from Groundwater and/or Surface Water Runoff* (Eggers 2011b) and evaluating the potential for indirect effects resulting from construction of the water containment system.

A discussion regarding potential indirect wetland hydrology effects at the Plant Site, including conversion to other wetland community types, a change in vegetation without a change in community type, conversion to uplands, or other effects is provided below in Section 5.2.3.2.4. These effects were categorized by applying the Eggers and Reed (1997) wetland classification system to each wetland type based on the wetland sensitivity class tables for rising groundwater tables that were developed for a previously proposed mine project in Wisconsin (PolyMet 2013b).

Potential Indirect Effects on Wetlands Abutting the Partridge River and Four Creeks

An estimate of potential indirect wetland effects (wetland acres by wetland type and type of effect) was determined for wetlands abutting the following:

- the Partridge River, as a result of changes in river flow resulting from the NorthMet Project Proposed Action (during operation and post-closure); and
- the three creeks north and west of the Plant Site (Trimble Creek, Mud Lake Creek, and Unnamed Creek) and Second Creek south of the Plant Site, as a result of changes in streamflow resulting from operation of the Plant Site and containment system.

Changes in river and creek flow were estimated using mass balance techniques.

Potential Indirect Wetland Effects Resulting from Water Quality Changes

A screening analysis for depositional effects was conducted that estimated potential annual deposition of dust, metals, and sulfur to wetlands within and adjacent to the Mine Site and Plant Site from fugitive dust through air dispersion/deposition modeling (AERMOD). Emission rates

and particle size distributions were based on total particulate matter. The estimated deposition from fugitive dust emissions was used to identify wetlands that have the potential for water quality changes (e.g., potential for water chemistry changes related to sulfide dust deposition). The estimated deposition from fugitive dust emissions was used to identify a threshold for a negative effect on vegetation. The estimated inputs of the dust, metals, and sulfur to wetlands were evaluated for significance to potential changes in water quality. The receptors of interest were the wetlands that were not identified as directly affected.

Leakage from stockpiles at the Mine Site was evaluated to determine if wetlands would be affected. The amount of stockpile leakage water that would potentially discharge to surface waters and wetlands downgradient of the stockpiles was based on the water quality modeling (see Section 5.2.2). Wetlands within the surficial aquifer groundwater flowpaths from mine features were identified and then further characterized into minerotrophic and ombrotrophic wetlands per Eggers 2011a. Wetlands were then evaluated to determine the potential for indirect effects based on potential water quality changes from the mine features.

Tailings Basin groundwater seepage at the Plant Site was evaluated to determine if wetlands would be affected. The chemistry from the Tailings Basin groundwater seepage based on the water quality modeling (see Section 5.2.2) was determined. Wetlands within the downgradient zone were identified and then further characterized into minerotrophic and ombrotrophic wetlands (Eggers 2011a). Wetlands were then evaluated to determine the potential for indirect effects based on potential water quality changes from the Tailings Basin.

Wetlands within and adjacent to the Transportation and Utility Corridor were assessed to determine if indirect wetland effects would occur to wetlands as a result of water quality changes. The following was evaluated: the potential release of dust from railcars transporting ore from the Mine Site to the Plant Site, use of Dunka Road, and product shipping at the Plant Site.

5.2.3.2 NorthMet Project Proposed Action

The NorthMet Project Proposed Action would result in both direct and indirect effects. This section describes effects within the NorthMet Project area and provides a summary of wetland effects. Estimates of both direct and indirect wetland effects have changed during the EIS process as the result of refined analysis and changes in project design. The effects identified in this SDEIS are based on the most current information available and may differ from those identified in prior reports. Avoidance, minimization, mitigation, and monitoring measures for the NorthMet Project Proposed Action are discussed in Section 5.2.3.3.

5.2.3.2.1 Mine Site and Transportation and Utility Corridor Direct Wetland Effects

Direct wetland effects would result from the following Mine Site and Transportation and Utility Corridor components: construction and/or installation of the mine pits, Category 1 Stockpile, Category 2/3 Stockpile, Overburden Storage and Laydown Area, haul roads, rail transfer loadout, WWTF, perimeter dike, culverts, groundwater discharge pipe, groundwater containment system, stormwater collection ditches and ponds, CPS, process water pipes and ponds, Treated Water Pipeline, transmission lines, and Dunka Road upgrades. The Mine Site features would result in 758.2 acres of directly affected wetlands (see Figure 5.2.3-1). Table 5.2.3-1 summarizes the directly affected wetlands within the Mine Site by community type while Table 5.2.3-2 identifies the activity that causes the effects expected at the Mine Site. Three wetland types comprise 89

percent of the expected wetland effects in the Mine Site, including 508.3 acres of coniferous bog (67 percent), 97.8 acres of shrub swamp (13 percent), and 70.3 acres of coniferous swamp (9 percent). Direct effects would be caused by fill (10 percent), excavation (12 percent), or a combination of fill and excavation (78 percent). The majority of the wetlands (99 percent) that would be directly affected wetlands are rated high quality, while 1 percent are rated as moderate quality (PolyMet 2013b).

Table 5.2.3-1 Total Projected Direct Wetland Effects at the Mine Site and the Transportation and Utility Corridor

Eggers and Reed Class¹	Directly Affected Wetlands at Mine Site			Directly Affected Wetlands at Transportation and Utility Corridor		
	Acres	%	No.	Acres	%	No.
Coniferous bog	508.3	67	22	0.9	12	2
Coniferous swamp	70.3	9	7	1.6	22	7
Deep marsh	0.1	<1	1	0.0	0	0
Hardwood swamp	12.5	2	2	0.0	0	0
Open bog	4.8	1	4	0.0	0	0
Open Water (includes shallow, open water, and lakes)	0.0	0	0	0.0	0	0
Sedge/wet meadow	38.2	5	5	0.0	0	0
Shallow marsh	23.4	3	6	0.6	8	3
Shrub swamp (includes alder thicket and shrub-carr)	97.8	13	12	4.1	57	13
Total Direct Effects	758.2	100	59	7.2	100	25

Source: PolyMet 2013b.

¹ Eggers and Reed 1997.

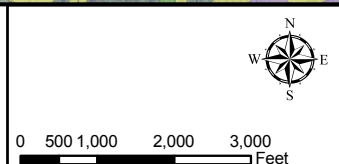
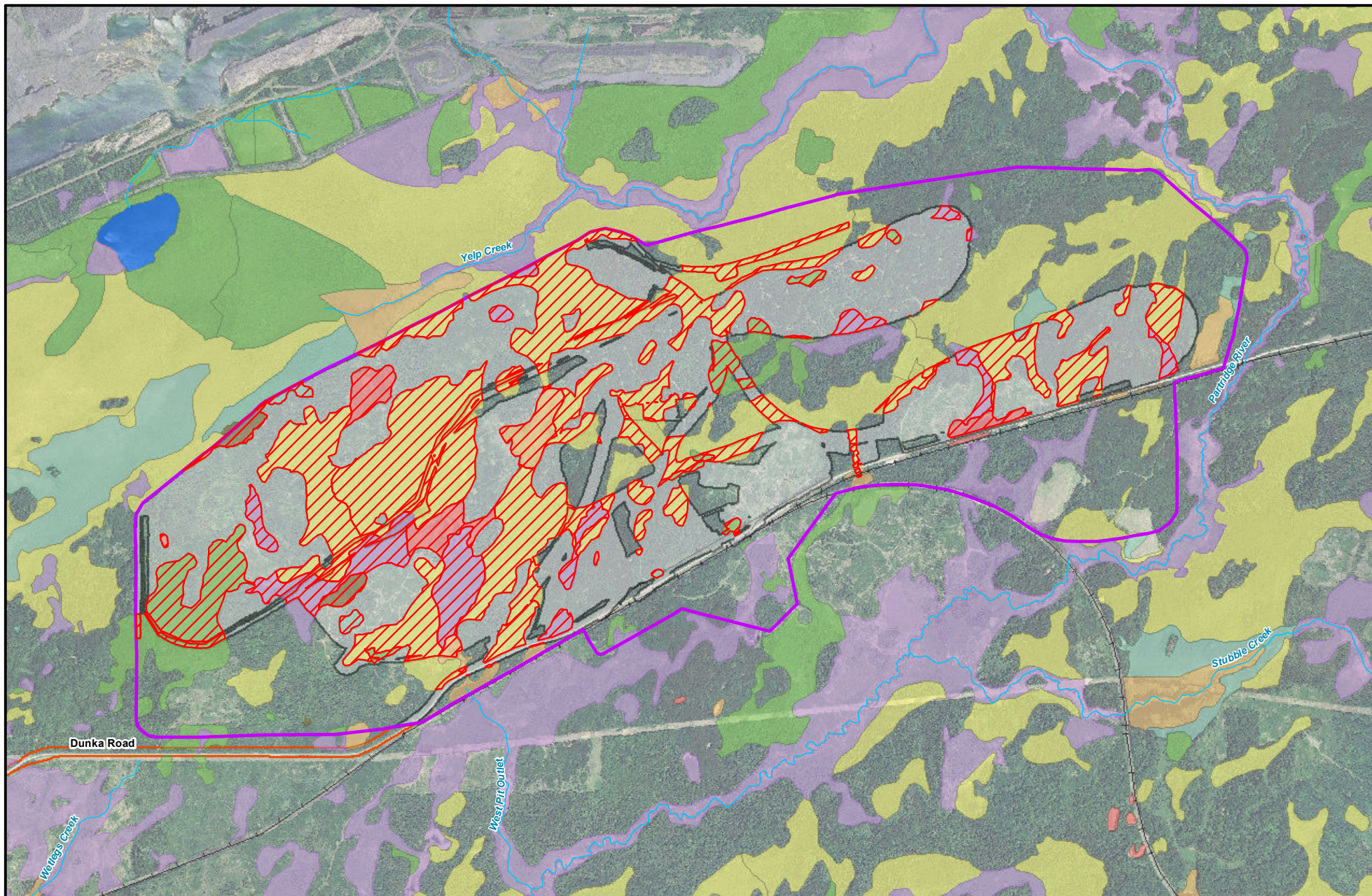


Figure 5.2.3-1
Mine Site Wetlands and Direct Wetland Effects
 NorthMet Mining Project and Land Exchange SDEIS
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Table 5.2.3-2 Type of Projected Direct Wetland Effects at the Mine Site and the Transportation and Utility Corridor

Type of Effect	Directly Affected Wetlands at Mine Site			Directly Affected Wetlands at Transportation and Utility Corridor		
	Acres	%	No.	Acres	%	No.
Fill	77.3	10	23	7.2	100	25
Excavation	87.9	12	14	0.0	0	0
Fill and Excavation	593.0	78	22	0.0	0	0
Total Direct Effects	758.2	100	59	7.2	100	25

Source: PolyMet 2013b.

PolyMet proposes to minimize wetland effects by placing waste rock back into the East Pit and Central Pit after year 11, thereby reducing the need for additional surface stockpile areas that would otherwise affect wetlands. In addition, PolyMet proposes to combine the saturated overburden and temporary stockpiles, and leave only unsaturated overburden and peat in the Overburden Storage and Laydown Area. By doing so, the footprint of these stockpiles would be reduced, resulting in fewer direct wetland effects.

In approximately year 40, flooding to the West Pit would be complete. Discharge from the West Pit would be pumped to the WWTF for treatment. The WWTF would then be upgraded to include RO treatment to achieve a 9 mg/L sulfate effluent, which would then be discharged into a wetland and finally through the West Pit Outlet Creek to the Partridge River. The direct effects on this wetland have been included within the wetland effect direct totals in Table 5.2.3-1.

Construction activities within the Transportation and Utility Corridor would affect 7.2 acres of wetlands, all of which would be filled. Table 5.2.3-1 summarizes the directly affected wetlands within the Transportation and Utility Corridor by community type while Table 5.2.3-2 identifies the activity that causes the effects expected within the Transportation and Utility Corridor. The wetland types that would be directly affected include shrub swamps (57 percent), coniferous swamps (22 percent), coniferous bogs (12 percent), and shallow marshes (8 percent) (see Figure 5.2.3-2). All of the wetlands to be directly affected are rated as high quality. The rail spur was designed to avoid wetlands to the extent possible within the requirements for rail construction based on a portion of the spur being located on an existing rail alignment.

5.2.3.2.2 Mine Site and Transportation and Utility Corridor Indirect Wetland Effects

The potential indirect wetland effects were assessed by identifying wetlands in Area 1 within 500-ft increments beginning at the edge of the mine pits and extending to a maximum distance of 10,000 ft (see Figure 5.2.3-3) (PolyMet 2013b). The area of evaluation for the Mine Site potential indirect wetlands effects included only wetlands within Area 1 where wetland type information had been developed and does not include the directly affected wetlands.

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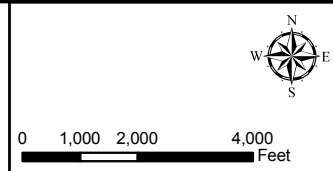
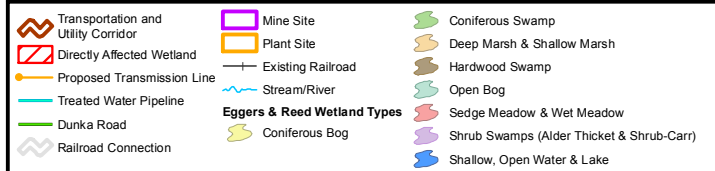
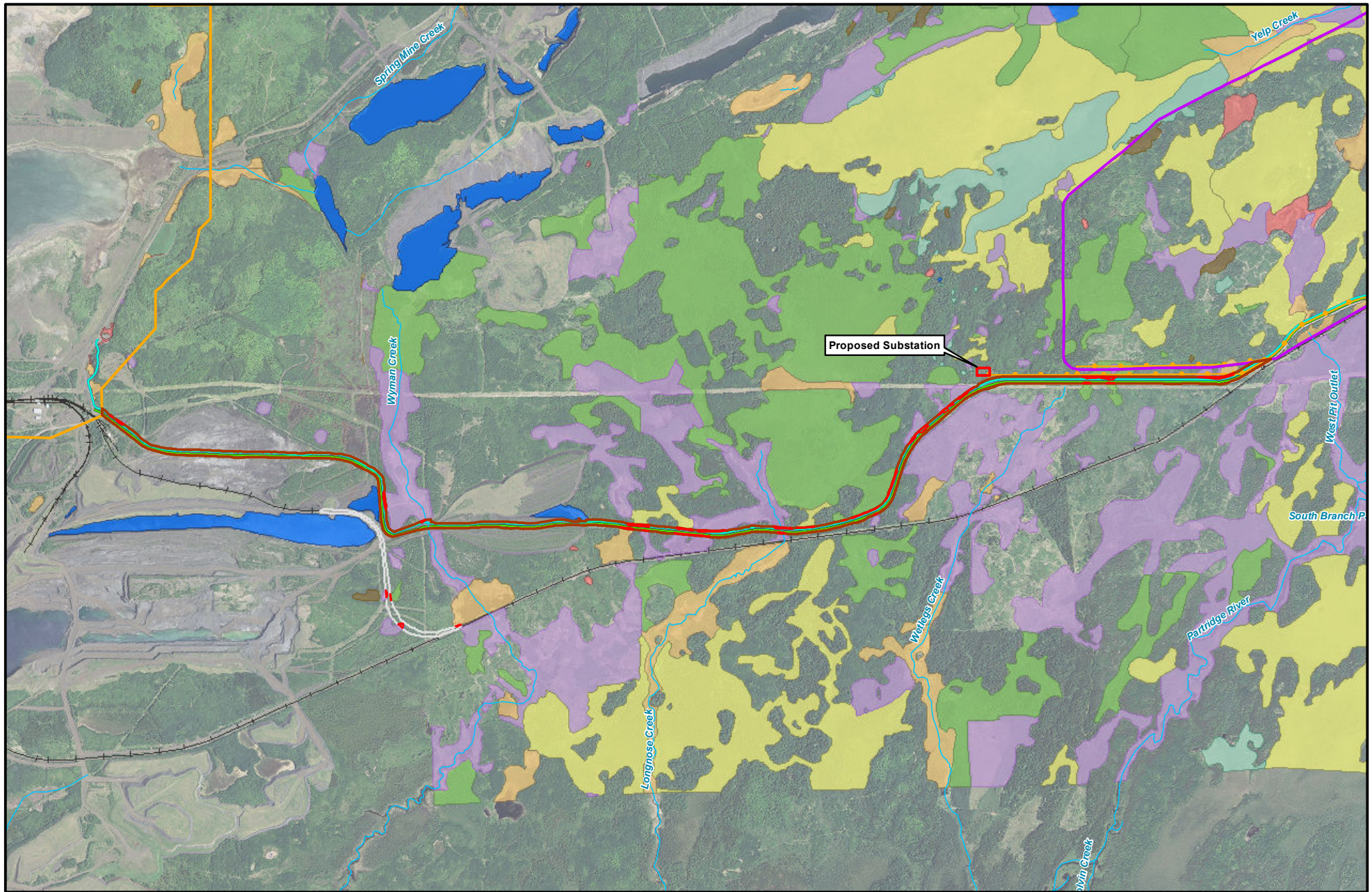


Figure 5.2.3-2
Transportation and Utility Corridor
Wetlands and Direct Wetland Effects
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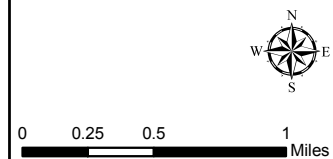
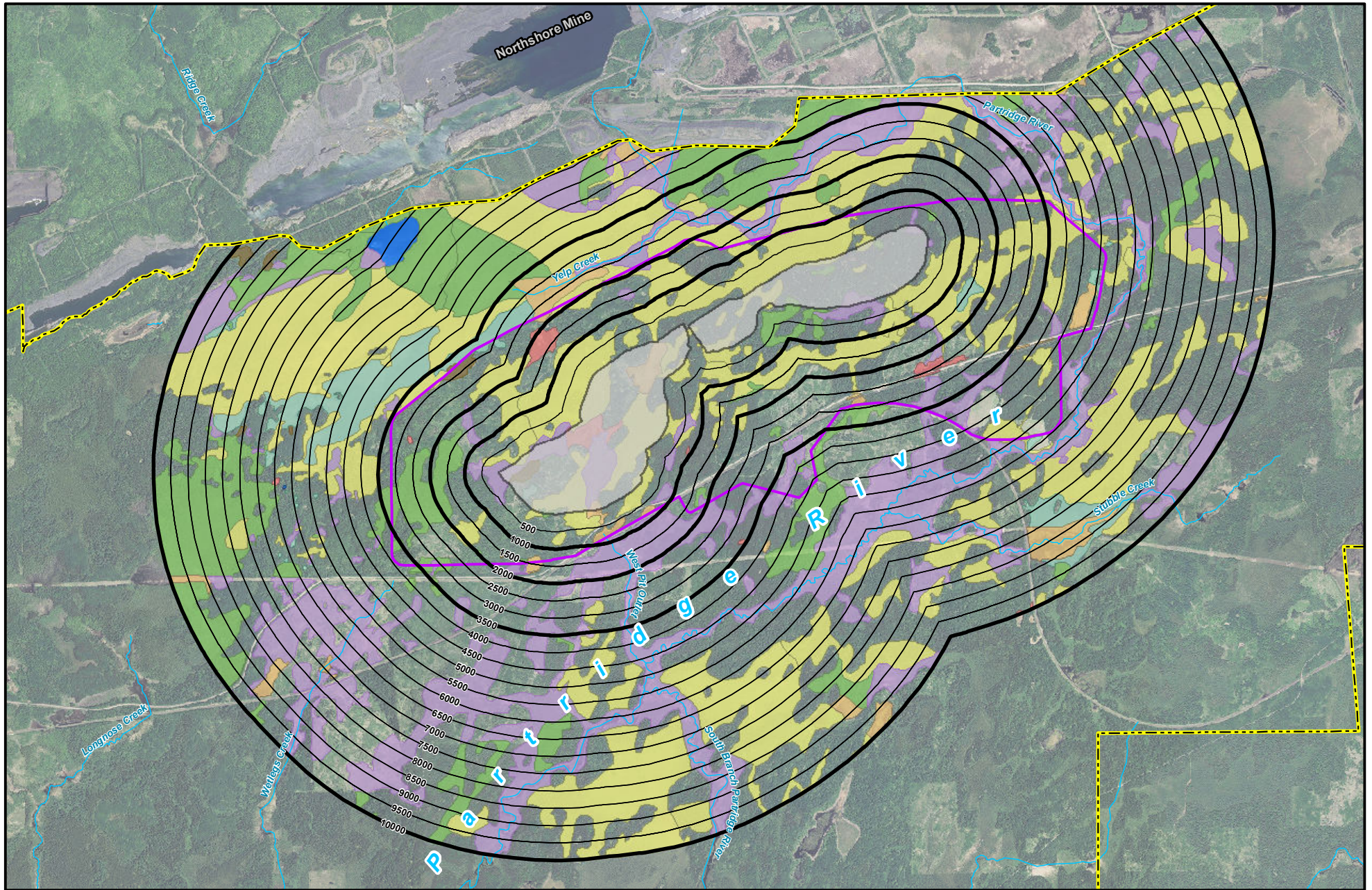


Figure 5.2.3-3
Wetlands within 500 ft Increments at the Mine Site
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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Wetland Fragmentation

Construction of the Mine Site features (e.g., open pits, stockpiles, haul roads, etc.) would result in 26.4 acres of wetland fragments (see Figure 5.2.3-4). Wetlands were determined to be fragmented and their associated remaining acreage included as a potential indirect wetland effect if they were small remnants of a directly affected wetland located between Mine Site features (e.g., in the area between the Category 1 Stockpile and the West Pit or along Dunka Road or the Railroad Connection Corridor). The majority of the wetland fragments in the Mine Site would consist of coniferous bog (79 percent), alder thickets (14 percent), coniferous swamp (7 percent), and sedge/wet meadow (less than 1 percent). In addition, a 0.01 acre alder thicket would become fragmented just outside of the Transportation and Utility Corridor near Dunka Road but within Area 1 (PolyMet 2013b). No wetlands would become fragmented along the Railroad Corridor.

Changes in Hydrology Due to Change in Watershed Area

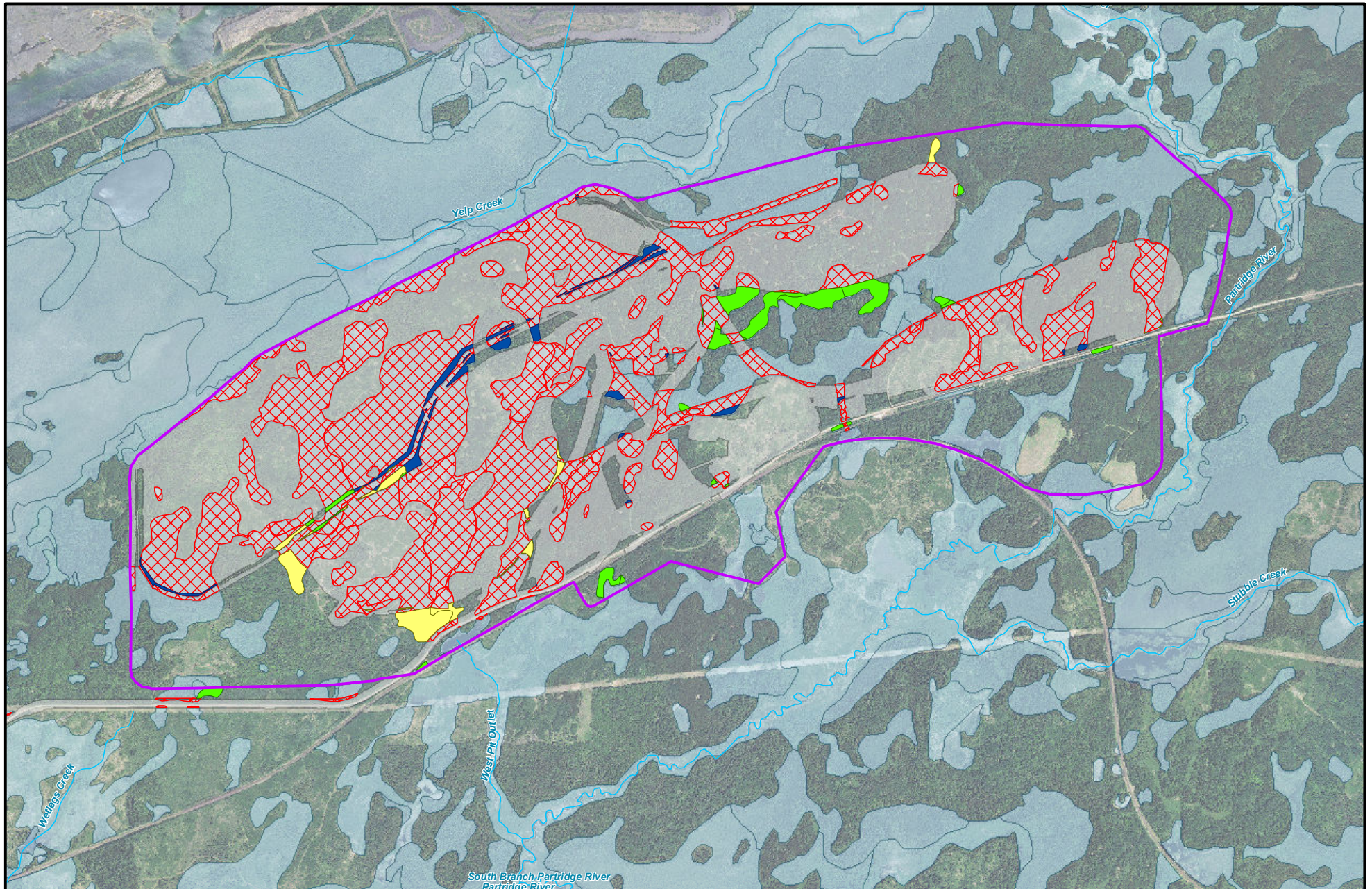
The potential for indirect effects to wetland acreage due to change in watershed area was assessed by evaluating the change in watershed area per acre of wetland (PolyMet 2013b). Watersheds were defined for each wetland within the Mine Site boundary, as well as wetlands outside the Mine Site with a watershed area that may be affected by NorthMet Project area features. Wetland and watershed areas were determined for the following conditions: existing conditions, during operations when the maximum amount of watershed has been removed (i.e., maximum NorthMet Project Proposed Action extent), and at long-term closure.

The analysis was completed by first defining the watershed area (i.e., the sum of upland area and wetland area). For each wetland in the Mine Site, GIS was used to determine the upland area (acres) and wetland area (acres) within each watershed area (acres). Using these acreages, the percentage of a wetland within its watershed was calculated. In addition, the tributary acres per wetland acre were determined as a proportion of the watershed area to wetland area; the equivalent watershed yield (acre-feet per year) was determined for the existing, maximum operational extent, and long-term closure conditions (the average net precipitation rate is 11.77 inches per year); and the change in the equivalent yield (inches per year) estimated over the life of the NorthMet Project Proposed Action was evaluated relative to existing conditions equivalent yield to calculate the maximum percent change in yield (PolyMet 2011m; PolyMet 2013b).

The existing conditions include wetlands that represent the existing and relatively undisturbed conditions at the Mine Site. The analysis included wetlands and associated watersheds that are partially or completely within the Mine Site boundary. There are a total of 3,325 acres of wetlands within 6,287 acres of watershed, which results in approximately 53 percent of the analysis area covered by wetlands (PolyMet 2013b).

During operations, some wetlands and watershed areas may be directly affected by the NorthMet Project Proposed Action and would no longer be considered as a tributary area to the wetland. Consequently, the amount of water potentially contributed by the watershed to support the hydrology of the remaining wetlands may also change.

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- Mine Site
- Disturbed Area
- Directly Affected Wetland
- Fragmented Wetlands
- Wetlands

Potential Indirect Wetland Effects

- Decrease in Yield per Wetland Acre of Greater Than 20%
- Increase in Yield per Wetland Acre of Greater Than 20%
- Stream/River



0 500 1,000 2,000 3,000 Feet

Figure 5.2.3-4
Wetlands Potentially Indirectly Affected
by Change in Watershed Area
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There would be 20 wetlands, indirectly affected, displaying an increase or decrease of greater than 20 percent equivalent yield. Ombrotrophic coniferous bogs and open bogs were not included in the total wetland acreage because their hydrology is supported by precipitation and is not dependent on the size of the watershed. There would be 35 acres (11 wetlands) that would have the potential to experience an increase in yield per wetland acre of greater than 20 percent, and 15 acres (9 wetlands) that would likely experience a decrease in yield per wetland acre in excess of 20 percent (see Figure 5.2.3-4). The 49.4 acres of indirectly affected wetland types include alder thickets (52 percent), coniferous swamp (34 percent), minerotrophic coniferous bog (8 percent), shallow marsh (6 percent), and sedge/wet meadow (less than 1 percent) (PolyMet 2013b).

During reclamation, a portion of the wetlands and wetland watersheds within the Mine Site would be restored to the existing condition.

Changes in Hydrology Due to Drawdown

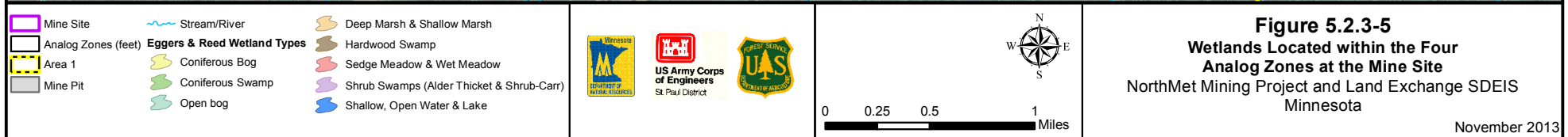
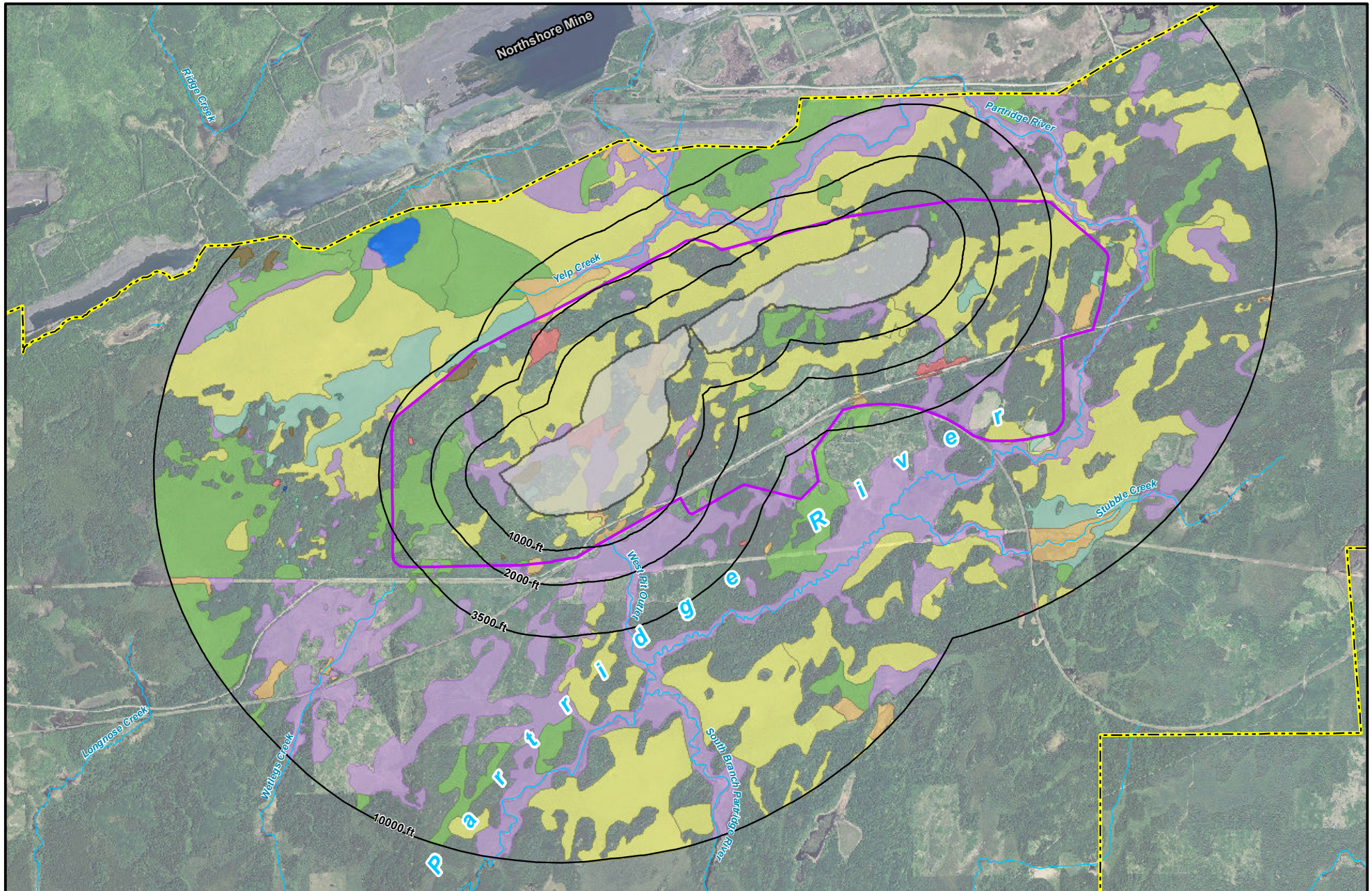
The geologic and hydrogeologic settings of the Mine Site and the analog sites are fairly similar with a thin veneer of heterogeneous unconsolidated deposits underlain by fractured bedrock. The hydraulic conductivities of the unconsolidated deposits and bedrock are lower at the Mine Site than at the analog sites, and so it is expected that the wetland impact zones would likely overestimate the extent of potential wetland effects. Because of the thin, discontinuous nature of the surficial deposits at the Mine Site, drawdown effects are expected to be more localized at the Mine Site than at the analog sites. Additionally, the numerous bedrock outcrops present at the Mine Site are expected to act as barriers to flow in the unconsolidated aquifer, thereby limiting the area of influence of the mine pits. Whereas, the analog sites have fewer or no bedrock outcrops compared to the Mine Site. Last, the presence of the Partridge River approximately 4,000 to 6,000 ft south (downstream) of the mine pits is likely to act as a natural barrier to the expansion of the cone of depression within the surficial aquifer from 3,500 to 10,000 ft from the pit (PolyMet 2013b).

Open and coniferous bog wetlands within and surrounding the Mine Site were subcategorized as either ombrotrophic (hydrology and mineral inputs entirely from direct precipitation) or minerotrophic (some degree of mineral inputs from groundwater and/or surface water runoff) to determine if the bogs would be affected by groundwater drawdown. Ombrotrophic bogs would likely not be affected by groundwater drawdowns associated with proposed mining operations, whereas more minerotrophic bogs would have a higher likelihood of being affected.

The potential indirect wetland effect from glacial aquifer drawdown was based on the analog impact zone with the greater potential drawdown (zone closer to the open pit mine) for wetlands that lie on both sides of the analog distance boundary. Wetlands were identified within four analog impact zones (0-1,000 ft, >1,000-2,000 ft, >2,000-3,500 ft, and >3,500-10,000 ft) from the edge of the mine pits within Area 1 (see Figure 5.2.3-5).

The change in wetland hydrology from groundwater drawdown at the Mines Site was assessed by two different methodologies; therefore, total potential indirect wetland effects were provided based on both approaches. The two approaches are as follows:

- **Wetlands Crossing Analog Zones:** Wetlands that were located within multiple analog impact zones were *included* in the analog impact zone closest to the edge of the mine pits. The likelihood of wetland hydrology impact was categorized as High, Medium, Low, and No Impact for each analog impact zones.
- **Wetlands within Analog Zones:** Wetlands that were located within multiple analog impact zones were *split* along zone edges and acreages were calculated by zone. As a result, the acreage for wetlands crossing zone edges was split among multiple zones, rather than included in the analog impact zone that was closest to the edge of the mine pits. The likelihood of wetland hydrology impact was categorized as High, Medium, Low, and No Impact for each analog impact zones.



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Based on the wetlands crossing analog zones analysis approach, there would be 1,328.0 acres of wetlands in the 0-1,000 ft zone, 618.6 acres in the >1,000-2,000 ft zone, 1,162.0 acres of wetlands in the >2,000-3,500 ft zone, and 2,718.3 acres of wetlands in the >3,500-10,000 ft zone beyond the edge of the pits (see Table 5.2.3-3; Figures 5.2.3-6 through 5.2.3-10) (PolyMet 2013b; PolyMet 2013b, updated wetland data received July 29, 2013).

Table 5.2.3-3 Wetlands Crossing Analog Impact Zones Resulting from Potential Changes in Hydrology

Likelihood of Wetland Hydrology Effect Based on Wetland Type for Each Analog Distance	Wetland Area (acres) within each Analog Increment				Eggers and Reed Wetland Community
	0-1,000 ft	1,000-2,000 ft	2,000-3,500 ft	3,500-10,000 ft	
0 – 1,000 ft					
High Likelihood	866.9	-	-	-	Coniferous swamp, hardwood swamp, sedge/wet meadow, shrub-carr, and alder thicket
Moderate Likelihood	8.3	-	-	-	Deep marsh, shallow marsh, and shallow, open water
Low Likelihood	76.7	-	-	-	Minerotrophic coniferous bog
No Effect	376.1	-	-	-	Ombrotrophic coniferous bog and open bog
1,000 – 2,000 ft					
Moderate Likelihood	-	522.4	-	-	Coniferous swamp, hardwood swamp, sedge/wet meadow, shrub-carr, and alder thicket
Low Likelihood	-	4.1	-	-	Deep marsh, shallow marsh, and shallow, open water
No Effect	-	92.1	-	-	Minerotrophic and ombrotrophic coniferous bog and open bog
2,000 – 3,500 ft					
Low Likelihood	-	-	293.1	-	Coniferous swamp, hardwood swamp, sedge/wet meadow, shrub-carr, and alder thicket
No Effect	-	-	868.9	-	Deep marsh, shallow marsh, and shallow, open water, minerotrophic and ombrotrophic coniferous bog and open bog
3,500 – 10,000 ft					
No Effect	-	-	-	2,718.3	All wetland types
Total Acres of Wetland	1,328.0	618.6	1,162.0	2,718.3	

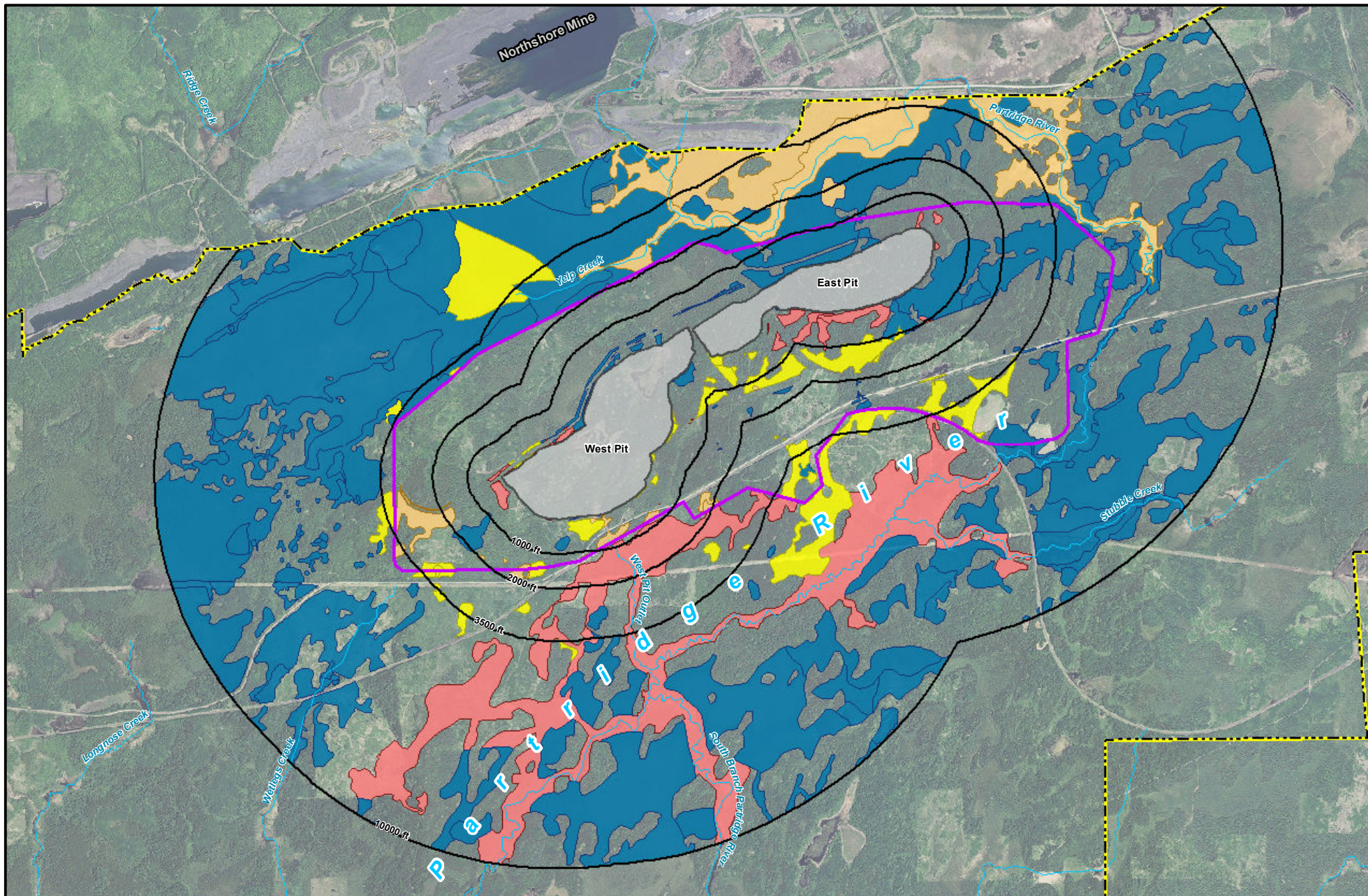
Source: PolyMet 2013b; PolyMet 2013b, updated wetland data received July 29, 2013.

Under this methodology approach, the likelihood of wetland hydrology effects would be as follows: no effect on 4,055.2 acres of wetlands (70 percent); low likelihood to 373.9 acres of wetlands (6 percent); moderate likelihood to 530.7 acres of wetlands (9 percent); and high likelihood to 866.9 acres of wetlands (15 percent) (see Table 5.2.3-3). Within 0-10,000 ft from the edge of the mine pits, wetland types with a high likelihood of wetland hydrology effects include shrub swamps (910 acres), coniferous swamp (19 acres), and sedge/wet meadow (less than 1 acre); with a moderate likelihood include shrub swamp (327 acres), coniferous swamp

(195 acres), deep marsh (5 acres), shallow marsh (3 acres), and hardwood swamp (less than 1 acre); and with a low likelihood include coniferous swamp (223 acres), coniferous bog (77 acres), shrub swamps (68 acres), shallow marsh (4 acres), sedge/wet meadow (2 acres), and hardwood swamp (less than 1 acre) (PolyMet 2013b).

The wetlands categorized as high likelihood are dominated by one alder thicket (886 acres) that has approximately 4 acres (less than 1 percent) within the 0-1,000 ft analog impact zone. The remainder of this wetland (more than 99 percent) is located more than 1,000 ft away from the edge of the mine pits and extends out to the edge of Area 1 (see Figure 5.2.3-6).

Based on the analog data, hydrologic effects to peat wetlands would only be observed to occur within 1,000 ft from the edge of the mine pits. Therefore, wetlands were categorized within the analog impact zones using an alternate method to determine the likelihood of wetland hydrology effects as described below.



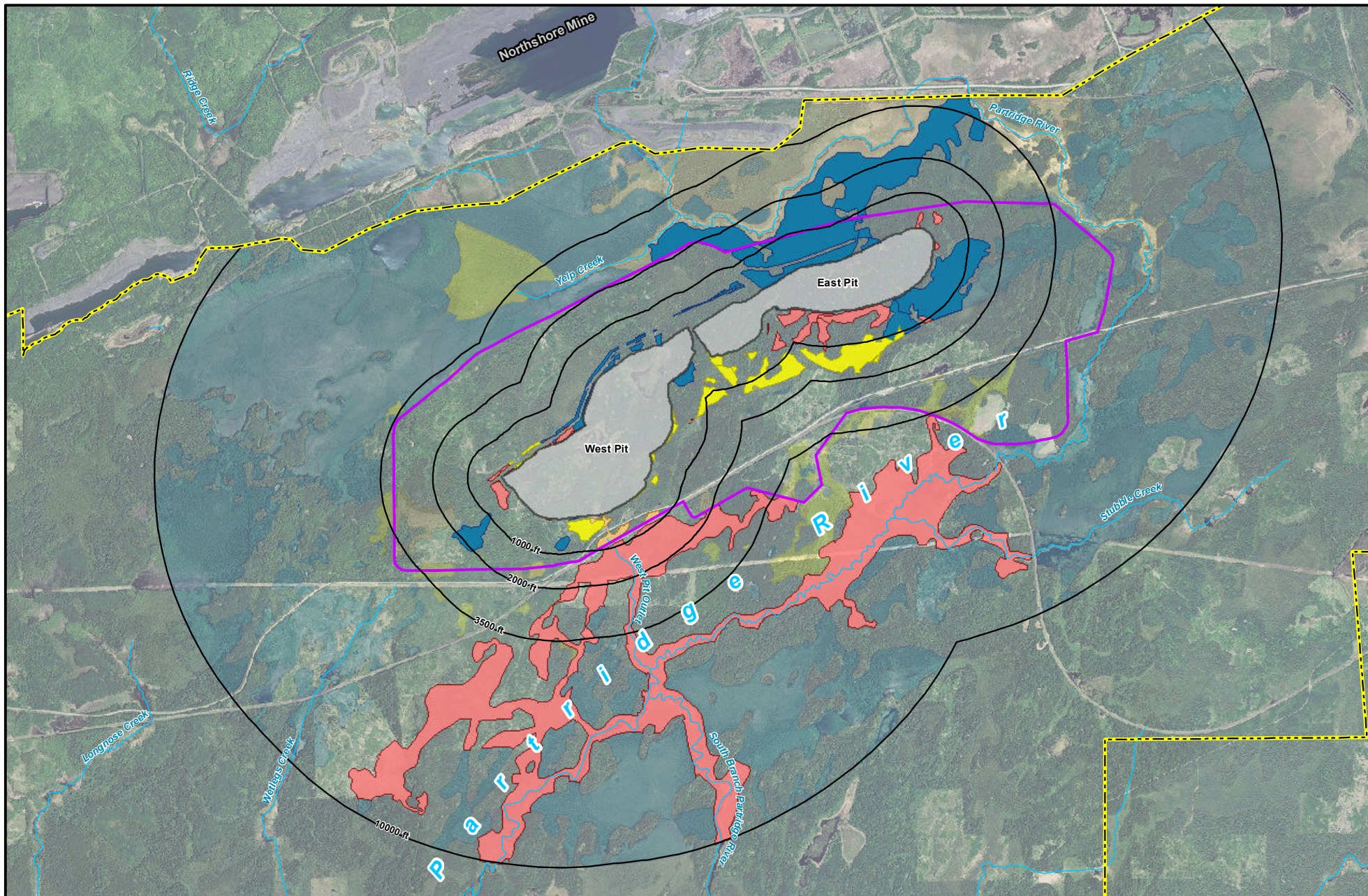
- | | |
|---------------------|---|
| Mine Site | Likelihood of Wetland Hydrology Effect |
| Mine Pit | High Likelihood |
| Analog Zones (feet) | Moderate Likelihood |
| Area 1 | Low Likelihood |
| Stream/River | No Effect |



Figure 5.2.3-6
Wetlands Crossing Analog
Zones - 0-10,000 feet of Edge of Mine Pits
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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- | | |
|---------------------|---|
| Mine Site | Likelihood of Wetland Hydrology Effect |
| Mine Pit | High Likelihood |
| Analog Zones (feet) | Moderate Likelihood |
| Area 1 | Low Likelihood |
| Stream/River | No Effect |

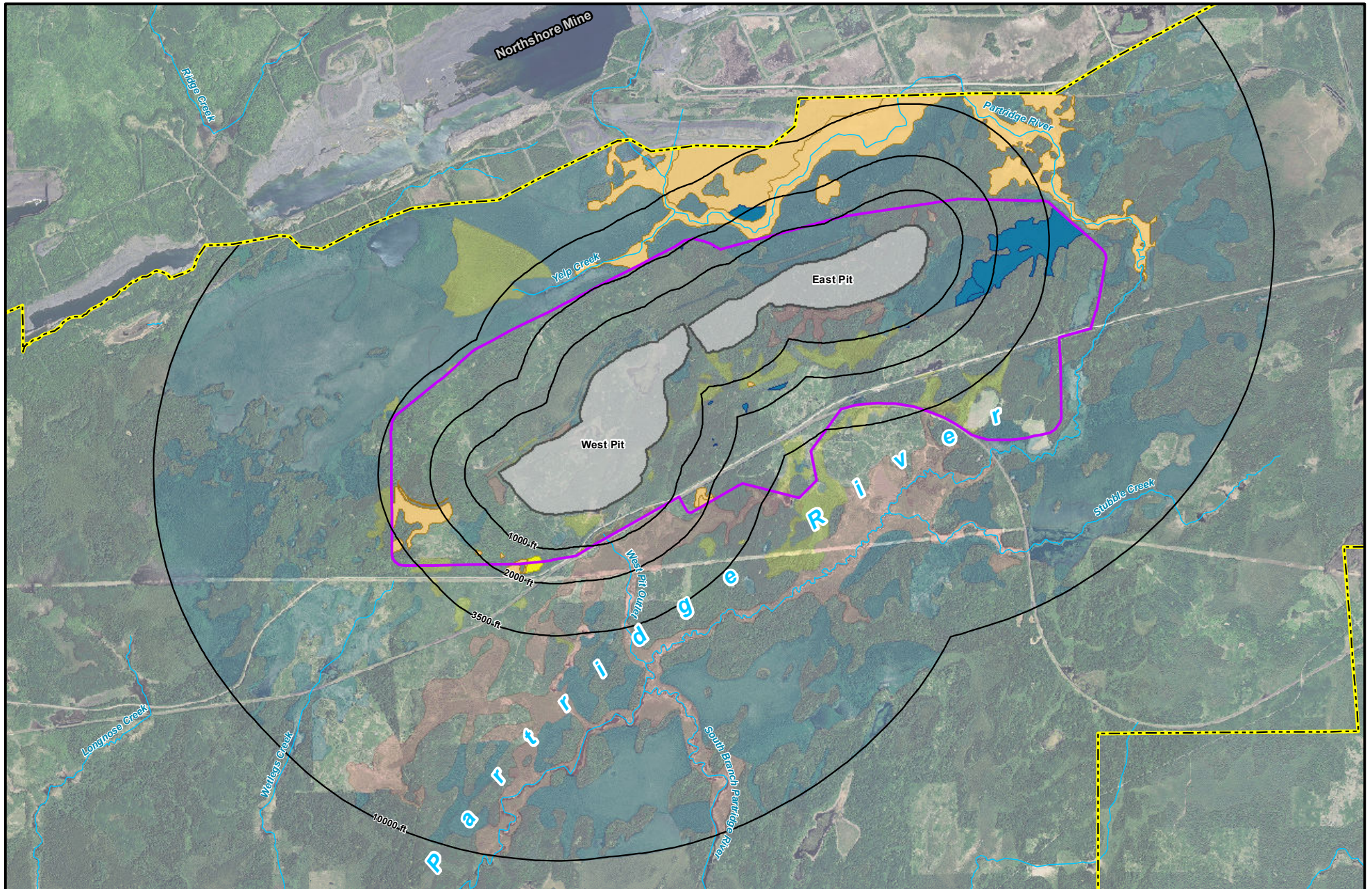


0 0.25 0.5 1 Miles

Figure 5.2.3-7
Wetlands Crossing Analog Zones -
0-1,000 feet of Edge of Mine Pits
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

November 2013

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|---------------------|---|
| Mine Site | Likelihood of Wetland Hydrology Effect |
| Mine Pit | High Likelihood |
| Analog Zones (feet) | Moderate Likelihood |
| Area 1 | Low Likelihood |
| Stream/River | No Effect |

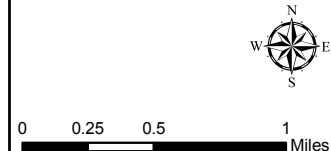
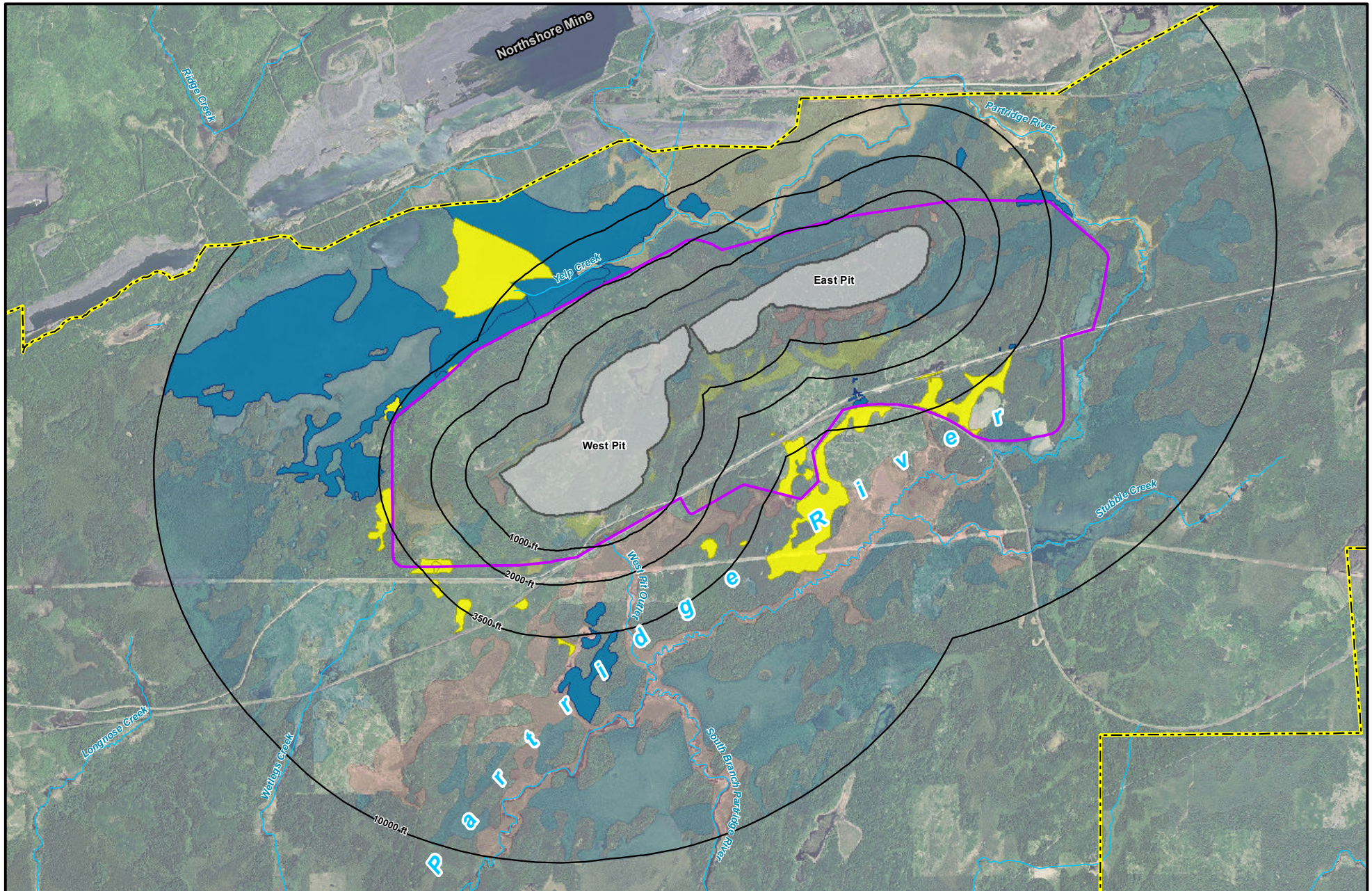


Figure 5.2.3-8
Wetlands Crossing Analog Zones -
>1,000-2,000 feet of Edge of Mine Pits
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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- | | |
|---------------------|---|
| Mine Site | Likelihood of Wetland Hydrology Effect |
| Mine Pit | High Likelihood |
| Analog Zones (feet) | Moderate Likelihood |
| Area 1 | Low Likelihood |
| Stream/River | No Effect |

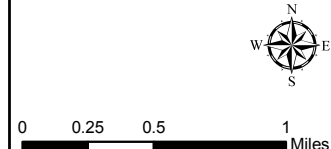


Figure 5.2.3-9
Wetlands Crossing Analog Zones -
>2,000-3,500 feet of Edge of Mine Pits
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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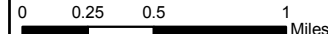
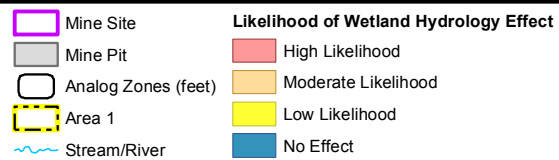
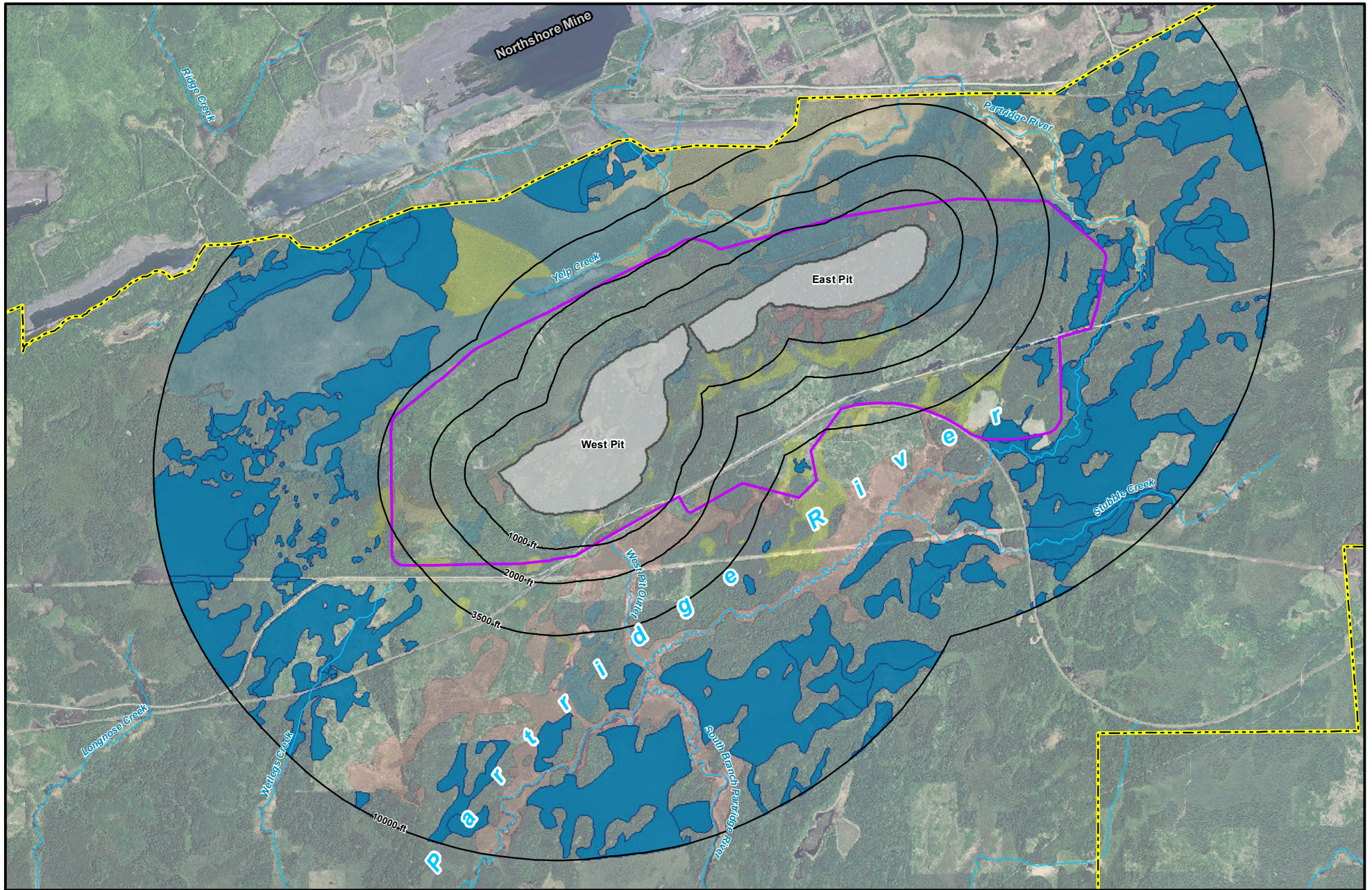


Figure 5.2.3-10
Wetlands Crossing Analog Zones -
>3,500-10,000 feet of Edge of Mine Pits
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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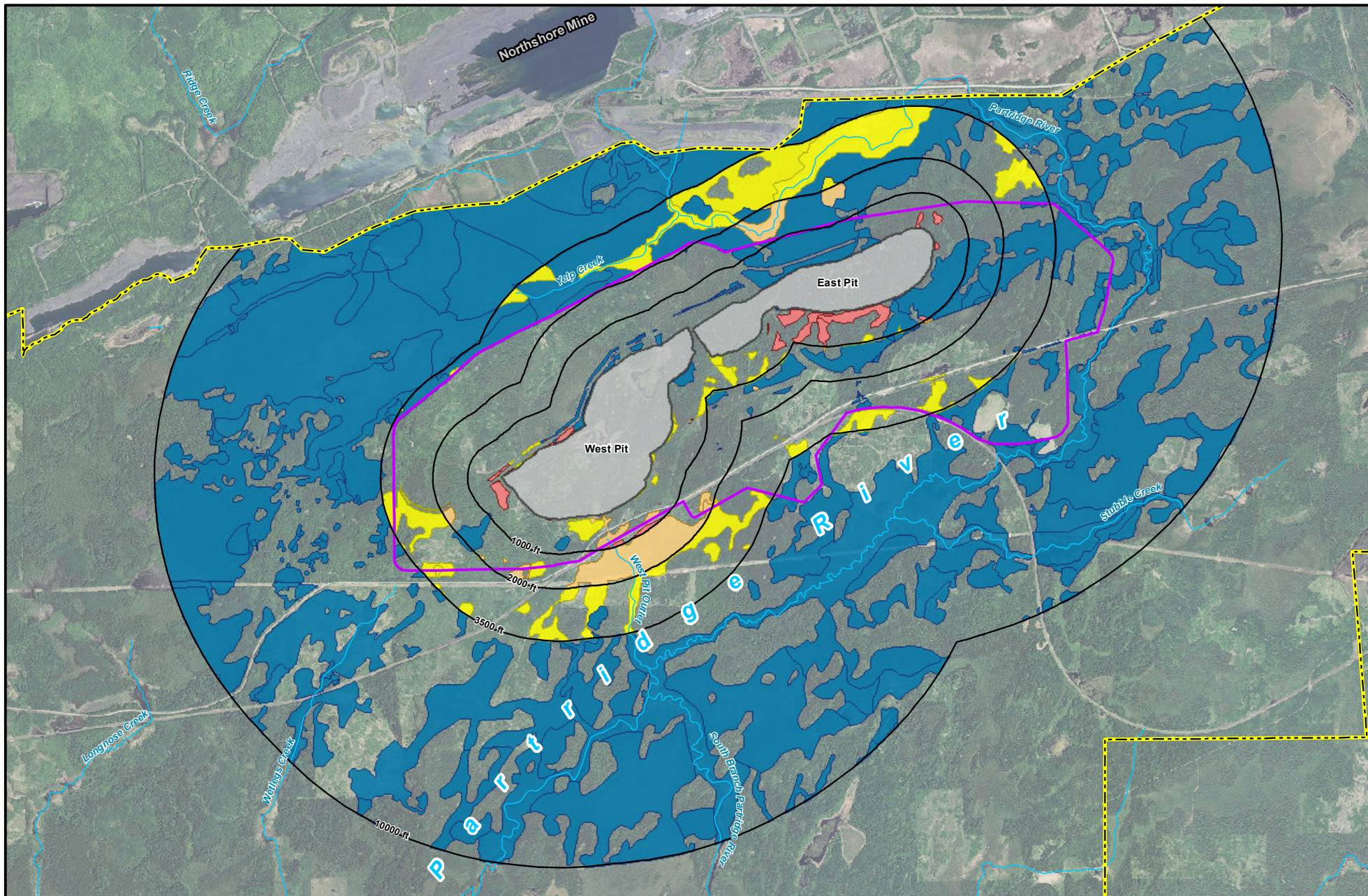
For the method approach of wetlands within analog zones, wetlands that were located within multiple analog impact zones were split along zone edges, and acreages were calculated by zone. The acreage of each wetland type located within these impact zones is summarized in Table 5.2.3-4 and locations are shown in Figures 5.2.3-11 through 5.2.3-15. Using this analysis approach, there would be 233.5 acres of wetlands in the 0-1,000 ft zone, 311.0 acres in the >1,000-2,000 ft zone, 718.0 acres of wetlands in the >2,000-3,500 ft zone, and 4,564.4 acres of wetlands in the >3,500-10,000 ft zone (PolyMet 2013b).

Table 5.2.3-4 Wetlands Within Analog Impact Zones Resulting from Potential Changes in Hydrology

Likelihood of Wetland Hydrology Effect Based on Wetland Type for Each Analog Distance	Wetland Area (acres) within each Analog Increment				Eggers and Reed Wetland Community
	0-1,000	1,000- 2,000	2,000- 3,500	3,500- 10,000	
	ft	ft	ft	ft	
0 – 1,000 ft					
High Likelihood	46.4	-	-	-	coniferous swamp, hardwood swamp, sedge/wet meadow, shrub-carr, and alder thicket
Moderate Likelihood	8.3	-	-	-	deep marsh, shallow marsh, and shallow, open water
Low Likelihood	32.5	-	-	-	minerotrophic coniferous bog
No Effect	146.3	-	-	-	ombrotrophic coniferous bog and open bog
1,000 – 2,000 ft					
Moderate Likelihood	-	110.8	-	-	coniferous swamp, hardwood swamp, sedge/wet meadow, shrub-carr, and alder thicket
Low Likelihood	-	4.1	-	-	deep marsh, shallow marsh, and shallow, open water
No Effect	-	196.1	-	-	minerotrophic and ombrotrophic coniferous bog and open bog
2,000 – 3,500 ft					
Low Likelihood	-	-	385.0	-	coniferous swamp, hardwood swamp, sedge/wet meadow, shrub-carr, and alder thicket
No Effect	-	-	333.0	-	deep marsh, shallow marsh, and shallow, open water, minerotrophic and ombrotrophic coniferous bog and open bog
3,500 – 10,000 ft					
No Effect	-	-	-	4,564.4	all wetland types
Total Acres of Wetland	233.5	311.0	718.0	4,564.4	

Source: PolyMet 2013b.

Under this methodology approach, the likelihood of wetland hydrology effects would be as follows: no effect on 5,239.8 acres of wetlands (90 percent); low likelihood to 421.6 acres of wetlands (7 percent); moderate likelihood to 119.1 acres of wetlands (2 percent); and high likelihood to 46.4 acres of wetlands (1 percent) (see Table 5.2.3-4). Within 0-10,000 ft from the edge of the mine pits, wetland types with a high likelihood of wetland hydrology effects include shrub swamps (27 acres), coniferous swamp (19 acres), and sedge/wet meadows (less than 1 acre); those with a moderate likelihood include shrub swamp (96 acres), coniferous swamp (14 acres), deep marsh (5 acres), shallow marsh (3 acres), and hardwood swamp (less than 1 acre); and those with low likelihood include shrub swamp (247 acres), coniferous swamp (135 acres), coniferous bog (33 acres), shallow marsh (4 acres), sedge/wet meadow (2 acres), and hardwood swamp (1 acre) (PolyMet 2013b).



- | | |
|---------------------|---|
| Mine Site | Likelihood of Wetland Hydrology Effect |
| Mine Pit | High Likelihood |
| Analog Zones (feet) | Moderate Likelihood |
| Area 1 | Low Likelihood |
| Stream/River | No Effect |

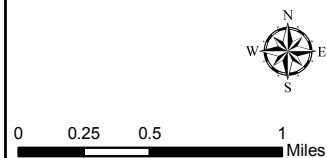
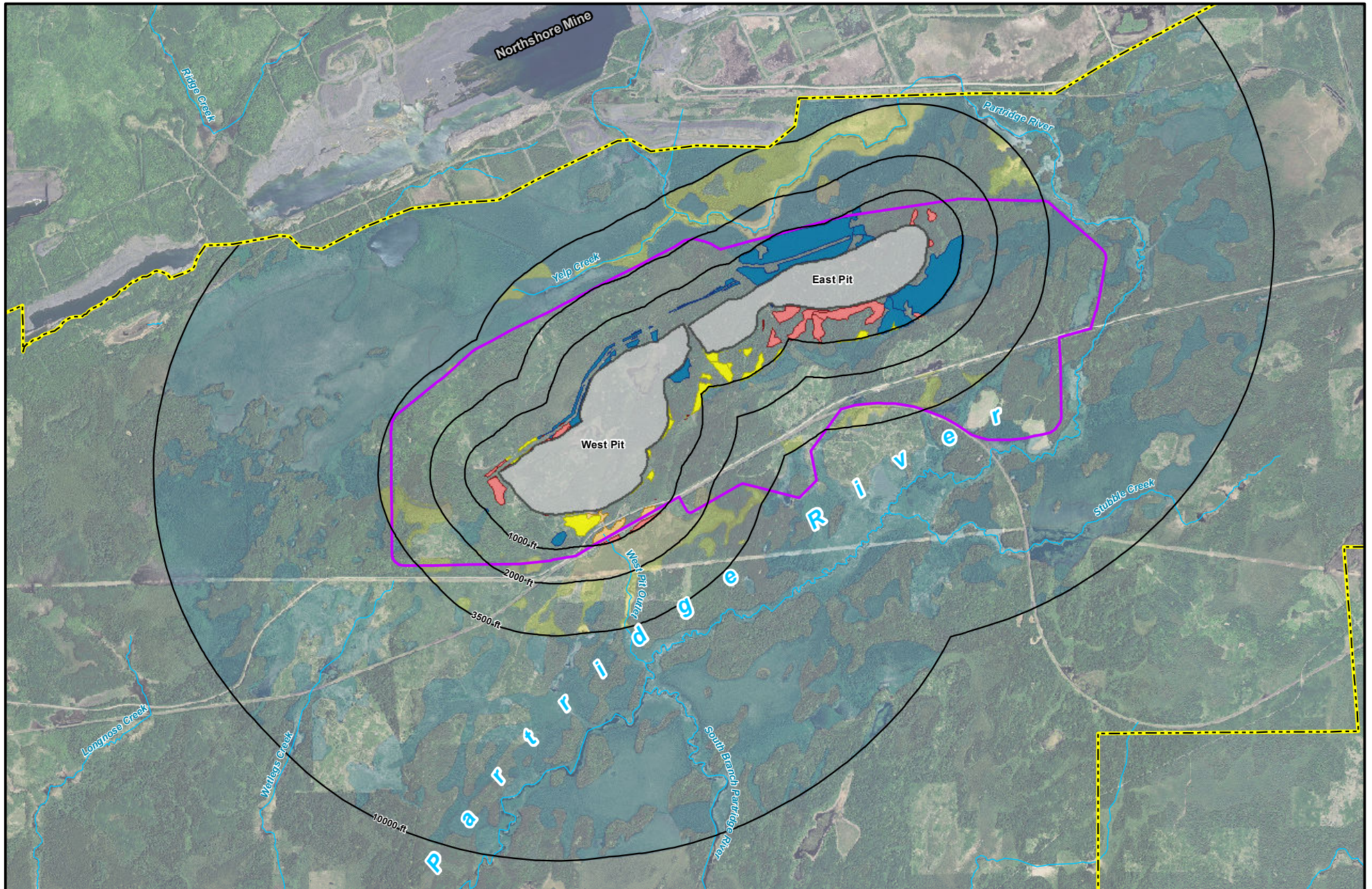


Figure 5.2.3-11
Wetlands Within Analog Zones -
0-10,000 feet of Edge of Mine Pits
 NorthMet Mining Project and Land Exchange SDEIS
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|---------------------|---|
| Mine Site | Likelihood of Wetland Hydrology Effect |
| Mine Pit | High Likelihood |
| Analog Zones (feet) | Moderate Likelihood |
| Area 1 | Low Likelihood |
| Stream/River | No Effect |

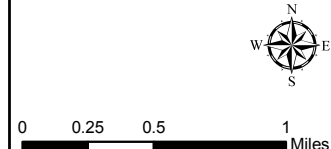
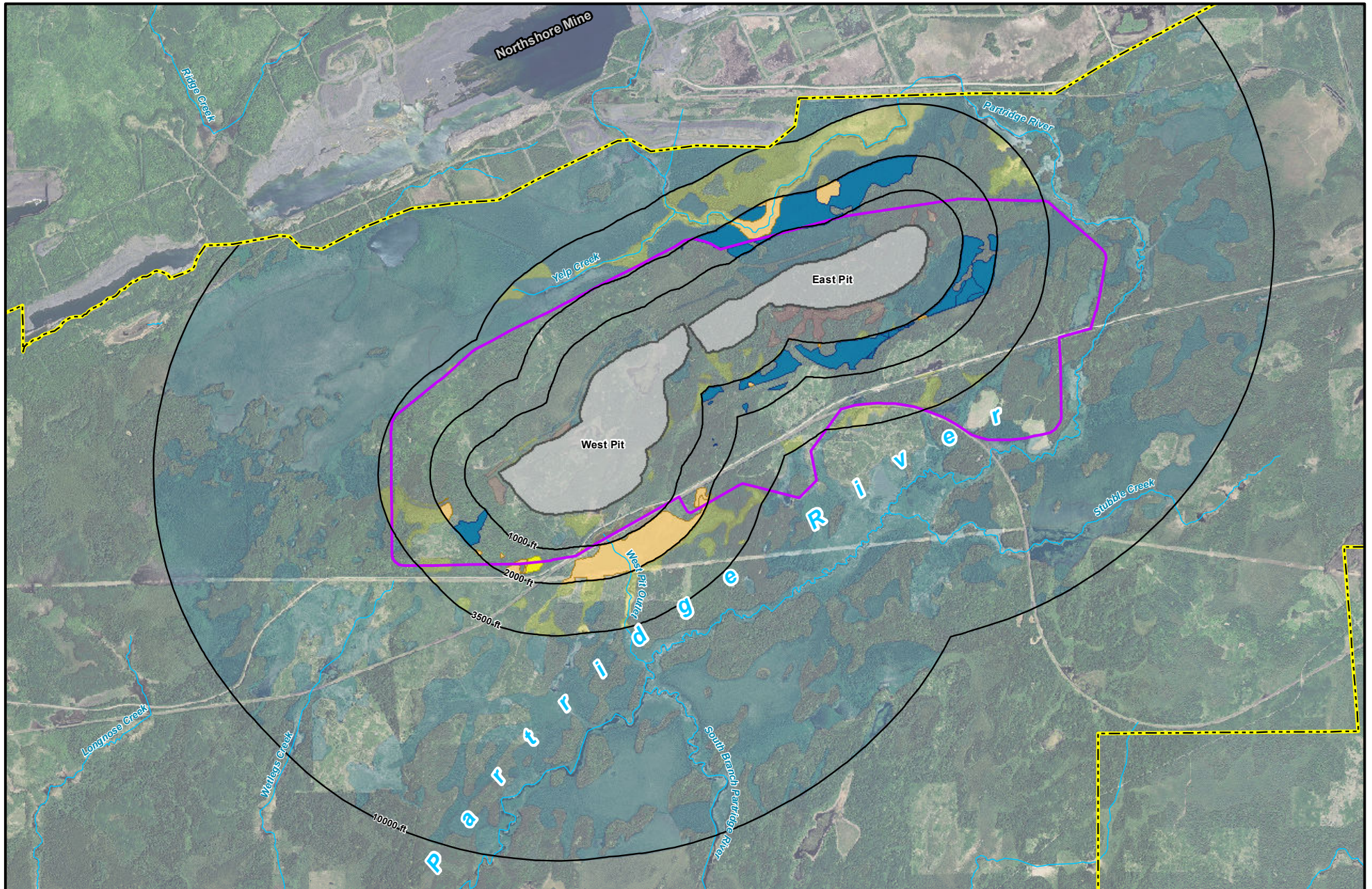


Figure 5.2.3-12
Wetlands Within Analog Zones -
0-1,000 feet of Edge of Mine Pits
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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|---------------------|---|
| Mine Site | Likelihood of Wetland Hydrology Effect |
| Mine Pit | High Likelihood |
| Analog Zones (feet) | Moderate Likelihood |
| Area 1 | Low Likelihood |
| Stream/River | No Effect |

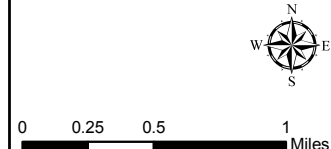
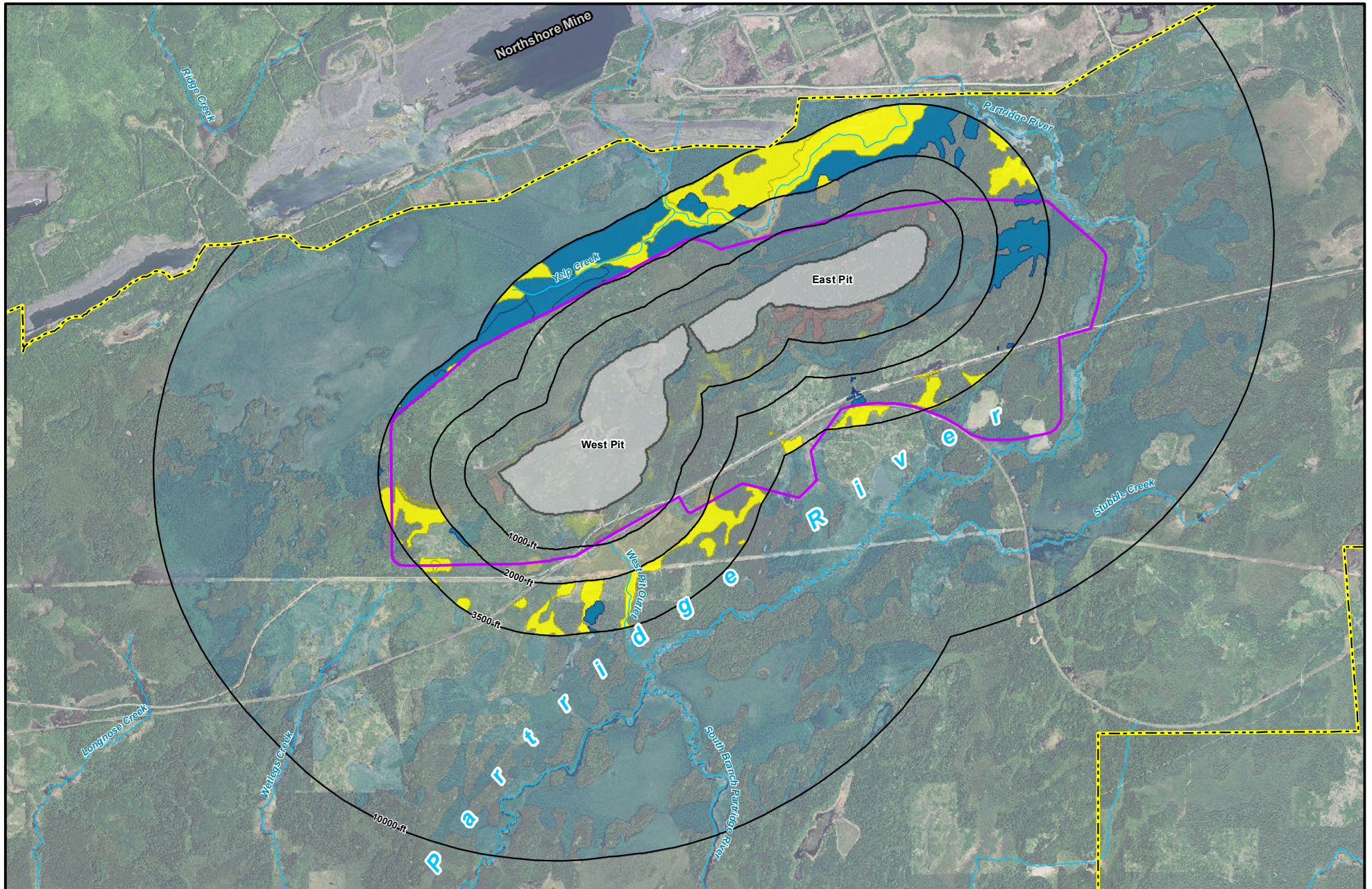


Figure 5.2.3-13
Wetlands Within Analog Zones -
>1,000-2,000 feet of Edge of Mine Pits
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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- | | |
|---------------------|---|
| Mine Site | Likelihood of Wetland Hydrology Effect |
| Mine Pit | High Likelihood |
| Analog Zones (feet) | Moderate Likelihood |
| Area 1 | Low Likelihood |
| Stream/River | No Effect |

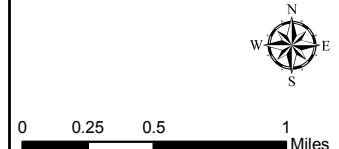
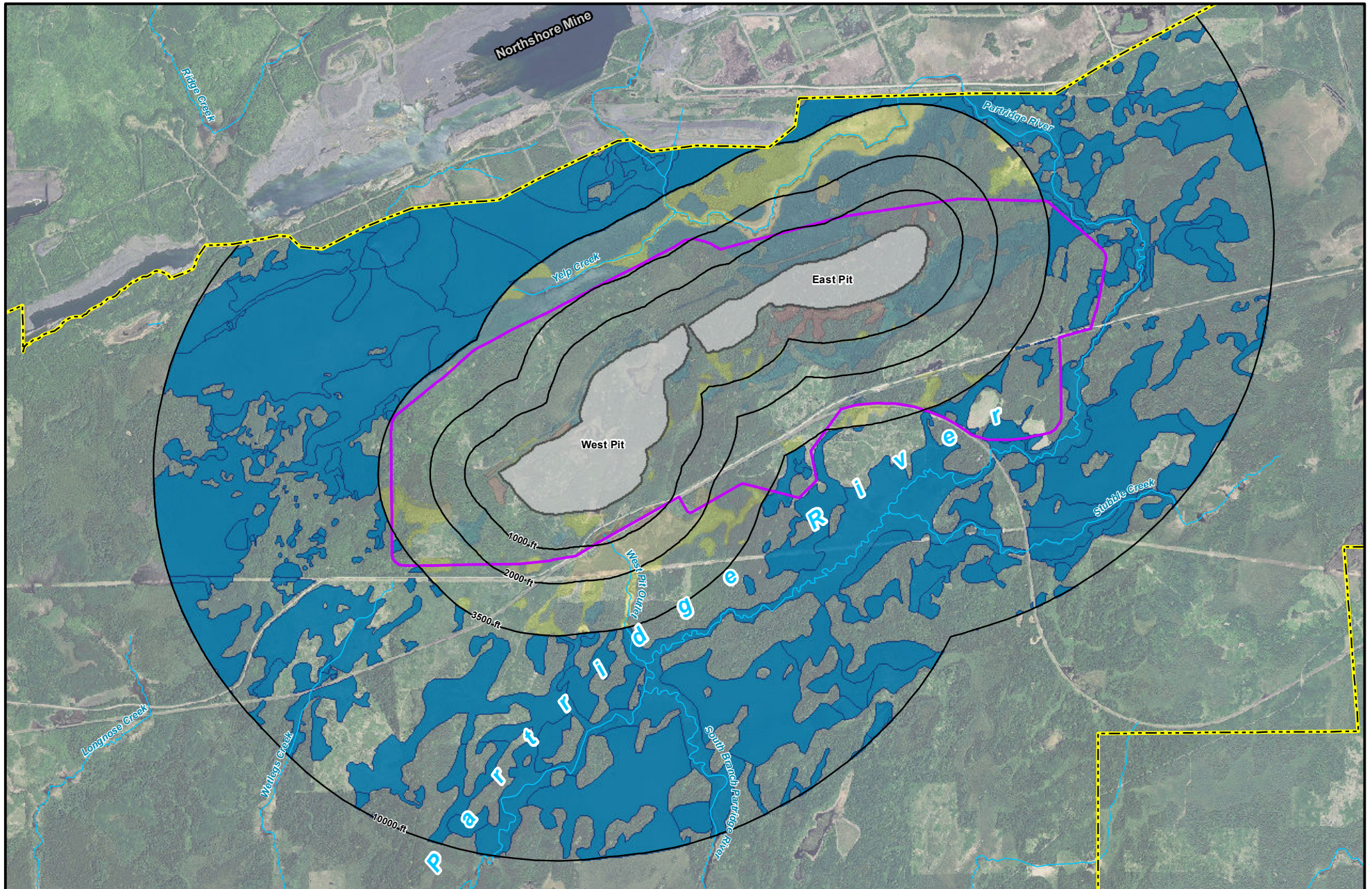


Figure 5.2.3-14
Wetlands Within Analog Zones -
>2,000-3,500 feet of Edge of Mine Pits
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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- | | |
|---------------------|---|
| Mine Site | Likelihood of Wetland Hydrology Effect |
| Mine Pit | High Likelihood |
| Analog Zones (feet) | Moderate Likelihood |
| Area 1 | Low Likelihood |
| Stream/River | No Effect |



0 0.25 0.5 1 Miles

Figure 5.2.3-15
Wetlands Within Analog Zones -
>3,500-10,000 feet of Edge of Mine Pits
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The potential indirect wetland hydrology drawdown effects on each wetland type were assessed based on the wetland sensitivity class tables for falling groundwater tables found in the Crandon mine project document titled *Wetland Impact Assessment Technical Memorandum – Appendix B*. The following provides a general discussion regarding potential indirect wetland effects that could occur based on hypothetical hydrologic drawdown levels using the hydrologic wetland sensitivity method. The potential indirect wetland effects that could occur include: conversion to other wetland community types, a change in vegetation without a change in community type, conversion to uplands, or other effects.

Three categories of hydrologic wetland sensitivity, each with associated groundwater drawdown levels for each wetland community type, were created for the hypothetical hydrologic drawdown wetland sensitivity assessment (PolyMet 2013b).

- None-to-Slight: Water level changes in which effect on the community would be slight to none with the potential for slight changes in abundance of various species but no change in species present. Monitoring or mitigation not anticipated.
- Moderate: Water level changes that may have a moderate effect on the wetland community with the potential for the loss and addition of some species. Monitoring recommended with mitigation based on monitoring results.
- Severe: Water level changes expected to result in severe effects on the community with the potential for considerable loss of characteristic plant species and invasion by other species, conversion of wetland type or conversion to upland. Monitoring should be conducted and mitigation may be required. According to the hydrologic wetland sensitivity method, wetlands in which groundwater is not the principal source of water and in which mitigation of surface water is planned (e.g., streamflow augmentation) should be excluded from this category.

The hydrologic wetland sensitivity method estimated how wetland communities would respond to groundwater drawdown by assuming that they would change to drier native plant communities or variants of the original community. No data or research was utilized from actual wetlands responding to groundwater drawdown; therefore, this analysis and related data can only be used as an initial estimate of what changes could be expected should groundwater levels actually fall as a result of the NorthMet Project Proposed Action. Monitoring of hydrology and vegetation within potentially affected wetlands represents the best method for documenting actual community changes resulting from hydrology changes, understanding complex hydrologic conditions, and identifying potential future indirect effects related from mine features.

The preliminary information developed for the hydrologic wetland sensitivity method was utilized to estimate what type of wetland effects might occur at the Mine Site assuming various, theoretical groundwater drawdown levels. Table 5.2.3-5 provides a summary of the estimated wetland community changes using the groundwater drawdown thresholds for each wetland type based on the hydrologic wetland sensitivity method.

Table 5.2.3-5 Potential Wetland Community Changes Due to Drawdown

Impact Sensitivity Category	None		Moderate		Severe	
Community Type	Water Level Drawdown (ft)	Potential Effect	Water Level Drawdown (ft)	Potential Effect	Water Level Drawdown (ft)	Potential Effect
Ombrotrophic Coniferous and Open bog	<1	None	1-2	Minor changes in vegetation; Increased tree growth	>2	Possible conversion of wetland type
Minerotrophic Coniferous and Open bog	<0.5-1	None	0.5-2	Change in vegetation; Increased tree growth	>2	Possible conversion of wetland type
Shallow marsh ¹	<1	None	1-3	Conversion of type	>3	Conversion of wetland type
Deep marsh ¹	<2	None	2-4	Conversion of type	>4	Conversion of wetland type
Shallow, open water ¹	<2	None	2-4	Conversion of type	>4	Conversion of wetland type
Conifer swamp	<0.75-2	None	0.75-4	Minor changes in vegetation; Increased tree growth	>2-4	Change in vegetation
Hardwood swamp	<2	None	2-4	Change in vegetation; Increased tree growth	>4	Conversion of wetland type; possible conversion to upland
Alder thicket	<1	None	1-4	Change in vegetation; Increased shrub growth	>4	Conversion of wetland type; increased shrub growth
Shrub-carr	<0.5	None	0.5-3	Change in vegetation; Increased shrub growth	>3	Conversion of wetland type
Sedge/wet meadow	<0.5	None	0.5-3	Change in vegetation; Conversion of type	>3	Conversion to upland

Source: PolyMet 2013b.

¹ Shallow marsh, deep marsh, and shallow open water communities were not evaluated in the hydrologic wetland sensitivity method as described in the Wetland Work Plan, but were estimated based on best professional judgment (PolyMet 2013b).

For minor groundwater drawdown (ranging from 0.5 to 2 ft), no substantial wetland community changes were identified. For the moderate sensitivity category (water level changes ranging from 0.5 to 4 ft), some changes to vegetation would be possible in all wetland communities with marshes, open water, and meadows, potentially resulting in conversion of wetland type, and there could be increased shrub or tree growth in shrub or forested wetlands. For the severe sensitivity category, nearly all wetland community types would be estimated to convert to other wetland types with a few wetlands estimated to convert to upland, including sedge/wet meadows

and possibly hardwood swamps (PolyMet 2013b). Monitoring to document effects to wetlands would be recommended for all potential effects in the moderate and severe categories.

Groundwater modeling cannot reasonably estimate potential indirect wetland effects; therefore, analog impact zones can provide a reasonable estimate of the extent of potential indirect wetland effects resulting from hydrologic effects. In addition, the evaluation of theoretical groundwater drawdown levels can help estimate what types of potential indirect wetland effects might occur. However, wetland hydrology is a complex mix of precipitation, surface runoff, and in some cases, groundwater. The response of complex natural systems to human disturbances can only be estimated. Therefore, monitoring of wetland hydrology and vegetation communities would occur to document the extent and magnitude of wetland responses (potential indirect effects) to human disturbances. The monitoring plan, developed as part of the Section 404 permit, would be based on those wetlands that have a high likelihood of indirect effects as a result of groundwater drawdown. Permit conditions would likely include an adaptive management plan to account for any additional effects that may be identified in the annual monitoring and reporting.

Wetlands Abutting the Partridge River

There are 1,478.5 acres of wetlands abutting the Partridge River within Area 1 (see Figure 4.2.3-2) are presented in Table 5.2.3-6.

Table 5.2.3-6 Wetlands Abutting the Partridge River

Eggers and Reed Class¹	Wetland Size (acres)	Wetland Size (percent)
Coniferous bog	193.0	13
Shallow marsh	12.1	1
Shrub swamp (including alder thicket or shrub-carr)	1,273.5	86
Total Acres of Wetlands	1,478.5	100

Source: PolyMet 2013b.

¹ Eggers and Reed 1997.

The XP-SWMM model identified that the changes in average annual flow (and therefore stage) of the Partridge River would be within the naturally occurring annual variation for the Partridge River. Thus, no potential indirect wetland effects were identified for the wetlands abutting the Partridge River (PolyMet 2013b).

Water Quality Changes

The screening analysis for depositional effects conducted to estimate potential annual deposition of dust, metals, and sulfur to wetlands within and adjacent to the Mine Site was performed using AERMOD. The estimated deposition from fugitive dust emissions was used to identify wetlands that have the potential for water quality changes. The estimated deposition from fugitive dust emissions was used to identify a threshold for a negative effect on vegetation. Below is a summary of the assessment from the *NorthMet Project Wetlands Data Package* (PolyMet 2013b).

Receptors

The receptors of interest for this analysis were the wetlands that were not directly affected. The respective initial receptor grids for the Mine Site were set up with near-field receptor spacing of 250 meters (within the ambient air boundary and out to 1,000 meters beyond the ambient air boundary) and far-field receptor spacing of 1,000 meters (from 1 km out to 5 km from the ambient air boundary).

Dust Deposition and Speciation to Individual Metals and Sulfur

For the dust emission sources identified for assessing potential metals and sulfur deposition at the Mine Site, the highest estimated dust deposition rate for each receptor node was then speciated to the respective metal and sulfur deposition rates based on the contribution of the sources to a receptor node and the metal and sulfur composition identified for each contributing source (e.g., ore and waste rock at the Mine Site). The estimated metal or sulfur deposition for each contributing dust source at a receptor node was then summed to provide a “total” deposition rate for each respective metal and for sulfur at that receptor location. Dust deposition rates were speciated for arsenic, cadmium, chromium, lead, manganese, nickel, and selenium. Copper and vanadium were also included. For each receptor node, the post-processing of the dust deposition rate by source contribution was then summed to provide a “total” metal deposition rate and a “total” sulfur deposition rate.

Estimates of Rural Background Deposition

For dust, an annual effects-level deposition rate of 365 grams per square meter per year ($\text{g/m}^2/\text{yr}$) was compared to modeled annual dust deposition rates. This deposition rate is a potential effects threshold for photosynthesis (i.e., potential for reduced photosynthesis due to “dusting” of the plant surface). However, for this analysis, the vegetative surface area of the wetlands was not calculated or included in the analysis. The modeled dust deposition rate was assumed to be applied to the land surface area which is a smaller area than the vegetative surface area. Vegetative surface area can be up to 13 times greater than the land surface area. By only assessing dust deposition to the land surface area instead of the vegetative surface area, it is likely the ratio of modeled deposition rate to the effects level was being overestimated. In other words, the modeled deposition rate is not being spread over the larger surface area of the vegetation, which would reduce the effective deposition rate. Because this application did not include the deposition of dust to the vegetative surface area, it is likely that the areas identified to exceed the effects threshold of $365 \text{ g/m}^2/\text{yr}$ have been overestimated.

For metals, background deposition is based on the data from *Atmospheric Deposition of Trace Metals at Three sites near the Great Lakes* (Sweet et al. 1997), which indicated that precipitation was under-collected by 45 to 70 percent when sample volumes were compared to corresponding rain gage amounts. Because wet deposition was considered to be underestimated, the wet deposition component was adjusted upward by a factor of 1.6.

Total background sulfur deposition included both wet and dry deposition, which was calculated to be $0.16 \text{ g/m}^2/\text{yr}$. The estimated background deposition used in the analysis for metals and sulfur was from data collected at sites characterized as open areas in rural settings that were reasonably distant from industrial sources and population centers. For forested areas, dry deposition may be underestimated. Vegetation can effectively scavenge fine particles and

aerosols from the atmosphere and this interception can result in dry deposition being 50 percent or more of the total deposition. A monitoring site in Ely (Fernberg Road), dry deposition was assumed to be 22 percent of total deposition. Therefore, it is likely that the background sulfur deposition estimated for this analysis may be low due to an underestimation of dry deposition; however, no adjustments were made to the background sulfur deposition estimated for this analysis.

Significance Levels for Estimating the Potential Effects for Identifying Future Monitoring

For dust, metals, and sulfur, the following general categories were used for assessing the significance of a modeled deposition rate at a receptor node:

- Less than 100 percent of background: no potential for effects expected.
- Greater than 100 percent of the background value: potential for effects, include in future wetland monitoring.

These are general categories of potential for effects. Since this was a screening analysis to identify wetlands for potential inclusion in the monitoring program, there was some flexibility in identifying a potential level of deposition that suggested a potential for effect and would then trigger a requirement for monitoring. Another consideration for selecting a deposition rate that was a high percent of the background rates was the likely overestimation of modeled deposition and the underestimation of background deposition.

Adding to the conservatism in the modeling of particulate metals, this screening analysis used a maximum dust deposition from a range of possible modeled values and a high-end metal or sulfur concentration for each source contributing to that receptor node to derive a maximum potential metal or sulfur deposition for a receptor node.

Using a maximum concentration for each contributing emission source to speciate a metal or sulfur deposition from a maximum modeled dust deposition rate for each receptor node overestimates individual metal or sulfur deposition. Also adding to the conservatism of this analysis is the underestimation of background deposition because the ratio of the NorthMet Project Proposed Action-related deposition is compared to the background deposition. If background deposition is underestimated, that would indicate that estimated NorthMet Project Proposed Action-related deposition at more receptor nodes would be higher than background and further increase the area for potential future monitoring. The underestimation of background metal deposition (i.e., wet deposition due to under-collection of precipitation) was identified by Sweet et al. (1997). In addition to the underestimation of background metal deposition, background wet sulfate deposition may be underestimated, as well, because the National Atmospheric Deposition Program data for the Fernberg Road monitoring site indicated rainfall in the last 3 years was about 22 percent below the annual average. If sulfate deposition from 2007 and 2008 was used (both years approximately normal for precipitation amount), a background sulfur deposition rate of 0.23 g/m²/yr was calculated—about 44 percent higher than the background deposition used in the screening analysis. If the higher estimate of background sulfur deposition was used in the screening analysis, a smaller number of receptor nodes would have been identified to have modeled sulfur deposition that was more than 100 percent of background deposition and the area for potential monitoring would be smaller than that identified. Also, it was found that for forested areas, dry deposition may be systematically underestimated due to

sample collection and analysis methodology. It is possible that the background sulfur deposition estimated for this analysis may be low due to an underestimate of dry deposition.

Given the potential for overestimation of modeled deposition and underestimation of background deposition, and balancing the conservatism when their respective results are combined in this analysis, it seems reasonable to select the wetlands estimated to receive greater than 100 percent of background deposition (a potential doubling of the background deposition) for consideration in potential future monitoring (PolyMet 2013b).

Fugitive Dust/Metals and Sulfide Dust Emissions

At the Mine Site, dust deposition was concentrated relatively close to the ore loading area near the southern portion of the ambient air boundary. All receptors have model-estimated dust deposition of 25 percent or less of the effects-level background of 365 g/m²/yr (see Figure 5.2.3-16). The highest model-estimated metal and sulfur depositions at the Mine Site were in two defined areas, which include the ore loading area and at the east end of the Category 2/3 Stockpile (see Figure 5.2.3-17). All of the receptor nodes with the highest model-estimated deposition rates were located within the ambient air boundary.

Of the 19,914 acres of wetlands identified within the Mine Site receptor grid, deposition modeling results indicated that 234 acres of wetlands could be potentially indirectly affected (modeled metal deposition rates greater than 100 percent of background). Of the 234 acres of wetlands, 228 acres (97 percent) would be located within the Mine Site ambient air boundary (PolyMet 2013b). The 234 acres of wetlands should be included in any future monitoring to be conducted for the NorthMet Project Proposed Action. The deposition modeling results for dust, metals, and sulfur would likely not have an adverse effect on wetlands; however, the modeling only indicated those areas that had deposition rates greater than 100 percent of background deposition.

Mine to Plant Site Railroad Corridor – Ore Spillage

The potential release of dust from railcars transporting ore from the Mine Site to the Plant Site was addressed in the May 6, 2011, Air IAP Summary Memo (PolyMet 2013b):

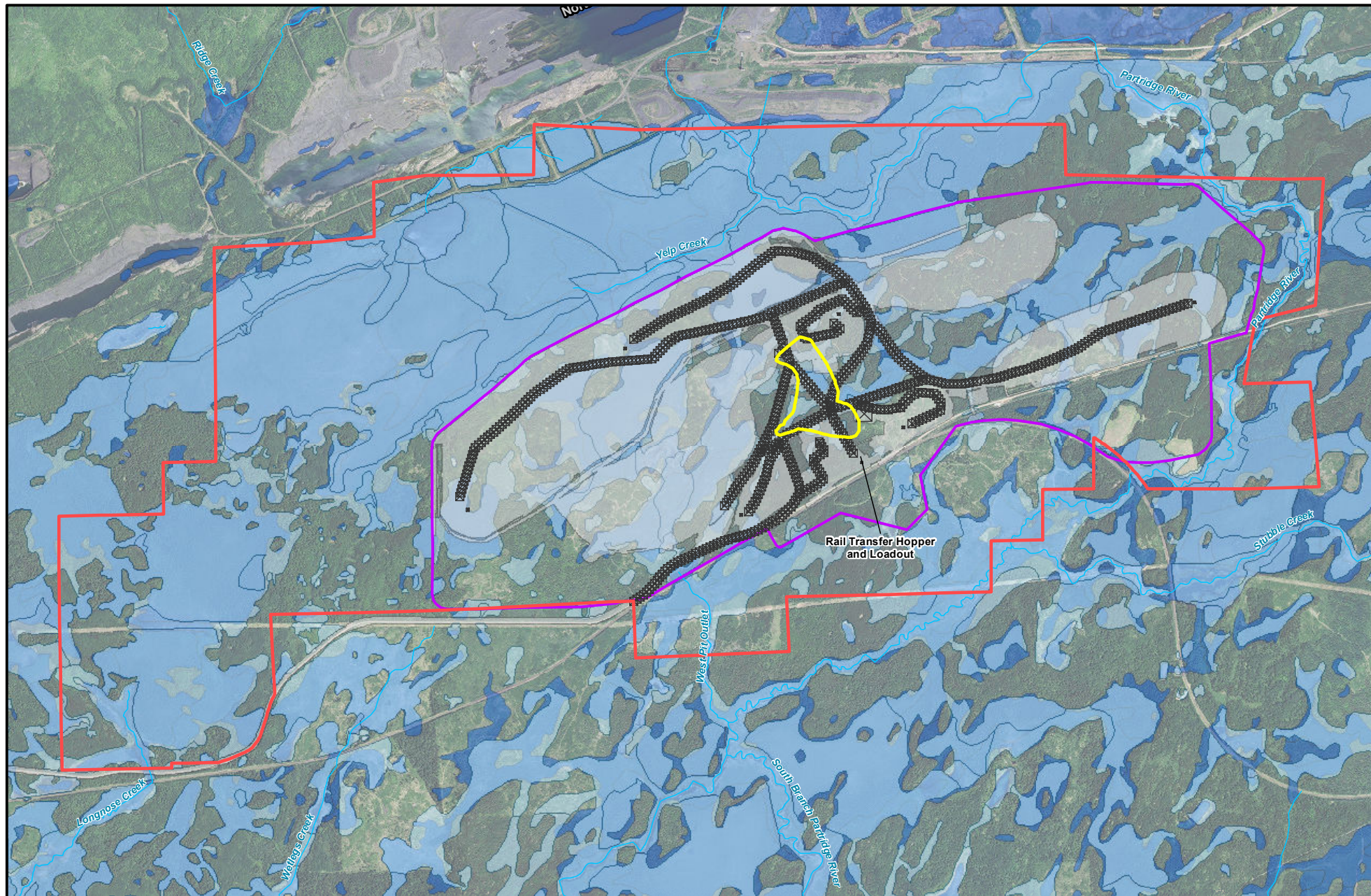
The air IAP group concluded that there would be minimal air impacts from any dust generated from ore hauled in the railcars due to the coarse nature of the ore.

Based on this conclusion, air modeling of potential release of dust from railcars will not be performed because the potential wetland effects would not be significant.

The air IAP group concluded that any dust generated from ore hauled in railcars would be coarse in nature (i.e., relatively large particles). These larger particles would tend to deposit near the railcar and not be dispersed to any great extent. An estimate of the spillage of ore fines along the rail corridor is provided in Section 8.4.3 of the Waste Characterization Data Plan (PolyMet 2013l). Assuming that all spillage of the coarse material would occur in a 2-meter-wide strip on both sides of the centerline of the railway (total width equals 4 meters) over the entire haul distance after loading (approximately 8 miles or 13,000 meters), results in approximately 0.11 kilograms per square meter (kg/m²) of ore fines annually or 2.14 kg/m² for the 20-year NorthMet Project Proposed Action. This equates to 0.002 inch of depth annually or 0.05 inches for the 20-year NorthMet Project Proposed Action.

Wetlands that have contributing watersheds that include no segments of the railway (e.g., many of the wetlands uphill to the north of the rail corridor) were identified as having no potential indirect effects from rail spillage. Wetlands immediately abutting the railway and whose watersheds included the rail centerline were identified as potentially being affected, although the effects may not extend to the full area of the wetland. Wetlands that have contributing watersheds, which include natural areas that are larger than 675 square meters per meter of track (one-sided) in the contributing watershed, were identified as having no potential indirect effects. Approximately 543 acres of wetlands along the railroad corridor could be potentially indirectly affected by the NorthMet Project Proposed Action.

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- Ambient Air Boundary
- Extent of Highest Estimated Deposition
- Receptors with Deposition of 25% of Background
- Mine Site
- Disturbed Area
- Volume Sources (Roads)
- Wetlands
- NWI Wetland
- Stream/River

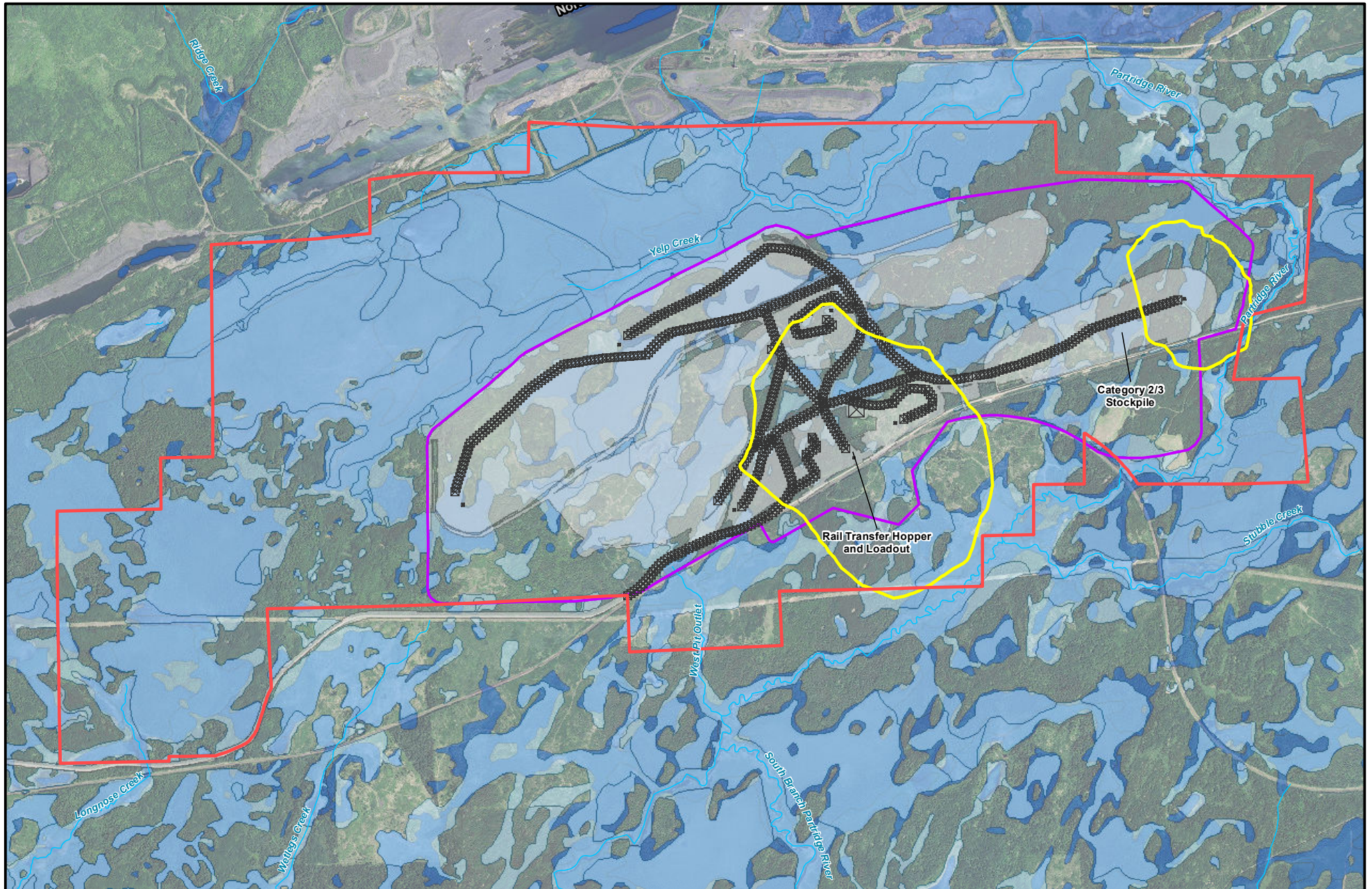


0 1,000 2,000 4,000
Feet

Figure 5.2.3-16
Model - Estimated Dust Deposition Compared to
Background Effects Level - Mine Site
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- Ambient Air Boundary
- Extent of Highest Estimated Deposition
- Receptors with Deposition of 100% of Background
- Mine Site
- Disturbed Area
- X Volume Sources (Roads)
- Wetlands
- NWI Wetland
- Stream/River



0 1,000 2,000 4,000 Feet

Figure 5.2.3-17
Model - Estimated Metal Deposition Compared to
Background Effects Level - Mine Site
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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Leakage from Stockpiles/Mine Features and Seepage from Mine Pits

The stockpiles, mine pits, and other mine features (e.g., WWTF) are located within the Partridge River Watershed. Water containing constituents generated in the waste rock stockpiles and mine pits has the potential to enter the shallow groundwater system via potential leakage through the liners (e.g., stockpiles and WWTF equalization basins) or seepage from the pits. The leakage or seepage that enters groundwater would then be transported toward the Partridge River along groundwater flowpaths. There are five groundwater flowpaths connecting the mine features to the Partridge River, which include: East Pit – Category 2/3 flowpath, Ore Surge Pile flowpath, WWTF flowpath, Overburden Storage and Laydown Area flowpath, and West Pit flowpath. Because the water quality within these flowpaths has the potential to change as a result of the NorthMet Project Proposed Action, these same flowpaths were considered in the assessment of potential indirect wetland effects associated with leakage or seepage from mine features (PolyMet 2013b).

Wetlands were identified within the groundwater flowpaths, and the bog wetlands within and surrounding the Mine Site were subcategorized as either ombrotrophic or minerotrophic consistent with the November 2011, USACE Memorandum (Eggers 2011a). There are 515.8 acres of wetland resources within the groundwater flowpaths. Other wetlands were classified as dominated by groundwater, although all wetlands receive precipitation and virtually all water movement in peat wetlands occurs horizontally in the upper layers of peat. Approximately 66 percent of the wetlands within the flowpaths are classified as dominantly minerotrophic (groundwater-fed) while 33 percent of the wetlands are supported only by precipitation (ombrotrophic) (see Table 5.2.3-7).

Water quality modeling results indicate groundwater quality along each flowpath would likely change from existing conditions. It was conservatively assumed that these changes may cause potential indirect effects to the character, function, and quality of minerotrophic wetlands; therefore, it was also assumed that all downgradient minerotrophic wetlands located within the five Mine Site surficial aquifer flowpaths may have potential indirect wetland effects related to water quality changes as a result of leakage/seepage from mine features (PolyMet 2013b). This analysis indicates areas that can be conservatively assumed to have potential indirect effects due to changes in groundwater quality. These specific wetland areas are identified for consideration in future monitoring to be conducted during facility operations.

Table 5.2.3-7 Wetlands within the Mine Site Groundwater Flowpaths

Eggers and Reed Class¹	Hydrology	Overburden Storage and Laydown					East Pit - Category 2/3
		West Pit	Area	WWTF	Ore Surge Pile	Acres	
		Acres	Acres	Acres	Acres	Acres	Acres
Coniferous bog (Minerotrophic)	Precipitation/ Groundwater	0.04	0.0	0.0	0.0		6.3
Coniferous bog (Ombrotrophic)	Precipitation	16.5	0.0	0.0	0.0		148.2
Coniferous swamp	Groundwater	0	2.9	20.1	10.2		0.04
Deep marsh	Groundwater	4.9	0.0	0.0	0.0		0.0
Open bog	Precipitation	0.0	0.0	0.0	0.0		8.9
Sedge/wet meadow	Groundwater	0.0	0.0	0.0	0.0		1.2
Shallow marsh	Groundwater	3.4	0.1	0.0	0.0		5.5
Shrub swamps (including alder thicket and shrub-carr)	Groundwater	90.5	47.7	18.8	27.6		103.1
Total Acres of Wetland		115.3	50.7	38.9	37.8		273.2

Source: PolyMet 2013b.

¹ Eggers and Reed 1997.

The Partridge River currently represents the primary discharge location for shallow groundwater at the Mine Site. During operations, reclamation, and long-term closure, groundwater in areas south of the mine pits would continue to discharge to the Partridge River while groundwater in areas north of the mine pits would discharge to the mine pits. The amount of groundwater discharge to surface water and wetlands between the mine features and the Partridge River would be expected to be minimal relative to the amount of groundwater discharge to the Partridge River itself. Significant quantities of groundwater are not expected to discharge to the wetlands because of the very low hydraulic conductivities of the underlying peat layers. The leakage/seepage analysis could not indicate or suggest that an effect or adverse effect would occur on wetlands; however, the analysis only indicated those areas that could be conservatively assumed to have a potential indirect effect due to changes in groundwater (PolyMet 2013b).

Dunka Road Effects

Loaded mine haul trucks would not travel on the Dunka Road. Empty mine haul trucks would only travel on Dunka Road when they are in need of maintenance at the Area 1 Shop. The total one-way trips per year have been estimated to be 44 trips. Given the low traffic volumes of haul trucks (less than one trip per week) and that the ore trucks would likely be empty; no potential indirect wetland effects were identified for wetlands abutting Dunka Road (PolyMet 2013b). The additional light vehicles (e.g., pickups and SUVs), field service trucks, and fuel trucks that would travel on Dunka Road more regularly would not contribute to wetland effects.

5.2.3.2.3 Plant Site Direct Wetland Effects

PolyMet proposes to reuse the former LTVSMC processing plant and Tailings Basin. The processing plant is located on uplands with no wetland resources present. The existing

constructed plant reservoir located east of the concentrator is not regulated as a wetland. Therefore, no direct wetland effects are anticipated in this portion of the Plant Site.

Direct wetland effects would result from the following Plant Site components: construction of the Tailings Basin, pump station, treated water discharge pipelines, flotation tailings pipeline, Tailings Basin containment system to manage Tailings Basin seepage, rock buttress for stability along the north and east sides of Cell 2E, drainage swale and overflow channel located northeast of Cell 2E, and the Hydrometallurgical Residue Facility.

Direct wetland effects within the Plant Site would total 147.1 acres. These wetlands effects would be caused by fill (12 percent), excavation (31 percent), excavation and fill (less than one percent), and the containment system (58 percent), and therefore, these wetlands would be permanently lost. Table 5.2.3-8 summarizes the directly affected wetlands within the Plant Site by community type while Table 5.2.3-9 identifies the activity that causes the effects expected within the Plant Site. The majority of the wetlands (94 percent) that would be affected are rated as low quality and 6 percent are rated as moderate quality wetlands.

The rock buttress described in Section 3.2.3 and Section 4.2.13 would abut the existing toe of the Tailings Basin. The water containment system would extend approximately 300 ft around the northern and western sides of the Tailings Basin, encapsulating the Tailings Basin, the rock buttress and wetlands between it and the rock buttress. Construction of the Tailings Basin for the NorthMet Project Proposed Action would also result in expansion of the existing eastern footprint onto natural highland. The majority of the affected wetlands are rated as low quality, primarily because the hydrology supporting these wetlands has been modified by seepage from the Tailings Basin and other drainage modifications made in the area (PolyMet 2013b). These hydrologic modifications have resulted in inundation and changes in wetland cover types from forested and scrub shrub wetlands (as evidenced in aerial photographs from the 1940s prior to LTVSMC operations) to deep marsh (Barr 2008b).

Wetlands located outside of the Cliffs Erie Permit to Mine Ultimate Tailings Basin boundary (this boundary is shown on Figure 5.2.3-18 and Figure 5.2.3-19) but within the Hydrometallurgical Residue Facility are included in the direct wetland effects analysis. As previously noted, approximately 28.6 acres of wetlands in the Hydrometallurgical Residue Facility are not subject to state or federal regulations as they are located within an actively permitted waste storage facility. Two wetlands located in the Hydrometallurgical Residue Facility are subject to state or federal regulation covering 7.5 acres and would be directly affected by fill. Both wetlands are shallow marsh wetlands (see Figure 5.2.3-19).

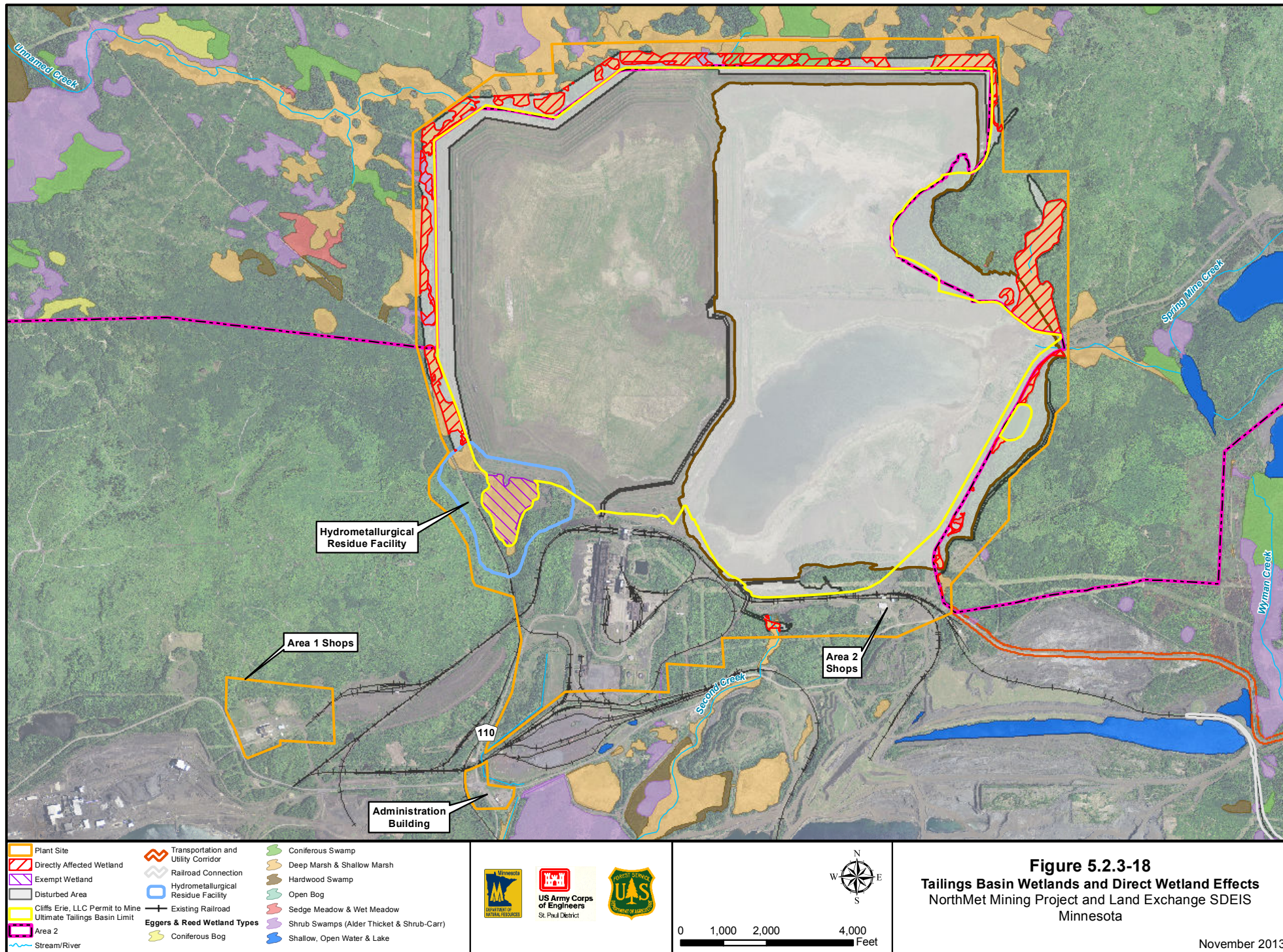
There would be no direct wetland effects along the Colby Lake Water Pipeline Corridor, as there would be no construction within this corridor.

Table 5.2.3-8 Total Projected Direct Wetland Effects for the Plant Site

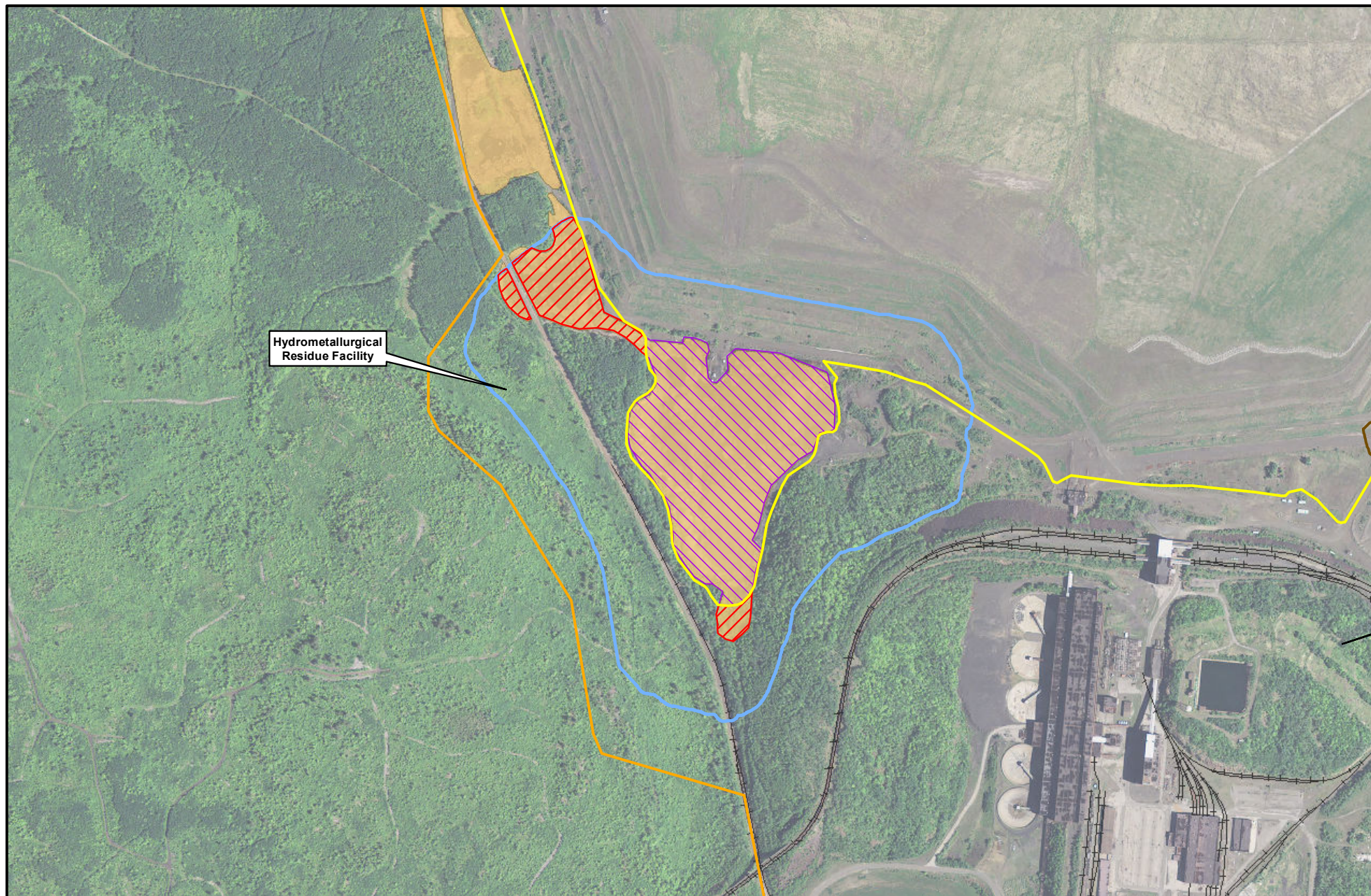
Eggers and Reed Class¹	Directly Affected Wetlands at the Plant Site		
	Acres	%	No.
Coniferous bog	0.0	0	0
Coniferous swamp	10.7	7	3
Deep marsh	73.4	50	14
Hardwood swamp	0.0	0	0
Open bog	0.0	0	0
Open water (includes shallow, open water, and lakes)	0.0	0	0
Sedge/wet meadow	1.4	1	5
Shallow marsh	52.7	36	14
Shrub swamp (includes alder thicket and shrub-carr)	8.9	6	6
Total Direct Effects	147.1	100	42

Source: PolyMet 2013b.

¹ Eggers and Reed 1997.



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<p>Hydrometallurgical Residue Facility</p> <p>Cliffs Erie, LLC Permit to Mine Ultimate Tailings Basin Limit</p> <p>Directly Affected Wetland</p> <p>Exempt Wetland</p> <p>Plant Site</p>	<p>Existing Railroad</p> <p>Stream/River</p> <p>Eggers & Reed Wetland Types</p> <p>Coniferous Bog</p> <p>Coniferous Swamp</p> <p>Hardwood Swamp</p>	<p>Deep Marsh & Shallow Marsh</p> <p>Open Bog</p> <p>Sedge Meadow & Wet Meadow</p> <p>Shrub Swamps (Alder Thicket & Shrub-Carr)</p> <p>Shallow, Open Water & Lake</p>		<p>0 250 500 1,000 Feet</p>	<p>Figure 5.2.3-19</p> <p>Hydrometallurgical Residue Facility</p> <p>Wetlands and Direct Wetland Effects</p> <p>NorthMet Mining Project and Land Exchange SDEIS</p> <p>Minnesota</p> <p>November 2013</p>
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Table 5.2.3-9 Type of Projected Direct Wetland Effects at the Plant Site

Type of Effect	Directly Affected Wetlands at the Plant Site		
	Acres	%	No.
Fill	17.0	12	16
Excavation	45.2	31	1
Fill and Excavation	0.2	<1	1
Containment System	84.7	58	24
Total Direct Effects	147.1	100	42

Source: PolyMet 2013b.

5.2.3.2.4 Plant Site Indirect Wetland Effects

The indirect wetland effects were assessed by identifying wetlands in Area 2 within 500-ft increments beginning at the Plant Site and continuing out to a total of 30,000 ft (see Figure 5.2.3-20). The area of evaluation for the Plant Site indirect wetlands effects included wetlands within Area 2 where wetland type information had been developed and wetlands within and near Second Creek, and does not include the directly affected wetlands. No wetlands are located within the former LTVSMC processing plant; therefore, no indirect wetland effects would occur from its reuse.

Wetland Fragmentation

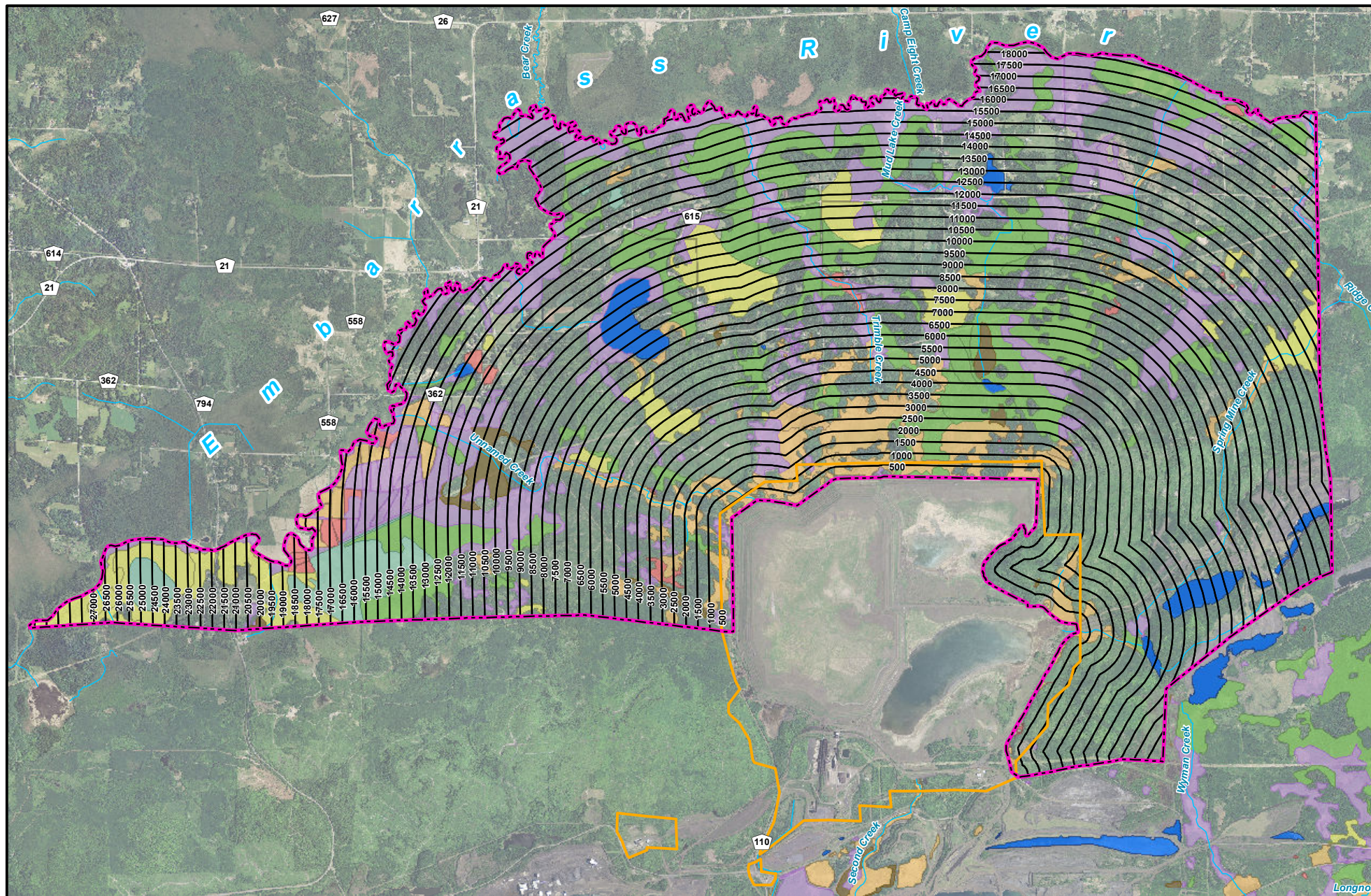
Construction of the Plant Site features (e.g., containment system) would result in 0.5 acre of wetland fragments. Wetland fragments would result in the following wetland types: shallow marsh (61 percent), deep marsh (35 percent), coniferous swamp (4 percent), and shrub swamps (less than 1 percent) (PolyMet 2013b). No wetland fragmentation would result from the streamflow augmentation activities for Second Creek (PolyMet 2013k).

Changes in Hydrology

There are three surficial aquifer groundwater flowpaths from the Plant Site (see Figure 5.2.3-21), which include: Unnamed Creek (west flowpath), Trimble Creek (northwest flowpath), and Mud Lake Creek (north flowpath). Wetland types within the flowpaths that would have potential indirect wetland effects resulting from changes in hydrology are presented in Table 5.2.3-10.

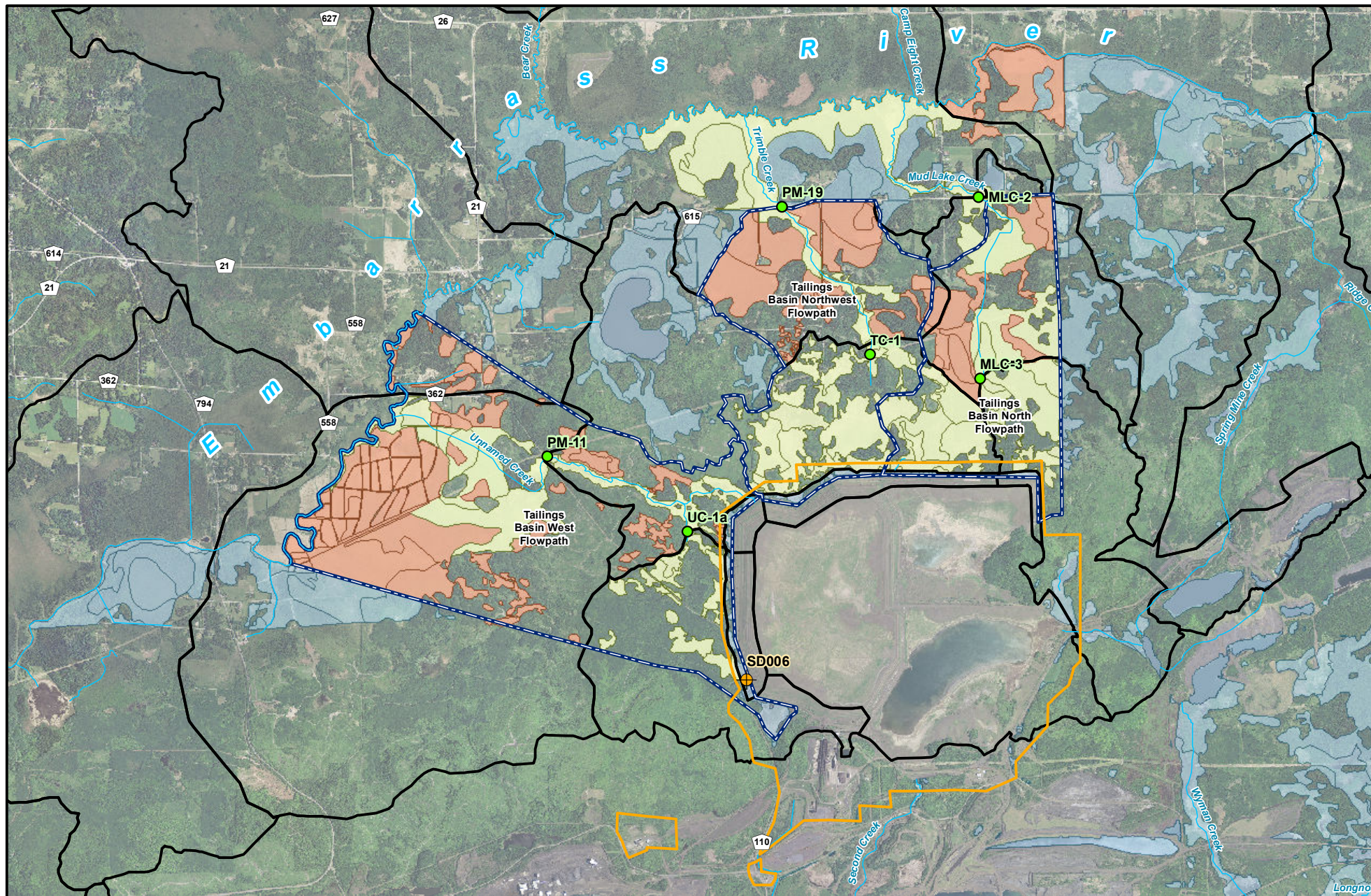
In addition, wetlands in and around Second Creek were assessed to determine if any indirect wetland effects associated with streamflow augmentation activities for Second Creek would occur. The area of analysis begins at the origin of Second Creek at the south end of the Tailings Basin Cell 1E, and ends at the east edge of County Highway 666. The majority of the area that was analyzed is located outside the Plant Site and Area 2 boundaries (see Figures 5.2.3-18 and 5.2.3-20). There are 298.9 acres of wetlands within the Second Creek assessment area: shrub swamp (44 percent); shallow marsh (35 percent); hardwood swamp (7 percent); deep marsh (7 percent); coniferous swamp (6 percent); wet meadow (less than 1 percent); and open water (less than 1 percent) (PolyMet 2013k).

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<p>500 ft Increments</p> <p>Area 2</p> <p>Plant Site</p> <p>Stream/River</p>	<p>Eggers & Reed Wetland Types</p> <p>Coniferous Bog</p> <p>Coniferous Swamp</p> <p>Hardwood Swamp</p> <p>Open Bog</p>	<p>Deep Marsh & Shallow Marsh</p> <p>Sedge Meadow & Wet Meadow</p> <p>Shrub Swamps (Alder Thicket & Shrub-Carr)</p> <p>Shallow, Open Water & Lake</p>	<p>Minnesota DEPARTMENT OF NATURAL RESOURCES</p> <p>US Army Corps of Engineers St. Paul District</p> <p>U.S. FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE</p>	<p>0 0.25 0.5 1 1.5 Miles</p>	<p>Figure 5.2.3-20 Wetlands within 500 ft Increments at the Plant Site NorthMet Mining Project and Land Exchange SDEIS Minnesota</p>	<p>November 2013</p>
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|--|---|
| Plant Site | Wetlands |
| Surface Water Monitoring Location | Wetlands with Potential for Indirect Effects |
| Approximate Location of NorthMet Project Surface Water Discharge | Surface Water and Groundwater |
| Groundwater Flow Path | Groundwater Only |
| Embarrass River Subwatershed | Stream/River |

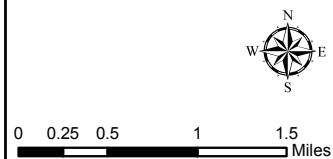


Figure 5.2.3-21
Wetlands within Groundwater Flowpaths at the Plant Site
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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Table 5.2.3-10 Wetlands within the Plant Site Flowpaths

		Hydrology		
		Unnamed Creek (west flowpath)	Trimble Creek (northwest flowpath)	Mud Lake Creek (north flowpath)
Eggers and Reed Class¹		Acres	Acres	Acres
Coniferous bog (Ombrotrophic)	Precipitation	37.6	196.6	58.1
Coniferous swamp	Groundwater	375.5	308.4	630.6
Deep marsh	Groundwater	130.9	97.6	125.8
Hardwood swamp	Groundwater	126.1	0.0	40.9
Open bog	Precipitation	157.5	0.0	0.0
Open water	Groundwater	8.3	0.0	7.4
Sedge/wet meadow	Groundwater	99.3	17.7	0.4
Shallow marsh	Groundwater	196.5	225.8	124.1
Shrub swamps (including alder thicket and shrub-carr)	Groundwater	721.5	236.9	144.9
Total acres of wetland		1,853.0	1,083.0	1,132.3

Source: PolyMet 2013b.

¹ Eggers and Reed 1997.

The Tailings Basin containment system would collect approximately 90 percent of the seepage from the Tailings Basin to groundwater and 100 percent of the seepage from the Tailings Basin to surface water. All of the surface flow that currently upwells near the west, northwest, and north toes of the Tailings Basin would be captured and treated by the WWTP and then discharged to the tributaries to prevent significant hydrologic effects due to reduction in flow. Additionally, during periods when there would be insufficient flow from the WWTP, water would be transferred from Colby Lake to augment the discharge to the tributaries in order to prevent significant hydrologic effects. To the west, the discharge(s) would be directed to a location near the existing surface discharge SD006 (see Figure 5.2.3-21). To the northwest and north, the discharge(s) would be spigotted at multiple locations along the downstream side of the Tailings Basin containment system to add flow to the adjacent wetlands, similar to what occurs under existing conditions (PolyMet 2013b). Table 5.2.3-11 shows the expected amount of discharge needed on an average annual basis; discharge needs can be met by either water from the WWTP or from Colby Lake. For a detailed discussion of seepage from the Plant Site, refer to Section 5.2.2.

Seepage from the south side of the Plant Site is generally restricted by bedrock outcrops and does not contribute to the groundwater flow south of the Plant Site. All of the seepage from the south side of the Plant Site is surface water, thereby forming the headwaters of Second Creek. There would be no potential indirect effects on wetlands in or abutting Second Creek as a result of changes in groundwater flow (PolyMet 2013k).

Table 5.2.3-11 Determination of Combined Flow Requirement for the Watersheds from the Wastewater Treatment Plant and Colby Lake

Type of Flow Requirement	Unnamed Creek (PM-11) (west flowpath)	Trimble Creek (TC-1) (northwest flowpath)	Mud Lake Creek (MLC-3)⁵ (north flowpath)
	gpm	gpm	gpm
Total annual average surface flow ¹	1,180	1,888	665
Expected future contribution from the watershed ²	664	599	439/734
Minimum requirement from WWTP/Colby Lake ³	280	911	93/0
Maximum allowable from WWTP/Colby Lake ⁴	752	1,667	359/64
Percent of WWTP discharge before the drainage swale is constructed	17%	54%	6%
Percent of WWTP discharge after the drainage swale is constructed	18%	57%	0%

Source: PolyMet 2013b.

¹ Existing annual average flow in the tributary.

² The future contribution from the watershed decreases because the Tailings Basin containment system, which is away from the toes of the Tailings Basin, removes watershed area and any runoff from the outer banks of the Tailings Basin.

³ 80% of the existing total annual average surface flow, less the expected future watershed contribution.

⁴ 120% of the existing total annual average surface flow, less the expected future watershed contribution.

⁵ X / Y values: X indicates the flow values before the drainage swale is in place; Y indicates the flow values after the watershed area to Mud Lake Creek is increased (from 1.34 to 2.24 mi²) because of the construction of the drainage swale at time greater than 7 years.

The augmentation described above has been designed such that the average annual water yield at the toe of the Tailings Basin would be within plus or minus 20 percent of the NorthMet Project No Action Alternative, which is within the range of annual variability in precipitation as well as streamflow, within the Partridge River and Embarrass River watersheds. Therefore, changes to downstream hydrology, including adjacent wetlands, would be expected to be within the range of that typically observed due to natural variability (PolyMet 2013b; PolyMet 2013k). No potential indirect wetland effects would be anticipated for the wetlands abutting Second Creek (PolyMet 2013k).

Potential indirect effects on Mud Lake Creek, Trimble Creek, and Unnamed Creek due to reduced or increased seepage at the toe of the Tailings Basin are greatest immediately downstream of the toe, where seepage and augmentation account for nearly all the water yield. Downstream of the toe, the indirect effects on these three creeks would be reduced as the watershed area tributary to that location increases, and the portion of total water yield derived from runoff increases. Therefore, hydrologic effects diminish as distance from the Tailings Basin increases. Wetlands further from the Tailings Basin would likely experience less potential for indirect effects due to hydrologic changes (PolyMet 2013b).

Wetland hydrology is a complex mix of precipitation, surface runoff, and, in some cases, groundwater. Despite the use of augmentation to mitigate effects, the response of complex natural systems to human disturbances could only be estimated. Therefore, monitoring of wetland hydrology and vegetation communities would be the most appropriate way to document the extent and magnitude of wetland responses to the NorthMet Project Proposed Action.

Please refer to Section 5.2.3.2.2, Changes in Hydrology Due to Drawdown subsection, for the hydrologic wetland sensitivity assessment that was performed to estimate how wetland communities would respond to groundwater drawdown by assuming that they would change to drier native plant communities or variants of the original community.

Wetlands Abutting Unnamed Creek, Trimble Creek, Mud Lake Creek, and Second Creek

There are 2,754.8 acres of wetlands abutting Unnamed Creek, Trimble Creek, and Mud Lake Creek within Area 2, and Second Creek, which include shrub swamps, coniferous swamp, hardwood swamp, shallow marsh, deep marsh, and sedge/wet meadow (see Figure 4.2.3-5) are presented in Table 5.2.3-12.

Table 5.2.3-12 Wetlands Abutting Unnamed Creek, Trimble Creek, Mud Lake Creek, and Second Creek

	Unnamed Creek		Trimble Creek		Mud Lake Creek		Second Creek		Total Wetlands Abutting Creeks	
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Eggers and Reed Class¹										
Coniferous swamp	16.3	3	130.3	15	474.3	41	0.0	0	620.9	23
Deep marsh	53.8	10	5.9	1	0	0	14.3	8	74.0	3
Hardwood swamp	98.1	19	0	0	31.0	3	0.0	0	129.1	5
Sedge/wet meadow	0	0	17.7	2	0	0	0.0	0	17.7	1
Shallow marsh	85.8	16	36.7	4	0	0	45.8	26	168.3	6
Shrub swamp (including alder thicket or shrub-carr)	273.0	52	695.8	78	657.1	57	118.8	66	1744.7	63
Total Acres of Wetlands	527.1	100	886.4	100	1,162.4	100	178.9	100	2,754.8	100

Sources: PolyMet 2013b; PolyMet 2013k.

¹ Eggers and Reed 1997.

Water management at the Plant Site would consist of flow augmentation immediately downstream of the Tailings Basin containment system to minimize hydrologic effects on downstream watercourses (PolyMet 2013b). The hydrologic analysis (see Section 5.2.2) estimated that the changes in average annual flow of Unnamed Creek, Trimble Creek, and Mud Lake Creek would be within the annual variability that naturally occurs within the Embarrass River Watershed. Therefore, no potential indirect wetland effects were identified for the wetlands abutting Unnamed Creek, Trimble Creek, and Mud Lake Creek (PolyMet 2013b). The hydrologic analysis (see Section 5.2.2) estimated that the changes in average annual flow of Second Creek would be within the annual variability that naturally occurs within the Partridge and Embarrass River Watersheds. Therefore, no potential indirect wetland effects were identified for the wetlands abutting Second Creek (PolyMet 2013k).

Water Quality Changes

The screening analysis for depositional effects conducted to estimate potential annual deposition of dust, metals, and sulfur to wetlands within and adjacent to the Plant Site was performed using AERMOD. The estimated deposition from fugitive dust emissions was used to identify wetlands that have the potential for water quality changes. The estimated deposition from fugitive dust emissions was used to identify a threshold for a negative effect on vegetation.

Below is a summary of the assessment from the *NorthMet Project Wetlands Data Package* (PolyMet 2013b).

Receptors

The receptors of interest for this analysis were the wetlands that were not directly affected. The respective initial receptor grids for the Plant Site were set up with near-field receptor spacing of 250 meters within the ambient air boundary and the far-field receptor spacing was 1,000 meters from the ambient air boundary out to 5 km.

Dust Deposition and Speciation to Individual Metals and Sulfur

For the dust emission sources identified for assessing potential metals and sulfur deposition at the Plant Site, the highest estimated dust deposition rate for each receptor node was then speciated to the respective metal and sulfur deposition rates based on the contribution of the sources to a receptor node and the metal and sulfur composition identified for each contributing source (e.g., tailings at the Plant Site). The estimated metal or sulfur deposition for each contributing dust source at a receptor node was then summed to provide a “total” deposition rate for each respective metal and for sulfur at that receptor location. Dust deposition rates were speciated for arsenic, cadmium, chromium, lead, manganese, nickel, and selenium. Copper and vanadium were also included. For each receptor node, the post-processing of the dust deposition rate by source contribution was then summed to provide a “total” metal deposition rate and a “total” sulfur deposition rate.

Estimates of Rural Background Deposition

For dust, an annual effects-level deposition rate of 365 g/m²/yr was compared to modeled annual dust deposition rates. This deposition rate is a potential effects threshold for photosynthesis (i.e., potential for reduced photosynthesis due to “dusting” of the plant surface). However, for this analysis, the vegetative surface area of the wetlands was not calculated or included in the analysis. The modeled dust deposition rate was assumed to be applied to the land surface area, which is a smaller area than the vegetative surface area. Vegetative surface area can be up to 13 times greater than the land surface area. By only assessing dust deposition to the land surface area instead of the vegetative surface area, it is likely the ratio of modeled deposition rate to the effects level was being overestimated. In other words, the modeled deposition rate is not being spread over the larger surface area of the vegetation which would reduce the effective deposition rate. Because this application did not include the deposition of dust to the vegetative surface area, it is likely that the areas identified to exceed the effects threshold of 365 g/m²/yr have been overestimated.

For metals, background deposition is based on the data from *Atmospheric Deposition of Trace Metals at Three sites near the Great Lakes* (Sweet et al. 1997), which indicated that precipitation was under-collected by 45 to 70 percent when sample volumes were compared to corresponding rain gage amounts. Because wet deposition was considered to be underestimated, the wet deposition component was adjusted upward by a factor of 1.6.

Total background sulfur deposition included both wet and dry deposition, which was calculated to be 0.16 g/m²/yr. The estimated background deposition used in the analysis for metals and sulfur was from data collected at sites characterized as open areas in rural settings that are reasonably distant from industrial sources and population centers. For forested areas, dry

deposition may be underestimated. Vegetation can effectively scavenge fine particles and aerosols from the atmosphere and this interception can result in dry deposition being 50 percent or more of the total deposition. A monitoring site in Ely (Fernberg Road), dry deposition was assumed to be 22 percent of total deposition. Therefore, it is likely that the background sulfur deposition estimated for this analysis may be low due to an underestimation of dry deposition; however, no adjustments were made to the background sulfur deposition estimated for this analysis.

Significance Levels for Estimating the Potential Effects for Identifying Future Monitoring

For dust, metals, and sulfur, the following general categories were used for assessing the significance of a modeled deposition rate at a receptor node:

- Less than 100 percent of background: no potential for effects expected.
- Greater than 100 percent of the background value: potential for effects, include in future wetland monitoring.

These are general categories of potential for effects. Since this was a screening analysis to identify wetlands for potential inclusion in the monitoring program, there was some flexibility in identifying a potential level of deposition that suggested a potential for effect and would then trigger a requirement for monitoring. Another consideration for selecting a deposition rate that was a high percent of the background rates was the likely overestimation of modeled deposition and the underestimation of background deposition.

Adding to the conservatism in the modeling of particulate metals, this screening analysis used a maximum dust deposition from a range of possible modeled values and a high-end metal or sulfur concentration for each source contributing to that receptor node to derive a maximum potential metal or sulfur deposition for a receptor node.

Using a maximum concentration for each contributing emission source to speciate a metal or sulfur deposition from a maximum modeled dust deposition rate for each receptor node overestimates individual metal or sulfur deposition. Also adding to the conservatism of this analysis is the underestimation of background deposition because the ratio of the NorthMet Project Proposed Action-related deposition is compared to the background deposition. If background deposition is underestimated, that would indicate that estimated NorthMet Project Proposed Action-related deposition at more receptor nodes are higher than background and further increases the area for potential future monitoring. The underestimation of background metal deposition (i.e., wet deposition due to under-collection of precipitation) was identified by Sweet et al. (1997). In addition to the underestimation of background metal deposition, background wet sulfate deposition may be underestimated, as well, because the National Atmospheric Deposition Program data for the Fernberg Road monitoring site indicated rainfall in the last three years was about 22 percent below the annual average. If sulfate deposition from 2007 and 2008 was used (both years approximately normal for precipitation amount), a background sulfur deposition rate of 0.23 g/m²/yr was calculated—about 44 percent higher than the background deposition used in the screening analysis. If the higher estimate of background sulfur deposition was used in the screening analysis, a smaller number of receptor nodes would have been identified to have modeled sulfur deposition that was more than 100 percent of background deposition and the area for potential monitoring would be smaller than that identified. Also, it was found that for forested areas, dry deposition may be systematically

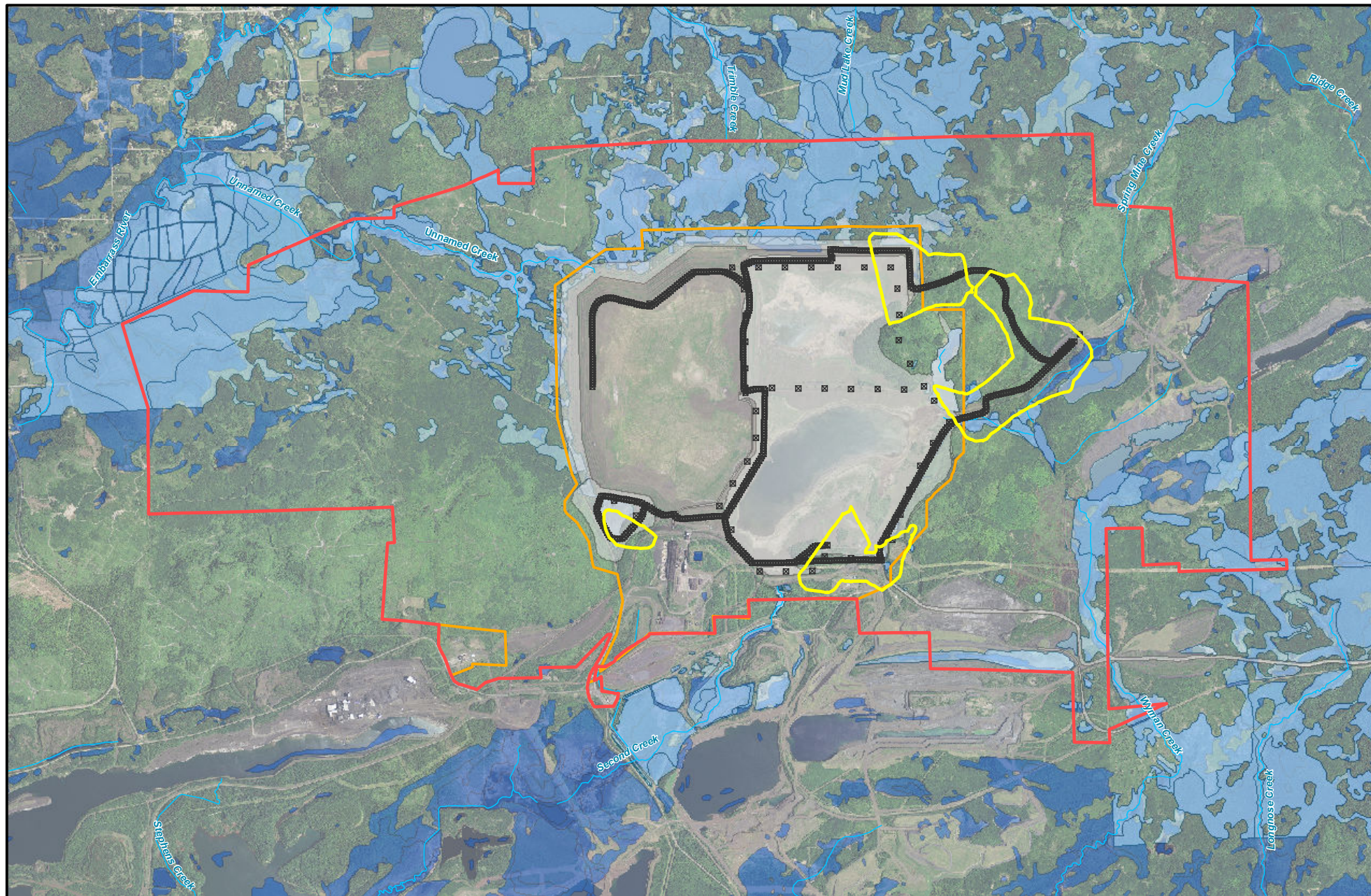
underestimated due to sample collection and analysis methodology. It is possible that the background sulfur deposition estimated for this analysis may be low due to an underestimate of dry deposition.

Given the potential for overestimation of modeled deposition and underestimation of background deposition, and balancing the conservatism when their respective results are combined in this analysis, it seems reasonable to select the wetlands estimated to receive greater than 100 percent of background deposition (a potential doubling of the background deposition) for consideration in potential future monitoring (PolyMet 2013b).

Fugitive Dust/Metals and Sulfide Dust Emissions

At the Plant Site, dust deposition was highest in three locations: southwest corner, northwest of the Plant Site; southeast corner; and the northeast corner, towards Area 5. All receptors have model-estimated dust deposition of 50 percent or less of the effects-level background of 365 g/m²/yr (see Figure 5.2.3-22). At the Plant Site, there would be two locations showing model-estimated deposition rates greater than 100 percent of background deposition: 1) approximately the southern and western two-thirds of the basin and 2) a small area on the northern and eastern portion of the ambient air boundary (see Figure 5.2.3-23). Approximately 90 percent of the receptor nodes with the highest model estimated deposition rates (rates greater than 100 percent of background deposition) are located within the ambient air boundary. The remaining 10 percent of the receptor nodes with the highest modeled deposition are located to the south and east of the Plant Site outside of the ambient air boundary (PolyMet 2013b). No potential indirect wetland effects from fugitive dust to Second Creek would occur (PolyMet 2013k).

Of the 25,846 acres of wetlands identified within the Plant Site receptor grid, deposition modeling results indicate that 193.9 acres of wetland could be potentially indirectly affected (modeled metal deposition rates greater than 100 percent of background). Of the 193.9 acres, 58.8 acres would be located within the Plant Site ambient air boundary (PolyMet 2013b; PolyMet 2013k). The 193.9 acres of wetlands should be included in any future monitoring to be conducted for the NorthMet Project Proposed Action. The deposition modeling results for dust, metals, and sulfur would likely not have an adverse effect on wetlands; however, the modeling only indicated those areas that had deposition rates greater than 100 percent of background deposition (PolyMet 2013b; PolyMet 2013k).



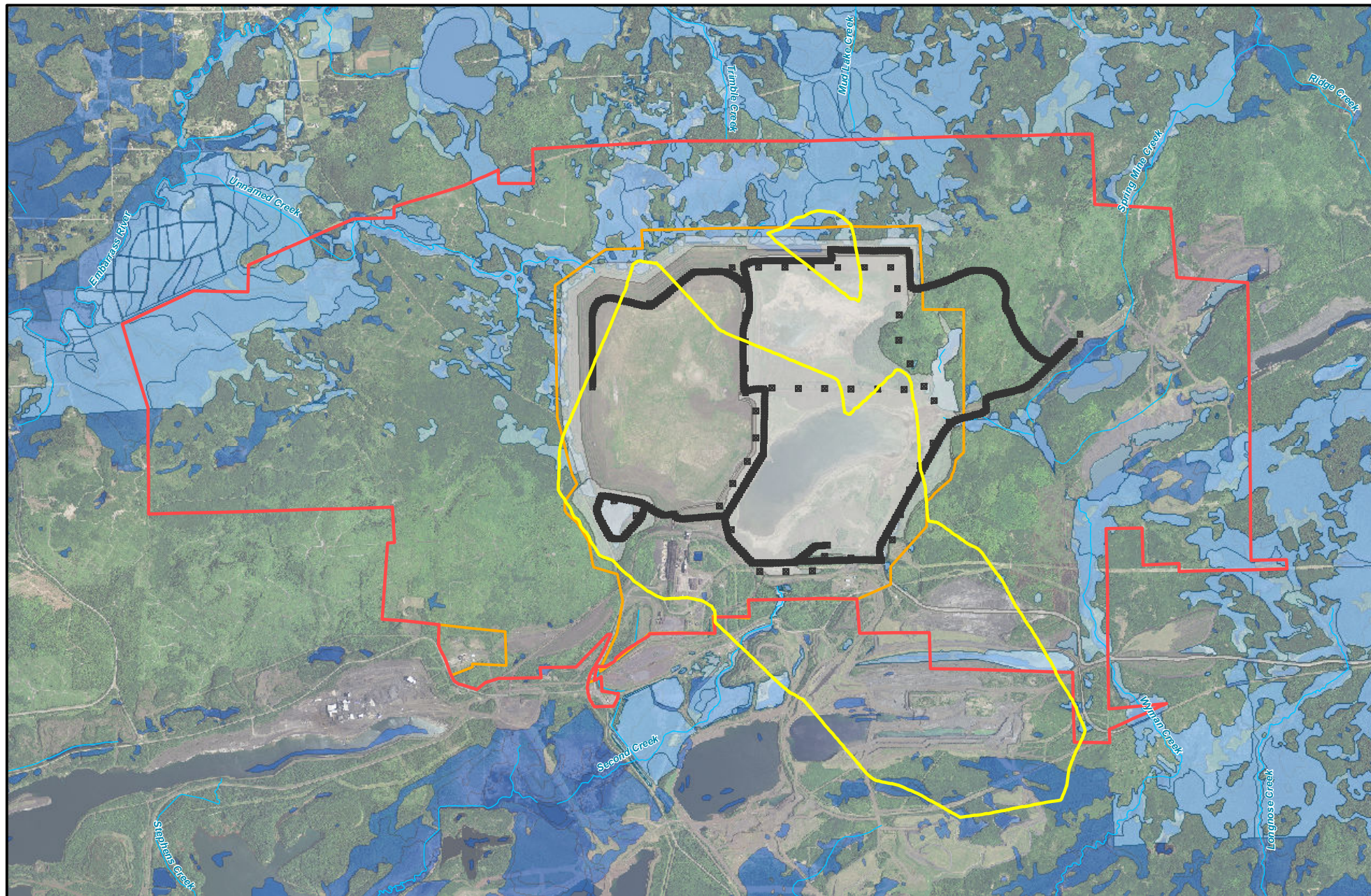
- Ambient Air Boundary
- Extent of Highest Estimated Deposition
- Plant Site
- Disturbed Area
- Volume Sources (Roads)
- Wetlands
- NWI Wetland
- Stream/River



0 0.25 0.5 1 Miles

Figure 5.2.3-22
Model - Estimated Dust Deposition Compared to
Background Effects Level - Plant Site
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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- Ambient Air Boundary
- Extent of Highest Estimated Deposition
- Plant Site
- Disturbed Area
- Volume Sources (Roads)
- Wetlands
- NWI Wetland
- Stream/River

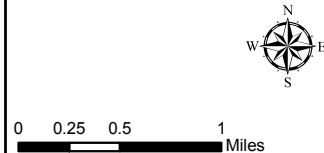


Figure 5.2.3-23
Model - Estimated Metal Deposition Compared to
Background Effects Level - Plant Site
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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Water Quality Changes

The NorthMet Project Proposed Action is predicted to meet all water quality evaluation criteria, or not worsen conditions where contamination already exceeds the criteria. The collection of existing seepage by the containment system and augmentation with Colby Lake and WWTP effluent water would generally improve downstream water quality relative to current conditions. Effects that would occur on surface water and groundwater quality are discussed in Section 5.2.2. Even if water quality improves, there would be a potential for indirect effects to wetlands due to changes in water quality. Potential indirect wetland effects due to water quality changes that would likely occur would be a result of changes in groundwater quality, in surface water quality, or in both groundwater and surface water quality (PolyMet 2013b).

Wetland areas that would be potentially affected by water quality changes are shown in Figure 5.2.3-21 and listed in Table 5.2.3-13. Note that within this section, the term groundwater and surface water refer to the path by which NorthMet Project Proposed Action water leaves the Tailings Basin (e.g., potential effects from Tailings Basin groundwater seepage that discharges to surface water at a downstream location are classified as a potential effect due to changes in groundwater quality).

Table 5.2.3-13 Wetland Areas Potentially Indirectly Affected by Changes in Water Quality

Wetland Area Potentially Affected by Changes in Water Quality	Mud Lake Creek (North) Acres	Trimble Creek (Northwest) Acres	Unnamed Creek (West) Acres	Downstream of Groundwater Flowpaths³ Acres	Total Acres
Groundwater Quality ¹	296.5	514.0	1,162.1	--	1,972.7
Surface Water and Groundwater Quality ²	835.8	568.9	690.9	570.2	2,665.7
Total	1,132.3	1,082.9	1,853.0	570.2	4,638.4

Source: PolyMet 2013b.

¹ Groundwater refers to water leaving the Tailings Basin within the surficial aquifer. Effects resulting from the discharge of that seepage to surface water have been considered an effect due to groundwater in the analysis.

² All areas potentially affected by changes in surface water quality have also been potentially affected by changes in groundwater quality.

³ Potentially affected wetlands are located along Trimble Creek and Mud Lake Creek, but outside of groundwater flowpaths (see also Footnote (1)).

Potential for indirect effects from changes in groundwater quality may occur anywhere along the modeled groundwater flowpaths previously mentioned. Wetlands abutting the three creeks that may be indirectly affected (4,068.2 acres) by changes in groundwater quality are shown on Figure 5.2.3-21. The effects on groundwater quality diminish as distance from the Tailings Basin increases, as the relative portion of total groundwater that originates from the Tailings Basin decreases (see Section 5.2.2). It has been determined that the amount of Tailings Basin seepage remaining in the surficial aquifer would be small; therefore, the potential for indirect effects as a result of changes in groundwater quality are anticipated to be small.

Potential effects from changes in groundwater quality may also occur in wetlands abutting tributary streams (all reaches of Unnamed Creek, Trimble Creek, and Mud Lake Creek) into which affected groundwater would discharge (see Figure 5.2.3-21). Wetlands abutting these

streams and outside of the modeled groundwater flowpaths resulted in an additional 570.2 acres of potential indirect effects due to changes in groundwater quality (PolyMet 2013b).

Potential indirect effects from changes in surface water quality would also likely occur in wetlands within the surface watersheds immediately downstream of the Tailings Basin, which includes watersheds upstream of modeling locations UC-1a, TC-1, and MLC-3 (see Figure 5.2.3-21). The potential indirect effects from changes in surface water quality include 1,158 acres of wetlands (all of which would also likely be potentially indirectly affected by changes in groundwater quality). Downstream of these locations, potential indirect effects due to changes in surface water quality are limited to wetlands abutting the tributary streams. These areas include an additional 1,505 acres of wetlands (all of which may also be potentially indirectly affected by changes in groundwater quality) (PolyMet 2013b).

As with effects from changes in groundwater quality, potential effects as a result of changes in surface water quality would be expected to diminish as distance from the Tailings Basin increases and flows originating from the NorthMet Project Proposed Action are diluted by natural runoff.

The wetland hydrology downstream of the Tailings Basin is too complex to be accurately incorporated into the Plant Site probabilistic model detailed in Section 5.2.1. The response of such complex natural systems to water quality changes originating at the Tailings Basin can only be estimated (PolyMet 2013b). Therefore, monitoring of wetland hydrology and vegetation communities would be the best way to document the extent and magnitude of wetland responses (potential indirect wetland effects) to the NorthMet Project Proposed Action.

5.2.3.2.5 Summary of NorthMet Project Proposed Action Direct and Indirect Wetland Effects

Direct wetland effects for the NorthMet Project Proposed Action are summarized in Table 5.2.3-14. Of the 177 wetlands within the NorthMet Project area, 126 wetlands would be directly affected, totaling 912.5 acres of direct wetland effect. The Mine Site would contain the majority of the direct wetland effects. The majority of the direct effects would occur as a result of a combination of filling and excavation (65 percent) (see Table 5.2.3-15).

Table 5.2.3-14 Total Projected Direct Wetland Effects for the NorthMet Project Proposed Action

Eggers and Reed Class¹	Directly Affected Wetlands		
	Acres	%	No.
Coniferous bog	509.1	56	24
Coniferous swamp	82.6	9	17
Deep marsh	73.5	8	15
Hardwood swamp	12.5	1	2
Open bog	7.6	1	2
Open water (includes shallow, deep, open water, and lakes)	0.0	0	0
Sedge/wet meadow	39.6	4	10
Shallow marsh	76.7	8	23
Shrub swamp (includes alder thicket and shrub-carr)	110.8	12	31
Total Direct Effects	912.5	100²	126

Source: PolyMet 2013b.

¹ Eggers and Reed 1997.

² Percent totals are less than 100 percent due to rounding.

Table 5.2.3-15 Type of Projected Direct Wetland Effects for the NorthMet Project Proposed Action

Type of Effect	Directly Affected Wetlands		
	Acres	%	No.
Fill	101.5	11	64
Excavation	133.1	15	15
Fill and Excavation	593.2	65	23
Containment System	84.7	9	24
Total Direct Effects	912.5	100	126

Source: PolyMet 2013b.

Potential indirect wetland effects from the NorthMet Project Proposed Action would result from one or more of the following six factors: 1) wetland fragmentation, 2) change in wetland hydrology resulting from changes in watershed area, 3) changes in wetland hydrology due to groundwater drawdown, 4) water quality changes related to deposition of dust, 5) water quality changes related to ore spillage along the Transportation and Utility Corridor, and 6) changes in water quality related to leakage from stockpiles/mine features and seepage from mine pits. A rating system (0-6) was developed for the wetlands based on the number of factors that may potentially affect it. Wetlands that were not indirectly affected were rated as zero and wetlands that were indirectly affected by all six factors were rated as a six; however, no wetlands were rated as a six (PolyMet 2013b). The NorthMet Project Proposed Action could indirectly affect up to either 7,350.7 acres of wetlands located within and around the NorthMet Project area, based on the method of wetlands crossing analog impact zones, or up to 6,498.1 acres of wetlands located within and around the NorthMet Project area, based on the method of wetlands within analog impact zones (PolyMet 2013k; PolyMet 2013q). The indirect wetland effect acreages presented herein, based on the analyses that were conducted, help identify

wetlands that would be the focus of monitoring for potential indirect effects. Potential indirect wetland effects are presented in Table 5.2.3-16.

Table 5.2.3-16 Summary of Projected Potential Indirect Wetland Effects for the NorthMet Project Proposed Action

Rating ¹	Total Indirect Wetlands (based on the method of wetlands crossing analog impact zones)		Total Indirect Wetlands (based on the method of wetlands within analog impact zones)	
	Acres	%	Acres	%
1	4,046.3	55	3,470.6	53
2	3042.9	41	2,813.1	43
3	245.3	3	206.0	3
4	15.9	<1	8.1	<1
5	0.3	<1	0.3	<1
Total Acres of Indirect Wetland Effect ²	7,350.7	100	6,498.1	100

Sources: PolyMet 2013b; PolyMet 2013k; PolyMet 2013q.

¹ A wetland may be potentially indirectly affected by none of the six factors or up to a maximum of six, with different combinations of factors possible. A rating was developed for the wetlands based on the number of factors that may potentially affect it – from No Effect (0 factors) to 6 (all six factors potentially indirectly affecting the wetland).

² The analyses and assessments were completed using the same set of wetlands that were not directly affected; therefore, there are wetlands that may be potentially indirectly affected by more than one type of assessed source. The potential indirect wetland effects for each wetland cannot be summed across the analysis as this would likely result in double-counting of wetland acres. The results of the analyses and assessments identify areas to be monitored for potential wetland effects.

As discussed below, wetland mitigation for potential indirect wetland effects would be determined by the agencies during permitting. If the NorthMet Project Proposed Action were to be permitted and it was determined that the NorthMet Project Proposed Action would cause future wetland effects, wetland monitoring would be conducted. Wetland hydrology and vegetation would be monitored, and additional monitoring locations may be considered during permitting. A component of the monitoring plan would be based on those wetlands that would have a high likelihood of indirect effects as a result of groundwater drawdown. The likelihood of potential wetland hydrology effects (low, moderate, and high), based on the method of wetlands crossing analog impact zones, would be 1,771.5 acres, of which 866.9 acres of wetlands (15 percent) would have a high likelihood of wetland hydrology effects. The likelihood of potential wetland hydrology effects (low, moderate, and high), based on the method of wetlands within analog impact zones, would be 587.1 acres, of which 46.4 acres of wetlands (1 percent) would have a high likelihood of wetland hydrology effects. If the monitoring determined that indirect wetland effects had occurred, additional compensation may be required if determined necessary by the permitting agencies.

In the event that the wetland monitoring identified additional indirect effects, appropriate measures (i.e., adaptive management practices) would be implemented, such as hydrologic controls or additional compensatory mitigation. Permit conditions would likely include an adaptive management plan to account for any additional effects that may be identified in the annual monitoring and reporting.

5.2.3.3 NorthMet Project Proposed Action Avoidance, Minimization, Mitigation, and Monitoring Measures

This section discusses measures that were taken to avoid and minimize wetland effects, evaluates PolyMet's proposed wetland mitigation for unavoidable effects, discusses other potential mitigation measures that may benefit wetlands, and identifies key elements of a wetland monitoring plan.

5.2.3.3.1 Wetland Avoidance and Minimization

PolyMet proposes to avoid and minimize wetland effects through a number of measures that are incorporated into the proposed mine plan.

At the Mine Site, waste rock would be placed back into the East Pit and Central Pit after year 11, thereby reducing the need for additional surface stockpile areas that would otherwise affect wetlands. In addition, PolyMet proposes to combine the saturated overburden and temporary stockpiles that contain membrane liners, which were separate in the original NorthMet Project Proposed Action design. The Overburden Storage and Laydown Area would only store peat and unsaturated overburden (PolyMet 2013c). By reducing the footprint of the Overburden Storage and Laydown Area and stockpiles, direct wetland effects were reduced. Similarly, PolyMet proposes to move the Category 4 Stockpile to the footprint of the Central Pit, which would be mined later and thus avoid additional direct wetland effects. Reactive waste rock stockpiles would be lined, and stormwater runoff that contacted reactive rock would be contained to help prevent water quality-related effects on adjacent wetlands. In addition, hydrologic effects would be reduced by the use of seepage control measures, which would be installed at the mine pits to restrict shallow groundwater movement through higher permeability areas and help prevent drawdown of wetland water levels near mine pits. Haul road construction/layout has been re-configured to have fewer haul roads and locations thereby reducing land and wetland disturbance and truck distance to be driven. Haul road construction would include placement of large rocks as a foundation to allow shallow subsurface groundwater flowpaths in the wetlands to be maintained within the active areas of the Mine Site between the pits and stockpiles.

Specifically, utilizing existing Plant Site infrastructure, the existing LTVSMC Tailings Basin, and the Transportation and Utility Corridor all serve as avoidance measures since building these on undeveloped sites could affect at least hundreds of acres of additional wetlands. Reusing existing infrastructure limits wetland effects from these activities to previously disturbed areas. Additionally, cutoff berms/walls, trenches, and sump and pump systems would be used to collect current and future surface seepage from around the toe of the Tailings Basin (PolyMet 2011m). This surface seepage would ultimately be re-routed to the Tailings Basin, thus avoiding or minimizing discharges to surrounding wetlands. Construction of the containment system, however, would reduce the amount of seepage flowing to four tributaries of the Embarrass River (PolyMet 2013c). Streamflow would be augmented using WWTP effluent and water from Colby Lake so that the target annual average flow that supports existing wetland hydrology would be met.

5.2.3.3.2 Wetland Mitigation

As previously noted, jurisdictional wetlands are regulated under state and federal laws, including the WCA (*Minnesota Rules* Chapter 8420), *Minnesota Rules*, part 7050.0186, and Sections 401 and 404 of the CWA. In addition, some wetlands are also designated as Minnesota Public Waters and subject to the Public Waters Work Permit Rules (*Minnesota Rules* Chapter 6115). However, no public water wetlands would be affected by the NorthMet Project Proposed Action.

Both the state and federal wetland regulations require that a permit, approval, and/or certification be issued by the regulatory agency for wetland effects as defined by the respective regulations. The USACE St. Paul District is the permitting authority for the DA permit pursuant to Section 404 of the CWA; the MDNR Division of Lands and Minerals administers the WCA approval process as part of the Permit to Mine (*Minnesota Rules*, part 8420.0200, subpart 1D); and the MPCA has authority under Section 401 of the CWA to certify that discharges authorized under Section 404 comply with water quality standards.

The wetland mitigation planning process relied on the WCA wetland replacement siting rules (*Minnesota Rules* part 8420.0522), state compensatory mitigation requirements under state water quality standards (*Minnesota Rules* part 7050.0186), and the USACE *St. Paul District Policy for Wetland Compensatory Mitigation in Minnesota* (2009), which prioritizes the location of project-specific compensation to first replace lost wetlands on-site, then within the same watershed or county, and finally within adjacent watersheds. The primary goal of wetland mitigation is to restore high-quality wetland communities of the same type, quality, function, and value as those to be affected to the extent practicable. To achieve that goal, state and federal guidelines were followed during the wetland mitigation planning process, with a preference placed on restoring drained wetlands over creating wetlands. The five main categories of mitigation methods considered appropriate in northern Minnesota by state and federal agencies were 1) restoration of former or degraded wetlands, 2) enhancement of existing wetlands, 3) wetland preservation, 4) wetland creation, and 5) upland buffers.

The USACE St. Paul District Policy for Wetland Compensatory Mitigation in Minnesota (2009) applies three factors to determine compensation ratios: in-place versus out-of-place, in-kind versus out-of-kind, and in-advance versus not in-advance. These factors are defined as follows:

- In-place mitigation means the replacement of the impacted aquatic site would take place in the same 8-digit Hydrologic Unit Code (HUC) watershed as the proposed affected resource. The USACE St. Paul District Policy uses the term “in-place” to include on site, which is defined as an area located on the same parcel of land as the impact site, or on a parcel of land contiguous to the impact site.
- Out-of-place mitigation means the replacement of the impacted aquatic site would take place in a different 8-digit HUC watershed as the proposed impacted resource.
- In-kind mitigation means the replacement of the impacted aquatic site with one of the same hydrologic regime and plant community types (same species composition).
- Out-of-kind mitigation means the replacement of an impacted aquatic site with one of a different hydrologic regime and plant community type (different species composition).
- In-advance mitigation is a form of mitigation that is designed, permitted, and constructed in advance of a permitted impact.

The temporal loss issue is addressed by the in-advance versus not-in-advance factor. The Federal Mitigation Rule states that compensation ratios of greater than 1:1 can be applied to account for factors including temporal loss and the difficulty of restoring or establishing certain wetlands/aquatic resources (33 CFR 332.3 (f)).

The Federal Mitigation Rule also states that “difficult-to-replace” wetlands/aquatic resources include bogs and forested wetlands (33 CFR 323.3(e)(3) and Preamble, page 19633). The majority of wetlands that would be affected by the NorthMet Project Proposed Action would be “difficult to replace” (coniferous bog, open bog, coniferous swamp, and hardwood swamp) (USACE 2013).

USACE St. Paul District Policy (2009) states that compensation ratios can be raised on a case-by-case basis if the affected wetland/aquatic resource provides rare or exceptional functions, including plant communities that rate “exceptional” using MnRAM, or have a high rating using a Floristic Quality Assessment. Most of the wetlands that would be affected by the NorthMet Project Proposed Action would be of pre-European settlement condition and rate at the highest Floristic Quality Assessment levels for those plant communities in Minnesota. MnRAM vegetative diversity/integrity ratings would be “exceptional” for these pre-European settlement condition wetlands. Therefore, per the 2009 policy, the District Engineer may determine that a higher compensation ratio would be required to offset losses of wetlands that would be difficult to replace and/or provide an exceptional level of functions.

USACE St. Paul District Policy states a base compensation ratio of 1.5:1 (1.5 credits of compensatory mitigation for every 1 acre of wetland loss), and a minimum of 1:1, with a provision for a case-by-case determination of higher ratios to account for factors including difficult-to-replace, rare, and/or exceptional wetlands/aquatic resources. For low- to moderate-quality wetlands, the 1.5:1 base ratio would apply in accordance with District Policy. For effects on high-quality wetlands, the USACE may require additional compensation in accordance with District Policy. The 1.5:1 ratio can be reduced by qualifying for the following incentives, but can be no less than a minimum 1:1 ratio:

- In-place incentive: the project-specific mitigation site is located on site or within the same 8-digit HUC watershed as the authorized wetland effects or bank credits are purchased within the same bank service area—reduce ratio by 0.25.
- In-kind incentive: the mitigation wetlands are of the same type (same wetland plant community) as the wetlands authorized to be affected—reduce ratio by 0.25.
- In-advance incentive: 1) a project-specific mitigation site must have wetland hydrology and initial hydrophytic vegetation established at least one full growing season in advance of the authorized wetland effects provided initial performance standards are met, or 2) USACE-approved bank credits are purchased—reduce ratio by 0.25.

If none of these incentives are met, the mitigation ratio required is 1.5:1. If one of the three incentives is met, the required mitigation ratio is 1.25:1; if two or three are met, the ratio is 1:1. According to USACE St. Paul District’s compensatory wetland mitigation policy (USACE 2009), requirements for mitigation can exceed the 1.5:1 mitigation ratio if the affected wetlands provide rare or exceptional functions.

District guidance on compensatory mitigation emphasizes the consideration of a functional approach to offset proposed project effects. While bogs and forested wetlands are characterized

as difficult to replace, the proposed compensation sites for the NorthMet Project Proposed Action (discussed below) would be likely to achieve in-kind compensation to offset functional losses. The proposed mitigation sites were selected based on availability and the high likelihood of meeting performance criteria.

The USACE St. Paul District has not made a final determination of the compensation ratios that would be required. A decision on whether proposed compensation would qualify for the 0.25 incentive for in-advance requires additional information including: 1) development of performance standards that would specify the hydrology and initial vegetation to be established, and 2) number of growing seasons that wetland compensation sites would be established in advance of authorized impacts.

The compensatory mitigation ratios proposed in the SDEIS for the NorthMet Project Proposed Action are based on recommended USACE St. Paul District guidance. They assume successful outcomes for the proposed compensatory mitigation sites. Base compensation ratios could be increased to 2:1 for effects on high-quality, difficult-to-replace bog and forested wetlands. For effects on low- and moderate-quality wetlands, a base ratio of 1.5:1 would be applied. In-kind, in-place, and in-advance incentives to reduce the recommended base ratios would be considered at the time of permitting. USACE St. Paul District guidance on recommended compensation ratios takes these incentives into account. The final decision on compensatory mitigation ratios will be determined at the time of the CWA Section 404 permit decision based on current District guidance.

USACE compensatory wetland mitigation is regulated by 33 CFR 332.3(n), which describes the use of financial assurances. The District Engineer may determine that financial assurances are unnecessary for a compensatory mitigation project if alternate mechanisms are available to ensure a high level of confidence that the mitigation would be provided and maintained. In the state permitting process for WCA, *Minnesota Rules*, part 8420.0552, sets forth replacement standards and requires financial assurances to ensure successful wetland replacement. Additionally, the MDNR has the authority through the Permit to Mine process to require a performance bond or other instrument that meets criteria in rule as means to ensure compliance with *Minnesota Rules*, part 6130, which includes successful completion of reclamation and closure activities.

The CWA Section 404 permit and the Permit to Mine both have financial assurance mechanisms to ensure successful completion of the 1) compensatory mitigation (in the case of the CWA Section 404) and 2) NorthMet Project Proposed Action (in the case of the Permit to Mine). Financial assurance can be a condition of a permit under CWA Section 404, and the MDNR has authority to require a performance bond or other instrument that meets criteria in rule for compliance with the conditions of the Permit to Mine. Section 3.2.2.4 provides a discussion of the financial assurance for the NorthMet Project Proposed Action.

The USACE generally requires compensatory mitigation for adverse effects to aquatic resources under 33 CFR 332.3(n). This regulation establishes standards and criteria for the general compensatory mitigation requirements of the Section 404 permit. Specifically, 33 CFR 332.3(n)(1) addresses financial assurance stating:

The district engineer shall require sufficient financial assurances to ensure a high level of confidence that the compensatory mitigation project will be successfully completed, in accordance with applicable performance standards.

Compensatory wetland mitigation for the NorthMet Project Proposed Action is expected to be approved and constructed in advance of any authorized wetland effects (under the Section 404 permit) and, therefore, would not require financial assurance. However, the USACE can consider financial assurance for potential indirect wetland effects and monitoring when additional detail has been provided.

Minnesota Rules, part 7050.0186, requires compensatory mitigation to be sufficient to ensure replacement of the diminished or lost designated uses of the wetland that was physically altered. To the extent prudent and feasible, the same types of wetlands affected are to be replaced in the same watershed, before or concurrent with the actual alteration of the wetland. In addition, the WCA states that for wetlands in counties where 80 percent or more of pre-settlement wetlands exist, including St. Louis County, minimum replacement ratio requirements are as determined by mitigation location and type (see Table 5.2.3-17). Based on the WCA wetland replacement standards (*Minnesota Rules* 8420.0522, Subpart 4), the mitigation credits will qualify at a ratio of either 1:1 or 1.5:1. The actual replacement ratios required in permitting may be more than the minimums shown in Table 5.2.3-17, subject to the evaluation of wetland functions and values.

Table 5.2.3-17 Summary of Wetland Mitigation Ratios

Regulation	Location of Effect	Replacement	Minimum Replacement Ratio
Minnesota Administrative Rules			
		Minimum Replacement Ratios: Wetland Banking	
	>80% area or agricultural land	Outside bank service area	1.5:1
		Within bank service area	1:1
	<50% area, 50-80% area, and non-agricultural land	Outside bank service area	2.5:1
		Within bank service area	2:1
		Minimum Replacement Ratios: Project-Specific	
	>80% area or agricultural land	Outside major watershed or out-of-kind	1.5:1
		Within major watershed and in-kind	1:1
	<50% area, 50-80% area, and non-agricultural land	Outside major watershed or out-of-kind	2.5:1
		Within major watershed and in-kind	2:1
USACE			
	>80% area	Not in-place, in-kind nor in-advance	1.5:1
		In-place, in-kind and in-advance	1:1
	<80% area	Not in-place, in-kind nor in-advance	2.5:1
		In-place, in-kind and in-advance	2:1

Sources: Wetland Conservation Act; USACE 2009.

Minnesota Rules 8420.0522 outlines the replacement standards for wetlands as regulated under WCA. *Minnesota Rules* 8420.0522, subparts 9(A) and (B) discuss financial assurance requirements for compensatory wetland mitigation stating:

(A) For wetland replacement that is not in advance, a financial assurance acceptable to the local government unit must be submitted to, and approved by, the local government unit to ensure successful replacement. The local government unit may waive this requirement if it determines the financial assurance is not necessary to ensure successful replacement. The local government unit may incorporate this requirement into any financial assurance required by the local government unit for other aspects of the project.

(B) The financial assurance may be used to cover costs of actions necessary to bring the project into compliance with the approved replacement plan specifications and monitoring requirements.

The financial assurance requirements would be part of the WCA permitting process for the NorthMet Project Proposed Action.

Section 401 of the CWA requires the MPCA to certify that all projects that receive a federal license or permit are in compliance with state and federal water quality guidelines. Therefore, as part of their review, the MPCA conducts a separate review for compliance with water quality standards and policies and guidelines, which includes mitigation for wetland effects and approval of the wetland replacement ratios. This review process must be completed before the DA permit pursuant to Section 404 of the CWA can be issued.

PolyMet would ultimately need to satisfy both the federal and state mitigation requirements. The NorthMet Project Proposed Action is estimated to directly affect 912.5 acres. Depending on the location, type, and timing of compensatory mitigation, the minimum required amount of replacement wetlands for direct effects, based upon USEPA recommendations, could potentially range from 912.5 acres up to 1,825.0 acres (i.e., 1:1 to up 2:1 compensation ratios).

Wetland mitigation for potential indirect wetland effects would be determined by the agencies during permitting. If the NorthMet Project Proposed Action were to be permitted, wetland monitoring would be conducted to determine if the NorthMet Project Proposed Action would cause future indirect wetland effects. Wetlands hydrology and vegetation would be monitored, and additional monitoring locations may be considered during permitting. A component of the monitoring plan would be based on those wetlands that have a high likelihood of indirect effects as a result of groundwater drawdown. If the monitoring determined that indirect wetland effects had occurred, additional compensation may be required if determined necessary based on monitoring results. In the event that the wetland monitoring identified additional indirect effects, appropriate measures (i.e., adaptive management practices) would be implemented such as hydrologic controls or additional compensatory mitigation. Permit conditions would likely include an adaptive management plan to account for any additional effects that may be identified in the annual monitoring and reporting.

Wetland Mitigation Study Limits

The NorthMet Project area lies in St. Louis County in the St. Louis River Watershed (#3) within the Lake Superior basin (wetland mitigation Bank Service Area #1). Locations for wetland mitigation projects were evaluated in the following priority order:

- on-site;
- off-site in the St. Louis River Watershed and adjacent watersheds tributary to Lake Superior;
- off-site in watersheds adjacent to the St. Louis River Watershed; and
- off-site in watersheds neighboring adjacent watersheds.

Each of these potential locations areas is described below.

On-site Mitigation

In accordance with the USACE's St. Paul District Compensatory Wetland Mitigation Policy (USACE 2009) and state guidelines, the potential for creating wetlands on-site was considered first. The Wetland Management Plan (PolyMet 2013h) has identified the following on-site mitigation. On-site wetland mitigation (101.8 acres) is planned in the following areas: temporary Category 2/3 Stockpile, Overburden Storage and Laydown Area, some haul roads and adjacent ditches, and WWTF ponds and process water ponds. Establishment of on-site wetlands is expected to occur during reclamation. Of the 101.8 acres of planned on-site wetland mitigation, 72 acres of wetlands may be created at the temporary mine stockpile areas after removal of the Category 2/3 Stockpile and the Overburden Storage and Laydown Area. The remaining acres of wetland mitigation would be within the other above mentioned Project areas. Because it may not be feasible to construct wetlands on the entire footprint of these temporary areas, it has been assumed that only the area equivalent to the directly affected wetlands within the footprints would be viable for wetland mitigation. Design of wetland mitigation areas would be further evaluated in the detailed reclamation design and would include the preservation of upland buffer around the perimeter of the wetland mitigation areas. The establishment of the estimated 101.8 acres of on-site wetland mitigation is not included in the mitigation credits. The generation of wetland credits in these areas has the potential to be used on a contingency basis, but compensatory credit will not be considered up front.

Off-site Mitigation

The initial wetland mitigation study scope focused on the areas containing greater than 80 percent of their historic wetland resources as defined in the WCA. This area was selected as the initial study area to comprehensively cover the priority mitigation areas, with the understanding that suitable opportunities may not be available within each priority area.

Available wetland mitigation banking credits that were available for purchase by PolyMet were evaluated in portions of bank service areas 1 through 6 and found to be insufficient to satisfy the compensatory mitigation requirements for the NorthMet Project Proposed Action. Subsequently, a GIS analysis was performed to identify potential wetland mitigation sites within the defined study area. The primary goal of the analysis was to identify large, potentially drained wetlands located primarily on private or tax-forfeit land within the study area to provide preliminary data for more detailed ground investigations to proceed. To achieve the goal of the mitigation plan, which is to replace lost wetland functions and values using compensatory wetland types in-kind to the degree practicable, areas where drained wetlands could be restored were preferable over areas where wetlands could be created (Barr 2008m). Other siting criteria used in the GIS analysis included potential wetland enhancement areas, potential wetland preservation areas, and potential wetland creation areas (Barr 2008m). Sites were identified by overlaying and evaluating numerous existing spatial data sources to locate those sites with the greatest mitigation potential. Some of the data sources utilized included the following:

- geomorphology/soil types (Loesch 1997);
- land ownership (separated by county/state/federal and private ownership) (MLMIC 1983);
- land slope/Digital Elevation Model (MLMIC 1999);
- streams/ditches (MDNR 1980);

- major watersheds; and
- land cover (Loesch 1998).

The analysis was conducted by establishing specific filtering criteria to identify potential wetland mitigation sites. The general filtering criteria included the following:

- land slopes of less than or equal to 1 percent slope;
- mapped areas as peat or lacustrine geomorphology;
- private or county tax-forfeiture property;
- areas within 1.1 miles of a ditch; and
- areas meeting all of the above criteria with at least 100 contiguous acres.

The analysis was limited to sites with more than 100 acres of wetland mitigation potential due to the anticipated difficulties in planning numerous, small wetland mitigation projects, and the desire to identify opportunities that were feasible. In addition, the NorthMet Project Proposed Action represented an opportunity to restore large wetland systems and provide greater public and ecological benefit that are typically not available with smaller projects.

This GIS analysis resulted in the development of a polygon data layer, which contained nearly 900 areas with potential for mitigation in the study area. This analysis resulted in several findings.

First, a large proportion of the study area was in state and federal ownership. Discussions with the various state and federal entities regarding wetland mitigation on their respective properties resulted in the following conclusions:

- The USFS was unable to provide assurances that they would be able to protect restored wetlands on federal lands in perpetuity as required by wetland regulations.
- The State of Minnesota provided general criteria for restoring wetlands on state lands. The criteria required either a justification for how revenue production (i.e., peat mining, forest harvest) would not be affected or provide land in exchange that had a comparable value. PolyMet determined that these were not acceptable criteria and the state provided no certainty that the NorthMet Project Proposed Action would be viable if PolyMet expended 1 to 2 years of effort to meet the imposed criteria. This conclusion was supported in part by an effort to restore wetlands on Site 8362, a partially state-owned site, as discussed below.
- The Board of Water and Soil Resources has oversight regarding the administration of the Minnesota WCA. The Board of Water and Soil Resources provides guidance and interpretation of the WCA rules and has the most extensive experience with application of the rules. The Board of Water and Soil Resources' experience with wetland restoration on tribal lands found that impressing permanent conservation easements granted to the state was not possible to protect the restored wetlands.
- PolyMet had a signed agreement with St. Louis County near Floodwood to restore wetlands as mitigation (see discussion on Site 8362 below) for the NorthMet Project Proposed Action. The agreement was nullified by the state courts. In addition, legal proceedings through the state legislature and state court would have been required for ditch abandonment and for placement of a conservation easement on the land.

Therefore, it was determined that, because of these uncertainties and risks, mitigation on state and federal lands represented a minimal potential for a private enterprise to conduct compensatory wetland mitigation on these lands.

Second, many of the wetland systems within the study area have not been affected by historic drainage or other significant alteration. In areas lacking significant alterations, wetland preservation and establishment of upland buffers constitute the primary methods to generate wetland compensation credits within the study area. Wetlands that meet the criteria for wetland restoration credits include completely drained wetlands, partially drained wetlands, and wetlands with at least a 20-year history of agricultural production (Barr 2008m).

Third, much of the study area was characterized by surface geology that is not indicative of large wetland systems prone to easy drainage. The majority of the Arrowhead region, including Cook, Lake, and much of St. Louis counties, is mapped with surface geology typified by steep, igneous bedrock terrains; rolling till plains; and rolling to undulating areas of supraglacial drift (Loesch 1997). These geomorphological associations are also typically associated with steeper land slopes containing few drained or sufficiently altered wetlands.

Opportunities exist for accomplishing the preferred method of wetland compensation—restoration—within the St. Louis River Watershed and northeastern Minnesota in general. Tens of thousands of acres of peatlands are adversely affected by ditch systems. Specific to the St. Louis River Watershed, hundreds of acres of ditched, hydric soils in agricultural use exist in the central portion of the watershed. A determination by the USACE as to the practicality of wetland restoration within one or more of these sites has not been completed.

St. Louis River Watershed

Approximately 101 potential wetland mitigation areas were identified within the St. Louis River Watershed and other watersheds tributary to Lake Superior. The specific areas identified as having potential for wetland restoration were evaluated in more detail by reviewing NWI maps, plat maps, recent aerial photographs, and USGS topography to find the sites with the highest potential.

The sites with the highest potential were further evaluated by conducting site visits and meetings with various regulatory agencies. The majority of these potential mitigation sites, however, were eliminated from further consideration due to issues that included: lack of wetland drainage or altered land uses that would qualify as wetland restoration of enhancement (e.g., unaltered sites can qualify for regulatory compensation credits such as wetland preservation and upland buffers); infeasibility of planning numerous small projects; potential flooding of private property, roads, or other infrastructure; upstream ditch drainage through the potential wetland restoration areas that would have to be maintained; potential soil contamination; regulatory applicability; complex land ownership; existing peat mining operations; and legal considerations.

For purposes of the CWA regulatory program, the term *highest potential* is not the applicable standard for evaluating compensatory mitigation. Rather, *practicable* is the standard used in conjunction with the fundamental goal of compensatory mitigation: replace lost wetland functions, in-kind and in-place, to the extent practicable. Potential compensation sites are not limited to those that are least difficult and/or least expensive. Sites that have some greater difficulty and/or cost may be practicable, particularly if they are the only sites that would meet the fundamental goal of compensatory mitigation.

The area around Meadowlands and Floodwood appeared to have the most suitable characteristics. Two contiguous areas in this region, covering approximately 270 square miles, were mapped as level peat. The one site found to be initially feasible was designated as Site 8362. Site 8362 was located within the same watershed as the NorthMet Project area, had the greatest potential for wetland restoration with limited peripheral issues, and contained the potential to restore bog wetlands similar to those proposed for effect. Thus, Site 8362 was initially selected for further study and PolyMet signed an agreement with St. Louis County. Approximately 640 acres of the site are owned by the State of Minnesota with the remainder designated as tax-forfeit land. Further pursuit of wetland restoration activities at Site 8362 was halted for a number of reasons that rendered the site impracticable, including the following:

- The district court nullified PolyMet's agreement with St. Louis County in April 2007, thereby not allowing any further study of the site.
- There was a lack of local support, and there was, in fact, broad opposition from local residents.
- Extensive hydrologic monitoring and evaluation was required to document the degree of drainage at the site to support the proposed mitigation credits. This would have required long-term monitoring to adequately demonstrate the drainage and there was uncertainty regarding the outcome of such monitoring. Such monitoring activities were no longer allowed after April 2007 due to the district court action.
- Preservation credits would only be allowed where there was a demonstrable threat that could be eliminated (i.e., peat mining, tree-topping, or all-terrain vehicle activity). There are only about 400 acres of documented minable peat and the County had indicated they were unlikely to agree to limit tree-topping activities. Therefore, the ability to show a demonstrable threat that would meet regulatory criteria appeared unlikely.
- Even if the agreement with the county was reestablished, that agreement would have required ditch-abandonment proceedings in district court with public hearings that would have likely been opposed by local residents.
- The agreement with the County (if it were to be reinstated) would have also required receiving legislative authorization to place a permanent conservation easement over the restoration area. The likelihood of that was uncertain.

One additional wetland restoration area has been further identified since the DEIS within the NorthMet Project area watershed. The Zim Sod (Zim) wetland mitigation site is located in St. Louis County in the St. Louis River major watershed (#3), within the Lake Superior basin (bank service area #1).

Watersheds Adjacent to the St. Louis River Watershed

With Site 8362 no longer a feasible mitigation option, pursuit of the high-priority sites identified in watersheds adjacent to the St. Louis River Watershed was initiated along with the continued search for existing bank credits, wetland banks in various stages of planning, and various other potential wetland mitigation opportunities located in central and northwestern parts of Minnesota.

Fifteen sites were determined to have high potential for wetland mitigation in watersheds located adjacent to the St. Louis River Watershed. Of these, 10 sites were evaluated in the Mississippi River-Grand Rapids Watershed, three sites were evaluated in the Kettle River Watershed, and two sites were evaluated in the Nemadji River Watershed. After further study, these sites were eliminated from further consideration due to issues that included: lack of wetland drainage or altered land uses that would fit the regulatory requirements for restoration credit; potential flooding of roads or other infrastructure; upstream ditch drainage through the wetland that would have to be maintained; complex land ownership; existing peat mining operations; and legal considerations.

Watersheds Neighboring Adjacent Watersheds

Ten potential wetland mitigation sites, initially determined to have some potential, were located in watersheds neighboring the watersheds adjacent to the St. Louis River. These sites were evaluated to determine the relative potential for mitigation, the level of risk and uncertainty, and the likely costs. These sites were primarily located in Aitkin County.

Eight of these 10 sites were eliminated from further consideration due to issues that included unwilling landowners, significant private properties that would be hydrologically affected by wetland restoration, insufficient agricultural history, insufficient wetland drainage to qualify for restoration credit, considerable existing upstream drainage through the site, or active pursuit of the properties by others. Two priority properties were identified with willing landowners that had the potential to accomplish compensatory wetland mitigation for nearly the entire NorthMet Project area. These sites are located in watersheds neighboring those adjacent to the St. Louis River and outside the 1854 Ceded Territory. These two sites included the Aitkin mitigation site (Aitkin) and the Hinckley mitigation site (Hinckley). USACE St. Paul wetland compensatory mitigation replacement ratios are based on three factors: in-place versus out-of-place, in-kind versus out-of-kind, and in-advance versus not in-advance (see Table 5.2.3-17). As previously stated, the USACE St. Paul District has not made a final determination of the compensation ratios that would be required for the NorthMet Project Proposed Action. Base compensation ratios would be either 2:1 or 1.5:1 depending on the location, quality of the wetland, wetland type, and timeframe of the compensation. The final decision on compensatory mitigation ratios will be determined at the time of the CWA Section 404 permit decision based on current District guidance.

Off-site Wetland Restoration Projects

The off-site wetland restoration projects, as defined in the Wetland Management Plan (PolyMet 2013h), that would provide required mitigation for the NorthMet Project Proposed Action wetland effects include Hinckley, Aitkin, and the Zim wetland mitigation sites. As previously noted, the Zim site is located within the NorthMet Project area 8-digit HUC watershed, whereas Aitkin and Hinckley are located outside the 8-digit HUC watershed area. The initial phases of restoration on all of the proposed off-site wetland mitigation sites would be completed at least one full growing season in advance of the authorized wetland effects provided initial performance standards are met for which the mitigation would compensate. The proposed mitigation is expected to compensate for all the direct wetland effects, as well as the indirect fragmentation effects—a total of 939.4 acres. The majority of the credits would be in-kind mitigation and nearly one-half of the credits would be from within the NorthMet Project area

watershed. Out-of-kind credits would be used to mitigate for effects on 39.9 acres of deep marsh communities that would not be fully mitigated in-kind at the proposed mitigation sites (PolyMet 2013q). The Section 404 permit application provides more details on how the mitigation credits would be used.

Mitigation credits assumed for calculations include 100 percent credit for restoration of drained/farmed wetlands and created ponds, 75 percent credit for creation of on-site wetlands, 50 percent credit for partially drained wetlands and ditches, 25 percent credit for upland buffer, and 12.5 percent credit for preservation. The final mitigation credits required to offset the effects of the proposed NorthMet Project Proposed Action would be determined by the agencies during wetland permitting.

Aitkin Site

The Aitkin site is currently an active sod farm that has been drained by ditches and subsurface drain tiles. The overall objective of the restoration plan is to restore the hydrology by removal of the internal drainage system and the construction of outlets that regulate the required hydrological conditions (Barr 2008m). The site has also been used for sod, wheat, soybeans, sunflowers, and wild rice production. The 1,070-acre site is located north of the city of Aitkin, Minnesota, in Aitkin County. The site is in the Elk-Nokasippi major watershed within bank service area #5, adjacent to bank service area #1 where the NorthMet Project area would be located.

The site is located outside of the NorthMet Project area watershed. The proposed wetland mitigation area includes 810.2 acres of wetland restoration and 123.1 acres of upland buffer preservation. Restoration methods on the site are designed to restore the following wetland types: (Type 2) fresh wet meadow, (Type 2) sedge meadow, (Type 3) shallow marsh, (Type 4) deep marsh, (Type 6) shrub-carr, (Type 6) alder thicket, (Type 7) hardwood swamp, (Type 7) coniferous swamp, and (Type 8) coniferous and open bog.

The minimum replacement ratio that would be allowed by the USACE is 1:1 for those wetlands that would be replaced with the same wetland type, and at least one full growing season in advance of the authorized wetland effects provided initial performance standards are met; however, base compensation ratios could be increased to 2:1 for effects on high-quality, difficult-to-replace bog and forested wetlands. For effects on low- and moderate-quality wetlands, a base ratio of 1.5:1 would be applied. In-kind, in-place, and in-advance incentives to reduce the recommended base ratios would be considered at the time of permitting (see Tables 5.2.3-18 and 5.2.3-19). Compensation proposed at the Aitkin Site would be expected to meet in-kind compensation, resulting in a compensation ratio for high-quality wetland effects of 1.75:1, and if in advance, the ratio would be reduced to 1.5:1. For low- to moderate-quality wetlands, the recommended base ratio of 1.5:1 would be required and could be reduced to 1.25:1 if in-kind and 1:1 if also in-advance.

Under the Minnesota WCA, the replacement ratio that would likely be allowed is 1.5:1 for those wetlands that are replaced with the same wetland type and out of the NorthMet Project area watershed (see Tables 5.2.3-18 and 5.2.3-20). The site-specific mitigation design includes the following methods of restoration to receive wetland mitigation credits:

- restoration of effectively drained wetland on 810.2 acres for 100 percent mitigation credit or 810.2 credits; and

- restoration of native vegetation on 123.1 acres of uplands and filled ditches, for 30.8 credits based on the 25 percent credit calculation for upland buffer.

The vegetation and hydrology would likely be restored to the site over a 1- to 2-year construction period, followed by 10 to 20 years of management or more, if warranted. The restoration work is expected to begin on the site after permit approval such that the initial phases of the restoration would be completed more than one full growing season before the effects from the NorthMet Project Proposed Action would occur (PolyMet 2013q). Performance standards have been developed for the mitigation site to guide the restoration activities and to monitor whether vegetation and hydrology are meeting the design goals. A permanent conservation easement or deed restriction would be prepared and recorded to protect the site within 1 year after initializing the restoration activities. The wetland restoration area would be monitored for 10 to 20 years beginning in the first full growing season after completing hydrologic restoration and ending upon certification by the USACE and MDNR that the wetlands have met performance standards (PolyMet 2013h; PolyMet 2013q).

Once hydrology restoration has been achieved, an adaptive management program is proposed to guide development of the restored wetlands to achieve the targeted conditions. The vegetative restoration of each non-forested, non-bog community would be conducted to promote the establishment of characteristic native species that are present in the seed bank or that may be transported to the area from adjacent wetlands. General site preparation would be concurrent with hydrological restoration activities. Existing, non-native, and invasive vegetation would be removed through mechanical means or herbicide application. Diverse, native wetland vegetation is expected to develop in the restoration wetlands from the existing seed bank and from the wetland vegetation that surrounds the wetland restoration site through vegetative propagation and seed dispersal mechanisms. At the end of the second growing season these areas would be assessed to determine if additional seeding is required. These areas include sedge and wet meadows, shallow and deep marsh, emergent fringes, shrub-carr, and alder thicket.

Hardwood and coniferous swamp along with open and coniferous bogs would require herbaceous and woody species seeding as well as some woody seedling installation. Open and coniferous bogs would also require the installation of a sphagnum moss layer. The Mine Site may provide up to half the donor soil material (i.e., sphagnum) for this mitigation site.

Vegetation in the existing upland areas would be managed to promote natural succession of the existing plant communities. The primary maintenance activity would be control of non-native invasive species such as buckthorn, honeysuckle, and garlic mustard.

Hinckley Site

The Hinckley site currently has about 375 acres under agricultural production and has been drained by ditches and sub-surface drain tiles. This 511-acre site is located southwest of the city of Hinckley, Minnesota at the intersection of Sod Road and Highway 107. The mitigation site is located in Pine County in the Snake River major watershed (#36) within bank service area #6, adjacent to bank service area #1 where the NorthMet Project area is located. The overall objective of the Hinckley restoration plan is to restore the hydrologic connection between upstream watersheds and the restoration site and to disable the internal drainage system on-site. The restoration process would start with activities to restore site hydrology (Barr 2008m).

The site is located outside of the NorthMet Project area watershed. The proposed wetland mitigation area includes 313.0 acres of wetland restoration and 79.2 acres of upland buffer preservation. Restoration methods on the site are designed to restore the following wetland types: (Type 1) seasonally flooded, (Type 2) fresh wet meadow, (Type 2) sedge meadow, (Type 3) shallow marsh, (Type 6) shrub-carr, (Type 6) alder thicket, (Type 7) hardwood swamp, (Type 7) coniferous swamp, and (Type 8) coniferous bog.

The minimum replacement ratio that would be allowed by the USACE is 1:1 for those wetlands that are replaced with the same wetland type, and at least one full growing season in advance of the authorized wetland effects provided initial performance standards are met; however base compensation ratios could be increased to 2:1 for effects on high-quality, difficult-to-replace bog and forested wetlands. For effects on low- and moderate-quality wetlands, a base ratio of 1.5:1 would be applied. In-kind, in-place, and in-advance incentives to reduce the recommended base ratios would be considered at the time of permitting (see Table 5.2.3-18 and Table 5.2.3-19). Compensation proposed at the Hinckley Site would be expected to meet the in-kind incentive, resulting in a compensation ratio for high-quality wetland effects of 1.75:1, and if in-advance, the ratio would be reduced to 1.5:1. For low- to moderate-quality wetlands, the recommended base ratio of 1.5:1 would be required and could be reduced to 1.25:1 if in-kind and 1:1 if also in-advance.

Under the Minnesota WCA, the replacement ratio that would likely be allowed is 1.5:1 for those wetlands that are replaced with the same wetland type and out of the NorthMet Project area watershed (see Tables 5.2.3-18 and 5.2.3-20). The site-specific mitigation design includes the following methods of restoration to receive wetland mitigation credits:

- restoration of effectively drained wetlands on 306.1 acres for 100 percent mitigation credit or 306.1 credits;
- hydrologic restoration of 6.9 acres of partially drained wetlands to receive 50 percent credit or 3.5 credits; and
- restoration of native vegetation on 79.2 acres of uplands and filled ditches, for 19.8 credits based on the 25 percent credit calculation for upland buffer.

The vegetation and hydrology would likely be restored to the site over a 1- to 2-year construction period, followed by 10 to 20 years of management or more, if warranted. The restoration work is expected to begin on the site after permit approval such that the initial phases of the restoration would be completed more than one full growing season before the effects of the NorthMet Project Proposed Action would occur (PolyMet 2013q). Performance standards have been developed for the mitigation site to guide the restoration activities and to monitor whether vegetation and hydrology are meeting the design goals. A permanent conservation easement or deed restriction would be prepared and recorded to protect the site within 1 year after initializing the restoration activities. The wetland restoration area would be monitored for 10 to 20 years beginning in the first full growing season after completing hydrologic restoration and ending upon certification by the USACE and MDNR that the wetlands have met performance standards (PolyMet 2013h; PolyMet 2013q).

Once hydrology restoration has been achieved, an adaptive management program is proposed to guide development of the restored wetlands to achieve the targeted conditions. The vegetative restoration of each non-forested, non-bog community would be conducted to promote the

establishment of characteristic native species that are present in the seed bank or that may be transported to the area from adjacent wetlands. General site preparation would be concurrent with hydrological restoration activities. Existing, non-native, and invasive vegetation would be removed through mechanical means or herbicide application. Diverse, native wetland vegetation is expected to develop in the restoration wetlands from the existing seed bank and from the wetland vegetation that surrounds the wetland restoration site through vegetative propagation and seed dispersal mechanisms. At the end of the second growing season, these areas would be assessed to determine if additional seeding is required. These areas include sedge and wet meadows, shallow and deep marsh, emergent fringes, shrub-carr, and alder thickets.

Hardwood and coniferous swamp along with open and coniferous bogs would require herbaceous and woody species seeding as well as some woody seedling installation. Open and coniferous bogs would also require the installation of a sphagnum moss layer. The Mine Site may provide up to half the donor soil material (i.e., sphagnum) for this mitigation site.

Vegetation in the existing upland areas would be managed to promote natural succession of the existing plant communities. The primary maintenance activity would be control of non-native invasive species such as buckthorn, honeysuckle, reed canary grass, and garlic mustard.

Zim Site

The Zim site is currently an active sod farm that has been drained by ditches and sub-surface drain tiles. This site is located in two separate units (north and south) on approximately 569 acres of land located southwest of the city of Eveleth, Minnesota. The site is located in St. Louis County in the St. Louis River major watershed (#3), within the Lake Superior basin (bank service area #1). The overall objective of the Zim restoration plan is to restore a native wetland plant community.

The site is located within the NorthMet Project area watershed. The proposed wetland mitigation area includes 508.2 acres of wetland restoration and preservation, and 22.7 acres of upland buffer preservation. Restoration methods on the site would be designed to restore a (Type 8) coniferous bog community; however, developing a bog community is highly dependent on soil and groundwater parameters that are difficult to control. Therefore, a coniferous swamp community would be the contingent community if the soil and groundwater conditions are not adequate for bog regeneration. Coniferous bog or swamp is the target for the whole site; however, where trees do not successfully establish, the target community would be a sedge meadow or open bog. If the target community changes, the credit ratios would be recalculated and would be determined by the USACE and MDNR during the permitting process.

The minimum replacement ratio that would be allowed by the USACE is 1:1 for those wetlands that are replaced with either the same wetland type, or at least one full growing season in advance of the authorized wetland effects provided initial performance standards are met; however, base compensation ratios could be increased to 1.5:1 for effects on high-quality, difficult-to-replace bog and forested wetlands. For effects on low- and moderate-quality wetlands, a base ratio of 1.5:1 would be applied. In-kind, in-place, and in-advance incentives to reduce the recommended base ratios would be considered at the time of permitting (see Tables 5.2.3-18 and 5.2.3-19). Compensation proposed at the Zim Site would be expected to meet both in-kind and in-place incentives, thereby reducing the compensation ratio for high-quality wetland effects from 2:1 to 1.5:1. If in-advance, the ratio would be further reduced to 1.25:1. For low- to

moderate-quality wetlands, the recommended base ratio of 1.5:1 would be required and could be reduced to 1.25:1 if in-kind and 1:1 if also in-advance.

Under the Minnesota WCA, the replacement ratio that would likely be allowed is 1:1 for those wetlands that are replaced with the same wetland type and in the same watershed (see Table 5.2.3-18 and Table 5.2.3-20). The site-specific mitigation design includes the following methods of restoration to receive wetland mitigation credits:

- restoration of effectively drained wetlands on 401.5 acres for 100 percent mitigation credit or 401.5 credits;
- creation of 8.3 acres of excavated ponds for 100 percent mitigation credit or 8.3 credits;
- hydrologic restoration of 48.1 acres of partially drained wooded wetlands to receive 50 percent credit or 24.1 credits;
- restoration of natural surface grade and wetland conditions in 21.5 acres of ditches, which would be filled to receive 50 percent credit or 10.8 credits;
- restoration of native vegetation on 22.7 acres of effectively drained wetlands and filled ditches, each of which would remain drained due to open ditches that cannot be filled, for 5.7 credits based on the 25 percent credit calculation for upland buffer; and
- easement protection of 28.8 acres of native coniferous bog communities at 12.5 percent credit for a total of 3.6 credits for preservation.

The vegetation and hydrology would be restored to the site over a 1- to 2-year construction period, followed by 10 to 20 years of management or more, if warranted. The restoration work is expected to begin on the site after permit approval such that the initial phases of the restoration would be completed more than one full growing season before the effects of the NorthMet Project Proposed Action would occur (PolyMet 2013q). Performance standards have been developed for the mitigation site to guide the restoration activities and to monitor whether vegetation and hydrology are meeting the design goals (Barr 2011k). A permanent conservation easement or deed restriction would be prepared and recorded to protect the site within 1 year after initializing the restoration activities. The wetland restoration area would be monitored for 10 to 20 years beginning in the first full growing season after completing hydrologic restoration and ending upon certification by the and MDNR that the wetlands have met performance standards (PolyMet 2013h; PolyMet 2013q).

Table 5.2.3-18 Summary of Proposed Wetland Mitigation Credits

Community/Credit Type	Wetland Mitigation Within Project Watershed			Wetland Mitigation Outside Project Watershed			Total Wetland Mitigation Acres	Total Wetland Mitigation Credits ⁵
	Zim Sod (acres)	On-site (acres)	Total Credits	Aitkin (acres)	Hinckley (acres)	Total Credits		
Off-site Restoration of Effectively Drained Wetlands ¹								
Deepwater	0.0	---	0.0	0.0	0.0	0.0	0.0	0.0
Type 1 Seasonally Flooded	0.0	---	0.0	0.0	20.1	20.1	20.1	20.1
Type 2 Fresh (Wet) Meadow	0.0	---	0.0	21.8	14.3	36.1	36.1	36.1
Type 2 Sedge Meadow	0.0	---	0.0	47.1	39.1	86.2	86.2	86.2
Type 3 Shallow Marsh	0.0	---	0.0	86.9	1.4	88.3	88.3	88.3
Type 4 Deep Marsh	0.0	---	0.0	33.6	0.0	33.6	33.6	33.6
Type 5 Shallow, Open Water	8.3	---	8.3	0.0	0.0	0.0	8.3	8.3
Type 6 Shrub-Carr	0.0	---	0.0	83.9	87.1	171.0	171.0	171.0
Type 6 Alder Thicket	0.0	---	0.0	82.8	27.4	110.2	110.2	110.2
Type 7 Hardwood Swamp	0.0	---	0.0	52.6	7.1	59.7	59.7	59.7
Type 7 Coniferous Swamp	0.0	---	0.0	89.1	8.4	97.5	97.5	97.5
Type 8 Open Bog	0.0	---	0.0	74.2	0.0	74.2	74.2	74.2
Type 8 Coniferous Bog	401.5	---	401.5	238.2	101.2	339.4	740.9	740.9
Off-site Restoration of Partially Drained Wetlands and Ditches ²								
Type 2 Sedge Meadow	0.0	---	0.0	0.0	0.8	0.4	0.8	0.4
Type 6 Shrub-Carr	0.0	---	0.0	0.0	0.0	0.0	0.0	0.0
Type 7 Coniferous Swamp	0.0	---	0.0	0.0	0.0	0.0	0.0	0.0
Type 7 Hardwood Swamp	0.0	---	0.0	0.0	6.1	3.1	6.1	3.1
Type 8 Coniferous Bog	69.6	---	34.8	0.0	0.0	0.0	69.6	34.8
Off-site Site Preservation ³								
Type 8 Coniferous Bog	28.8	---	3.6	0.0	0.0	0.0	28.8	3.6
Off-site Upland Buffer	22.7	---	5.7	123.1	79.2	50.6	225.0	56.3
On-site Wetland	---	101.8	---	---	---	---	101.8	---
On-site Upland Buffer ⁴	---	---	---	---	---	---	---	---
Upland Buffer Total	22.7	---	5.7	123.1	79.2	50.6	225.0	56.3
Wetland Total	508.2	101.8	448.2	810.2	313.0	1,119.8	1,733.2	1,568.0
Total	530.9	101.8	453.9	933.3	392.2	1,170.3	1,958.2	1,624.2

Source: PolyMet 2013q.

¹ Credits for restoration of completely drained wetlands are worth 100 percent of the acreage restored based on USACE St. Paul District Policy (Restoration via re-establishment) and the Minnesota WCA Chapter 8420.0526, Subpart 3.

- ² Credits for restoration of partially drained wetlands are worth 50 percent of the acreage restored based on USACE St. Paul District Policy (Restoration via rehabilitation) and the Minnesota WCA Chapter 8420.0526, Subpart 4.
- ³ Credits for wetland preservation are worth 12.5 percent of the acreage protected under a conservation easement based on USACE St. Paul District Policy (Preservation) and the Minnesota WCA Chapter 8420.0526, Subpart 9 (per *Minnesota Statute* 103G.2251 modified August 1, 2011).
- ⁴ Credits for upland buffers are worth 25 percent of the acreage of native, non-invasive vegetation established or maintained adjacent to the wetland based on USACE St. Paul District Policy (Preservation) and the Minnesota WCA Chapter 8420.0526, Subpart 1.
- ⁵ The determination of final mitigation credits required to offset the effects of the proposed NorthMet Project Proposed Action would be determined by the agencies during wetland permitting. The public notice for the DA permit application will be reissued when the SDEIS becomes available.

Table 5.2.3-19 Summary of Proposed Wetland Mitigation for Direct Effects Utilizing USACE Credits

Wetland or Credit Type	Mitigation Credits Available ¹					NorthMet Project Proposed Action Direct Wetland Effects in Acres ^{1,3}			Total Credits Required for Mitigation at Base Ratio ^{1,10}	No More Than 2 Apply ¹⁰			Total Applied Mitigation Credits ^{1,7,8,10}	Applied Mitigation Ratio ^{9,10}
	Zim Sod	Aitkin	Hinckley	On-Site ²	Total Mitigation Credits Available	Non-Forested, Non-Bog, and Low or Medium Quality Wetland (Base Ratio 1.5:1) ⁴	Bogs, Forested, and High Quality Wetland (Base Ratio 2:1) ⁵	Total Impact Acres		Incentive for Credits In-Kind -0.25:1	Incentive for Credits In-Place -0.25:1	Incentive for Credits In-Advance ⁶ -0.25:1		
Deepwater	0.0	0.0	0.0	---	0.0	0.0	0.0	0.0	0.0	---	---	---	0.0	0
Type 1 Seasonally Flooded	0.0	0.0	20.1	---	20.1	0.0	0.0	0.0	0.0	---	---	---	0.0	---
Type 2 Fresh (Wet) Meadow	0.0	21.8	14.3	---	36.1	1.4	14.4	15.8	30.9	(4.0)	---	(4.0)	23.0	1.46
Type 2 Sedge Meadow	0.0	47.1	39.5	---	86.6	6.8	17.1	23.9	44.3	(6.0)	---	---	38.3	1.61
Type 3 Shallow Marsh	0.0	86.9	1.4	---	88.3	53.1	23.9	77.0	127.5	(19.3)	---	(19.3)	89.0	1.16
Type 4 Deep Marsh	0.0	33.6	0.0	---	33.6	73.6	0.1	73.7	110.6	(8.4)	---	(18.4)	83.7	1.14
Type 5 Shallow, Open Water	8.3	0.0	0.0	---	8.3	0.0	0.0	0.0	0.0	---	---	---	0.0	---
Type 6 Shrub-Carr	0.0	83.9	87.1	---	171.0	1.4	2.5	3.9	7.1	(1.0)	---	---	6.1	1.57
Type 6 Alder Thicket	0.0	82.8	27.4	---	110.2	7.5	103.1	110.6	217.4	(27.6)	---	---	189.8	1.72
Type 7 Hardwood Swamp	0.0	52.6	10.2	---	62.8	0.0	12.5	12.5	24.9	(3.1)	---	---	21.8	1.75
Type 7 Coniferous Swamp	0.0	89.1	8.4	---	97.5	0.0	84.4	84.4	168.9	(21.1)	---	---	147.8	1.75
Type 8 Open Bog	0.0	74.2	0.0	---	74.2	0.0	7.6	7.6	15.3	(1.9)	---	---	13.4	1.75
Type 8 Coniferous Bog (in watershed)	440.0	0.0	0.0	---	440.0	0.0	530.0	530.0	1,060.0	(132.5)	(110.0)	---	817.5	1.54
Type 8 Coniferous Bog (out-of-watershed)	0.0	238.2	101.2	---	339.4						---			
Wetland - In-Kind/In-Place	---	---	---	---	0.0	---	---	---	---	---	---	---	---	---
Wetland Total ¹	448.3	810.2	309.6	0.0	1,567.9	143.8	795.6	939.4	1,806.8	---	---	---	1,430.5	---
Upland Buffer	5.7	30.8	19.8	---	56.3	---	---	---	---	---	---	---	---	---
Total ¹	454.0	841.0	329.3	0.0	1,624.2	939.4			1,806.8	(224.7)	(110.0)	(41.6)	1,430.5	1.52
										(376.3)				
Total Surplus Wetland Mitigation Credits for NorthMet Project Proposed Action (Total Credit Minus Total Applied Mitigation Credit) ^{1,10}					193.7									

Source: PolyMet 2013q.

¹ Totals may not add exactly due to rounding.

² No wetland types defined.

³ The total includes fragmentation of wetlands that would occur at the Mine Site and Plant Site (26.9 acres).

⁴ Base ratio 1.5:1 per USACE St. Paul District Policy (USACE 2009) for wetlands that are not considered high quality or difficult to replace, which includes forested wetland and bog communities.

⁵ Base ratio 2:1 per USACE May 29, 2013 Draft Memorandum (USACE 2013) for wetlands that are high quality or difficult to replace, which includes forested wetland and bog communities.

⁶ Based on USACE May 29, 2013 Draft Memorandum (USACE 2013) for in-advance qualification assuming all mitigation would be constructed one full growing season before wetland effects were to occur.

⁷ Total Applied Mitigation Credits = Total Credits Required for Mitigation minus Incentive Credits.

⁸ Credits applied may include surplus credits from different wetland types.

⁹ The ratio of credits applied to NorthMet Project Proposed Action effects (not including the surplus credits).

¹⁰ The determination of final mitigation credits required to offset the effects of the proposed NorthMet Project Proposed Action would be determined by the agencies during wetland permitting. The public notice for the DA permit application will be reissued when the SDEIS becomes available.

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Table 5.2.3-20 Summary of Proposed Wetland Mitigation for Direct Effects Utilizing Minnesota Wetland Conservation Act Credits

Wetland or Credit Type	Mitigation Credits Available ¹					NorthMet Project Proposed Action Direct Wetland Effects in Acres ^{1,3}	Credit Surplus after 1:1 In-Kind Replacement (Deficit) ^{1,4,9}	Additional Mitigation Required +0.5 ^{5,9}	Applied Mitigation Ratio ⁹
	Zim Sod	Aitkin	Hinckley	On- Site ²	Total Mitigation Credits Available				
Deepwater	0.0	0.0	0.0	---	0.0	0.0	0.0	---	---
Type 1 Seasonally Flooded	0.0	0.0	20.1	---	20.1	0.0	20.1	---	1.5:1
Type 2 Fresh (Wet) Meadow	0.0	21.8	14.3	---	36.1	15.8	20.3	7.9	1.5:1
Type 2 Sedge Meadow	0.0	47.1	39.5	---	86.6	23.9	62.7	11.9	1.5:1
Type 3 Shallow Marsh	0.0	86.9	1.4	---	88.3	77.0	11.3	38.5	1.5:1
Type 4 Deep Marsh	0.0	33.6	0.0	---	33.6	73.7	(40.1)	36.9	1.5:1
Type 5 Shallow, Open Water	8.3	0.0	0.0	---	8.3	0.0	8.3	0.0	1.5:1
Type 6 Shrub-Carr	0.0	83.9	87.1	---	171.0	3.9	167.1	2.0	1.5:1
Type 6 Alder Thicket	0.0	82.8	27.4	---	110.2	110.6	(0.4)	55.3	1.5:1
Type 7 Hardwood Swamp	0.0	52.6	10.2	---	62.8	12.5	50.3	6.2	1.5:1
Type 7 Coniferous Swamp	0.0	89.1	8.4	---	97.5	84.4	13.1	42.2	1.5:1
Type 8 Open Bog	0.0	74.2	0.0	---	74.2	7.6	66.6	3.8	1.5:1
Type 8 Coniferous Bog (in watershed)	440.0	0.0	0.0	---	440.0	530.0	249.3	---	1:1 ⁶
Type 8 Coniferous Bog (out-of-watershed)	0.0	238.2	101.2	---	339.4			45.0	1.5:1 ⁷
Wetland - In-Kind/In- Place	---	---	---	---	---	---	---	---	---
<i>Wetland Total</i> ¹	448.3	810.2	309.6	0.0	1,567.9	939.4	628.6	249.7	---
Upland Buffer	5.7	30.8	19.8	---	56.3	---	56.3	---	---
Total ¹	454.0	841.0	329.3	0.0	1,624.2	939.4	684.9	249.7	1.26:1 ⁸
Total Surplus Wetland Mitigation Credits for NorthMet Project Proposed Action (Total Credit minus 1:1 Credits minus Additional Mitigation Required)^{1,9}							435.2		
Total Wetland Mitigation Credits Used for NorthMet Project Proposed Action^{1,9}							1,189.1		

Source: PolyMet 2013q

- ¹ Totals may not add exactly due to rounding.
- ² No wetland types defined.
- ³ The total includes fragmentation of wetlands that would occur at the Mine Site and Plant Site (26.9 acres).
- ⁴ Credit Surplus after 1:1 In-Kind Placement = Total Mitigation Credits Available minus Total Impact Area.
- ⁵ Additional mitigation required for mitigation out of the watershed at Aitkin and Hinckley sites. Determined by multiplying 0.5 by Total Impact Area.
- ⁶ Remaining assumes 1:1 replacement since effects would be compensated in-kind and ahead of time.
- ⁷ Excess mitigation credits calculated based on bog effects not replaced in the watershed at Zim Sod (530.0-440.0=90 times 0.5 equals 45.0 credits).
- ⁸ The ratio of credits applied to NorthMet Project Proposed Action effects (not including the surplus credits).
- ⁹ The determination of final mitigation credits required to offset effects of the proposed NorthMet Project Proposed Action would be determined by the agencies during wetland permitting. The public notice for the DA permit application will be reissued when the SDEIS becomes available.

5.2.3.3.3 Mitigation Summary

Compensatory mitigation is required for the 912.5 acres of wetlands that would be directly affected. In addition, compensatory mitigation for the 26.9 acres of wetland fragmentation would be provided up front. The overall wetland mitigation strategy for the NorthMet Project Proposed Action is to compensate for unavoidable wetland effects in-place, in-kind where possible and in advance of effects when feasible. Due to both on- and off-site limitations and technical feasibility, it is not practicable to replace all affected wetland types with an equivalent area of in-kind wetlands. A combination of off- and on-site wetland mitigation projects would be implemented to fulfill the requirements for compensatory mitigation. PolyMet's current mitigation proposal includes:

- On-site mitigation totaling 101.8 acres of wetland creation during reclamation.
- Off-site mitigation including:
 - Aitkin Site – 810.2 acres of wetland restoration and 123.1 acres of upland buffer;
 - Hinckley Site – 313.0 acres of wetland restoration and 79.2 acres of upland buffer; and
 - Zim Site – 508.2 acres of wetland restoration and 22.7 acres of upland buffer.

Off-site wetland compensation of 1,631.4 acres could provide 1,568.0 wetland mitigation credits. In addition, a total of 225.0 acres of upland buffer areas are proposed to be established with native vegetation around the wetland restoration areas. In accordance with USACE guidelines, credit for the upland buffer areas would be at a 4:1 ratio, resulting in an additional 56.3 credits. The total off-site mitigation could provide 1,624.2 wetland mitigation credits. Tables 5.2.3-18, 5.2.3-19, and 5.2.3-20 provide a summary of wetland mitigation. Compensatory mitigation ratios determined in permitting may vary from these assumptions.

Finally, establishment of approximately 101.8 acres of wetland would likely occur during reclamation of the Mine Site; this establishment is not included in the mitigation credits discussed above.

In accordance with the federal Mitigation Rule, USACE policy, and overall requirements of the CWA, the primary focus of compensatory mitigation is to replace lost wetland functions within the same 8-digit HUC watershed as the impact site—in this case, the St. Louis River Watershed/Great Lakes Basin. Initially, no practicable compensation sites were found in the St. Louis River watershed, but subsequently, the Zim Site was found and incorporated as part of the compensatory mitigation plan. The permanent functional loss of wetlands within the St. Louis River Watershed/Great Lakes Basin will be considered by the USACE in its DA permit decision. This is particularly critical in that 8-digit HUC watersheds adjacent to the Great Lakes—including the St. Louis River Watershed—have been identified as coastal watersheds for purposes of the federal Mitigation Rule. Approximately 72 percent of the credits proposed would be located outside of this watershed. The Rule places additional emphasis on replacing coastal wetland losses within a coastal watershed. Should the USACE determine that a greater percentage of the compensation be accomplished within the St. Louis River Watershed/Great Lakes Basin, the applicant may be directed to re-evaluate compensation opportunities within that watershed.

The USACE requires a detailed compensatory mitigation plan for anticipated wetland effects that would occur during the first 5 years of the NorthMet Project Proposed Action. A detailed mitigation plan must be submitted for each subsequent 5-year increment of wetland effects to the USACE for approval. The anticipated wetland types to be restored off-site include a combination of the same and different types as the affected wetlands. Some off-site wetlands would be restored in advance of effects, while other wetlands would be restored after the effects.

The change in wetland hydrology from groundwater drawdown at the Mine Site was assessed by two different methodologies; therefore, total indirect wetland effects were provided based on both approaches. The NorthMet Project Proposed Action could indirectly affect up to either 7,350.7 acres of wetlands located within and around the NorthMet Project area, based on the method of wetlands crossing analog impact zones, or up to 6,498.1 acres of wetlands located within and around the NorthMet Project area, based on the method of wetlands within analog impact zones (PolyMet 2013k; PolyMet 2013q). Regardless of the method used, wetland mitigation for indirect wetland effects would be determined by the agencies during permitting. If the NorthMet Project Proposed Action were to be permitted, wetland monitoring would be conducted to determine if the NorthMet Project Proposed Action would cause future indirect wetland effects. Wetlands and vegetation would be monitored, and additional monitoring locations may be considered during permitting. A component of the monitoring plan would be based on those wetlands that have a high likelihood of indirect effects as a result of groundwater drawdown. If the monitoring determined that indirect wetland effects had occurred, additional compensation may be required if determined necessary by the permitting agencies. In the event that the wetland monitoring identified additional indirect effects, appropriate measures (i.e., adaptive management practices) would be implemented such as hydrologic controls or additional compensatory mitigation. Permit conditions would likely include an adaptive management plan to account for any additional effects that may be identified in the annual monitoring and reporting.

5.2.3.3.4 Monitoring

Wetland monitoring would be performed within the NorthMet Project area to demonstrate performance of wetland mitigation and to determine if indirect wetland effects were occurring. Monitoring of the restored areas would assess whether or not the restored wetlands are in conformance with performance standards and would determine whether continued monitoring would be required.

The wetland restoration area monitoring would begin during the first full growing season after completing hydrologic restoration. In addition to monitoring of the restored wetlands, one reference wetland of each restoration community type would be monitored within the general area of each restoration site in areas with relatively natural hydrologic conditions similar to that of the proposed target communities. A monitoring plan would be submitted to the appropriate state and federal agencies for review and approval that would include proposed locations of reference wetlands prior to implementing the monitoring program.

Vegetative monitoring would entail conducting a detailed vegetation survey at least once per year (typically July to August) in each wetland mitigation community, as well as the reference wetland communities, to evaluate the success of the restoration during the appropriate monitoring period for each community type.

Hydrologic monitoring would involve the installation and periodic monitoring of shallow recording wells. Continuous recording wells would be utilized to the extent feasible and would be placed throughout the sites sufficient to characterize hydrology. Water elevations would be recorded at least once per week from May through mid-July and monthly thereafter until the end of the growing season.

The duration of monitoring would depend on the target wetland communities at each site and the success of establishment of those communities. Bogs and forested wetlands would be monitored for up to 20 years, or more if warranted. Monitoring of emergent and shrub-carr wetland communities would continue for up to 10 years, or more if warranted. Certain components of the monitoring may be discontinued sooner if performance standards were met and approval was provided by the USACE and MDNR (PolyMet 2013h; PolyMet 2013q).

Water monitoring is discussed in Section 5.2.2.3.6. Water quality would be monitored downstream and piezometers would be located in the wetlands.

Off-site Wetland Monitoring

Several shallow water table monitoring wells were installed on the Zim site and a reference wetland in May 2012 to characterize the pre-restoration hydrology and continue until the initiation of restoration. After restoration, the monitoring design may be altered to better characterize restored conditions (PolyMet 2013q). Hydrology monitoring wells would be removed from Zim at the end of year 5, if the hydrology performance standards were met (Barr 2011k).

Hydrologic monitoring at the Aitkin and Hinckley sites would be completed with monitoring stations in each community type to document water levels relative to reference monitoring wells and proposed performance standards. Monitoring would be conducted in the shallow marsh (Type 3) and deep marsh (Type 4) communities using staff gages or modified stilling wells. Hydrology monitoring in saturated soil communities would be completed using shallow water table monitoring wells within each community recorded several times each day for the duration of the growing season (PolyMet 2013q). Hydrologic parameters for Hinckley and Aitkin would be evaluated in the mitigation areas more intensively during the first 2 years and then would be performed at a level appropriate to the hydrologic characteristics of each area thereafter (Barr 2008m).

Monitoring reports would be prepared and submitted for Zim in years 1, 3, 5, 8, 10, 15, and 20, as necessary, after restoration is complete. The monitoring report completed after the tenth growing season would assess whether or not the restoration was sufficiently complete and whether or not additional monitoring and reporting were needed. A monitoring report for Hinckley and Aitkin, respectively, would be prepared annually during the first 5 years of monitoring. After year 5, monitoring reports would be provided following growing seasons 8 and 10 for the shrub communities and following growing seasons 8, 10, 15, and 20 for the forested and bog communities. Reports would describe the status of the wetland mitigation, summarize the results of the vegetative and hydrologic monitoring, discuss management activities and corrective actions conducted during the previous year, and discuss activities planned for the following year. The reports would be submitted to the USACE and MDNR by December 31 of each year.

If the restored wetland communities at any of the mitigation sites did not meet performance standards, remedial or corrective actions and possibly additional mitigation credits may be required and would be determined by the USACE and MDNR during the permitting process.

Monitoring of Mine Site and Plant Site Wetlands for Potential Indirect Effects

If monitoring of wetlands for potential indirect effects did determine effects were occurring, additional compensation may be required, if determined necessary, based on monitoring results. Monitoring is proposed within all wetlands containing a potential indirect wetland impact factor rating of 3 to 5 and a sampling of those wetlands with factor ratings of 1 or 2 (PolyMet 2013q). A component of the monitoring plan would be based on those wetlands that would have a high likelihood of indirect effects as a result of groundwater drawdown. Permit conditions would likely include an adaptive management plan to account for any additional effects that may be identified in the annual monitoring and reporting. To determine if indirect effects would occur, hydrology, vegetation, and wetland boundaries would be monitored, documented, and compared with baseline monitoring and reference wetlands. The Section 404 permit application includes criteria on how effects would be assessed. If indirect wetland effects, based on the criteria presented in the Section 404 permit application, were to occur, PolyMet would work with the USACE and MDNR to respond, which may include the option to provide compensatory mitigation for any documented indirect effects. An adaptive approach would be used to evaluate the most effective monitoring strategy for potential indirect effects. The monitoring plan would be updated annually based on results from the previous year. A total of 42 monitoring wells and four reference wells are proposed to document potential indirect wetland effects (PolyMet 2013h; PolyMet 2013q).

In 2005, 20 shallow manual wells and four recording wells were initially installed at 19 locations around the Mine Site. A total of 11 monitoring locations were situated around the perimeter of the Mine Site and are not expected to be affected by the NorthMet Project Proposed Action. The remaining eight monitoring locations are located within the Mine Site and have the potential to be affected by the NorthMet Project Proposed Action. In 2008, two wells were removed because they were within future stockpile locations, two new wells were added at the Mine Site, one well was relocated out of the direct effect area, and two wells were installed in reference wetlands located west of the Mine Site (PolyMet 2013b). Furthermore, in 2008, all monitoring locations were instrumented with recording wells so water levels could be recorded every 2 to 4 hours. In 2010, two wells were relocated because they were determined to be in areas that would be directly affected by the NorthMet Project Proposed Action (PolyMet 2013b). During 2008 through 2010, there were 21 locations monitored at the Mine Site. Pre-project monitoring did not include collection of vegetation or wetland boundaries other than what was completed during the wetland delineation and baseline wetland type evaluation (PolyMet 2013h; PolyMet 2013q).

Shallow monitoring wells were installed at eight locations around the Plant Site in 2010. One of the eight wells was installed in a reference wetland located north of the Plant Site that would not be affected by the NorthMet Project Proposed Action. Two monitoring wells were placed west of the Plant Site along Unnamed Creek; two wells were placed north of the Plant Site, adjacent to a large deep marsh wetland complex; and three wells were placed along the flowpath of Trimble Creek. The monitoring wells were typically placed to a depth of 2 to 5 ft bgs.

Pre-project hydrology monitoring of wetlands and groundwater within and surrounding the Mine Site started in 2005 and in 2010 at the Plant Site, and would continue throughout the NorthMet

Project Proposed Action in accordance with the planned study (PolyMet 2013b). The objectives of the Mine Site and Plant Site wetland hydrology monitoring studies include the following:

1. Gain a better understanding of the wetland hydrology at the Mine Site and Plant Site (i.e., defining whether specific wetlands are recharging the surficial deposits aquifer or are discharging to surface waters).
2. Collect baseline hydrology data at the Mine Site and Plant Site that could be used to assess the effect of the NorthMet Project Proposed Action on wetland hydrology.
3. Review the data collected at the Mine Site in the hydrogeologic study along with the wetland hydrology data to determine whether specific wetlands within the Mine Site area have perched water tables or are in direct hydrologic connection with the surficial deposits aquifer.
4. Determine the potential for indirect wetland effects at the Mine Site and Plant Site resulting from the NorthMet Project Proposed Action.

The majority of the pre-project monitoring locations would be utilized for future monitoring. The monitoring of the well locations would be expanded to include vegetation sampling and wetland boundaries, and additional monitoring locations may be considered during permitting. Details of the vegetation and wetland boundary monitoring are presented in the Section 404 permit application. Six existing wells at the Mine Site would be removed due to either being located within areas of direct project effects or areas where no potential indirect effects would likely occur. Wetland hydrology monitoring would be conducted during operation of the NorthMet Project Proposed Action to document indirect wetland effects. Prior to the start of the NorthMet Project Proposed Action, monitoring would be established based on permit conditions, which would describe the purpose, methods, and criteria to be implemented to document indirect wetland effects.

In addition to the existing wetland monitoring locations, additional monitoring locations would be installed. The additional monitoring locations would occur in areas that lack an existing monitoring well and have been identified as having the potential for indirect wetland effects described above. At the Mine Site, an additional 16 monitoring locations are proposed and are planned within all wetlands that have received effect factor ratings of 2, 3, or 4 near the NorthMet Project area features and in several wetlands with effect factor ratings of 1 that would be located throughout the Mine Site. Within the Plant Site, four new wells are proposed and would include a variety of wetland community types and occur throughout all areas of potential indirect impact factors. The monitoring wells are planned within all wetlands with effect factor ratings of 3 and within a sampling of wetlands with effect factor ratings of 1 and 2 located throughout the areas of potential indirect wetland effects. Within the Transportation and Utility Corridor, three new monitoring locations are proposed within wetlands that have effect factor ratings of 1 (PolyMet 2013q).

Pre-project monitoring locations would include three reference wetlands approved by the USACE and MDNR to document the natural hydrologic fluctuations in wetlands that would not be affected by the NorthMet Project Proposed Action and would facilitate interpretation of the NorthMet Project Proposed Action hydrologic data. More details on the reference wetland locations are provided in the Section 404 permit application. Water monitoring is discussed in Section 5.2.2.3.6. Water quality would be monitored downstream and piezometers would be located in the wetlands.

5.2.3.3.5 Reporting

Reports would be compiled to document activities at the off- and on-site wetland mitigation projects, which would be implemented to fulfill the requirements for compensatory mitigation.

Off-site Monitoring Reports for Wetland Restoration

Reports have been prepared to document the activities that would be conducted at the off-site wetland mitigation sites, which include information regarding existing conditions at the site, construction activities, management activities, wetland restoration goals, performance standards, schedules, and monitoring plans (Barr 2008m; Barr 2011k). These plans were developed to comply with WCA rules (*Minnesota Rules*, chapter 8420), Section 404 of the CWA as administered by the USACE, and *Minnesota Rules*, part 7050.0186 (wetland mitigation) as administered by the MPCA.

A project-specific wetland mitigation plan for Zim was prepared that describes the compensatory wetland mitigation that would be used to replace unavoidable wetland effects associated with the NorthMet Project Proposed Action. The preliminary wetland mitigation plan was submitted to the USACE in November 2011 (PolyMet 2013b).

A wetland restoration plan for Hinckley and Aitkin was prepared describing the compensatory wetland mitigation that would be used to replace unavoidable wetland effects associated with the NorthMet Project Proposed Action. Preliminary wetland restoration plans were submitted to the USACE and MDNR Division of Lands and Minerals in August 2007 (PolyMet 2013b).

Reporting on Mine Site and Plant Site Wetland Hydrology for Potential Indirect Effects

Pre-project wetland hydrology monitoring reports, generated to meet reporting requirements, have been compiled and document 5 years of pre-project planning and monitoring at the Mine Site (2005 to 2009). PolyMet has continued to conduct wetland hydrology monitoring since 2009 at the Mine Site. Pre-project wetland hydrology monitoring at the Plant Site has also been conducted for years 1, 2, and 3 (2010, 2011, and 2012) at the Plant Site and is ongoing. Future project wetland hydrology monitoring reports would be submitted in accordance with any permit issued.

5.2.3.4 NorthMet Project No Action Alternative

Under the NorthMet Project No Action Alternative, the NorthMet Project Proposed Action would not occur and, therefore, the NorthMet Project Proposed Action would have no direct and indirect wetland effects. However, forest harvesting would continue to occur in portions of the federal lands, including the Mine Site. Direct and indirect effects of the NorthMet Project No Action Alternative on wetlands are not expected, as the federal lands would continue to be managed as they currently are. The use of privately owned land could affect wetlands under the NorthMet Project No Action Alternative; however, any wetland effects would require state and/or federal permits. Existing disturbed wetlands associated with the Tailing Basin seepage areas may recover more quickly to a more natural hydrology and wetland system under the NorthMet Project No Action Alternative than under the NorthMet Project Proposed Action.

5.2.4 Vegetation

This section describes the environmental consequences of the NorthMet Project Proposed Action to vegetation, which include direct effects on land cover types, native plant community types, MBS Sites of Biodiversity Significance, and rare or sensitive plant species, as well as effects from existing or introduced invasive non-native species.

Summary

The NorthMet Project Proposed Action would disturb 1,718.6 acres of the Mine Site and have the greatest effect on upland conifer forest land cover types. Approximately 2,178 acres of the Plant Site would be disturbed by the NorthMet Project Proposed Action, with most effects occurring in already disturbed areas and tailings ponds. All land within the Transportation and Utility Corridor would be affected (120.2 acres), the majority of which is already disturbed.

The NorthMet Project Proposed Action would affect 1,718.6 acres of MBS Sites of High Biodiversity Significance, 698.2 acres of “imperiled-vulnerable” or “vulnerable” native plant communities, 92.6 acres of “apparently secure” native plant communities, and 178.9 acres of “widespread and secure” native plant communities.

Disturbed areas would be reclaimed during operations and at closure. Reclamation objectives would include rapidly establishing a self-sustaining plant community, controlling air emissions, controlling soil erosion, providing wildlife habitat, and minimizing the need for maintenance. Seed mixes and methodologies would be designed to minimize the introduction of invasive species. Reclamation seed mixes would be approved during permitting.

There are no federally listed plant species at the NorthMet Project area. There are 11 state-listed plant species, all at the Mine Site; nine species would be directly affected and two would be indirectly affected by the NorthMet Project Proposed Action.

Indirect effects from the NorthMet Project Proposed Action could include dust deposition on vegetation, hydrology changes, ore spillage along the Transportation and Utility Corridor, and erosion on the Tailings Basin. Mitigation measures would be in place for each of these potential effects.

5.2.4.1 Methodology and Evaluation Criteria

This section compares the types of data presented in Section 4.2.4 for the NorthMet Project area. Specifically, GIS data were obtained from the MDNR regarding GAP land cover types, native plant communities, MBS Sites of Biodiversity Significance, and listed ETSC plant species within the NHIS. Data were obtained from the USFS regarding MIH types, forest stand age classes, RFSS, invasive non-native species, and landscape ecosystems. Separate NorthMet Project area-specific listed species survey reports were also utilized to supplement MDNR NHIS data and estimate effects on populations.

GIS analysis was used to calculate effects on the data layers mentioned above. The effects were calculated for habitat types, classifications, and species where they overlap the NorthMet Project area footprints.

Direct effects on natural features (e.g., vegetative cover types, plant communities, MBS Sites of Biodiversity Significance, and rare species) occur through clearing, filling, and other

construction activities. A direct effect on an ETSC plant species occurs when the action results in the removal or loss (i.e., taking) of an individual plant or entire plant population. Direct effects are those that are a result of the NorthMet Project Proposed Action, that are immediate, and that often last for years.

An indirect effect occurs when a cover type, plant community, Site of Biodiversity Significance, or rare species experiences a change in vegetative composition. Indirect effects can occur over time or after the action is completed and can occur on- or off-site. Indirect effects on vegetation may include changes in hydrology, deposition of particulate matter (dust), changes in successional stage, alteration of microclimate (e.g., tree removal resulting in drier soil conditions), loss of pollinators or loss of fungal associates in the rooting zone, erosion and sedimentation, and invasion of non-native species. Indirect effects were estimated by comparing the proximity of the NorthMet Project area infrastructure footprints to existing natural features (e.g., habitat types, plant species present).

5.2.4.2 NorthMet Project Proposed Action

This section describes the effects of NorthMet Project Proposed Action construction, operation, and closure on vegetation cover types and plant species. Potential effects from invasive non-native species are discussed separately.

5.2.4.2.1 Mine Site

Effects on Cover Types

Habitat Types

Construction and operation of the NorthMet Project Proposed Action at the Mine Site would directly affect 1,718.6 acres (57 percent of the Mine Site) of land with various MDNR GAP land cover designations as a result of excavating the mine pits and creating overburden and waste rock stockpiles and associated internal haul roads and drainage ditches. As shown in Table 5.2.4-1, these effects would include 62 percent (741.9 acres) of the upland conifer forest at the Mine Site. Other high-acreage directly-affected cover types include lowland coniferous forest (437.2 acres) and upland deciduous forest (354.7 acres). Approximately 1,295.9 acres, or about 43 percent of the Mine Site, would not be disturbed. The wetland field assessment indicated a high level of wetland quality. Section 5.2.3 provides a more detailed discussion of wetland effects.

Table 5.2.4-1 Direct Effects on Cover Types at the Mine Site

Cover Types	Affected Acres	Non-affected Acres¹	Total Cover Type Acres	Percent of Cover Type Affected
Upland coniferous forest	741.9	453.6	1,195.5	62
Lowland coniferous forest	437.2	344.0	781.2	56
Upland deciduous forest	354.7	293.3	648.0	55
Shrubland	133.0	108.7	241.7	55
Disturbed	44.0	84.0	128.0	34
Aquatic environments	6.0	6.7	12.7	47
Upland conifer-deciduous mixed forest	1.5	0.9	2.4	63
Cropland/grassland	0.2	4.7	4.9	4
Lowland deciduous forest	0.0	0.1	0.1	0
Total ²	1,718.6	1,295.9	3,014.5	57

Source: MDNR 2006b.

¹ Areas of cover types not directly affected by mine pits, stockpiles, roads, or other infrastructure.

² Total acres may be more or less than presented due to rounding.

Minnesota Biological Survey

Approximately 353.6 acres of the One Hundred Mile Swamp MBS Site of High Biodiversity Significance and 1,364.9 acres of the Upper Partridge River MBS Site of High Biodiversity Significance would be affected by the NorthMet Project Proposed Action. The portions of these two MBS sites that are within the Mine Site area represent a small portion of the mapped Sites of High Biodiversity Significance in St. Louis County (2 percent) and the State of Minnesota (less than 1 percent). Habitat effects associated with the NorthMet Project Proposed Action would not result in a large percentage decline in statewide areas ranked as high by the MBS (MDNR 2008a).

Approximately 698.2 acres of the “imperiled-vulnerable” or “vulnerable” native plant communities—the black spruce-Jack pine woodlands (FDn32c; 495.5 acres; 20 percent of community within Laurentian Uplands subsection) and rich black spruce swamp (FPn62a; 202.7 acres; 1 percent of community within Laurentian Uplands subsection)—would also be affected. Approximately 92.6 acres of the “apparently secure” native plant communities—i.e., black spruce bog: treed subtype (APn80a1; 77.7 acres; 4 percent of community within Laurentian Uplands subsection) and poor tamarack-black spruce swamp (APn81b; 14.9 acres; less than 1 percent of community within Laurentian Uplands subsection)—would be affected. Approximately 178.9 acres of “widespread and secure” native plant communities would also be affected, including alder (maple-loosestrife) swamp (FPn73a; 42.5 acres; 3 percent of community within Laurentian Uplands subsection), aspen-birch forest: balsam fir subtype (FDn43b1; 101.1 acres; less than 1 percent of community within Laurentian Uplands subsection), and poor black spruce swamp (APn81a; 35.3 acres; less than 1 percent of community within Laurentian Uplands subsection).

Culturally Important Plants

Effects on wild rice as a result of the NorthMet Project Proposed Action are expected to be minimal. The 10-mg/L sulfate standard for wild rice would be met for the Embarrass River, since the containment and seepage collection system would capture seepage presently going to the

Embarrass River tributaries. The Partridge River will, at certain times of the year, exceed the 10-mg/L sulfate standard, mostly during winter low-flow conditions. During the remainder of the year, in high-flow conditions, the NorthMet Project Proposed Action has a low probability of increasing sulfate contributions. Effects, as well as water quality standards, are discussed more thoroughly in Section 5.2.2.

While a distinct list of plant species important to the Bands is not available, Sections 4.2.9 and 5.2.9 discuss more broadly the effects on the ecological subsections, large landscapes, and connected ecosystems.

Indirect Effects

In addition to the direct effects mentioned above, potential indirect effects on remaining vegetative cover types at the Mine Site could be associated with dust from road traffic and mining operations and with changes in hydrology. Dust on leaves can affect the rates of photosynthesis and respiration, which both influence plant growth. If sulfide-containing dust is deposited on leaves, it could react with oxygen in the air and water from precipitation to create sulfates over a period of weeks to months. This residual build-up in the soil could inhibit growth by slowly acidifying the soil conditions. Such effects of fugitive dust, if any, could potentially occur south of the East Pit and West Pit where haul roads are concentrated and the Rail Transfer Hopper and other facilities are located. The distance dust travels depends on wind speed, antecedent weather conditions, dust particle size, and vegetation density near the source. PolyMet proposes to implement various dust-control measures such as stabilizing disturbed soils by temporarily establishing vegetation and water spraying during dry periods (consistent with *Minnesota Rules*, part 6132.2800). As Section 5.2.7 further describes, fugitive dust control measures would result in 90 percent control at the Mine Site. These measures, which are standard practice for existing taconite mines on the Mesabi Iron Range, have proven to be adequate to minimize potential indirect effects from fugitive dust. As Section 5.2.3 explains, vegetation located within zones with a high likelihood of hydrology effects would be more likely to have community changes than those with no or low likelihood of effect.

Reclamation

Reclamation activities help to offset a portion of the effects of a project. Reclamation and revegetation at the Mine Site would promote cover development and initiate vegetative succession on stockpiles, the combined East Central Pit, and Mine Site infrastructure footprints. Fertilizer would be applied at rates recommended for each group of species planted, and would be worked into the soil to a depth of 8 inches on the level and 4 inches on all slopes (PolyMet 2012n). On areas to be mulched after seeding, no more seed would be sown than could be mulched the same day. Seed would be sown via mechanical Truax native seed drills or hydrospraying at specified rates of application, unless inaccessible or wet areas dictate the use of hand-operated spreaders. Seedbeds would be firmed using cultipackers, or seeds would be hand-raked into the soil, before mulching. Six different types of mulch could be applied, depending on the situation. As nutrients and organic matter are returned to the soil, the conditions on the reclaimed areas would become more suitable for migration of nearby native herbaceous and woody species.

The Category 1 Stockpile would be incrementally and progressively reclaimed throughout the life of the mine, starting in year 14, to minimize erosion of the outer slopes, promote post-closure

land use, and minimize the need for active site care and maintenance during the post-closure period. Prior to construction of the cover system, the stockpile surfaces would be graded for long-term stability, to promote vegetation growth and erosion control, and to develop a surface drainage network over the stockpile (PolyMet 2012s). After grading, an engineered geomembrane system would be constructed. The geomembrane system would consist of, from top to bottom: 18 inches of rooting zone soil consisting of on-site unsaturated overburden mixed with peat, as needed, to provide organic matter; 12 inches of granular drainage material with drain pipes to facilitate lateral drainage of infiltrating precipitation and snowmelt off the stockpile cover; a 40 mil geomembrane barrier layer; and a 6-inch soil bedding layer below the geomembrane (PolyMet 2013c). The stockpile would then be locally contoured to provide some topographic variety to the surface. Finally, the stockpile would be seeded with a certain selection of grasses/forbs at the top and bench flats and a potentially different group of species for the slopes, depending on the availability and suitability of the species (PolyMet 2012n). The three groups of species designated for the top and benches would include a native, slow-growth mix; a non-native, rapid-growth mix; and a mix of both native and non-native species. The species mix for the stockpile slopes would contain the same native species as the stockpile bench and flats, and a slightly modified group of non-native species. The cover would store precipitation within the loose layer during the period when vegetation is dormant. The trapped water would then be removed from the cover system by transpiration of the plants during the growing season and evaporation. Vegetation would also aid in stabilizing the cover from wind and rain erosion (PolyMet 2012s).

Both the Category 2/3 Stockpile and the Category 4 Stockpile would be temporary and would be removed at closure. Temporary stockpile reclamation would begin during operations. The material in these stockpiles would be relocated to the East Pit starting in year 11 (PolyMet 2013c). After removal of the material, the footprint of the Category 2/3 Stockpile and portions of the Category 4 Stockpile that do not become the Central Pit would be reclaimed by subsequent seeding and planting of grass and forb species similar to those planted for the Category 1 Stockpile top and benches (PolyMet 2012n). Depressions in both temporary stockpile footprints with sufficient hydrology and soil conditions would be seeded with a different group of native grasses (e.g., fringed brome, bluejoint, Virginia wild rye, tall manna grass, fowl bluegrass, tussock sedge, pointed broom sedge, dark green bulrush, and woolgrass) and forbs (e.g., Canada anemone, marsh milkweed, flat-topped aster, common boneset, grass-leaved goldenrod, spotted Joe Pye weed, blue monkey flower, giant goldenrod, and Eastern panicled aster) suitable for wet soils. The West Pit would become open water, while the combined East Central Pit would be partially filled with material from the Category 2/3 Stockpile and Category 4 Stockpile to support wetland vegetation with species discussed above for the removed stockpile depressions (see Table 5.2.4-2). The pit wall overburden slopes would be planted with the same mix mentioned for stockpile slopes above (PolyMet 2012n). The acres reclaimed (see Table 5.2.4-2) do not equal the acres disturbed as some haul roads and buildings would remain after cessation of operations.

Following demolition of Mine Site buildings and parking areas, suitable overburden would be placed over the footprint, to a depth of 2 ft., and revegetated (PolyMet 2013a). Mine Site roads deemed unnecessary for future access by the MDNR would be scarified and revegetated, as well. Disturbed areas, building sites, and reclaimed roads would all be seeded with a similar mix of grass and forb species as that planted on the Category 1 Stockpile top and benches (PolyMet 2012n).

Table 5.2.4-2 Proposed Vegetation Types and Acreages for Reclaimed Stockpiles and Pits at the Mine Site

Type	Proposed Reclamation Vegetation	Acres
Category 1 Stockpile	Grassland/herbaceous	526
Category 2/3 Stockpile (Removed)	Wetland; Grassland/herbaceous	180
Category 4 Stockpile (Removed)	Wetland; Grassland/herbaceous	57*
Ore Surge Pile (Removed)	Wetland; Grassland/herbaceous	31
Overburden Storage and Laydown Area (Removed)	Wetland; Grassland/herbaceous	41
Combined East Central Pit	Wetland	207*
West Pit	Open pit lake	321
Roads, Parking Areas, Buildings	Grassland/herbaceous	88

Source: PolyMet 2012n; PolyMet 2013c; PolyMet 2012s; Kearney, Barr Engineering, Pers. Comm., February 6, 2013.

*The Central Pit would be mined at the location of the temporary Category 4 Stockpile after it is removed. The reclamation acres for the Category 4 Stockpile and the Combined East Central Pit overlap.

Effects of Invasive Non-native Plants

Disturbances associated with the construction of the Mine Site would result in exposed soil surfaces that would have the potential for colonization by invasive species. PolyMet proposes to temporarily vegetate and stabilize disturbed areas during operation and permanently reclaim during closure by spreading seeds. Species proposed for revegetation on most disturbed areas and the Category 1 Stockpile top and benches include native and non-native species. There are native grass species (e.g., fringed brome, switchgrass, Canada wild rye, bluejoint, poverty oatgrass, slender wheatgrass, fowl bluegrass, and false melic) and native forb species (e.g., common yarrow, pearly everlasting, flat-topped aster, tall cinquefoil, large-leaved aster, stiff goldenrod, smooth wild rose, black-eyed susan, gray goldenrod, upland white goldenrod, Lindley's aster, smooth aster, and American vetch). According to the PolyMet Reclamation Seeding and Mulching procedure (PolyMet 2012n), preference would be given to establishing native plant communities, and the introduction of invasive plant species would be avoided to the extent practicable. Reclamation objectives include rapidly establishing a self-sustaining plant community, controlling air emissions, controlling soil erosion, providing wildlife habitat, and minimizing the need for maintenance.

Non-native species that could be planted include: oats, winter wheat, alfalfa, timothy, redtop, alsike clover, white clover, Canada bluegrass, intermediate wheatgrass, cicer milkvetch, birdsfoot trefoil, perennial ryegrass, smooth brome grass, meadow brome, and red fescue. These species are known to establish quickly and form a nearly complete groundcover, which can help prevent erosion, maintain water quality, and increase soil stability on more susceptible areas. The legume species listed would also fix atmospheric nitrogen into the soil to help re-establish soil nutrients. Generally, these species would be planted as temporary cover crops until the native species developed and could out-compete them. However, some of the proposed species are considered invasive (e.g., birdsfoot trefoil, redtop, smooth brome grass, Canada bluegrass). Section 5.2.4.2.4 discusses suggested mitigation measures for non-native or invasive species.

The proposed Type 1 mulch (hay, straw, and agricultural grass/legume cuttings) would be relatively free of seed-bearing stalks or propagules of noxious weed species, as defined by the rules and regulations of the Minnesota Department of Agriculture (PolyMet 2012n).

The introduction of invasive non-native species would be more detrimental to the relatively high-quality vegetation communities at the Mine Site than to those at the Plant Site, which is already heavily disturbed. Introduction of invasive non-native species could result in decreased diversity of plant species and habitats available to wildlife species. Several ETSC plant species at the Mine Site may be susceptible to increased competition from invasive non-native species. There are already a few occurrences of yellow sweetclover and bladder campion at the Mine Site, which may invade future disturbed areas.

Minnesota's noxious weed law (*Minnesota Statutes* § 18.75-18.91) contains procedures for controlling and eradicating noxious weeds on all lands within the state. None of the species proposed to be potentially planted are considered state-prohibited noxious weeds. The MDNR has made recommendations for non-invasive species for the seed mix and the final seed mix would be approved during permitting.

Effects on Threatened and Endangered Plant Species

The MDNR NHIS and separate rare species surveys were utilized to map known ETSC species locations using GIS data. Updated MDNR Element Occurrence attribute data were used to estimate the NorthMet Project area and statewide population numbers of a species, per MDNR guidance (Joyal, MDNR, Pers. Comm., February 13, 2012). An individual is defined here as a single plant of a species. A colony (observation) is a group of individual plants of one species in a distinct geographic location. A population is a group of individuals or colonies of one species that may be separated geographically, but are close enough geographically to interbreed and persist over time.

No federally listed threatened or endangered plant species occur at the Mine Site. However, the NorthMet Project Proposed Action would have both direct (nine species) and indirect (two species) effects on state-listed ETSC plant species at the Mine Site, affecting 1 percent of the known statewide populations for these 11 species. Table 5.2.4-3 summarizes the direct and indirect NorthMet Project Proposed Action effects on each of the ETSC plant species that are located in the vicinity of the Mine Site, which includes some of the Transportation and Utility Corridor. These numbers may overestimate the actual effects as a proportion of the number of actual populations in the state. Intensive surveys, such as those performed at the Mine Site, have not been performed throughout the state; therefore, the actual number of statewide populations may be larger than that identified in the MDNR NHIS.

Rulemaking was conducted with the intent to update the list of ETSC species (*Minnesota Rules*, parts 6134.0100 to 6134.0400), with new listings becoming effective on August 19, 2013. The FEIS will consider any new listings, or changes in the previous listings, associated with the updated list.

Table 5.2.4-3 Effects on Known State-listed ETSC Plant Populations in the Vicinity of the Mine Site, Including the Transportation and Utility Corridor

Plant Species (state status/ global status ¹)	Known Mine Site Populations					Known Statewide Populations				
	Total Populations ^{2,7}	Total Individuals	Direct Effects ³ (Populations)	Indirect Effects ⁴ (Populations)	Unaffected Populations	Total Known Populations ^{5,7}	Average Individuals per Population ⁶	Percent Directly Affected (Populations)	Percent Indirectly Affected (Populations)	Total Percent Affected (Populations)
<i>Botrychium campestre</i> (SC/G3)	1	1	1	0	0	69	unknown	1	0	1
<i>Botrychium pallidum</i> (E/G3)	1	21	1	0	0	99	15	1	0	1
<i>Botrychium rugulosum</i> (T/G3)	1	4	1	0	0	72	14	1	0	1
<i>Botrychium simplex</i> (SC/G5)	3	1,580	3	0	0	210	25	1	0	1
<i>Caltha natans</i> (E/G5)	1	56	1	0	0	12	unknown	8	0	8
<i>Eleocharis nitida</i> (T/G4)	1	~1,562 ft ²	1	0	0	49	450	2	0	2
<i>Juncus stygius</i> var. <i>americanus</i> (SC/G5)	1	1	0	1	0	30	unknown	0	3	3
<i>Platanthera clavellata</i> (SC/G5)	1	3	0	1	0	123	unknown	0	1	1
<i>Ranunculus lapponicus</i> (SC/G5)	1	~919 ft ²	1	0	0	83	51	1	0	1
<i>Sparganium glomeratum</i> (SC/G4)	1	78	1	0	0	158	82	1	0	1
<i>Torreyochloa pallida</i> (SC/G5)	1	~25 ft ²	1	0	0	74	unknown	1	0	1
Total	13	NA	11	2	0	979	NA	NA	NA	NA

Source: MDNR 2011m; MDNR 2013a.

- ¹ The state status is E – Endangered; T – Threatened; and SC – Species of Concern. The global ranks range from G1 to G5. A lower global ranking (e.g., G3) indicates a species at higher global risk than higher ranking (e.g., G5) (NatureServe 2011).
- ² Populations are interpreted from MDNR NHIS data using Element Occurrence, which differs from the DEIS, which used colonies as the population estimate.
- ³ Direct effects are expected for those populations that would be removed or buried by mine activities. Effects are calculated for populations rather than individuals because of the large variation and inaccuracies in the estimates of number of individuals per population.
- ⁴ Indirect effects may occur to those populations within or near the Mine Site. These populations may be affected by changes in hydrology, water quality, dust, or inadvertent activities. As above, effects are given for populations rather than individuals.
- ⁵ Statewide population data provided by Lisa Joyal (MDNR) on March 26, 2013.
- ⁶ Population estimates are approximate and used for comparative purposes only. The number of individuals is based upon populations for which data exist.
- ⁷ Data included here were provided by the Division of Ecological Resources, MDNR, and were current as of March 13, 2013. These data are not based on an exhaustive inventory of the state. The lack of data for any geographic area shall not be construed to mean that no significant features are present.

The NorthMet Project Proposed Action would directly affect 9 of the 11 stated-listed ETSC plant species found at or in the immediate vicinity of the Mine Site (see Table 5.2.4-3). Most of the direct effects would involve the complete loss of colonies within a population as a result of excavation of the mine pits, burial under stockpiles, or disturbance during infrastructure construction.

The NorthMet Project Proposed Action would indirectly affect 2 of the 11 state-listed ETSC plant species found at or in the immediate vicinity of the Mine Site (see Table 5.2.4-3). The NorthMet Project Proposed Action may also result in indirect effects on some colonies of the directly affected state-listed ETSC plant species at the Mine Site. These indirect effects may occur as a result of changes in hydrology or water quality, deposition of particulate matter (dust), application of road salts, or weed incursion. Individual species appear to differ in their response to these indirect effects. For example, several of the ETSC plant species typically occur along or in old tailings ponds or along roadsides where disturbance and dust are frequent. To a certain extent, each species' sensitivity to disturbance can be inferred from currently occupied habitats. Habitats were considered "disturbed" if they consisted of tailings ponds, gravel pits, landing pads, logging roads, ditches, or roadsides. Disturbance-tolerant species may, in some cases, actually be disturbance-dependent. However, several species may not actually be disturbance-tolerant, as much as they are able to colonize previously disturbed sites. Repeated soil disturbance near these species may have an effect on such populations in the short term. Overall, less than 1 percent of the known statewide populations for these state-listed ETSC species would be indirectly affected by the NorthMet Project Proposed Action. In some cases, potential indirect effects on ETSC plant species that would be near, but outside, the footprint of these facilities could be avoided or reduced by fencing or flagging ETSC populations to prevent disturbance.

Minnesota's endangered species law (*Minnesota Statute*, § 84.0895) and associated rules (*Minnesota Rules*, parts 6212.1800–6212.2300 and 6134) impose a variety of restrictions, permits, and exemptions pertaining to ETSC species. "The law and rules prohibit taking, purchasing, importing, possessing, transporting, or selling" endangered or threatened plants, including their parts or seeds, without a permit (MDNR 2011m). "Taking," as it relates to plants includes picking, digging, or destroying. There is the potential that PolyMet would need to seek a Take Permit from the MDNR for state-listed ETSC plant species. If it is determined by the MDNR that there are no feasible alternatives to taking, the applicant must pursue compensatory mitigation. Transplantation is generally not considered by the MDNR to be acceptable mitigation for taking of endangered or threatened species (MDNR 2011m). The MDNR suggests that typical compensatory mitigation for taking endangered or threatened species in Minnesota include the following:

- funding state acquisition of another site where the species occurs that is currently unprotected and vulnerable to destruction,
- funding additional survey work to locate other sites, and/or
- funding research to improve our understanding of the habitat requirements or protection needs of the species (MDNR 2011m).

A discussion of the effects on each individual ETSC species is provided below.

Botrychium campestre (prairie moonwort) populations are commonly observed on sparsely vegetated mineral soil from sediments of iron mine tailings ponds and grassy railroad

embankments (NatureServe 2011). Of the 69 known populations statewide, one colony of one population within the Mine Site area, along Dunka Road, could be directly affected by pipeline construction and road improvements/maintenance as part of the NorthMet Project Proposed Action (1 percent affected) (see Table 5.2.4-3). This species is less tolerant of disturbance than other *Botrychium* species; however, since it prefers sparsely vegetated areas, it may actually expand into disturbed areas along Dunka Road in the future. At the Mine Site, grassland areas would not be affected, but around 34 percent of previously disturbed areas would be affected, resulting in potentially reduced on-site habitat for this species (see Table 5.2.4-1).

Botrychium pallidum (pale moonwort) populations are most commonly observed on mine tailings basins and along roadsides. Of the 99 known populations statewide, three colonies of one population within the Mine Site, along Dunka Road, could be directly affected by pipeline construction and road improvements/maintenance as part of the NorthMet Project Proposed Action (1 percent affected) (see Table 5.2.4-3). One separate colony is located near the railroad track and may be indirectly affected. This species, however, appears to be semi-tolerant of disturbance since sites that are kept open by regular disturbance are particularly suitable (NatureServe 2011). Colonies may actually expand into newly disturbed areas along Dunka Road and at the Mine Site. Grassland areas at the Mine Site would not be affected, but around 34 percent of previously disturbed areas would be affected, resulting in reduced on-site habitat for this species (see Table 5.2.4-1).

Botrychium rugulosum (ternate, or St. Lawrence, grapefern) often occurs on tailings basins, along roadsides, and in shaded wetland forests. Of the 72 known extant populations in Minnesota, one population (with four individuals) occurs along Dunka Road at the Mine Site (1 percent affected) (see Table 5.2.4-3). This population may be directly affected by vehicle operation or road improvements and maintenance as part of the NorthMet Project Proposed Action. This species appears to be semi-tolerant of disturbance and populations. At the Mine Site, around 62 percent of upland conifer forests and around 55 percent of upland deciduous forests would be affected, resulting in much less on-site habitat for this species (see Table 5.2.4-1).

Botrychium simplex (least moonwort) frequently occurs in shrublands, forests, tailings basins, and along roadsides. Of the 210 known populations statewide, three occur at the Mine Site, all of which are expected to be directly affected (see Table 5.2.4-3). Of these populations, 21 colonies are expected to be directly affected—seven from stockpiles and mine pits, and another 14 from construction of the haul roads, water pipeline, ditches, railroad track, or transmission line (1 percent affected). The colonies affected by stockpiles and mine pits would be removed, while the colonies affected by construction of pipelines or ditches may be reduced in the short term. Depending on proximity to construction activities, some of these colonies would likely recover by expanding along Dunka Road and at the Mine Site post-closure, as this species appears to be semi-tolerant of disturbance. At the Mine Site, around 34 percent of disturbed areas and around 55 percent of shrublands would be directly affected, resulting in less on-site habitat for this species (see Table 5.2.4-1).

Caltha natans (floating marsh-marigold) is found primarily in relatively undisturbed habitats and is not likely to be tolerant of disturbance. Of the 12 known populations statewide, one population, which consists of 13 colonies, occurs at the Mine Site (see Table 5.2.4-3). One colony is expected to be directly affected by stockpile development. Two other colonies are located close to Dunka Road and could be indirectly affected by road construction or

improvements. Ten other colonies are located in the vicinity of, but outside, the Mine Site, several of which occur along the Partridge River. Since water from the West Pit would be discharged downstream of these colonies, it is unlikely there would be indirect effects on them. Since the known statewide population for this species is rather small, the effect on its population in Minnesota would be correspondingly larger (8 percent affected). The mitigation measures mentioned above, particularly the purchase of an unprotected site with a population of the species, should be assessed. At the Mine Site, around 47 percent of aquatic environments would be directly affected, resulting in reduced on-site habitat for this species (see Table 5.2.4-1).

Eleocharis nitida (neat spike-rush) at the Mine Site is primarily observed in roadside ditches along Dunka Road with gravel or sandy substrates. Of the 49 known populations in the state, one occurs on the Mine Site (2 percent affected) (see Table 5.2.4-3). Of this population, eight colonies are found along Dunka Road, and three colonies are located along the railroad tracks. All of the eight Dunka Road colonies are likely to be directly affected by ditch construction. The other three colonies may be indirectly affected by changes in hydrology or water quality. This species seems to be semi-tolerant of disturbance since it has inhabited roadside ditches. At the Mine Site, around 47 percent of aquatic environments and 34 percent of disturbed areas would be directly affected, resulting in less on-site habitat for this species (see Table 5.2.4-1).

Juncus stygius var. *americanus* (bog rush) has 30 known populations in the state, none of which occur at the Mine Site; however, one population is located upgradient of the Mine Site within the One Hundred Mile Swamp (see Table 5.2.4-3). This population would not be directly affected, but it may be indirectly affected by changes in hydrology (3 percent affected). However, Section 5.2.3 indicates there would likely be no wetland hydrology effects in this area. At the Mine Site, around 56 percent of lowland coniferous forests would be directly affected, resulting in reduced habitat nearby for this species (see Table 5.2.4-1).

Platanthera clavellata (club-spur orchid) has 123 known populations in the state, none of which occur at the Mine Site; however, one population is located upgradient of the Mine Site within the One Hundred Mile Swamp (see Table 5.2.4-3). This population would not be directly affected, but three colonies may be indirectly affected by changes in hydrology, since the species is sensitive to this type of change (1 percent affected). However, Section 5.2.3 indicates there would likely be no wetland hydrology effects in this area. At the Mine Site, around 56 percent of lowland coniferous forests would be directly affected, resulting in reduced habitat nearby for this species (see Table 5.2.4-1).

Ranunculus lapponicus (lapland buttercup) is found in conifer/sphagnum bogs on the Mine Site. Of the 83 known populations statewide, one population occurs at the Mine Site (1 percent affected) (see Table 5.2.4-3). Of this population, three colonies are expected to be directly affected by construction of a waste rock stockpile. The other four colonies may be indirectly affected by changes in hydrology, water chemistry, or dust. This species may face short- and long-term effects at the Mine Site since it is most likely intolerant of disturbance. At the Mine Site, around 56 percent of lowland coniferous forests would be directly affected, resulting in much less on-site habitat for this species (see Table 5.2.4-1).

Sparganium glomeratum (clustered bur-reed) has been observed along roadsides and in lowland forests. Of the 158 known populations statewide, one population occurs at the Mine Site (1 percent affected) (see Table 5.2.4-3). Of this population, eight colonies would be directly affected—three colonies by construction of the mine pits and stockpiles, and five colonies along

Dunka Road by construction of the water pipeline, railroad track, or transmission line. The remaining five colonies may be indirectly affected by changes in hydrology, water quality, or dust. This species may be slightly tolerant of some disturbance, since it can be found along disturbed wetland edges; however, short-term effects may be more pronounced than long-term effects. At the Mine Site, around 47 percent of aquatic environments and 56 percent of lowland coniferous forests would be directly affected, resulting in much less on-site habitat for this species (see Table 5.2.4-1).

Torreyochloa pallida (Torrey's manna-grass) is often seen along roadsides and may be semi-tolerant of disturbance. Of the 74 known populations statewide, one occurs at the Mine Site (1 percent affected) (see Table 5.2.4-3). Of this population, one colony along Dunka Road may be directly affected by construction of a transmission line. The remaining three colonies are located away from any proposed construction and may be sufficiently removed from potential direct and indirect effects of the NorthMet Project Proposed Action. At the Mine Site, around 47 percent of aquatic environments and 56 percent of lowland coniferous forests would be directly affected, resulting in less on-site habitat for this species (see Table 5.2.4-1).

Regional Foresters Sensitive Species

The USFS RFSS data layer indicates there are no known RFSS plants on the federal lands, which include the majority of the Mine Site. However, several state-listed ETSC plant species known to exist on the Mine Site are also listed as RFSS plants in the Superior National Forest. Six of these species would be affected by the NorthMet Project Proposed Action, including *Botrychium pallidum*, *Botrychium rugulosum*, *Botrychium simplex*, *Caltha natans*, *Eleocharis nitida*, and *Juncus stygius* var. *americanus*.

MIH types are not fully mapped for the Mine Site since not all of it consists of federal land, but MIH types are mapped for the federal lands located within the Mine Site. On this portion of the Mine Site, upland forest (MIH 1; approximately 531 acres affected) would be affected the most of all MIH types, which means RFSS plant species listed under the upland forest category (see Table 4.2.4-5) could be most affected by the NorthMet Project Proposed Action. However, since there are suitable habitats for each RFSS species within each MIH type, a direct correlation between loss of MIH and loss of RFSS plants cannot be made. Upland conifer forest (MIH 5; approximately 505 acres affected) lands would be the next group most affected, though there is overlap of this category with upland forest since upland conifer forest occurs within upland forest types. Some RFSS species that occupy upland forest may also be affected by this category. Lowland black spruce-tamarack forest (MIH 9; approximately 483 acres affected) would be subject to effects comparable to upland conifer forest, and some of the RFSS species listed in this category would be affected similarly. The lowland emergent wetland type would be affected (approximately 11 acres affected), but likely only one of the five RFSS plant species listed for that type may be minimally affected. Aquatic habitat (MIH 14) is not mapped at the Mine Site; however, there are some aquatic habitats on the parcel that would be affected and, thus, some of the RFSS species listed in this category may be affected. Section 5.2.6 provides further discussion of effects on aquatic habitats and species.

The one RFSS plant not listed as an ETSC species but that is known to occur on the Mine Site, according to MDNR NHIS data, is *Botrychium michiganense*, which is very closely related to *Botrychium hesperium*. *B. hesperium* typically occurs in western states, while *B. michiganense* typically occurs around the Great Lakes states. One population is known to occur on the Mine

Site, of which five colonies would be affected by stockpile development, haul road placement, or the Transportation and Utility Corridor immediately adjacent to the Mine Site (MDNR 2013a). It often occurs in grassy roadsides and fields, and requires at least somewhat open habitat created by natural disturbance events. While anthropogenically disturbed areas have been observed to harbor reasonably large numbers of individuals, habitat created in this way has not been proven to support long-term viable populations (NatureServe 2013). At the Mine Site, grassland areas would not be affected, but around 34 percent of previously disturbed areas would be affected, resulting in potentially reduced on-site habitat for this species (see Table 5.2.4-1).

The USFS determined that the NorthMet Project Proposed Action would not affect 20 RFSS plants on the Superior National Forest. These 20 species include: alpine milkvetch, *Arctoparmelia centrifuga*, *Arctoparmelia subcentrifuga*, Braun's holly fern, creeping rush, Chilean sweet-cicely, Douglas' hawthorn, white mountain saxifrage, largeleaf sandwort, little goblin moonwort, Northern arnica, maidenhair spleenwort, muskroot, nodding saxifrage, Oakes' pondweed, Scotch false asphodel, short sedge, smooth woodsia, triangle grapefern, and Wain's cup lichen. In addition, the NorthMet Project Proposed Action may affect individuals, but are not likely to cause a trend to federal listing or loss of viability for the remaining 38 RFSS plants on the Superior National Forest. Please see the Biological Evaluation listed on the USFS website (<http://www.fs.usda.gov/goto/superior/northmet>) for more information about effects on RFSS plants.

5.2.4.2.2 Transportation and Utility Corridor

Effects on Cover Types

Habitat Types

Construction and transportation activities within the Transportation and Utility Corridor, as part of the NorthMet Project Proposed Action, would affect all 120.2 acres of the MDNR GAP land cover designations (see Table 5.2.4-4). The majority of effects would be on formerly disturbed (94.4 acres) and grassland areas (9.8 acres).

Table 5.2.4-4 Direct Effects on Cover Types at the Transportation and Utility Corridor

Cover Types	Affected Acres	Non-affected Acres	Total Cover Type Acres	Percent of Cover Type Affected
Disturbed	94.4	0	94.4	100
Cropland/grassland	9.8	0	9.8	100
Shrubland	7.7	0	7.7	100
Aquatic environments	2.7	0	2.7	100
Upland deciduous forest	2.7	0	2.7	100
Upland coniferous forest	2.6	0	2.6	100
Lowland coniferous forest	0.2	0	0.2	100
Lowland deciduous forest	0.0	0	0.0	100
Upland conifer-deciduous mixed forest	0.0	0	0.0	100
Total ¹	120.2	0	120.2	100

Source: MDNR 2006b.

¹ Total acres may be more or less than presented due to rounding.

Minnesota Biological Survey

The NorthMet Project Proposed Action would affect 22.5 acres of MBS Sites of High Biodiversity Significance (2.9 acres of the One Hundred Mile Swamp and 19.6 acres of the Upper Partridge River) within the Transportation and Utility Corridor. Similar to the Mine Site, this 22.5-acre area represents a very small portion of the mapped Sites of High Biodiversity Significance in St. Louis County (less than 1 percent) and the State of Minnesota (less than 1 percent). Habitat effects associated with the NorthMet Project Proposed Action would not result in a large percentage decline in those areas ranked as high by the MBS.

NorthMet Project Proposed Action activities within the corridor would also affect approximately 2 acres of “widespread and secure” native plant communities, including 2 acres of the aspen-birch forest: balsam fir subtype (FDn43b1; less than 1 percent of community within Laurentian Uplands subsection), and less than 0.1 acre of the low shrub poor fen (APn91a; less than 1 percent of community within Laurentian Uplands subsection).

Indirect Effects

Potential indirect effects on vegetative cover types remaining along the Transportation and Utility Corridor could include those caused by dust from road traffic or spillage from rail cars. Section 5.2.4.2.1 provides further discussion on the effects of dust. The new proposed side-dump rail ore cars are a different design than the bottom-dump rail pellet cars that were used during past LTVSMC operations. The side-dump rail ore cars are designed to contain fine ore pieces to the center of the cars where they are unlikely to spill through the hinge gaps (PolyMet 2013c). Larger pieces of ore that are spilled from the cars would be recovered during routine maintenance of the track, thus minimizing indirect effects. As Section 5.2.7 further describes, no significant reactive airborne fugitive dust from the rail transport is expected. Smaller effects in already-disturbed areas could occur along Dunka Road near the Mine Site. A water pipeline for treated water and a transmission line would be constructed along Dunka Road on previously disturbed land. Construction of the pipeline and transmission line would expose soil during construction and could bury vegetation under rock fill.

Reclamation

Dunka Road would not be reclaimed after the NorthMet Project area is closed, since it is an existing private road. Railroad track and ties that are not used by common carriers would be removed and recycled (PolyMet 2013c). The treated water pipeline between the Mine Site and Plant Site would be removed (PolyMet 2013a).

Effects of Invasive Non-native Plants

The Transportation and Utility Corridor is already disturbed, and contains several non-native and/or invasive species. Disturbance associated with the widening of Dunka Road and installation of the water pipeline, transmission line, and rail line would result in exposed soil surfaces that would have the potential for colonization of invasive species. Therefore, the general effects of invasive non-native plant species at the Transportation and Utility Corridor would be the same as the Mine Site or Plant Site.

Effects on Threatened and Endangered Plant Species

No federally listed threatened or endangered plant species occur within the Transportation and Utility Corridor. The NorthMet Project Proposed Action would have both direct and indirect effects on the same state-listed ETSC plant species as those found at the Mine Site. Since some of the populations occur along Dunka Road near or overlapping the Mine Site, they are discussed in Section 5.2.4.2.1 along with the effects on plant populations at the Mine Site. Table 5.2.4-3 summarizes the direct and indirect effects of the NorthMet Project Proposed Action on each of those ETSC plant species. For the ETSC species located within the Transportation and Utility Corridor not adjacent to the Mine Site (*Botrychium pallidum*), effects are discussed below (see Table 5.2.4-5). As mentioned for the Mine Site, these numbers may overestimate the actual effects as a proportion of the number of actual populations in the state.

Rulemaking was conducted with the intent to update the list of ETSC species (*Minnesota Rules*, parts 6134.0100 to 6134.0400), with new listings becoming effective on August 19, 2013. The FEIS will consider any new listings, or changes in the previous listings, associated with the updated list.

Table 5.2.4-5 Effects on Known State-listed ETSC Plant Populations in the Transportation and Utility Corridor

Plant Species (state status/ global status ¹)	Known Mine Site Populations					Known Statewide Populations				
	Total Populations	Total Individuals	Direct Effects ² (Populations)	Indirect Effects (Populations)	Unaffected Populations	Total Known Populations ³	Average Individuals per Population ⁴	Percent Directly Affected (Populations)	Percent Indirectly Affected (Populations)	Total Percent Affected (Populations)
<i>Botrychium pallidum</i> (E/G3)	3	16	3	0	0	99	15	3	0	3
Total	3	16	3	0	0	99	NA	NA	NA	NA

Source: Barr 2012w.

¹ The state status is E – Endangered. The global ranks range from G1 to G5. A lower global ranking (e.g., G3) indicates a species at higher global risk than higher ranking (e.g., G5) (NatureServe 2011).

² Direct effects are expected for those populations that would be removed or buried by road improvement activities. Effects are calculated for populations rather than individuals because of the large variation and inaccuracies in the estimates of number of individuals per population.

³ Statewide population data provided by Lisa Joyal (MDNR) on March 26, 2013. Statewide population data does not include the three populations of *B. pallidum* found during NorthMet Project Proposed Action-specific survey (Barr 2012w), as these were not included in NHIS data, thus inflating effects on statewide population.

⁴ Population estimates are approximate and used for comparative purposes only. The number of individuals is based upon populations for which data exist.

The NorthMet Project Proposed Action would directly affect the one stated-listed ETSC plant species (*Botrychium pallidum*) found within the Transportation and Utility Corridor not adjacent to the Mine Site (see Table 5.2.4-5). The direct effects would involve the complete loss of populations as a result of disturbance during road construction and improvement activities. Section 5.2.4.2.1 above discusses Minnesota's endangered species law, as well as permits and mitigation for ETSC species.

Botrychium pallidum (pale moonwort) populations are most commonly observed on mine tailings basins and along roadsides. Of the 99 known NHIS populations statewide, six colonies of three populations along Dunka Road could be directly affected by road improvements or maintenance as part of the NorthMet Project Proposed Action (3 percent affected) (see Table 5.2.4-5). These populations were found during a separate species survey and are not included in the NHIS data. In addition, without the NHIS element occurrence attribute, it was estimated that there are three distinct populations by virtue of three separate locations of the six colonies. Thus, the effects on statewide populations are slightly inflated. All of the grassland and previously disturbed areas along the Transportation and Utility Corridor would be affected, resulting in reduced on-site habitat for this species (see Table 5.2.4-4).

5.2.4.2.3 Plant Site

Effects on Cover Types

Habitat Types

Construction, operation, and closure of the NorthMet Project area at the Plant Site would have fewer effects on native vegetation than at the Mine Site because much of the Plant Site (61 percent) has already been heavily disturbed or is barren (see Table 4.2.4-8). Most of the effects of the NorthMet Project Proposed Action are on disturbed areas or tailings ponds, but other affected areas include isolated stands of forest or shrublands (see Table 5.2.4-6). Other effects on MDNR GAP land cover types at the Plant Site are smaller. Approximately 2,177.5 acres (48 percent) of the Plant Site would be affected by NorthMet Project Proposed Action activities. A description of the potential effects on wetlands north of the Tailings Basin is presented in Section 5.2.3.

Table 5.2.4-6 Direct Effects on Cover Types at the Plant Site¹

Cover Types	Affected Acres	Non-affected Acres ²	Total Cover Type Acres	Percent of Cover Type Affected
Disturbed	1,102.5	1,653.0	2,755.5	40
Aquatic environments	572.7	64.0	636.7	90
Upland deciduous forest	290.1	356.6	646.7	45
Shrubland	139.5	193.9	333.4	42
Upland coniferous forest	52.0	47.8	99.8	52
Lowland coniferous forest	20.7	21.2	41.9	49
Cropland/grassland	0.0	0.0	0.0	0
Lowland deciduous forest	0.0	0.0	0.0	0
Upland conifer-deciduous mixed forest	0.0	0.0	0.0	0
Total	2,177.5	2,336.5	4,514.0	48

Source: MDNR 2006b.

¹ This table reflects only those effects on plant communities occurring within the boundaries of the Plant Site. The table does not include the potential indirect effects on the wetlands north of the Tailings Basin due to hydrology changes.

² Areas of cover types not within a 50-ft buffer of buildings, Tailings Basin/spillway reclamation area, or railroad connection.

Minnesota Biological Survey

There are no MBS Sites of Biodiversity Significance or native plant communities identified at the Plant Site.

Indirect Effects

In addition to the direct effects mentioned above, indirect effects on vegetation at and surrounding the Plant Site could include dust or erosion. Vegetation would be established on tailings dams during construction to minimize erosion and fugitive dust (PolyMet 2013m). Water level would be managed in the Tailings Basin to limit the amount of exposed beach, which would minimize dust. Additionally, other fugitive dust control measures (e.g., mulching, temporary seeding, and dust suppressants) would be applied to inactive beaches. As Section 5.2.7 further describes, fugitive dust control measures would result in an 80 percent reduction of emissions at the Plant Site. In the event erosion occurs on the Tailings Basin, it would be corrected and re-vegetated; if necessary for repetitive or excessive erosion, channels or outfall structures would be designed to address the issue.

Reclamation

At closure, the buildings and other infrastructure at the Plant Site would be removed, and foundations would be razed and buried to a minimum depth of 2 ft. with overburden material suitable for vegetation. Plant Site roads that are not deemed necessary for access by the MDNR would be scarified and vegetated, and asphalt from paved surfaces would be removed and recycled. These disturbed areas would be seeded with the same potential three mixes (native, non-native, or mixed) as those mentioned for disturbed areas in Section 5.2.4.2.1 (PolyMet 2012n).

The Tailings Basin would be incrementally reclaimed by a qualified professional pursuant to *Minnesota Rules*, part 6132.2700. As dams are constructed, exterior slopes would be stabilized and vegetated in accordance with requirements in the Fugitive Emissions Control Plan (PolyMet 2013m). Inactive interior beach areas would be temporarily vegetated as necessary for fugitive

dust control, using oats, winter wheat, annual ryegrass, white clover, redtop, and alsike clover, or some combination of these species for various times of the year (PolyMet 2012n). The exterior dam faces would be permanently vegetated by a qualified reclamation contractor according to requirements of the Reclamation Seeding Plan. Upland areas would be planted with permanent vegetation and mulched to control potential fugitive dust in accordance with requirements in the Fugitive Emissions Control Plan. Upland beach areas would be planted with the same potential three mixes (native, non-native, or mixed) as that mentioned for disturbed areas in Section 5.2.4.2.1, while the dam slopes and benches would be planted with the same mix as that mentioned for the slopes of the Category 1 Stockpile (PolyMet 2012n). Interior portions would be graded to provide a gently sloping surface that effectively routes storm water runoff to the interior of the Tailings Basin and promotes wetlands creation between the beach and pond areas. Exposed beach areas would be amended with bentonite to limit oxygen infiltration into the tailings. The cover layer of tailings would be replaced and vegetated in accordance with requirements of the Reclamation Seeding Plan (PolyMet 2013m). Wet soils near the Tailings Basin pond would be planted with the same mix as that mentioned for the East Pit backfill and depressions in the temporary stockpile footprints (see Section 5.2.4.2.1) (PolyMet 2012n). Establishment of dense vegetative cover and root mass is among the most effective methods to minimize erosion, so the quality and density of the vegetation would be periodically reviewed after final reclamation construction is complete. Areas where vegetation does not become well established would receive additional seeding and/or fertilizer and other amendments in accordance with requirements of the Reclamation Seeding Plan. Reclamation areas would be inspected in spring and fall to repair erosion areas and failed seeding areas, until MDNR determines that the areas are stable and self-sustaining.

Reclamation of the Hydrometallurgical Residue Facility would include removal of ponded water from the cell surface, removal of pore water from the residue, construction of the cell cover system, and establishment of vegetation and surface water runoff controls. The exterior slopes of the Hydrometallurgical Residue Facility dams would be incrementally reclaimed throughout the life of the mine. This would include stabilization and vegetation in accordance with *Minnesota Rules*, part 6132.3200. Final reclamation would generally consist of grading the cell area into a gently sloping surface. The cover would consist of a layer of LTVSMC tailings immediately above the drained residue. This would be topped, if necessary, with a non-woven needle-punched geotextile fabric. Next, a geosynthetic clay barrier layer and a 40 mm LDPE or similar MPCA-approved geomembrane barrier layer would be placed (PolyMet 2013c). Additional LTVSMC coarse tailings and/or common borrow and cover soils would be placed on top of the barrier layer to create a surface capable of sustaining a vegetated cover (PolyMet 2012e). The Hydrometallurgical Residue Facility dam slopes and benches would be planted with the same mix as that mentioned for the Category 1 Stockpile slopes in Section 5.2.4.2.1 (PolyMet 2012n). Turf and final cover would be inspected and maintained by mowing once per year or as needed, fertilizing when visual inspection indicates poor vegetation growth, and implementing repairs.

The Colby Lake Water Pipeline Corridor would not be subject to any additional disturbance or effects as a result of the NorthMet Project Proposed Action. Maintenance activities would likely continue to occur on the pipeline.

Effects of Invasive Non-native Plants

The revegetation plan following closure at the Plant Site is similar to what is planned at the Mine Site as described above. Use of the proposed seed mix could introduce invasive non-native species, depending on which species are included in the mix, to an area of primarily native vegetation that surrounds the Plant Site. However, the existing LTVSMC Tailings Basin and most of the Plant Site are already heavily disturbed, and several invasive non-native species currently inhabit these areas (e.g., smooth brome grass, reed-canary grass, yellow sweet clover). These species, once introduced, are difficult to remove and could spread to and colonize susceptible areas following future disturbance (e.g., blowdown, logging, fire). These species may reduce diversity, out-compete native vegetation, and provide lower quality habitat for some specialist animal species. Generally, dominance by invasive non-native species would reduce the quality of native cover types and habitat remaining at the Plant Site. The MDNR has made recommendations for non-invasive species for the seed mix and the final seed mix would be approved during permitting.

Effects on Threatened and Endangered Plant Species

The NorthMet Project Proposed Action would likely have no effect on federal or state ETSC plant species at the Plant Site or Colby Lake Water Pipeline Corridor because none are known to occur within the boundaries of these areas, according to MDNR NHIS data. However, no site-specific studies have been conducted at the Plant Site and so potential species not reported in the NHIS data may not be represented.

5.2.4.2.4 Potential Mitigation Measures

Mine Site Mitigation Measures

A preferred mitigation measure would be to reseed with the native species, provided they can perform as effectively as the non-native species. In some areas where erosion control would be critical to prevent slope failures, non-native species may be needed. Temporary stabilization efforts using non-native species should use non-invasive plant species to minimize the long-term risk to surrounding plant communities. In the event invasive non-native species are introduced, an additional mitigation measure would be to implement a monitoring and control program for invasive species (including noxious weeds) to ensure these species do not overtake surrounding native communities. Additionally, the purchase of an unprotected site with a population of *Caltha natans* should be assessed as mitigation, since the statewide population is lower than the other ETSC species affected.

Plant Site Mitigation Measures

The measures outlined in the Mine Site Mitigation Measures section above should be applied to the Plant Site as well. Another recommended mitigation measure may also benefit vegetation at the Plant Site specifically. The addition of organic amendments (peat) to the top foot of the Tailings Basin would improve soil and water quality and promote the development of shoreline and near-shore wetland vegetation.

5.2.4.3 NorthMet Project No Action Alternative

5.2.4.3.1 Effects on Cover Types

Under the NorthMet Project No Action Alternative, the Mine Site would not be developed, the Transportation and Utility Corridor would not be disturbed beyond routine maintenance, and the Plant Site would have no additional tailings added to the existing LTVSMC Tailings Basin. Forest-harvesting would continue to occur on the federal land portions of the Mine Site under the Forest Plan. While timber harvests would result in the immediate loss of some habitat types, permanent changes are not expected. The Forest Plan calls for an increase in older-age stands, which would likely come at the expense of younger-age stands in the long term. The majority of the federal lands are designated as General Forest – Longer Rotation Management Area, which correlates with the increase in older-age stands overall. The former LTVSMC processing plant would be reclaimed and revegetated in accordance with its separate closure plan sooner than under the NorthMet Project Proposed Action. Direct and indirect effects of the NorthMet Project No Action Alternative on cover types are considered minimal, as the Mine Site and portions of federal lands would continue to be managed in the same way they have been, and the Transportation and Utility Corridor and Plant Site have been disturbed in the past.

5.2.4.3.2 Effects of Invasive Non-native Plants

Invasive or non-native species may still invade the Mine Site as a result of logging, mineral exploration, vehicle traffic, and natural disturbances, but are likely to do so much more slowly than under the NorthMet Project Proposed Action. Invasive non-native species already exist at the Transportation and Utility Corridor and Plant Site, but they would likely spread more slowly under the NorthMet Project No Action Alternative than under the NorthMet Project Proposed Action due to less disturbance.

5.2.4.3.3 Effects on Threatened and Endangered Plant Species

Under the NorthMet Project No Action Alternative, colonies of state-listed ETSC plant species would not be affected. Timber harvests are expected to continue to occur on the federal land portions of the Mine Site. The NorthMet Project area has historically been logged and the state-listed ETSC plant species present on site have persisted. It is unlikely that continued logging, which now is more likely to employ best management practices to minimize detrimental effects, would affect the species in the long term. Likely indirect effects under the NorthMet Project No Action Alternative could come from increased competition as succession proceeds to older-age forest stands or with invasive non-native species. Effects of increased competition could include reduced spore production and consequently reduced population size in the early successional plant species (e.g., *Botrychium* spp.). Continued maintenance would likely occur along Dunka Road and the railroad where several of the *Botrychium* populations occur. Long-term succession at these locations is unlikely due to this maintenance, and these populations could persist given available habitats. The Transportation and Utility Corridor and Plant Site contain no occurrences of state-listed ETSC plant species and so the NorthMet Project No Action Alternative is not expected to have any effects.

The USFS determined that the NorthMet Project No Action Alternative would have no effect on all 58 RFSS plants on the Superior National Forest. Please see the Biological Evaluation listed on the USFS website (<http://www.fs.usda.gov/goto/superior/northmet>) for more information about effects on RFSS plants.

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5.2.5 Wildlife

This section describes the environmental consequences of the NorthMet Project Proposed Action to wildlife including direct effects such as the loss of individuals/populations of affected species or a decrease in habitat, as well as indirect effects such as displacement, competition, or changes in the greater regional area.

Summary

The NorthMet Project Proposed Action is expected to affect one federally listed species, the Canada lynx, through localized direct decrease and fragmentation of designated critical habitat and the increased potential (albeit low) for incidental take resulting from vehicular collisions due to increased NorthMet Project Proposed Action-related traffic. Restoration of disturbed areas as part of mine closure would potentially create lynx habitat, although this successional process could take decades. The NorthMet Project Proposed Action is not likely to affect the state-listed bald eagle, which is also protected under federal law (although not a federally listed endangered or threatened species). Four additional state-listed species, which include the gray wolf, the eastern heather vole, the wood turtle, and the yellow rail, may be affected by the NorthMet Project Proposed Action. It is expected that the Laurentian tiger beetle would not be affected. SGCN, RFSS, and other wildlife species, including those considered tribally or culturally significant, may be affected by human activity, noise and vibration, rail and vehicle traffic, and decrease of habitat.

5.2.5.1 Methodology and Evaluation Criteria

This section uses data presented in Section 4.2.5 to analyze effects on wildlife. Specifically, survey reports and GIS data were obtained regarding land cover and habitat types, forest stand age classes, listed ETSC, SGCN, RFSS, and other wildlife species. GIS analysis was used to calculate direct and indirect effects on these resources.

The analysis of direct effects included the potential of a take of federally or state-listed species. Pursuant to the federal ESA, *take* is defined as “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.” Take of an individual or population could occur for various reasons such as traffic collisions, habitat destruction, or change in an individual or population’s habitat use due to noise, other disturbance, or contamination of food or water sources. Take of a listed species would be considered a significant effect. The USFWS can issue a permit for the incidental take of a federally listed wildlife species consistent with the goal of conservation of the species. Permit applicants must design, implement, and demonstrate availability of funding for a conservation plan that minimizes and mitigates harm to the affected species during the proposed project. Without a permit, the take of a federally listed protected species is punishable by fines or imprisonment. Permitting for taking of a state-listed species is regulated by the MDNR.

Analysis was also conducted for potential indirect effects on federally or state-listed species, such as increased competition for resources or habitat due to displacement of individuals from the affected area into the territory of other animals, or other indirect effects that cause mortality or reduced breeding and recruitment in the future population.

In addition to listed species, analysis was completed of potential direct and indirect effects on habitat types that affect population size and long-term viability for other species potentially at risk (SGCN, RFSS, and species of cultural concern). Direct effects could include vegetation removal by clearing, burial, or other destructive activity. Indirect effects could include changes within larger ecological units (e.g., the Laurentian Uplands or Partridge River Watershed), but not necessarily at the Mine Site or Plant Site, that could occur at a later point in time, such as a change in long-term vegetation composition or dominance, habitat conversion due to hydrologic changes, invasion by non-native species, or disruption of natural disturbance regimes (e.g., the annual natural hydrological cycle). Depending on the magnitude of the effect, direct effects may require mitigation.

5.2.5.2 NorthMet Project Proposed Action

This section describes the effects on wildlife due to construction and operation activities.

5.2.5.2.1 Federally Listed Species

As required under Section 7 of the ESA, the USACE and the USFS have initiated consultation with the USFWS regarding potential effects on federally listed species to ensure that actions they authorize or permit would not jeopardize listed species or designated critical habitats. Consultation is currently ongoing and will continue throughout the EIS process. If additional species are federally listed following issuance of the SDEIS, they will be analyzed and discussed in the FEIS.

A Biological Assessment is being prepared as part of the consultation process. The Biological Assessment analyzes effects on the Canada lynx and the gray wolf, in the event that the gray wolf is re-listed. The organization of the methodologies and discussion in the Biological Assessment may be different from the SDEIS. The Biological Assessment also contains a determination of effects for both species. The conclusions of the consultation process will be included in the FEIS.

Canada Lynx

In 2009, it was estimated that there were likely fewer than 200 lynx in Minnesota (Moen 2009). However, individuals can travel well beyond their home range, specifically when prey is scarce, at times more than 1,000 km (Moen 2010). Three individual lynx have been harvested in Ontario, approximately 400 road miles from their known locations in Minnesota. Of the 55 incidental take records the USFWS has documented from 2001 through 2013, two of the records involved lynx killed by trains, and seven of the records involved lynx struck by vehicle traffic along roads (USFWS 2013).

The NorthMet Project area is currently within the 8,065 square mile designated critical habitat for the Canada lynx (USFWS 2009), which includes much of St. Louis, Lake, and Cook counties. Surveys identified at least 20 different individual lynx were identified within 18 miles (ENSR 2006), and lynx sign was observed on the Mine Site in 2010. A collared and studied lynx, L11, was identified adjacent to the NorthMet Project area, south of Dunka Road. This animal may have been using the NorthMet Project area for forage and travel as part of her home range between when she was collared in early 2004 and when she was trapped in Ontario, Canada in 2006. Lynx tracks were observed at the Mine Site in 2010, and there have been multiple observations of lynx sign within 5 miles of the federal lands (USFS 2013).

Site clearing and mining activities associated with the NorthMet Project Proposed Action would potentially affect lynx by reducing available habitat and increasing habitat fragmentation. The total effect from increased activity is not known, as lynx have been known to habituate to increased human activity (Sunde et al. 1998). The NorthMet Project Proposed Action mining activities would disturb approximately 2 square miles (1,454.0 acres) of suitable lynx habitat, currently a mix of upland forest and lowland forest and bog. Restoration of disturbed areas as part of mine closure would eventually create potential lynx habitat, although this successional process could take decades. Potential lynx habitat would be lost for the duration of mine operations (over 20 years) and an additional 20 years or more after closure before suitable lynx habitat would again occur at the Mine Site (ENSR 2006).

Assuming that the territory of a resident lynx is 58 square miles for males and 28 square miles for females, the reduction of habitat at the Mine Site corresponds to a reduction of three to seven percent of an individual's territory (ENSR 2006). Territory size expands in response to periods of reduced snowshoe hare density, and the related lynx and snowshoe hare populations tend to loosely follow a 10-year cycle, though other factors contribute to lynx population shifts. ENSR 2006 surveys for the NorthMet Project Proposed Action were done during a low point in the lynx/snowshoe hare density cycle.

Though no lynx were identified during the ENSR 2006 surveys, those that may currently be using the Mine Site could expand their territory into surrounding areas. Surveys conducted in 2006 by Moen et al. found evidence of at least 20 individuals within 18 miles of the NorthMet Project area, and lynx sign has been observed on the Mine Site by the USFS. Lynx density in the vicinity is considered low relative to the rest of the Minnesota lynx range (ENSR 2006). Individuals displaced from the Mine Site may be affected by increased stress and potential mortality due to utilization of unfamiliar territory and competition with other lynx or predator species. Although the NorthMet Project Proposed Action would result in a reduction and fragmentation of lynx habitat at the Mine Site, little to no effect on statewide lynx populations would occur as it is unlikely that an individual lynx or pair of lynx would be affected by the habitat decrease.

According to the USFS, LAUs are land areas identified for purposes of analysis and development of conservation measures for lynx (USFS 2004b). They range in size from just under 17,000 acres up to more than 91,000 acres. As discussed in Section 4.2.5.2.1, the federal lands (including the Mine Site) are located within LAU 12.

The USFS determined that approximately 2,737 acres, or 4.0 percent of LAU 12 is currently unsuitable for lynx use (USFS 2013). As noted above, the NorthMet Project Proposed Action would disturb 1,454 acres of lynx habitat, making them unsuitable for lynx. The percent of LAU 12 unsuitable for lynx would increase to 6.1 percent. This percentage is well within the Forest Plan guideline (G-WL-3) that unsuitable habitat is not exceed 30 percent of the LAU.

The increased vehicle traffic associated with the NorthMet Project Proposed Action mining activities could affect species such as the lynx. An average of 2,066 miles per day of vehicular traffic is expected within the Mine Site, primarily to haul ore to the rail siding and waste rock to the stockpiles (see Table 5.2.5-1).

Table 5.2.5-1 Vehicle Traffic within the Mine Site Only

Vehicle type	Vehicle Weight (Tons)	Speed (Average MPH)	Total Road Miles in Mine Site	Annual Vehicle Miles Traveled (Estimated)	Estimated Average Total Miles Per Day (Estimated)
Haul Trucks and Construction Vehicles	81.5-425	12-14	15.3	61,400-979,000	2,066.0

Source: Barr 2012i.

Although there is the potential for incidental take as a result of vehicle collisions with lynx, haul traffic at the Mine Site would likely have little direct effect on lynx. Current lynx use of the Mine Site appears to be very low; in the future, the area would be heavily affected by mining operations and not likely to be used by lynx.

The NorthMet Project area is currently within designated critical habitat for the Canada lynx (USFS 2008). Lynx may be affected by increased vehicle and train traffic. Lynx are highly mobile and lynx habitat can be found immediately adjacent to the corridor. The increased vehicle traffic associated with the NorthMet Project Proposed Action, including train and small vehicle traffic between the Mine Site and Plant Site, could potentially result in vehicle collisions with lynx (see Table 5.2.5-2). The NorthMet Project Proposed Action would generate 1,734.9 miles of vehicle traffic between the Mine Site and Plant Site each day. This traffic would consist primarily of light trucks and maintenance vehicles traveling 30 to 45 mph and a few large fuel trucks, waste/supply trucks, and trains traveling 15 to 40 mph.

Table 5.2.5-2 Vehicular and Train Traffic Volume along the Transportation and Utility Corridor

Vehicle Type	Vehicle Weight (Tons)	Speed (Min – Max MPH)	Total Miles (Per Day)
Light Cars, Trucks, and Vans – primarily Mine Site to Area 2 Shops	2	30-45	961.1
Fuel Trucks, Supply and Waste Trucks	40	25-40	346.7
Haul Trucks	81.5 – 240	35	9.1
Trains	3,000	15-25	418.0
Total			1,734.9

Source: Barr 2012i.

Though vehicle traffic increases the chance of incidental lynx mortality, this species does not rely upon roads for travel (Moen 2010). Straight-line movement of collared lynx through the roadless BWCAW suggests that when roads are not available, lynx will still travel in a line where possible. As such, while lynx may be affected by vehicle traffic along the Transportation and Utility Corridor, the flat terrain near the NorthMet Project area would allow lynx to travel through the area.

Evidence of lynx was not found during surveys of the Plant Site. Approximately 76 percent of the Plant Site cover/habitat type is disturbed or aquatic, which is considered unsuitable lynx habitat. Lynx are unlikely to utilize the Plant Site, but may forage in the surrounding area. As such, activities at the Plant Site are unlikely to affect the Canada lynx.

State and federal forest lands near the Mine Site or Plant Site would continue to provide refuge for lynx, and it is likely lynx would favor these areas over those affected by mining for the

duration of mine operations. Overall, the effects on the Canada lynx described above would result in the localized direct decrease and fragmentation of habitat, including designated critical habitat, and the increased potential (albeit low) for incidental take resulting from vehicular collisions; however, these effects are not anticipated to threaten the overall species population level and abundance in Minnesota.

5.2.5.2.2 State-listed Species

Rulemaking was conducted with the intent to update the list of Endangered, Threatened, and Special Concern Species (*Minnesota Rules*, part 6134.0100 to 6134.0400), with new listings becoming effective on August 19, 2013. The FEIS will consider any new listings, or changes in the previous listings, associated with the updated list.

Gray Wolf

On May 4, 2011, the USFWS proposed to reinstate the April 2009 decision to delist the gray wolf population in the western Great Lakes after it was relisted in July 2009. This decision was finalized on December 26, 2011, and was effective January 27, 2012. The final rule also removes the designation of critical habitat in Minnesota.

Field surveys indicate the likelihood of a single wolf pack whose territory includes the Mine Site and Plant Site. The footprint of the Mine Site would remove approximately 2 square miles (1,454 acres) of habitat, or 1 percent to a maximum of 10 percent of a single wolf pack territory. This reduction in available habitat is small and is not expected to affect the highly mobile wolf population in the region, which is considered healthy by the MDNR. After closure, this area would again be available and suitable as wolf habitat, but, as described above for the lynx, this would not occur for more than 40 years.

Vehicle collisions are a cause of wolf mortality (Fuller and Harrison 2005). The increased vehicular activity associated with the NorthMet Project Proposed Action could potentially result in vehicle collisions with wolves. The haul road network would increase the road density (linear miles of road per square mile of habitat) at the Mine Site; however, mining operations would disturb the Mine Site such that it would reduce habitat availability for the gray wolf. Therefore, the haul road network itself would not influence the overall effects of the NorthMet Project Proposed Action on the gray wolf.

State and federal forest lands near the Mine Site or Plant Site would continue to provide refuge for wolves, and it is likely wolves would favor these areas over those affected by mining for the duration of mine operations. The gray wolf population in Minnesota (estimated at 2,922 gray wolves) is considered fully recovered by the MDNR as it has surpassed the federal delisting goal of 1,251 to 1,400 wolves. The MDNR established a hunting and trapping season for 2012, with a quota of 400 wolves (MDNR 2012i), split between an early hunting season and a later hunting and trapping season. Additional wolves may be taken if they pose a threat to people, pets, or livestock.

Overall the effects described above would result in the direct decrease and fragmentation of habitat suitable for the gray wolf, the increased potential for incidental take from vehicular collisions, and indirect decline in prey species due to habitat decrease. Together these factors are not anticipated to threaten the overall species population level and abundance in Minnesota.

Bald Eagle

Bald eagles typically nest in large trees within 500 ft of lakes or rivers (Guinn 2004). There are no large lakes or rivers at the Mine Site that would provide optimal nesting/foraging habitat, though the Partridge River (approximately 0.5 mile south of the Mine Site) would provide some, though less-than-optimal, habitat. The Partridge River is 4.9 miles south of the Plant Site, and the Embarrass River is 2.5 miles north and west. The USFWS National Bald Eagle Management Guidelines (USFWS 2007) suggest that human activity within 0.25 mile to 2 miles can be seen or heard by eagles and, depending on the level of screening and habituation of individual eagles, may cause them to abandon a nest. Generally, the closer the activity is, the greater the effect. If eagles were to nest on the portion of the Partridge River or the Embarrass River near the NorthMet Project area, they could be within the 2-mile disturbance range. The nearest recorded bald eagle nest to the Mine Site is approximately 6.5 miles to the southeast (MDNR 2013a).

Bald eagle nesting territories in Minnesota generally have a 10-mile radius that varies with habitat quality (Guinn 2004). Bald eagle nests near the NorthMet Project area are on average 5.7 miles apart (3.8 to 9.4 mile range), which is less than the average territory radius. This suggests that the area is densely populated with bald eagle nesting territories and that no new eagles are likely to move into the area (MDNR 2013a). As eagles become more numerous, any eagles seeking to establish new territories in the area would need to select lower quality habitat and/or move into closer proximity to human activity.

Surface water contaminants (e.g., mercury) that are absorbed by prey species such as waterfowl via dietary exposure (e.g., through the consumption of fish) could lead to ingestion of contamination by eagles (Marr 2008). However, bald eagles are relatively insensitive to the toxic effect of mercury exposure through their food (Judd 2013). In addition, waterfowl and some birds of prey demethylate mercury, which reduces their potential exposure.

The NorthMet Project Proposed Action is not likely to affect bald eagles because the known nesting sites are more than 2 miles from the NorthMet Project area; optimal habitat for nesting and foraging bald eagles is not present at the Mine Site, Plant Site, or Transportation and Utility Corridor; and bald eagles are not sensitive to mercury exposure.

Wood Turtle

There is no habitat suitable for wood turtles at the Mine Site and no individuals are known to occur. Individuals could potentially use the southern riparian fringe of the Mine Site though no wood turtles are currently known to occur in the fringe areas that would be affected by the project. The fringe areas would also not be affected by activities at the Transportation and Utility Corridor. There is no suitable habitat for wood turtles at the Plant Site and no individuals are known to occur.

The predicted small decrease in Upper Partridge River flow during active mining is not likely to negatively affect the wood turtle. The most likely effect of a decrease in water level would be to expose additional nesting areas. Over the long term, the exposed soil on the lower bank would be overtaken by vegetation from the upper bank and become less suitable habitat for the wood turtle.

Wood turtles are not likely to be affected by project activities because there would be no direct loss of individuals, populations, or suitable habitat and the NorthMet Project Proposed Action would have no indirect effects on downstream habitat.

Eastern Heather Vole

The eastern heather vole has not been observed within 10 miles of the Mine Site nor has it been found in small mammal surveys in the region (Christian 1993; Jannett 1998). The NorthMet Project area is at the southern edge of its range. Approximately 1,445 acres of potentially suitable habitat exist at the Mine Site (see Table 4.2.4-1), and there is potentially suitable habitat for the species along the Transportation and Utility Corridor. Additionally, there is potentially suitable habitat for the eastern heather vole at the Plant Site, 32 percent of which may be affected by the NorthMet Project Proposed Action (see Table 5.2.4-4). The eastern heather vole could be present at the NorthMet Project area, but, if so, it is likely to be in very small numbers. Given the lack of known occurrences of eastern heather vole in the area, the habitat effects are unlikely to jeopardize the presence of eastern heather vole in Minnesota.

Yellow Rail

The yellow rail was not found during PolyMet's surveys at the Mine Site and was not reported in the NHIS database within 10 miles of the NorthMet Project area. Small, scattered areas of its preferred habitat, sedge/wet meadow, are present at the Mine Site, but the minimum nesting patch size used by rails (54 acres) (Goldade et al. 2002) exceeds the total amount of suitable habitat available (39.5 acres at the Mine Site and 1.5 acres at the Plant Site; refer to Section 4.2.3). Since the yellow rail was not detected in surveys and patches of its preferred habitat are smaller than the reported minimum patch size for nesting, it is not expected that the NorthMet Project Proposed Action would affect the yellow rail.

Laurentian Tiger Beetle

The lack of suitable habitat and any NHIS recorded observations in the NorthMet Project area for the tiger beetle suggest that the species does not occur at the Mine Site, Plant Site, or Transportation and Utility Corridor. Therefore, the NorthMet Project Proposed Action should have no effect on the tiger beetle.

5.2.5.2.3 Species of Greatest Conservation Need

Along with federally and state-listed species, the NorthMet Project Proposed Action would affect SGCN at the Mine Site as a result of increased human activity and noise, collisions with vehicular and rail traffic, and decrease of habitat. Due to the number of SGCN species identified (see Table 4.2.5-1) effects are classified by the type of disturbance.

Increased Human Activity

SGCN would be directly affected through increased human activity due to mining activities. Factors such as noise, dust, light, and vehicle traffic may frighten some species and discourage their use of otherwise suitable habitat. In general, suitable habitat is available in the area adjacent to the NorthMet Project area and most mobile wildlife species would be displaced. Following migration to new areas, displaced individuals could increase the competition for resources in their new habitat. Displaced species could also suffer increased mortality due to foraging in new areas. Less mobile species, such as herptiles (e.g., frogs, turtles), would likely incur relatively high mortality rates since they cannot quickly migrate from the area and would be more susceptible to changing habitat conditions. During the winter, a combination of plowing and sand, gravel, or salt (magnesium chloride) applications would be used to keep roadways

passable. The potential exists for sand and salts to accumulate in the trenches adjacent to the roadways and affect less mobile species. These areas are not considered high quality habitat and are not likely to affect wildlife.

Effects on wildlife due to trapping and hunting are minimal because public access would be restricted. Through the Land Exchange Proposed Action, NorthMet Project area lands would enter into private ownership and would not be accessible for public use. As discussed in Section 5.2.11.2.1, public access is limited and would remain limited during mining operations and following mine closure. As such, wildlife species are not likely to be affected by changes in hunting and trapping activity.

Ground-nesting bird species and some raptor species have been known to utilize cliff areas for nesting and foraging. The SGCN include the northern goshawk, common nighthawk, and northern harrier. These birds could be affected by disturbance if they were to nest along the cliffs created by the pit rims.

Noise Effects

Noise associated with mining activities, including noise from vehicle and rail traffic, would likely affect wildlife. Mammals can be sensitive to sound levels below the range of human hearing, which is 20-16,000 hertz. The sensitivity thresholds for animals are generally lower, some below 20 hertz (US FHWA 2011). Effects due to acute noise (such as blasting) are not well studied, but would likely cause animals to startle and would interrupt forage or nesting activities (Larkin 1994). Noise does not appear to seriously affect invertebrates or fish, but does result in some disturbance to mammals (such as startling, forage interruption, and avoidance of the area of potential effect [Larkin 1994]). Bird communication would be masked by noise if the vocalizations are less than 18-20 dB above noise levels in the environment (US FHWA 2011). Changes in communication have been known to result in decreased reproduction and anomalies in learned vocalizations (Larkin 1994). Songbird populations have been shown to decrease with noise levels as low as 35 dB (Forman and Alexander 1998). Section 5.2.8 provides further discussion on the noise modeling predictions for the NorthMet Project area. Though wildlife species are likely to be sensitive to changes in noise levels, there are no local, national, or international standards or limits that are applicable to the NorthMet Project Proposed Action. Wildlife species may be affected by noise in the NorthMet Project area, though adjacent habitat is available.

Vehicular and Rail Traffic Effects

Wildlife mortality generally increases with increasing traffic volumes and vehicle speed. In general, highly mobile species and habitat generalists (species that utilize a wide variety of habitats) are known to have higher road mortalities.

As discussed above, vehicular traffic would average 2,066 miles per day within the Mine Site (see Table 5.2.5-1). Traffic effects from collisions with wildlife depend upon factors such as traffic volume, traffic speed, and the species involved. The potential for road effects increases if the roads are bordered by high-quality habitat or are crossed by wildlife travel corridors. The high density of affected wetlands at the Mine Site bordering the haul roads may result in a relatively high rate of amphibian and reptile effects. Shrubs and trees near roadsides can increase road crossings by deer and birds. The barrier effect of roads is greater for small mammals, amphibians, and reptiles than for birds and large mammals (Kaseloo 2004). Species that utilize

the small preserved forest island remnants between haul roads at the Mine Site would be most affected. Indirect effects from vehicle activities are expected locally at the Mine Site for SGCN species but would not be measurable at the scale of the Nashwauk and Laurentian Uplands or the Partridge River Watershed.

Effects at the Transportation and Utility Corridor are primarily related to vehicle and rail traffic. Travel between the Mine Site and Plant Site is expected to average 1,735 miles per day with travel speeds averaging between 15 and 45 mph, with trains, fuel, and waste/supply trucks traveling somewhat slower (see Table 5.2.5-2). SGCN may be affected by noise and light associated with vehicle and rail traffic, and by collisions with vehicles or trains.

Transportation effects at the Plant Site are primarily related to vehicle traffic associated with construction of the NorthMet Project Proposed Action. Typical daily operations at the Plant Site would generate approximately 828 miles of vehicle traffic, primarily light trucks. Though noise and light may affect SGCN at the Plant Site, the disturbed nature of the area would mean that effects would be negligible.

Wildlife Habitat Effects

The direct effect on wildlife habitat (and by inference on SGCN species) was assessed by evaluating the acres of habitat types that would be lost under the NorthMet Project Proposed Action. The changes in cover type are summarized in Table 5.2.5-3.

Table 5.2.5-3 Direct Effects on Key Habitat Types

Key Habitat Types	Total Acres¹ of Cover Type Present at Mine Site (Total Acres¹ of Cover Type Directly Affected)	Total Acres¹ of Cover Type Present at Transportation and Utility Corridor (Total Acres¹ of Cover Type Directly Affected)	Total Acres¹ of Cover Type Present at Plant Site (Total Acres¹ of Cover Type Directly Affected)
Mature Upland Forest, Continuous Upland/Lowland Forest (MIH1-13)	2,627.2 (1,535.3)	5.5 (5.5)	788.4 (362.8)
Open Ground, Bare Soils (no MIH)	128.0 (44.0)	94.4 (94.4)	2,755.5 (1,102.5)
Grassland and Brushland, Early Successional Forest (no MIH)	246.6 (133.2)	17.5 (17.5)	333.4 (139.5)
Aquatic Environments (MIH 14)	12.7 (6.0)	2.7 (2.7)	636.7 (572.7)
Total	3,014.5 (1,718.6)	120.1 (120.1)	4,514.0 (2,177.5)

Data from Tables 5.2.4-1, 5.2.4-4, and 5.2.4-5.

¹ Total acres may be more or less than presented due to rounding.

Mature Upland/Lowland Forest

At the Mine Site, approximately 1,535 acres (58 percent) of the mature forest would be lost as a result of the NorthMet Project Proposed Action. All of the SGCN found in this mature upland forest habitat are birds (see Table 4.2.5-1), which would be displaced, but likely not injured or killed, during mine construction and operation. Nesting birds could be affected during the

breeding season, especially during brooding and until fledglings become independent. Reclamation of the Mine Site would include revegetating nearly all disturbed ground according to *Minnesota Rules*, part 6132.2700.

Of the 5.5 acres of mature upland/lowland forest along the Transportation and Utility Corridor, all 5.5 acres would be affected. As such, activities would affect SGCN in mature upland/lowland forest habitat along the Transportation and Utility Corridor, though effects would be narrow and primarily located along the corridor.

Most of the Plant Site is developed or disturbed with only approximately 17 percent (788 acres) consisting of forest habitat (see Table 5.2.5-3). Approximately 363 acres of this forest habitat at the Plant Site would be disturbed, most of which is in small or isolated patches of aspen-birch forest that are in poor to fair condition (MDNR 2013a). Therefore, activities at the Plant Site would not have an effect on SGCN using mature upland/lowland forest habitat.

Reclamation and revegetation of the NorthMet Project area would initiate vegetative succession on stockpiles, the East Pit and Central Pit, and Mine Site infrastructure (PolyMet 2012s). The Category 1 Stockpile would be incrementally and progressively reclaimed throughout the life of the mine through contouring the stockpile to provide topographic variety, covering with a layer of evapotranspiration soil, and finally seeding of grasses and forbs.

Reclamation and re-vegetation of the NorthMet Project area would improve wildlife habitat relative to conditions during mine operations; however, the quality of habitat for SGCN is likely to remain degraded for some decades after closure relative to pre-mining operations due to conversion of high-quality habitat to lower-quality habitat.

Open Ground/Bare Soils

The likelihood of SGCN using open ground or bare soils at the Mine Site, Transportation and Utility Corridor, or Plant Site is small. These areas were the result of past mining activity, are generally of low-quality, and are expected to decrease after mine closure as a result of reclamation.

Therefore, NorthMet Project Proposed Action effects on open ground/bare ground habitat should result in little effect on wildlife.

Brush/Grassland

Approximately 133 of the 247 total acres (54 percent) of brush/grassland at the Mine Site would be directly affected by the NorthMet Project Proposed Action. Brush and grassland (including early successional forest) at the Mine Site and Plant Site consist of small vegetative patches that are generally not suitable for SGCN. Young trees (less than 4 inches dbh) make up most of this habitat type (ENSR 2005). One SGCN associated with this habitat type, the American woodcock, was observed by USFS personnel at the Mine Site. The least weasel may occur as well. Most of the other SGCN (see Table 4.2.5-1) are associated with large patches of grassland and savanna habitats, which are not present at the Mine Site.

Stands of brush/grassland (including early successional forest) along the Transportation and Utility Corridor consist of small vegetative patches that are generally not suitable to SGCN. Young trees (less than 4 inches dbh) make up most of this habitat type (ENSR 2005). Most of the other SGCN (see Table 4.2.5-1) are associated with large patches of grassland and savanna

habitats. Though all 17.5 acres of brush/grassland at the Transportation and Utility Corridor would be directly affected, activities at the Transportation and Utility Corridor would not affect grassland/brush SGCN based on the fragmented nature of this habitat.

Similar to the Mine Site, brush/grassland (including early successional forest) at the Plant Site consists of small vegetative patches that are generally not suitable to SGCN. Young trees (less than 4 inches dbh) make up most of this habitat type (ENSR 2005). Most of the other SGCN (see Table 4.2.5-1) are associated with large patches of grassland and savanna habitats. Approximately 140 of the 333 acres of brush/grassland at the Plant Site would be directly affected by the activities at the Plant Site. The reclaimed Plant Site, specifically the Tailings Basin, would be revegetated with grassland vegetation species. Overall, the NorthMet Project Proposed Action would have no adverse effects on grassland/brush SGCN.

During reclamation, PolyMet would remove or cover portions of the existing road, railroad, and ditch and dike systems and restore them. Reclamation of these areas, which currently constitute poor wildlife habitat, would ultimately enhance wildlife habitat when compared to current conditions. Some SGCN, such as the eastern meadowlark, northern harrier, and common nighthawk would most likely use the grasslands until they are replaced by early successional forest about 20 to 50 years after closure. Early successional forests are likely to support the two following SGCN: white-throated sparrow and American woodcock.

Open Water

SGCN such as the black duck, American bittern, and swamp sparrow utilize open water habitats. The NorthMet Project Proposed Action would create approximately 321 acres of open water at the Mine Site by eventually flooding the West Pit, which is estimated to fill in year 40. The West Pit would be fenced as a deterrent to wildlife species even though this habitat is not likely to provide high quality foraging habitat for waterfowl because of a lack of emergent or submerged vegetation along the pit fringes. Ponds at the wastewater treatment facilities would also be fenced to prevent wildlife from using the water. At the Plant Site, open water habitat primarily occurs in the existing LTVSMC Tailings Basin. None of the SGCN targeted during a 2005 survey were observed on open water during the survey (ENSR 2005); however, common waterfowl and water birds were observed at the Tailings Basin during migration, in particular Canada goose and ducks. Existing open water habitat would be maintained during operations, though the acreage of open water would fluctuate according to processing needs.

Wildlife, specifically aquatic birds, may utilize open water habitat created by the NorthMet Project Proposed Action. Wildlife species have been observed utilizing the existing LTVSMC Tailings Basin, as well as other Mesabi Iron Range tailings basins, specifically during migration. Unlike arid states such as Nevada, pit lakes and tailings basins are not the only readily available source of open water for wildlife use. Minnesota has over 13 million acres of lakes and wetlands, and the NorthMet Project Proposed Action would result in less than one hundredth of a percent increase in habitat. Though adjacent habitat is readily available, wildlife species may still utilize the Tailings Basin.

Some wildlife species, specifically those that feed on aquatic prey, may be susceptible to mercury exposure (USEPA 1997) directly from open water sources such as the pit lake and Tailings Basin pond, and indirectly at the Partridge River and Embarrass River. Effects to aquatic species are discussed in Section 5.2.6.2. Specific species such as loons, osprey, mink,

and otter may be affected. As discussed in Section 5.2.5.2.2, eagles may be less likely to be affected by mercury. While wildlife use of open water created by the NorthMet Project Proposed Action may be limited due to fencing and available habitat, wildlife species may be affected.

Surface water quality standards do not apply to the pit lake or Tailings Basin. Any discharge water, such as the pit lake overtopping, would be treated in order to meet water quality standards and, as such, would not likely affect wildlife species.

Wetlands

Of the wetland-related SGCN, the marbled godwit and olive-sided flycatcher were surveyed for, but not found (ENSR 2005). The bog copper butterfly also was not found during surveys and there are no known NHIS records of any sightings within 12 miles of the Mine Site. As discussed above, the black duck, American bittern, and swamp sparrow are not likely to be present because they require open water and non-forested wetlands, which are relatively scarce at the Mine Site. The red-backed salamander is primarily an upland species, but may be present along the edges of mixed hardwood swamps. The disa alpine butterfly may inhabit the black spruce bogs of the Mine Site and is historically known to occur in the Laurentian and Nashwauk Uplands (MDNR 2006d).

Based on the site-specific wetland delineation, the NorthMet Project Proposed Action would directly affect 758.2 acres of wetlands at the Mine Site, primarily coniferous bog (508.3 acres directly affected), shrub swamp (97.8 acres directly affected), and coniferous swamp (70.3 acres directly affected). These wetland types are common in the Partridge River Watershed. Consequently, the decrease of this habitat at the Mine Site is expected to displace wildlife into surrounding similar habitat, which would be large enough to absorb the displaced wildlife.

There are 7.2 acres of wetlands/open water along the Transportation and Utility Corridor, and those 7.2 acres would be affected by activities along the corridor. There are 147.1 acres of affected wetland at the Plant Site. On-site wetland use by the SGCN described above may be limited, and these wetlands are generally considered to be of low quality.

Wetland mitigation is proposed both on-site and off-site. Approximately 101.8 acres of wetland creation is proposed for on-site mitigation. This would not replace in-kind the wetland habitat affected (primarily coniferous bog and shrub/conifer swamp). Off-site mitigation would consist of 1,631.4 acres of wetland compensation and 225.0 acres of upland buffer areas of various habitat types at three sites.

Multiple Habitats

Species using multiple habitats and known to occur on or near the NorthMet Project area (e.g., gray wolf, Canada lynx, least flycatcher) are discussed above. Most multiple-habitat SGCN use mature/continuous and early successional forest. NorthMet Project Proposed Action effects are therefore largely limited to the mature/continuous forest habitats described above.

Wildlife Corridors

There is one wildlife corridor located approximately 0.5 mile northwest of the Mine Site (see Figure 6.2.3-1). Mine Site operations, which provide a source of disturbance from noise and mining activity, would indirectly affect the corridor by reducing the effective, undisturbed size of the large habitat block southeast of the corridor. These activities would limit access to the

corridor in the vicinity of the Mine Site; however, the corridor would continue to be accessible north of the Mine Site and from south and southwest of the corridor. Vegetative restoration of the stockpiles and disturbed areas, as proposed during closure, would mitigate some of the effects of habitat loss in this large habitat block in the long term. Not all of the Mine Site would be available for habitat restoration due to fencing around the mine pits and the open water in the West Pit.

Rail and vehicular traffic between the Mine Site and Plant Site would increase as a result of the NorthMet Project Proposed Action. While the Transportation and Utility Corridor is outside of wildlife corridors, it runs parallel to the wildlife corridors and would potentially affect wildlife use.

Additionally, there is one wildlife corridor located approximately 1 mile southeast of the existing Plant Site. The existing LTVSMC Tailings Basin provides poor habitat, is not likely to be heavily used by wildlife, and currently obstructs animal movement. Because current use is already limited, increased activity at the Tailings Basin would have minimal effect on wildlife movement through the corridor. The proposed vegetative restoration of the Tailings Basin and adjacent processing plant at closure may increase the value of the corridor by improving habitat to the northwest. The mining features surrounding this corridor would not be complete barriers to wildlife movement (Barr 2009a).

5.2.5.2.4 Regional Forester Sensitive Species

A Biological Evaluation containing further information about RFSS species has been prepared and is posted on the USFS website (<http://www.fs.usda.gov/goto/superior/northmet>). Similar to the Biological Assessment, the organization of the methodologies and discussion in the Biological Evaluation may be different from the SDEIS. The Biological Evaluation also contains determinations of effect for RFSS species.

The USFS determined that the NorthMet Project Proposed Action may affect individuals but is not likely to cause a trend to federal listing or loss of viability for 18 RFSS terrestrial wildlife species on the Superior National Forest.

Of the 18 terrestrial RFSS on the 2011 list for the Superior National Forest, four of these are also state-listed ETSC species (gray wolf, bald eagle, wood turtle, and eastern heather vole) and are discussed above. Seven other RFSS (the boreal owl, olive-sided flycatcher, bay-breasted warbler, Connecticut warbler, taiga alpine, Freija's grizzled skipper, and Nabokov's blue) are on the SGCN list and are discussed by habitat type in Table 4.2.5-1 and above. The remaining seven species, including the northern myotis, eastern pipistrelle, little brown bat, northern goshawk, great gray owl, three-toed woodpecker, and Quebec emerald are discussed below.

Baseline acoustic surveys for bats, which include the northern myotis, the eastern pipistrelle, and the little brown bat, have been completed in the Superior National Forest east of the NorthMet Project area (Abel 2011). These studies generally found that bat foraging activity is highest near aquatic features. Forest edges, such as those along utility corridors, are also used for bat foraging. Bats tend to forage along these features more than in interior forest habitat. The RFSS bat species may utilize forage habitat at the Mine Site, but there are no caves or mine shafts that could be used for hibernation. The three RFSS bats may forage along the edge habitat at the Transportation and Utility Corridor, but there are no caves or mine shafts present that may be used for hibernation. Bats have occasionally been observed in Plant Site buildings, but do not

hibernate or roost in great numbers at the Plant Site. The NorthMet Project Proposed Action is not expected to affect bat hibernacula, but would reduce roosting and foraging habitat.

The northern goshawk may occasionally be present at the Mine Site, since nest sites have been identified by the USFS approximately 0.75 mile west of the Mine Site and near the proposed East Pit and Central Pit areas. Goshawks have nested on the Mine Site and adjacent federal lands in 2000, 2009, 2011, and 2013 (USFS 2013). Two goshawk territories have been identified at or near the Mine Site, as they have nested on the Mine Site and adjacent federal lands in 2000, 2009, 2011, and 2013 (USFS 2013). The One Hundred Mile Swamp goshawk territory, which is within the Mine Site, is no longer considered active. The Wetlegs Creek goshawk territory, located on the federal lands adjacent to the Mine Site, is still considered active and is being monitored. The NorthMet Project Proposed Action would directly affect one of the two known nest site areas. The northern goshawk may be occasionally present at the Transportation and Utility Corridor, due to the proximity of the active goshawk territory. No nests are known to occur at the Plant Site. Because the northern goshawk has nested in the area was identified during calling surveys, activities at the Mine Site may affect the northern goshawk.

During owl surveys (AECOM 2009a), one great gray owl was observed foraging along the Transportation and Utility Corridor near the Mine Site. A great gray owl had used a historic goshawk nest at the Mine Site. Great gray owls nested in the NorthMet Project area in 2006 (AECOM 2009a), 2010, and 2011 (USFS 2013). Owls are sensitive to disturbance, so populations would be unlikely to use the NorthMet Project area during mine operations, though the species may be affected by the NorthMet Project Proposed Action as it has been observed and has nested in the area.

Systematic survey data for three-toed woodpeckers are lacking; however, one bird was observed during overall field surveys (ENSR 2000) and by USFS personnel in 2007. Generally, the young age of the forest habitat at the Mine Site is not suitable for three-toed woodpeckers, and populations or individuals in the area are not likely to occur. Woodpeckers are sensitive to disturbance and would not be expected to use the Mine Site during mining operations. Though not surveyed, the Transportation and Utility Corridor and Plant Site lack the old-growth forest or recent burn habitat preferred by the three-toed woodpecker. Woodpeckers are sensitive to disturbance and would not be expected to use the Transportation and Utility Corridor or Plant Site. Though existing populations are estimated to be low, and prime habitat is not available, the three-toed woodpecker may be affected by loss of overall forest habitat in the NorthMet Project area.

The Quebec emerald dragonfly inhabits poor fens, a wetland type not identified at the Mine Site but similar to the sedge/wet meadow that is present. Approximately 38.2 of the existing 39.5 acres of wet meadow/sedge meadow at the Mine Site would be affected by mining activities. The presence of the Quebec emerald dragonfly in the region and the existence of similar habitat at the Mine Site suggest that this species may be affected. There are no poor fens found along the Transportation and Utility Corridor or Plant Site, though approximately 1.5 acres of sedge/wet meadow are present at the Plant Site, and 1.4 acres would be affected by activities. There has only been one documented occurrence of this species in Minnesota (Lake County in 2006, more than 20 miles east of the NorthMet Project area) (Minnesota Odonata Survey Project 2012); therefore, the likelihood of observing Quebec emerald dragonfly individuals or populations within the vicinity of the NorthMet Project area is low. As such, this species is not expected to be affected.

5.2.5.2.5 Other Wildlife Species

Other wildlife species in the NorthMet Project area, including common and/or game species (such as white-tailed deer, moose, bear, fox, porcupine, etc.) would likely be affected in ways similar to special status species. Mobile individuals would avoid direct effects but may be indirectly affected by a decrease of habitat. Given the adjacent habitat available to these species, local effects are expected, but these would not threaten overall populations. Effects on wildlife species important to the Bands are discussed in Section 5.2.9 on a connected ecosystems level.

Due to the relative stability in population and harvest levels for white-tailed deer and bear (MDNR 2013b, MDNR 2013c), along with the limited hunting access at the NorthMet Project area and available adjacent habitat, the NorthMet Project Proposed Action is not likely to threaten deer or bear populations or hunting opportunities.

Habitat fragmentation and loss, climate change, disease, and predation are all potential factors in moose population decline (MDNR 2013d). The key habitat types considered moose habitat include mature forest, grassland/brushland, and aquatic environments. A total of 2,775.2 acres of these key habitat types would be directly affected by the NorthMet Project Proposed Action (see Table 5.2.5-3). As such, the NorthMet Project Proposed Action will affect moose individuals in the vicinity through habitat loss and fragmentation, though not likely at a population level.

5.2.5.3 NorthMet Project No Action Alternative

5.2.5.3.1 Mine Site

Under the NorthMet Project No Action Alternative, mining would not occur. As described in Section 5.2.4.3.1, forest harvesting would continue to occur in portions of the federal lands, including the Mine Site. While timber harvests would result in the immediate decrease of some habitat types, permanent changes are not expected and conversion from one habitat type to another would benefit some species. Direct and indirect effects of the NorthMet Project No Action Alternative on wildlife and their habitat types are not expected, as the federal lands would continue to be managed as they currently are. Species individuals may still be affected due to existing land use (timber harvest, exploration, vehicle traffic, etc.) but effects are less than those expected under the NorthMet Project Proposed Action. The use of privately owned land at the Mine Site would also determine effects on wildlife under the NorthMet Project No Action Alternative.

5.2.5.3.2 Plant Site

Under the NorthMet Project No Action Alternative, the former LTVSMC processing plant would be reclaimed and areas revegetated in accordance with the Reclamation Plan much sooner than under the NorthMet Project Proposed Action. Revegetation would restore habitat for some species. Species individuals may still be affected due to disturbances related to reclamation, but effects are less than those expected under the NorthMet Project Proposed Action.

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5.2.6 *Aquatic Species*

This section describes the potential effects of the NorthMet Project Proposed Action on fish and aquatic macroinvertebrate communities, especially special status species, associated with waterbodies found in the NorthMet Project area. These potential effects include changes in physical habitat (including flow), riparian and aquatic connectivity, and water quality.

Summary

The NorthMet Project Proposed Action could affect aquatic physical habitat via changes in flow, affect riparian and aquatic connectivity via construction activities within the riparian zone, affect water quality by increasing solute concentrations above Class 2B standards, and, as a result of these changes, potentially affect aquatic species including special status species (i.e., federally or state-listed threatened and endangered species, RFSS, and MDNR SGCN).

The NorthMet Project Proposed Action would reduce flow in the Partridge River by a maximum of about 8 percent and reduce flow in the Embarrass River by a maximum of about 2 percent, and change flows in several tributary streams draining to the Partridge and Embarrass rivers by a maximum of about plus or minus 20 percent, which would fall into the range of annual natural variability in terms of precipitation. These reduced flows are not anticipated to result in any measurable effect on available aquatic habitat in any streams in the NorthMet Project area, as long as seasonal flow variation is also maintained. Studies conducted by the USGS in streams and rivers indicated that the severity of flow alteration had a direct correlation on the community alteration of fish and macroinvertebrates (Carlisle et al. 2013).

The NorthMet Project Proposed Action activities would not occur within the riparian buffer of any streams; therefore the NorthMet Project Proposed Action would not affect the extent of natural vegetative cover along riparian areas and would not result in a decrease in the RCI. The NorthMet Project Proposed Action would also not result in any new dams, bridges, or culverts within perennial or intermittent streams; therefore, the NorthMet Project Proposed Action would not affect the hydrologic connectivity along streams and would not result in a decrease in the ACI. In the general vicinity of the NorthMet Project area, there are numerous case histories of dewatered mine pits in wetland areas. The historical information clearly indicates that there has not been extensive loss (i.e., drying up) of wetlands next to these pits except perhaps within 100 ft or so of the pit rim. This may be explained by the hydrogeology, which typically consists of a thin and moderately permeable surficial unit overlying low-permeability bedrock. Even when the pit water level is well below the top of bedrock, the low-permeability bedrock limits the amount of surficial groundwater that can drain downward into the pit and there is sufficient recharge to the surficial unit to maintain wetland conditions. It is anticipated that riparian zones (wetlands) adjacent to the Partridge River would not experience any measurable groundwater drawdown, particularly coupled with minimal surface water flow change due to the NorthMet Project Proposed Action.

Water quality modeling (see Section 5.2.2) predicts that the NorthMet Project Proposed Action would meet all Class 2B (aquatic life) water quality standards with the possible exception of aluminum and lead in Embarrass River tributaries draining the Tailings Basin. For aluminum, ambient water quality, at times, already exceeds the Class 2B standard in both the Partridge River and Embarrass River. In the Partridge River, the NorthMet Project Proposed Action would not measurably increase aluminum concentrations relative to the Continuation of Existing

Conditions Scenario results. In the Embarrass River, the increase in concentration relative to the Continuation of Existing Conditions Scenario would be due to capturing relatively low concentration seepage from the Tailings Basin and increasing the relative contribution of higher concentration ambient groundwater and surface waters. In terms of lead, the two potential exceedances would be a side effect of the NorthMet Project Proposed Action due the reduction in surface water hardness that would result from the capture and removal of dissolved solids by the WWTP and the associated decrease in the hardness-based lead evaluation criterion. Most of the lead-loading causing this exceedance would occur during years 0 to 25 and would come from non-contact surface water rather than from a NorthMet Project Proposed Action-related facility. Although all other solutes are predicted to meet Class 2B water quality standards, the aggregate of these solutes, primarily metals, has the potential to affect aquatic biota. Effects on aquatic biota from the lead exceedance due to changes in hardness are not well-understood, but would likely increase the potential to adversely affect aquatic life.

In terms of special status species, there are no federal or state-listed threatened or endangered fish or macroinvertebrate species known to occur in the NorthMet Project area (USFWS 2011). There are four special status aquatic species (i.e., RFSS and SGCN) that have not been found in the NorthMet Project area, but suitable habitat is likely to occur and the species could be present.

The NorthMet Project area encompasses several waterbodies within both the Partridge and Embarrass River watersheds that provide a variety of habitats for aquatic biota. Predicted effects on aquatic biota from the NorthMet Project Proposed Action are possible due to changes in water chemistry, including increases in heavy metals. Effects on the success of fish spawning in tributary streams would be addressed by maintenance of seasonal, bankfull flows over the life of the NorthMet Project Proposed Action, especially when stream-related flow augmentation occurs within the Embarrass River Watershed.

5.2.6.1 Methodology and Evaluation Criteria

The operation, reclamation, and closure of the NorthMet Project Proposed Action may result in changes in the physical aquatic habitat or water quality that would result in effects on fish and aquatic species. To assess these effects, predicted changes in water quality and flow, as presented in Section 5.2.2, were used in combination with data on existing aquatic biota conditions, as discussed in Section 4.2.6, to determine potential effects on aquatic biota in surface waterbodies located in the NorthMet Project area.

The following criteria were considered in this evaluation:

- physical alteration of stream conditions and the effect on fish and macroinvertebrate assemblages;
- numeric water quality standards established for the protection of aquatic life in affected waterbodies;
- the structure or function of the aquatic species assemblages in affected stream segments; and
- effects on one or more protected aquatic species or their habitat.

With respect to mercury, the criteria is an increase in the body burden of mercury in aquatic biota since this is the primary mechanism through which mercury affects aquatic life.

5.2.6.2 NorthMet Project Proposed Action

5.2.6.2.1 Partridge River

This section describes the potential effects of the NorthMet Project Proposed Action on aquatic resources in the Partridge River Watershed, including effects on physical habitat, riparian and aquatic connectivity, and water quality.

Physical Habitat Effects

Hydrologic changes often have effects on fish and aquatic macroinvertebrates. While many aspects of the hydrologic regime can be important to the maintenance of fish and macroinvertebrate assemblages, reduction in baseflow (the portion of streamflow from groundwater) is particularly relevant because it represents a loss of habitat.

In the Partridge River, results of the water modeling (described in Section 4.2.2)—as predicted at monitoring stations SW-002, SW-004, and SW-004a—were used to describe predicted flow for the upper Partridge River Watershed within the vicinity of the Mine Site. These monitoring stations were selected due to their geographical location (see Figure 5.2.6-1), and likely represent the area that would best describe potential maximum effects along the Partridge River.

At SW-002, SW-004, and SW-004a, baseflow (i.e., average 30-day annual low flow) gradually decreases during the first 11 years of mining, but in the worst case only represents a 4 to 7 percent reduction and a 0.02 to 0.16 cfs reduction in absolute flow (year 11). In terms of long-term closure, the average annual 30-day minimum flow is estimated to decrease from 0.42 cfs (existing conditions) to 0.41 cfs at SW-002 and from 0.95 cfs (existing conditions) to 0.92 cfs at SW-004. At SW-004a, the average annual 30-day minimum flow is estimated to increase from 2.53 cfs (existing conditions) to 3.08 cfs (see Table 5.2.6-1). The annual daily mean flow would follow similar trends as the 30-day annual low flow, with a maximum decrease of 5 percent at year 11 and remain the same as existing conditions for long-term closure. Most of these changes in flow are too small to be measurable and, therefore, hydrologic alteration is not expected to degrade physical aquatic habitat by destabilizing the stream channel.

The effects from the NorthMet Project Proposed Action on seasonal flow would be negligible and, therefore, no adverse effects on aquatic habitat or species are anticipated.

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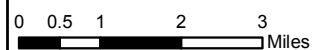
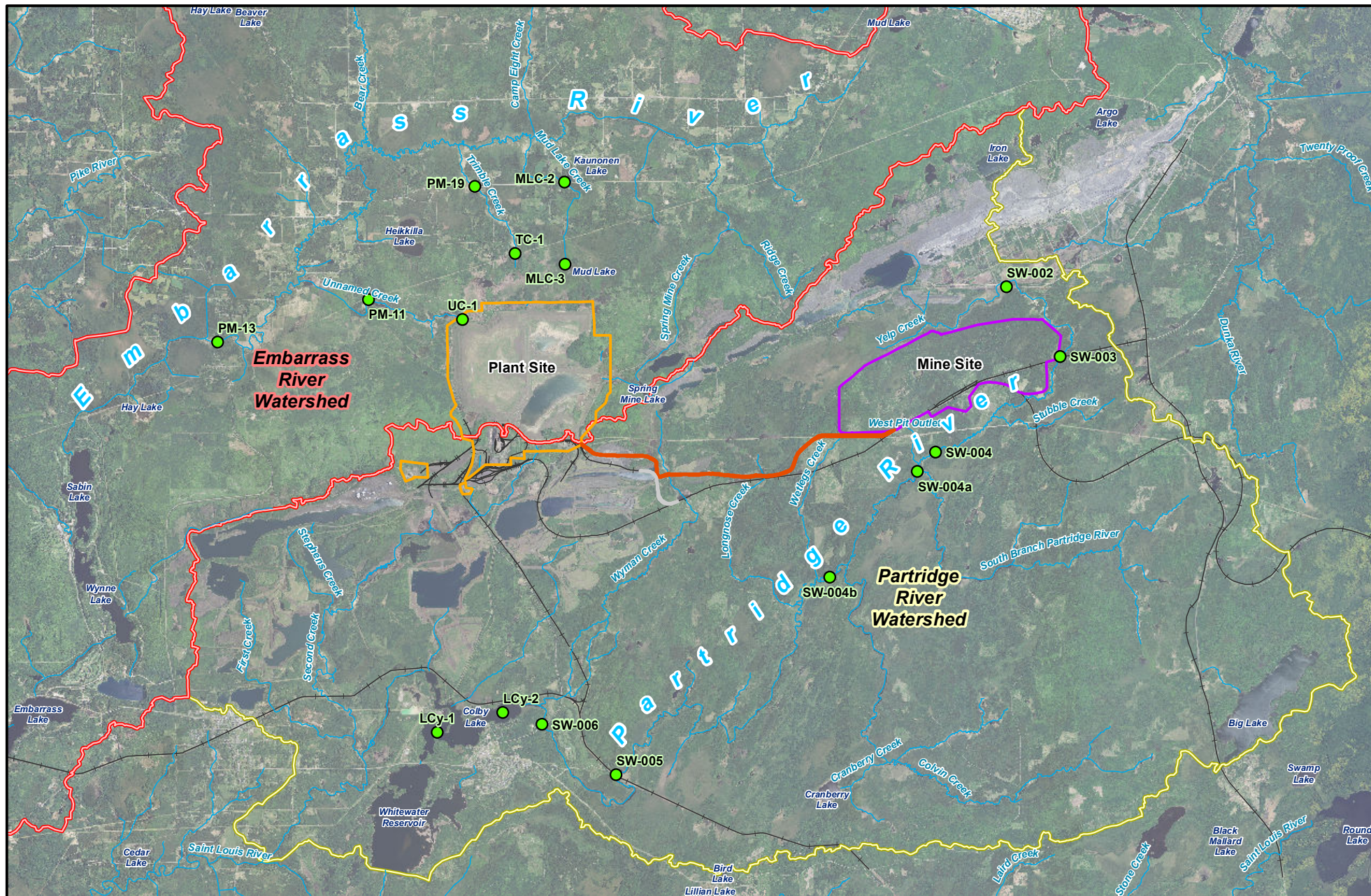


Figure 5.2.6-1
Partridge and Embarrass River Watershed
Surface Water Evaluation Locations
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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Table 5.2.6-1 Partridge River Flow Modeling Results for Evaluation Locations SW-002, SW-004, and SW-004a

SW-002								SW-004							SW-004a						
Statistic (Unit)	Existing Conditions	Year 1	Year 2	Year 11	Year 20	West Pit Filling	Long-term Closure	Existing Conditions	Year 1	Year 2	Year 11	Year 20	West Pit Filling	Long-term Closure	Existing Conditions	Year 1	Year 2	Year 11	Year 20	West Pit Filling	Long-term Closure
Annual Daily Mean (cfs)	4.63	4.44	4.44	4.40	4.65	4.63	4.63	10.63	10.28	10.28	10.17	10.42	10.71	10.71	29.17	28.71	28.62	27.89	28.40	28.23	29.46
October Mean (cfs)	8.35	8.00	8.01	7.94	8.39	8.35	8.35	19.24	18.57	18.58	18.37	18.81	19.35	19.35	52.85	52.01	51.84	50.48	51.39	51.08	52.81
November Mean (cfs)	2.59	2.45	2.44	2.41	2.53	2.52	2.52	6.60	6.08	6.08	6.02	6.16	6.30	6.30	17.86	17.20	17.14	16.77	17.03	16.96	17.87
December Mean (cfs)	0.74	0.72	0.72	0.71	0.74	0.74	0.74	1.93	1.76	1.75	1.73	1.77	1.82	1.82	5.61	5.38	5.36	5.25	5.32	5.30	6.02
January Mean (cfs)	0.47	0.45	0.45	0.45	0.47	0.47	0.47	1.14	1.05	1.05	1.04	1.06	1.09	1.09	3.28	3.18	3.17	3.09	3.14	3.12	3.82
February Mean (cfs)	1.29	1.24	1.24	1.22	1.29	1.28	1.28	2.93	2.83	2.83	2.80	2.87	2.95	2.95	8.03	7.90	7.87	7.67	7.81	7.76	8.56
March Mean (cfs)	7.30	6.99	7.01	6.95	7.36	7.33	7.33	15.74	15.43	15.46	15.29	15.67	16.16	16.16	43.24	42.83	42.67	41.47	42.30	41.99	43.66
April Mean (cfs)	16.62	15.88	15.89	15.73	16.60	16.52	16.53	38.80	37.36	37.38	36.97	37.85	38.89	38.89	108.99	107.09	106.74	104.09	105.89	105.29	108.06
May Mean (cfs)	4.78	4.57	4.59	4.55	4.85	4.83	4.83	11.38	10.98	10.99	10.88	11.16	11.47	11.47	31.85	31.40	31.32	30.53	31.11	30.90	32.21
June Mean (cfs)	3.78	3.65	3.66	3.63	3.83	3.82	3.82	8.37	8.29	8.31	8.23	8.45	8.67	8.66	22.20	22.10	22.02	21.47	21.87	21.76	22.84
July Mean (cfs)	2.52	2.44	2.44	2.43	2.56	2.55	2.55	5.72	5.59	5.59	5.54	5.67	5.81	5.81	15.03	14.85	14.76	14.38	14.65	14.56	15.50
August Mean (cfs)	3.28	3.16	3.16	3.14	3.31	3.31	3.31	6.99	7.00	6.98	6.92	7.08	7.28	7.28	18.24	18.17	18.29	17.82	18.15	18.06	19.09
September Mean (cfs)	3.84	3.71	3.70	3.66	3.88	3.85	3.85	8.66	8.37	8.35	8.27	8.47	8.68	8.67	22.75	22.34	22.20	21.61	22.01	21.85	22.97
Average Annual 30-day Max (cfs)	23.02	22.04	22.06	21.85	23.10	23.00	23.01	52.71	51.20	51.23	50.66	51.91	53.38	53.38	146.83	144.89	144.63	140.98	143.48	142.71	146.29
Average Annual 90-day Max (cfs)	11.65	11.16	11.16	11.06	11.69	11.64	11.64	26.88	26.03	26.04	25.75	26.38	27.13	27.13	74.55	73.44	73.25	71.39	72.67	72.24	74.40
Average Annual 30-day Min (cfs)	0.42	0.40	0.40	0.40	0.42	0.41	0.41	0.95	0.89	0.89	0.88	0.90	0.93	0.92	2.53	2.46	2.44	2.37	2.41	2.39	3.08
Average Annual 90-day Min (cfs)	0.53	0.51	0.51	0.50	0.53	0.52	0.52	1.22	1.14	1.14	1.12	1.15	1.17	1.17	3.25	3.16	3.14	3.07	3.11	3.09	3.79
Avg. Hydrograph Increase (cfs/day)	4.57	4.45	4.47	4.47	4.69	4.67	4.65	8.04	8.01	8.07	7.99	8.28	8.59	8.59	23.91	24.15	24.21	23.40	23.75	23.95	24.27
Avg. Hydrograph Decrease (cfs/day)	1.66	1.60	1.62	1.61	1.70	1.68	1.69	2.75	2.78	2.79	2.76	2.85	2.95	2.95	7.88	8.01	8.02	7.85	7.95	8.01	8.09

Source: Barr 2012g.

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No effects on aquatic resources are anticipated from hydrologic changes at the Partridge River tributary streams, Colby Lake, or Whitewater Reservoir, from the NorthMet Project Proposed Action. Hydrologic changes would be minimal (inflow reduced by a maximum of less than 2 percent). Withdrawals at Colby Lake would create an average annual water level fluctuation of about 3.6 ft, compared to 3.9 ft for zero withdrawal. Withdrawals at the Whitewater Reservoir would create an annual fluctuation of about 4.2 ft compared to 2.9 ft for zero withdrawal. Effects on Colby Lake and Whitewater Reservoir are expected to be negligible as they would be well within the range of effects experienced during the former LTVSMC taconite mining operations.

Approximately 500 gpm of seepage flows from the existing LTVSMC Tailings Basin to the headwaters of Second Creek. Under the current LTVSMC Consent Decree, most of this seepage is captured and pumped back to the Tailings Basin, resulting in a net reduction in base flow to Second Creek. The NorthMet Project Proposed Action would continue pumping this seepage back to the Tailings Basin for water quality protection reasons, but would augment flows in Second Creek at approximately 80 percent of the current seepage volume (i.e., about 400 gpm) with a combination of WWTP effluent and/or Colby Lake water throughout NorthMet Project Proposed Action operations, reclamation, and long term closure. The proposed 80 percent of historic flow augmentation volume would fall into the range of annual natural variability in precipitation and streamflow (PolyMet 2013b); therefore, the designed flow augmentation to Second Creek is not expected to affect the available aquatic species habitat by degrading the habitat with decreased flow to the headwater portions of this stream and would in fact help mitigate the hydrologic effect associated with the current pump back requirements.

Riparian and Aquatic Connectivity

The NorthMet Project Proposed Action activities would not occur within the riparian buffer of any streams; therefore, the NorthMet Project Proposed Action would not affect the extent of natural vegetative cover along riparian areas and would not result in a change in the RCI for the Partridge River.

The NorthMet Project Proposed Action would not result in any new dams, bridges, or culverts within perennial or intermittent streams; therefore, the NorthMet Project Proposed Action would not affect the hydrologic connectivity along streams and would not result in a change in the ACI for the Partridge River.

Water Quality Effects

Surface water chronic standards, specifically the Class 2B standards, were developed to be protective of aquatic life and to promote the “propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life, and their habitats” (*Minnesota Rules*, part 7050.0222). The chronic standards reflect “the highest water concentration of a toxicant to which organisms can be exposed indefinitely without causing chronic toxicity” (*Minnesota Rules*, part 7050.0218, subpart 3, item I).

As described in more detail in Section 5.2.2, the GoldSim water quality model results were screened to compare the single highest monthly P90 water quality prediction from among 2,400 months covered over the 200 year model period by the simulation with Continuation of Existing Conditions Scenario values and the water quality evaluation criteria (see Section 5.2.2.1). The screening analysis indicates that the NorthMet Project Proposed Action would meet all

Minnesota Class 2B water quality standards and proposed evaluation criteria with the exception of aluminum (see Table 5.2.6-2).

The results indicate aluminum would exceed the Class 2B standard (125 µg/L) at all evaluation locations. Maximum aluminum P90 values for the NorthMet Project Proposed Action ranged from a low 165.4 µg/L (SW-002) to a high of 173.7 µg/L (SW-005 and SW-006). However, Partridge River concentrations at the same locations for the Continuation of Existing Conditions Scenario are essentially identical, also exceeding the standard. Therefore, the NorthMet Project Proposed Action would not worsen existing conditions relative to aluminum concentrations in the Partridge River. The NorthMet Project Proposed Action is also estimated to result in a net decrease in mercury loadings to the Partridge River (see Sections 5.2.3.4 and 6.2.3.3).

Table 5.2.6-2 Maximum Modeled Monthly P90 Surface Water Concentrations for the Partridge River within the Vicinity of the Mine Site

Parameter	Stream Standard ¹	Units	SW-002		SW-004		SW-004a	
			NorthMet Project Proposed Action	Continuation of Existing Conditions Scenario ³	NorthMet Project Proposed Action	Continuation of Existing Conditions ³	NorthMet Project Proposed Action	Continuation of Existing Conditions ³
General								
Chloride	230	mg/L	21.8	21.8	22.5	22.5	22.8	22.8
Metals Total								
Aluminum	125	µg/L	165.4	165.4	169.1	168.9	171.7	173.5
Antimony	31	µg/L	1.66	1.66	1.66	1.66	3.97	1.67
Arsenic	53	µg/L	5.96	5.96	5.17	5.10	5.61	3.91
Boron	500	µg/L	174.5	174.4	177.8	177.8	179.6	179.7
Cadmium	1.3 - 2.7 ²	µg/L	0.12	0.12	0.13	0.12	0.61	0.12
Chromium	11	µg/L	1.77	1.77	1.84	1.84	1.87	1.86
Cobalt	5	µg/L	0.58	0.58	1.1	0.63	2.18	0.74
Copper	4.2 - 10.5 ²	µg/L	2.02	2.03	2.27	2.21	4.28	2.57
Lead	0.97-3.8 ²	µg/L	0.44	0.44	0.53	0.51	1.28	0.64
Nickel	23.6-58.7	µg/L	2.91	2.91	2.95	2.95	15.7	2.98
Selenium	5	µg/L	0.61	0.61	0.61	0.61	1.27	0.61
Silver	1	µg/L	0.12	0.12	0.12	0.12	0.14	0.12
Thallium	0.56	µg/L	0.27	0.27	0.25	0.24	0.22	0.21
Zinc	54.2-135 ²	µg/L	26.0	26.0	27.1	27.1	33.5	27.4

Source: Section 5.2.2.

¹ Some stream standards vary with hardness.

² Range of P10 to P90 standard associated with varying hardness; applicable standard varies with modeled or measured hardness at evaluation location.

³ Continuation of Existing Conditions.

Note: Bolded numbers show exceedances at the P90 modeled concentrations.

Colby Lake

As discussed in Section 5.2.2 and exhibited in Table 5.2.6-3, Colby Lake would exceed the evaluation criteria for aluminum under the NorthMet Project Proposed Action. Comparing these evaluation criteria exceedances to the Continuation of Existing Conditions Scenario indicates no effects on aquatic species would result from the NorthMet Project Proposed Action, as modeled values are very similar under the No Action Continuation of Existing Conditions Scenario.

Table 5.2.6-3 Maximum Modeled Monthly P90 Surface Water Concentrations for Colby Lake

Parameter	Colby Lake Evaluation Criteria	Units	Continuation of Existing Conditions (Max P90 Value)	NorthMet Project Proposed Action (Max P90 Value)
General				
Chloride	230	mg/L	22.7	22.7
Metals Total				
Aluminum	125	µg/L	173.6	173.0
Antimony	5.5	µg/L	1.65	1.69
Arsenic	2	µg/L	0.65	0.90
Cadmium	5	µg/L	0.12	0.15
Chromium	11	µg/L	1.86	1.87
Cobalt	2.8	µg/L	0.56	0.68
Copper	NA	µg/L	2.09	2.25
Lead	NA	µg/L	0.31	0.38
Nickel	NA	µg/L	2.98	3.94
Selenium	5	µg/L	0.61	0.63
Silver	1	µg/L	0.12	0.12
Thallium	0.28	µg/L	0.05	0.05
Zinc	NA	µg/L	27.5	27.6

Source: Barr 2013c, Mine Site Modeling Results, ver. 5.

Note: Bold font indicates an exceedance of the Class 2B water quality standards evaluation criteria.

Special Status Species

There are no federally listed or state-listed threatened or endangered fish or macroinvertebrate species known to occur in the Partridge River (USFWS 2011). There are four special status aquatic species that have not been found in the NorthMet Project area, but suitable habitat is likely to occur and the species could be present, including:

- Quebec emerald dragonfly – RFSS species,
- Ebony boghaunter – RFSS species,
- Creek heelsplitter mussel – SGCN and RFSS species, and
- Northern brook lamprey – SGCN and RFSS species.

Since the NorthMet Project Proposed Action is not predicted to result in any measurable changes in low flows and negligible changes in average flows, no effects on RCI and ACI, and no change in water quality for any of the Class 2B water quality standards, no effects on aquatic special status species is expected within the Partridge River Watershed.

Furthermore, the USFS determined that the NorthMet Project Proposed Action would not affect three RFSS aquatic species on the Superior National Forest, which include lake sturgeon, nipigon cisco, and shortjaw cisco. In addition, the NorthMet Project Proposed Action may affect individuals, but would not likely cause a trend to federal listing or loss of viability for the remaining six RFSS aquatic species, discussed in Section 4.2.6, on the Superior National Forest. Please see the Biological Evaluation listed on the USFS website (<http://www.fs.usda.gov/goto/superior/northmet>) for more information about effects on RFSS aquatic species.

5.2.6.2.2 Embarrass River Watershed

This section describes the potential effects of the NorthMet Proposed Action on aquatic resources in the Embarrass River Watershed, including effects on physical habitat, riparian and aquatic connectivity, and water quality.

Physical Habitat Effects

The NorthMet Project Proposed Action could potentially affect flows in the three tributary streams draining the Tailings Basin (i.e., Mud Lake Creek, Trimble Creek, and Unnamed Creek) and flow in the Embarrass River downstream of these tributary effects (i.e., PM-13). As discussed in Section 5.2.2, PolyMet proposes to capture nearly all seepage from the Tailings Basin, and to mitigate this effect by augmenting flows to the three Embarrass River tributary streams (and Second Creek in the Partridge River) with WWTP effluent and/or Colby Lake water to maintain average annual flows in these tributaries within 20 percent of existing conditions (see Table 5.2.6-4). This tributary streams flow augmentation would result in only about a 2 percent reduction in average annual flow at PM-13 in the Embarrass River. Changes in average annual flow of this magnitude (less than 20 percent) would fall into the range of annual natural variability in terms of precipitation; however, seasonal flow data was not available for this watershed—in particular the tributaries. Dampening of the hydrologic curve could have a negative effect on aquatic biota due to stream destabilization, including aggradation, degradation, and resultant loss of habitat. Maintenance of spring bankfull flow is particularly important for the success of fish spawning in tributaries because high flows trigger spawning runs and maintain spawning habitat. Effects on the success of fish spawning in tributary streams would be addressed by maintenance of seasonal, bankfull flows over the life of the NorthMet Project Proposed Action, especially when stream-related flow augmentation occurs within the Embarrass River Watershed.

Table 5.2.6-4 Predicted Minimum Flow to the Embarrass River Tributaries

Tributary	Historical Average Annual Flow (gpm)	NorthMet Project Designed Average Annual Flow (gpm)¹
Mud Lake Creek	665	532
Trimble Creek	1,888	1,510
Unnamed creek	1,180	944
Total	3,733	2,986

Source: Barr 2013a.

¹ Includes predicted future flow contribution of headwaters watershed.

Water Quality Effects

As described in more detail in Section 5.2.2, the GoldSim water quality model results were screened to compare the single highest monthly P90 water quality prediction from among 2,400 months (Partridge River) or 6,000 months (Embarrass River) covered over the 200- to 500-year model period with the Continuation of Existing Conditions Scenario modeled values and the water quality evaluation criteria (see Section 5.2.2.1). The screening analysis indicates that the NorthMet Project Proposed Action would meet all Minnesota Class 2B water quality standards and proposed evaluation criteria with the exception of aluminum and lead (see Table 5.2.6-5).

The results indicate aluminum would exceed the Class 2B standard (125 µg/L) at all evaluation locations. Maximum aluminum P90 values for the NorthMet Project Proposed Action ranged from a low 151.1 µg/L (TC-1) to a high of 175.9 µg/L (MLC-3). As discussed in Section 5.2.2, however, the predicted increases in aluminum are not the result of increased aluminum loadings from the NorthMet Project Proposed Action, but rather the result of capturing Tailings Basin seepage (via the groundwater containment system) with low concentrations of aluminum, which tends to dilute higher aluminum concentrations in ambient groundwater and surface water, and replacing it, at least partially, with higher aluminum concentration Colby Lake water.

Maximum lead P90 concentrations are predicted to exceed the Class 2B water quality standard, which is hardness-based, in Unnamed Creek and Trimble Creek. As discussed in Section 5.2.2, the groundwater containment system would capture virtually all of the high-hardness seepage from the Tailings Basin and would replace it with lower-hardness effluent from the WWTP. This reduction in hardness results in a decrease in the water quality standard. Most of the lead-loading causing this exceedance would occur during years 0 to 25 and would come from non-contact surface water rather than from a NorthMet Project Proposed Action-related facility.

Although maximum solute P90 concentrations are expected to meet Class 2B water quality standards for solutes other than aluminum and lead, the NorthMet Project Proposed Action is projected to alter the existing water quality of the Embarrass River by increasing solute concentrations from 2 to almost 30 times the existing level. The addition of WWTP and, when necessary, Colby Lake water to Unnamed Creek, Trimble Creek, Mud Lake Creek as part of the augmentation program is projected to contribute to these loading increases, as well as to reduce hardness by over 50 percent in these tributaries.

The NorthMet Project Proposed Action is predicted to result in a net increase in mercury loadings to the Embarrass River (see Sections 5.2.2.3.4 and 6.2.3.3). This is primarily attributable to the redirection of flow associated with the construction of the East Dam as part of the Tailings Basin expansion to the Embarrass River.

Effects on aquatic biota from the lead exceedance due to changes in hardness are not well understood, but would likely increase the potential to adversely affect aquatic life.

Table 5.2.6-5 NorthMet Project Proposed Action and Continuation of Existing Conditions Scenario Maximum P90 Surface Water Concentrations for the Embarrass River Watershed within the Vicinity of the Plant Site

Parameter	Stream Standard ¹	Units	PM-13		PM-11		PM-19		MLC-2	
			NorthMet Project Proposed Action	Continuation of Existing Conditions	NorthMet Project Proposed Action	Continuation of Existing Conditions	NorthMet Project Proposed Action	Continuation of Existing Conditions	NorthMet Project Proposed Action	Continuation of Existing Condition
General										
Chloride	230	mg/L	9.9	12.2	8.97	22.8	8.01	22.5	10.4	19.2
Metals Total										
Aluminum	125	µg/L	166.7	165.6	160.8	142.8	151.5	126.8	173.0	155.5
Antimony	31	µg/L	7.8	0.29	18.8	0.31	18.5	0.31	1.5	0.31
Arsenic	53	µg/L	5.2	1.8	10.00	2.39	9.80	3.56	3.5	3.8
Boron	500	µg/L	136.4	212.7	367.4	500.2	357.4	403.4	119.0	276.7
Cadmium	1.4 – 9.03 ²	µg/L	0.95	0.13	1.99	0.18	1.94	0.16	0.20	0.15
Chromium	11	µg/L	4.0	2.2	7.97	1.96	7.78	1.77	2.3	2.1
Cobalt	5	µg/L	2.6	1.5	5.00	4.27	4.91	3.07	1.8	1.8
Copper	5.018 – 38.4 ²	µg/L	5.7	2.7	9.00	4.05	8.86	3.22	4.3	2.6
Lead	1.32 – 26.2 ²	µg/L	1.6	0.75	3.00	0.69	2.94	1.02	1.3	1.2
Nickel	29.1 – 211.6 ²	µg/L	26.4	4.5	50.0	7.21	49.0	5.37	15.6	4.1
Selenium	5	µg/L	2.7	1.3	4.99	1.09	4.88	1.01	1.3	1.2
Silver	1	µg/L	0.14	0.13	0.21	0.14	0.21	0.13	0.13	0.13
Thallium	0.56	µg/L	0.25	0.25	0.24	0.23	0.23	0.22	0.26	0.25
Vanadium	NA	µg/L	7.2	5.4	9.6	5.2	9.4	5.2	5.6	5.4
Zinc	66.9 – 221.2 ²	µg/L	55.9	17.8	100.0	15.4	97.9	15.26	21.5	17.9

Source: Section 5.2.2.

¹ Some stream standards vary with hardness.

² Range associated with varying hardness; exact numbers vary with modeled hardness at evaluation location.

Note: Shaded cells show exceedances at the P90 modeled concentrations.

Special Status Species

There are no federally listed or state-listed threatened or endangered fish or macroinvertebrate species known to occur in the Embarrass River (USFWS 2011). There are four special status aquatic species that have not been found in the NorthMet Project area, but suitable habitat is likely to occur and the species could be present, including:

- Quebec emerald dragonfly – RFSS species,
- Ebony boghaunter – RFSS species,
- Creek heelsplitter mussel – SGCN and RFSS species, and
- Northern brook lamprey – SGCN and RFSS species.

The NorthMet Project Proposed Action is not predicted to result in any measurable changes in low flows, and there would be negligible changes in average annual flows, no effects on RCI and ACI, and no change in water quality for any of the Class 2B water quality standards.

Similarly for the Embarrass River, as stated above for the Partridge River, the USFS determined that the NorthMet Project Proposed Action would not affect three RFSS aquatic species on the Superior National Forest, which include lake sturgeon, nipigon cisco, and shortjaw cisco. In addition, the NorthMet Project Proposed Action may affect individuals, but would not likely cause a trend to federal listing or loss of viability for the remaining six RFSS aquatic species, discussed in Section 4.2.6, on the Superior National Forest.

5.2.6.3 NorthMet Project No Action Alternative

Under the NorthMet Project No Action Alternative, the NorthMet Project Proposed Action would not occur and associated effects on fish and other aquatic life would not occur.

Although under the No Action Alternative, the NorthMet Project Proposed Action, including the proposed Tailings Basin seepage collection and water treatment engineering controls, would not occur, the No Action Alternative would not necessarily be static. In this case, it is anticipated that the water quality of seepage from the existing LTVSMC Tailings Basin would improve over time as a result of natural attenuation and/or possible additional mitigation measures at some point in the future pursuant to new requirements in permits or other state or federal remediation requirements.

5.2.7 Air Quality

This section assesses the effects of the NorthMet Project Proposed Action on air quality. Procedures for air quality assessments vary depending upon the level of emissions from a proposed project. The USEPA defines sources as “major” or “minor,” depending on their emissions levels of regulated pollutants (250 tpy of any criteria pollutant, 100,000 tpy of GHGs, 10 tpy of a single HAP, or 25 tpy of all HAPs). As presented in this section, the NorthMet Project Proposed Action has been defined as a synthetic minor source according to this definition, since the project will limit its emissions through permit restrictions to less than the emission levels stated above. However, at the request of several state and federal agencies, much of the analyses were conducted to address requirements for major sources. Discussions of the air quality assessment methodologies, air quality effects, and potential mitigation measures are addressed for criteria pollutants, air toxics, and amphibole fibers.

Summary

The NorthMet Project Proposed Action has been designed so that it is considered a synthetic minor source for air permitting purposes. However, the evaluation of the NorthMet Project Proposed Action in this SDEIS has treated it as a major source due to its sensitive nature. Compliance with state and federal ambient air quality standards and growth increments, designed to protect human health and the environment, were evaluated using generally accepted state and federal threshold criteria. The NorthMet Project Proposed Action has been shown to not cause or contribute to significant air quality effects. Local and regional effects, up to 300-km from the project facilities, were evaluated to incorporate federally sensitive, pristine area resources such as BWCAW and Voyageurs National Park. Effects of dust from mining and ore transport are generally confined to areas disturbed by project activities. Control technologies similar to Federal Best Available Control Technologies (termed BACT-like) were evaluated and applied to the project equipment in order to minimize the potential for air emissions. In particular, BACT-like controls were incorporated to reduce mercury emissions to levels that would not impede current State of Minnesota mercury emissions reduction goals. BACT-like fine-particulate matter emission controls were also incorporated to specifically control the release of more than 99.9 percent of amphibole fibers in the ore.

5.2.7.1 Methodology and Evaluation Criteria

The following subsections describe the air quality standards used in the assessments, local and federal regulations that affect the NorthMet Project Proposed Action, and modeling methodologies and specific modeling assessments conducted, as well as the criteria used to define significant effects from operation of the NorthMet Project Proposed Action.

5.2.7.1.1 Regulatory Setting

Air Quality Standards

The USEPA has established NAAQS for seven criteria air pollutants including NO₂, SO₂, CO, O₃, PM₁₀, PM_{2.5}, and lead. Primary standards are established to protect the public health; secondary standards are set to protect public welfare, including protection from damage to animals, crops, vegetation, visibility, and buildings.

The MPCA has also promulgated ambient air standards for the State of Minnesota, known as the MAAQS. In addition to the criteria pollutants, the MAAQS contain standards for TSP and hydrogen sulfide (H₂S). As with the NAAQS, the MAAQS primary standards are established to protect the public health; secondary standards are set to protect public welfare, including protection from damage to animals, crops, vegetation, visibility, and buildings.

The NAAQS and MAAQS are summarized in Table 5.2.7-1.

Table 5.2.7-1 Summary of NAAQS and MAAQS

Pollutant	Averaging Period	Standard Value (ppm)	Standard Value (µg/m³)	Standard Type¹	Notes
Carbon Monoxide	1-Hour	35	40,000	Primary	Not to be exceeded more than once per year
	1-Hour ²	30	35,000	Primary	
	8-Hour	9	10,000	Primary and Secondary	
	Annual Arithmetic Mean	0.05	100	Primary and Secondary	Not to be exceeded
Nitrogen Dioxide					Not to exceed the 98 th percentile of the Maximum Daily 1-hour Values averaged over a 3-year period
	1-Hour	0.10	188	Primary	
Ozone	8-Hour	0.075	147	Primary and Secondary	4 th highest daily maximum 8-hour average
Lead	Quarterly		0.15	Primary and Secondary	Rolling 3-month average
Total Suspended Particulate (TSP) ²	Annual Geometric Mean		75 60	Primary Secondary	Not to be exceeded
	24-Hour		260 150	Primary Secondary	Not to be exceeded more than once per year
	Annual Arithmetic Mean ²		50	Primary and Secondary	Not to be exceeded
PM ₁₀	24-Hour		150	Primary and Secondary	Not to be exceeded more than once per year on average over 3 years
	Annual Arithmetic Mean		12	Primary and Secondary	Not to exceed the 3-year average of the weighted annual mean concentrations
PM _{2.5}	24-Hour		35	Primary and Secondary	Not to exceed the 3-year average of the 98 th percentile of 24-hour concentrations

Pollutant	Averaging Period	Standard Value (ppm)	Standard Value ($\mu\text{g}/\text{m}^3$)	Standard Type ¹	Notes
Sulfur Dioxide	Annual Arithmetic Mean	0.03 0.02	80 60	Primary Secondary ²	Not to be exceeded
	24-Hour	0.14	365	Primary and Secondary	Not to be exceeded more than once per year
	3-Hour	0.5	1,300	Primary and Secondary	
	3-Hour ²	0.35	915	Secondary	
	1-Hour ²	0.5	1,300	Primary	
	1-Hour	0.075	196	Primary	Not to exceed the 99 th percentile of the Maximum Daily 1-hour Values averaged over a 3-year period
Hydrogen Sulfide ²	½-Hour	0.05	70	Primary	Not to be exceeded over 2 times per year
	½-Hour	0.03	42	Primary	Not to be exceeded over 2 times in any 5 consecutive days

Source: MPCA 2013b; USEPA 2013.

¹ Primary standards set limits to protect human health; secondary standards set limits to protect public welfare.

² MAAQS only.

Federal Regulations

Attainment Status

Under the CAA, the USEPA has defined all areas within the United States as one of two classifications, attainment or non-attainment. “Attainment areas” are those areas that either have collected ambient air quality data to demonstrate that they are in compliance or they do not have demonstrated non-compliance with the NAAQS, and so they are known as “unclassified areas.” An area that does not meet NAAQS is considered to be a “nonattainment area” for that pollutant, and the USEPA requires the state to develop state implementation plans to control existing and future emissions in order to bring the area into compliance with the NAAQS. The NorthMet Project area has been designated by the USEPA as attainment for all air quality pollutants.

Prevention of Significant Deterioration Review

Under the CAA, the federal Prevention of Significant Deterioration (PSD) requirements provide for a pre-construction review and permit process for the construction and operation of a new or modified major stationary source in attainment areas. The review includes the following:

- BACT demonstration;
- ambient air quality analysis to assess potential project effects with NAAQS and PSD increments;
- an assessment of Air Quality Related Value (AQRV) of the direct and indirect effects of a project on general growth, soil, vegetation, and visibility for Class I regions within 300 km;

- an ambient monitoring program if no representative data are available; and
- public comment.

The USEPA's PSD program allows all attainment areas various levels of air quality protection and growth depending upon its designated class. Class I areas are special areas of natural wonder and scenic beauty—such as national parks, national monuments, and wilderness areas—where air quality should be given special protection. Class II areas are non-Class I areas that are allowed moderate growth and air quality degradation with Class II incremental limits. Class III areas are all non-Class I areas that are deemed unclassified and allow maximum growth and air quality degradation with no incremental limits. For attainment areas, the USEPA has promulgated PSD increments for four pollutants (NO₂, SO₂, PM₁₀, and PM_{2.5}) for both Class I and Class II regions. The increments are designed to allow for ambient concentrations within an area to increase by the maximum allowable amount above baseline concentrations. Class I PSD increments are designed to keep pristine areas clean and have more restrictive allowable increment thresholds. Class II PSD increments are designed to allow further growth within the rest of the country. Table 5.2.7-2 provides a summary of the Class I and Class II PSD increments.

Table 5.2.7-2 Summary of Allowable Prevention of Significant Deterioration Class I and Class II Increments

Pollutant, Averaging Period	Allowable Increment (µg/m ³)	
	Class I Region	Class II Region
SO ₂ , 3-hour	25	512
SO ₂ , 24-hour	5	91
SO ₂ , Annual	2	20
NO ₂ , Annual	2.5	25
PM ₁₀ , 24-hour	8	30
PM _{2.5} , 24-hour	2	9
PM _{2.5} , Annual	1	4

The NorthMet Project area is located within a Class II attainment area, as designated by the USEPA. In relation to the NorthMet Project Proposed Action, the federal CAA defines a source as a major source in an attainment area if it has any criteria pollutant emissions above 250 tpy or 100,000 tpy of GHG emissions. Because the NorthMet Project Proposed Action is proposing to limit its actual emissions below “major source” thresholds for the federal PSD program, the NorthMet Project Proposed Action is not subject to PSD requirements and, thus, modeling of PSD increment consumption requirements do not specifically apply for permitting. For the purposes of this SDEIS, NorthMet Project Proposed Action effects have been compared to the PSD Class I (generally pristine areas) and Class II (remaining areas) increments, as requested by several agencies, to ensure that the NorthMet Project Proposed Action is not contributing to any significant air quality effects.

Air Quality Related Values

In addition to PSD increments, major PSD sources that are located within 186 miles (300 km) of a Class I area may be required by the FLM to evaluate effects on AQRVs, which may include flora/fauna, visibility, water quality, soils, and odor for a specific Class I area. The NorthMet Project area is within 186 miles (300 km) of four Class I areas: BWCAW and Rainbow Lakes

Wilderness (administered by the USFS) and Voyageurs National Park and Isle Royale National Park (under the administration of the National Park Service). Although the NorthMet Project Proposed Action is agreeing to emission limits to avoid being a major PSD source, an evaluation of the applicable AQRV was conducted for comparison in this SDEIS. Table 5.2.7-3 provides the distances to each Class I area from the NorthMet Project area.

Table 5.2.7-3 NorthMet Project Setting Relative to Class I Regions

Class I Region	Distance from NorthMet Project Area (km/mi)
BWCAW	34/21
Voyageurs National Park	82/51
Rainbow Lakes Wilderness	142/88
Isle Royale National Park	218/135

New Source Performance Standards

The federal New Source Performance Standards are technology-based standards that are applicable to new or modified stationary sources of regulated emissions. The New Source Performance Standards program has defined emission limitations for approximately 70 source categories that are designated by size, as well as type of process. A comprehensive list of the applicable regulations for this facility would be included as part of the air quality permit. The following is a partial list of standards that apply to the NorthMet Project Proposed Action; these could vary depending on the final assessment of the permit application by the MPCA:

- Subpart A – General Provisions, which provides for general notification, recordkeeping, and monitoring requirements.
- Subpart LL – Standards of Performance for Metallic Minerals Processing Plants, which covers particulate and opacity emission limits for any new, modified, or reconstructed sources.
- Subpart OOO – Standards of Performance for Nonmetallic Mineral Processing Plants, which limits particulate emissions and opacity from new, modified, or reconstructed sources processing nonmetallic mineral (e.g., limestone or construction rock).
- Subpart IIII – Standards of Performance for Stationary Compression Ignition Internal Combustion Engines, which limits NO_x, PM, CO, fuel oil sulfur content, and opacity for new, modified, and reconstructed stationary compression ignition internal combustion engines.
- Subpart Dc – Standards of Performance for Small Industrial-Commercial-Institutional Steam Generating Units which, depending on fuel type, can regulate PM and/or SO₂ emissions from new, modified, or reconstructed boilers.

Air Conformity Determination

A conformity determination must be conducted by the lead federal agency if a federal action would generate emissions exceeding the conformity threshold levels (de minimis) of the pollutant(s) for which a Class I or Class II region is designated as a nonattainment area or as a maintenance area. Since the NorthMet Project area is classified as in attainment for all criteria pollutants, a General Conformity Determination is not required.

State of Minnesota Regulations

Nonferrous Mineland Reclamation rules, *Minnesota Rules* part 6132.800, administered by the MDNR, require the control of dust from areas disturbed specifically by mining operations.

Also, the MPCA has promulgated rules concerning the control and permitting of all sources (not just for mining operations) throughout Minnesota. The following regulations are evaluated for the NorthMet Project Proposed Action.

Prevention of Significant Deterioration Review

Minnesota Rules, part 7007.3000, incorporate by reference the federal PSD requirements that provide for a pre-construction review and permit process for the construction and operation of a new or modified major stationary source in attainment areas.

The NorthMet Project Proposed Action is designed to limit emissions below major source thresholds (i.e., to be permitted as a synthetic minor source). Thus, for permitting purposes, the NorthMet Project Proposed Action would not be considered a major source for PSD (BACT demonstration, PSD increment assessment, and AQRV assessment would not be required via *Minnesota Rules*, part 7007.3000). However, a comprehensive analysis of NAAQS, MAAQS, PSD Class I and II increments, and AQRV is allowed, under *Minnesota Rules*, part 7007.0100(7)(k) and (v), as part of the evaluation of effect. An evaluation of pollution control technology was conducted for the Mine Site and Plant Site (Barr 2007l, Barr 2007o, Barr 2011, Barr 2012).

Minnesota Standards of Performance

A comprehensive list of Minnesota Standards of Performance would be identified in the air quality permit. The following is a list of Minnesota Standards of Performance applicable to the NorthMet Project Proposed Action. This list may change, depending upon the final assessment of the permit application by the MPCA.

Control of Fugitive PM (*Minnesota Rules*, part 7011.0150), which applies to bulk material handling operation, roads, and other fugitive sources. The rule prohibits the release of “avoidable amounts” of PM, and facilities are required to take reasonable precautions to prevent the discharge of visible fugitive emissions beyond the property line.

Standards of Performance of Stationary Internal Combustion Engines (*Minnesota Rules*, part 7011.2300). This applies to the emergency fire water pumps and the emergency generators, and limits SO₂ emissions to 0.5 pound per million British thermal units (lb/MMBTU) heat input.

Standards of Performance for Post-1969 Industrial Process Equipment (*Minnesota Rules*, part 7011.0715). This would apply to all new ore-handling equipment and other new sources that would generate PM emissions for which a standard of performance has not been promulgated in a specific rule. Due to the remote location of the NorthMet Project area (i.e., any source that is not in the Minneapolis-Saint Paul Air Quality Control Region or the City of Duluth, and which is located not less than 0.25 mile from any residence or public roadway), the required control equipment efficiency standard would be 85 percent.

Standards of Performance for Existing Indirect Heating Equipment (*Minnesota Rules*, part 7011.0510). The rule limits the PM emissions to between 0.4 and 0.6 lb/MMBTU, limits SO₂

emissions to between 1.6 and 4.0 lb/MMBTU, and limits opacity to 20 percent. This may apply to existing indirect heaters if used in the mining and processing operations.

Standards of Performance for New Indirect Heating Equipment (*Minnesota Rules*, part 7011.0515). The rule limits emissions of PM to between 0.1 and 0.4 lb/MMBTU, SO₂ emissions to between 0.8 and 4.0 lb/MMBTU, NO_x emissions to between 0.2 to 0.7 lb/MMBTU, and opacity to 20 percent. This may apply to new indirect heaters that may be used in the mine processing operations.

Standards of Performance for Fossil-Fuel-Burning Direct Heating Equipment (*Minnesota Rules*, part 7011.0610). The rule limits PM emissions based upon process throughput and limits opacity to 20 percent. This may apply to process heaters that may be used in the mine processing operations.

Standards of Performance for Pre-1969 Industrial Process Equipment (*Minnesota Rules*, part 7011.0710). The rule limits mass PM emissions based upon process weight and limits opacity to 20 percent. Alternatively, due to the remote location of the NorthMet Project area, compliance can be demonstrated with a pollution control equipment efficiency of 85 percent. This may apply to existing ore-handling equipment that may be used in the mine processing operations.

Standards of Performance for Stationary Compression Ignition Internal Combustion Engines (*Minnesota Rules*, part 7011.3520). The rule incorporates federal Standards of Performance for Stationary Compression Ignition Internal Combustion Engines under 40 CFR, Part 60, Subpart IIII. This may apply to fire water pumps and emergency generators that may be used in the mine processing operations.

Stationary Reciprocating Internal Combustion Engines (*Minnesota Rules*, part 7011.8150). The rule incorporates federal National Emissions Standards for Hazardous Air Pollutants under 40 CFR, Part 63, Subpart ZZZZ. This may apply to fire water pumps and emergency generators that may be used in the mine processing operations.

5.2.7.1.2 Evaluation Criteria

Various state and federal air quality standards and emissions standards have been established to minimize degradation of air quality. The criteria used for the evaluation of potential effects on air quality from the NorthMet Project Proposed Action or an alternative are whether it would cause an exceedance of NAAQS or MAAQS.

In addition to legally applicable statutory or regulatory requirements, the following criteria also were considered in evaluating effects from the NorthMet Project Proposed Action:

- consumption of PSD increments as defined by the CAA Title I, PSD rule;
- adverse effects on visibility in Class I areas;
- adverse effects on other AQRV in Class I areas; and
- adverse effects on human health as determined by an Air Emissions Risk Analysis (AERA) (MPCA 2013b).

5.2.7.1.3 Proposed Action Emissions

From an air quality perspective, emissions from the NorthMet Project Proposed Action would be expected to occur from the mining operations at the Mine Site and ore/concentrate processing at the Plant Site. Although the emission generating activities at these two sites are separated geographically, they are joined by the rail line that would be used to transport ore from the Mine Site to the Plant Site. As such, the three components constitute a single project for permitting purposes, and, thus, the total emissions from both sites are summed for the purposes of this analysis.

At the Mine Site, emissions were estimated for material handling sources associated with excavation, portable crushing and screening operations, blast hole drilling, use of unpaved roads, and vehicle exhaust.

Material handling includes the loading of overburden, waste rock, lean ore, and ore into trucks with shovels or loaders. After it is hauled, the ore would be dumped into the Rail Transfer Hopper and the overburden, waste rock, and lean ore would be unloaded at the appropriate stockpile or pit. The crushing and screening operations would be used to break up and separate the larger rocks from soil and gravel in the overburden to produce rock suitable for construction purposes. Haul trucks would travel over unpaved roads from the excavation site to the rail loading and stockpiling areas. Fugitive emissions would be generated as part of these operations. In order to minimize fugitive emissions, the NorthMet Project Proposed Action will utilize several control measures. These include minimization of drop distances for ore-screening, truck loading/unloading, and rail-loading; water and other dust suppressants on haul roads (90 percent control); water sprays for rock crushing and screening; down-hole watering during blasting operations; and environmental observations and recording. In addition, two ambient air quality monitors are proposed to minimize fugitive dust effects at the mine.

At the Plant Site, point source emissions are predicted to occur from the crushing plant, flotation operation autoclaves and other hydrometallurgical processes, process consumables handling, and combustion. In addition, fugitive emissions are expected to occur from raw materials handling, Plant Site roads, the Tailings Basin, and from vehicle use of Dunka Road. Water spraying or other dust suppression would be used on all unpaved roads at the Plant Site, resulting in an 80 percent reduction in associated fugitive emissions.

PolyMet is proposing to accept emission limits below the major source threshold (stationary sources less than 250 tpy for criteria pollutants and 100,000 tpy for GHGs) so as to be classified as a synthetic minor PSD source and therefore not be subject to PSD requirements including modeling attainment with PSD increments for permitting purposes. As demonstrated in Table 5.2.7-4, below, the NorthMet Project Proposed Action does not have projected controlled emissions above major PSD thresholds on an annual basis. PSD required modeling analyses, however, were performed for this SDEIS to assess its effect to ensure that the minor-source NorthMet Project Proposed Action does not cause or contribute to significant effects.

Criteria Pollutants

Criteria pollutant emissions are expected from both the Mine Site and Plant Site. Detailed information on the emission calculations for each site source is available as separate documents (Barr 2012a; Barr 2013). Table 5.2.7-4 summarizes the NorthMet Project Proposed Action

maximum emissions for the Mine Site, Plant Site, and total emissions from PSD-regulated stationary sources for comparison with PSD Major Source Thresholds.

Table 5.2.7-4 Annual Criteria Air Pollutant Emissions for Prevention of Significant Deterioration-regulated Stationary Sources

Pollutant	Plant Site Projected Controlled Emissions (tpy)	Mine Site Projected Controlled Emissions (tpy)	Total Projected Controlled Emissions (tpy)	PSD Major Source Thresholds (tpy)
NO _x	117	5	122	250
SO ₂	7	0.8	8	250
TSP	201	9	210	250
PM ₁₀	192	4	196	250
PM _{2.5}	190	2	192	250
VOC	50	0.2	50	250
Lead	0	0	0	250
CO	127	2	129	250

In accordance with PSD permitting requirements, for this assessment, mobile emissions and fugitive emissions sources are not included in the determination of a major source. Under PSD requirements, fugitive sources are only included if the stationary source is defined as one of 28 named source categories. The NorthMet Project Proposed Action is not included in any of the USEPA-listed source categories; therefore, fugitive sources are not included in the determination of a major source. However, to assess modeled air effects, mobile and fugitive emissions from the operations were evaluated. The non-PSD-regulated mobile source emissions and fugitive emissions are summed in Table 5.2.7-5. Due to the size of the ore rock being transported, the design of the railcars, and the short distance of transport from the Mine Site to the Plant Site, the ore fines are expected to be coarse in nature. Thus, no significant reactive airborne fugitive dust from the rail transport is expected (MDNR et al. 2011b) and is not included in the fugitive emissions. Any spillage of the ore fines is expected to be within 2 meters of the rail line, along the path, and any effects of the reactive ore on the ground has been addressed in Section 5.2.3.

Table 5.2.7-5 Annual Air Pollutant Emissions for non-Prevention of Significant Deterioration-regulated Mobile Sources and Fugitive Sources

Pollutant	Plant Site Projected Controlled Emissions (tpy)	Mine Site Projected Controlled Emissions (tpy)	Total Projected Controlled Emissions (tpy)
NO _x	58	321	379
SO ₂	0	2	2
PM ₁₀	238	462	700
PM _{2.5}	31	77	108

Hazardous Air Pollutants Emissions

Small amounts of potentially toxic compounds, which are referred to as HAPs, are expected to be associated with the NorthMet Project Proposed Action. Table 5.2.7-6 provides the estimate of HAP emissions for the NorthMet Project Proposed Action stationary sources. These emission levels reflect potential emissions taking into account the proposed pollution control equipment for the NorthMet Project Proposed Action (controlled). As seen in the table, total emissions of a single HAP are below 10 tpy and the combined HAP emissions are below 25 tpy, indicating that the HAP emissions would not exceed USEPA major source thresholds for HAPs. Although HAP emissions from mobile sources were not included in the table to address emission thresholds, these emissions were used in assessing the potential effects on human health. The AERA itself is not limited to an assessment of HAPs, but is inclusive of any air toxic pollutant that screened in during the scoping process.

Table 5.2.7-6 Annual Hazardous Air Pollutant Emissions for Prevention of Significant Deterioration-regulated Stationary Sources

Pollutant	Plant Site Projected Controlled Emissions (tpy)	Mine Site Projected Controlled Emissions (tpy)	Total Projected Controlled Emissions (tpy)	Major Source Threshold (tpy)
Single HAP ¹	4	2	6	10
Combined HAPs	14	3	17	25

¹ Nickel is the HAP with the highest emissions for the Plant Site; manganese has the highest emissions at the Mine Site. Highest single HAP emissions for the Proposed Action are the nickel emissions. Values in Table 5.2.7-6 reflect nickel emissions.

Greenhouse Gas Emissions

Direct and indirect GHG emissions would be associated with the NorthMet Project Proposed Action. Direct emissions are emitted from project sources; indirect emissions are from sources that are not part of the project, but are generated from activities that support the project (e.g., off-site electrical needs). These gases include primarily carbon dioxide (CO₂), N₂O, and methane (CH₄). GHG emissions are estimated based upon their global warming potential and are expressed in carbon dioxide equivalents (CO₂e). Global warming potential is the relative effect a specific compound has on the overall global warming effects. The global warming potential factors for the three pollutants are 1, 310, and 21, respectively. For this assessment, the CO₂e is estimated by multiplying the specific emissions by its global warming potential factor and then summing the results. Table 5.2.7-7 summarizes the controlled direct GHG emissions for the NorthMet Project Proposed Action. As seen from the table, total direct GHG emissions are less than 100,000 tpy of CO₂e and would not exceed the USEPA major source thresholds for GHGs.

Table 5.2.7-7 Annual Greenhouse Gas Emissions for Prevention of Significant Deterioration-regulated Stationary Sources

Pollutant	Plant Site Projected Controlled Emissions (tpy)	Mine Site Projected Controlled Emissions (tpy)	Total Projected Controlled Emissions (tpy)	Major Source Threshold (tpy)
CO ₂	75,532	1,740	77,232	-
N ₂ O	0.9	0.08	1.0	-
CH ₄	0.5	0.02	0.5	-
Total CO₂e¹	75,836	1,764	77,600	100,000

¹ CO₂e is used to assess PSD applicability and considers only emissions from stationary sources.

Estimated annual maximum potential emissions of the NorthMet Project Proposed Action are based on the NorthMet Project Proposed Action as currently proposed running at maximum capacity (potential) (see Table 5.2.7-7). Potential annual GHG emissions from the NorthMet Project Proposed Action, as opposed to maximum potential emissions, are shown below in Table 5.2.7-8. Potential emissions are the sum of direct and indirect GHG emissions. Potential GHG emissions from the NorthMet Project Proposed Action are calculated using The Climate Registry General Reporting Protocol (Climate Registry 2008) and the MPCA General Guidance for Carbon Footprint Development in Environmental Review (MPCA 2011e). Emissions are calculated using default emission factors for specific fuels from the two documents. The annualized carbon footprint is summarized in Table 5.2.7-8; the lifetime carbon footprint is provided in Table 5.2.7-9.

For this analysis, emission estimates for the direct and indirect source equipment used generally accepted emission factors and estimation methods from the World Resource Institute Greenhouse Gas Protocol Standard, the Intergovernmental Panel on Climate Change (IPCC), and the MPCA General Guidance on Carbon Footprint in Environmental Review. Emissions estimates from secondary emissions sources generally utilized emissions factors that would represent estimates greater than actual values (high estimation) or best estimates of actual values based upon literature review (central tendency) (Barr 2011e).

Table 5.2.7-8 NorthMet Project Proposed Action Annual Greenhouse Gas Emissions

Pollutant	Potential Direct Emissions¹ (CO₂e – mtpy)²	Potential Indirect Emissions³ (CO₂e – mtpy)	Potential Total Emissions (CO₂e – mtpy)
Mine Site Point Source	1,600	--	--
Mine Site Mobile Source	38,086	--	--
Plant Site Point Source	138,641	--	--
Plant Site Mobile Source	8,014	--	--
Terrestrial Carbon Loss	10,000		
Totals	196,341	511,000	707,342

¹ Maximum Potential Direct Emissions are all emissions from sources that are under direct control of the NorthMet Project Proposed Action and full maximum capacity.

² CO₂e is in metric tons per year (mtpy).

³ Indirect emissions: Emissions that are a consequence of the activities of the reporting entity, but that occur at sources owned or controlled by another entity. For example, emissions that occur at a power plant as a result of electricity being generated and subsequently used by the NorthMet Project Proposed Action.

Table 5.2.7-9 NorthMet Project Proposed Action Lifetime Greenhouse Gas Emissions

Pollutant	Potential Direct Emissions¹ (CO₂e – mt)²	Potential Indirect Emissions (CO₂e – mt)⁶	Potential Total Emissions (CO₂e – mt)
Mine Site Emissions ³	793,734		
Plant Site Emissions ³	2,933,181		
Construction Emissions ⁴	94,186		
Reclamation Emission ⁵	1,549,688		
Subtotals	5,370,789	10,220,000	15,590,789
Terrestrial Carbon Loss ⁷	199,963	-	199,963
Totals	5,570,752	10,220,000	15,790,752

¹ Maximum Potential Direct Emissions are all emissions from sources that are under direct control of the NorthMet Project Proposed Action and full maximum capacity.

² CO₂e is in metric tons (mt).

³ Based upon maximum annual emissions occurring for 20 years.

⁴ Includes Phase I (flotation concentration production only) and Phase II (Hydrometallurgical Plant) construction.

⁵ Based on 20-year closure period and 30-year long-term closure period for the WWTF and WWTP.

⁶ Indirect emissions: Emissions that are a consequence of the activities of the reporting entity, but that occur at sources owned or controlled by another entity. For example, emissions that occur at a power plant as a result of electricity being generated and subsequently used by the NorthMet Project Proposed Action.

⁷ Terrestrial carbon loss includes: wetland carbon loss, 20 years of emissions from stockpiled peat, and emission from peat used in reclamation.

5.2.7.1.4 Predictive Modeling Approach

Detailed air dispersion modeling was conducted to evaluate compliance with NAAQS and MAAQS, to support PSD increment analysis, and to identify other potential effects on Class I and Class II areas. Although the NorthMet Project Proposed Action is not considered a major source for PSD considerations, the modeling analysis was conducted pursuant to the PSD regulations. The methods used for modeling are summarized below.

NAAQS, MAAQS, and Class II Increment Modeling Approach

To assess the effects on air quality, air dispersion modeling techniques were utilized. The MPCA prefers the AERMOD modeling system, and USEPA has included AERMOD as an approved guideline model. Meteorological data (2006 to 2010) from the Hibbing station and concurrent International Falls mixing height data, suitable for input to AERMOD, were used to evaluate the NorthMet Project Proposed Action. The AERMINUTE meteorological processor was used to develop the meteorological dataset for AERMOD.

The air quality modeling addressed individual point sources, as well as all sources of fugitive particulate matter. The modeling was conducted to determine the extent of effects from criteria pollutant emissions on ambient air quality and to identify the significant impact area for each pollutant. Modeling was conducted for PM₁₀, PM_{2.5}, NO₂, and SO₂ and their respective applicable averaging times at both the Mine Site and Plant Site (Barr 2012b; Barr 2012d). Ozone emissions were not modeled or analyzed for NAAQS due to the regional nature of ozone formation involving complex interaction of multi-pollutants. It should be noted that ozone is not emitted directly from any mining or ore-processing source. Emissions of lead and CO were not modeled for the NorthMet Project Proposed Action following the MPCA-approved modeling protocols for the Plant Site and Mine Site.

NorthMet Project Proposed Action emissions were initially modeled and compared to their respective Significant Impact Limit (SIL), as provided in Table 5.2.7-10 for each of the pollutants and averaging times. The SIL is the threshold for a given pollutant and averaging time, where no further modeling analysis is required. Modeled concentrations above the SIL do not define a significant effect in the context of the EIS; rather, where the modeled concentrations are above the SIL, more refined modeling is required in order to evaluate compliance with PSD increments and NAAQS. The farthest distance from the source where the concentration is above the SIL defines the circular region that would require further affect modeling.

All point and fugitive sources associated with the Mine Site and Plant Site were included in the source input files for PSD Class II increment modeling, with the exception of the Plant Site unpaved roads, which were in operation at the baseline date. Additionally, data on the following nearby major increment-consuming (or increment-expanding) sources, which were determined and provided by the MPCA, were also included as source input:

- Northshore Mine;
- Mesabi Nugget;
- Mesabi Mining Project;
- Cliffs Erie pellet yard; and
- Former LTVSMC processing plant.

Model inputs for these sources were provided by the MPCA. For comparison to the NAAQS, a background concentration was added to the modeled concentration. PM₁₀ background concentrations represent the 2008 to 2010, 3-year average concentrations for the high-second-high 24-hour concentration and maximum annual average concentration from the Virginia, Minnesota air quality monitoring site. PM_{2.5} background concentrations represent the 2008-2010 average concentrations for the highest 2nd high (H2H) 24-hour and annual average concentrations from the same station. Hourly SO₂ and NO₂ background concentrations are from 2008-2010 MPCA update data for use in modeling assessments (MPCA 2012i) for sites outside Minneapolis.

Class I Area-Related Modeling Approach

An air quality modeling analysis was conducted to estimate effects of the NorthMet Project Proposed Action on air quality in Class I areas. The Class I AQRV analyses addressed PSD Class I increments for SO₂, PM₁₀, NO₂, sulfur and nitrogen deposition, and visibility impairment. Regional haze is addressed in Section 6.2.3.8.8. The dispersion modeling analysis used standard USEPA long-range transport modeling methodologies and followed guidance as presented in: 1) USEPA's Guideline on Air Quality Models, the Interagency Workgroup on Air Quality Modeling Phase 2 report; 2) the Federal Land Managers' Air Quality Related Values Work Group (FLAG) Phase I report (revised November 2010); and 3) the "FLM Recommendations on Class I Area Analyses." The analyses also incorporated suggestions and guidance received from the USFS and the National Park Service. The California Puff (CALPUFF) air quality modeling system (version 5.8, June 23, 2007 release) was used for all Class I area analyses.

Input options and data utilized in the models generally corresponded to default or USEPA-recommended values along with representative, NorthMet Project Proposed Action-specific

source input parameters. The CALPUFF modeling analysis used refined meteorological fields from the CALMET subprogram of CALPUFF, developed from the 5th Generation NCAR/Penn State Mesoscale Model prognostic meteorological data for the available years 2002, 2003, and 2004. These were refined using concurrent surface, upper air, and precipitation data as outlined in the Final SDD. CALMET settings were based on the USEPA Office of Air Quality Planning and Standards memorandum “Clarification on EPA-FLM Recommended Settings for CALMET” (August 31, 2009). Hourly surface data from approximately 88 stations and precipitation data from 99 stations were used along with upper air data from four stations. No cloud data were used.

Pollutant emissions modeled in CALPUFF were SO₂, NO_x, PMC (coarse particulate matter), PMF (fine particulate matter), elemental carbon, secondary organic aerosols, and SO₄. Additionally, the pollutants SO₄, NO₃, and HNO₃ were modeled as products of the chemical transformation of SO₂ and NO_x. For the AQRV analysis, the MESOPUFF II scheme was used for the chemical mechanism to compute chemical transformation rates based on user-supplied background values for ozone and ammonia. Per MPCA guidance, the MESOPUFF II algorithm and secondary particulate formation were not used in the PM₁₀ increment consumption evaluation. Finally, the CALPOST and POSTUTIL post-processing programs were used to generate values of pollutant concentration, deposition, and visibility.

For the increment consumption analysis, emissions were modeled as the worst case over the expected life of the NorthMet Project Proposed Action. For the AQRV analysis, four emissions scenarios, representing emissions at different stages of the NorthMet Project Proposed Action, were modeled. The scenarios differ only in mobile source emissions (which were not included in the increment analysis). The effects of all four scenarios on visibility within the Class I areas are presented in Section 5.2.7.2.1.

5.2.7.2 NorthMet Project Proposed Action

This section describes effects that may occur on local and regional air quality from implementing the NorthMet Project Proposed Action. Potential effects on visibility that could occur from increases in project emissions are also discussed. The results of the modeling are used to represent an upper bound for assessing potential effects from the NorthMet Project Proposed Action.

5.2.7.2.1 NAAQS and Prevention of Significant Deterioration Increment Impact Analysis

State and federal air quality rules prohibit emissions from a new facility that cause or contribute to an exceedance of MAAQS or NAAQS. To demonstrate NorthMet Project Proposed Action effects relative to NAAQS and PSD increments, an air dispersion modeling analysis for the NorthMet Project Proposed Action was conducted (Barr 2012b; Barr 2012d; Barr 2012e; Barr 2013g).

Initial Significant Impact Limit Analysis

The Mine Site and Plant Site are located 8 miles apart, but are connected by a private railway that was originally constructed to transport iron ore pellets from Cliffs Erie’s process plant to their ore dock. A portion of this railway is proposed to be used for the transportation of ore from the Mine Site to the Plant Site. Although the site may be permitted as a single facility, the Mine Site and Plant Site emission sources are not adjacent to each other but rather separated by a

substantial (8 miles) distance. Therefore, it is appropriate and informative to perform individual air dispersion modeling for two distinct sets of receptors, one set surrounding the Mine Site and the second surrounding the Plant Site. For the Mine Site receptor grid, both Mine Site and Plant Site emissions were modeled explicitly. However, for the Plant Site receptor grid, only the emissions from the Plant Site were included, since previous modeling of the Mine Site emissions showed that effects were below the SIL in the region encompassing the Plant Site receptor grid. SILs have been established by the USEPA such that concentrations below these levels are not anticipated to contribute to a change in the overall effect when combined with other nearby source effects. The MPCA approved the exclusion of the Mine Site emissions in assessing the effects at the Plant Site receptor grid locations, as they would not likely contribute to a change in the overall effects. The results are discussed below.

The Plant Site PM₁₀ emissions were modeled with all sources operating at full capacity in a single modeling run. This conservatively predicts (overestimates) the effects, as not all sources would be capable of operating simultaneously at full capacity. PM₁₀ and PM_{2.5} are the primary pollutants emitted from the Plant Site. Emissions of SO₂ and NO_x would be relatively small because the process is conducted at relatively low temperatures and would not include any continuously operating fuel combustion sources. The Mine Site emission rates are based on a daily average mining rate of 32,000 tons of ore.

Table 5.2.7-10 shows modeled effects at the Mine Site and Plant Site receptors compared to the SIL. The maximum modeled effects are maximums from either the Mine Site or the Plant Site analyses, since each analysis includes all NorthMet Project emissions, as defined above. The USEPA has developed SILs as a way to screen out, from further PSD analysis, pollutants that are not expected to cause any significant contribution to existing air quality levels. The emissions included are at 100 percent capacity for each averaging period.

The overall effects within the Plant Site receptor grid predicted higher maximum concentrations than the effects within the Mine Site receptor grid for all pollutants modeled. As seen in the table, maximum PM₁₀ and PM_{2.5} concentrations in both regions (and for all averaging periods) were above their respective SILs, so further analysis in those regions, for those pollutants, was conducted. For NO₂ and SO₂, the effects in the Plant Site receptor grid exceed their SILs for all averaging periods and additional analysis was conducted for this receptor region. The NO₂ and SO₂ effects in the Mine Site receptor grid are all below each respective SIL, and, thus, no additional analysis was conducted.

Table 5.2.7-10 Highest NorthMet Project Proposed Action Effects and Prevention of Significant Deterioration Class II Significant Impact Limits

Pollutant	Averaging Time	PSD Class II Significant Impact Limits ($\mu\text{g}/\text{m}^3$)	Plant Site Area Modeled Effects ($\mu\text{g}/\text{m}^3$) ¹	Mine Site Area Modeled Effects ($\mu\text{g}/\text{m}^3$) ¹
SO ₂	1-hour	7.83	<i>103</i>	0.7
	3-hour	25	<i>85</i>	0.5
	24-hour	5	<i>35</i>	0.1
	Annual	2	<i>6</i>	0.01
PM ₁₀	24-hour	5	<i>44</i>	<i>30</i>
	Annual	1	<i>12</i>	<i>6.3</i>
PM _{2.5}	24-hour	1.2	<i>17</i>	<i>10</i>
	Annual	0.3	<i>6</i>	<i>2.2</i>
NO ₂	1-hour	7.52	<i>88</i>	5.3
	Annual	1	<i>3</i>	0.1

¹ Bold and italicized values exceed SIL.

Prevention of Significant Deterioration Class II Increment Analysis

Based upon the results of the SIL analysis, PSD Class II increment analyses were completed for PM₁₀ for both the Mine Site and Plant Site receptor grid locations. In addition, a PSD Class II increment analysis was conducted for NO₂ and SO₂ only at the Plant Site receptors. Even though maximum PM_{2.5} concentrations exceed the SILs, the minor source baseline date for increment analysis in St. Louis County has not been set. Therefore, no increment analysis can be conducted for this pollutant. However, modeling of PM_{2.5} was conducted for comparison with the PM_{2.5} NAAQS; the results are presented later in this section. The modeling included all NorthMet Project Proposed Action increment-consuming sources at maximum emission rates plus all nearby increment-consuming (and expanding) emissions sources, including the Cliffs Erie pellet yard, the former LTVSMC processing plant, Northshore Mine, and Mesabi Nugget. The results of the increment analyses are shown in Table 5.2.7-11, along with a comparison to the allowable Class II PSD increments.

Table 5.2.7-11 Results of Class II Prevention of Significant Deterioration Increment Analysis

Pollutant	Averaging Time	Plant Site Receptor Grid Modeled Effects ($\mu\text{g}/\text{m}^3$) ^{(1) (3)}	Mine Site Receptor Grid Modeled Effects ($\mu\text{g}/\text{m}^3$) ^{(1) (3)}	PSD Increment Limits ($\mu\text{g}/\text{m}^3$)
SO ₂	3-hour	85	NA	512
	24-hour	35	NA	91
	Annual	6	NA	20
PM ₁₀ ⁽²⁾	24-hour	27	27	30
	Annual	-0.1	6	17
NO ₂	Annual	3.2	NA	25

¹ SO₂ concentrations were not modeled due to negligible incremental effect.

² Modeled PM₁₀ concentrations are based on operating scenarios at year 8 and year 13.

³ Plant Site modeled emissions include expansion credit and are evaluated at Plant Site boundary. Mine Site modeled emissions include Plant Site, Mesabi Nugget, Cliffs Erie pellet yard, and former LTVSMC processing plant and existing LTVSMC Tailings Basin.

The table displays the maximum predicted concentrations for each pollutant of concern and each averaging period for both the Mine Site and Plant Site receptor grid locations. Since the receptor grid locations for the Mine Site and Plant Site represent separate distinct regions, the maximum modeled effect for each modeling region is compared separately with the PSD Class II increment limit to assess potential significant effects. Overall, all modeled effects are below their respective PSD Class II limits; however, the maximum 24-hour PM₁₀ effects in the Mine Site and Plant Site modeling regions approach the Class II increment (27 µg/m³ versus 30 µg/m³).

Mine Site Receptors Analysis

The PM₁₀ modeling was conducted for two operating scenarios corresponding to the temporary stockpile phase and the in-pit disposal/stockpile reclamation phase that would occur over the 20-year life of the mine. The worst case years for temporary stockpile phase waste rock (year 8) and in-pit disposal (year 13) were chosen to represent the worst case for the entire mine life. NO_x and SO₂ would be primarily emitted by mobile sources. Due to the low modeled concentrations and constant emission rates for NO_x and SO₂, only one scenario (year 8) was modeled for these two criteria pollutants. The modeling results for the Mine Site receptors, including sources from the haul road, material handling, mine pits, and diesel locomotives indicate that the highest modeled 24-hour H2H PM₁₀ concentration was 27 µg/m³ for the year 8 operating scenario and 29 µg/m³ for the year 13 operating scenario (shown on Table 5.2.7.11). The H2H corresponds to not exceeding a standard more than once per year, as defined by the applicable standard. NO₂ and SO₂ effects from the NorthMet Project Proposed Action at the Mine Site were below the SILs, so no additional modeling including nearby sources was performed.

Plant Site Receptors Analysis

The Plant Site PM₁₀ emissions were modeled with all sources operating at full capacity in a single modeling run (independent of operating year). This conservatively predicts (overestimates) the effects, as not all sources would be capable of operating simultaneously at full capacity. The operation at the Plant Site, including fugitive sources, building vents, limestone material handling, and vehicular traffic on unpaved roads results in a maximum increment concentration for PM₁₀ of 18 µg/m³ on the Plant Site boundary receptor grid, based on the 24-hour H2H modeling. Modeled effects for SO₂ and NO_x at the Plant Site receptors are also below the PSD Class II increments thresholds.

The data in Table 5.2.7-11 summarize the PSD increment modeling results and demonstrate that the NorthMet Project Proposed Action, in conjunction with all other neighboring PSD sources, would satisfy all state and federal increment requirements. The maximum concentrations for the Mine Site receptor grid and the Plant Site receptor grid are presented separately. Since the two receptor grids represent two separate AOCs, the maximum concentrations are not additive.

NAAQS and MAAQS Impact Analysis

The NAAQS modeling predicted the maximum effect of development at the Mine Site and Plant Site combined with activities at other regional sources. The highest total effects modeled, plus background concentrations, are compared to applicable MAAQS and NAAQS. Maximum emission rates were modeled for all NorthMet Project Proposed Action sources and key criteria pollutants (i.e., NO_x, SO₂, PM₁₀, and PM_{2.5}).

Table 5.2.7-12 summarizes the results of the NAAQS model analysis for the Mine Site and Plant Site separately. The modeled concentration from either the Mine Site receptors or the Plant Site receptors was added to the ambient background to assess total effect, since, in each area, modeling analysis included the entire NorthMet Project area and nearby sources. The highest 6th high (H6H) PM₁₀ concentration for the 5-year modeling period was used for comparison to the NAAQS PM₁₀ 24-hour standard. The highest 8th high (H8H) 1-hour NO₂ and 24-hour PM_{2.5} concentration for the 5-year modeling period was used for comparison to the NAAQS NO₂ 1-hour standard and the PM_{2.5} 24-hour standard, respectively. The H8H concentration represents the 98th-percentile daily maximum concentrations modeled over a 5-year period, as defined by each standard. The highest 4th high (H4H) 1-hour SO₂ concentration for the 5-year modeling period was used for comparison to the 1-hour SO₂ NAAQS. The H4H concentration represents the 99th-percentile daily maximum 1-hour concentrations modeled over a 5-year period, as defined by the standard. The H2H 3-hour and 24-hour SO₂ concentrations were used for comparison with the 3-hour and 24-hour SO₂ NAAQS. Maximum annual average concentrations for NO₂, SO₂, PM₁₀, and PM_{2.5} were compared against their respective annual average NAAQS.

Mine Site

The analysis for the Mine Site included potential emissions from the nearby sources included in the NAAQS analysis, specifically Mesabi Nugget, Cliffs Erie Pellet Yard, Northshore Mine, and the Plant Site. The sources to the west of the Mine Site (Mesabi Nugget, Cliffs Erie Pellet Yard, and the Plant Site) were modeled collectively in a separate modeling run to determine their maximum modeled effect on the Mine Site receptor grid (Barr 2012b).

The PM₁₀ NAAQS modeling results conservatively added the maximum modeled emissions from the Mine Site and Plant Site and the maximum modeled effect from the other nearby sources to background concentrations for comparison to the NAAQS. Cumulative modeling and further analyses for NO₂ and SO₂ were not performed because the NO₂ and SO₂ concentrations at the Mine Site were shown to be well below the SILs.

The maximum effects from the Mine Site analysis are slightly higher for PM₁₀ and slightly lower for PM_{2.5} than the effects from the Plant Site summarized below in Table 5.2.7-12. The maximum predicted annual PM_{2.5} concentration (Mine Site contribution plus background) was 10 µg/m³ or approximately 83 percent of the corresponding NAAQS. The maximum predicted 24-hour PM_{2.5} concentration was 32 µg/m³ or approximately 91 percent of the short-term PM_{2.5} standard. All other predicted concentrations are at or below 60 percent of the allowable levels, which demonstrates compliance with MAAQS and NAAQS.

Table 5.2.7-12 Results of Class II NAAQS Modeling

Pollutant	Averaging Time	Maximum Modeled – Plant Site ($\mu\text{g}/\text{m}^3$)^{1,2}	Maximum Modeled – Mine Site ($\mu\text{g}/\text{m}^3$)¹	Total ($\mu\text{g}/\text{m}^3$)^{2,3}	NAAQS and MAAQS ($\mu\text{g}/\text{m}^3$)
SO ₂	1-hour	<i>109</i>	NA	<i>109</i>	1,300 ⁽⁴⁾
	1-hour	<i>109</i>	NA	<i>109</i>	196 ⁽⁵⁾
	3-hour	<i>97</i>	NA	<i>97</i>	915
	24-hour	<i>40</i>	NA	<i>40</i>	365
	Annual	<i>7</i>	NA	<i>7</i>	60
PM ₁₀	24-hour	<i>80</i>	<i>88</i>	<i>88</i>	150
	Annual	<i>26</i>	<i>29</i>	<i>29</i>	50 ⁽⁶⁾
PM _{2.5}	24-hour	<i>34</i>	<i>32</i>	<i>34</i>	35
	Annual	<i>11⁽⁷⁾</i>	<i>10</i>	<i>11</i>	12
NO ₂	1-hour	<i>177</i>	NA	<i>177</i>	188 ⁽⁸⁾
NO ₂	Annual	<i>21</i>	NA	<i>21</i>	100

¹ Maximum concentrations include background.

² Concentrations exceeding the standard are bolded and italicized.

³ Total concentration displayed is the maximum modeled concentration, from either the Plant Site receptors or Mine Site receptors, added to the background concentration.

⁴ MAAQS for 1-hour SO₂.

⁵ NAAQS for 1-hour SO₂.

⁶ The annual NAAQS for PM₁₀ was rescinded on October 17, 2006.

⁷ The maximum modeled Plant Site concentration was calculated as the maximum design value as defined by the USEPA guidance (USEPA 2013).

⁸ NAAQS for 1-hour NO₂.

Plant Site

The NAAQS modeling on the Plant Site ambient boundary included all Plant Site sources plus emissions from the Tailings Basin and unpaved roads. Maximum predicted concentrations were added to background values to calculate maximum ambient air concentrations. All predicted concentrations are below allowable levels, and the results demonstrate compliance with all MAAQS and NAAQS.

5.2.7.2.2 Prevention of Significant Deterioration Class I Modeling Analysis

Modeling analysis was conducted to assess the effects from the emissions of the NorthMet Project Proposed Action in four USEPA-designated Class I areas within the NorthMet Project area. Modeled effects were assessed against the PSD Class I Increment and AQRVs.

Prevention of Significant Deterioration Class I Increment Modeling Results

Maximum pollutant concentrations within the BWCAW, Voyageurs National Park, Isle Royale National Park, and Rainbow Lakes Wilderness Class I areas were estimated for each of three years and are provided in Table 5.2.7-13. As shown in the table, all of the concentrations, except for the maximum 24-hour PM₁₀ concentration at BWCAW, are below their respective Class I SIL threshold. This indicates that the NorthMet Project Proposed Action contribution to increment consumption would be considered de minimis relative to other sources. The exceedance of the PM₁₀ 24-hour Class I SIL at BWCAW triggers an additional cumulative modeling analysis, including all nearby increment consuming and expanding PM₁₀ sources. The cumulative analysis for this pollutant and averaging period are discussed in Section 6.2.7.

Table 5.2.7-13 Summary of Prevention of Significant Deterioration Class I Increment Analysis

Pollutant	Averaging Period	Year Evaluated			Max (µg/m³)	Class I Inc (µg/m³)	Class I SIL (µg/m³)
		2002	2003	2004			
Boundary Waters Canoe Area Wilderness							
SO ₂	3-Hour	0.106	0.082	0.088	0.106	25	1
	24-Hour	0.020	0.025	0.021	0.025	5	0.2
	Annual	0.001	0.001	0.001	0.001	2	0.1
NO ₂	Annual	0.037	0.036	0.029	0.037	2.5	0.1
PM ₁₀	24-Hour	0.331	0.263	0.278	0.331	8	0.3
	Annual	0.016	0.020	0.015	0.020	4	0.2
Voyageurs National Park							
SO ₂	3-Hour	0.014	0.010	0.020	0.020	25	1
	24-Hour	0.004	0.005	0.004	0.005	5	0.2
	Annual	0.000	0.000	0.000	0.000	2	0.1
NO ₂	Annual	0.004	0.005	0.005	0.005	2.5	0.1
PM ₁₀	24-Hour	0.072	0.131	0.081	0.131	8	0.3
	Annual	0.004	0.004	0.004	0.004	4	0.2
Isle Royale National Park							
SO ₂	3-Hour	0.001	0.001	0.001	0.001	25	1
	24-Hour	0.000	0.000	0.000	0.000	5	0.2
	Annual	0.000	0.000	0.000	0.000	2	0.1
NO ₂	Annual	0.002	0.001	0.001	0.002	2.5	0.1
PM ₁₀	24-Hour	0.031	0.018	0.019	0.031	8	0.3
	Annual	0.002	0.001	0.001	0.002	4	0.2
Rainbow Lakes Wilderness							
SO ₂	3-Hour	0.003	0.003	0.003	0.003	25	1
	24-Hour	0.001	0.001	0.001	0.001	5	0.2
	Annual	0.000	0.000	0.000	0.000	2	0.1
NO ₂	Annual	0.002	0.002	0.002	0.002	2.5	0.1
PM ₁₀	24-Hour	0.030	0.033	0.021	0.033	8	0.3
	Annual	0.002	0.001	0.002	0.002	4	0.2

In 2010, the USEPA promulgated a Class I increment for PM_{2.5}. However, the minor source baseline date for PM_{2.5} has not been triggered for the NorthMet Project area. Therefore, a comparison of PM_{2.5} concentration with the PM_{2.5} Class I increment and SILs is not required and was not performed.

Class I Areas – Air Quality Related Values Impact Analysis

An air quality modeling analysis was conducted to estimate the effect of the NorthMet Project Proposed Action on air quality in Class I areas. The analysis addressed visibility impacts on the BWCAW, Rainbow Lakes Wilderness, Voyageurs National Park, and Isle Royale National Park. The Class I AQRV analyses also included sulfur and nitrogen deposition and SO₂ effects on soils, water, and vegetation. The results are discussed below.

Class I Visibility Analysis

A visibility impact analysis was carried out for BWCAW, Voyageurs National Park, and Isle Royale National Park. The Rainbow Lakes Wilderness does not have an AQRV for visibility. The recommended methodology for assessing visibility impacts, according to FLAG guidance,

involves the use of CALPOST to process the data on concentrations of pollutants from the CALPUFF modeling of 24-hour emissions. In CALPOST, a daily value of light extinction is defined by the concentrations of each pollutant that can affect visibility, taking into account the efficiency of each particle type in scattering light and the relative humidity, which influences the size of sulfates and nitrates. The FLM has established threshold changes in light extinction (Δb_{ext}) as a percentage of natural background that represent potential adverse effects on visibility. These thresholds are 5 percent (a potentially detectable change) and 10 percent (a level that may represent an unacceptable degradation). In the revised FLAG guidance of 2010, the FLM also lists a threshold of less than 5 percent as “presumptive no adverse impact” when compared to the highest 98th percentile daily predicted impact.

The FLAG 2010 guidance indicates that CALPOST Method 8 is now the preferred visibility impact calculation method for Class I AQRV analysis. Method 8 uses Class I area-specific monthly average relative humidity to calculate light extinction. Method 8 also compares visibility impacts with the 20 percent best pristine days. The previous preferred methodology, Method 2, used the CALPUFF-generated hourly relative humidity data to calculate light extinction. Method 2 compares visibility impacts on annual average pristine conditions. Since previous NorthMet Project Proposed Action modeling used the FLAG 2000 guidance, NorthMet Project Proposed Action visibility impact results calculated using both Method 8 and Method 2 are presented below for comparison.

Table 5.2.7-14 presents results of the initial CALPUFF visibility analysis following the previous FLAG methodology, Method 2, for each NorthMet Project Proposed Action scenario. The maximum change in light extinction for Voyageurs National Park and Isle Royale National Park is below the 5 percent threshold with changes predicted at 4.50 percent and 1.23 percent, respectively. The maximum change in light extinction at the BWCAW for the three years modeled was predicted to be 11.08 percent. The data in Table 5.2.7-14 indicate that calculated visibility impacts greater than 5 or 10 percent could occur at some point within the BWCAW on a small number of days each year.

Table 5.2.7-14 Class I Area Visibility Results for NorthMet Project Proposed Action (Method 2 Analysis)

Class I Area and Meteorological Data Year	Days with $\geq 5\%$ Visibility Impact	Days with $\geq 10\%$ Visibility Impact	Maximum Δb_{ext} (%)
Scenario 1			
BWCAW 2002/2003/2004	8/1/0	1/0/0	11.08/7.88/4.66
Voyageurs National Park 2002/2003/2004	0/0/0	0/0/0	2.28/4.50/2.76
Isle Royale National Park 2002/2003/2004	0/0/0	0/0/0	1.12/1.13/1.23
Scenario 2			
BWCAW 2002/2003/2004	7/1/0	1/0/0	10.88/7.75/4.56
Voyageurs National Park 2002/2003/2004	0/0/0	0/0/0	2.23/4.41/2.72
Isle Royale National Park 2002/2003/2004	0/0/0	0/0/0	1.10/1.11/1.20
Scenario 3			
BWCAW 2002/2003/2004	7/1/0	1/0/0	10.99/7.82/4.61
Voyageurs National Park 2002/2003/2004	0/0/0	0/0/0	2.26/4.46/2.74
Isle Royale National Park 2002/2003/2004	0/0/0	0/0/0	1.11/1.12/1.22
Scenario 4			
BWCAW 2002/2003/2004	3/1/0	0/0/0	9.44/6.80/3.97
Voyageurs National Park 2002/2003/2004	0/0/0	0/0/0	1.84/3.80/2.39
Isle Royale National Park 2002/2003/2004	0/0/0	0/0/0	0.93/0.93/0.99

Table 5.2.7-15 presents results of the initial CALPUFF visibility analysis following the current FLAG methodology, Method 8, for each NorthMet Project Proposed Action scenario. Method 8 requires the eighth-highest visibility impact to be compared with the 5 percent and 10 percent thresholds. The eighth-highest changes in light extinction for the BWCAW, Voyageurs National Park, and Isle Royale National Park are below the 5 percent threshold with changes predicted at 4.86 percent, 1.11 percent, and 0.44 percent, respectively, and demonstrate no expected adverse visibility impacts compared to pristine conditions. These results of the NorthMet Project Proposed Action reflect emission reduction measures to reduce the potential for visibility impacts in the BWCAW, which include: upgrades to the insulation in the existing Crusher and Concentrator buildings, utilization of low-NO_x space heating equipment, a plan to phase in vehicles that meet Tier 4 emission standards, use of efficient gen-set locomotives, the reduction of dust collector exhaust for heating demand reductions, use of appropriate pollution control equipment, and use of lower emitting fuels where feasible.

Table 5.2.7-15 Class I Area Visibility Results for NorthMet Project Proposed Action (Method 8 Analysis)

Class I Area and Meteorological Data Year	98% Days with $\geq 5\%$ Visibility Impact	98% Days with $\geq 10\%$ Visibility Impact	8th Highest Δb_{ext} (%)
Scenario 1			
BWCAW 2002/2003/2004	0/0/0	0/0/0	4.86/3.92/3.85
Voyageurs National Park 2002/2003/2004	0/0/0	0/0/0	0.89/1.11/0.97
Isle Royale National Park 2002/2003/2004	0/0/0	0/0/0	0.44/0.21/0.23
Scenario 2			
BWCAW 2002/2003/2004	0/0/0	0/0/0	4.74/3.83/3.80
Voyageurs National Park 2002/2003/2004	0/0/0	0/0/0	0.85/1.09/0.96
Isle Royale National Park 2002/2003/2004	0/0/0	0/0/0	0.43/0.19/0.22
Scenario 3			
BWCAW 2002/2003/2004	0/0/0	0/0/0	4.80/3.87/3.83
Voyageurs National Park 2002/2003/2004	0/0/0	0/0/0	0.86/1.09/0.97
Isle Royale National Park 2002/2003/2004	0/0/0	0/0/0	0.43/0.20/0.22
Scenario 4			
BWCAW 2002/2003/2004	0/0/0	0/0/0	4.21/3.45/3.42
Voyageurs National Park 2002/2003/2004	0/0/0	0/0/0	0.74/0.97/0.82
Isle Royale National Park 2002/2003/2004	0/0/0	0/0/0	0.36/0.17/0.19

Effects on Soils, Waters, and Vegetation

Deposition of Nitrogen and Sulfur

Potential effects on soils, waters, and vegetation in Class I areas due to deposition of sulfur and nitrogen were evaluated based upon model-predicted annual deposition for the NorthMet Project Proposed Action emissions from the Mine Site and Plant Site. Impacts were evaluated according to the USFS publication “Screening Procedures to Evaluate Effects of Air Pollution on Eastern Wildernesses Cited as Class I Air Quality Areas.” Criteria for assessment of deposition impacts are different for USFS areas (BWCAW and Rainbow Lakes Wilderness) and National Park System areas (Voyageurs National Park and Isle Royale National Park). The National Park Service has established a Deposition Analysis Threshold (DAT) of 0.01 kilograms per hectare per year (kg/ha/yr) for both sulfur and nitrogen deposition for Class I areas in the eastern United States. The DAT is a level below which adverse effects from a new or modified source are not anticipated and are considered insignificant. The USFS has established Green Line Values for assessing impacts of deposition at BWCAW and Rainbow Lakes Wilderness, which account for soil conditions and water chemistry in development of safe levels. The Green Line values represent the total pollutant loading below which there are no adverse effects (Barr 2012k). As such, for BWCAW and Rainbow Lakes Wilderness, background deposition levels are added to the maximum NorthMet Project Proposed Action impacts from all scenarios to assess against Green Line Values. The current background nitrogen deposition for Rainbow Lakes Wilderness

(5.88 kg/ha/yr) is at the Green Line Value range for nitrogen (5 to 8 kg/ha/yr). All other background deposition values for BWCAW and Rainbow Lakes Wilderness are below their respective Green Line Values (see Table 5.2.7-16).

The CALPUFF results for each of the Class I areas were processed with CALPOST to calculate total annual deposition of sulfur and nitrogen at each receptor as a result of the NorthMet Project Proposed Action maximum annual average emissions. Total sulfur deposition is calculated from the wet (rain, snow, fog) and dry (particle, gas) deposition of SO₂ and sulfate; total nitrogen is represented by the sum of nitrogen from wet and dry fluxes of nitric acid, nitrate, ammonium sulfate, and ammonium nitrate, and the dry flux of NO_x.

Terrestrial effects of nitrogen and sulfur deposition for the Class I areas are shown in Table 5.2.7-16. As stated earlier, Green Line Values (Wilderness Areas) are compared to the maximum modeled NorthMet Project Proposed Action deposition plus background; the DAT values (National Parks) are compared to the modeled NorthMet Project Proposed Action effects only. As seen from the table, the maximum predicted total sulfur and nitrogen deposition are all below Green Line Value ranges for BWCAW. The maximum predicted total sulfur deposition is also below the Green Line Value for Rainbow Lakes Wilderness. However, the maximum predicted total nitrogen deposition at Rainbow Lakes Wilderness (5.9 kg/ha/yr) is within the Green Line Value range of 5 to 8 kg/ha/yr. The nitrogen deposition contribution from the NorthMet Project Proposed Action emissions is 0.02 percent of the total nitrogen deposition impact (0.001 kg/ha/yr). Table 5.2.7-16 also compares the ambient annual and 3-hour SO₂ concentrations due to the NorthMet Project Proposed Action to the Green Line Values. Modeled concentrations of SO₂ in both wilderness areas are below the Green Line Values for SO₂ concentration.

Finally, Table 5.2.7-16 compares terrestrial impacts of sulfur and nitrogen deposition in the Class I areas to the DAT values. The maximum predicted total sulfur and nitrogen values are below the DAT value of 0.01 kg/ha/year.

Table 5.2.7-16 Terrestrial Effects of Annual Deposition of Sulfur and Nitrogen from the NorthMet Project Proposed Action in Class I Areas

Class I Area	Proposed Action Effects	Background Level	Total (Proposed Action + Background)	Terrestrial Green Line Value	Deposition Analysis Threshold
BWCAW					
Annual avg. SO ₂ (µg/m ³)	0.001	1.2	1.2	5 µg/m ³	NA
3-hour max. SO ₂ (µg/m ³)	0.105	10.8	10.9	100 µg/m ³	NA
Sulfur (kg/ha/yr)	0.000	2.85	2.9	5-7 kg/ha/yr	NA
Nitrogen (kg/ha/yr)	0.009	4.75	4.8	5-8 kg/ha/yr	NA
Rainbow Lakes Wilderness					
Ann. avg. SO ₂ (µg/m ³)	0.000	1.6	1.6	5 µg/m ³	NA
3-hour max. SO ₂ (µg/m ³)	0.003	14.4	14.4	100 µg/m ³	NA
Sulfur (kg/ha/yr)	0.000	2.98	3.0	5-7 kg/ha/yr	NA
Nitrogen (kg/ha/yr)	0.000	5.88	5.9	5-8 kg/ha/yr	NA
Isle Royale National Park					
Sulfur	0.000	NA	NA	NA	0.01 kg/ha/yr
Nitrogen	0.000	NA	NA	NA	0.01 kg/ha/yr
Voyageurs National Park					
Sulfur	0.000	NA	NA	NA	0.01 kg/ha/yr
Nitrogen	0.001	NA	NA	NA	0.01 kg/ha/yr

Table 5.2.7-17 summarizes the aquatic effects from sulfur and nitrogen deposition for the Class I areas. Green Line Values for aquatic effects at the wilderness areas are based upon total sulfur deposition, as well as total sulfur deposition plus 20 percent of the total nitrogen deposition (sulfur + 20 percent nitrogen). Maximum predicted values for these two measures for all scenarios were below the Green Line Value ranges for BWCAW. The maximum predicted total sulfur deposition and total sulfur plus 20 percent nitrogen deposition for Rainbow Lakes Wilderness are just below the Green Line Value, and nearly all of the effects are associated with the current background level. Aquatic effects at the National Parks are also compared to the DAT values. The modeled maximum annual nitrogen and sulfur deposition effects due to the NorthMet Project Proposed Action have levels below the respective National Park Service DAT levels for both Voyageurs National Park and Isle Royale National Park. The highest effects are predicted in Voyageurs National Park, with values approximately one-tenth of the incremental DAT level for sulfur and one-fifth of the incremental nitrogen DAT level.

Table 5.2.7-17 Aquatic Effects of Deposition of Sulfur and Nitrogen from the NorthMet Project Proposed Action in Class I National Park Areas

Class I Area	Proposed Action Effects (kg/ha/yr)	Background Level (kg/ha/yr)	Total (Proposed Action + Background) (kg/ha/yr)	Aquatic Green Line Value (kg/ha/yr)	Deposition Analysis Threshold (kg/ha/yr)
BWCAW					
Total Sulfur	0.000	2.85	2.85	7.5-8.0	NA
Total S + 20% of Total N	0.002	3.80	3.80	9-10	NA
Rainbow Lakes Wilderness					
Total Sulfur	0.000	2.98	2.98	3.5-4.5	NA
Total S + 20% of Total N	0.000	4.16	4.16	4.5-5.5	NA
Isle Royale National Park					
Total Sulfur	0.000	NA	NA	NA	0.01
Total N	0.000	NA	NA	NA	0.01
Voyageurs National Park,					
Total Sulfur	0.000	NA	NA	NA	0.01
Total N	0.001	NA	NA	NA	0.01

SO₂ Effects on Flora and Fauna

Potential SO₂ effects on flora and fauna in Class I areas were evaluated using the model-predicted concentrations from NorthMet Project Proposed Action emissions. The USFS has set screening criteria for potential air pollution effects on vegetation for SO₂ as a total annual average ambient concentration of 5 µg/m³. As stated earlier, Green Line screening values “were set at levels at which it was reasonably certain that no significant change would be observed in ecosystems that contain large numbers of sensitive components.”

Though the USFS screening levels were established specifically for Class I areas administered by the USFS (i.e., BWCAW and Rainbow Lakes Wilderness) the same criteria were applied to Voyageurs National Park and Isle Royale National Park, which are administered by the National Park Service but do not have published standards similar to the USFS. Table 5.2.7-18 compares maximum CALPUFF NorthMet Project Proposed Action impacts from all scenarios and existing background concentrations to the Green Line screening levels for each Class I area. The summation of the NorthMet Project Proposed Action and background contributions is well below the Green Line levels so no threat to sensitive vegetation in Class I areas is expected from direct SO₂ emissions produced by the NorthMet Project Proposed Action.

There are no established screening criteria for NO₂ and PM₁₀ for effects on flora and fauna. As shown in Class I increment modeling results (Barr 2012), modeled maximum annual concentrations of NO₂ and PM₁₀ from the NorthMet Project Proposed Action are below the secondary NAAQS standards (protecting vegetation), so it is not expected that there would be impacts on the Class I areas from these pollutants.

Table 5.2.7-18 Comparison of Projected Class I SO₂ Concentrations to Green Line Screening Criteria for Vegetation Effects

Class I Area	Background Air Concentration (µg/m ³)	Max. Modeled Proposed Action Contribution (µg/m ³)	Total Proposed Action Air Concentration (µg/m ³)	Green Line Concentration (µg/m ³)
	Annual	Annual	Annual	Annual
BWCAW	1.2	0.001	1.2	5
Isle Royale National Park	2.0	0.000	2.0	5
Rainbow Lakes Wilderness	1.6	0.000	1.6	5
Voyageurs National Park	0.7	0.000	0.7	5

5.2.7.2.3 Potential Estimated Human Health Risk from the Plant and Mine Sites Air Emissions

This section includes the assessment of potential human health effects from the NorthMet Project Proposed Action. Separate AERAs were conducted for the Mine Site and Plant Site due to the large distances (approximately 6 miles) between the Mine Site and Plant Site sources. It should be noted that AERAs from the Mine Site and Plant Site are also considered cumulatively in Section 6.7.5.

Estimations of additional lifetime cancer risk, potential for non-cancer effects from chronic exposures, and potential non-cancer health effects from short-term exposures were conducted for hypothetical residents, farmers, off-site workers, and/or for short-term visitors. The hypothetical individuals were assumed to breathe outdoor air for the entire exposure duration. Inhalation exposures were assessed for an approximate lifetime (approximately 70 years) for the resident and farmer; a maximum hour for the short-term visitor; and 8-hour days, 250 days per year for 25 years for the off-site worker (USEPA 1993). Hypothetical short-term and off-site worker ingestion exposures were not assessed. The farmer ingestion exposure was assessed for a 40-year duration and the resident ingestion exposure was assessed for a 30-year duration. When both ingestion and inhalation risks were assessed, these were summed for a total multi-pathway risk. This screening procedure is conservative and is intended as a regulatory tool to define whether more detailed analysis is warranted rather than estimating risk levels for actual individuals.

Mine Site Air Emissions Risk Analysis

An AERA was conducted for the Mine Site in January 2008 for the DEIS. A Supplemental AERA was conducted as part of the project changes defined with the current NorthMet Project Proposed Action (Barr 2013j). The screening human health risk analysis followed the MPCA-accepted November 2011 Work Plan (Barr 2011h). Sulfuric acid aerosol emissions were screened out of the quantitative assessment for potential acute inhalation effects by scaling the Plant Site 2005 modeled acute inhalation hazard quotients to the current potential sulfuric acid emissions. As identified in the Mine Site AERA, the quantitative evaluation identified 11 chemicals for evaluation (CFEs), which are summarized in Table 5.2.7-19. The identified CFEs include six risk-driver chemicals from the 2008 AERA (dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, manganese compounds, nickel compounds, NO₂, and dioxins/furans). The remaining five compounds are from the 2008 AERA that now have toxicity values (acetaldehyde, arsenic compounds, cobalt compounds, crystalline silica, and diesel particulate).

Table 5.2.7-19 Chemicals for Evaluation of the Incremental Human Health Risk Assessment for the Mine Site

Chemical	Total Mine Site	Total Mine Site	Total Mine Site	Total Mine Site
	Maximum Hourly Emission Rate (Year 8) (g/sec)	Total Mine Site Annual Emission Rate (Year 8) (g/sec)	Maximum Hourly Emission Rate (Year 13) (g/sec)	Total Mine Site Annual Emission Rate (Year 13) (g/sec)
Acetaldehyde	2.44E-05	1.40E-06	2.44E-05	1.40E-06
Arsenic	0.0013	0.0004	0.0014	0.0005
Cobalt	0.0036	0.0025	0.0040	0.0027
Crystalline Silica	0.5820	0.3952	0.6467	0.4339
Dibenzo(a,h)anthracene	2.92E-06	2.57E-06	2.92E-06	2.57E-06
Diesel Particulate Matter	0.2276	0.2237	0.2276	0.2237
Indeno(1,2,3-cd)pyrene	3.41E-06	2.99E-06	3.41E-06	2.99E-06
Manganese	0.0638	0.0450	0.0702	0.0488
Nickel	0.0245	0.0152	0.0266	0.0166
Oxides of Nitrogen	12,5173	9.2554	12,5173	9.2254
Dioxins/Furans (as 2,3,7,8-TCDD TEQ)	4.12E-10	3.73E-10	4.12E-10	3.73E-10
Number of CFEs	11			

g/sec = Gram(s) per second

Estimations of additional lifetime risk and potential non-cancer effects from chronic (long-term) exposures were conducted for both inhalation and ingestion exposures for the hypothetical resident and farmer. The resident is assumed to inhale outdoor air and ingest soil and produce grown at a site of maximum air concentration. The farmer scenario assumed inhalation of outdoor air and ingestion of soil and produce, and also includes ingestion of meat and dairy products grown at the location of maximum air concentration.

Air dispersion modeling was conducted for the Mine Site to estimate maximal annual and hourly air concentrations for the CFE using the AERMOD model with 5 years of hourly meteorological data from the Hibbing weather station. The assessment was conducted for the years 8 and 13, which were determined to be the years of highest air emissions. Direct (inhalation) and indirect (ingestion) risk estimates were made for inhalation and bioaccumulative toxic pollutant ingestion, respectively, using the MPCA Risk Analysis Screening Spreadsheet, which estimates potential incremental cancer and noncarcinogenic human health effects for long-term exposures.

Acute inhalation risks were estimated for the ambient air at and beyond the Mine Site property boundary (see Large Figure 4 in Barr 2013j). Because of the historical and present mining and industrial land use around the Mine Site, the reasonable future land use for residential and farming was considered in assessing chronic risks for areas (i.e., receptors) outside of the Mineral Mining/Industrial District air boundary (see Large Figure 5 in Barr 2013j). The Mineral Mining/Industrial District air boundary encompasses an area approximately 1 km beyond the Mine Site air boundary and no farmers or residents are expected to be present within this area either presently or for the foreseeable future.

The results of the Mine Site assessment demonstrate that the chronic additional lifetime cancer and non-cancer effects, as well as the potential acute non-cancer health effects from direct exposure (inhalation) at the Mine Site property boundary for off-site workers were below

guidance levels (Supplemental Air Emission Risk Analysis – Mine Site, Barr 2013j). The MEI inhalation pathway additional lifetime cancer risk at the Mine Site ambient air boundary was estimated from the assessment of year 13 emissions with a maximum value of $5\text{E-}06$, which is below the MDH guideline value of $1\text{E-}05$. The maximum potential sub-chronic and acute non-cancer risk estimates were calculated to be 0.2 and 0.8 respectively, which are both below the guidance level of 1.0.

The multi-pathway cancer risk for the hypothetical farmer was estimated to be $1\text{E-}05$. This is at the MDH additional lifetime cancer risk guidance level of $1\text{E-}05$. The major risk drivers were dioxins and dibenzo(a,h)anthracene associated with potential emissions from mine vehicles. It should be noted that maximum multi-pathway additional lifetime cancer risk is located at the Mining/Industrial District boundary. The nearest small farms are located 6.5 miles from the Mine Site.

The multi-pathway additional lifetime cancer risk for a hypothetical nearby resident at the Mining/Industrial District boundary was $8\text{E-}07$, which is below the MDH guidance value of $1\text{E-}05$. The major risk drivers for cancer endpoints for this receptor were nickel compounds, arsenic compounds, and dioxins.

The non-cancer chronic multi-pathway hazard indices (HIs) for the farmers and residents were each calculated to be 0.04, which is below the MDH guidance value of 1.0. Due to the variation (i.e., each compound has a unique concentration where health effects are expected for a target organ) in estimating the health effects for noncarcinogenic effects, the HI is the sum of the individual ratios of the maximum concentration divided by the chemicals' health benchmark. This ratio is then compared to a general guidance value of 1.0. Thus, the chronic non-cancer results for both the hypothetical farmer and resident were approximately 4 percent of the guidance value where health effects become more likely to occur.

The acute non-cancer HI was predicted at the Mine Site operating boundary with a value of 0.8, as compared to the MDH's acute HI guidance level of 1.0. This screening value sums all of the acute HIs for all pollutants regardless of their toxic endpoint (specific target organ) and the specific locations of maximum modeled air concentrations of the compounds. The risk driver for acute inhalation was NO_2 from the natural gas combustion. When adjusting HIs for the various locations of the maximum modeled annual average air concentration for risk-driver pollutants (i.e., risk-driver pollutant concentrations differ in space), the maximum acute HI for the off-site worker was reduced to 0.8, below the acute guidance level. Table 5.2.7-20 provides a summary of the Mine Site risk assessment.

Table 5.2.7-20 Summary of the Incremental Human Health Risk Assessment for the Mine Site

Exposure Route	Exposure Scenario	Location and Type of Receptor	Potential Non-cancer Health Effects (HI) ¹	Potential Cancer Effects (Risk Estimate) ²
Inhalation Exposure Only	Acute (1-hour)	Mine Site Property Boundary	0.80	NA
		Mine Site Property Boundary	0.20	5E-06
Multi-pathway Exposure	Chronic (~lifetime)	Farmer	0.04	1E-05
		Resident	0.04	8E-07

¹ HI is the sum of individual non-cancer chemical quotients for acute or chronic exposure. Incremental non-cancer (chronic and acute) guideline value is 1.0.

² Potential human health risks from carcinogenic chemicals (summed for all chemicals) were estimated using the MPCA's Risk Assessment Screening Spreadsheet. Incremental cancer risk guideline value is 1E-05.

Plant Site Air Emission Risk Analysis

As with the Mine Site, an AERA was conducted for the Plant Site and results were reported in the scoping EAW (May 2005). The 2005 AERA included specific chemicals for potential evaluation as defined in MPCA's AERA Guidance (MPCA 2004). NorthMet Project Proposed Action changes since May 2005 resulted in the AERA being revised for the DEIS. A Supplemental AERA was conducted, as part of the changes defined with the current NorthMet Project Proposed Action (Barr 2013k). The screening human health risk analysis followed the MPCA-accepted August 2011 Work Plan (Barr 2011o). Sulfuric acid aerosol emissions were screened out of the quantitative assessment for potential acute inhalation effects by scaling the 2005 modeled acute inhalation hazard quotients to the current potential sulfuric acid emissions. As identified in the Plant Site AERA, the quantitative evaluation identified 10 CFEs, which are summarized in Table 5.2.7-21. The identified CFEs include three risk-driver chemicals from the 2007 AERA (arsenic compounds, nickel compounds, and NO₂) and four compounds from the 2007 AERA that now have toxicity values (acetaldehyde, cobalt compounds, crystalline silica, and diesel particulate). The remaining three were added either because of increased emissions (hydrochloric acid and manganese) or new emissions from mobile diesel sources included in the analysis (dioxins/furans).

Table 5.2.7-21 Chemicals for Evaluation of the Incremental Human Health Risk Assessment for the Plant Site

Chemical	Maximum Hourly Emission Rate 2012 (g/sec)	Annual Emission Rate 2012 (g/sec)
Acetaldehyde	1.66E-05	9.49E-07
Arsenic	3.03E-03	7.75E-04
Cobalt		5.44E-03
Crystalline Silica		1.30E+00
Diesel Particulate Matter		4.47E-02
Hydrochloric Acid	2.45E+00	2.90E-02
Manganese		5.91E-02
Nickel	1.33E-01	1.36E-01
Oxides of Nitrogen	1.10E+01	
Dioxins/Furans (as 2,3,7,8-TCDD TEQ)		1.12E-10
Number of CFEs		10

g/sec = Gram(s) per second

Similar to the Mine Site AERA, air dispersion modeling was conducted to estimate air concentrations for the CFE, using the AERMOD model with 5 years of hourly meteorological data from the Hibbing weather station. Direct and indirect risk estimates were made for inhalation and bioaccumulative toxic pollutant ingestion, respectively, using the MPCA Risk Analysis Screening Spreadsheet, which estimates potential incremental cancer and noncarcinogenic human health risks for both acute and long-term effects.

Acute risks were estimated for the ambient air at and beyond the NorthMet Project area ownership boundary for off-site workers. Because of the historical and present mining and industrial land use around the Plant Site, the reasonable future land use for residential and farming was considered in assessing chronic risks for areas (i.e., receptors) outside of the former LTVSMC processing plant air boundary. The former LTVSMC processing plant ambient air boundary encompasses most of the industrial land use in the Hoyt Lakes area and no farmers or residents are expected to be present within this area for the foreseeable future.

Initially, a screening level human health risk is conducted where all CFEs maximum concentrations are assumed to occur at the same location. A refinement to the risk assessment is the calculation of maximal potential health effects paired in both space and time. That is, when the health effect impacts are calculated for all pollutants at each receptor and meteorological condition modeled. The results of the Plant Site assessment demonstrate that the chronic additional lifetime cancer and noncarcinogenic effects are at or below guidance levels and the acute noncarcinogenic health effects are also below the guidance level, when adjusted for locational differences (Supplemental Air Emission Risk Analysis – Plant Site, Barr 2013k).

The multi-pathway (ingestion and inhalation) additional lifetime cancer risk at the former LTVSMC processing plant ambient air boundary was estimated to be 1E-05 for farmers and 5E-06 for a hypothetical nearby residents, which is below the MDH guidance level value of 1E-05. Similarly, the off-site worker inhalation additional lifetime cancer risk at the NorthMet Project area boundary was predicted at 1E-05, also at the MDH additional lifetime cancer risk

guidance level. The major risk drivers for these estimated cancer endpoints were cobalt, nickel, and dioxins/furans (farmers only).

The non-cancer chronic multi-pathway HI for the farmers and residents were each calculated to be 0.2, primarily from the potential nickel emissions. Due to the variation (i.e., each compound has a unique concentration where health effects are expected for a target organ) in estimating the health effects for noncarcinogenic effects, the HI is the sum of the individual ratios of the maximum concentration divided by the chemicals' reference exposure level and compared to a general guidance value for chronic HI as 1.0. Thus, the chronic non-cancer results for both the hypothetical farmer and resident were approximately 20 percent of the chronic guidance level, below which health effects would not occur. The chronic HI for the hypothetical off-site worker was estimated to be 1, which is at the chronic guidance level.

The acute inhalation HI at the former LTVSMC processing plant ambient air boundary was 0.5, as compared to the MDH's acute HI guidance level of 1.0. This boundary was the location assessed in consideration of a potential resident. This HI is a summation of all of the acute hazard quotients for all pollutants regardless of their toxic endpoint (specific target organ) and the specific locations of maximum modeled air concentrations of the compounds. The risk drivers for the acute inhalation pathway at the location of a potential resident were NO₂ emissions from the natural gas combustion and nickel from the Hydrometallurgical Plant. When adjusting HIs for the various locations of the maximum modeled annual average air concentration for risk-driver pollutants (i.e., risk-driver pollutant concentrations differ in space), the acute inhalation HI for the off-site worker was 1.0, at the acute guidance level. Table 5.2.7-22 provides a summary of the Plant Site risk estimates.

Table 5.2.7-22 Summary of the Incremental Human Health Risk Impacts for the Plant Site

Exposure Route	Exposure Scenario	Location and Type of Receptor	Potential Non-cancer Health Effects (HI)¹	Potential Cancer Effects (Risk Estimate)²
Inhalation Exposure Only	Acute (1-hour)	Off-Site Worker Plant Site Property Boundary	1.0	NA
	Acute (1-hour)	Resident at former LTVSMC ambient air boundary	0.5	NA
	Chronic (~ lifetime)	Plant Site Property Boundary	1.0	1E-05
Multi-pathway Exposure	Chronic (~ lifetime)	Farmer	0.2	1E-05
		Resident	0.2	5E-06

¹ HI is the sum of individual non-cancer chemical risks for acute or chronic exposure. Incremental non-cancer (chronic and acute) guideline value is 1.0.

² Potential human health risks from carcinogenic chemicals (summed for all chemicals) were estimated using the MPCA's Risk Assessment Screening Spreadsheet. Incremental cancer risk guideline value is 1E-05.

5.2.7.2.4 Greenhouse Gases Impact Analysis

The science, policy, and regulatory frameworks regarding GHGs are continually evolving and are often subject to differing interpretation. For the purposes of the SDEIS, the information presented below is intended to provide the current understanding through June 15, 2012 with subsequent information regarding climate change updated in the FEIS.

Global Effects

According to the IPCC, since preindustrial times, human activities, particularly the burning of fossil fuels, have resulted in increases in the concentrations of GHGs in the earth's atmosphere (IPCC 2007). It is estimated that 40 percent of a pulse emission of CO₂ remains in the atmosphere for approximately 100 years. Approximately 15 to 30 percent of the emissions are expected to remain after 1,000 years and 10 to 15 percent are expected to remain after 10,000 years. The estimated mean lifetime of emitted fossil CO₂ is between 30,000 and 50,000 years (Archer 2005). As such, the atmospheric GHG levels are likely to continue to rise over the next few decades. GHGs absorb in the infrared part of the electromagnetic spectrum. At elevated atmospheric concentrations, they act to warm the lower atmosphere and surface of the earth. The IPCC's most recent report (IPCC 2007) found that, under a business-as-usual scenario, globally averaged surface temperature would increase 2.5 to 10.4°F between 1990 and 2100.

Globally, an "unequivocal" warming of 1.3°F (plus or minus 0.3°F) occurred between 1905 and 2005 (IPCC 2007). Other data have shown that the global average temperature has increased by about 1.2 to 1.4°F since 1890, with the 14 warmest years of the past century occurring between 1997 and 2012 (Hansen et al. 2013). The observed increases in global average surface temperature may also be seen in the records of average annual temperatures at the regional and state level. Over the past century, temperatures in the United States have risen at an average rate of 0.11°F per decade, with the past 25 years showing temperature increases of approximately 0.56°F per decade (NOAA 2007). The annual average temperature of Minnesota has increased approximately 1°F in the last century, from 43.9°F (1888 to 1917 average) to 44.9°F (1963 to 1992 average) (MPCA 2009). The winter season has brought even more dramatic increases of up to five degrees in parts of northern Minnesota (MPCA 2009). Much of the warming observed in Minnesota has occurred over the last few decades. The observed rate and total increase in temperatures appear more extreme when the more recent years on record are averaged.

Climate changes can involve changes in temperature as well as changes in other meteorological conditions, such as precipitation patterns and shifts in seasons. These changes could affect forest ecosystems, water resources, other unique ecosystems, agriculture, and human health over the next century. Future emissions scenarios, using an ensemble of results from multiple global climate models, suggest an increase in annual precipitation of 10 to 15 percent over the next 70 to 90 years in the Great Lakes Region (USGCRP 2009), although regional results from these models are more uncertain than global results. The current modeling also suggests that winter and spring precipitation would increase 20 to 25 percent; summer rainfall declines 5 to 10 percent in the model results.

Although the degree of effect is uncertain, particularly when analyzed at the regional and local levels, water resources could be affected by changes in climate patterns. Due to increased temperature, evaporation would likely increase which could reduce levels in lakes, rivers, and streams up to 12 inches (MDNR 2009). Increased precipitation could also affect flooding

conditions. In addition, severe weather patterns could be affected, resulting in more frequent maximum 25- and 100-year precipitation events and flood patterns. Warmer temperatures may shorten winter seasons, resulting in decreased ice cover on the lakes and streams, as well as early ice breakup in the spring.

If Minnesota's climate becomes drier, forest areas near the prairie-forest border could be replaced with grassland ecosystems (Frelich and Reich 2009). Minnesota's forested areas could decrease by 50 to 70 percent (MPCA 2003). On the other hand, if increased precipitation occurs, resulting in a wetter climate, over long periods of time the current conifers would be replaced with hardwood trees. Pine, birch, and maple forests would be replaced with oak, elm, and ash.

Minnesota's wetland and bog ecosystems may also face changes due to increased precipitation. Variation in wet periods, dry periods, and severe storm frequency could lead to changes in wetland type and distribution that includes wetland losses in some areas and wetland gains in other areas.

Due to the negative effects of peak daytime temperatures during anthesis and grain filling on crop growth, climate change could have a dramatic effect on agriculture. However, climate change will also lengthen the growing season of certain crops within the region, leading in some instances to increased, rather than decreased, agricultural productivity. Droughts, floods, and damage from insects and invasive weeds, could increase the challenges by farmers in the day-to-day management of farms and livestock.

Increased temperatures could increase the potential for heat-related illnesses and insect-borne diseases. Changes in air quality health effects could occur due to the increased temperatures. Higher VOC and ozone levels may occur, as increased temperatures may increase duration and frequency of stagnation conditions that would allow air pollution to build up.

Regulatory Actions

The USEPA has issued regulations under the CAA, and in some cases other statutory authorities, to address issues related to climate change. In addition, MPCA has recently modified its air permit rules to incorporate new federal permit requirements for GHG emissions and currently requires an evaluation of GHG emissions in the environmental review process for projects that must obtain stationary source air permits.

On October 30, 2009, the Final Mandatory Greenhouse Gas Reporting Rule was published requiring suppliers of fossil fuels or industrial GHGs, manufacturers of vehicles and engines, and facilities that emit 25,000 or more mtpy of GHGs to submit annual emission reports to USEPA. The gases covered by the emissions reporting rule are CO₂, CH₄, N₂O, HFCs, PFCs, SF₆, and other fluorinated gases including nitrogen trifluoride and hydrofluorinated ether. The rule required that the first annual GHG emission report be submitted on March 31, 2011, for 2010 emissions. The first reporting deadline was extended to September 20, 2011.

In response to the 2007 United States Supreme Court ruling in *Massachusetts v. EPA*, 549 US 497 (2007), on April 17, 2009 the USEPA Administrator signed a Proposed Endangerment and Cause or Contribute Findings for Greenhouse Gases under the Section 202a of the CAA. The Administrator found that current and projected concentrations of the mix of six key GHGs in the atmosphere threaten the public health and welfare of current and future generations. The Administrator further found that the combined emissions of CO₂, CH₄, N₂O, and HFCs from motor vehicles and motor vehicle engines contribute to rising atmospheric concentrations of

these key GHGs and hence are a threat to public health and welfare. These findings were a prerequisite to finalizing the GHG standards for light-duty vehicles. On April 1, 2010, USEPA and the DOT's National Highway Safety Administration issued the first national rule limiting GHG emissions from cars and light trucks. This rule confirmed that January 2, 2011 was the first date that a 2012 model year vehicle meeting these rule requirements may be sold in the U.S.

Based upon the above and USEPA's "PSD Interpretive Memo" (identifying that a pollutant is subject to regulation either by a specific provision in the CAA or a regulation adopted by USEPA), USEPA issued a final rule on May 13, 2010 that set GHG thresholds for permits for new and existing sources under New Source Review PSD permit and Title V operating permit requirements, known as the Greenhouse Gas Tailoring Rule. Under the rule and beginning on July 1, 2011, new sources, such as the NorthMet Project Proposed Action, with greater than 100,000 tpy of GHG or existing facilities that increase their GHG emissions by more than 75,000 tpy are subject to PSD and would require BACT for GHG emissions.

Concurrent with USEPA actions, a series of Congressional proposals were developed that, had they been passed, would have changed the U.S. climate policy. GHG emissions legislation considered during the 109th and 110th sessions (January 2005 to January 2007, and January 2007 to January 2009, respectively) of the U.S. Congress ranged from carbon taxes to cap-and-trade and from energy efficiency requirements to moratoriums on coal-fired power plant approvals. Of the legislation proposed during the 109th and 110th Congresses, notable legislative actions include the following:

- Lieberman-Warner Climate Security Act of 2007 (S. 2191);
- Boxer-Lieberman-Warner Climate Security Act Substitution Amendment of 2008 (S. 3036);
- American Clean Energy and Security Act of 2009 (Waxman-Markey – H.R. 2454);
- Clean Energy Jobs and American Power Act of 2009 (Kerry-Boxer (S. 1733)); and
- Kerry-Lieberman American Power Act of 2010.

None of these bills have passed both houses of Congress.

At the state level, efforts to curb statewide and regional GHG emissions are underway. More than half of U.S. states have joined in regional efforts to reduce GHG emissions. In 2007, as part of the Midwestern Greenhouse Gas Reduction Accord, Minnesota committed (along with Illinois, Iowa, Kansas, Michigan, Wisconsin, and the Province of Manitoba, Canada) to long-term GHG reduction targets of 60 to 80 percent below 2005 emission levels. Participants have agreed to pursue the implementation of a regional cap-and-trade system as well as a consistent regional GHG emissions tracking system.

In May 2008, the Governor of Minnesota signed legislation requiring the Minnesota Department of Commerce (MDC) and the MPCA to track and report GHG emissions. In 2007 legislation was passed and signed into law that established GHG emissions reduction targets for 2015 and 2025 of 15 percent and 30 percent, respectively, and directed the Department of Commerce to develop interim reduction recommendations through a length stakeholder process. The 2015 and 2025 goals were designed as milestones toward meeting the State's goal of reducing GHG emissions to a level at least 80 percent below 2005 levels by 2050. Developments in Minnesota's climate change and GHG policy would likely continue as Minnesota strives to meet the goals established in the Next Generation Energy Act of 2007.

On January 13, 2013, the MPCA adopted permanent rules to implement the new GHG permit requirements set by the USEPA. These rules set Part 70 permit thresholds for GHGs at 100,000 tpy. The rule changes also modify requirements for capped and registration permits and insignificant activities. The MPCA has implemented USEPA's final decision to defer including biogenic CO₂ emissions in permitting through permanent rulemaking for biogenic sources for PSD and Title V purposes.

In addition to policies directed at reducing statewide GHG emissions, Minnesota has instituted policies requiring the evaluation of GHG emissions as a part of the environmental review process for certain proposed actions that require stationary source air emissions permits. In July 2008, MPCA issued a General Guidance for Carbon Footprint Development in Environmental Review. The MPCA guidance requests that proposers, in the course of environmental review under MEPA, prepare a GHG inventory for proposed actions that would require stationary source air emissions permits.

NorthMet Project Proposed Action and Climate Change

The NorthMet Project Proposed Action results in direct on-site emissions of GHGs and off-site indirect emissions associated with power generation. There are no analytical or modeling tools to reliably evaluate the incremental effect of a proposed action's discrete GHG emissions on the global and regional climate. In addition, there are no analytical or modeling tools to reliably evaluate any cascading effects, or cumulative effects, from a particular proposed action's GHG emissions on natural ecosystems and human economic systems in a given state or region.

The total potential direct annual emissions from the NorthMet Project Proposed Action are projected to be 196,342 mtpy of CO₂e. This is 0.12 percent of the statewide emissions for Minnesota, 0.003 percent of the United States emissions, and 0.00038 percent of the annual global emission estimations. Combining the direct and indirect emissions from the NorthMet Project Proposed Action (697,342 mtpy CO₂e), the total represents 0.44 percent, 0.01 percent, and 0.0014 percent of the annual statewide, U.S., and global emissions, respectively (Barr 2012s). It is possible that, due to global demand for copper, nickel, and precious metals, some of these emissions will occur regardless of the development of the NorthMet Project Proposed Action.

With climate change, average annual temperatures in Minnesota may increase 3 to 5°F over the lifetime of the facility. There may also be a 5 to 15 percent increase in precipitation over the life of the operation (20 years) and reclamation (60 years) (NOAA 2013). Increased temperatures and precipitation may have effects on wetlands, forests, and other cover types that are likely to affect carbon storage and sequestration in these ecosystems. There could be localized impacts due to meteorological changes. Even though a quantitative assessment of the effects could not be conducted, proposed reclamation and mitigation activities described in Section 5.2.7.4.3 can offset some of the carbon emissions caused by NorthMet Project Proposed Action. Overall, climate change could also affect visibility.

5.2.7.2.5 Mercury Deposition Impact Analysis

Total potential mercury emissions to air are estimated to be 4.6 lbs/year from the Plant Site. The primary sources of air emissions are expected to be two emission units that are part of the hydrometallurgical process: the autoclave vent and the autoclave flash vent. The combined air

emissions from these two units are estimated to be 4.1 lbs/year. Most of the remaining estimated mercury emissions (0.5 lb/year) are from natural gas used to fuel a package boiler and for space heating. Less than 0.1 lb/year are estimated to be released by the mining, crushing, and milling processes and through wind erosion from the Tailings Basin. Additional information regarding each of these emission sources is summarized in *Mercury Emission Control Technology Review Version 2* (Barr 2012r). Overall, about 95 percent of the mercury originating in the ore is expected to remain within—or be adsorbed to—the tailings and the hydrometallurgical residue, where it would remain isolated from further transport to the environment.

The low percentage of estimated mercury released to the air is primarily because the oxidizing conditions in the autoclave would cause most of the mercury that is released from the concentrate into the exhaust gas to be in either the oxidized (Hg^{+2}) or particle-bound (Hg(p)) form. Oxidized mercury is water soluble and would be captured in the facility's wet scrubber system. Particle bound mercury would be collected in any device designed to control particulate emissions, such as the autoclave scrubber system. As a result, most of the mercury emitted to the air would be in the elemental (Hg^0) form. Detailed calculations for all Plant Site emission units are provided in UpdatedCalcsPlant Ver7.0_2_26_13 (Barr 2013d).

An evaluation was conducted for the potential deposition of mercury related to the Plant Site air emissions to assess the NorthMet Project Proposed Action's potential effects on mercury concentrations in fish and the potential health risks to a hypothetical recreational fisher, as well as a subsistence fisher consuming locally caught fish. The analysis was conducted for five nearby lakes: Heikkila Lake, Colby Lake, and Whitewater Lake (located within 10 km of the Plant Site) and Wynne Lake and Sabin Lake (located within 12 km of the Plant Site). The analysis used the MPCA's Mercury Risk Estimation Method to assess the potential incremental change in fish mercury concentrations and the potential incremental risks to human health.

Only the Plant Site's potential mercury air emissions were evaluated, as they represent essentially all of the NorthMet Project Proposed Action-related mercury air emissions (Barr 2013k). The Mine Site AERA did not assess potential local mercury deposition because potential emissions are less than 1.0 lb/yr (Barr 2011h).

The results of the analysis from the two mercury speciation scenarios on the five nearby lakes estimated that the potential incremental increase in mercury concentrations in the top predator fish would range from 0.001 ppm (Scenario 2, Whitewater Lake) to 0.016 ppm (Scenario 1, Wynne Lake), depending upon the lake and scenario evaluated (see Revised Table 4, Barr 2013k). Scenario 1 assumed that the oxidized and particle-bound mercury released would be 50 percent and 25 percent of the total mercury, respectively. Scenario 2 assumed maximum control efficiency for these fractions, reducing the total percentage released to 10 percent for each. It should be noted that due to the conservatively higher oxidized and particle-bound mercury speciation assumption in Scenario 1, the effects for Scenario 1 are greater than the mercury effects for Scenario 2 for each lake evaluated. These are small compared to the existing Hg concentrations in the top predator fish (95th percentile), which range from 0.35 ppm at Whitewater Lake to 1.34 ppm at Wynne Lake. The NorthMet Project Proposed Action incremental risk quotients for a recreational fisher ranged from 0.013 (Scenario 1) at Whitewater Lake to 0.081 at Wynne Lake; both are below the incremental risk guideline level of 1.0. The incremental risk quotients for subsistence and tribal anglers ranged from 0.098 (Whitewater Lake) to 0.606 (Wynne Lake) for Scenario 1, also below the incremental risk guidance level. Finally, the incremental risk quotients for the subsistence fisher (Treaty Protected catch rate)

ranged from 0.132 (Scenario 1, Whitewater Lake) to 0.538 (Scenario 1, Wynne Lake), again below the incremental risk guidance level.

It should be noted that all of the lakes' mercury background concentrations result in a background risk quotient above 1.0 without any incremental increase from the NorthMet Project Proposed Action, which is a common occurrence in Minnesota lakes. Widespread contamination of fish from atmospheric pollution is why Minnesota established a statewide mercury TMDL. The TMDL seeks to reduce atmospheric deposition everywhere in the state in order to make the state's lakes and streams fishable, as required by federal regulations.

In September 2009, the MPCA published Guidelines for New and Modified Mercury Air Emission Sources. The guidelines were developed to limit the mercury emissions from new and expanding sources in order to meet the TMDL goal of total statewide mercury emissions of 789 lbs/year by 2025. In 2012, MPCA revised the guidelines (MPCA 2012h), which includes the following requirements that apply to the NorthMet Project Proposed Action:

- Define and employ BACT on mercury emitting sources. If best controls reduce emissions by less than 90 percent, the new source would be subject to periodic review for opportunities for improved control efficiency and must comply with TMDL requirements.
- Complete environmental review as required by Minnesota law, including for a proposed action and associated cumulative effects.
- For facilities where the MPCA determines a project's mercury emissions will not impede the statewide mercury emissions reduction goals within the mercury TMDL, an emissions limit will be placed into the facility's permit and the project is not be required to submit a mitigation plan.

The NorthMet Project Proposed Action selected a two-stage mercury control system that is expected to achieve 25 percent control for elemental mercury and 90 percent control for particle bound and oxidized mercury (Barr 2012r). Because the total mercury control is less than 90 percent, PolyMet moved forward with the remaining TMDL requirement. In addition, PolyMet has conducted a cumulative effects analysis on the local mercury deposition and bioaccumulation in fish (Barr 2012b) and the assessment of the cumulative effects is provided in Section 6.7.5.

MPCA has conducted a review of the NorthMet Project Proposed Action mercury emissions and has determined that it will not impede the reduction goals (MPCA 2013b). Thus, no minimization and mitigation plan will be required for the NorthMet Project Proposed Action.

5.2.7.3 NorthMet Project No Action Alternative

Since this alternative would not involve introducing new emission sources, the NorthMet Project No Action Alternative would have no additional effects on air quality either regionally or locally. Therefore, air quality would be substantially similar to existing conditions.

5.2.7.4 Mitigation Measures

If, during permitting, it is determined that mitigation measures are necessary, the measures described in this section could be considered. PolyMet has proposed the following mitigation measures to reduce effects on air quality associated with GHGs.

5.2.7.4.1 Greenhouse Gas Reduction Measures

Review of Current Mitigation Included In the NorthMet Project Proposed Action

The NorthMet Project Proposed Action incorporates both energy and production efficiency to reduce associated GHGs (Barr 2011e). The potential to minimize and reduce GHG emissions from changes in existing land cover (i.e., release of carbon tied up in terrestrial biomass, soils, or peat and the loss of carbon sequestration capacity from the environment) are also discussed (Barr 2011e). The following provides a summary of the reduction measures.

PolyMet proposes a hydrometallurgical process, rather than a pyrometallurgical process, which would result in reduced energy usage. The hydrometallurgical process is expected to reduce the NorthMet Project Proposed Action's energy demand by 50 percent over comparable pyrometallurgical processes. However, while energy use is reduced by one-half, GHG emissions do not decline per unit of production from what would be expected from a pyrometallurgical process, principally because of the large load of non-energy process emissions associated with hydro processing.

PolyMet also proposes to use premium efficiency motors in selected locations rather than standard motors. Motor efficiencies typically vary between 85 and 96 percent, depending upon the size and load of the motor. Gravity transport of process slurries would also be used where possible, instead of pumps. PolyMet proposes to configure the processing plant such that the overall power factor for the facility is as close to one (energy input to energy output) as practical, which would help minimize electricity use.

The primary production excavators and two of the three blast-hole drills would be electric rather than diesel powered, eliminating a direct source of GHG emissions. PolyMet would purchase new gen-set locomotives, which are more efficient and use less fuel than conventional locomotives. Space heating in the former LTVSMC processing plant is a major contributor to total direct GHG emissions and PolyMet would employ natural gas heaters. Per unit of useful energy, the combustion of natural gas results in lower CO₂e emissions than does the combustion of other fuels. Of the three feasible space heating options, electric heating, propane-fired heating, and natural gas-fired heating, natural gas-fired heating would result in aggregate in CO₂ emissions that would be about 80 percent lower than those for electric heating and 66 percent lower than those for propane-fired heaters.

PolyMet evaluated additional methods to reduce the NorthMet Project Proposed Action's GHG emissions but found the additional methods infeasible (Barr 2011e). The methods evaluated included electric drive mine haul trucks, electric locomotives, newer mill technology, flotation alternatives, and the use of waste heat from autoclaves for space heating.

Additional Mitigation

To mitigate GHG effects associated with a change in existing land cover (i.e., secondary effects), PolyMet would provide compensatory wetland mitigation (see Section 5.2.3 of this SDEIS) for direct effects on wetlands as well as for indirect effects on fragmented wetlands. One of the goals of the compensatory mitigation is to restore high-quality wetland communities of the same type, quality, function, and value as those affected by the NorthMet Project Proposed Action. Given site limitations and technical feasibility, it is impracticable to replace all affected wetland types with an equivalent area of in-kind wetlands. Off-site wetland compensation of 1,631.4 acres

wetland restoration and/or preservation, and 225.0 acres of upland buffer have been planned. This off-site mitigation would take place at three sites in northern Minnesota. Based upon the proposed wetland mitigation plan, the number of acres replaced would equal and/or exceed the total number of acres of all types of wetlands lost to NorthMet Project Proposed Action-related activities, other than deep marsh and the final ratios would be determined during wetland permitting. However, the excess replacement would contribute to some degree to compensation of the NorthMet Project Proposed Action's effects on deep marsh wetlands.

5.2.7.4.2 Rail Car Ore Transport Fugitive Dust Mitigation Measures

Rail cars have been designed to centralize the ore fines to the central portion of the rail car to minimize the potential for spillage during transport. Due to the natural moisture content and large size of the ore being mined, fugitive dust from rail car transport is expected to be minimal. Three additional fugitive dust control measures have been identified as part of the Mine Site Fugitive Emission Control Plan. These include the minimizing the drop distance of the ore into the railcars, reporting dusty conditions during loading and transport, and conducting one observation per train to evaluate rail car loading conditions. In addition, annual training will be conducted for all locomotive workers on methods to minimize fugitive dust during ore transport and loading.

5.2.7.4.3 Voluntary Mitigation Measures

Based upon the emissions defined in Section 5.2.7.1.3, the majority of the NO_x and SO₂ emissions are associated with mobile sources (e.g., diesel trucks, locomotives, mining equipment). Although the analysis of these pollutants showed that the NorthMet Project Proposed Action would not cause or significantly contribute to air quality exceedances, a voluntary anti-idle program could further reduce these emissions, as well as PM and GHG. Although there is no regulatory requirement for a program, PolyMet is considering the implementation of an idling reduction policy that will consider the size, fuel type, and function of each type of vehicle, as well as weather conditions and anticipated duration of vehicle stoppage. The policy would need to account for extreme weather conditions in order to avoid potential construction or production delays from the inability of vehicles to restart once turned off. In addition, vehicle owner's policies and maintenance requirements would have to be incorporated for heavy construction equipment and light vehicles that are not owned and operated by PolyMet. The results of such a policy would benefit by reducing environmental impacts, improving worker health and safety, and reducing fuel usage and engine wear.

5.2.7.5 Amphibole Mineral Fibers

5.2.7.5.1 Environmental Consequences

Background

The NorthMet Project Proposed Action would mine ore from the Duluth Complex, which may contain amphibole fibers. Taconite ore mined from the Biwabik Iron Formation at the Northshore Mine and processed at the Silver Bay plant, has received public attention with regard to potential releases of fibers formed from amphibole mineral crystals, a class of silicate minerals containing iron and magnesium such as those found with taconite ore on the east end of the Mesabi Iron Range in northeast Minnesota. The Biwabik Iron Formation slopes under the Duluth

Complex at the Mine Site from northwest to southeast. The proposed pit bottom is greater than 100 ft above the Biwabik Iron Formation at the closest point.

The State of Minnesota's definition of amphibole mineral fibers incorporates asbestos and non-asbestos amphibole fibers. The term "asbestos" is a regulatory and commercial term designating mineral products that possess high tensile strength, ability to be separated into long, thin, flexible fibers, low thermal and electrical conductivity, high mechanical and chemical durability, and high heat resistance. The fibers can be woven into various commercial products because of their flexibility. Asbestos refers to the fibrous variety of several naturally occurring silicate minerals.

Regulatory definitions for classifying fibers vary. The USEPA defines the dimensions of an asbestos fiber as a particle 5 micrometers (μm) in length or longer with an aspect ratio of at least 20:1 (USEPA 1993). A μm is one millionth (10^{-6}) of a meter. The National Institute for Occupational Safety and Health (NIOSH) defines an "occupational fiber" as a particle 5 μm in length or longer with an aspect ratio of at least 3:1 (NIOSH 1994). Minnesota agencies define a Minnesota regulated fiber (MN-fiber) as an amphibole or chrysotile mineral particle with an aspect ratio of 3:1 or greater with no limit on length (MDH Methods 851 and 852).

Asbestos Fibers

Asbestos is made up of fiber bundles with two or more of the following features:

- parallel fibers occurring in bundles;
- fiber bundles displaying splayed ends;
- matted masses of individual fibers; and
- fibers showing curvature.

Bundles have splaying ends and are extremely flexible. These long, thin fibers, called "fibrils," often less than 0.5 μm in width, can be easily separated from each other, which is one of the most important characteristics of asbestos (MSHA 2005). The mean aspect ratio for fibers can range from 20:1 to 100:1 or higher for fibers longer than 5 μm . Asbestos exposure has been identified as the cause of both malignant and non-malignant diseases.

The USEPA Integrated Risk Information System has classified asbestos as a Group A Human Carcinogen (USEPA 2008). This classification means that there is sufficient human and animal carcinogenicity data to support the weight-of-evidence characterization of asbestos as a human carcinogen from the inhalation route of exposure. The Group A classification is based on observations in occupationally exposed workers of increased mortality and incidence of lung cancer, mesothelioma, and gastrointestinal cancer. Evidence of carcinogenicity via the ingestion pathway was not supported in the animal studies reviewed for the USEPA Integrated Risk Information System classification in 1988 (USEPA 2008). In 2011, USEPA released a draft report, *Toxicological Review of Libby Amphibole Asbestos in Support of Summary Information on the Integrated Risk Information System Iris* (USEPA 2011e) to characterize the hazards by exposure to Libby Amphibole Asbestos for carcinogenicity and non-cancer health effects. The USEPA Scientific Advisory Board completed a comprehensive review of the report and provided recommendations on January 30, 2013. As part of the recommendations, the Scientific Advisory Board recommended additional review be conducted to re-evaluate the uncertainty factors, including recent cohort studies conducted on amphibole fibers in Minnesota (USEPA 2013). A

review of the toxicological literature for asbestos was performed for the MDNR (ERM 2009). A brief description of potential human health effects from inhalation exposure to asbestos fibers, summarized from this toxicological literature review, follows.

Lung cancers caused by asbestos are mainly bronchial carcinomas and are indistinguishable from those caused by smoking or other agents (Doll and Peto 1985). Carcinomas do not generally form until several years after the initial exposure. Mesothelioma is a form of cancer almost always associated with a previous exposure to asbestos. The cancer forms in the mesothelium, most commonly in the pleura, the outer lining of the lungs and chest cavity. Symptoms take 15 to 50 years after exposure to appear and include shortness of breath and coughing. There is no cure for human mesothelioma (Suzuki and Yuen 2002).

Asbestosis is a disease associated with occupational levels of exposure to asbestos (Atkinson 2006). Most patients with asbestosis suffer from shortness of breath and a dry cough (Mossman and Churg 1998). It is characterized by chronic inflammation of the parenchymal tissue of the lungs. Asbestosis appears to be associated with a high level of aggregate exposure, either a very high level over a short period or a low level for an extended period (Atkinson 2006). Historically, asbestosis progresses even after workers are no longer exposed to asbestos dust (Atkinson 2006).

The disease pathway of lung cancer and asbestosis from asbestos exposure is through inhalation. Another disease pathway under investigation is ingestion. The Agency for Toxic Substances and Disease Registry, a federal public health agency of the U.S. Department of Health and Human Services presents a summary of the non-respiratory cancers and asbestos exposure. The conclusion of the Agency for Toxic Substances and Disease Registry summary is that epidemiological studies do not clearly or consistently show a strong link between non-respiratory cancers and exposure to asbestos in humans. Four relevant animal studies are found in the literature. Three of the studies were conducted to investigate the effects on the digestive tract of rats of ingestion of asbestos fibers. One of the studies investigated the effects of milled taconite ore on the digestive tract of hamsters. One of the rat studies concluded that there were no health effects. One of them reported no statistically significant health effects, but cautioned that evidence from the study suggests that asbestos fibers are “not inert” in the digestive tract. The third rat study found that the asbestos inhibited the uptake of certain sugars in the digestive tract. The hamster study concluded that no deleterious health effects and no tumors were observed in the subjects. Because there is a lack of evidence suggesting an ingestion of asbestos is a disease pathway, there is no subsequent analysis on the risk of asbestos ingestion.

There are two groups of minerals that can crystallize as asbestos: serpentine and amphibole. Serpentine and amphibole minerals can have fibrous and nonfibrous structures. While there are approximately 100 minerals that may contain asbestos fibers, there are six regulated types of asbestos. The six regulated minerals and their associated mineral group are:

- Chrysotile (Serpentine);
- Crocidolite (Reibeckite) (Amphibole);
- Amosite (Cummingtonite-grunerite) (Amphibole);
- Anthophyllite Asbestos (Amphibole);

- Tremolite Asbestos (Amphibole); and
- Actinolite Asbestos (Amphibole).

From a mineral perspective, amphibole minerals are distinguished from each other by the amount of sodium, calcium, magnesium, and iron that they contain.

A mineral can be analyzed for asbestos using a microscope. Chrysotile asbestos is easily identified by microscopic analysis because of its distinct particle shape. For amphiboles, the distinction between asbestos and non-asbestos fibers is not clear. Amphibole particles have a spectrum of shapes from blocky to prismatic to acicular to asbestiform. According to USGS (2001), asbestiform refers to a specific type of mineral fibrosity in which crystal growth is primarily in one dimension and the crystals form as long, flexible fibers. Amphiboles also break (or cleave) into smaller fragments when finely ground. Long, thin cleavage fragments resemble asbestos fibers. An analyst can compare amphibole particle shapes to asbestos reference materials and determine whether a sample is asbestiform with a fair degree of certainty. However, according to USGS, "...unless a fiber bundle has splaying ends, it is impossible to determine if a single long, thin particle grew that way (as asbestos) or is a cleavage fragment" (USGS 2001). It is more difficult to classify individual fibers as asbestiform or cleavage fragments because individual fibers do not exhibit all the characteristics of a population. According to USGS (2001), a cleavage fragment is a particle formed by comminution (i.e., crushing, grinding, or breaking) of minerals, often characterized by parallel sides. Cleavage fragments tend to be roughly twice as thick as asbestos fibers (Addison and McConnell 2008). The aspect ratio distributions (i.e., length-to-width ratio) of a population of cleavage fragments and a population of asbestos fibers can overlap. This overlap means that some fibers may be classified as either cleavage fragments or asbestos fibers (Millette 2006). The State of Minnesota does not distinguish cleavage fragments from other fibers if they meet the 3:1 aspect ratio.

Non-Asbestos Fibers

The toxicological literature review prepared for the MDNR (ERM 2009) also discussed non-asbestos fibers. A brief summary follows.

Palekar et al. (1979) found non-asbestiform particles to be cytotoxic (meaning toxic to cells); however, epidemiological studies have found limited potential for carcinogenesis from cleavage fragments. Gamble and Gibbs (2008) provided a review of several epidemiological studies regarding exposure to cleavage fragments including several involving taconite miners. They found that there was no statistically significant increase in either lung cancer or mesothelioma from exposure to taconite mining. Ilgren (2004) reviewed animal and human studies and came to the same conclusion. Additionally, Gylseth et al. (1981) performed a study in which non-asbestiform amphibole dust in the lungs of taconite miners was examined. Whereas Gylseth et al. (1981) concluded that exposure to the miners constituted a minor carcinogenic risk, they could not exclude exposure to taconite as a contributing factor to the lung cancer found in the miners examined. Asbestosis and mesothelioma latency periods of 15 to 50 years are not uncommon, creating uncertainties in the interpretation of studies performed to date. It should be noted that taconite is mined in the Biwabik Formation, whereas the ore proposed to be mined for the NorthMet Project Proposed Action is from the Duluth Complex, which is not in contact with the Biwabik Formation at the NorthMet Deposit.

Other Considerations

The MDH considers the role of amphibole fibers in the induction of asbestos-related health effects to be uncertain at this time and they assume that amphibole fibers have the potential for an as yet undetermined toxicity and potency relative to amphibole asbestos.

The October 2005 SDD for the NorthMet Proposed Action EIS identified that the "... EIS will provide information about the presence of fibers in the NorthMet deposit." Since February 2006 fibers-related information has been submitted to the Minnesota State Agencies (MDNR; MPCA; MDH) for their review and consideration. The report entitled *Fiber Information, NorthMet Mine and Ore Processing Facilities Project, Fibers Data Related to the Processing of NorthMet Deposit Ore* (2007m), hereafter referred to as the "2007 Mineral Fibers Report," provided the bulk of the fibers-related data and information.

The Northshore Mine and Silver Bay processing plant have been associated with releases of amphibole mineral fibers to the air and water. The NorthMet Project area is in close proximity to the existing Northshore Mine. Ore in intrusive rocks to be mined from the NorthMet Deposit in the Duluth Complex is 700 million years younger than the taconite ore obtained from the Northshore Mine in the Biwabik Iron Formation and was formed under different conditions (Barr 2007m).

The MEQB has reported that the Duluth Complex contains minor amounts of amphibole minerals, but did not identify chrysotile as a mineral of concern (MEQB 1979). The MEQB (1979) identified that the concentration of asbestiform amphibole minerals in the Duluth Complex ore is expected to be low, "...less than 0.1 ppm by weight in the mineralized areas of the Duluth Complex...." Composite samples using ore from the NorthMet Deposit collected during flotation pilot plant studies in 2000 conducted for PolyMet (SGS 2004) provided results for amphibole and serpentine minerals representative of the MEQB (1979) conclusions. Recognizing the differences between the NorthMet Deposit versus the Biwabik Iron Formation, the MPCA, MDNR, and MDH requested that PolyMet provide additional information on fiber-related data for its mining and processing operations in the NorthMet Deposit.

PolyMet conducted additional flotation pilot testing in July and August 2005. Collected samples considered to be representative of the head feed, tailings, and flotation process water associated with processing ore from the NorthMet Deposit were prepared for analysis by Transmission Electron Microscopy by additional grinding of the ore and tailings samples with mortar and pestle to produce a very fine powder. Stevenson (1978) states that the finer a material is ground, the higher the number of "fibers" identified by MDH counting rules (MDH Methods 851 and 852). According to the laboratory conducting this analysis, this only affects fiber counts, not the identification of asbestiform fibers since asbestiform fibers have high tensile strength and flexibility (Barr 2007).

Amphibole and serpentine mineral fibers are of primary interest for the NorthMet Project Proposed Action. Overall, amphibole mineral fibers were found to represent a relatively small percent of the mineral fibers associated with the processing of NorthMet Deposit ore (Flotation Pilot Testing in July and August 2005); amphibole mineral fibers were approximately 9 percent of the fibers identified from all collected samples of ore, tailings, and process water. Serpentine mineral fibers were not identified in samples of ore, tailings, or process water collected from the flotation pilot testing. However, PolyMet's petrographic observations indicate that serpentine

minerals are about 2 percent of the minerals associated with the waste rock from the NorthMet Project Proposed Action.

Data provided in the 2007 Mineral Fibers Report indicates that about 95 percent of the mineral fibers identified in samples collected from the flotation pilot testing were 3 microns or smaller in size, with most being less than 2 microns in size. Therefore, PM_{2.5} (fine particulate) could be used as a surrogate for all mineral fibers, including amphibole and serpentine mineral fibers.

These data suggest a low probability of asbestos fiber generation from the proposed operations. However, with the presence of amphibole minerals in the Duluth Complex and the presence, albeit low, of MN-fibers from analysis of NorthMet Deposit samples, the potential exists for the release of amphibole mineral fibers from the proposed operations, which could pose a potential public health risk of uncertain magnitude.

5.2.7.5.2 Evaluation Criteria

There are many factors that contribute to carcinogenesis and disease from exposure to asbestos and non-asbestos fibers via inhalation. The literature review prepared for the MDNR (ERM 2009) summarizes the results of many toxicological studies presenting varying conclusions as to the significance of fiber aspect ratios, fiber lengths, and cleavage fragments in the expression of human health effects. However, in the case of amphibole cleavage fragments, the literature review suggests a minor carcinogenic risk though some researchers could not exclude exposure as a contributing factor to lung cancer. In addition, the MDH is currently updating an epidemiological study of workers in Minnesota's iron mining industry. There have been 58 cases of mesothelioma documented among the 72,000 workers in the study (MDH 2008).

Based upon a scientific review study on asbestos and elongated mineral particles conducted by NIOSH, the MDH has reported that males within the area of the taconite mining and milling industry had more than two times the mesothelioma rate than the rest of the state and that females had a lower mesothelioma rate than the state average; strongly suggesting an industrial etiology. However, the findings from the epidemiological case studies have suggested that the excess of mesothelioma observed among the taconite miners may have been from exposure to commercial asbestos, rather than from the nonasbestiform amphibole elongated mineral particles generated during the iron ore processing (NIOSH 2011).

The University of Minnesota is directing a \$4.9 million research effort (known as the Minnesota Taconite Workers Health Study), funded by the State of Minnesota, which will lead to a greater understanding of taconite worker health issues, including an epidemiological investigation into causes of excess cases of mesothelioma among taconite workers. The program has 5 core design studies which include: occupational exposure assessment, mortality study, incidence studies, respiratory health survey of taconite workers and spouses, and environmental study of airborne particulates (University of Minnesota 2012). The program reports progress annually to the Minnesota State Legislature and there are reports filed for each year beginning in 2009 with the most recent in April 2013. The 2013 mortality study update reports that the risk of workers contracting mesothelioma increases by about 3 percent per year worked in those with more, compared to those with less, work time; however, the occupational exposure update of the same report concludes that the mine sources of amphibole elongate mineral particles are not major components of total elongate mineral particles – in other words, the worker exposure resulting in

the increase in mortality is primarily due to commercial asbestos exposure and not the rock being mined (University of Minnesota 2013).

Although a risk assessment protocol for evaluating asbestos by type and dimensions has been developed for the USEPA by Berman and Crump (2003), it may never be formally adopted. This model does not consider fibers shorter than 10 μm in length. To date, there is no accepted methodology for performing a formal health risk assessment for the quantitative assessment of human health effects from airborne fibers emitted from the proposed operations.

However, amphibole minerals are present in the Duluth Complex and in close proximity to the NorthMet Deposit. Thus, there remains an uncertain level of potential health risk from airborne amphibole fibers for the NorthMet Project Proposed Action. Several measures of regulatory requirements will assist in minimizing emissions of fibers. Compliance with the requirements for blasting, found in *Minnesota Rules*, Chapter 6132, will minimize fugitive dust from blasting operations. Dust suppression plan for the tailings basins will be evaluated and approved by the MPCA as part of the air permit. In addition, the NorthMet Project Proposed Action will be required to comply with Federal Mine Safety and Health Administration's regulations for mining operations that include implementation of standards for asbestos exposure to minimize worker exposure.

5.2.7.5.3 NorthMet Project Proposed Action

This section describes the likelihood of exposures to airborne amphibole mineral fibers from the proposed mining and processing operations. MN-fibers identified in samples collected from the 2005 flotation pilot testing of material representative of processing NorthMet Deposit ore (Barr 2007d) were predominately less than 2.5 μm in aerodynamic diameter (99.6 percent less than 2.5 μm), placing them in the fine fraction of particulate matter ($\text{PM}_{2.5}$). A small fraction of these fibers were identified as amphibole (approximately 9 percent).

Although not calculated from the flotation pilot testing data (Barr 2007d), the probability of amphibole mineral fibers released from the NorthMet Project Proposed Action is not zero. Potential airborne fibers could contain asbestos fibers, which have known health effects. However, based on the samples analyzed from the NorthMet Deposit (Barr 2007d) and from other data collected by the MEQB (1979) for the Duluth Complex, the probability of amphibole asbestos being released to air is very low. Non-asbestos amphibole mineral fibers in these emissions have less well known health effects; however, these fibers are regulated as MN-fibers under the MPCA permits. These fibers have been regulated by MPCA air and water permits at the Northshore Mining Company (formerly Reserve Mining Company) operation in Silver Bay since the Reserve decision. The MPCA and the MDH have emphasized additional control of fine particles to minimize potential exposure to amphibole mineral fibers.

PolyMet's June 2007 Fibers Data Report (Barr 2007m) included an assessment of alternative control technologies for the proposed Plant Site operations. These data were taken from a BACT-like analysis for $\text{PM}_{2.5}$ for the Plant Site prepared for PolyMet (Barr 2007o). At the time that the BACT report was submitted (February 2007), PolyMet's intention was to permit the project as a PSD major source, so the Plant Site would have been subject to BACT requirements for PM_{10} .

In a September 2007, Supplemental Fibers Data Report (Barr 2007m), PolyMet incorporated project changes made in a July 2007 Supplemental Detailed Project Description (Barr 2007g) to

further reduce particulate matter and fugitive dust emissions from the Plant Site and Mine Site, as well as additional changes related to particulate matter control and monitoring for amphibole MN-fibers following August 2007 discussions.

PolyMet also submitted updated control technology reviews in October 2007 (Barr 2007o) and in February 2012 (Barr 2012r). In the time since the previous report, PolyMet had decided to propose permitting the project as a synthetic minor source with respect to PSD regulations. This means that BACT requirements do not apply. However, PolyMet agreed to install “BACT-like” pollution control equipment in the crushing plant for fine particulate matter. The control technology report includes the determination of BACT-like controls using the top-down BACT approach.

Under the USEPA’s PSD regulations, 40 CFR 52.21(b)(12):

Best available control technology means an emissions limitation (including a visible emission standard) based on the maximum degree of reduction for each pollutant subject to regulation under CAA that would be emitted from any proposed major stationary source or major modification which the Administrator, on a case-by-case basis, taking into account energy, environmental, and economic effects and other costs, determines is achievable for such source or modification through application of production processes or available methods, systems, and techniques. This includes fuel cleaning or treatment or innovative fuel combustion techniques for control of such a pollutant. In no event shall application of BACT result in emissions of any pollutant that would exceed the emissions allowed by any applicable standard under 40 CFR parts 60 and 61. If the Administrator determines that technological or economic limitations on the application of measurement methodology to a particular emissions unit would make the imposition of an emissions standard infeasible, a design, equipment, work practice, operational standard, or combination thereof, may be prescribed instead to satisfy the requirement for the application of BACT. Such standards would, to the degree possible, set forth the emissions reduction achievable by implementation of such design, equipment, work practice or operation, and would provide for compliance by means which achieve equivalent results.

Since MN-fibers are predominately in the PM_{2.5} size range a PM_{2.5} BACT-like analysis for the proposed PolyMet operations was performed in accordance with the USEPA’s “top-down” approach (USEPA 1990), where control technologies are ranked in order of effectiveness, and starting with the most stringent technology, each are evaluated until a technology cannot be ruled out on technological or economic grounds. At the time this review was conducted, PM_{2.5} was not regulated under PSD and the NorthMet Project Proposed Action is not subject to PSD, so BACT does not apply. Rather, the analysis was done to determine the best control for PM_{2.5} and thus for fibers.

The vast majority of potential emissions of MN-fibers for the NorthMet Project Proposed Action would occur from the ore crushing operations at the Plant Site, with minor potential emissions from the Tailings Basin and the Mine Site (Barr 2007o). The Tailings Basin would be operated to minimize all fugitive particulate emissions by management to minimize exposed beach areas, and wind erosion fugitive dust by treatment of the Tailings Basin roads and inactive beach areas. The deposition of wet tailings would keep the active work area wet and prevent wind erosion.

Capillary action near the pond edge is expected to keep the fines wet and minimize the potential for entrainment of the fines into the air.

The potential for the release of amphibole mineral particles to the air at the Mine Site is low because the ore would not be crushed at the Mine Site and the unpaved road surfaces would be constructed of material that is not likely to contain amphibole minerals. PolyMet's decision to use larger haul trucks at the Mine Site, as well as the incorporation of an updated mine plan into the emission calculations, has reduced the estimated fugitive particulate emissions, further reducing the potential for emissions of airborne amphibole mineral particles.

PolyMet is proposing to permit the NorthMet Project Proposed Action as a synthetic minor source with respect to PSD regulations. Therefore, a BACT determination, required under PSD, does not apply. Recent BACT determinations were reviewed and evaluated to identify the best controls currently used in the metallic ore processing industries for fine particulates (Barr 2012h). As a result, the NorthMet Project Proposed Action would install emission controls in the crushing plant, such that the emissions of fine particulate matter from the ore crushing and associated material handling sources are controlled consistent with recent BACT determinations. The controls would include the use of fabric filters (baghouse or cartridge) designed to reduce emissions to 0.0025 gram per dry standard cubic foot at each unit (Barr 2011). These controls would be applied to all emission sources within the coarse crushing operations (10 units), the drive house (2 units), the fine crushers (8 units), and the concentrator (15 units).

In addition to these controls, the NorthMet Project Proposed Action would also use high-efficiency particulate air (HEPA) filters following the fabric filters on selected units. The HEPA filters would be used when exhaust air from the fabric filters is routed back into the building to provide an added level of assurance that worker exposure to inhalable dust is minimized. In this case, the venting of exhaust air back into a building provides a benefit of reducing the heating fuel demand that offsets the additional cost and energy usage associated with re-routing of air back into a building (Barr 2012h). The combination of the cartridge and HEPA filters for fine particulates has a removal efficiency of 99.97 percent. Six units within the coarse crushing operations and nine units within the concentrator would utilize the HEPA filters year-round. Eight of the 10 units within the drive house and fine crusher operations would utilize the HEPA filters during heating season only (Barr 2011).

The use of HEPA filters, during non-essential operations, would provide little air quality benefits for reducing exposure to fine particulates outside the facility boundary. In addition, the modeled PM_{2.5} effects demonstrate that the PM_{2.5} concentrations, which are in the same size range as the amphibole fibers, rapidly decrease in magnitude in all directions. As such, the operational and air pollution equipment controls for the NorthMet Project Proposed Action represent the highest feasible level of fine particulate matter control and, coupled with Hoyt Lakes being 5 miles from the Plant Site, further reduce the potential for public exposure to airborne amphibole mineral fibers.

There is the potential that asbestos fibers may be found in water that has come in contact with amphibole mineral crystals at the Mine Site. The USEPA has developed drinking water standards for asbestos that drinking water utilities must comply with based upon information on the USEPA website (<http://water.epa.gov/drink/contaminants/basicinformation/asbestos.cfm>). This standard, an MCL, is 7 million fibers per liter. The USEPA has provided proven methods of water treatment to meet the MCL, including coagulation/filtration, direct and diatomite filtration,

and corrosion control. Water in contact with waste rock, ore, and pit walls would be treated during operations utilizing a greensand filter. No discharge would occur off site. During post-closure, a greensand filter, pre-filters, and a RO system would be used to treat water to meet water quality standards prior to discharge. This treated water would be discharged into the Partridge River, which flows into Colby Lake, the only lake in the area used for drinking water. It is the source of drinking water for the City of Hoyt Lakes. Currently, the City utilizes sand filters, coagulation, and settling and has been in compliance with the asbestos standards. When the RO treatment system is constructed at the Mine Site, it would operate in the same fashion as the City's treatment system. As such, the discharge from the Mine Site is expected to be in compliance with the federal standard prior to it being treated again by the City of Hoyt Lakes.

Baseline ambient air monitoring for mineral fiber concentration is currently being done at Hoyt Lakes. The monitoring location was approved by the MPCA and the monitoring is being conducted according to MPCA methodology. Ambient air monitoring for mineral fibers would also be conducted following facility startup. The mineral fibers data collected after the facility start-up would enable MPCA ample data to compare ambient concentrations, including NorthMet Project Proposed Action emissions, with the baseline conditions.

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5.2.8 Noise and Vibration

This section describes effects on humans, including effects on recreational and cultural/spiritual activity, of noise, vibration, and airblast related to the NorthMet Project Proposed Action. The effects on wildlife are described in Section 5.2.5.

Summary

Both noise and vibration dissipate with distance. The residences closest to the mine are at a distance where blasting and other NorthMet Project Proposed Action-related noise would not be heard. The NorthMet Project Proposed Action would comply with all daytime and nighttime regulatory noise limits at sensitive receptors, and the changes in total noise level from current conditions during nighttime operations would not be perceptible. Immediate access to areas around the mine would be restricted. Members of the general public who may be recreating near the NorthMet Project area and tribal members who may have a cultural and spiritual connection to archeological sites in the Superior National Forest, in areas immediately near the mine, may occasionally experience noise and/or vibration associated with the NorthMet Project Proposed Action.

5.2.8.1 Methodology and Evaluation Criteria

This section describes the methodologies and criteria used to evaluate potential noise, ground vibration, and airblast at areas of the Mine Site and Plant Site. NorthMet Project Proposed Action-related sound levels were estimated using the International Standards Organization (ISO) 9613-2 sound-propagation model. The Site Law Formula was the basis for estimating vibration effects. Airblast was estimated using the Terrock model. Each is a desktop model that estimates project effects using site-specific conditions. Estimated effects were compared to federal, state, or local regulations or to project design standards, as appropriate. For noise and vibration, the area of potential effect was defined as a 20-mile radius from the Mine Site and a 20-mile radius from the Plant Site. The area of potential effect for airblast was the distance from the source where measured effects were below the known level for human effects.

5.2.8.1.1 Noise

Noise Impact Assessment Methodology

The noise impact assessment areas for the NorthMet Project Proposed Action include the noise-sensitive receptors within a 20-mile radius of the Mine Site and a 20-mile radius of the Plant Site. The 20-mile radius was selected in order to include the southern edge of the BWCAW, which is located approximately 20 miles north of the Mine Site and Plant Site. The ISO 9613-2 sound-propagation model (*Acoustics-Attenuation of Sound during Propagation Outdoors*) is accepted worldwide and was used to determine the extent of noise effects from the NorthMet Project Proposed Action. This model is the only one that encompasses a standardized method for calculating sound propagation and is the basis for most sophisticated computer modeling programs (Ray 2010). This sound-propagation model consists of octave-band algorithms with nominal mid-band frequencies from 63 to 8,000 Hz for computing the attenuation of sound originating from a point sound source or an assembly of point sources. The source(s) may be mobile or stationary. The model predicts equivalent continuous A-weighted sound pressure

levels (L_{eq}) from sources of known sound emission and accounts for the following site conditions and physical effects:

- Meteorological conditions favorable to sound propagation (i.e., downwind propagation with wind speeds between 1 and 5 meters per second when measured 3 to 11 meters above the ground). This is a conservative approach because not all receptors may be located downwind of the sources (i.e., receptors located upwind would experience less noise since noise propagates farther downwind than upwind).
- Topography and the extent of ground absorption from different surfaces.
- Noise emission of each source, as well as its location and elevation.
- Location and elevation above local ground level of all sensitive receptors.
- Screening from any enclosures, barriers, earth berms, buildings, or vegetation.
- Attenuation due to distance (geometrical divergence) and atmospheric absorption.
- Increase in noise level due to reflections from nearby facades and reflective objects.

For the noise assessment of the NorthMet Project Proposed Action, ground topography or surface effects were modeled assuming that the area around the source and the receptors would be a mixed 50 percent hard non-absorptive ground (e.g., paved surfaces, water, ice, concrete, and all other ground surfaces having a low porosity) and 50 percent soft absorptive surface (e.g., ground covered by grass, trees, and farm land, and all other ground surfaces having a high porosity). This is a conservative assumption, as almost 100 percent of the ground adjacent to the mine sound sources and closest receptors is porous with more absorptive capacity that can attenuate noise levels. Temperature and relative humidity of 20 °C and 70 percent, respectively, were used in estimating the attenuation due to atmospheric absorption. Attenuation due to geometric divergence or spreading is mainly a function of the distance between the sound source and the receiver. A further conservative assumption is that the modeling analysis did not include any potential shielding effects from pit walls, waste rock stockpiles, berms, or vegetation.

Sound power levels for all equipment and trucks at the Mine Site and Plant Site were based on measured octave-band sound power data obtained from similar mine projects in Australia (Bassett Acoustics 2004; URS 2005). For modeling purposes, it was conservatively assumed that all equipment at the Mine Site and Plant Site would operate continuously.

Noise Impact Assessment Criteria

Noise effects are commonly judged according to two general criteria: the extent to which a project would exceed federal, state, or (where applicable) local noise regulations, and the estimated degree of disturbance to people who live in or use an area.

According to the noise standards for Minnesota (*Minnesota Rules*, part 7030.0040, subpart 2), permissible noise levels are broadly classified according to land uses such as residential, commercial, or industrial. The standards distinguish between daytime and nighttime noise, with less noise permitted at night. The standards list the sound levels not to be exceeded for more than 10 and 50 percent of the time (L_{10} and L_{50}) during any 1 hour period. The applicable Minnesota Noise Standards are shown in Table 5.2.8-1. Section 4.2.8 provides additional discussion of common noise levels.

Table 5.2.8-1 Applicable Noise Standards for Different Land Uses in Minnesota

Noise Area Classification ¹	Noise Standard (dBA)			
	Daytime (7 a.m. to 10 p.m.)		Nighttime (10 p.m. to 7 a.m.)	
	L ₅₀	L ₁₀	L ₅₀	L ₁₀
1	60.0	65.0	50.0	55.0
2	65.0	70.0	65.0	70.0
3	75.0	80.0	75.0	80.0

Source: *Minnesota Rules*, part 7030.0040, subpart 2; MPCA 2008.

¹ The land use activities associated with each Noise Area Classification (NAC) are described in *Minnesota Rules*, part 7030.0040, subpart 2 and MPCA 2008.

- Land use activities under NAC 1 include household units, group quarters, residential hotels, transient lodging camp grounds, correctional institutions, mobile home parks or courts, health and educational services, religious activities, resorts, camping and picnicking areas, motion picture production, and other cultural, entertainment, and recreational activities.
- Land use activities under NAC 2 include rail, road, water, and air transportation activities (passenger), wholesale and retail trade, parks, recreational activities (except entertainment assembly and race tracts), automobile parking, personal services, business services, and other professional services (repair, legal, and contract construction services).
- Land use activities under NAC 3 include manufacturing, petroleum refining and related industries, primary metal industries, race tracks, fair grounds and amusement parks, agricultural and fishing-related activities, retail trade (eating and drinking) and transportation, communication, and utilities (except transportation services and arrangements).

As shown in Table 5.2.8-1, the most stringent standard is the nighttime (10 p.m. to 7 a.m.) standard in a NAC 1, which is 50 dBA for no more than 50 percent of the time (L₅₀). In other words, a nighttime L₅₀ of 50 dBA means that from 10 p.m. to 7 a.m., noise levels may not exceed 50 dBA more than 30 minutes in an hour. Similarly, a nighttime L₁₀ of 55 dBA means that during these same hours, noise levels may not exceed 55 dBA more than 6 minutes in an hour. Land use activities under NAC 1 include household units or private residences, mobile home parks, transient lodging campgrounds and picnic areas, churches, schools, hospitals, and other cultural, entertainment, and recreational activities.

There are no federal or local noise regulations that would apply to the NorthMet Project Proposed Action.

In addition to state and federal standards, the degree of disturbance becomes a key factor in the evaluation of noise effects, which, in this case, includes a focus on residents in the vicinity of the NorthMet Project Proposed Action, as well as people who frequent the area for recreation, fishing, and hunting, and tribal members who may be involved in traditional natural resource harvests on national forest lands. The concept of human disturbance is known to vary with a number of interrelated factors including: changes in noise levels; the presence of other, non-project-related noise sources in the vicinity; people's attitudes toward the project; the number of people exposed; and the type of human activity affected (e.g., sleep or quiet conversation as compared to physical work or active recreation).

NorthMet Project Proposed Action-related noise effects have been evaluated at sensitive receptors using the state daytime and nighttime noise standards (L₅₀ and L₁₀) for NAC 1. These noise standards would apply to the NorthMet Project area throughout the years that the mine is operating (years 1 to 20), when elevated sound level activities from mining, hauling, and crushing operations would occur. The same noise standards would also apply to any potential noise source during closure and post-closure (i.e., after year 20).

Area of Audibility for Boundary Waters Canoe Area Wilderness

Sound from project activities may be audible even if the sound level is lower than the background ambient level. This is because stationary (e.g., drill rigs, crushers) and mobile sources (e.g., dump trucks, graders) associated with mining and crushing activities at the Mine Site and Plant Site may be of a different quality (e.g., electric motor or diesel engine versus a bird call) than natural ambient sound.

It is assumed that noise associated with drilling, excavating, hauling, and crushing activities may be audible up to the location that sound level emitted from these project-related sources attenuates to a level that is 8 dBA below ambient A-weighted sound level. This is identified by the National Park Service at 64 FR 3969-3972 for noise emitted by aircraft that may affect Park visitors. There may be some variability when comparing sound propagation from aircraft engines as done by the National Park Service versus project-related sources (electric motors, diesel engines, etc.). However, for the purpose of this analysis, the 8 dBA method is considered adequate to estimate audible distance from noise sources at the Mine Site and Plant Site. It should be noted that the area of audibility usually applies to certain areas considered by the National Park Service to require substantial restoration of natural quiet (64 FR 3969-3972). For the NorthMet Project Proposed Action, the area of audibility or audibility impacts applies to the BWCAW only. An area of audibility could also be calculated for other non-wilderness receptor locations such as recreational sites within the vicinity of the NorthMet Project area. However, since the area of audibility is based on measured baseline levels for each receptor of concern, separate areas of audibility would be needed for each receptor type. Applying the area of audibility for the BWCAW for other receptor locations is conservative due to the expected higher baseline levels in these areas.

5.2.8.1.2 Vibration and Airblast

Ground Vibration Impact Assessment Methodology

The ground vibration impact assessment area for the NorthMet Project Proposed Action encompasses a 20-mile radius from the Mine Site. When an explosive is detonated in a blasthole, a pressure wave is generated in the surrounding rock. As this pressure wave moves from the borehole, it forms seismic waves by displacing particles in the earth (e.g., glacial till, bedrock). Ground vibration varies with distance from the blast, charge mass per hole, type of explosive, geological conditions, and blasting specifications. For similar geological conditions and blasting specifications, ground vibration varies with distance from the blast and charge mass per hole, according to the Site Law formula. This formula has been used for assessing ground vibration effects from blasting activities at multiple mine and quarry sites in Australia and has also been used in this assessment. The formula accounts for different rock types with a site constant K_g (see note in Table 5.2.8-4 for definition of K_g). Typical K_g factors for free-face hard or highly structured rock, free-face average rock, and heavily confined rock are 500, 1,140, and 5,000, respectively (Dyno Nobel 2010). This vibration assessment has been conducted using a range of these three K_g factors to allow for varying degrees of vibration transmission through different rock types.

Airblast Overpressures Impact Assessment Methodology

The impact assessment area for airblast overpressure for the NorthMet Project Proposed Action is the same area that was used to evaluate ground vibration. An airblast is an airborne shock wave that results from the detonation of explosives. The magnitude of airblast overpressure levels at a point remote from the blast is a function of many parameters including charge mass (mass of explosive per drilled hole), confinement, burden (distance between two drilled holes and perpendicular to the free face), attenuation rate, shielding direction relative to the blast, and meteorological conditions at the time of the blast. The attenuation rate for low-frequency blast vibration has been found from experience to be a 9 dBL reduction per doubling of distance (Terrock Consulting Engineers 2009).

Analysis of blasting data from mines and quarries has permitted a relationship to be established between the maximum 120 dBL distance (the distance in front of the blast that the 120 dBL contour occurs), charge mass per hole, and burden using the Terrock model. This model has been used for assessing airblast effects from blasting activities at multiple mine and quarry sites in Australia and has also been used in this assessment. The model accounts for a dimensionless empirical constant, k_a (usually 250 for quarry and mine blasting), and determines the maximum distance to the 120 dBL contour from the blast site.

Ground Vibration and Airblast Overpressure Evaluation Criteria

Humans can feel ground vibration and airblast overpressures at levels well below those that can cause damage to property. Ground vibration and airblast overpressure limits, therefore, have two aspects: an environmental or acceptable human response (annoyance) limit, and a limit to prevent structural damage (which should be considered separately).

To minimize human annoyance and prevent structural damage to properties outside mining areas, the effects of ground vibration and air overpressure from blasting operations must meet the requirements of *Minnesota Rules*, part 6132.2900, subpart 2. According to the *Minnesota Rules*, the maximum PPV from blasting should not exceed 1 in/s (25.4 mm/s) at the location of a structure located on lands not owned or controlled by the permittee. Air overpressure on lands not owned or controlled by the permittee should not exceed 130 dB, as measured on a linear peak scale (dBL) sensitive to a frequency band ranging from 6 cycles per second to 200 cycles per second.

Ground vibration and air blast (overpressure) from rock blasting are primarily related to the weight of explosive detonated at any single instant and the distance to a structure or sensitive receptor.

Aside from the *Minnesota Rules*, there are no specific federal or local vibration regulations associated with mine blasting that would apply to the NorthMet Project Proposed Action.

5.2.8.2 NorthMet Project Proposed Action

5.2.8.2.1 Noise

The primary sources of noise from the Mine Site (3,014.5 acres) during operations would be drilling; blasting; excavation work (hydraulic excavators, front-end loaders); dump trucks hauling material along mine haul roads; material-handling activities at the Rail Transfer Hopper, Overburden Storage and Laydown Area, and waste rock stockpiles; and train horns. Noise would

also be generated from auxiliary and support equipment such as tracked dozers, wheel dozers, graders, water trucks, backhoes, and fuel trucks. The sound power levels for each of these sources, based on data from operating mines, are summarized in Table 5.2.8-2.

Table 5.2.8-2 Maximum Sound Power Levels of Major Equipment and Trucks during Operations at the Mine Site and Plant Site

									Overall Linear- Weighted Sound Power Level (dBL)	Overall A- Weighted Sound Power Level (dBA)
Noise Source Description	Octave Band Center Frequency (Hz)									
	63.0	125.0	250.0	500.0	1000.0	2000.0	4000.0	8000.0		
Mine Site										
Rotary Drill Rig	110.0	123.0	114.0	119.0	111.0	109.0	103.0	98.0	125.0	119.0
Hydraulic Excavator (31-cy)	111.0	122.0	118.0	117.0	115.0	110.0	104.0	99.0	125.0	119.0
Hydraulic Excavator (31-cy)	111.0	122.0	118.0	117.0	115.0	110.0	104.0	99.0	125.0	119.0
Hydraulic Excavator (31-cy)	111.0	122.0	118.0	117.0	115.0	110.0	104.0	99.0	125.0	119.0
Front-end Loader (21.5-cy)	112.0	111.0	112.0	114.0	112.0	112.0	106.0	101.0	120.0	117.0
Tracked Dozer (582-hp)	118.0	118.0	104.0	100.0	104.0	102.0	97.0	92.0	121.0	109.0
Tracked Dozer (582-hp)	118.0	118.0	104.0	100.0	104.0	102.0	97.0	92.0	121.0	109.0
Wheel Dozer (450-hp)	117.0	123.0	119.0	111.0	107.0	101.0	91.0	83.0	125.0	115.0
Grader (275-hp)	111.0	117.0	113.0	105.0	101.0	95.0	85.0	77.0	119.0	109.0
Grader (275-hp)	111.0	117.0	113.0	105.0	101.0	95.0	85.0	77.0	119.0	109.0
Water Truck (937-hp)	107.0	110.0	116.0	114.0	109.0	107.0	101.0	102.0	120.0	116.0
Water Truck (937-hp)	107.0	110.0	116.0	114.0	109.0	107.0	101.0	102.0	120.0	116.0
Wheel Loader (800-hp)	112.0	111.0	112.0	114.0	112.0	112.0	106	101.0	120.0	117.0
Backhoe (110-hp)	111.0	117.0	113.0	105.0	101.0	95.0	85.0	77.0	119.0	109.0
Fuel Truck (150-hp)	111.0	117.0	113.0	105.0	101.0	95.0	85.0	77.0	119.0	109.0
Fuel Truck (150-hp)	111.0	117.0	113.0	105.0	101.0	95.0	85.0	77.0	119.0	109.0
Dump Truck (240-ton)	95.0	100.0	109.0	114.0	117.0	116.0	111.0	100.0	121.0	121.0
Dump Truck (240-ton)	95.0	100.0	109.0	114.0	117.0	116.0	111.0	100.0	121.0	121.0
Dump Truck (240-ton)	95.0	100.0	109.0	114.0	117.0	116.0	111.0	100.0	121.0	121.0

Noise Source Description	Octave Band Center Frequency (Hz)								Overall Linear- Weighted Sound Power Level (dBL)	Overall A- Weighted Sound Power Level (dBA)
	63.0	125.0	250.0	500.0	1000.0	2000.0	4000.0	8000.0		
Mine Site										
Dump Truck (240-ton)	95.0	100.0	109.0	114.0	117.0	116.0	111.0	100.0	121.0	121.0
Dump Truck (240-ton)	95.0	100.0	109.0	114.0	117.0	116.0	111.0	100.0	121.0	121.0
Dump Truck (240-ton)	95.0	100.0	109.0	114.0	117.0	116.0	111.0	100.0	121.0	121.0
Dump Truck (240-ton)	95.0	100.0	109.0	114.0	117.0	116.0	111.0	100.0	121.0	121.0
Dump Truck (240-ton)	95.0	100.0	109.0	114.0	117.0	116.0	111.0	100.0	121.0	121.0
Dump Truck (240-ton)	95.0	100.0	109.0	114.0	117.0	116.0	111.0	100.0	121.0	121.0
Total Sound Power Level from all equipment at the Mine Site	125.0	131.0	128.0	128.0	128.0	127.0	121.0	113.0	136.0	133.0
Plant Site										
Primary Crusher	123.0	123.0	121.0	111.0	106.0	105.0	100.0	94.0	127.0	116.0

¹ Assumes all mine equipment and trucks would be in continuous operation at any given time at the Mine Site.

² Sound power levels for all equipment and trucks at the Mine Site were taken from the Noise and Vibration Assessment for the Clermont Coal Mine Project, Queensland Australia, August 2004 (Bassett Acoustics 2004). Sound power levels for backhoe and fuel trucks were not available and were assumed to be the same as for the graders due to their similar hp ratings.

³ Sound power levels for the primary crusher at the Plant Site (116 dBA) were taken from the McArthur River Mine Open Cut Project, Australia (URS 2005).

⁴ All mine and plant equipment were assumed to be approximately 5 meters from ground level.

⁵ Total sound power level from all equipment at the Mine Site was calculated by logarithmically adding all the octave-band sound power levels for each piece of equipment at the site.

To estimate potential noise effects on closest receptors, noise from proposed mine operations was modeled using the ISO 9613-2 sound-propagation model, as described in Section 5.2.8.1. The Mine Site assessment predicted effects at nine different receptor locations scattered throughout the vicinity of the site. The closest noise-sensitive areas to the Mine Site are shown on Figure 4.2.8-1; the closest of these is the City of Babbitt, located 6.5 miles north of the Mine Site. In addition to the nine identified receptors, other sensitive receptors such as trails and recreational sites (family campgrounds, camp sites, boating, fishing, swimming, and family picnic areas) within the NorthMet Project are vicinity are also shown on Figure 4.2.8-1. All major mine equipment and trucks shown in Table 5.2.8-2 were assumed to be operating simultaneously. Modeled sound levels from all mine equipment and trucks experienced at the nearest receptors during daytime and nighttime mine operations (excluding baseline levels and plant sources), are shown in Table 5.2.8-3.

Table 5.2.8-3 Predicted Noise Levels at Nearest Receptors to Mining and Hauling Operations at Mine Site (excludes Baseline Levels)

Receptor	Distance to Mine Site (miles) ²		Daytime Noise Levels at Closest Receptors to Mine Site (excludes Baseline Levels) (dBA)			Nighttime Noise Levels at Closest Receptors to Mine Site (excludes Baseline Levels) (dBA)		
	Distance	Direction	L _{eq}	L ₅₀	L ₁₀	L _{eq}	L ₅₀	L ₁₀
Private Residences (R-1)	8.4	NW	11.9	10.9	14.7	11.9	10.9	14.7
Hoyt Lakes (R-2)	10.3	SW	9.1	8.1	11.9	9.1	8.1	11.9
Boy Scout Camp (R-3)	12.3	SW	6.7	5.7	9.5	6.7	5.7	9.5
Babbitt (R-4)	6.5	N	15.2	14.2	18.0	15.2	14.2	18.0
Skibo (R-5)	9.1	S	10.8	9.8	13.6	10.8	9.8	13.6
Aurora (R-6)	13.8	SW	5.1	4.1	7.9	5.1	4.1	7.9
Ely (R-7)	20.4	N-NE	0.0	0.0	3.8	0.0	0.0	3.8
BWCA Wilderness (R-8)	21.9	N	0.0	0.0	3.8	0.0	0.0	3.8
Tower (R-9)	19.3	NW	0.3	0.0	3.8	0.3	0.0	3.8

¹ N=North, S=South, E=East, W=West, NW=Northwest, NE=Northeast, SW=Southwest

Table 5.2.8-3 indicates that the highest noise levels that would be experienced during operations at the Mine Site would occur at the closest receptors in Babbitt. Excluding baseline levels, L₅₀ and L₁₀ noise levels from the Mine Site are 14.2 and 18.0 dBA, respectively. Due to the low noise contribution from the Mine Site sources, total L₅₀ and L₁₀ noise levels at Babbitt and other receptors during daytime and nighttime, inclusive of baseline noise levels, would remain the same (i.e., no change in baseline levels when combined with Mine Site noise levels). The predicted L_{eq} at noise-sensitive receptors around the Mine Site were converted to L₅₀ and L₁₀ using a USEPA calculation methodology (USEPA 1974). The calculation was based on an assumed standard deviation of 3 dBA for sound level distribution.

The primary sources of noise along the Transportation and Utility Corridor would be trains and train horns used during ore transport from the Mine Site to the Plant Site. The noise from the trains and their horns is expected to have minimal effects because the railroad route between the two locations is approximately 4 to 5 miles from the nearest receptors. Up to 22 trains per day are expected to deliver ore to the Plant Site. This frequency of traffic is less than that experienced on the rail line during past mining operations.

The primary sources of noise from the Plant Site would be crushers. Noise from other sources such as pumps at the existing LTVSMC Tailings Basin is expected to be minor in comparison to noise from the crushers, and, as such, was not quantified. The sound power level for the crushers was estimated to be 116 dBA (Table 5.2.8-2). Sound-propagation modeling was performed for the crushers using the ISO 9613-2 sound-propagation model and assumptions described in Section 5.2.8.1. Modeled sound levels experienced at the nearest receptors during ore-crushing operations, plus baseline levels (excluding baseline levels and mine sources), are shown in Table 5.2.8-4.

Table 5.2.8-4 Predicted Noise Levels at Nearest Receptors to Ore-crushing Operations at Plant Site (excludes Baseline Levels)

Receptor	Distance to Mine Site (miles) ²		Daytime Noise Levels at Closest Receptors to Plant Site (excludes Baseline Levels) (dBA)			Nighttime Noise Levels at Closest Receptors to Plant Site (excludes Baseline Levels) (dBA)		
	Distance	Direction	L _{eq}	L ₅₀	L ₁₀	L _{eq}	L ₅₀	L ₁₀
Private Residences (R-1)	4.2	N	14.5	13.5	17.3	14.5	13.5	17.3
Hoyt Lakes (R-2)	5.6	S	11.0	9.9	13.8	11.0	9.9	13.8
Boy Scout Camp (R-3)	6.5	S	9.2	8.2	12.0	9.2	8.2	12.0
Babbitt (R-4)	11.8	NE	2.1	1.1	4.9	2.1	1.1	4.9
Skibo (R-5)	10.5	SE	3.5	2.5	6.3	3.5	2.5	6.3
Aurora (R-6)	6.7	SW	9.0	7.9	11.8	9.0	7.9	11.8
Ely (R-7)	24.4	NE	0.0	0.0	3.8	0.0	0.0	3.8
BWCA Wilderness (R-8)	23.0	N	0.0	0.0	3.8	0.0	0.0	3.8
Tower (R-9)	15.4	NW	0.0	0.0	3.8	0.0	0.0	3.8

¹ N=North, S=South, NW=Northwest, NE=Northeast, SW=Southwest, SE=Southeast

Table 5.2.8-4 indicates the highest nighttime L₅₀ and L₁₀ levels that would be experienced at the closest receptor (private residences, 4.2 miles north of the Plant Site) due to operations at the Plant Site are 13.5 and 17.3 dBA, respectively, exclusive of baseline levels. Due to the low noise contribution from the Plant Site crushers, total L₅₀ and L₁₀ at the private residences and other receptors during daytime and nighttime, inclusive of baseline noise levels, would remain the same (i.e., no change in baseline levels at closest receptors when combined with Plant Site noise levels).

The total combined noise effect from operations at the Mine Site, Transportation and Utility Corridor, and Plant Site, plus baseline levels, is discussed in Section 5.2.8.2.3. The area of audibility is also discussed in Section 5.2.8.2.3.

5.2.8.2.2 Ground Vibration and Airblast Overpressure

The potential for ground vibration from hauling material via dump trucks along the mine haul road is expected to be low since rubber-tired vehicles do not generate any significant amount of ground vibration. However, blasting at the Mine Site could affect surrounding residential receptors and structures or buildings with regard to ground vibration and airblast overpressure. The potential effects of ground vibration and airblast overpressure are discussed below. PolyMet has committed to develop an ore and rock blasting program with industry standard methods and experiences from other area mines, including blast vibration damage prevention and monitoring.

Ground Vibration from Blasting at the Mine Site

Except at very close distances to a blast, when permanent ground displacement could occur, ground vibration is an elastic wave motion and the ground returns to its original position after the wave passes. The attenuation rate varies based on the characteristics of the rock through which the vibration travels. Characteristics such as faults and jointing planes, degree and depth of weathering, and the top soil profile contribute to a wide variation of vibration levels.

The potential effect of ground vibration from blasting at the Mine Site was assessed using the Site Law formula, as described in Section 5.2.8.1. The vibration assessment was conducted over a range of K_g factors that represent the vibration transmission through different types of ore or waste rock. Using the Site Law formula and appropriate blast parameters, the limiting distances (i.e., distances beyond which an effect would not occur using different K_g factors) for ore and waste rock blasts at ground vibration levels ranging from 0.5 to 25.4 mm/s were calculated and are shown in Table 5.2.8-5. Ground vibration contours from blasting at the Mine Site are shown on Figure 5.2.8-1 (based on a maximum K_g factor of 5,000 for heavily confined rocks).

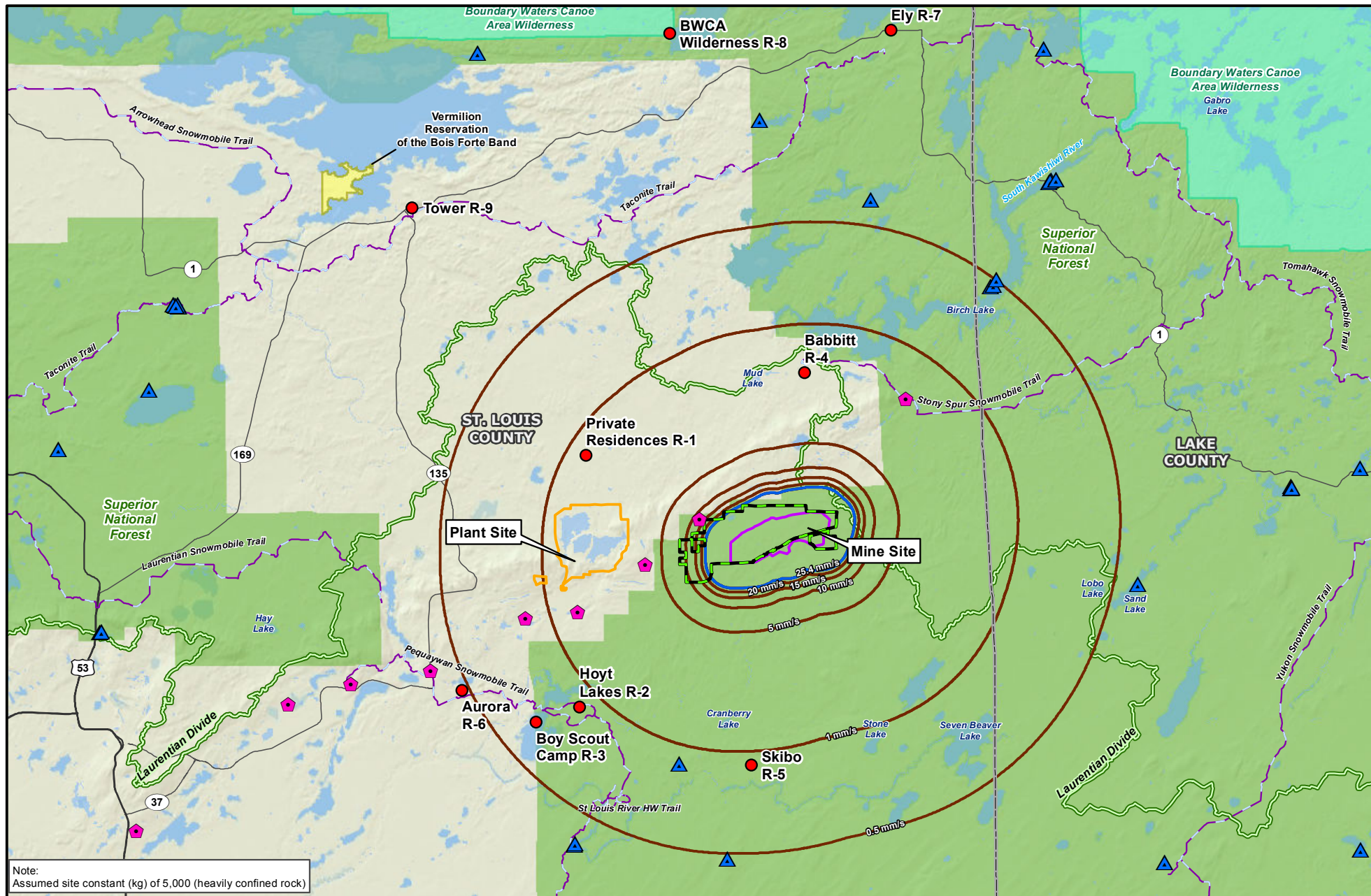
Table 5.2.8-5 Limiting Distances for Ore and Waste Rock Blasts at Incremental Ground Vibration Levels

Ground Vibration, PPV (mm/sec)	Limiting Distance from Blast, D (m) ¹		
	$k_g = 500$	$k_g = 1,140$	$k_g = 5,000$
25.4	375	627	1,581
20	435	728	1,835
15	521	872	2,197
10	671	1,123	2,830
5	1,035	1,733	4,365
3	1,424	2,384	6,007
1	2,830	4,738	11,936
0.5	4,365	7,306	18,407

Notes:

k_g = Site specific empirical constant for predicting ground vibration levels (dimensionless). Usually determined by site calibration. Typical K_g factors for free face hard /highly structured rock, free face average rock, and heavily confined rock are 500, 1140, and 5000, respectively.

¹ Limiting distances for predicting ground vibration levels from blasting were estimated based on the charge mass per hole (3,388 kg/hole). The charge mass per hole was estimated using the blast parameters and specification for this project such as blasthole diameter (311 mm), hole length (22.6 m), burden (8.84 m), spacing (10.1 m), and explosive density (1.69 kg/m³).



Note:
Assumed site constant (kg) of 5,000 (heavily confined rock)

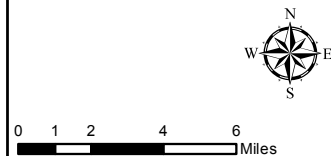
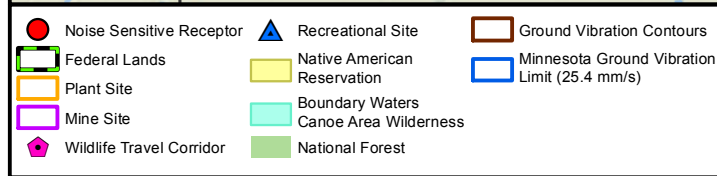


Figure 5.2.8-1
Predicted Ground Vibration Contours from Blasting at the Mine Site
NorthMet Mining Project and Land Exchange SDEIS
Minnesota

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The environmental effects of blasting at non-ferrous mining operations are regulated by the MDNR to ensure that the effects of ground vibrations from production blasts would not be detrimental to human health or welfare or property outside the mining area. According to *Minnesota Rules*, part 6132.2900, subpart 2, the maximum PPV from blasting shall not exceed 1 in/s (25.4 mm/s) at the location of a structure located on lands not owned or controlled by the permittee. Assuming a worst-case K_g of 5,000 (heavily confined rocks) and 3,388 kg (7,471 lbs) of explosives per blast hole, the limiting distance for blasts at ground vibration levels of 25.4 mm/s (1 in/s) is 1,581 meters (0.98 mile) and the impact area for this Minnesota ground vibration limit is approximately 11,334 acres (see Table 5.2.8-5; Figure 5.2.8-1). None of the human or structural receptors are located within this ground vibration impact area. The maximum ground vibration level for the closest human or structural receptor in the City of Babbitt, 6.5 miles north of the Mine Site, from the blast site is predicted to be on the order of 1.24 mm/s (0.05 in/s). The predicted ground vibration at all nearby human and structural receptors resulting from blasting at the Mine Site would be well below the applicable limits in Minnesota. Blasting would not occur at night.

Figure 5.2.8-1 shows that there are no residences, recreational sites, trails, or MPCA staff recommended wild rice waters within the Minnesota ground vibration impact area (i.e., the Minnesota ground vibration limit of 25.4 mm/s, which is the blue contour line on the figure [11,334 acres]). The closest recreational site is a family picnic area located approximately 9 miles south of the Mine Site and Plant Site (near Skibo). This family picnic area as well as other recreational sites located further away such as those near Birch Lake and South Kawishiwi River are outside the impact area. The closest wildlife corridor located northeast of the Mine Site is also outside the impact area. The Upper St. Louis River contains wild rice beds used by tribal members for traditional resource harvests. The wild rice beds are usually in close proximity to MPCA staff-recommended wild rice waters such as Mud Lake and Birch Lake (north of Mine Site), Lobo Lake and Sand Lake (east of Mine Site), Stone Lake and Seven Beaver Lake (southeast of Mine Site), Cranberry Lake (south of Mine Site), and Hay Lake (west of Plant Site). There are no wild rice beds or MPCA staff-recommended wild rice waters within the impact area.

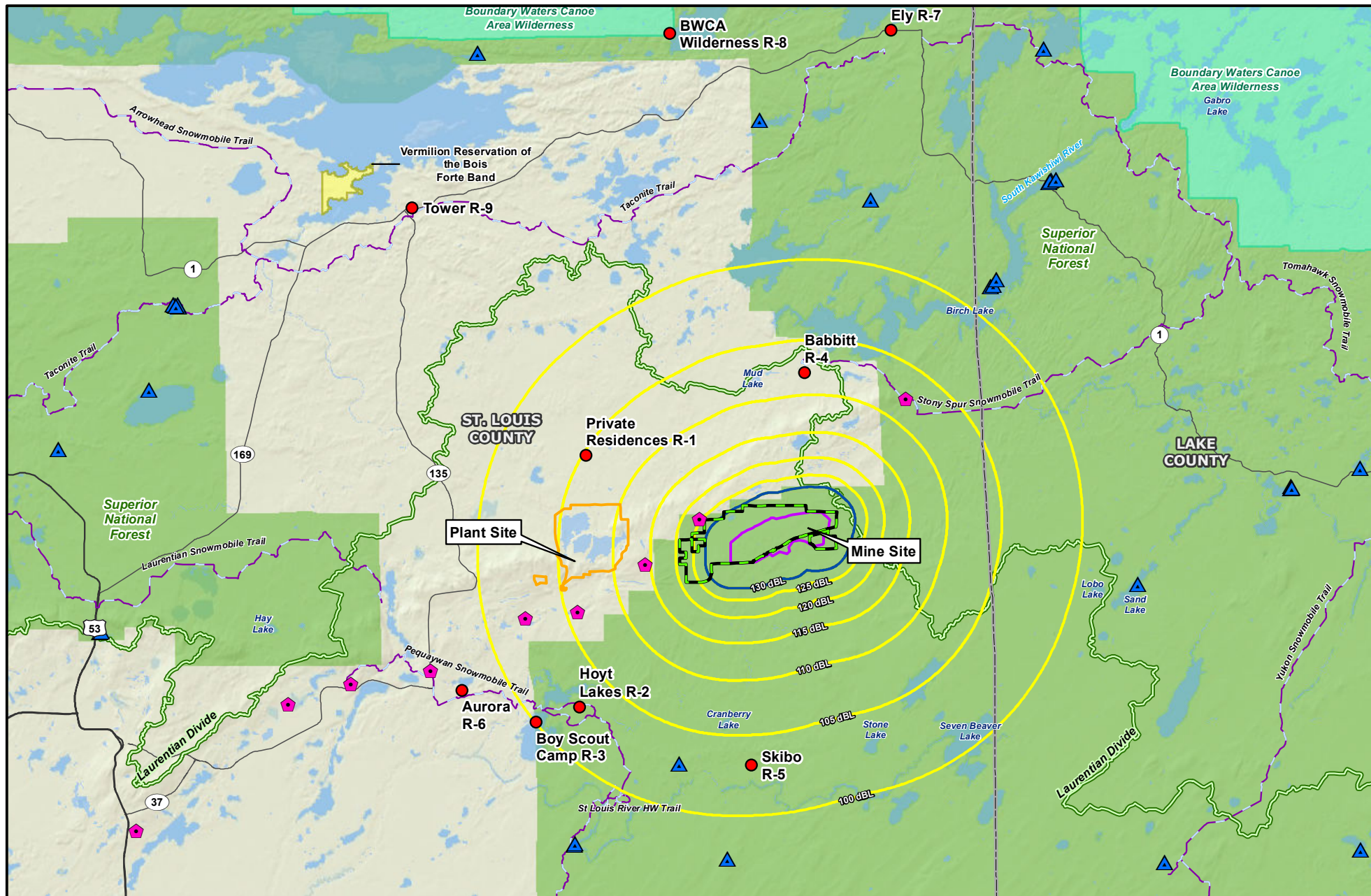
Though not depicted on Figure 5.2.8-1 due to sensitivity regarding cultural resources and locations, three archaeological sites have been identified within the NorthMet Project area: Spring Mine Lake Sugarbush, *Mesabe Widjiu* [Laurentian Divide], and BBLV Trail Segment #1 (USFS #01-569). The Spring Mine Lake Sugarbush and the *Mesabe Widjiu* are located more than 2 miles away from the Mine Site (approximately 1 mile from the Plant Site). Since ground vibration impacts from blasting at the Mine Site would be experienced less than a mile from the blast site, both archaeological sites are expected to be outside the ground vibration impact area (11,334 acres). The BBLV Trail Segment #1 (USFS #01-569), used by the Ojibwe people during early mineral exploration hundreds of years ago, remains an important cultural and spiritual connection for the Bands. The BBLV Trail Segment #1 (USFS #01-569) crosses the NorthMet Project area. Portions of the trail segment that cross the Mine Site are expected to be within the ground vibration impact area and may experience ground vibration levels close to the Minnesota standards. Details of the location and uses of the archaeological sites are discussed in Section 4.2.9, Cultural Resources.

Based on the information above, ground vibration levels from mine blasting are expected to be below the Minnesota ground vibration standards for humans and structures (*Minnesota Rules*,

part 6132.2900, subpart 2), including people that use the Superior National Forest for recreational activities such as family campgrounds, camp sites, fishing, boating, swimming, and family picnic areas. Immediate access to areas around the Mine Site would be restricted, but tribal members who may have a cultural and spiritual connection to archaeological sites in the Superior National Forest, in areas immediately near the mine, may occasionally experience ground vibration associated with the NorthMet Project Proposed Action. Mitigation measures for the impacted cultural resource areas are discussed in Section 5.2.9, Cultural Resources. During the closure and post-closure phases (i.e., after year 20), blasting at the Mine Site would cease, so no blast-related ground vibration would occur. Machinery, such as planters used to restore and rehabilitate the Mine Site during the closure phase, would not generate a significant amount of ground vibration. Therefore, potential ground vibration levels during the closure and post-closure phases are expected to be below the Minnesota ground vibration standards for humans and structures (*Minnesota Rules*, part 6132.2900, subpart 2).

Airblast Overpressure from Blasting at the Mine Site

The airblast overpressure effect from the Mine Site was assessed using the Terrock model, as described in Section 5.2.8.1. Using this analytical method for ore and/or waste rock blasts at the Mine Site, the 120 dBL distance for the assumed blast specifications is a maximum of 3,451 meters (2.2 miles) in front of the blast (see Table 5.2.8-6). The incremental distances for airblast overpressure levels from 100 to 130 dBL were calculated using an attenuation rate of a 9 dBL decrease per doubling of distance (Terrock Consulting Engineers 2009). Airblast contours for these overpressure levels from blasting at the Mine Site are shown on Figure 5.2.8-2.



<ul style="list-style-type: none"> Noise Sensitive Receptor Federal Lands Plant Site Mine Site Wildlife Travel Corridor 	<ul style="list-style-type: none"> Recreational Site Native American Reservation Boundary Waters Canoe Area Wilderness National Forest 	<ul style="list-style-type: none"> Airblast Contour Minnesota Airblast Limit (130 dBL) 			<p>Figure 5.2.8-2 Predicted Airblast Contours from Blasting at the Mine Site NorthMet Mining Project and Land Exchange SDEIS Minnesota</p>
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Table 5.2.8-6 Limiting Distances for Ore and Waste Rock Blasts at Incremental Airblast Overpressure Levels

Hole Diameter, d (mm)	Burden, B (mm)	Charge Mass per Hole, M (kg/hole)	Distance to the 120 dBL Contour, D ₁₂₀ (m)	Distance to the 130 dBL Contour, D ₁₃₀ (m)	Distance to the 125 dBL Contour, D ₁₂₅ (m)	Distance to the 115 dBL Contour, D ₁₁₅ (m)	Distance to the 110 dBL Contour, D ₁₁₀ (m)	Distance to the 105 dBL Contour, D ₁₀₅ (m)	Distance to the 100 dBL Contour, D ₁₀₀ (m)
311	8,839	3,388	3,451	1,602	2,351	5,065	7,434	10,912	16,016

Note: Based on the computed distance for the 120 dBL contours, the distances for the other airblast contour levels (130 dBL, 125 dBL, 115 dBL, 110 dBL, 105 dBL, and 100 dBL) were calculated using an attenuation rate of 9 dBL decrease per doubling of distance.

As with ground vibration, the environmental effects of airblasts are regulated by the MDNR. According to *Minnesota Rules*, part 6132.2900, subpart 2, air overpressure on lands not owned or controlled by the permittee shall not exceed 130 dBL. The distance from the Mine Site to the 130 dBL compliance level is 1,602 meters (1 mile) and the impact area for this Minnesota airblast overpressure limit is approximately 11,469 acres. None of the receptors (buildings or structures) is close enough to the Mine Site to achieve this level of exposure (Figure 5.2.8-2). The maximum airblast overpressure level for the closest receptor in the City of Babbitt is predicted to be approximately 106 dBL. The predicted airblast overpressures at all nearby receptors resulting from blasting activities at the Mine Site would be below the applicable limits in Minnesota. Blasting would not occur at night.

Figure 5.2.8-2 shows that there are no residences, recreational sites, trails, or state wild rice beds within the Minnesota airblast overpressure impact area (11,469 acres). The closest recreational site is a family picnic area located approximately 9 miles south of the Mine Site and Plant Site (near Skibo). This family picnic area as well as other recreational sites located further away such as those near Birch Lake and South Kawishiwi River are outside the impact area. The closest wildlife corridor located northeast of the Mine Site is also outside the impact area.

Though not depicted on Figure 5.2.8-2 due to sensitivity regarding cultural resources and locations, three archaeological sites have been identified within the NorthMet Project area: Spring Mine Lake Sugarbush, *Mesabe Widjiu* [Laurentian Divide], and BBLV Trail Segment #1 (USFS #01-569). The Spring Mine Lake Sugarbush and the *Mesabe Widjiu* are located more than 2 miles away from the Mine Site and (approximately 1 mile from the Plant Site). Since airblast impacts from blasting at the Mine Site would be experienced approximately 1 mile from the blast site, both archaeological sites would be outside the airblast impact area (11,469 acres). As noted previously, the BBLV Trail Segment #1 (USFS #01-569) crosses the NorthMet Project area. Portions of the trail segment that cross the Mine Site would be within the airblast impact area and may experience airblast levels close to the Minnesota standards. Details of the location and uses of the archaeological sites are discussed in Section 4.2.9, Cultural Resources.

Based on the information above, airblast overpressure levels from mine blasting would be below the Minnesota airblast standards for humans and structures (*Minnesota Rules*, part 6132.2900, subpart 2); including people that use the Superior National Forest for recreational activities such as family campgrounds, camp sites, hiking, fishing, boating, swimming, and family picnic areas. Immediate access to areas around the mine would be restricted, but tribal members who may have a cultural and spiritual connection to archaeological sites in the Superior National Forest, in

areas immediately near the mine, may occasionally experience airblast overpressures associated with the NorthMet Project Proposed Action. Mitigation measures for the impacted cultural resource areas are discussed in Section 5.2.9, Cultural Resources.

During the closure and post-closure phases (i.e., after year 20), blasting at the Mine Site would cease, so no airblast overpressures would occur during the closure and post-closure phases.

Vibration and Airblast Overpressure from Rail Transport

The transport of ore via trains from the Mine Site to the Plant Site could generate ground vibration within a few feet of the rail ROW, but due to the low volume of trains, such vibration levels are expected to be below the Minnesota ground vibration standards for humans and structures (*Minnesota Rules*, part 6132.2900, subpart 2). No blasting would occur along the Transportation and Utility Corridor, so ground vibration or airblast overpressure effects are not expected in this area.

Vibration and Airblast Overpressure at Plant Site

The crushers, water pumps (near the Tailings Basin) and other large stationary equipment that would be located at the Plant Site are designed to ensure that potential ground vibration effects are minimized to acceptable levels. Therefore, during operation, vibration levels at the receptors closest to the Plant Site would be below the Minnesota vibration standards for humans and structures (*Minnesota Rules*, part 6132.2900, subpart 2). No blasting would occur at the Plant Site, so ground vibration or airblast overpressure effects are not expected.

5.2.8.2.3 Total Noise Effects from NorthMet Project Proposed Action Operations

To determine the combined noise effect of the NorthMet Project Proposed Action, the total noise generated from operations at both the Mine Site and Plant Site was logarithmically added to the existing ambient daytime and nighttime baseline levels. Noise effects from rail transport were also assessed, but qualitatively.

Operations at the Mine Site and Plant Site would occur 24 hours per day. The total noise that would be experienced at any receptor location during the daytime (7 a.m. to 10 p.m.) and nighttime (10 p.m. to 7 a.m.) would be equal to the combined noise from both the mining and hauling operations at the Mine Site and the ore-crushing operations at the Plant Site, plus baseline noise levels.

Decibels are logarithmic values, so calculating the additive effect of two separate noise sources is a logarithmic calculation rather than an algebraic addition. This means that individual sound levels cannot be added directly to get the combined sound level. This also means that the greater the distance between two sound levels, the smaller the effect the lesser dB level will have on the total sound level.

The total noise associated with NorthMet Project Proposed Action operations when mining, hauling, and ore-crushing operations occur concurrently was calculated using data from Tables 5.2.8-3 (Mine Site) and 5.2.8-4 (Plant Site), along with baseline noise levels, and is summarized in Table 5.2.8-7. The calculations for daytime and nighttime noise levels are presented for comparison with the Minnesota noise standards. Aside from comparison to absolute noise limits, the NorthMet Project Proposed Action was also evaluated based on projected noise increases above baseline levels (i.e., 3 dB threshold of perception per MPCA 2008). In all cases, the

NorthMet Project Proposed Action, when in operation, would comply with the applicable standard. Figures 5.2.8-3, 5.2.8-4, 5.2.8-5, and 5.2.8-6 show L_{50} and L_{10} noise contours at 5 dBA intervals during the daytime and nighttime.

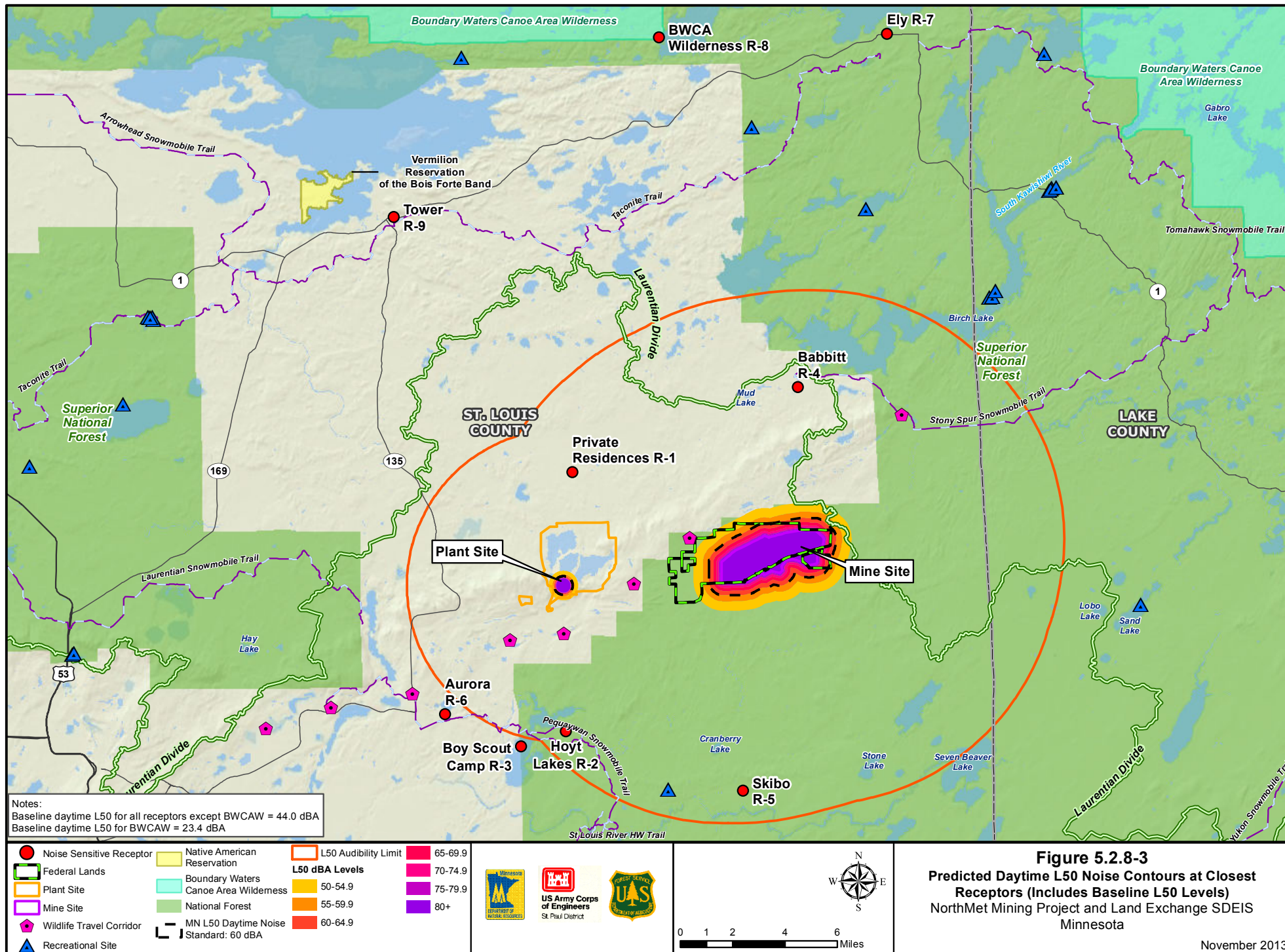
Table 5.2.8-7 Total Noise Associated with Concurrent Operations at the Mine Site and Plant Site (includes Baseline Levels)

Receptor	Daytime and Nighttime Baseline Noise Levels (dBA)			Daytime Noise Levels at Closest Receptors to Mine Site and Plant Site Operations (plus Baseline Levels) ¹ , (dBA)			Nighttime Noise Levels at Closest Receptors to Mine Site and Plant Site Operations (plus Baseline Levels), (dBA)			Minnesota Daytime and Nighttime Noise Standards for Residential Areas (dBA)		
	L _{eq}	L ₅₀	L ₁₀	L _{eq}	L ₅₀	L ₁₀	L _{eq}	L ₅₀	L ₁₀	L _{eq}	L ₅₀	L ₁₀
Private Residences (R-1)	45.0 dBA (D); 35.0 dBA (N)	44.0 dBA (D); 34.0 dBA (N)	48.8 dBA (D); 37.8 dBA (N)	45.0	44.0	48.8	35.1	34.1	37.9	NA	60.0 dBA (D); 50.0 dBA (N)	65.0 dBA (D); 55.0 dBA (N)
Hoyt Lakes (R-2)	45.0 dBA (D); 35.0 dBA (N)	44.0 dBA (D); 34.0 dBA (N)	48.8 dBA (D); 37.8 dBA (N)	45.0	44.0	48.8	35.0	34.0	37.8	NA	60.0 dBA (D); 50.0 dBA (N)	65.0 dBA (D); 55.0 dBA (N)
Boy Scout Camp (R-3)	45.0 dBA (D); 35.0 dBA (N)	44.0 dBA (D); 34.0 dBA (N)	48.8 dBA (D); 37.8 dBA (N)	45.0	44.0	48.8	35.0	34.0	37.8	NA	60.0 dBA (D); 50.0 dBA (N)	65.0 dBA (D); 55.0 dBA (N)
Babbitt (R-4)	45.0 dBA (D); 35.0 dBA (N)	44.0 dBA (D); 34.0 dBA (N)	48.8 dBA (D); 37.8 dBA (N)	45.0	44.0	48.8	35.0	34.0	37.8	NA	60.0 dBA (D); 50.0 dBA (N)	65.0 dBA (D); 55.0 dBA (N)
Skibo (R-5)	45.0 dBA (D); 35.0 dBA (N)	44.0 dBA (D); 34.0 dBA (N)	48.8 dBA (D); 37.8 dBA (N)	45.0	44.0	48.8	35.0	34.0	37.8	NA	60.0 dBA (D); 50.0 dBA (N)	65.0 dBA (D); 55.0 dBA (N)
Aurora (R-6)	45.0 dBA (D); 35.0 dBA (N)	44.0 dBA (D); 34.0 dBA (N)	48.8 dBA (D); 37.8 dBA (N)	45.0	44.0	48.8	35.0	34.0	37.8	NA	60.0 dBA (D); 50.0 dBA (N)	65.0 dBA (D); 55.0 dBA (N)
Ely (R-7)	45.0 dBA (D); 35.0 dBA (N)	44.0 dBA (D); 34.0 dBA (N)	48.8 dBA (D); 37.8 dBA (N)	45.0	44.0	48.8	35.0	34.0	37.8	NA	60.0 dBA (D); 50.0 dBA (N)	65.0 dBA (D); 55.0 dBA (N)
BWCA Wilderness (R-8)	34.0 dBA (D); 34.0 dBA (N)	23.4 dBA (D); 23.4 dBA (N)	33.2 dBA (D); 33.2 dBA (N)	34.0	23.4	33.2	34.0	23.4	33.2	NA	60.0 dBA (D); 50.0 dBA (N)	65.0 dBA (D); 55.0 dBA (N)
Tower (R-9)	45.0 dBA (D); 35.0 dBA (N)	44.0 dBA (D); 34.0 dBA (N)	48.8 dBA (D); 37.8 dBA (N)	45.0	44.0	48.8	35.0	34.0	37.8	NA	60.0 dBA (D); 50.0 dBA (N)	65.0 dBA (D); 55.0 dBA (N)

Notes:

D= Daytime; N = Nighttime; NA = Not applicable (there are no L_{eq} standards for noise under the Minnesota Noise Standards).

¹ Total noise levels during daytime and nighttime were estimated by logarithmically adding the predicted noise levels from operations at the Mine Site (Table 5.2.8-3) and Plant Site (Table 5.2.8-4) with the existing baseline noise levels (baseline levels are provided in Table 4.2.8-3).



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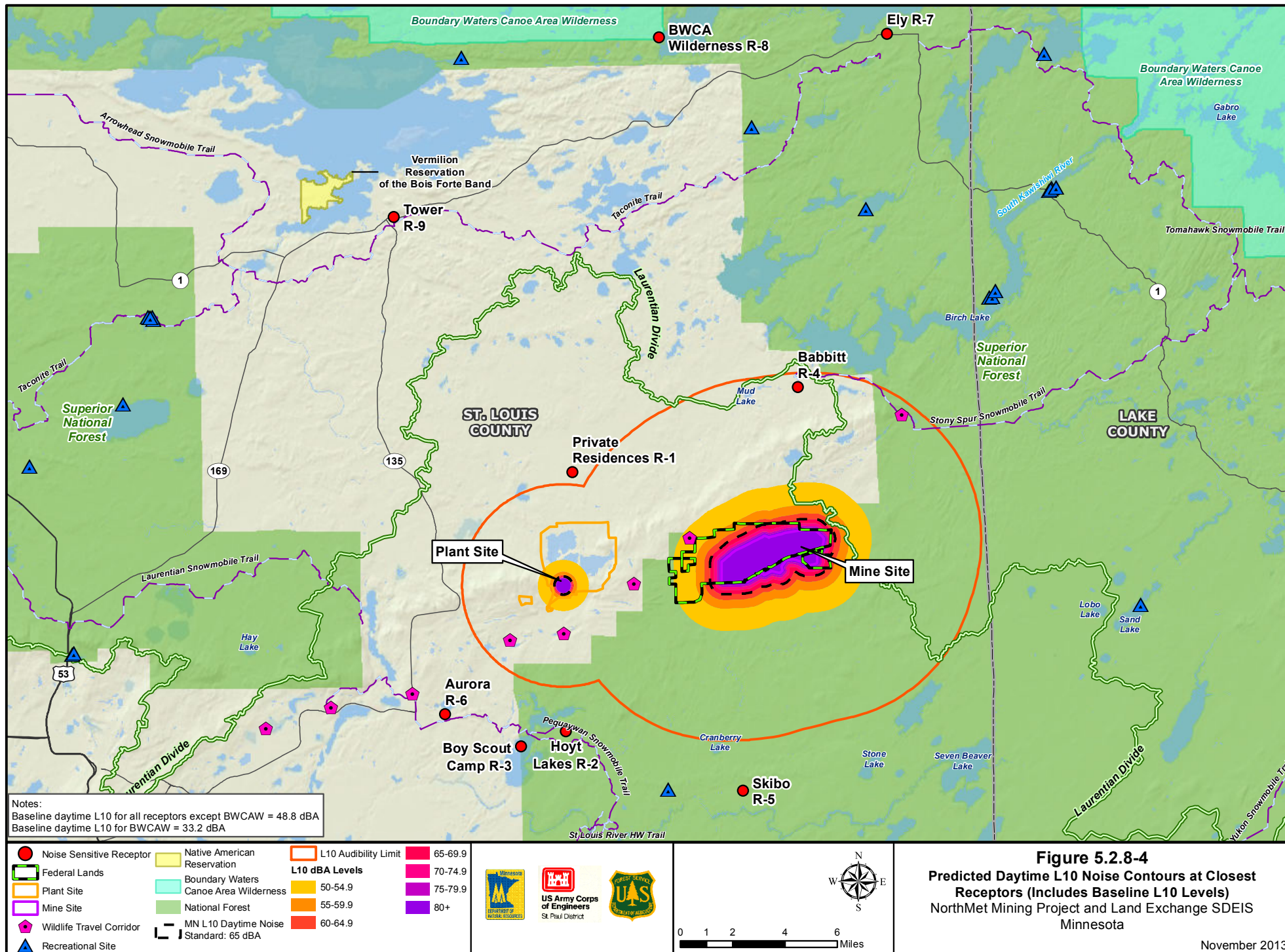
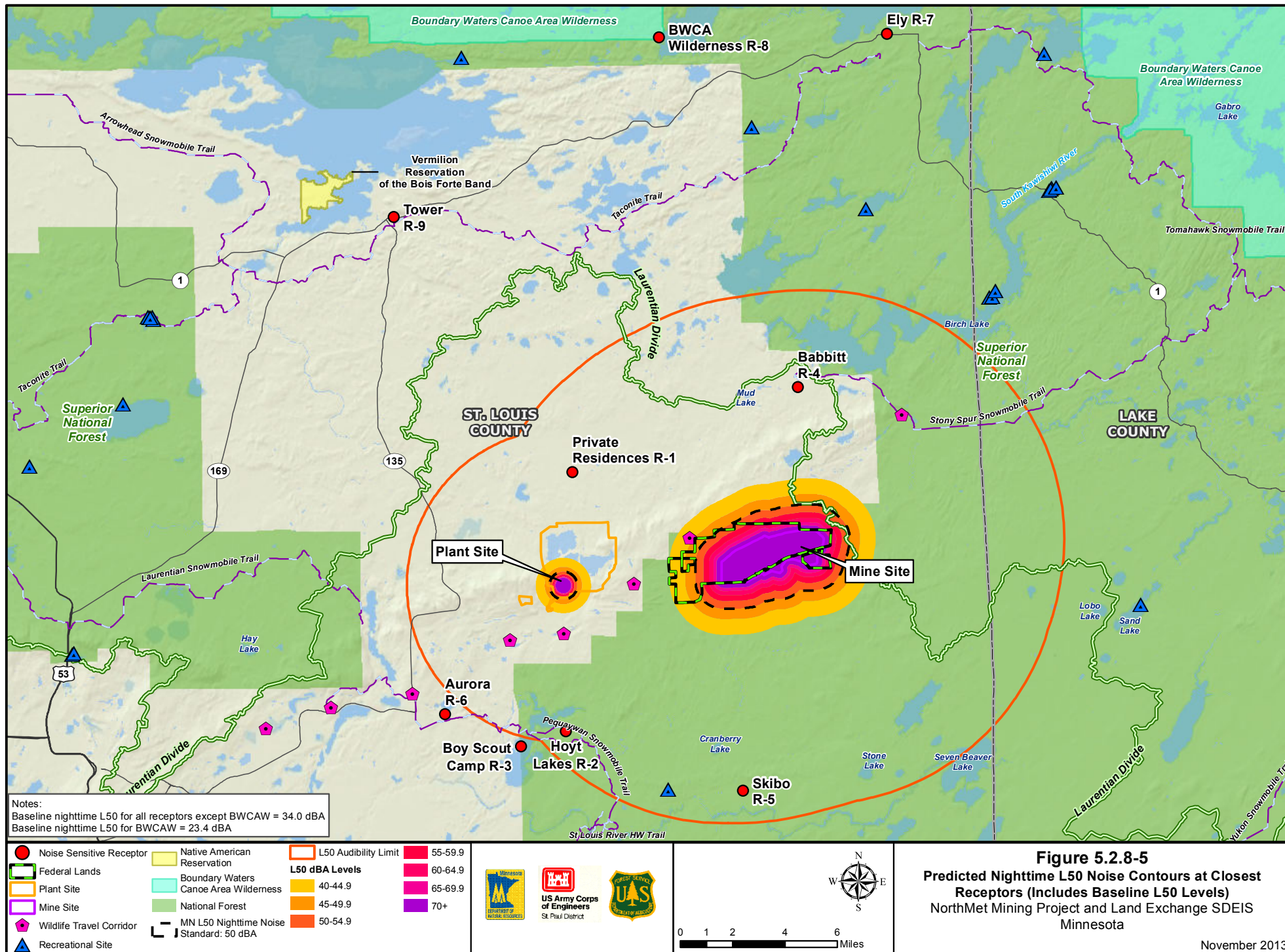
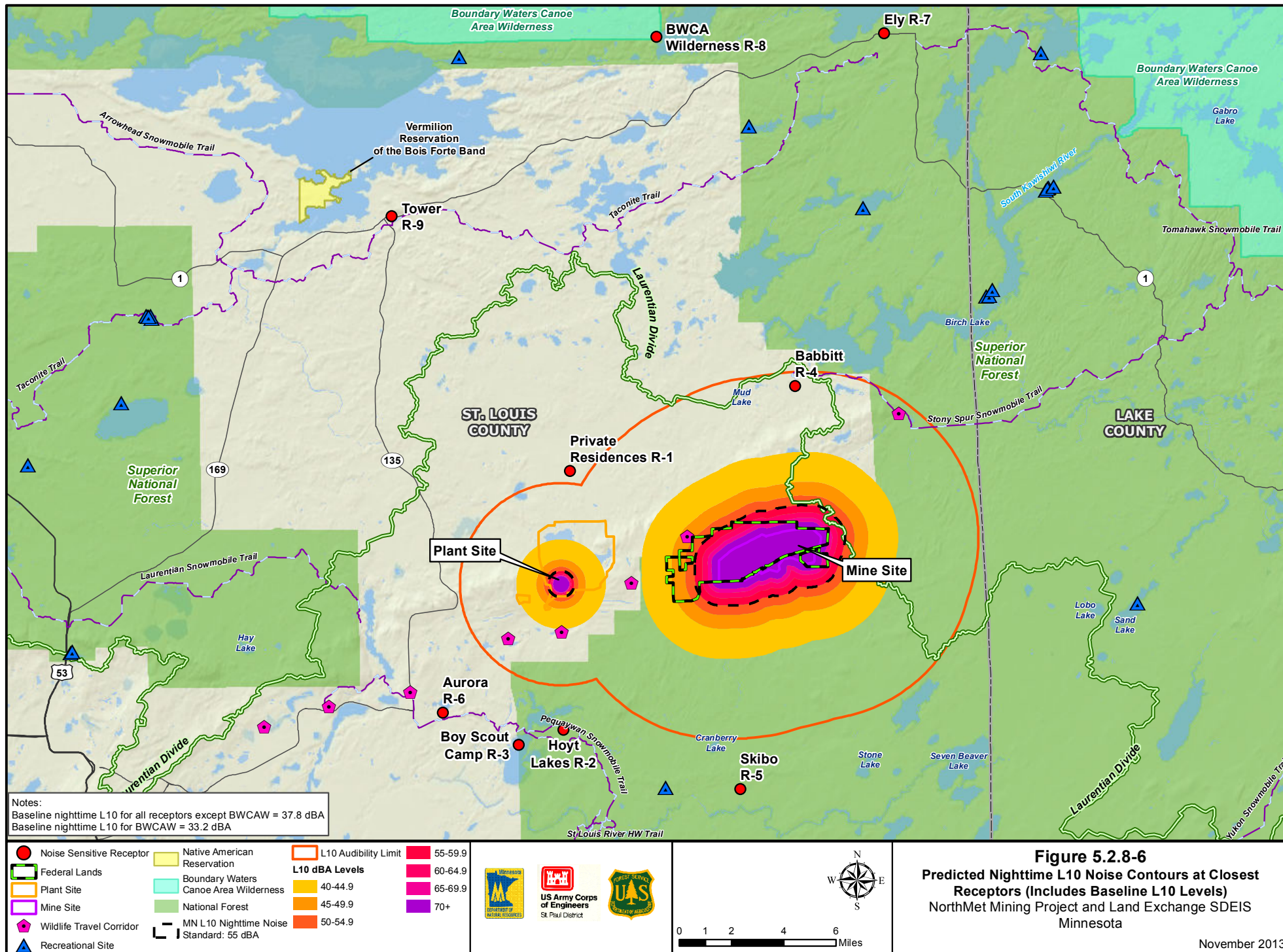


Figure 5.2.8-4
Predicted Daytime L10 Noise Contours at Closest Receptors (Includes Baseline L10 Levels)
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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Daytime Operation Impacts (7 a.m. to 10 p.m.)

Table 5.2.8-7 and Figures 5.2.8-3 and 5.2.8-4 present the total estimated daytime L_{50} and L_{10} levels that would be experienced at the closest receptors to the Mine Site and Plant Site. Noise from Mine Site and Plant Site operations, plus baseline levels, are predicted to be well below the Minnesota daytime noise standards of 60 dBA (L_{50}) and 65 dBA (L_{10}) for residential areas, trails, recreational sites (family campgrounds, campsites, boating, fishing, swimming, and family picnic areas), and MPCA staff-recommended wild rice waters and beds (used by tribal members for traditional resource harvests).

As an example of how the total noise level is calculated, the L_{50} daytime level of 44 dBA for private residences shown in Table 5.2.8.7 is the result of adding 10.9 dBA (daytime L_{50} levels from Mine Site operations only, excluding Plant Site operations and baseline levels), 13.5 dBA (daytime L_{50} levels from Plant Site operations only, excluding Mine Site operations and baseline levels), and 44 dBA, which is the assumed daytime L_{50} baseline level. The result of the logarithmic addition indicates that noise from the Mine Site and Plant Site has no measureable effect on the baseline conditions of the closest receptors. Figure 5.2.8-3 shows that the daytime L_{50} impact area for the closest receptors would be 6,629 and 255 acres at the Mine Site and Plant Site, respectively. Similarly, Figure 5.2.8-4 shows that the daytime L_{10} impact area for the closest receptors would be 6,266 and 242 acres at the Mine Site and Plant Site, respectively. These receptors are well outside the daytime impact areas. The closest recreational site is a family picnic area located approximately 9 miles south of the Mine Site and Plant Site (near Skibo). This family picnic area as well as other recreational sites located further away such as those near Birch Lake and South Kawishiwi River are outside the daytime impact area.

The Upper St. Louis River contains wild rice beds harvested by tribal members. The wild rice beds are usually in close proximity to MPCA staff-recommended wild rice waters such as Mud Lake and Birch Lake (north of Mine Site), Lobo Lake and Sand Lake (east of Mine Site), Stone Lake and Seven Beaver Lake (southeast of Mine Site), Cranberry Lake (south of Mine Site), and Hay Lake (west of Plant Site). Details of the location and uses of the cultural/tribal resource areas are discussed in Section 4.2.9, Cultural Resources.

The closest wildlife corridor located northeast of the Mine Site is also outside the daytime impact area. The highest daytime noise levels, including baseline levels, predicted for the closest NAC 1 receptor to the Mine Site (i.e., Babbitt (R-4)) were 44 dBA (L_{50}) and 48.8 dBA (L_{10}). The daytime noise effect of the Mine Site on Babbitt is an increase of 0 dBA (L_{50}) and 0 dBA (L_{10}) from baseline levels. Similarly, the highest daytime noise levels, including baseline levels, predicted for the closest NAC 1 receptor to the Plant Site (i.e., Private Residences (R-1)) were 44 dBA (L_{50}) and 48.8 dBA (L_{10}). The daytime noise effect of the Plant Site on the private residences is an increase of 0 dBA (L_{50}) and 0 dBA (L_{10}) from baseline levels. This 0 dBA increase is below the 3 dBA threshold of perception per the MPCA's *Guide to Noise Control in Minnesota* (MPCA 2008) and would not be perceptible to residents, recreational users, or tribal members that use the MPCA staff-recommended wild rice waters and beds for harvesting purposes.

As discussed earlier, noise from trains and train horns during ore transportation during the day from the Mine Site to the Plant Site is expected to be minimal because the railroad route between the two is approximately 4 to 5 miles from the nearest receptors. Up to 22 trains per day are expected to deliver ore to the Plant Site. This frequency of traffic is less than that experienced on the rail line during past mining operations.

Blasting at the Mine Site is a source of impulsive or non-continuous noise. Blasting noise is not included in the noise level estimates shown in Table 5.2.8-7 because mine-blasting is typically an instantaneous event (not continuous or steady), and would occur only during daytime periods. PolyMet expects that blasting of ore and waste rock would take place approximately once every 2 or 3 days. This would usually include separate blasts of ore and waste rock benches. Rock-blasting could potentially have noise levels ranging from 111 to 115 dBA at 50 feet from the blasting site. With modern blasting techniques, the blasting would be experienced by the nearest receptors as a faint warning whistle or siren, followed by a very brief, muted clap of thunder.

Public acceptance is generally improved by scheduling blasting at the same time every day to further reduce the startle factor. The closest receptor (City of Babbitt) is located 6.5 miles from the Mine Site, so noise effects from blasting are not expected to be significant. In addition, noise effects from blasting would only occur during the early stages of mining, when blasting occurs at the surface down to a few feet below ground levels. As the depth of the pit increases over the life of the mine, noise effects from blasting would be attenuated by the pit walls.

Though not depicted on Figures 5.2.8-3 and 5.2.8-4 due to sensitivity regarding cultural resources and locations, three archaeological sites have been identified within the NorthMet Project area: Spring Mine Lake Sugarbush, *Mesabe Widjiu* [Laurentian Divide], and BBLV Trail Segment #1 (USFS #01-569). The Spring Mine Lake Sugarbush and the *Mesabe Widjiu* are located more than 2 miles away from the Mine Site and approximately 1 mile from the Plant Site (approximated 2 miles from the plant crushers). Based on these distances, both archaeological sites are expected to be outside the daytime noise impact area for the Mine Site (6,629 acres) and Plant Site (255 acres). As noted previously, the BBLV Trail Segment #1 (USFS #01-569) crosses the NorthMet Project area. Portions of the trail segment that cross the Mine Site and Plant Site are expected to be within the daytime impact area and may experience daytime noise levels close to the Minnesota standards.

Details of the location and uses of the archaeological sites are discussed in Section 4.2.9, Cultural Resources.

Nighttime Operation Impacts (10 p.m. to 7 a.m.)

Table 5.2.8-7 and Figures 5.2.8-5 and 5.2.8-6 indicate that the total estimated nighttime L_{50} and L_{10} levels that would be experienced at the receptors closest to the Mine Site and Plant Site are expected to be below the Minnesota nighttime noise standards of 50 dBA (L_{50}) and 55 dBA (L_{10}). Figure 5.2.8-5 shows that the nighttime L_{50} impact areas for the closest residential areas, trails, MPCA staff-recommended wild rice waters (used by tribal members for traditional resource harvests), and recreational sites would be 11,456 acres and 568 acres at the Mine Site and Plant Site, respectively.

Similarly, Figure 5.2.8-6 shows that the nighttime L_{10} impact areas for the closest residential areas, trails, MPCA staff-recommended wild rice waters, and recreational sites would be 10,695 acres and 503 acres at the Mine Site and Plant Site, respectively. These receptors are well outside the nighttime impact areas. As indicated above, the closest recreational site is a family picnic area located approximately 9 miles south of the Mine Site and Plant Site (near Skibo). This family picnic area as well as other recreational sites located further away such as those near Birch Lake and South Kawishiwi River are outside the nighttime impact area. There are no MPCA staff-recommended wild rice waters or beds within the nighttime impact area. Details of the location and use of cultural/tribal resource areas are discussed in Section 4.2.9 and 5.2.9. The closest wildlife corridor located northeast of the Mine Site is also outside the impact area. The highest nighttime L_{50} and L_{10} levels, including baseline levels, predicted for the closest receptor to the Mine Site (i.e., Babbitt (R-4)) were 34 dBA and 37.8 dBA, respectively. The nighttime noise effect of Mine Site operations on Babbitt is a net increase of 0 dBA (L_{50}) and 0 dBA (L_{10}) from baseline levels. Similarly, the highest nighttime L_{50} and L_{10} levels, including baseline levels, predicted for the closest receptor to the Plant Site (i.e., Private Residences (R-1)) were 34.1 dBA and 37.9 dBA, respectively. The nighttime noise effect of the Plant Site on the private residences is an increase of 0.1 dBA (L_{50}) and 0.1 dBA (L_{10}) from baseline levels. This increase of 0.1 dBA is below the 3 dBA threshold of perception per the MPCA's *Guide to Noise Control in Minnesota* (MPCA 2008) and would not be perceptible to residents, recreational users, and tribal members that use MPCA staff-recommended wild rice waters and beds for traditional resource harvests. It should be noted that the noise model conservatively assumes that all mine equipment shown in Table 5.2.8-2 would be operating simultaneously during daytime and nighttime. Under actual conditions, the predicted noise levels would be lower because not all equipment would be operating simultaneously and some equipment would not operate at all during nighttime.

Though not depicted on Figures 5.2.8-5 and 5.2.8-6 due to sensitivity regarding cultural resources and locations, three archaeological sites have been identified within the NorthMet Project area: Spring Mine Lake Sugarbush, *Mesabe Widjiu* [Laurentian Divide], and BBLV Trail Segment #1 (USFS #01-569). The Spring Mine Lake Sugarbush and the *Mesabe Widjiu* are located more than 2 miles from the Mine Site and approximately 1 mile from the Plant Site (approximated 2 miles from the plant crushers). Based on the distances, both archaeological sites are expected to be outside the nighttime noise impact areas for the Mine Site (11,456 acres) and Plant Site (568 acres). As noted previously, the BBLV Trail Segment #1 (USFS #01-569) crosses the NorthMet Project area. Portions of the trail segment that cross the Mine Site and Plant Site are expected to be within the nighttime impact area and may experience nighttime noise levels close to the Minnesota standards. Details of the location and uses of the archaeological sites are discussed in Section 4.2.9, Cultural Resources.

Mine-blasting and ore transportation via trains along the Transportation and Utility Corridor would not occur between 10 p.m. and 7 a.m., so there would not be noise effects associated with these activities at night.

Summary of Daytime and Nighttime Operation Noise Impacts

Based on the information above, the total predicted daytime and nighttime noise (L_{50} and L_{10}) level experienced at NAC 1 areas such as the closest residential areas (the City of Babbitt north of the Mine Site, and private residences located north of the Plant Site), trails, recreational sites (including recreational sites at Birch Lake and South Kawashiwi River), and MPCA staff-recommended wild rice waters and beds used by tribal members for traditional resource harvests would meet the Minnesota daytime and nighttime noise standards. In addition, the projected noise increase above baseline levels would be below the 3 dBA threshold of perception. Immediate access to areas around the mine would be restricted, but tribal members who may have a cultural and spiritual connection to archaeological sites in the Superior National Forest, in areas immediately near the Mine Site or Plant Site, may occasionally experience noise associated with the NorthMet Project Proposed Action. Mitigation measures for the impacted cultural resource areas are discussed in Section 5.2.9, Cultural Resources.

During closure and post-closure (i.e., after year 20), the major noise sources and activities at the Mine Site and Plant Site (e.g., drilling, blasting, mining, excavation work, hauling, and crushing operations) would cease. Progressive reclamation would occur throughout the 20-year mine life for features such as the permanent stockpile and pit areas at the Mine Site and at the exterior slopes of the Tailings Basin at the Plant Site. This would leave a smaller portion of the Mine Site and Plant Site needing to be reclaimed at closure. During the closure phase, machinery, such as planters, used to restore and/or rehabilitate the Mine Site and Plant Site and conduct other reclamation activities (e.g., structure demolition, dike removal, etc.) would generate some noise; however, such noise would occur over a short time period and mostly during daytime periods when increased noise levels would be more tolerable. Therefore, noise levels at the Mine Site and Plant Site during the closure and post-closure phases are expected to be below the Minnesota noise standards and below the 3 dBA threshold of perception.

Area of Audibility for the Boundary Waters Canoe Area Wilderness

The L_{50} audibility area would be approximately 247,612 acres around the Mine Site and Plant Site, assuming all noise sources are operating simultaneously during daytime and nighttime (Figure 5.2.8-3 and 5.2.8-5). Similarly, the L_{10} audibility area would be approximately 131,035 acres around the Mine Site and Plant Site, assuming all noise sources are operating simultaneously during daytime and nighttime (see Figures 5.2.8-4 and 5.2.8-6). The BWCAW is outside this area of audibility. Therefore, sound from the Mine Site and Plant Site operations would not be audible at the BWCAW. While some receptors (e.g., residential areas like Babbitt and Hoyt Lakes and a family picnic area near Skibo) are within this area of audibility shown on Figures 5.2.8-3 to 5.2.8-6, it should be noted that the area of audibility was calculated based on the low measured baseline levels for BWCAW, which is a place of natural quiet (L_{50} of 23.4 dBA and L_{10} of 33.2 dBA). The baseline levels for the recreational sites and residential areas are likely higher than the BWCAW baseline levels (though actual measurements have not been taken at these areas), so actual area of audibility for these other receptors would be much smaller than that for BWCAW.

5.2.8.3 NorthMet Project No Action Alternative

Under the NorthMet Project No Action Alternative, the NorthMet Project Proposed Action would not occur and there would be no increase in noise and vibration levels in any of the areas proposed for project development. Therefore, there would be no change in existing noise and vibration levels at the closest receptors.

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5.2.9 Cultural Resources

This section summarizes the environmental consequences of the NorthMet Project Proposed Action on historic properties, including the potential effects, types of avoidance, effect minimization measures, and potential mitigation measures that are relevant to these historic properties. Additionally, this section summarizes the environmental consequences of the NorthMet Project Proposed Action on 1854 Treaty resources—i.e., those areas and species that are traditionally or culturally important to the Bands.

The federal Co-lead Agencies have identified several historic properties in consultation with the SHPO and the Bands. The federal Co-lead Agencies have also consulted with the SHPO and the Bands concerning NRHP eligibility of the Sugarbush, *Mesabe Widjiu*, BBLV Trail, Erie Mining Company Railroad Mine and Plant Track, and Erie Mining Company Concentrator Building. All other cultural resources identified as part of the NorthMet Project Proposed Action, as identified in Section 4.2.9.2.4, were determined to be not eligible for inclusion in the NRHP, and therefore will not receive further consideration under Section 106 during review of the NorthMet Project Proposed Action. The federal Co-lead Agencies are currently refining statements of significance and boundaries for these properties.

Preliminary effect determinations have been drafted by the federal Co-lead Agencies for review and comment by the Bands and the SHPO. The federal Co-lead Agencies believe that there would be no adverse effect on the Sugarbush and the Erie Mining Company Railroad Mine and Plant Track. However, the *Mesabe Widjiu*, BBLV Trail, and Erie Mining Company Concentrator Building would be adversely affected by the NorthMet Project Proposed Action. These preliminary determinations will be used to facilitate ongoing consultation with the Bands and the SHPO pertaining to the application of adverse effect criteria to these properties. Mitigation measures to resolve adverse effects would be developed after consultation on the effect determinations and consideration of any measures to avoid or minimize adverse effect.

5.2.9.1 Methodology and Evaluation Criteria Overview

In consultation with the SHPO, the Bands, and PolyMet, the federal Co-lead Agencies must apply the criteria of adverse effects to historic properties within the APE to evaluate the potential effect of the NorthMet Project Proposed Action on the historic properties, as codified in 36 CFR 800.5.

An adverse effect is found when an undertaking may alter, directly or indirectly, any of the characteristics of a historic property that qualify the property for inclusion in the NRHP in a manner that would diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association. These elements of integrity are discussed at length in Section 4.2.9. Adverse effects may include reasonably foreseeable effects that occur later in time, are farther removed, or are cumulative.

Direct effects caused by the undertaking occur at the same time and place. Indirect effects caused by the undertaking are later in time or further removed in distance but are still reasonably foreseeable. The federal Co-lead Agencies confer with consulting parties to determine the undertaking's effects on historic properties, to resolve adverse effects, and to develop mitigation measures as necessary. For the NorthMet Project Proposed Action, the following is a summary of potential effect types:

- physical disturbance or damage to all or part of the property caused by ground disturbance (e.g., digging, trenching, etc.);
- introduction of visual, atmospheric, or audible elements that could diminish the integrity of the property's significant historic features during short-term NorthMet Project Proposed Action-related construction and operation of aboveground facilities and roads, as well as long-term effects from operation;
- change in the character of the use or of physical features within the property's setting that contribute to its significance; and
- transfer of property out of federal ownership without adequate conditions to ensure consideration of historic properties.

Effects determinations have the following three possible outcomes:

1. Finding of no historic property affected – The undertaking does not have the potential to cause effects on historic properties that may be present.
2. Finding of no adverse effect – The historic property would be affected; however, the effects of an undertaking do not meet the criteria of adverse effect, or measures have been taken to avoid or minimize adverse effects.
3. Finding of adverse effect – The undertaking may affect the integrity, which would alter, directly or indirectly, any of the characteristics of a historic property that qualify it for inclusion in the NRHP. If an adverse effect is found, the federal Co-lead Agencies shall consult further to resolve the adverse effect.

5.2.9.1.1 Types of Potential Effects

The potential for the NorthMet Project Proposed Action to affect a historic property may depend on the project stage and the development and use of the NorthMet Project area. Potential effects that may occur during the construction and operations of the NorthMet Project Proposed Action are discussed in the following subsections.

Construction

NorthMet Project Proposed Action construction activities could affect cultural resources in a variety of ways, including the following:

- possible direct damage to cultural resources within the construction footprint;
- possible indirect damage to cultural resources through vibrations caused by earth-moving and heavy equipment;
- temporary loss of community access to cultural resources, such as cultural resources of traditional significance;
- potential permanent visual effects that alter the viewshed to or from a cultural resource as it pertains to the cultural resource's setting and feeling;
- potential temporary visual effects on cultural resources while heavy equipment and numerous personnel are present;

- increased dust and noise that may affect historic structures or cultural resources of traditional significance near the construction area; and
- discovery of previously unknown cultural resources within the construction footprint.

The duration of the construction phase would affect the degree of effects on cultural resources. Potential indirect effects during construction—such as noise, dust, vibrations, heavy equipment traffic, and changes in viewshed—could be temporary and would be expected to last for the duration of construction in specific areas and for discrete periods of time.

Operations

During the operations phase of the NorthMet Project Proposed Action, only previously surveyed and assessed areas would be expected to require periodic disturbance; therefore, the potential for additional direct effects to cultural resources would be limited.

Indirect effects during operations could consist of a permanent change in viewshed to historic structures near NorthMet Project area facilities, and a periodic increase in noise, vibration, and dust created by vehicular traffic conducting operation and maintenance activities.

5.2.9.1.2 Mitigation Measures

Mitigation measures would be taken to avoid or minimize effects on historic properties, to the extent practicable. The following are potential mitigation measures:

- avoidance, which could be accomplished by shifting the footprint away from the resource, limiting activities in the vicinity of the resource, monitoring construction activities near the resource to inform whether additional actions are warranted, or through any combination of these techniques;
- minimization, which would reduce the effects on the resource through avoidance measures as described above, but would not completely eliminate the effects; and
- mitigation, which would offset that effect through some of the following means:
 - protection of a similar resource nearby;
 - detailed documentation of the resource through data recovery (i.e., excavations, in the case of archaeological sites, or Historic American Buildings Survey/Historic American Engineering Record documentation, in the case of historic structures);
 - contributions to the preservation of cultural heritage in the affected community;
 - interpretative exhibits highlighting information gained about cultural resources through the NorthMet Project Proposed Action; or
 - some combination of these strategies.

Because the NorthMet Project Proposed Action would likely result in adverse effect, the Co-lead Agencies will consult with the SHPO, the Bands, and PolyMet to identify practicable ways to avoid, minimize, or mitigate the harmful effects of the undertaking. The ACHP would become involved in consultation if requested by an agency, SHPO, Bands, other consulting parties, or member of the public with a demonstrated interest. If an adverse effect were identified, federal agencies would have to notify the ACHP, who may become involved if the effect met their

criteria for involvement. This consultation process would likely result in the development of a Memorandum of Agreement (MOA), which identifies the steps the federal Co-lead Agencies would take to avoid, minimize, or mitigate the adverse effect.

5.2.9.2 Affected Cultural Resources

This section describes the environmental consequences of the NorthMet Project Proposed Action on historic properties within the APE. As outlined in Section 4.2.9, the federal Co-lead Agencies, the Bands, and the SHPO agree that the Concentrator Building (SL-HLC-008), Erie Mining Company railroad (SL-HLC-015), Sugarbush, the *Mesabe Widjiu*, and the BBLV Trail are eligible for inclusion in the NRHP. The federal Co-lead Agencies have also drafted preliminary effects determinations, which will also be subject to further consultation. However, after consulting with the Bands and SHPO, the federal Co-lead Agencies will make final decisions regarding effects from the NorthMet Project Proposed Action.

5.2.9.2.1 Historic Properties

The Concentrator Building (SL-HLC-008) is a key property and reflects Erie Mining Company's decades of experimentation in production and engineering design (Zellie 2007). The Co-lead Agencies have determined the Concentrator Building eligible for inclusion in the NRHP under Criterion A in the areas of industry and engineering, and also under Criterion C in the area of engineering.

Direct effects to this property would consist of interior and exterior refurbishment and use. For example, emission controls on ore grinding equipment would be replaced with components that meet or exceed the particulate emission standard required of new sources at taconite plants. To reduce space heating requirements, the building insulation would be improved. Additionally, the concentrator building would be demolished at mine closure and decommissioning, consistent with Minnesota state mining standards. There would be minor exterior and interior alterations to the other primary plant buildings and structures. The NorthMet Project Proposed Action would include the construction of several new buildings adjacent to the Concentrator Building. Based on the above considerations, the federal Co-lead Agencies believe that the NorthMet Project Proposed Action would adversely affect the Concentrator Building.

The federal Co-lead Agencies have determined the Erie Mining Company railroad (SL-HLC-015) eligible for inclusion in the NRHP under Criterion A in the areas of Commerce, Industry, and Transportation. Although the majority of the main track of railroad is outside of the NorthMet Project area, the mine track and plant track segments would be directly affected near the NorthMet Project area.

Direct effects to this property would consist of refurbishment and use. Refurbishment, however, is not expected to result in significant alterations. Nonetheless, the Erie Mining Company railroad would be removed at mine closure and decommissioning, consistent with Minnesota state mining standards. There would be no expected indirect effects, as the use of the Plant Site and mining activities would be consistent with the railroad's original use. Based on the above considerations, the federal Co-lead Agencies believe that the NorthMet Project Proposed Action would not adversely affect the Erie Mining Company railroad.

The federal Co-lead Agencies have determined the Sugarbush eligible for inclusion in the NRHP under Criterion A for its association with important Ojibwe spiritual and cultural practices.

Under Criterion D, the site is significant for its potential to answer important questions about possible 19th century and 20th century Ojibwe maple sugaring practices.

Direct effects on this property would not result from the NorthMet Project Proposed Action. The Sugarbush is not within the footprint of the Mine Site, the Plant Site, or any other ancillary NorthMet Project area features.

Based on an indirect visual effects analysis conducted for the NorthMet Project Proposed Action and the site visits conducted in 2010, the federal Co-lead Agencies believe that the NorthMet Project Proposed Action would not result in a visual intrusion that would diminish the integrity of setting, feeling, or associations. The Sugarbush is a number of miles from the Mine Site and sufficiently screened from the Plant Site and the Tailings Basin where those project features are not visible. The Plant Site and Tailings Basin are existing LTVSMC mine features. Their footprint would not be expanded to any significant extent, nor would the addition of material be visible from the Sugarbush to a significantly greater extent than current conditions.

The analysis of possible atmospheric effects that was completed for the NorthMet Project Proposed Action indicates that the Sugarbush is not in an area expected to be affected by dust deposition. The Sugarbush and its grove of mature maple trees has existed throughout the past 50 years of mining, which included the use of the existing Plant Site and Tailings Basin as well as numerous mineral extraction locations (mine pits) in close proximity to the Sugarbush in comparison to the Mine Site.

The Sugarbush may be associated with the trail systems, such as the BBLV Trail, that are known to have traversed this area. The portion of that trail corridor in proximity to the Sugarbush has been for the most part destroyed by past mining operations. The NorthMet Project Proposed Action would not result in the loss of any additional portions of that corridor, or trails, in proximity to the Sugarbush. For further discussion, see the discussion of effects on the BBLV Trail.

Based on this analysis, the federal Co-lead Agencies believe that there would be no direct effects resulting from the NorthMet Project Proposed Action nor would there be any significant changes to the setting, feeling, or associations of the Spring Mine Lake Sugarbush.

After consultation with the Bands concerning effects on the Sugarbush, the Co-lead Agencies acknowledged that the analysis of atmospheric effects on the Sugarbush was an estimation based on modeling and that dust deposition is expected to occur near this property. The Co-lead Agencies feel it is reasonable to believe that atmospheric effects to the Sugarbush would not be adverse, but also believe that it is appropriate to require monitoring of the Sugarbush to ensure it is not adversely affected. The details of a monitoring plan would be developed through consultation with the SHPO and the Bands and incorporated into the MOA that stipulates appropriate treatment for properties or mitigation for adverse effects.

The federal Co-lead Agencies have determined the *Mesabe Widjiu* eligible for inclusion in the NRHP under Criterion A for its association with important Ojibwe spiritual and cultural practices.

Direct effects on the *Mesabe Widjiu* would occur at the Tailing Basin, which currently abuts a portion of that land form. Expansion of the Tailings Basin would intrude on that portion of the *Mesabe Widjiu*. Direct effects on the *Mesabe Widjiu* at the Mine Site would not occur as the *Mesabe Widjiu* is not considered to be within the footprint of the Mine Site. However, the

boundaries of the *Mesabe Widjiu* are still the subject of consultation with the SHPO and the Bands.

Indirect effects to the *Mesabe Widjiu* would result from the features at the Mine Site location. Although there are existing mine features between the *Mesabe Widjiu* and the Mine Site location, the NorthMet Project Proposed Action would further diminish the integrity of setting and feeling. The large-scale alterations to the landscape resulting from mine pits, stockpiles, material handling facilities, etc., would be long-term changes that would further diminish the association of the *Mesabe Widjiu* with the natural features of the Partridge River headwaters. Although the Mine Site has been disturbed by logging, roads brushed out for mineral exploration, and linear features, such as Dunka Road or the railroad, these disturbances are smaller. The effect of the NorthMet Project Proposed Action would also remove a portion of the BBLV Trail corridor, further diminishing the *Mesabe Widjiu*'s association with that historic property.

Although the federal Co-lead Agencies are not aware of specific locations adjacent to the NorthMet Project area that are used by the Bands, this does not diminish the significance of effects for that portion of the *Mesabe Widjiu*. Given the nature of Ojibwe spiritual practices, which is a personal connection to the natural elements of the environment, locations of this type are very difficult to identify. The *Mesabe Widjiu* is a historic property to which the Ojibwe have had a spiritual connection for hundreds of years.

Based on the above considerations, the federal Co-lead Agencies believe that the NorthMet Project Proposed Action would adversely affect the *Mesabe Widjiu*.

The federal Co-lead Agencies have determined that the BBLV Trail is significant for the role it played in the broad patterns of Ojibwe land use and early mineral exploration. It is eligible for inclusion in the NRHP under Criteria for Evaluation A and D.

The portion of the BBLV Trail that lies within the Mine Site would be directly affected by the NorthMet Project Proposed Action, which would result in its permanent removal. Based on this, the federal Co-lead Agencies believe that the NorthMet Project Proposed Action would adversely affect the BBLV Trail.

5.2.9.2.2 Treaty Resources

Natural resources important to Ojibwe culture can be recognized even when tribal use of a natural resource may not qualify that resource as a historic property for further consideration under Section 106. The right to hunt, fish, and gather on lands within the 1854 Ceded Territory is protected by the 1854 Treaty. Limitation or elimination of access to public lands within the 1854 Ceded Territory for these purposes may be considered an effect on 1854 Treaty rights. The loss of 1854 Treaty resources may also have an effect on the Bands' ability to exercise 1854 Treaty rights.

An analysis of effects on 1854 Treaty resources, as described and discussed in Section 4.2.9, is limited by the lack of available information concerning the use of such resources. To help determine how the Bands have traditionally exercised their usufructuary rights on or near the NorthMet Project area, the Bands conducted interviews of individual members of Bois Forte, Fond du Lac, and Grand Portage, although only the results of interviews with Bois Forte were made available.

There is little specific information concerning the use of natural resources by the Bands in the NorthMet Project area, other than the Sugarbush, which is being considered under Section 106 of the NHPA. This likely reflects limited present day or recent past subsistence gathering in the NorthMet Project area due to general inaccessibility. This lack of data also precludes the quantitative analysis of how Band members would be affected socioeconomically by effects on 1854 Treaty resources, further discussed in Section 5.2.10. The primary source of data for assessing effects from the NorthMet Project Proposed Action on 1854 Treaty resources is from the analysis of the environment discussed in detail in Section 4.2.9 of this SDEIS.

As stated in Table 5.2.9-1 below, the NorthMet Project Proposed Action would affect 4,016.1 acres within the Nashwauk Uplands and Laurentian Uplands subsections, which constitutes a total of 0.3 percent of these two subsections.

Table 5.2.9-1 Acres of the Laurentian Uplands and Nashwauk Uplands Subsections Affected by the NorthMet Project Proposed Action

Land Cover	Total Acres	Acres Affected by the NorthMet Project Proposed Action	Percent of Combined Nashwauk Uplands and Laurentian Uplands Subsections Affected by the NorthMet Project Proposed Action
Aquatic Environments	396,966	581.4	0.1
Disturbed	46,174	1,240.9	2.7
Forest	885,566	1,903.6	0.2
Cropland/Grassland	48,602	290.2	0.6
Total	1,377,308	4,016.1	0.3

Source: MDNR 2011g; MDNR 2011i.

The cover type most affected by the NorthMet Project Proposed Action is disturbed land, which includes reuse of the existing LTVSMC Tailings Basin. Less than 1 percent of each of the remaining cover types would be affected. Effects on the 1854 Treaty resources associated with these cover types are discussed below.

Vegetation

Vegetation that would be affected by the NorthMet Project Proposed Action is covered in the vegetation analysis in Section 5.2.4. Consequences of the NorthMet Project Proposed Action would include direct effects on land cover types.

The NorthMet Project Proposed Action would disturb 1,718.6 acres of land at the Mine Site, with the largest effects to upland conifer forest and lowland conifer forest. Consequently, the plant species or resources regulated by the 1854 Treaty Authority for gathering within these cover types would likely be most affected (see Table 5.2.9-2). The Plant Site contains 2,177.5 acres that would be disturbed, although most effects occur in areas already previously disturbed. Though the aquatic environment cover type would be heavily affected at the Plant Site, it consists mostly of tailings ponds where no regulated plant species or resources would be present. The majority of the 120.2 acres of the Transportation and Utility Corridor has also already been disturbed.

Table 5.2.9-2 Affected Cover Types of Associated Species and Resources Regulated by the 1854 Treaty Authority at the NorthMet Project Area

Cover Types	Associated Plant Species or Resource	Affected Mine Site (Acres) ¹	Affected Transportation and Utility Corridor (Acres) ¹	Affected Plant Site (Acres) ¹
Upland coniferous forest	Conifer boughs, princess pine, birch bark, firewood, other plants or forest products	741.9	2.6	52.0
Lowland coniferous forest	Conifer boughs, princess pine, firewood, other plants or forest products	437.2	0.2	20.7
Upland deciduous forest	Princess pine, ginseng, birch bark, firewood, other plants or forest products	354.7	2.7	290.1
Shrubland	Firewood, other plants or forest products	133.0	7.7	139.5
Disturbed	NA	44.0	94.4	1,102.5
Aquatic environments	Wild rice, other plants or forest products	6.0	2.7	572.7
Cropland/Grassland	NA	0.2	9.8	0.0
Upland conifer-deciduous mixed forest	Conifer boughs, princess pine, ginseng, birch bark, firewood, other plants or forest products	1.5	0.0	0.0
Lowland deciduous forest	Princess pine, birch bark, firewood, other plants or forest products	0.0	0.0	0.0
Total		1,718.6	120.1	2,177.5

Source: 1854 Treaty Authority 2007.

¹ Acres from Section 5.2.4.

In addition to the direct effects discussed above, there may also be indirect effects on cover types. Hydrology changes and dust from traffic and mining operations could affect plant communities near the NorthMet Project area, which could further reduce plant species or resources regulated by 1854 Treaty Authority. Mitigation measures, which would minimize these effects, are discussed in Section 5.2.4. Subsistence gathering at these locations is probably limited because of general inaccessibility.

According to the NorthMet Project Cultural Landscape Study (Zellie 2012), some of the most common species include balsam fir, speckled alder, and low-bush blueberry (see Table 4.2.9-4). These species were identified in multiple community types and are more likely to remain within the NorthMet Project area, despite the direct and indirect effects from the NorthMet Project Proposed Action. Within the combined Laurentian Uplands and Nashwauk Uplands ecological subsections, less than 0.3 percent would be affected by the NorthMet Project Proposed Action. As an estimate, the species or resources listed in Table 4.2.9-4 could likely decrease by the same margin within these Ecological Classification System (ECS) subsections.

Wildlife

Similar to the effects on SGCNs discussed in Section 5.2.5, the NorthMet Project Proposed Action would affect 1854 Treaty Authority-regulated species as a result of increased human activity and noise, collisions with vehicular and rail traffic, and decrease of habitat. See Section 5.2.5 for a more thorough discussion of the types of effects on wildlife.

Increased Human Activity

The 1854 Treaty Authority-regulated species would be directly affected through increased human activity due to mining activities. Factors such as noise, dust, light, and vehicle traffic may frighten some species and discourage their use of otherwise suitable habitat. Displaced to other habitat, individuals could face increased competition for resources. Less mobile species, such as herptiles (e.g., frogs, turtles), would likely incur relatively high mortality rates due to less ability to leave the affected area. Cliff-nesting birds could be affected by disturbance if they were to nest along the cliffs created by the pit rims.

Noise Effects

Noise associated with mining activities, including noise from vehicle and rail traffic, would likely affect wildlife, including 1854 Treaty Authority-regulated species. Section 5.2.8 provides further discussion on the noise modeling predictions for the NorthMet Project area. Though wildlife species are likely to be sensitive to changes in noise levels, there are no local, national, or international standards or limits that are applicable to the NorthMet Project Proposed Action. State standards are discussed Section 5.2.8, Noise. Wildlife species may be affected by noise in the NorthMet Project area, though adjacent habitat is available.

Vehicular and Rail Traffic Effects

Traffic effects from collisions with wildlife depend upon factors such as traffic volume, traffic speed, and the species involved. Species that utilize the small preserved forest island remnants between haul roads at the Mine Site would be most affected. Indirect effects from vehicle activities are expected locally at the Mine Site for 1854 Treaty Authority-regulated species and the overall local ecosystem. Effects at the Transportation and Utility Corridor are primarily related to vehicle and rail traffic. The 1854 Treaty Authority-regulated species may be affected by noise and light associated with vehicle and rail traffic, and by collisions with vehicles or trains. Transportation effects at the Plant Site are primarily related to vehicle traffic associated with the construction of the Tailings Basin embankments and bentonite application, primarily during the construction phase of the NorthMet Project Proposed Action. The 1854 Treaty Authority-regulated species may be affected by noise and light associated with vehicle traffic and by collisions with vehicles.

Habitat Effects

The direct effect on wildlife habitat, and thus on species regulated by the 1854 Treaty Authority, was assessed by evaluating the acres of habitat types that would be lost under the NorthMet Project Proposed Action. The changes in cover type are summarized in Table 5.2.9-3.

Table 5.2.9-3 Direct Effects on Key Habitat Types

Key Habitat Types	Total Acres¹ of Cover Type Directly Affected at the Mine Site	Total Acres¹ of Cover Type Directly Affected at the Transportation and Utility Corridor	Total Acres¹ of Cover Type Directly Affected at the Plant Site
Mature Upland Forest, Continuous Upland/Lowland Forest (MIH1-13)	1,535.3	5.5	362.8
Open Ground, Bare Soils (no MIH)	44.0	94.4	1,102.5
Grassland and Brushland, Early Successional Forest (no MIH)	133.2	17.5	139.5
Aquatic Environments (MIH 14)	6.0	2.7	572.7
Total	1,718.5	120.1	2,177.5

Data from Tables 5.2.4-1, 5.2.4-4, and 5.2.4-5.

¹ Total acres may be more or less than presented due to rounding.

Mature Upland/Lowland Forest

At the Mine Site, 1,535.3 acres of the mature forest would be lost as a result of the NorthMet Project Proposed Action. All 5.5 acres of mature upland/lowland forest along the Transportation and Utility Corridor would be affected. Approximately 363 acres of forest habitat at the Plant Site would be disturbed, most of which is in small or isolated patches of aspen-birch forest that are in poor to fair condition (MDNR 2013a).

The 1854 Treaty Authority-regulated species are largely mobile and would likely be displaced, not injured or killed, during mine construction and operation. Reclamation of the Mine Site would include revegetating nearly all disturbed ground according to *Minnesota Rules*, part 6132.2700. Reclamation and revegetation of the NorthMet Project area would improve wildlife habitat relative to conditions during mine operations; however, the quality of habitat for 1854 Treaty Authority-regulated species would remain degraded for decades after closure relative to pre-mining conditions.

Open Ground/Bare Soils

No 1854 Treaty Authority-regulated species are identified as utilizing open ground or bare soils habitat at the Mine Site, Transportation and Utility Corridor, or Plant Site. These areas were the result of past mining activity, are generally of low-quality, and are expected to decrease after mine closure as a result of reclamation.

Brush/Grassland

Approximately 133 acres of brush/grassland at the Mine Site would be directly affected by the NorthMet Project Proposed Action. Young trees (less than 4 inches dbh) make up most of this habitat type (ENSR 2005). Although all 17.5 acres of brush/grassland at the Transportation and Utility Corridor would be directly affected, activities at the Transportation and Utility Corridor would not affect grassland/brush 1854 Treaty Authority-regulated species based on the

fragmented nature of this habitat. Approximately 140 acres of brush/grassland at the Plant Site would be directly affected by the activities at the Plant Site. The reclaimed Plant Site, specifically the Tailings Basin, would be revegetated with grassland vegetation species. Overall, the NorthMet Project Proposed Action would have a minimal effect on grassland/brush 1854 Treaty Authority-regulated species.

Open Water

The NorthMet Project Proposed Action would create approximately 321 acres of open water at the Mine Site by eventually flooding the West Pit, which is estimated to fill in year 40. At the Plant Site, open water habitat primarily occurs in the existing LTVSMC Tailings Basin. Existing open water habitat would be maintained during operations, though the acreage of open water would fluctuate according to processing needs. See Section 5.2.5 for further discussion of wildlife use of the open water at the NorthMet Project area.

Wetlands

Based on the site-specific wetland delineation, the NorthMet Project Proposed Action would directly affect 758.2 acres of wetlands at the Mine Site, though surrounding similar wetland habitat would likely be adequate to absorb the displaced wildlife. There are 7.2 acres of wetlands along the Transportation and Utility Corridor, all of which would be affected by activities along the corridor. There would be 147.1 acres of wetland at the Plant Site directly affected (see Section 4.2.3 and 5.2.3). On-site wetland use by 1854 Treaty Authority-regulated species may be limited. Wetlands at the Mine Site are considered 99 percent high quality, 100 percent high quality along the Transportation and Utility Corridor, and 94 percent low quality and 6 percent moderate quality at the Plant Site.

Wetland mitigation is proposed both on- and off-site. Approximately 101.8 acres of wetland creation is proposed for on-site mitigation. Off-site mitigation would consist of 1,856.4 acres of wetland restoration and upland buffer.

Aquatic Species

The potential environmental effects of the NorthMet Project Proposed Action on fish and aquatic macroinvertebrate communities found in the vicinity of the NorthMet Project area are primarily discussed in Section 5.2.6. Direct and indirect effects could include changes in water quality and alteration of physical habitat.

The NorthMet Project Proposed Action would not result in physical habitat effects on the Partridge River or Embarrass River watersheds as a result of hydrologic changes. Generally, fish species regulated by the 1854 Treaty Authority (see Table 4.2.9-6) that occur in the NorthMet Project area would not experience effects from physical habitat loss or alteration.

The GoldSim water quality model predicts that the NorthMet Project Proposed Action would not cause or contribute to any exceedances of groundwater and surface water quality evaluation criteria within the Partridge River, Embarrass River, or downstream along the St. Louis River. See Section 5.2.2 for a more thorough discussion of water quality effects and 5.2.6 for a discussion of water quality effects pertaining to aquatic species.

The NorthMet Project Proposed Action is expected to result in a net decrease in mercury loadings to the Partridge River from 24.2 to 23.0 grams per year, primarily as a result of a

decrease in natural runoff and a proportional increase in water discharged from the West Pit via the WWTF. It is also expected to result in a net increase in mercury loadings to the Embarrass River from 22.3 to 22.9 grams per year, primarily due to the redirection of flow associated with the construction of the East Dam as part of the Tailings Basin expansion to the Embarrass River. However, the NorthMet Project Proposed Action would also result in a 31 percent reduction in sulfate loads at PM-13, which would reduce the potential for mercury methylation. Overall, the NorthMet Project Proposed Action is not expected to increase the mercury content in fish in the St. Louis River. See Sections 5.2.2 and 5.2.6 for a more thorough discussion of mercury bioaccumulation.

Overall Effects on 1854 Treaty Resources

As discussed above, the NorthMet Project Proposed Action would have effects on 1854 Treaty resources—i.e., those areas and species that are traditionally or culturally important to the Bands. There are two categories of effects: those relating to plant and animal species of interest to Band members, and those relating to areas where these plant and animal species are hunted, fished, or gathered. As discussed above and in other resource-specific sections of the SDEIS, the NorthMet Project Proposed Action would result in direct environmental effects due to ground-disturbing activities. Band members' use of the NorthMet Project area is not well-defined, and did not emerge through interviews. A good faith effort was made on the part of the Co-lead Agencies to identify use areas in or adjacent to the NorthMet Project area; however, those efforts resulted in little specific information concerning historic subsistence use and no information regarding recent subsistence activity at the Mine Site, Transportation and Utility Corridor, or Plant Site. In addition, as described in Section 5.2.11, the NorthMet Project area is surrounded by private land and cannot be easily accessed due to private roads. Without private landowner permission, there is minimal opportunity for the Bands to exercise usufructuary rights (hunting, fishing, and gathering) on this property.

Construction and operation of the NorthMet Project Proposed Action is not likely to significantly reduce overall availability of 1854 Treaty resources that are typically part of subsistence activities in the 1854 Ceded Territory. Some individuals and localized populations may be affected, but overall species populations are expected to remain available. Additionally, noise and other consequences of operations would affect migration or other animal species behavior.

The importance of fish as a subsistence resource in Ojibwe communities is well documented historically, and fish continue to be an important component of the day-to-day diet, while fishing itself remains an important socio-cultural and economic activity in Tribal communities across the Upper Great Lakes. The NorthMet Project Proposed Action could affect the availability of 1854 Treaty resources for some Band members because of real or perceived factors. For instance, bioaccumulation of mercury in fish could affect Band members' willingness to rely on subsistence fishing as a contribution to household economies, as well as affect continuation of traditional fishing practices, but there is no evidence that this availability would significantly affect subsistence use given the lack of information showing recent or historic fishing activity in the NorthMet Project area.

Effects on the environment, including any from increased mercury, are all expected to meet the standards and regulations set forth by the appropriate state or federal agency or program. These laws are intended to protect important natural and cultural resources and include, but are not limited to the ESA, CWA, and CAA. Effects on 1854 Treaty resources are difficult to quantify

when the effects are within environmental standards, yet above current baseline conditions. As such, cultural effects on the Bands would be difficult to quantify in regards to such incremental increases below standards or effects to species where appropriate mitigation is used.

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5.2.10 Socioeconomics

This section describes the potential socioeconomic consequences of the NorthMet Project Proposed Action on communities in the study area (consisting of St. Louis, Lake, and Cook counties—see Section 4.2.10 and Figure 4.2.10-1). Socioeconomics includes demographic characteristics of the study area’s population, economic characteristics (employment, income, market composition—i.e., the types of firms and employers located in the study area), public finance, housing, public services, and the economic characteristics of subsistence activities. The cultural aspects of subsistence, specifically for Native American populations, are discussed in the Section 5.2.9. Individual subsistence products (e.g., wild rice, game animals, etc.) are discussed in appropriate resource-specific sections of the SDEIS.

Summary

The NorthMet Project Proposed Action would generate as many as 500 direct jobs during peak construction and 360 direct jobs during operation. These direct jobs would generate additional indirect and induced employment, estimated to be 332 additional construction-phase jobs and 631 additional operations-phase jobs. While some skilled workers would be involved only temporarily and possibly relocate from outside the region, the majority of the NorthMet Project Proposed Action-related jobs are expected to be filled by those currently residing in the Arrowhead region.

Federal, state, and local taxes would total up to an estimated \$80 million annually. During operations, there would be approximately \$231 million per year in direct value added through wages and rents and \$332 million per year in direct output related to the value of the extracted minerals. As with employment, these direct economic contributions would create indirect and induced contributions estimated at \$99 million in value added and \$182 million in output.

The NorthMet Project Proposed Action would create slightly increased demand for housing and public services in cities and towns near the NorthMet Project area. The resulting increase in housing demand and prices could have minor effects on the Environmental Justice (EJ) populations.

The NorthMet Project No Action Alternative would have no effects.

5.2.10.1 Methodology and Evaluation Criteria

As discussed in Section 4.2.10, the study area for socioeconomics includes Cook, Lake, and St. Louis counties. Because socioeconomic consequences are measured and felt across a broad geographic area, this section does not distinguish between the Mine Site, Transportation and Utility Corridor, and Plant Site. Rather, this section describes the socioeconomic consequences of the NorthMet Project Proposed Action across the entire three-county study area and, where appropriate, includes the study area communities listed in Section 4.2.10.

5.2.10.1.1 Evaluation Criteria

Specific criteria used to evaluate socioeconomic consequences include the following:

- Changes in local population, employment, or earnings associated with NorthMet Project Proposed Action operations.
- Changes in public sector revenues, expenditures, or the underlying fiscal conditions of local governments.
- Changes in economic activity for non-mining industries in the region, particularly the tourism industry.
- Changes in demand for temporary or permanent housing during NorthMet Project Proposed Action construction, operation, and closure periods.
- Changes in long-term demands on public services and infrastructure that reduce capacities in these systems, either triggering the need for capital expansion or resulting in a discernible reduction in the level of service provided.
- Displacement or other use of property that affects residences or businesses.
- Disproportionate effects on minority (including Native American) or low-income populations, including human health or environmental effects, and subsistence—especially if the NorthMet Project Proposed Action results in large reductions in abundance or major redistribution of subsistence resources, substantial interference with harvestable access to active subsistence sites, or major increases in non-rural resident hunting (Barnard Dunkelberg 2009).

5.2.10.1.2 Determination of Study Area

As discussed in Section 4.2.10, the socioeconomic study area for this section includes all of Cook, Lake, and St. Louis counties (the three counties that comprise the Arrowhead region of Northeastern Minnesota). This study area includes the Mine Site, Transportation and Utility Corridor, and Plant Site, as well as all of the tracts involved in the Land Exchange Proposed Action. The size of this study area also captures much of the region's recreational resources (which are important economic engines) and a substantial portion of the 1854 Ceded Territory, which is important to the Bands. Finally, the three-county study area is large enough to reflect a regional economic picture against which the NorthMet Project Proposed Action's effects can be compared.

Where possible, the analysis of effects is based on a quantitative comparison of baseline conditions (see Section 4.2.10) against predicted future conditions in the entire three-county area. In cases where such quantitative data are not available for the entire region (e.g., the IMPLAN model discussed in Section 5.2.10.1.3), the evaluation of effects is either limited to St. Louis County—the site of the NorthMet Project area—or includes the other counties but only qualitatively.

5.2.10.1.3 IMPLAN Model Methodology

Many of the socioeconomic effects of the NorthMet Project such as increased population, housing demand, and effects on public facilities and services are functions of the jobs and revenue that the NorthMet Project Proposed Action creates. To model these effects, the

University of Minnesota Duluth Labovitz Bureau of Business and Economic Research (BBER) used the IMPLAN software package. IMPLAN uses an input-output approach to model the economic effects of changes in baseline conditions (e.g., a large industrial project such as the NorthMet Project Proposed Action). IMPLAN reports direct, indirect, and induced effects (definitions of these terms are provided below) in terms of employment, output (the value of production), and value added (wages, rents, taxes, etc.).

For the SDEIS, BBER used version 3.0 of IMPLAN; this version uses economic baseline data from 2009, the most recent year for which data were available to BBER at the time the model was developed (BBER 2012). (The model does assume a recovery—by the mining industry, and the overall economy—from the recession that was in place in 2009.) Due to their small populations, workforces, and their distance from the NorthMet Project area, Cook and Lake counties are not expected to experience substantial additional effects from the NorthMet Project Proposed Action. As a result, the IMPLAN model includes only St. Louis County, which acts as a proxy for the entire three-county study area.

Economic effects were modeled for two construction phases: a 15-month Phase I and a 12-month Phase II that would begin 6 months after completion of Phase I. The phases represent two distinct periods of activity in mine construction involving distinct skill sets and activities. Two operations phases were also modeled: a 6-month Startup Phase and a Typical Year (BBER 2012). The IMPLAN model did not project the number of years of operation, due to the inherent difficulty of predicting how variations in the grade of the extracted material or macroeconomic forces—such as industry cycles or metal prices (see below)—would affect mine life. The Typical Year estimate is intended to model the economic effects of standard operations, recognizing that “some years will be a little better, others a little worse” (BBER 2012). The IMPLAN model also did not include effects during the closure phase or the post-closure period, again due to the difficulty of predicting the timing and extent of those phases.

The IMPLAN model focuses on three categories of economic effects:

- Employment: calculated in terms of jobs, not full-time equivalent (FTE) positions. The model does not make a distinction between full-time, part-time, permanent, or temporary jobs. Direct employment estimates were provided by PolyMet.
- Value added: measures economic contributions to the local economy through wages, rents, interest, and profits.
- Output: the value of the goods or services (e.g., minerals and processed mineral products) produced.

Each category of effects comprises three separate components:

- Direct effects: new jobs, spending, and output resulting directly from the NorthMet Project Proposed Action (e.g., PolyMet employees, salaries, spending, and sales).
- Indirect effects: additional inter-industry spending and employment resulting from direct effects (e.g., wholesale purchase of tires by tire retailers who are NorthMet Project Proposed Action vendors).
- Induced effects: additional household expenditure resulting from the direct and indirect effects (e.g., increased patronage of local restaurants by employees of PolyMet or affiliated industries).

The findings of the IMPLAN model are presented in section 5.2.10.2.

5.2.10.1.4 Sources of Uncertainty and Variability

The anticipated socioeconomic effects of the NorthMet Project Proposed Action are based on the best available data, economic modeling, and lessons learned from the history of metal mining in the Mesabi Iron Range. As this history shows, there are numerous sources of economic uncertainty surrounding a project such as the NorthMet Project Proposed Action. The largest overarching socioeconomic concerns related to the NorthMet Project Proposed Action are listed below. Their relationship to the determination of effects is discussed, as appropriate, throughout the remainder of Section 5.2.10.

Industry Cycles

The feasibility of mining is strongly tied to the market price of the commodities being extracted. When prices are high, mining activity is high (the “boom”); when prices drop, mining activity can often slow down or cease entirely (the “bust”). Such changes in mining activity would have effects on host communities. The diverse economy of the study area could offset the degree to which the effects of a bust are experienced. Though this “boom and bust” phenomenon is often present in mining economies, IMPLAN does not model this phenomenon (or assume that it will occur) because the duration of a boom or bust and the severity relative to modeled commodity prices cannot be predicted. Table 5.2.10-1 shows the metal prices assumed in the IMPLAN model, along with recent average prices and the lowest prices experienced during the 2008-9 recession. The potential effects of major changes in commodity prices are addressed in the discussions of effects during the operations phase.

Table 5.2.10-1 Comparison of Assumed (IMPLAN) and Actual Commodity Prices

Commodity	Price Assumed in IMPLAN ¹	Average Actual Price ²	Recent Low Price ³
Copper	\$2.90/lb	\$3.56/lb	\$1.39/lb
Nickel	\$12.20/lb	\$9.47/lb	\$4.39/lb
Cobalt	\$23.50/lb	\$111.69/lb	\$13.56/lb
Platinum	\$1,230.00/oz	\$1,689.00/oz	\$843.00/oz
Gold	\$635.00/oz	\$1,485.00/oz	\$755.00/oz

Sources: BBER 2012 (commodity prices); Foth 2012 (average actual price); PolyMet, Pers. Comm., March 29, 2012 (recent low price).

¹ Prices based on PolyMet’s 2008 Bankable Feasibility Study (PolyMet 2008). This is the most detailed published information available, and PolyMet is legally bound to these data.

² Three-year rolling average metal prices as of June 30, 2012 (Foth 2012).

³ Monthly low during 2008-2009 recession.

Changes in Industrial Productivity

Throughout the nation, “regional labor productivity [in mining and overall]...has increased dramatically” since publication of the 2009 DEIS (BBER 2012). Over the longer term (since approximately 1980), mining productivity in the Arrowhead region has also increased, due to mechanization and technological innovation (Powers 2007). As a result, far fewer miners are now required per unit of extracted material than before, which therefore lessens the effects of

booms and busts in mining communities. Continued technologically driven productivity increases could lead to lower employment than assumed by IMPLAN or other projections.

Local Employment

The NorthMet Project Proposed Action's socioeconomic effects may be influenced by the degree to which PolyMet hires employees who already live in the socioeconomic study area. The SDEIS assumes that at least some (but not all) direct and indirect jobs would be filled by current study area residents; more specific assumptions about the construction, operations, and closure phases are discussed in subsequent portions of this section, as are the ways in which changes in "local" employment shares would affect different aspects of the study area's socioeconomic character.

Environmental Costs and Non-market Value

The SDEIS contains extensive discussion of the environmental and social effects of the NorthMet Project Proposed Action (and the Land Exchange Proposed Action) in this section and other resource-specific sections. These effects could, in turn, have real and/or perceived economic costs. Non-market values refer to the importance given to characteristics of the land that have personal or community value, but that are not typically expressed in monetary value. Beauty, quiet, and the ability to view nature are examples of non-market values.

Neither NEPA nor CEQ requires the cost and benefits of a proposed action to be quantified in dollars or any other common metric; however, this SDEIS acknowledges that economic costs and loss of non-market value may result from environmental and social effects. Also acknowledged is that the agreement on the value (i.e., the "cost") of environmental effects is often difficult to achieve. Therefore, the approach of this SDEIS is to evaluate environmental and social effects directly, in the appropriate resource-specific section (e.g., the impacts on wildlife are discussed in the Wildlife section, and impacts on water quality are discussed in the Water Resources section).

5.2.10.2 NorthMet Project Proposed Action

This section evaluates the NorthMet Project Proposed Action's effects on socioeconomics in the three-county study area.

5.2.10.2.1 Population and Population Trends

This section discusses the changes in the study area's population resulting from the NorthMet Project Proposed Action. These population changes would be driven primarily by NorthMet Project Proposed Action-related changes in employment.

Construction

IMPLAN modeling estimates that construction activities would create an average of 500 direct and 128 indirect construction jobs over the 18-month Phase I period (the most labor-intensive portion of the construction phase). The 204 induced jobs during this phase are likely to be existing residents hired to accommodate the additional demand from direct and indirect jobs.

Typical mine construction involves fluctuating work flows and specialized crews that may be employed for short duration tasks within the construction time frame. Very few construction

phase employees would work within the NorthMet Project area for the entire 30-month construction period (including Phase I, the 6-month gap, and Phase II).

Given the NorthMet Project area, most construction employees would likely be from Minnesota, and many would already live in the study area. Many direct and indirect employees are likely to reside outside of the communities in the immediate vicinity of the NorthMet Project area (e.g., Hoyt Lakes, Babbitt, Biwabik, Aurora). However, mine workers in the Arrowhead region and beyond “are willing to commute considerable distance to...well-paid jobs...to protect investment in their homes” (Powers 2007). This finding is generally true of mine construction workers as well. As a result, most employees (regardless of project phase) would not need to relocate.

Due to the proximity of the NorthMet Project area to population centers such as Duluth (80 miles), Hibbing (50 miles), and Virginia (25 miles), the SDEIS assumes that 80 percent of direct and indirect construction labor (approximately 500 employees during Phase I of construction, which requires more workers than Phase II) would commute to the NorthMet Project Proposed Action construction site on a regular basis (PolyMet 20121). The SDEIS assumes that another 5 to 10 percent of direct and indirect workers (approximately 25 to 50 employees) would temporarily reside in the study area, at local hotels or in designated mobile home facilities, but would not relocate their families to the region.

The remaining 10 to 15 percent of the direct and indirect workforce (as many as approximately 100 employees) would relocate to the study area for portions (or all) of the construction process (PolyMet 20121). An influx of 100 workers would equate to as many as 225 total new residents (including family members—see the average population per housing unit in Table 4.2.10-14) who would seek long-term (e.g., more than a few months) residences in nearby communities. This represents an increase of less than one quarter of 1 percent over the 2010 population of the study area (approximately 216,000 residents—see Table 4.2.10-1), and slightly more than a 2 percent increase in the population of nearby cities (Aurora, Babbitt, Biwabik, Hoyt Lakes, Tower, and Virginia). Such a small increase would not meaningfully change the demographic composition of the study area; thus, construction of the NorthMet Project Proposed Action would have negligible effects on population.

Operations

During typical operations, the NorthMet Project Proposed Action would generate 360 direct and 330 indirect jobs. Direct and indirect employees are likely to work at the Mine Site, Plant Site, and in the study area for a substantial period of time (perhaps as long as the 20-year projected life of the mine). Direct and indirect employees who do not already live within commuting distance of the Mine Site and Plant Site (i.e., in the study area) are likely to relocate to the study area. It is not known how many direct employees would be current study area residents. PolyMet estimates that as many as 338 of the 360 new direct operations-phase positions (94 percent of these positions) could be filled by study area residents (PolyMet 2012k).

For purposes of this analysis, the SDEIS assumes that approximately 75 percent of direct and indirect operations phase employees would be local residents who would not need to relocate as a result of employment. The SDEIS also assumes that the vast majority of the 301 induced jobs created during operations would be filled by existing residents or the spouses and children of new NorthMet Project Proposed Action employees.

The remaining 25 percent of operations-phase workers (approximately 175 employees) would relocate to the study area with their families, causing a total increase of approximately 400 new residents (see the average population per housing unit in Table 4.2.10-14). This is less than one quarter of one percent of the study area population (approximately 216,000 residents).

These workers are likely to be younger, on average, than the existing populations of the study area communities, and may have higher overall incomes. Other demographic characteristics (race, level of education) cannot be determined. The effect of such a shift on housing and public services is discussed below.

Increases in worker productivity spurred by technological change could reduce the anticipated number of direct, indirect, and induced employees. The effect of such reductions would be to reduce the overall new population of the study area. This in turn would diminish the NorthMet Project Proposed Action's demographic effects.

Reclamation and Closure

During the closure of the NorthMet Project Proposed Action, PolyMet estimates that a reduced number of employees and contractors would remain employed for approximately 3 to 4 years for building demolition, but other closure activities would likely be followed by several years of reclamation activities (e.g., surface water quality monitoring). PolyMet is in the process of finalizing reclamation designs and estimates. Current estimates are based on experience at closure of the former LTVSMC processing plant and include 30 to 50 FTEs for the first 7 years, which includes demolition, remediation, reclamation, construction, and monitoring, and 5 to 10 FTEs for the following 30 years, which includes a period of monitoring, reporting, and active water treatment. During closure, direct, indirect, and induced employment associated with the project would decline. All other factors being equal, by the end of the seven-year closure period, the demographic characteristics of the study area would likely revert to levels that could be expected under the NorthMet Project No Action Alternative.

5.2.10.2.2 Employment and Income

Table 5.2.10-2 shows the anticipated economic contributions of the NorthMet Project Proposed Action, as modeled using IMPLAN. Detailed estimates of jobs by type are provided in the IMPLAN Report (BBER 2012). The IMPLAN model includes assumptions about the portion of employment, value added, and output that accrues to the study area (in the case of the IMPLAN model, this is limited to St. Louis County), as opposed to the amount that “leaks” to locations outside of St. Louis County (BBER 2012). While the data in Table 5.2.10-2 depict the economic effects of the project specifically on St. Louis County alone, they capture the vast majority of the NorthMet Project Proposed Action's effects in the entire three-county study area. By comparison, the total value added to the Minnesota economy in 2009 (from all sources) was \$268 billion (Henry Eichman, USFS Economist, Pers. Comm., July 26, 2013).

Table 5.2.10-2 Summary of IMPLAN Model Results

Phase¹	Direct Effect	Indirect Effect	Induced Effect	Total
Construction Phase I				
Value Added ²	\$143,637,243	\$41,774,260	\$61,120,854	\$246,532,357
Output ³	\$312,000,009	\$75,343,964	\$101,199,927	\$488,543,900
Employment	500	128	204	832
Construction Phase II				
Value Added	\$75,501,628	\$21,958,266	\$32,127,628	\$129,587,122
Output	\$164,000,005	\$39,603,897	\$53,194,833	\$256,798,717
Employment	264	68	107	439
Operations Phase – Startup				
Value Added	\$44,619,571	\$12,117,664	\$6,865,833	\$63,603,068
Output	\$64,122,003	\$23,821,174	\$11,367,855	\$99,311,032
Employment	300	275	251	826
Operations Phase – Typical Year				
Value Added	\$231,315,193	\$62,819,962	\$35,593,610	\$329,728,765
Output	\$332,418,993	\$123,492,880	\$58,932,833	\$514,844,706
Employment	360	330	301	991

Source: BBER 2012.

¹ The IMPLAN model did not include effects during the closure phase or post-closure period.

² Defined in BBER 2012 as “a measure of the affecting industry’s contribution to the local community; it includes wages, rents, interest and profits.”

³ Defined in BBER 2012 as “the value of local production required to sustain activities.”

Construction

Construction of the NorthMet Project would create as many as 832 jobs during the peak of Phase I, of which 500 would be mine construction jobs. Indirect and induced employment would be spread across a variety of industries, such as engineering, restaurants, medical providers, and hospitals (see Table 10 in BBER 2012). The NorthMet Project Proposed Action-related construction employment would increase overall study area employment by less than one percent at its peak (less during Phase II).

As discussed in Section 5.2.10.2.1, the SDEIS assumes that a substantial share of direct construction jobs would be filled by study area residents—particularly those with construction experience—while other study area residents would obtain indirect and induced jobs. Construction is therefore expected to at least marginally reduce the unemployment rate in the study area.

It is not known how much of the estimated \$376 million in total value added during the two parts of the construction phase would be dedicated to employee salaries, although employee pay is assumed to be a substantial share. The value added from the NorthMet Project Proposed Action is likely to be substantial compared to other non-ferrous (e.g., copper, nickel, lead, zinc) mining activity, but would be limited to the construction phase.

While employment related to the construction phase of the NorthMet Project Proposed Action would have minimal effects, the earnings from construction employees would be positive, albeit relatively short-lived (e.g., for no more than the 36-month overall construction phase).

Operations

Overall Effects

During typical year operations, the NorthMet Project Proposed Action would generate nearly 1,000 total direct, indirect, and induced jobs. This would increase study area employment by approximately one percent. One-third of new employment (360 jobs) would be direct mine-related jobs. The remainder would be spread among a variety of industries, such computer programming, restaurants, engineering, and health care (BBER 2012).

As discussed in Section 5.2.10.2.1, the SDEIS assumes that a substantial share of direct operations jobs would be filled by study area residents, particularly those with mining experience. In 2009, there were approximately 3,000 mining jobs in the study area (U.S. Census Bureau 2009). This figure does not include residents who have skills appropriate for the mining sector but who are not currently employed in mining. Other local residents are likely to obtain indirect and induced jobs. Operation of the NorthMet Project Proposed Action could reduce unemployment in the study area by nearly one percent (991 new jobs out of 111,090 members of the workforce, see Table 4.2.10-9).

It is not known how much of the estimated \$330 million in total value added during typical operations would be dedicated to employee salaries, although employee pay is assumed to be a substantial share. The NorthMet Project Proposed Action's estimated value added (and thus earnings) is substantial compared to the 2007 estimate of \$250 million in annual statewide value added economic effects from non-ferrous mining (BBER 2009).

Earnings and all economic contributions of the NorthMet Project are influenced by external market factors, such as those discussed in Section 5.2.10.1.4. Significant decreases in metal prices and/or competition from other regions or countries can lead to reduced production. PolyMet states that, due to its structure as a "low-cost producer," the NorthMet Project Proposed Action would be unlikely to completely cease operations during a recession (PolyMet, Pers. Comm., March 29, 2012). That statement notwithstanding, complete suspension of mining activity is not an uncommon response to recession or significant drops in commodity prices. This "bust" aspect of the cyclical economy is familiar to mining regions in Minnesota and beyond (Powers 2007; Freudenberg and Wilson 2002). Increases in productivity may not affect the output of the NorthMet Project Proposed Action (i.e., the sales price of the extracted and processed materials), but could reduce employment and value added.

To account for some of these concerns, commodity prices in the IMPLAN model are generally conservative, compared to price trends. In particular, copper, gold, and platinum prices used in the IMPLAN model are significantly below recent average prices. Nickel and cobalt, which are expected to comprise a small share of the total volume extracted by PolyMet, are significantly above current average prices, but were also conservative compared to contemporary prices that formed the basis of PolyMet's 2008 Bankable Feasibility Study (see notes in Table 5.2.10-1). Section 5.2.10.1.4 provides more information about sources of uncertainty and variability.

Effects on Regional Tourism

Effects on species (game animals, fish, and vegetation) and resources (water quality, air quality, and noise) that contribute to the tourism industry are discussed in appropriate sections of Chapter 5. Housing is also an important component of the tourism industry—the Arrowhead region is often regarded as a location for long vacations, rather than short day-trips—and is discussed in Section 5.2.10.2.4. To the degree that the NorthMet Project Proposed Action adversely affects those resources, then it also has the potential to affect the tourism industry. However, the presence of the NorthMet Project Proposed Action would not significantly affect regional recreation or visual resources (see Section 5.2.11.2.1), nor would it affect air or water quality or increase noise levels in popular regional recreation resources such as BWCAW (see Section 5.2.12). Consequently, there is also insufficient evidence to suggest that the presence of the NorthMet Project Proposed Action would affect the tourism industry as a whole.

As discussed in 5.2.10.2.1, the NorthMet Project Proposed Action would retain a small workforce, generating a corresponding small number of indirect and induced jobs, to perform post-mining activities such as demolition and reclamation as well as to maintain a very small post-closure staff. Using the IMPLAN model's construction-phase employment multipliers (BBER 2012) a 50-person closure staff (direct employment) could equate to as many as 30 indirect and induced jobs (a decline, compared to the 1,000 operations-phase jobs generated by the NorthMet Project Proposed Action). Because no minerals or other commodities would be extracted, the value added from the closure phase would be limited to employee salaries, rents, and other contributions.

Closure

Overall, the employment, output, and value added from the closure phase would be small compared to the study area's overall economy. More important, at mine closure, workers who held operations-phase direct, indirect, and induced jobs would be expected to secure alternative local employment, retire, or relocate out of area. There would likely be a spike in unemployment and a resulting decline in income during the transition between the operations and closure phases. The 991 operations-phase jobs (including direct, indirect, and induced jobs) collectively account for less than one percent of the overall study area workforce (111,090 individuals—see Table 4.2.10-9). Any increase in study area unemployment during and after closure—resulting from individuals who remain in the study area workforce but who cannot find jobs—would be minimal. As former employees moved, found new work in the area, or retired, unemployment and income would normalize to levels predicted for the NorthMet Project No Action Alternative (holding all other economic variables constant).

5.2.10.2.3 Public Finance

The IMPLAN model estimates the value of several federal and state taxes, including personal income taxes (i.e., taxes paid by employees on their salaries), indirect business taxes, and other taxes paid as a result of the NorthMet Project Proposed Action for the duration of the project (BBER 2012). PolyMet provided the tax estimates for taxes that would be paid directly by the company (PolyMet, Pers. Comm., March 29, 2012). The remainder of this section discusses those tax estimates.

Construction

Construction of the NorthMet Project Proposed Action would generate approximately \$51 million in federal tax revenue, and \$24 million in state tax revenue (combined, both construction phases) (BBER 2012). A portion of these tax contributions would be returned to the study area through various federal programs (e.g., grants to school systems and state governments) and through distributions from the state's general fund. However, such effects on local public finances are indirect and difficult to quantify. Other construction-phase revenues could include sales and use tax on some materials used for NorthMet Project Proposed Action construction, although most such materials and supplies are exempt from the tax (MDR 2011).

Operations

The majority of economic benefits to the local community through taxes would be realized during the operations period. IMPLAN modeling estimates that, during a typical year of operation, the federal government would receive approximately \$30 million, and the state and local governments would receive approximately \$39 million in taxes from the operation of the NorthMet Project Proposed Action.

PolyMet estimates that, if the NorthMet Project Proposed Action was currently in operation, its direct federal and state tax payments would have ranged from approximately \$37 to \$80 million per year during the previous 5-year period (PolyMet, Pers. Comm., March 29, 2012). Table 5.2.10-3 details how these direct tax payments would be divided among different state and federal taxes (as described in Section 4.2.10.1.3), if the NorthMet Project Proposed Action would have been in full operation in 2011. A substantial portion of state taxes would be returned to study area school systems, local governments, and local general funds.

Table 5.2.10-3 Estimated Annual NorthMet Project Proposed Action Taxes Paid, 2011
Dollars (millions)

	Minnesota Taxes¹	Federal Taxes¹
Net Proceeds Tax	\$5.9	NA
Occupation Tax	\$7.1	NA
Sales and Use Tax	\$2.4	NA
Withholding Tax on Royalty Payments ²	Undetermined	Undetermined
Ad Valorem Tax	\$0.2	NA
Total	\$15.6	\$64

Source: PolyMet, Pers. Comm., March 29, 2012.

¹ Assumes-full operation at 2011 metal prices.

² Royalty payments would be subject to a 6.25% withholding tax. The value of this tax cannot be calculated or estimated at this time.

The magnitude of tax contributions is strongly linked to commodity prices. A significant drop in commodity prices would likely result in a significant reduction in tax revenue generated by the NorthMet Project Proposed Action. Even under such circumstances, operation of the NorthMet Project Proposed Action would benefit the local economy.

Reclamation and Closure

Closure activities would last approximately 20 years after cessation of operations. The first seven years of this period would be the most active, and would include reclamation, demolition, and restoration of the site. Years 7 to 20 of closure would include low-intensity monitoring, maintenance, and water treatment activities, followed by covering of the Tailings Basin at the end of this period. Low-intensity post-closure activities (such as long-term monitoring and maintenance) would extend indefinitely beyond year 20 of closure.

During closure and post-closure, the NorthMet Project Proposed Action would generate a small amount of tax revenue from the above activities, primarily from income taxes and business taxes. Other revenue sources, such as net proceeds taxes, and local ad valorem taxes would no longer apply. By the end of the closure phase, contributions to public finances would return to levels that would be expected for the NorthMet Project No Action Alternative. Relative to existing conditions, closure of the NorthMet Project Proposed Action would generate a negligible benefit for public finances in the study area.

5.2.10.2.4 Housing

Housing effects are tied to both employment and earnings; increases in both of these factors can cause increased demand for housing. There are more than 24,000 vacant housing units in the study area, of which approximately 7,000 are “permanent” (not seasonal) vacant units (see Table 4.2.10-14). Of that total, approximately 4,000 non-seasonal vacant units are located in the individual study area communities listed in Section 4.2.10 (the remainder are scattered throughout St. Louis, Lake, and Cook counties). All of these communities are within a reasonable commuting distance of the NorthMet Project area (Powers 2007).

Construction

As described in Section 5.2.10.2.1, 75 percent of the construction-phase employees are expected to commute to their jobs from existing residences in or near the study area. Relatively few construction-phase employees (approximately 100) are expected to permanently relocate to the study area, due to the short-term and transient nature of mine construction. Given the existing vacant housing stock (and including seasonal units, which could be converted to permanent units at the owners’ discretion), this added demand in permanent housing in the study area would be largely imperceptible.

Approximately 25 to 50 employees may choose to procure temporary housing. This could consist of short-term rentals of available housing units (seasonal or otherwise), and use of mobile home parks or hotels/motels. Lodging and mobile home facilities close to the NorthMet Project area, such as those in Aurora, Hoyt Lakes and Babbitt, could be more heavily occupied throughout both phases of the construction period, affecting both availability and pricing for the region’s tourist demand. However, there are approximately 5,400 hotel rooms and more than 1,400 mobile home berths (as well as park facilities that permit mobile homes) in the study area (Northland Connection 2012). Construction-phase demand for these accommodations would not substantially limit availability.

Operations

Demand for permanent housing is likely to increase during the operations phase. As discussed in Section 5.2.10.2.1, approximately 175 workers would choose to relocate to the study area. The actual number of housing units required to accommodate this demand may be lower (less than 380), due to the presence of two-worker in-migrating households (e.g., the spouse of a direct employee may obtain an indirect or induced job). Even if there are no multiple-worker in-migrating households (an unlikely scenario), the study area has approximately 7,000 vacant non-seasonal housing units. Thus, the study area has adequate housing to accommodate the influx of workers associated with the NorthMet Project Proposed Action.

Individual communities close to the NorthMet Project area may experience more competition for available housing units. While it is unlikely that any single community would achieve 100 percent non-seasonal occupancy, such competition could drive up housing prices and could also encourage the renovation of existing housing units and/or construction of new housing units (either on vacant land or as replacements of older housing units). Given the small number of new residents, such effects would be minor.

As with other economic effects of the NorthMet Project Proposed Action, effects on housing are tied to market fluctuations and workforce productivity. Major changes in levels of production (caused by major changes in commodity prices) could cause effects on housing demand and value. However, the total estimated new housing demand associated with the NorthMet Project Proposed Action is relatively small compared to the region's existing housing supply. Even a market "bust" (a drop in commodity prices so severe that it causes shutdown of the NorthMet Project Proposed Action) should not dramatically alter the housing market in any single community, let alone the study area as a whole.

There are concerns that the presence of the NorthMet Project Proposed Action could reduce housing demand (and thus housing value) in the study area, because of the conflict between the NorthMet Project Proposed Action's heavy industrial character and the high-quality natural environment that supports the region's tourism economy and thus the housing market. As described in Section 5.2.11, the NorthMet Project Proposed Action's effects on recreation and visual resources would be very limited.

Given the coexistence of mining and tourism in the Arrowhead region, the NorthMet Project Proposed Action's effects on the study area's housing values would be minimal. The most likely result of the operation of the NorthMet Project Proposed Action is a minor increase in housing demand and prices in study area communities, with moderate effects in individual communities closest to the NorthMet Project area. Increased housing prices may or may not be a negative effect; average housing values in the communities closest to the NorthMet Project area are relatively low compared to other study area communities. Minor to moderate increases in housing value would likely be seen as a benefit by homeowners, and the opportunity to add newer housing stock (either through rehabilitation of existing units or the construction of new units) to the study area would generally improve property values, thus improving local property tax revenues in those communities.

Reclamation and Closure

During and following reclamation and closure of the NorthMet Project Proposed Action, it is likely that the demand for housing would drop as workers migrate from the area. Housing

characteristics (vacancy rates and values) would likely revert to levels that would be expected for the NorthMet Project No Action Alternative. However, increases in housing demand spurred by the strength of the tourism industry and the increasing popularity of the study area for retirement could obscure any such declines.

5.2.10.2.5 Public Services and Facilities

The NorthMet Project Proposed Action would affect public services and facilities in the study area both directly and indirectly. Direct effects would include services provided to the NorthMet Project Proposed Action itself, and would largely be limited to demand for emergency response in the case of an accident. Indirect effects would include increased demand for public services such as potable water, sewer, emergency services, and schools in communities where direct, indirect, and induced employees and their families live.

Most public water and sewer infrastructure in the study area was designed to accommodate larger populations than currently exist; therefore, the NorthMet Project Proposed Action would generally have no effect on these services (see Table 4.2.10-15). As Section 4.2.10.1.5 shows, emergency and medical services are equipped to handle existing demand, and most have mutual aid agreements in place with nearby cities to cooperatively respond to major emergencies.

The public schools in the study area were constructed to accommodate larger populations than currently exist in the study area (e.g., the larger populations that were associated with the iron and taconite mining industry in the 1960s and 1970s). Collectively, public schools in the study area have capacity for nearly 22,000 students, with existing enrollment of nearly 16,000 students. Thus, these schools are able to support new students without building new facilities. To address concerns about maintenance of older buildings, several school facilities in the region have already established renovation programs, and some schools in Duluth plan to downsize (see Section 4.2.10.1.5). These plans predate the NorthMet Project Proposed Action, and would not be accelerated or changed by new population associated with any phase of the NorthMet Project Proposed Action.

The five technical and community colleges and two four-year colleges located throughout the study area provide a variety of degree programs. These schools would continue to provide educational opportunities to new and existing study area residents seeking further education, including high school graduates and existing employees seeking to enhance their job skills. Several community colleges and universities in the study area offer, or are developing, educational curriculum related to jobs in the mining industry.

Construction

Direct demands from construction of the NorthMet Project Proposed Action would primarily fall on local emergency service providers who would respond to any emergencies at the NorthMet Project area.

A small number of construction-phase employees and their families (approximately 225 total new residents, as described in Section 5.2.10.2.1) are expected to permanently relocate to the study area, while another 150 employees would stay in the study area for moderate periods of time (from several weeks to several months), in hotels or mobile homes. All of these employees would generate indirect demand for drinking water, wastewater capacity, and emergency services; the relocated residents would also generate demand for space in public schools.

Public schools in the study area generally have sufficient capacity to accommodate new students. As described in Section 4.2.10.1.5, several school facilities in the region are in need of renovation. This need predates the NorthMet Project Proposed Action, and would not be exacerbated by the relatively small number of new students added by NorthMet Project Proposed Action construction.

Operations

Direct demands from operation of the NorthMet Project Proposed Action would primarily fall on local emergency service providers who would respond to any emergencies within the NorthMet Project area. Approximately 400 operation-phase employees and family members are expected to relocate to the study area (see Section 5.2.10.2.1). All of these employees and their families would generate demand for drinking water, wastewater capacity, emergency services, and school capacity.

Additional police, fire, and ambulance staff may be required to service increased populations in study area cities, particularly in smaller cities. However, these expansions are likely to consist of one to two employees per service (e.g., one new police officer, two new firefighters), per city, as well as upgrades of existing equipment, rather than wholesale expansions of police and fire departments. Increased tax revenues from the NorthMet Project Proposed Action would be expected to cover the costs of these expansions.

Reclamation and Closure

During reclamation and closure of the NorthMet Project Proposed Action, direct and indirect demands for public service would decrease to baseline levels (those present at the start of the NorthMet Project Proposed Action) due to the anticipated decrease in population and activity at the Mine Site and Plant Site. Any cap upgrades to public services and facilities constructed to accommodate operations-phase demands, such as newer police and fire vehicles, would be available to the remaining residents of the study area during closure and post-closure activities.

5.2.10.2.6 Environmental Justice and Subsistence

Evaluation of EJ effects—the degree to which the potential effects of the NorthMet Project Proposed Action or any alternative are felt disproportionately across a community, considering ethnicity, age, and income—follows criteria set forth in the following federal EOs:

- EO 12898, (*Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, 1994), directs federal agencies to incorporate EJ into their mission and activities. Federal agencies are to accomplish this by conducting programs, policies, and activities that substantially affect human health or the environment in a manner that does not exclude communities from participation in, deny communities the benefits of, or subject communities to discrimination under such actions, because of their race, color, or national origin.
- EO 13045, (*Protection of Children from Environmental Health Risks and Safety Risks*, 1997), requires each federal agency give high priority to the identification and assessment of environmental health and safety risks to children.

In particular, this EJ analysis focuses on the degree to which the NorthMet Project Proposed Action could disproportionately affect the populations described above and includes residents of

the study area, as well as Band members who use the study area for subsistence, regardless of where they live.

Minority (non-white) populations comprise less than 5 percent of the study area, and less than 5 percent of the individual communities listed in Table 4.2.10-3 (except for the three reservations). By comparison, the minority population of Minnesota was approximately 15 percent. The following groups in the study area meet the criteria described above:

- Approximately 13.5 percent of the study area population is below the federal poverty level, compared to 10 percent for the state.
- Native Americans comprise 2.3 percent of the study area, compared to 1.1 percent of the state population.
- Children (individuals under 18 years of age) comprise nearly 29 percent of the study area population, compared to 24 percent for the state.

Native American tribes exercise usufructuary rights to hunt, fish, and gather plants within the 1854 Ceded Territory, which includes the study area. This section discusses the degree to which the NorthMet Project Proposed Action would disproportionately affect these subsistence practices, with the understanding that these practices have both socioeconomic and cultural value for the Native American tribes. Section 5.2.9 discusses the cultural aspects of subsistence in greater detail.

Construction

As described in Section 5.2.10.2.2, the economic effects of construction of the NorthMet Project Proposed Action would be largely positive. Construction would provide new jobs, substantial new earnings, and indirect contributions to public finances. Potential negative socioeconomic effects of construction of the NorthMet Project Proposed Action include increased demand for short-term housing (hotels and mobile home facilities)—although this is a benefit for the owners of those facilities—and increased demand for public services (especially emergency services). These negative effects are generally minor.

Increased public service demands would not disproportionately affect EJ populations. Increased prices would negatively affect the study area's poorest residents who did not receive a commensurate direct or indirect economic benefit from the NorthMet Project Proposed Action. Approximately 150 workers are expected to relocate to or occupy short-term housing in the study area during construction. This number of new and temporary residents, and therefore demand for public services, is small compared to available vacant housing, although poor residents closer to the NorthMet Project area may experience higher prices and demand than in the study area as a whole.

The NorthMet Project area is within the 1854 Ceded Territory. Section 4.2.10.1.6 and Table 4.2.9-1 in Section 4.2.9 summarize available information about subsistence patterns and resources within the 1854 Ceded Territory. Construction of the NorthMet Proposed Action would make the Mine Site unavailable for subsistence use. The degree to which construction of the NorthMet Project Proposed Action would affect individual subsistence resources (i.e., fish, game, and plant species) outside of the Mine Site, Transportation and Utility Corridor, and Plant Site is discussed in Section 5.2.9 (Cultural Resources).

Operations

As described in Section 5.2.10.2.2, the economic effects of operation of the NorthMet Project Proposed Action would be largely positive. Operations would provide new jobs, substantial new earnings, and substantial direct and indirect contributions to public finances. In addition, the Bands operate four casinos in or near the study area (the Fond-du-Luth Casino in Duluth, operated by the Fond du Lac Band; the Black Bear Casino in Carlton, operated by the Fond du Lac Band; the Fortune Bay Resort Casino in Tower, operated by the Bois Forte Band; and the Grand Portage Lodge and Casino in Grand Portage, operated by the Grand Portage Band). While the Black Bear Casino is outside of the study area, it is nonetheless close enough to study area communities to potentially benefit from increased visitation and spending. Increased employment and income associated with the NorthMet Project Proposed Action could increase visitation and revenues at these facilities.

Potential negative socioeconomic effects of operation of the NorthMet Project Proposed Action include increased demand for housing (which could negatively affect the study area's poorest residents who did not receive a direct or indirect commensurate economic benefit from the NorthMet Project Proposed Action) and increased demand for public services and facilities.

Increased public service demands would not disproportionately affect minority and low income populations. The influx of direct, indirect, and induced NorthMet Project Proposed Action employees could cause demand for as many as 175 housing units across the study area. While this number is small compared to available vacant housing in the study area, some marginal increase in housing demand and cost, as well as demand for public services, is possible, particularly in communities closer to the NorthMet Project area. Increased housing competition would likely affect the study area's poorest residents, particularly renters (whose housing costs are more volatile), and particularly those living closer to the NorthMet Project area.

Operation of the NorthMet Project Proposed Action would make the Mine Site unavailable for subsistence use; noise and other consequences of operations could affect migration or other animal species behavior in the vicinity of the Mine Site and Plant Site (see Section 5.2.5, Wildlife).

Operations could affect individuals who consume fish harvested from nearby waterbodies. The NorthMet Project Proposed Action would increase mercury concentrations in the Embarrass River Watershed, as well as some nearby lakes, although it would decrease mercury concentrations in the Partridge River watershed (see Section 5.2.2.3.4). As described in Section 4.2.10.1.6, subsistence fishing and consumption is a common activity for Native American bands in the 1854 Ceded Territory. Members of the Grand Portage and Fond du Lac bands are known to consume substantially more fish than the assumed statewide average. As a result, increased mercury concentrations, and associated increases in mercury bioaccumulation in fish tissue could therefore constitute an EJ impact for Band members and other subsistence consumers of fish.

Reclamation and Closure

During reclamation and closure, socioeconomic characteristics of the study area would revert to conditions that would be expected for the NorthMet Project No Action Alternative. Employment, earnings, and contributions to public finances generated by the NorthMet Project Proposed Action would end (potentially with a phase-out period); housing demand and prices would ease as would demands for public services and facilities. Poorer residents of the study area would

have more difficulty coping with this transition if they hold lower-paying, less secure “induced” jobs (as opposed to direct or indirect jobs), as they may have more difficulty moving out of the study area to secure new jobs (particularly if housing values drop). However, given the relatively small number of jobs generated by the NorthMet Project Proposed Action (compared to the total number of jobs held by study area residents), these difficulties would not be substantially higher than existing conditions.

As during other phases, the NorthMet Project area would remain closed to the public—and thus unavailable for subsistence use—during and following the closure phase, thus preventing subsistence activities. Deposition of mercury from the NorthMet Project Proposed Action would cease at closure, but mercury bioaccumulation in fish tissue and existing fish consumption limits could persist beyond the mine’s operational life.

5.2.10.3 NorthMet Project No Action Alternative

Under the NorthMet Project No Action Alternative, the NorthMet Project Proposed Action would not be developed. There would be no NorthMet Project Proposed Action-related change to the study area. Externally existing demographic trends such as population growth or decline, and shifts in employment patterns would continue. The study area would not accrue the economic benefits of the NorthMet Project Proposed Action, nor would it experience any of the negative effects identified in this SDEIS. As described in Section 5.2.10.2, the presence of the NorthMet Project Proposed Action would not hamper growth of the Arrowhead region’s tourism industry; the NorthMet Project No Action Alternative would not hasten this growth, either. Overall, the NorthMet Project No Action Alternative would have no effect on socioeconomics in the study area.

5.2.11 Recreation and Visual Resources

This section describes the potential environmental effects of the NorthMet Project Proposed Action on recreational facilities and activities that typically take place in the NorthMet Project area, as well as the surrounding Arrowhead region. Recreation in this region is strongly tied to the aesthetic condition of the landscape so this section also describes the effects of anticipated project activities on visual resources in the NorthMet Project area and surrounding land.

Summary

Most of the Mine Site, a part of the Superior National Forest, is currently public land. However, the Mine Site is surrounded by private land that lacks public roads or trails and is therefore not publicly accessible. The Transportation and Utility Corridor and Plant Site are privately owned lands and are not open to the public for recreation. Direct effects on recreation in this area from the NorthMet Project Proposed Action will be limited. With the exception of the Skibo Vista Scenic Outlook, views of project activities will be limited by topography and distance. The NorthMet Project could reduce recreational use of nearby lands, including portions of the Superior National Forest, but would not affect recreational patterns and facilities in the Arrowhead region as a whole. The BWCAW and Voyageurs National Park (recreational resources that are discussed in greater detail in Section 5.2.12) are each more than 19 miles from the NorthMet Project Area. An analysis of potential air quality effects demonstrated that there are no expected effects on visibility in these areas when compared to pristine conditions.

5.2.11.1 Methodology and Evaluation Criteria

5.2.11.1.1 Recreation

The primary issues related to recreational facilities and activities on and near the proposed project facilities include the following:

- direct effects due to construction, operation, and closure of the NorthMet Project Proposed Action resulting in the reduction of the number and/or acreage of recreational facilities (parks, lakes, trails, etc.) potentially available for public use;
- indirect effects of the NorthMet Project Proposed Action, including reduction in the use of recreational facilities in areas surrounding the proposed project facilities due to noise, dust, and other disturbances; and
- the net effect of local (i.e., the area surrounding the Mine Site and Plant Site) and regional recreation during post closure.

Evaluation of the NorthMet Project Proposed Action against these criteria was based on comparison to the USFS ROS for land that is controlled by USFS. The USFS uses the ROS to inventory recreational settings and characteristics (see Section 4.2.11.1 for further explanation of the ROS).

Effects on the region's overall recreation resources (e.g., lands not necessarily controlled by USFS) are based on qualitative analysis of NorthMet Project Proposed Action activities, as they relate to the region's recreational opportunities (as summarized in Section 4.2.11). Specific considerations include distance (both direct and via road or trail) between the NorthMet Project and various recreation resources, and the likelihood that the NorthMet Project Proposed Action

would change the noise or visual environment, or the character of water, flora, and fauna present in these resources. These evaluations are based on extensive touring of the region and review of available mapping and descriptive material about the region's recreation resources.

5.2.11.1.2 Visual Resources

The primary issues related to visual resources on and near the Mine Site and Plant Site include the following:

- the nature and severity of effects of the NorthMet Project Proposed Action on sensitive viewpoints, including nearby homes, businesses, and vistas;
- changes to the extent or scale of visible mining disturbances; and
- the ultimate appearance of the NorthMet Project Proposed Action after reclamation is completed versus current and interim stages of active mining.

Evaluation of the NorthMet Project Proposed Action against these criteria was based on comparison to the USFS Scenery Management System classes for land that is or would be controlled by the USFS. The USFS uses the Scenery Management System to identify desired visual conditions, as expressed by SIOs (see Section 4.2.11.1 for further explanation of SIOs).

Effects on the region's overall visual environment (e.g., lands not necessarily controlled by USFS) are based on qualitative analysis of the NorthMet Project's activities (particularly structures, stockpiles, and other visible activities), as they relate to what observers are likely to see in the region. This understanding is based on extensive touring and photo-documentation of views and visual conditions in the region. In addition, GIS, printed maps, and aerial photography were used to identify potential sensitive viewpoints, for which visual simulations of future mine facilities were developed.

5.2.11.2 NorthMet Project Proposed Action

5.2.11.2.1 Recreation

Surface rights to most of the Mine Site are held by the USFS, as part of the Superior National Forest. As described in Section 4.2.11, the ROS classes for the portion of the Mine Site located on federal lands are Semi-Primitive Motorized and Roaded Natural. The setting and characteristics of the portion of the Mine Site located on private lands is similar to the Roaded Natural class. However, there is no officially established public access (e.g., roads or trails) to the Mine Site (see Section 4.2.11.1), and thus limited opportunity for recreational activity. No access (or recreational opportunities) would be allowed during construction, operation, or closure of the NorthMet Project Proposed Action. Accordingly, the NorthMet Project Proposed Action would have no effect on recreation within the Mine Site.

Construction and operation of the NorthMet Project Proposed Action would be entirely contained within the NorthMet Project area (i.e., the Mine Site, Transportation and Utility Corridor, and Plant Site). Thus, the NorthMet Project Proposed Action would not directly affect access to or use of regional recreational facilities such as other portions of the Superior National Forest, nearby parks and other public lands, or the BWCAW.

The public's enjoyment of recreational activities in the region—such as hunting, fishing, boating, hiking, and winter sports—is tied in part to visual resources, as discussed below, and also to a

wide variety of factors evaluated in other sections of Chapter 5.0. Such factors include, but are not limited to, the availability and quality of fish and other aquatic species, vegetation, wildlife (particularly game species), noise, air quality, water quality, and wetlands. Effects on these resources are presented in the corresponding sections in Chapter 5.0.

The mine facilities such as mine pits, stockpiles, and associated facilities would be set back from most publicly accessible land, including portions of the Superior National Forest south of the Transportation and Utility Corridor. In addition, the lack of designated trails in these portions of the Superior National Forest means that the number of recreational users who would approach the Mine Site would be limited. Nonetheless, the presence of the NorthMet Project Proposed Action would likely make recreational activities in the immediate vicinity of to the Mine Site, Transportation and Utility Corridor, and Plant Site less enjoyable (and therefore less likely) for some observers. In particular, three potential effects of the NorthMet Project Proposed Action could reduce recreational activity: noise, effects on fish populations (related to recreational fishing), and effects on wildlife populations (related to recreational hunting).

The presence of noise could discourage use of the portions of the Superior National Forest closest to the Mine Site and Plant Site (e.g., immediately south of the Transportation and Utility Corridor). Noise levels, including operational noise, ground vibration, and airblast overpressure, that exceed the most stringent category of state noise standards generally would not extend more than 0.9 mile from the Mine Site during the day and 2.3 miles at night (see Figures 5.2.8-1 through 5.2.8-4).

The ROS classes for those portions of the Superior National Forest within 2.3 miles of the Mine Site are Semi-Primitive Motorized and Non-Motorized. NorthMet Project Proposed Action-related noise would affect up to 6,450 acres of the Superior National Forest within this 2.3 mile area. In these areas, project-related noise could limit full realization of the intended ROS classifications. Outside of the 2.3 mile area, NorthMet Project Proposed Action-related noise would not be inconsistent with ROS classes.

NorthMet Project Proposed Action-related noise, air emissions, and water discharges could potentially influence wildlife behavior in portions of the Superior National Forest closest to the Mine Site and Plant Site, as discussed in the wildlife Section 5.2.5. To the degree that game species are disturbed by NorthMet Project Proposed Action-related noise, they could choose to avoid this portion of the Superior National Forest, leading to reduced hunting opportunities in these areas. However, the area affected by noise is small, approximately 0.2 percent of the more than 3 million acres of the Superior National Forest. Species displaced by noise are likely to remain in surrounding areas of the Superior National Forest; overall opportunities for hunting and wildlife viewing on public lands in the region are not expected to change substantially.

Excluding effects related to noise, fisheries, air quality, and other effects described elsewhere in Chapter 5.0, and given the proximity of active and past mining and industrial activity to high-quality recreational activity in the Arrowhead region (such as the BWCAW), there is no evidence that the presence of the NorthMet Project Proposed Action in and of itself would affect the public's ability to hunt, fish, and conduct other recreational activities, or affect the overall recreational experience (apart from specific activities) in the Arrowhead region as a whole.

After closure, PolyMet would retain ownership of the Mine Site and the federal lands, and public access would likely remain restricted.

The Plant Site is located at the former LTVSMC processing plant. It is owned by PolyMet, and it is not open to the public. Entry roads are gated and/or guarded. No recreational activity is permitted at this site, nor would it be permitted during construction, operation, and closure of the NorthMet Project Proposed Action.

5.2.11.2.2 Visual Resources

At the Mine Site, the maximum height of the waste rock stockpiles would range from approximately 1,840 ft amsl (Category 1 Stockpile and Category 4 Stockpile) to 1,770 ft amsl (Category 2/3 Stockpile), or a maximum stockpile elevation of 180 to 240 ft above ground surface (PolyMet 2013c). The Giants Range rises sharply to the north of the Mine Site, blocking views of the mine, stockpiles, and safety lights (used when the stockpiles are active) from receptors to the north and west, including the BWCAW.

The Mine Site would be in operation 24 hours per day; therefore, nighttime safety lighting of the active stockpiles would potentially contribute to a localized “glow” effect that could be visible in the night sky. Light sources at the Mine Site would be similar to light levels at other mining projects across the Iron Range. For example, most of the lighting at the Mine Site will be directed downward, such as at the digging area in the case of the shovels and loaders, at the driving surface in the case of the haul trucks and locomotives, and at the dumping area at the stockpiles and the rail transfer hopper. The area around the blasthole drills will be illuminated so the drill can maneuver around the pattern. PolyMet does not propose any further specific mitigation measures with respect to light effects (PolyMet, Pers. Comm., July 25, 2012).

The upland forest surrounding the Mine Site to the east, south, and west would shield ground-level views of the Mine Site (including mine, stockpiles, and associated facilities) in those areas. These forest stands are a mix of coniferous and deciduous forests upwards of 60 ft in height and would provide year-round screening within several miles of the Mine Site (except, perhaps, from portions of the Superior National Forest that are very close to the southern boundary of the Transportation and Utility Corridor).

Viewers at elevated vistas to the south would have clearer views of the Mine Site. Figure 5.2.11-1 simulates the profile of the maximum extent of stockpiles (the largest visible component of the Mine Site) from the Skibo Vista Overlook on the Superior National Forest Scenic Byway, approximately 12 miles south-southwest of the Mine Site. Given the 180- to 240-ft height of the stockpiles, a portion of these would be visible above the treeline. The stockpiles would not project above Giants Range or alter the silhouette of the skyline.

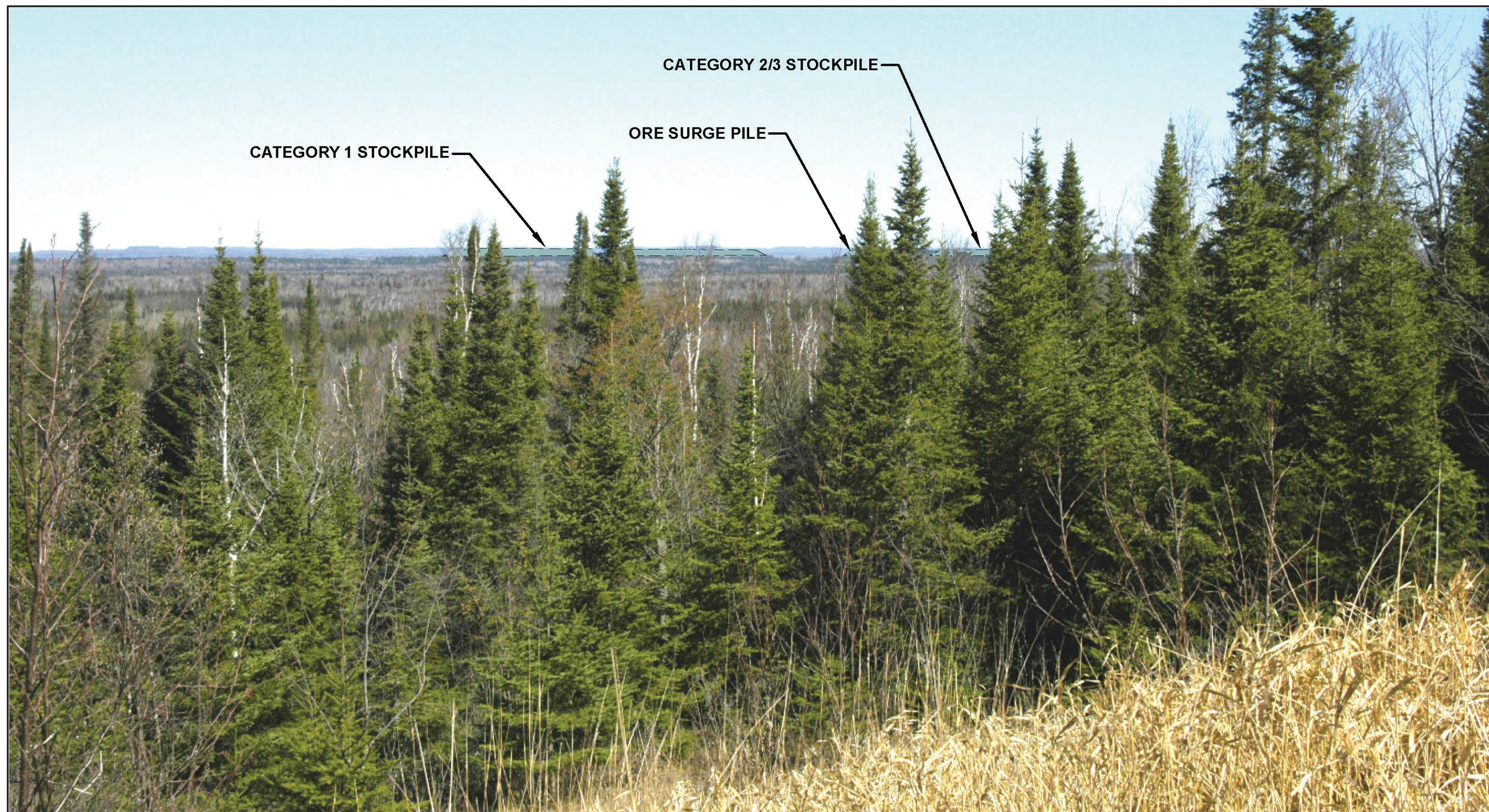


Figure 5.2.11-1
Photo Simulation - View of Mine Site from Skibo Overlook
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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Visual conditions would vary throughout the course of the mine's life. Initially, stockpiles would be less visible until heights exceed the surrounding treeline. The Category 2/3 Stockpile and Category 4 Stockpile would reach their maximum heights in year 11, after which they would be relocated into the East Pit. The Category 1 Stockpile would reach its maximum and permanent height in year 12 (excluding the cover material placed over the stockpile at mine closure). The height, shape, and coloring of the stockpiles would vary throughout the life of the mine; however, the coloring of the stockpiles would likely differ from the surrounding landscape, and would likely be more visible during winter months when screening from deciduous trees is at a minimum (although snow cover could tend to make the stockpiles look more like natural landforms). Viewers on elevated terrain to the east, north, or west of the Mine Site would generally have more limited views of the mine and stockpiles, although there could be sporadic direct views of the Mine Site, depending on exact location and vegetative screening.

Mining and associated industrial activities are long-established aspects of the Mesabi Iron Range landscape. The NorthMet Project Proposed Action would introduce visual elements to the landscape that are similar to other active mines in the region, such as the adjacent Northshore Mine. However, these visual disturbances would occur in an area that, as shown in Figure 5.2.11-1, is currently vegetated.

In addition to the new visible components of the Mine Site and Plant Site (see below), mine construction, operations, and closure would likely generate some visible diesel and fugitive dust emissions from mine vehicles. Construction and closure emissions would likely be difficult to discern from the Skibo Vista Overlook and other distant viewpoints (see Section 5.2.7 for more details on anticipated emissions). As with the mine facilities themselves, construction emissions would generally be difficult to see from closer viewpoints due to the screening effect of terrain and vegetation.

Visual conditions are subjective and based in part on individual preferences. While many viewers consider any substantial disturbance of the existing landscape to be undesirable, some viewers find industrial sites visually compelling. While much of northeast Minnesota's recreation and tourist economy is based on high-quality wildlife, wilderness, and vegetation, there are distinct mine-related tourism resources. The Low SIO of the federal lands associated with the Mine Site indicates that the Mine Site is an area where evidence of management activities may dominate the view.

Following the completion of the mining activities, the PolyMet reclamation plan would remove all buildings and facilities at the Mine Site, and would revegetate disturbed areas with an approved vegetation mix. The Category 1 Stockpile would remain in place, and would also be vegetated, to the degree possible. This structure would be noticeable above the treeline, especially in winter, as shown in Figure 5.2.11-1. However, other similar stockpiles are found throughout the region. Over time, this feature would take on the appearance of a vegetated hill, and would blend in with the overall landscape.

No substantial changes are anticipated to the visual character of the Plant Site during NorthMet Project Proposed Action operations. The NorthMet Project Proposed Action would use, update, and expand existing infrastructure at the former LTVSMC processing plant, including an expanded Tailings Basin, additional hydrometallurgical processing facilities, and refurbished mill buildings. Figure 5.2.11-2 shows the current view of the Plant Site from Skibo Overlook. New structures constructed as a result of the NorthMet Project Proposed Action would not be

visible from the overlook. During operations, steam plumes from the Plant Site would be visible under certain conditions, particularly from distant viewpoints such as Skibo Vista. To the degree that existing processing buildings are refurbished or removed (as appropriate), the NorthMet Project area would create the appearance of an active, maintained industrial site, rather than the current dilapidated appearance.

The Tailings Basin is visible to rural residences on County Road 358, located approximately 1 mile to the north of the Plant Site. The NorthMet Project Proposed Action would raise the elevation of Cells 1E and 2E to approximately the same elevation as the existing Cell 2W. The hydrometallurgical residue cells would raise the elevation on the southern portion of Cell 2W by about 40 feet. These changes would not be out of character with the existing Tailings Basin, although the low silhouette of the Tailings Basin on the southern horizon would be noticeably expanded.

Through the closure process, all buildings and facilities at the Plant Site would be removed. At-grade (or below-grade) slabs and foundations will remain and will be covered with surface overburden. Most structures would be removed within three years of the start of closure, except for water treatment facilities necessary to maintain post-closure water quality standards. The Plant Site would be revegetated and seeded to promote a self-sustaining community of regionally-appropriate vegetation. As a result, the visual appearance of the Plant Site during and following closure would evolve rapidly from the operations-phase industrial character to a vegetated area that progressively becomes indistinguishable from adjacent vegetated areas.

5.2.11.3 NorthMet Project No Action Alternative

5.2.11.3.1 Recreation

Under the NorthMet Project No Action Alternative, the NorthMet Project Proposed Action would not be developed. The Mine Site would remain unchanged, and the USFS would continue to retain surface rights to the federal lands that comprise portions of the Mine Site. Given other private ownership (e.g., the Transportation and Utility Corridor), the federal lands would remain generally inaccessible to the public. There would be no direct or indirect effects on recreational activities at the Mine Site or the region's surrounding recreational resources. Under the NorthMet Project No Action Alternative, the NorthMet Project Proposed Action would not be developed, and the Plant Site would remain off-limits to the public for recreation or other uses.

5.2.11.3.2 Visual Resources

Under the NorthMet Project No Action Alternative, the NorthMet Project Proposed Action would not be developed, and would retain the Low SIO assigned by USFS. The Mine Site would remain unchanged, and there would be no effects on visual resources at the Mine Site. Under the NorthMet Project No Action Alternative, the NorthMet Project Proposed Action would not be developed. The former LTVSMC process facility would be reclaimed, including building removal, in accordance with a separate closure plan. Reclamation activities could create a short-term disruption of the visual landscape, while long-term effects would be to reduce the developed nature of the site sooner than under the NorthMet Project Proposed Action.



PLANT SITE



Figure 5.2.11-2
Photo Simulation - View of Plant Site from Skibo Overlook
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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5.2.12 Wilderness and Other Special Designation Areas

Designations such as Wilderness or RNAs emphasize higher restrictions on human activity and access, while other designations, such as historic landmarks or scenic byways, emphasize management that seeks to enhance public enjoyment of certain spaces. Evaluation of the effects on each type of designation considered how each set of characteristics or management objectives would be changed by the NorthMet Project Proposed Action or the project alternatives. Potential effects could occur due to mining activity or due to changes in other human activity resulting from mining activity. No specific issues related to wilderness or special designations area were identified during public scoping. As discussed in Section 4.2.12, for the purposes of this analysis, the term “wilderness” is defined by the Wilderness Act of 1964 (Public Law 88-577) (16 USC § 1131-1136) of 1964. In its planning, management, and monitoring, the USFS identifies four characteristics of wilderness, as defined in the Wilderness Act: Untrammeled, Undeveloped, Natural, and Solitude or a Primitive and Unconfined Type of Recreation.

Summary

The NorthMet Project Proposed Action would have no direct effects on wilderness or special designation areas. Air quality and water quality in these areas would be virtually unchanged from existing conditions; distance from activities associated with the NorthMet Project Proposed Action would leave ambient noise levels also unchanged. The absence of these direct effects means that there would be no indirect effects on wildlife, vegetation, or aquatic species. There could be a minimal effect on the Skibo Vista Scenic Outlook along the Superior National Forest Scenic Byway and therefore an associated indirect effect on recreation.

5.2.12.1 Methodology and Evaluation Criteria

This section uses data presented in Section 4.2.12 for all wilderness or special designation areas (including state parks) within a 25-mile radius of the NorthMet Project area. While no direct effects on wilderness character are anticipated due to changes in air quality, water quality or noise, recreation opportunities could be indirectly affected because of a small change in visual character.

For land that is or would be controlled by the USFS, the recreation evaluation criteria of the ROS system were used to determine indirect project effects (see Section 5.2.11.1.1).

5.2.12.2 NorthMet Project Proposed Action

5.2.12.2.1 Federally Managed Areas

Table 5.2.12-1 lists the federally managed wilderness and other special designation areas within or adjacent to the NorthMet Project area and indicates significant features that would have the most bearing on the potential effects of the NorthMet Project Proposed Action.

Table 5.2.12-1 Federally Managed Wilderness and Other Special Designation Areas located within or Adjacent to the NorthMet Project Area

Special Designation Area	Distance (miles) to the NorthMet Project Area	Significant Feature
Boundary Waters Canoe Area Wilderness	25	Laurentian Divide
Voyageurs National Park	20	Laurentian Divide
Research Natural Areas		
Big Lake-Seven Beavers cRNA	12	Watershed, topography, vegetation
Keeley Creek RNA	25	Watershed, topography, vegetation
Dragon Lake cRNA	25	Watershed, topography, vegetation
Unique Biological Areas		
Little Isabella River UBA	25	Watershed, topography, vegetation
Harris Lake National Natural Landmark	20	Watershed, topography, vegetation
National Historic Landmark		
Soudan Iron Mine	18	Topography, vegetation
National Recreation Trail		
Taconite State Trail	15-17	Topography, vegetation

The table shows that all of the federally managed areas would be well-removed from activities related to the NorthMet Project Proposed Action and generally would be screened by intervening topography and vegetation.

The NorthMet Project Proposed Action has demonstrated that effects associated with Class I Increment, visibility and sulfur dioxide effects on flora and fauna were all well below their respective significance levels at all Class I areas, including the BWCAW and Voyageurs National Park. In addition, all sulfur dioxide and sulfur deposition relating to terrestrial and aquatic settings were well below “green light” significance levels in these areas. Total nitrogen deposition effects approach their significance levels at the BWCAW (see Section 5.2.7.2.2).

Due to the presence of the Laurentian Divide, there will be no direct effects to waters of the BWCAW or Voyageurs National Park. The NorthMet Project area is in the Lake Superior Basin, while these two Class I areas are to the northeast of the Laurentian Divide where streams and rivers flow to the Hudson Bay Basin.

As described in Section 5.2.8, daytime noise standards for sensitive receptors would not be reached beyond 0.8 mile from the Mine Site and 0.5 mile from the Plant Site. The nighttime noise standards would not be exceeded beyond 2.3 miles from the Mine Site and 1.5 miles from the Plant Site. The BWCAW and Voyageurs National Park, as well as the rest of the specially designated areas within 25 miles of the NorthMet Project area are all located at distances much greater than these ranges and so would not be expected to be directly affected by NorthMet Project Proposed Action-related noise. Nighttime views from the BWCAW toward the NorthMet Project area and nearby towns are such that light from the NorthMet Project Proposed Action would be indistinguishable from other sources of illumination.

The RNAs, cRNAs, and UBAs are also in watersheds not affected by the NorthMet Project Proposed Action so there will be no direct or indirect effects on surface water or groundwater in these areas. Topography and vegetation again screen these areas from view of the NorthMet Project Proposed Action-related activities so there are no direct effects on visual resources or indirect effects on recreation.

By virtue of distance, as well as topography and vegetation, the Taconite State Trail will experience neither direct nor indirect effects from the NorthMet Project Proposed Action.

By virtue of distance, topography, watershed, or vegetation, none of the four characteristics of Wilderness defined above (Untrammelled, Undeveloped, Natural, and Solitude or a Primitive and Unconfined Type of Recreation) would be affected by the NorthMet Project Proposed Action.

5.2.12.2.2 State-Managed Areas

Table 5.2.12-2 shows that all of the state-managed wilderness and other special designation areas would be well-removed from activities related to the NorthMet Project Proposed Action and generally would be screened by intervening topography and vegetation.

Table 5.2.12-2 State-Managed Wilderness and Other Special Designation Areas located within or Adjacent to the NorthMet Project Area

Special Designation Area	Distance (miles) to the NorthMet Project Area	Significant Feature
Boundary Waters Canoe Area Wilderness	25	Laurentian Divide
State Parks		
Soudan Underground Mine State Park	18	Watershed, topography, vegetation
Lake Vermilion State Park	16	Watershed, topography, vegetation
Iron Range Off-Highway State Park	11	Watershed, topography, vegetation
Bear Head Lake State Park	17	Watershed, topography, vegetation
National Historic Landmark		
Soudan Iron Mine	18	Topography, vegetation
National Scenic Byway		
Superior National Forest Scenic Byway	9	Topography, vegetation

All of the state parks have been shown to be in areas where predicted concentrations would be below secondary air standards that are designed to protect public welfare, including decreased visibility and damage to animals, crops, and vegetation. None of the state parks are within watersheds potentially affected by the NorthMet Project Proposed Action, so there would be neither direct effects on water quality nor indirect effects on aquatic species or wetlands.

Topography and vegetation screen the parks from view of the activities within NorthMet Project area, so there would be no direct effects on visual resources and no indirect effects on recreation.

The Superior National Forest Scenic Byway is at a distance where it is unaffected by project-related noise. Similar to other specially designated resources, there will be no direct or indirect effects due to air quality or water quality. Most of the Byway is screened from view of the NorthMet Project Proposed Action by topography and vegetation. However, from Skibo Vista Scenic Overlook, which is approximately 12 miles south-southwest of the Mine Site, a portion of the stockpiles would be visible above the treeline. This direct effect would also mean a potentially small indirect effect on recreation.

By virtue of distance, topography, watershed, or vegetation, none of the four characteristics of Wilderness defined above (Untrammelled, Undeveloped, Natural, and Solitude or a Primitive and Unconfined Type of Recreation) would be affected by the NorthMet Project Proposed Action.

5.2.12.3 NorthMet Project No Action Alternative

Under the NorthMet Project No Action Alternative, the NorthMet Project Proposed Action would not be developed. The NorthMet Project No Action Alternative presents no anticipated effect on the BWCAW, Voyageurs National Park, established and candidate RNAs, UBAs, National Historic Landmarks, the Superior National Forest Scenic Byway, and a National Recreation Trail, as the Mine Site and portions of the federal lands would continue to be managed in the same way they have been.

5.2.13 Hazardous Materials

Issues relating to the presence of hazardous materials or waste may include the accidental release of these materials during transportation, storage, handling, and/or use at the NorthMet Project area and any resulting potential effects on the environment. Environmental resources that could potentially be affected by hazardous materials and hazardous waste if they are accidentally released include: air, water, soil, and ecological resources. The APE therefore corresponds to the areas defined for each specific resource.

The NorthMet Project Proposed Action would use, or generate as waste, the following hazardous materials (Barr 2007e; Kevin Pylka, PolyMet, Pers. Comm., October 19, 2011; Kevin Pylka, PolyMet, Pers. Comm., May 11, 2012):

- fuels, equipment maintenance products, and solvents – diesel fuel, gasoline, oils, grease, lubricants, anti-freeze, solvents, and lead-acid batteries used for equipment operation and maintenance;
- plant reagents – sodium hydrosulfide, sodium hydroxide, acids, flocculants, and antiscalants used in processing plant applications;
- Mine Site WWTF chemicals – calcium hydroxide (hydrated lime), sodium metasilicate, ferric chloride, sodium hydroxide, polymer flocculent, carbon dioxide liquid, citric acid, and sodium hypochlorite;
- Plant Site WWTP chemicals – potassium permanganate, antiscalant, carbon dioxide liquid, and calcium hydroxide (hydrated lime);
- blasting agents – ANFO, emulsions, emulsion blends (a blend of ANFO and emulsion), blasting caps, initiators and fuses, and other high explosives used in blasting; and
- other materials – assay chemicals, and other by-products characterized as hazardous waste.

Mishandling of these materials or wastes could result in spills, accidental release, or discharge into the environment, which could cause effects on workers, waters of the state, or the general public. Mitigation measures to prevent releases in transportation, storage, and handling or use of these materials are described in several hazardous material management plans necessary to comply with various regulatory requirements for the NorthMet Project Proposed Action. The following sections present the methodology and criteria used to estimate the risks to the public and environment from the use of hazardous materials and the generation of hazardous waste during the construction, operation, and closure phases of the NorthMet Project Proposed Action. The presentation is broken down into the major activities of transportation, storage, and handling and use.

Summary

Materials defined as hazardous are a routine part of mining and ore processing. Their handling, storage, and disposal are regulated by a number of state and federal laws. Adherence to these will limit the potential for off-site effects on only the transport of large quantities of hazardous materials. Transport routes have been defined that limit the potential for effects on population centers and sensitive resources. Given overall project design and operational commitments, there

will be no significant adverse effects from the proposed use or generation of hazardous wastes by the NorthMet Project Proposed Action.

5.2.13.1 Evaluation Criteria

Several criteria are generally used in federal and State of Minnesota regulations and statutes to define the effects from an accidental spill, release, or discharge of contaminants or hazardous material or waste to the environment. The basic principle of these criteria is the protection of people and the environment. Based on this principle, the NorthMet Project Proposed Action would have an environmental effect if the following were to occur:

- a spill, release, or discharge of any hazardous material or hazardous waste during transportation that, if not recovered in a timely manner, could cause pollution of waters of the state, or other harm to the environment or to the public;
- a spill, release, or discharge of any hazardous material or hazardous waste during handling or use, which could cause pollution of waters of the state, or other harm to the environment or to the public;
- hazardous emissions from handling of any hazardous materials or hazardous waste that have the potential to cause harm to the public or the environment; and
- a spill, release, or discharge from on-site storage facilities exceeding the volumes of the primary and secondary containment structures, and which could not be recovered in a timely manner, and thus pollute waters of the state or cause other harm to the environment or to the public.

5.2.13.2 NorthMet Project Proposed Action

Federal and State of Minnesota regulations establish management and reporting requirements for hazardous materials. Based on current design, applicable administrative rules and statutes include the following:

- *Minnesota Statute 115.061 – Duty to Notify and Avoid Water Pollution (Minnesota Statutes, chapter 115, Water Pollution Control; Sanitary Districts);*
- *USEPA 40 CFR 302 – Designation, Reportable Quantities, and Notification, Section 6 – Notification Requirements (USEPA 40 CFR 300–399, Superfund; Emergency Planning; Community Right-to-Know Programs);*
- *USEPA 40 CFR 355 – Emergency Planning and Notification, Subpart C – Emergency Release Notification (USEPA 40 CFR 300–399, Superfund; Emergency Planning; Community Right-to-Know Programs);*
- *USEPA 40 CFR 355–372 – EPCRA (USEPA 40 CFR 300–399, Superfund; Emergency Planning; Community Right-to-Know Programs);*
- *USEPA 40 CFR 112 – Oil Pollution Prevention (USEPA 40 CFR 100–149, Water Programs);*
- *USEPA 40 CFR 68 – Chemical Accident Prevention Provisions (USEPA 40 CFR 70–99, Air Programs II);*

- USEPA Clean Air Act, Section 112(b) – Hazardous Air Pollutants (42 USC chapter 85, Air Pollution Prevention and Control);
- OSHA 29 CFR 1910.120 – Hazardous Waste Operations and Emergency Response (OSHA 29 CFR 1900–1910);
- DOT 49 CFR 100–180 – Hazardous Materials Transportation (Hazardous Materials Transportation 49 CFR 100–180, Chapter I, Pipeline and Hazardous Materials Safety Administration, DOT);
- MSHA Rule 30 CFR Part 47 Hazard Communication (Mine Safety Administration 30 CFR 1–199);
- *Minnesota Statutes*, Chapter 115 and Chapters 115A–115E – Water Pollution Control, through Oil and Hazardous Substance Discharge Preparedness (*Minnesota Statutes*, chapter 115, Water Pollution Control; Sanitary Districts);
- *Minnesota Rules*, Chapter 7151 – Aboveground Storage of Liquid Substances (*Minnesota Rules*, MPCA, chapter 7151);
- *Minnesota Rules*, Chapters 7045–7048 – Hazardous Waste (*Minnesota Rules*, MPCA, chapter 7045–7048);
- *Minnesota Rules*, Chapters 7507 and 7513 – Hazardous Materials (*Minnesota Rules*, MPCA, chapter 7507–7513);
- *Minnesota Rules*, Chapter 7035 – Solid Waste (*Minnesota Rules*, MPCA, chapter 7035); and
- *Minnesota Rules*, Chapter 6132 – Nonferrous Metallic Mineral Mining (*Minnesota Rules*, Department of Natural Resources, chapter 6132).

A list of the larger quantity hazardous materials transported, stored, handled, recycled, or disposed, and their classifications, that will be associated with the NorthMet Project Proposed Action construction, operation, and closure is provided in Table 5.2.13-1. The estimated delivery frequency, volumes, and annual use of these materials are also listed in Table 5.2.13-1.

Table 5.2.13-1 Hazardous Materials used during Construction, Operation, and Closure Phases of the NorthMet Project Proposed Action

Material	Classifications & Precautions**	Environmental Concern	Storage Capacity	Deliveries (Estimated Frequency)		Annual Use (Est.)
				Means	Approximate Rate	
ANFO	Explosive 1.1D or 1.5D: Irritant to skin and eyes. May cause nausea if ingested and irritation to nose and throat if ingested.	Harmful to aquatic life at low concentrations.	No on-site storage. Vendor provided on a daily basis.	Vendor/truck	883,333 lbs/month	10,600,000 lbs/year
Booster (solid - cord sensitive)	Explosive 1.1D: Eye irritant. Skin irritant. Inhalation of dust may cause irritation, sneezing or coughing.	May cause elevated nitrate levels in water and could affect aquatic animals.	No on-site storage. Vendor provided on a daily basis.	Vendor/truck	1,555/month	18,650/year
Emulsion	Explosive 1.5D: Eye irritant. May be harmful if ingested. Inhalation may cause dizziness, nausea, or intestinal upset.	May cause elevated nitrate levels in water and could affect aquatic animals.	No on-site storage. Vendor provided on a daily basis.	Vendor/truck	387,500 lbs/month	4,650,000 lbs/year
Diesel fuel	Flammable: Continued exposure to vapors can irritate eyes and lungs. Potentially fatal if ingested.	Any spill or release may cause adsorption to sediment and soil and may cause a visible sheen or deposit of a sludge or emulsion if released to surface waters creating a hazard for plants and animals.	<u>Mine:</u> 3 - 12,000 gal or 2 - 20,000 gal <u>Locomotives:</u> 15,000 gal <u>Plant:</u> 12,000 gal	Tanker truck (volume/ tanker truck = 5,500-9,000 gal)	74 tanker truck loads/month	<u>Mine:</u> 5,910,000 gal/year <u>Plant:</u> Uncertain, but relatively minor <u>Locomotives:</u> 473,040 gal/year
Grease (385 lbs/55-gallon drum)	Mild skin irritant, ingestion may cause discomfort.	Spill or release may cause adsorption to sediment and soil and may cause a visible sheen or deposit of a sludge or emulsion if released to surface waters creating a hazard for plants and animals.	Existing bulk storage at Area 1 and Area 2 Shops.	55-gal drums	<1 truck/month	<u>Mine:</u> Unknown <u>Plant:</u> Uncertain, but relatively minor <u>Locomotives:</u> 16 lb/year – each locomotive

Material	Classifications & Precautions**	Environmental Concern	Storage Capacity	Deliveries (Estimated Frequency)		Annual Use (Est.)
				Means	Approximate Rate	
Lubricating oil	Minimal health hazards.	Spill or release may cause adsorption to sediment and soil and may cause a visible sheen or deposit of a sludge or emulsion if released to surface waters creating a hazard for plants and animals.	<u>Mine:</u> 2,000 gal <u>Plant:</u> 2 – 7,000 gal 2 – 12,000 gal 1 – 12,338 gal	Tanker truck (typically <3,000 gal/tanker truck)	2 tanker truck loads/month	<u>Mine:</u> 47,000 gal/year <u>Plant:</u> Uncertain, but relatively minor <u>Locomotives:</u> 200 gal/year – each locomotive
Transmission oil	Minimal health hazards.	Spill or release may cause adsorption to sediment and soil and may cause a visible sheen or deposit of a sludge or emulsion if released to surface waters creating a hazard for plants and animals.	<u>Mine:</u> 1,500 gal	Tanker truck (typically <3,000 gal/tanker truck)	< 2 loads/month	<u>Mine:</u> 33,000 gal/year
Hydraulic oil	Minimal health hazards.	Spill or release may cause adsorption to sediment and soil and may cause a visible sheen or deposit of a sludge or emulsion if released to surface waters creating a hazard for plants and animals. Bio-accumulation is unlikely due to the very low water solubility; bio-availability to aquatic organisms is minimal.	<u>Mine:</u> 2,000 gal <u>Plant:</u> 2 - 2,500 gal	Tanker truck (typically <3,000 gal/tanker truck)	< 1 load/month	<u>Mine:</u> 13,000 gal/year <u>Plant:</u> Uncertain, but relatively minor
Coolant (ethylene glycol mix)	Harmful or fatal if swallowed; eye, skin, and respiratory irritant.	Practically non-toxic to aquatic organisms on an acute basis.	<u>Mine:</u> 600 gal <u>Plant:</u> 6,000 gal	55-gal drums and tanker truck (typically <3,000 gal/tanker truck)	1 delivery/month	<u>Mine:</u> 12,000 gal/year <u>Plant:</u> Uncertain, but relatively minor

Material	Classifications & Precautions**	Environmental Concern	Storage Capacity	Deliveries (Estimated Frequency)		Annual Use (Est.)
				Means	Approximate Rate	
Gasoline (light vehicles)	Flammable; harmful or fatal if swallowed; eye, skin, and respiratory irritant.	Spill or release may cause adsorption to sediment and soil and may cause a visible sheen or deposit of a sludge or emulsion if released to surface waters creating a hazard for plants and animals.	<u>Plant:</u> 2 - 6,000 gal	Tanker truck (typically <3,000 gal/tanker truck)	2 deliveries/month	<u>Plant:</u> 500 gal/day or 178,000 gal/year
Degreaser	Skin and eye irritant, potential inhalation hazard.	Spill or release may cause adsorption to sediment and soil and may cause a visible sheen or deposit of a sludge or emulsion if released to surface waters creating a hazard for plants and animals. Should not be released undiluted into the environment.	<u>Plant:</u> 1 - 400 gal 1 - 2,500 gal	55-gal drums and/or tanker truck (typically <3,000 gal/tanker truck)	As needed to keep full; < 1 delivery/month	Uncertain, likely less than 15,000 gal/year
Used oil	Minimal health hazards.	Spill or release may cause adsorption to sediment and soil and may cause a visible sheen or deposit of a sludge or emulsion if released to surface waters creating a hazard for plants and animals.	55-gal drums or storage tank	Not Applicable	Removed from site as needed typically by vendor with bulk tank truck; approximately 2 times/month	<u>Mine:</u> 47,000 gal/year <u>Plant:</u> Uncertain, but relatively minor <u>Locomotives:</u> 200 gal/year – each locomotive
Caustic (NaOH) (assume 10.7 lbs/gal)	Skin and eye irritant, corrosive.	No known environmental effects.	1,100-gal storage tank	Tanker truck (typically <3,000 gal/tanker truck)	1 load/month	64 t/year
Flocculant (MagnaFloc 10)	Inhalation irritant.	No known environmental effects.	1,875-lb bulk bags	Freight truck	1 truck/2 months	16.5 t/year
Flocculant (MagnaFloc 342)	Low overall toxicity.	Toxic to some species of fish if released into waters.	1,875-lb bulk bags of powder	Freight truck	< 1 truck/month	26 t/year

Material	Classifications & Precautions**	Environmental Concern	Storage Capacity	Deliveries (Estimated Frequency)		Annual Use (Est.)
				Means	Approximate Rate	
Flocculant (MagnaFloc 351)	Low overall toxicity.	No known environmental effects.	1,875-lb bulk bags of powder	Freight truck	<1 truck/month	179 t/year
Sulfuric acid (assume 15 lbs/gal)	Skin and eye irritant, corrosive.	Toxic to some species of fish if released into waters.	78,700-gal storage tank with secondary containment	Bulk rail tank car (13,000-gal or 98-t capacity)	2 tank cars/year	138 t/year
Hydrochloric acid (assume 10 lbs/gal)	Skin and eye irritant, corrosive.	If released into the soil, this material is not expected to biodegrade and may leach into groundwater.	59,500-gal storage tank with secondary containment	Bulk rail tank car (13,000-gal or 65-t capacity)	2 tank cars/month	1,485 t/year
Liquid sulfur dioxide	Extremely corrosive to exposed tissues, DOT poison gas, corrosive.	Toxic to some plants and animals if released into waters.	30,000-gal pressurized storage tank with secondary containment	Bulk rail tank car (15-55 t/car)	2 tank cars/month	1,254 t/year
Sodium hydrosulfide (assume 11 lbs/gal)	Extremely corrosive to exposed tissues. Contact with acid releases toxic gas. DOT corrosive.	Toxic to aquatic organisms if released into waters.	52,600-gal storage tank	Tanker truck (volume/tanker truck = 5,500-9,000 gal;	< 1 tanker/month	334 t/year
Potassium amyl xanthate (PAX)	DOT spontaneously combustible. Mild irritant. Heating and moisture produces H ₂ S, a toxic gas.	Toxic to animals in large quantities. Contact with water liberates extremely flammable gases, which can cause rapid burning and release of toxins into the air.	~30,000-gal storage tank	1,650-lb bulk bags, 25 bags/truck load	~5 trucks/month	1,075 t/year
Methyl isobutyl carbinol (assume 6.72 lbs/gal)	Flammable liquid.	This material is readily biodegradable and practically not bio-accumulable and is slightly adsorptive in soils and sediments. Practically non-toxic to aquatic animals if released into waters.	~10,000-gal storage tank	Tanker truck (volume/tanker truck = 5,500-9,000 gal)	~ 6 trucks/month	1,124 t/year
Limestone	Harmful if swallowed; eye, skin, and respiratory irritant.	Airborne particulates may cause some harm to environment dependent on concentrations.	Bulk - stockpiled on-site	Bulk rail car (70-110 t/rail car)	Up to 100 rail cars/week from April to October	87,341 t/year

Material	Classifications & Precautions**	Environmental Concern	Storage Capacity	Deliveries (Estimated Frequency)		Annual Use (Est.)
				Means	Approximate Rate	
Lime	Eye and skin irritant; harmful if swallowed. Avoid breathing vapor or dust.	Possibly hazardous in the short term. Degradation products are not likely; however, long term degradation products may arise.	Bulk - lime silo	Freight truck (20 – 25 t/truck)	15 loads/month	5,181 t/year
Magnesium hydroxide	Harmful if swallowed; eye, skin, and respiratory irritant.	Possibly hazardous in the short term. Degradation products are not likely; however, long term degradation products may arise.	Storage tank	Bulk rail car (65 – 104 t/rail car)	3 tank cars/month	3,674 t/year
Grinding metals (metal alloy grinding rods and balls)	Harmful if swallowed; eye and respiratory irritant, if fine particles.	Airborne particulates may cause some harm to environment dependent on concentrations.	None required	Bulk rail car (100 t/rail car)	13 rail cars/month	15,600 t/year
Flotation activators (copper sulfate)	Harmful if swallowed; eye and respiratory irritant.	Toxic to fish and plants if released into waters.	9,200-gal activator storage tank	Reuse from Oxidation Autoclave	Not applicable	650 t/year
Ferric chloride (35%)	Very hazardous if ingested; corrosive to eyes and skin; respiratory irritant.	Mutagen; harmful to fish and invertebrates; reproductive effects, low potential for bio-accumulation; no information regarding environmental fate or toxicity.	6,000- and 1,000-gal storage tank	Tanker truck (typically <3,000 gal/tanker truck)	1,200 gal/month	14,400 gal/year
Potassium permanganate	Eye and skin irritant; respiratory irritant.	Mutagen; ecological information not available.	Bulk (dry)	Freight truck	1,300 lbs/month	16,000 lbs/year
Liquid carbon dioxide	Gas is an asphyxiant; prolonged skin or eye contact to gas, liquid or solid (crystals) may cause severe frostbite.	No adverse effects; carbon dioxide does not contain Class I or II ozone depleting chemicals.	Bulk (liquefied gas)	Tanker (cylinder) truck	105 t/month	1250 t/year

Note: t = short tons; equal to 2,000 lbs.

The United Nations hazard classification system for classifying explosive materials and explosive components is recognized internationally and is used universally by the United States Department of Defense, United States Department of Energy (USDOE) contractors, and the DOT. UN numbers however, are different from the hazard class and division designations used by the DOT.

Hazard Classification 1.1D and 1.5D: 1.1 is a Hazard Class division for Class 1 (Explosives) and is defined as a Mass Detonation Hazard. It is expected that if one item in a container or pallet inadvertently detonates, the explosion will sympathetically detonate the surrounding items. The explosion could propagate to all or the majority of the items

stored together, causing a mass detonation. There will also be fragments from the item's casing and/or structures in the blast area. Hazard Class division 1.5 is an Explosive substance, very insensitive (with a mass explosion hazard).

The "D" is the Class 1 Compatibility Group defined as the secondary detonating explosive substance or black powder or article containing a secondary detonating explosive substance, in each case without means of initiation and without a propelling charge, or article containing a primary explosive substance and containing two or more effective protective features (UNO 2012).

**Precautions are described as indicated by NIOSH (2012), or those described in chemical-specific Material Safety Data Sheets (MSDSs) (Montana Refining Company 2011), (Dow 2009), (EDS 2009a), (CSCC 2005), (EDS 2009b), (Praxair Technology 2009b), (Flottec 2009), (Martin Marietta Materials 2007), (Western Lime Corporation 2009), (AluChem 2010), (Old Bridge Chemicals 1999), (H-Valley Chemical 2006), (ClearTech Industries 2010), and (Praxair Technology 2009a).

Material, Storage Capacity, Delivery Means, Delivery Approximate Rate, and Annual Use Estimate (Kevin Pylka, PolyMet, Pers. Comm., October 19, 2011), (Kevin Pylka, PolyMet, Pers. Comm., May 11, 2012)).

5.2.13.2.1 Transportation

All hazardous materials would be transported by commercial carriers in accordance with state and federal hazardous material shipping requirements. Such carriers would be licensed and inspected by the Minnesota DOT. Tanker trucks would possess a Certificate of Compliance issued by the Minnesota Motor Vehicle Division. These permits, licenses, and certificates would be the responsibility of the carrier. Federal regulations (49 CFR) require that all shipments of hazardous materials be properly identified and placarded. Shipping documents must be accessible and include MSDSs that describe the hazardous material, immediate health hazards, fire and explosion risks, immediate precautions, fire-fighting information, procedures for handling leaks or spills, first aid measures, and emergency response telephone numbers.

Hazardous waste would also be transported from the Mine Site and Plant Site for proper disposal. Transportation of these wastes would require compliance with state and federal regulations that include requirements for hazardous waste manifests with the shipments, labeling, and/or use of placards, and emergency information. PolyMet employees would be trained to manage all wastes in accordance with their specific job duties. Transportation of hazardous waste would be conducted by vendors also licensed and trained to manage hazardous waste.

As identified in Table 5.2.13-1, trucks would be used to transport a variety of hazardous materials to the Mine Site and Plant Site. Shipments of hazardous materials would originate from a number of locations. The risk of accidental truck spills was evaluated using two representative hazardous materials, diesel fuel and PAX, due to the relatively large number of deliveries and health risks associated with these materials (Rhyne 1994). Approximately 74 tanker truck loads of diesel fuel and 5 truckloads of PAX would be delivered monthly. These quantities would amount to approximately 17,800 and 1,200 shipments of diesel fuel and PAX, respectively, based on 20 years of estimated mine life.

For this evaluation, materials were assumed to be shipped from Duluth. These materials would be transported approximately 60 miles along State Highway 53 (four-lane divided highway) from Duluth to Eveleth, and then approximately 20 miles along State Highways 37 and 135 (two-lane highways) from Eveleth to the North Gate access road to the site. This route would take the materials through the towns of Duluth, Twig, Independence, Canyon, Cotton, Central Lakes, Eveleth, Gilbert, Biwabik, and Pineville and across the Cloquet, Whiteface, St Louis, and Embarrass rivers and Paleface Creek. These state highways already provide transportation routes for freight that includes hazardous materials and waste. St. Louis County Emergency Services are available for response to incidents associated with hazardous materials due to the current transport of these materials from existing businesses that use hazardous materials or generate hazardous waste within their operations. Emergency response services vary from medical rescue and ambulance services to fire-fighting and local HazMat-trained response teams stationed in various cities or districts along the defined transportation route. The locations of emergency response services are identified in multiple sectors within the county as defined by the St. Louis County Hazard Mitigation Plan prepared by the St. Louis County Emergency Management division of the St Louis County Sheriff's Office (St. Louis County 2005). The County HazMat Response Team is stationed in Duluth.

The effect of an accidental release would depend on the location in relation to population, local activities, the quantity released, environmental factors, and the nature of the released material. The probability of an accidental release of the representative hazardous materials described above during transportation was calculated using the Federal Highway Administration truck accident statistics model (Rhyne 1994) as presented in Table 5.2.13-2. The definition of hazardous materials, per the Minnesota Hazardous Materials and Uniform HazMat Registration Program is, “a substance or material capable of posing unreasonable risk to health, safety, and property when transported in commerce, as determined by the US Secretary of Transportation.” According to these statistics, the average rate of truck accidents for transport along a rural interstate highway, such as State Highway 53, is 0.64 per million miles traveled. For rural two-lane highways, such as State Highways 37 and 135, the average truck accident rate is 2.19 accidents per million miles traveled.

Table 5.2.13-2 Release Probability of Representative Materials Transported during Construction, Operation, and Closure Phases of the NorthMet Project Proposed Action

Material Transported	Rural State/Interstate Highway (four lane)						Rural State Highway (two lane)						
	No. of Truck Deliveries	Haul Distance (Miles)	Accident Rate Per Million Miles Traveled	Calculated Number of Accidents	Probability of Release Given an Accident (%)	Calculated Number of Spills	No. of Truck Deliveries	Haul Distance (Miles)	Accident Rate Per Million Miles Traveled	Calculated Number of Accidents	Probability of Release Given an Accident (%)	Calculated Number of Spills	Combined Total Estimated Release (Freeway and Rural Two- Lane)
Diesel Fuel	17,800.0	60.0	0.64	0.68352	18.8	0.12850	17,800.0	20.0	2.19	0.77964	18.8	0.14657	0.27
PAX	1,200.0	60.0	0.64	0.04608	18.8	0.00866	1,200.0	20.0	2.19	0.05256	18.8	0.00988	0.018

Source: Federal Highway Administration truck accident statistics model (Rhyne 1994).

The probability of a release or spill was based on accident statistics for liquid tankers carrying hazardous materials. The Federal Highway Administration statistics indicate that on average, 18.8 percent of the total accidents involving liquid tankers carrying hazardous materials resulted in a spill or release.

Using the accident and liquid tanker spill statistics, the evaluation indicates that the probability for an accidental release of liquids under truck transport during the life of the NorthMet Project Proposed Action is less than one spill accident for each of the representative materials considered. The release probability indicates there is a 1.8 percent probability of an accident resulting in a release of PAX, and a 27 percent probability of an accident resulting in a release of diesel fuel that could occur over the entire 20-year life of the NorthMet Project Proposed Action. The higher probability of a diesel fuel accident is due to the greater expected number of diesel fuel deliveries to the site.

The odds of a potential release of hazardous materials during a transportation accident would incrementally increase if the other shipments listed in Table 5.2.13-1 were included. An accidental release could range from a minor oil spill at the Mine Site and Plant Site, where cleanup equipment would be readily available, to a severe spill during transport involving a large release of diesel fuel or other hazardous material, where emergency cleanup equipment would not be readily available. Some of the chemicals could have immediate adverse effects on water quality and aquatic resources if a spill were to enter a surface water body. Considering the overall risk of an accident involving a spill, and the anticipated transport routes, the probability of a spill into a waterway would be moderate. An alternative transportation route, shorter by about 17 miles, was evaluated but rejected because of its close proximity to water bodies such as Wild Rice and Island lakes. The transportation route selected for this evaluation is longer, but is farther away from waterbodies, so in the event that an accidental spill or release of materials occurs, it could be managed in a more timely manner to reduce the likelihood of environmental harm. A shorter route could be used, but the probability of effect on a water body would be greater due to the proximity of the waterbodies.

A large-scale release of hazardous liquids delivered to the site by tanker truck (9,000-gallon capacity) or rail car (up to 13,000-gallon capacity)—such as diesel fuel, acid, or other hazardous materials—could have implications for public health and safety. The location of the release would again be the primary factor in determining potential effects. As indicated in Table 5.2.13-2, the probability of a release anywhere along a proposed transportation route was calculated to be low. Review of the Hazmat Intelligence Portal of the U.S. DOT indicates that the likelihood of a bulk rail incident is 40 percent less than that of a highway incident (PHMSA 2012b). The likelihood of a rail incident, when all incidents are included, is 82 percent less than that of a highway incident (PHMSA 2012a).

In addition to location, the potential harm presented by the material released is a factor in determining the effect of a release. A qualitative evaluation of the materials to be shipped indicates that the probability of causing harm is low for most materials. For example, though ANFO is an explosive, it will only detonate under specific conditions, such as when ignited with detonators, heat, or a sudden shock wave in a confined space. Caustic soda is corrosive and can be fatal if ingested or has prolonged contact with the skin; however, in a spill situation, emergency response would be undertaken to prevent or minimize exposure, such as restricting site access and immediate containment and removal. In the event of a release during transport, the commercial transportation company would be responsible for first response and cleanup.

Local and regional law enforcement, fire protection, and emergency planning agencies would also mobilize to secure the site and protect public safety.

In the event of an accident involving the release of hazardous material, 49 CFR requires that the carrier notify local emergency response personnel, the National Response Center (for discharge of reportable quantities of hazardous materials) (Hazardous Materials Transportation 49 CFR 100–180, Chapter I, Pipeline And Hazardous Materials Safety Administration, DOT). Minnesota Statutes require notification of the Minnesota State Duty Officer (Minnesota Statutes, chapter 115, Water Pollution Control). PolyMet and its hazardous material handlers and/or DOT-regulated contractors would be required to comply with these and similar regulatory requirements, which also stipulate emergency planning and response actions.

5.2.13.2.2 Storage

The approximate capacities of hazardous material storage tanks that would be at the NorthMet Project area are listed in Table 5.2.13-1. Mobile tanker trucks may be used on site to fuel and maintain haul trucks, mobile equipment, and locomotives. The number of these trucks and their capacities would be based on NorthMet Project Proposed Action specifications. Tanks and vessels would be positioned on approved secondary containment with interior sumps to route spilled products or process solutions to lined collection areas. In addition, hazardous materials would be unloaded on an approved containment surface with sumps to route spills to lined collection areas. Some of the hazardous material storage tanks at the Mine Site would be double-walled for provision of secondary containment. Mine Site hazardous material storage tanks without double-walls and Plant Site hazardous material storage tanks would be designed to have secondary containment sufficient to hold at least 110 percent of the volume of the largest tank in the containment area. Waste materials such as used motor oil, hazardous waste, and spent hazardous materials would be managed by PolyMet employees while on-site, and shipped off-site for recycling or disposal using a DOT-licensed transporter. In addition, fire assay wastes—including cupels, crucibles, and slag—would be managed by PolyMet employees while on site and shipped off site for recycling or disposal at a licensed facility using a DOT-licensed transporter. Certain materials may be stored on-site for a period before shipment. These materials would be stored in compliance with safety storage requirements as dictated by state and federal requirements. The storage period would also comply with Minnesota and federal storage timeline stipulations. All stored wastes would be appropriately labeled and dated for timeline inspection purposes.

5.2.13.2.3 Handling and Use

Over the life of the NorthMet Project Proposed Action, the probability of minor spills of oils and lubricants would be relatively high. Releases could occur during operations because of a poor connection of an oil or hydraulic line, or as the result of equipment failure. Effects of such minor spills could include contamination of surface water and soil; however, spills of this nature would likely be small, localized, and contained.

Some of these spills may be reportable. In Minnesota, spills or discharges of more than 5 gallons of petroleum products or any quantity of chemicals or materials, whether accidental or otherwise, are required by law to be reported to the Minnesota State Duty Officer at the MPCA, by the person with control of the spill, which, if not recovered, may cause pollution of waters of the state. The responsible NorthMet Project Proposed Action person is required to recover as rapidly

and thoroughly as possible such spilled material, and take immediate action as reasonably possible to minimize or abate pollution of waters of the state (*Minnesota Statutes*, section 115.061, Duty to Notify and Avoid Water Pollution).

Emergency release notification requirements under EPCRA (USEPA 40 CFR, chapter 355) exist in addition to the release notification requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (USEPA 40 CFR, chapter 302). If the NorthMet Project Proposed Action had a release of a CERCLA hazardous substance, it would be required to comply with the notification requirements of EPCRA, and the release notification requirements of CERCLA. If the reportable quantity of a substance were released within a 24-hour period at the NorthMet Project area, and the substance was on the list of extremely hazardous substances under EPCRA or the list of CERCLA hazardous substances (USEPA 40 CFR, chapter 302.4), then PolyMet would be subject to reporting requirements described in 40 CFR 355.60, 40 CFR 302, and the Emergency Notification Procedures in Minnesota as required by Title III of the Superfund Amendments and Reauthorization Act (USEPA 40 CFR, chapters 300 to 399).

The requirements for storage of oils and lubricants, including the requirement for spill prevention, control, and countermeasure (SPCC) planning are found in the Oil Pollution Prevention Act (USEPA 40 CFR, chapter 112) and MN § 115E (Minnesota Statutes, chapter 115, Water Pollution Control; Sanitary Districts). Applicable Minnesota Statutes include: Prevention and Response Plans (Section 115E.04), Response Plans for Tank Facilities (Section 115E.045, Subdivision 2), and Responses to Releases (Section 115C.03). A list of hazardous material management and response plans is presented in Table 5.2.13-3.

Table 5.2.13-3 Hazardous Material Management Plans

Plans	Applicable Statute/Regulation	Materials/Applications
SPCC Plan	USEPA 40 CFR chapter 112	Oil/petroleum spills
Toxic Pollution Prevention Plan (TPPP)	Minnesota Statutes, chapter 115D Subdivision 1(a) USEPA 40 CFR 260 - 279	Waste minimization, handling, storage, disposal, recycling of hazardous substances, chemicals, fluids, and other wastes. Transportation of hazardous materials.
	DOT 49 CFR	
Hazard Communications Standards	MSHA Rule 30 CFR Part 47	Evaluation of the hazards of chemicals mines produce or use and the provision of information to miners.
Emergency Response Plan	OSHA 29 CFR 1910.120 USEPA 40 CFR 68	Hazardous material release response guidance.
Spill Prevention/Response Plan	29 CFR 1910.120/CAA Section 112 Minnesota Statutes, chapter 115E (may also be applicable to trucking vendors)	General guidance Minnesota state guideline for responding to spills and releases.
Risk Management Program	USEPA 40 CFR 68	Hazard assessment, accident history, prevention program and training, and emergency response program.

The threshold quantity, as defined in 40 CFR 112, for triggering the requirement for development of a SPCC plan is 1,320 gallons of petroleum products in bulk container storage greater than 55 gallons. Since the NorthMet Project area would have more than 1,320 but less than 1,000,000 gallons of oil storage, an SPCC plan would be required under 40 CFR 112. The primary goal of an SPCC plan is to develop strategies to prevent oil spills from reaching Minnesota and United States waters. An SPCC plan is thus specific to each facility, providing persons responsible for planning emergency response site-specific information such as a description of facilities, storage information, preventative measures, response action, equipment, and contact information. An SPCC plan must also provide information for routine facility inspections.

To reduce the likelihood of incidental spills of petroleum products, a preliminary SPCC plan has been prepared for the NorthMet Project Proposed Action. The plan identifies potential emergencies that may arise during operations or an activity within the NorthMet Project area. The plan establishes a framework to respond effectively to the identified potential emergencies.

The final SPCC plan would include procedures, methods, equipment, and other requirements to prevent discharges of oil from facilities, and to contain such discharges, should they occur. The SPCC plan would also contain a detailed, facility-specific description of how the operations comply with the requirements of the Oil Pollution Prevention regulation (USEPA 40 CFR, Part 112). The SPCC plan would address measures such as secondary containment, facility drainage, dikes and barriers, sump and collection systems, retention ponds, curbing, tank corrosion protection systems, liquid level devices, and emergency shut-off or release alarms. The final SPCC plan must be certified by a Professional Engineer that in their professional judgment the following are true:

- the SPCC plan is adequate for the facility;
- technical standards have been considered;
- inspections and tests are adequate for the facility; and
- the SPCC plan has been prepared in accordance with good engineering practices, including consideration of applicable industry practice.

A final SPCC plan is not possible for the NorthMet Project Proposed Action until construction has been completed. However, PolyMet has prepared a preliminary SPCC plan that is compliant with 40 CFR 112 requirements.

The policies and procedures set forth in the SPCC plan, inclusive of PolyMet's Standard Operating Procedure for Storage Tank Management, would be prepared to comply with *Minnesota Rules*, Chapter 7151, Aboveground Storage of Liquid Materials.

The preliminary SPCC plan would be finalized and certified by a Professional Engineer, as required, after petroleum storage and handling facilities have been constructed. Based on current planning information, the final SPCC plan would need to address at least the following areas or activities involving petroleum and other oils:

- a truck fueling station;
- remote fueling activities (i.e., at the equipment operating location);
- ASTs;

- large-quantity oil-filled equipment;
- locomotive fueling (at Area 2); and
- a gasoline fueling station (at the main gate).

The fueling station would consist of an enclosed building for fueling, including floor drain sumps and holding tanks for collection of spills. The holding tanks would be cleaned out, as needed, by a contractor with appropriate certification or license, and the waste would be transported to a recycling, treatment, or disposal facility. One fueling station would typically be provided to fuel all mobile equipment with rubber tires (trucks, dumps, front end loaders, dozers, etc.). This equipment also may be fueled in place by remote fuel tankers. Remote fueling typically would be conducted for equipment located within the mine pits and at material stockpiles (e.g., excavators, dozers, and other tracked equipment). Portable spill clean-up kits would be available at the fueling stations and on the fuel tankers. Standard operating procedures, including spill response plans, would be prepared and associated training would be conducted for fueling operations. Equipment would be attended during fueling operations. When possible, remote fueling would not be performed near sensitive areas, where, if a release were to occur, surface water could be affected. At final design stage, an updated or final version of the current SPCC plan would be prepared for the NorthMet Project Proposed Action facilities, to address specific spill response, cleanup, release notifications, etc. For oil-filled equipment, an appropriate containment system would be constructed so that discharge from a primary containment system would not escape the containment system before cleanup occurs. Alternatively, facility procedures and a contingency plan would be established that define inspections and/or a monitoring program to detect equipment requiring service or failure, and/or discharge. ASTs would be located at the truck fueling station where fuel storage would meet secondary containment standards. The tanks would have a containment dike with membrane, or a concrete enclosure to contain leaks or spills. As previously indicated, double-walled ASTs would not require secondary containment.

The SPCC documents, along with manufacturer MSDSs, would be available in all areas where hazardous materials were expected to be used or produced, and at all areas of fuel and lube-oil storage.

5.2.13.2.4 Emergency Planning and Community Right-to-Know

Management of hazardous materials at the NorthMet Project area would be governed by a number of interrelated federal, state, and local regulations, as listed in the first part of this Hazardous Materials Section. The following discusses federal and Minnesota state actions under EPCRA, including its emergency response-planning activities, Hazardous Chemical Inventory Reporting (Tier II) requirements, and Toxics Release Inventory (TRI) reporting requirements. Minnesota's hazardous materials regulations are codified in the *Minnesota Rules*, chapters 7507 and 7513, and in Minnesota Statute, chapter 299K.

As required by EPCRA, Minnesota has established the Minnesota Emergency Response Commission (ERC), an agency within the Minnesota Department of Public Safety, Division of Homeland Security and Emergency Management. The Minnesota ERC coordinates information specific to hazardous materials at facilities around the state so that local emergency officials are able to prepare for emergencies. The Minnesota ERC serves as the repository for the EPCRA hazardous chemical inventory reports (Tier II reports). Along with the listing of hazardous

materials identified on Table 5.2.13-1, PolyMet would prepare and submit Tier II Emergency and Hazardous Chemical Inventory Report Forms for sodium hydroxide, hydrochloric acid, sodium hydroxide, sulfuric acid, and SO₂, and would be subject to reporting additional hazardous materials or chemicals maintained on-site in quantities greater than the Tier II reporting thresholds.

The Minnesota ERC also collects data from facilities reporting under the federal TRI report program mandated by SARA Title III, Section 313. The NorthMet Project Proposed Action would be subject to TRI reporting based on the quantities of sulfuric acid and SO₂ to be maintained at the NorthMet Project area and could include others depending on actual quantities.

Under the federal Pollution Prevention Act of 1990, facilities subject to TRI reporting must also provide information on the pollution prevention and recycling activities associated with the reported toxic chemicals. The NorthMet Project Proposed Action would be subject to Minnesota's Toxic Pollution Prevention Act (Minnesota Statutes, section 115D.07), and PolyMet would have to prepare a TPPP. The TPPP would describe the facility's processes and operations, and set objectives for the handling, storage, and disposal or recycling of hazardous materials and toxic chemicals to eliminate or reduce at the source, the use, generation, or release of toxic pollutants, hazardous substances, materials, and hazardous wastes.

Under the federal CAA Amendments of 1990 Section 112(r), the NorthMet Project Proposed Action would be subject to the Accidental Release Prevention/Risk Management Plan rule, based on the projected use of hydrochloric acid and other flammable and toxic substances (42 USC, chapter 85, Air Pollution Prevention and Control). PolyMet would be required to develop a Risk Management Program that would include:

- hazard assessment and potential effects of an accidental release, accident history, and evaluation of worst-case and accidental release scenarios;
- prevention program including safety precautions, maintenance, monitoring, and training measures; and
- emergency response program detailing emergency health care, training, and procedures for informing the public and response agencies should an accident occur.

The hazardous material management plans include procedures for evacuating personnel, maintaining safety, cleanup, neutralization activities, emergency contacts, internal and external notifications to regulatory authorities, and incident documentation. Proper implementation of the SPCC plan, TPPP, Hazard Communications, Emergency Response Plan, Spill Response Plans, and the Risk Management Program would minimize the incidents and effects associated with potential releases of hazardous materials.

If present, other hazardous or potentially hazardous materials or wastes would be characterized and managed per the hazardous materials management plans described in Table 5.2.13-3 above, and, if applicable, would adhere to the requirements defined in *Minnesota Rules*, chapter 7045, Hazardous Waste.

5.2.13.3 Potential Mitigation Measures

Mitigation of a hazardous material release would follow the principle of prevention, minimization, and treatment. Prevention would be achieved when any hazardous material was avoided, where possible, by replacing it with a substitute material that was not hazardous. To the extent possible, this has been done; where not possible, precautions to be defined in the TPPP would be taken to properly manage hazardous materials or substances, and keep the potential risk of exposure to a minimum. Accidentally released hazardous material would be treated quickly in accordance with the described plans.

In addition, mitigation processes or procedure definitions would be included in the following:

- hazardous communication materials, through communications and training programs;
- overfill protection procedures;
- provision for secondary containment;
- establishment of leak detection systems;
- preventative inspection and maintenance procedures; and
- emergency response plan.

These measures would be designed to ensure that accidental releases were prevented or minimized, and when they did occur, were responded to quickly and properly.

Monitoring activities proposed for prevention of incidental releases, mitigation, or quick removal of the effects, if hazardous materials were released, include the following:

- regular inspection and testing of storage containers and facilities;
- inspection of vessels for leaks, drips, or loss content of containers;
- verification of locks, emergency valves, and other safety devices, protective equipment, and floors;
- regular checks on the operability of emergency systems;
- periodic awareness training for employees;
- maintaining MSDSs at visible locations for easy access at all times; and
- regular monitoring of surface water and groundwater quality.

Monitoring and inspection would be an integral part of the hazardous material management processes at the NorthMet Project area.

Given current project design and operational commitments, this analysis did not identify significant adverse effects from proposed hazardous materials use or hazardous waste generation by the NorthMet Project Proposed Action. Therefore, no additional mitigation measures are proposed.

5.2.13.4 NorthMet Project No Action Alternative

The NorthMet Project No Action Alternative has no risk of environmental effect since no hazardous materials would be used, and no hazardous waste would be generated under this alternative.

5.2.14 Geotechnical Stability

The geotechnical stability of the proposed large-scale material storage facilities for the NorthMet Project Proposed Action is addressed in this section. These facilities are the waste rock stockpiles that would be created at the Mine Site; the Tailings Basin, which would be constructed on top of the existing LTVSMC Tailings Basin; and the Hydrometallurgical Residue Facility, which would be constructed at the existing LTVSMC Emergency Basin.

This section provides a summary of the required design criteria and the methodology and results of the iterative model and design process, as well as an overview of the proposed monitoring and mitigation measures.

Summary

Conceptual designs of the waste rock stockpiles, Tailings Basin, and Hydrometallurgical Residue Facility have been developed and shown by PolyMet, through an iterative design and model process, to meet the minimum safety factors and water quality criteria (see Section 5.2.2) acceptable to the Co-lead Agencies. The slope stability and liner integrity of these facilities would be monitored throughout operations and long-term closure. This approach would allow for identification of a need to implement adaptive mitigation measures as a contingency to further improve stability should the facilities perform differently from their designed and predicted performance.

5.2.14.1 Methodology and Evaluation Criteria

The direct environmental consequences of the proposed large-scale waste material storage facilities, including the disturbance footprint and water effects, are discussed under the respective environmental factors in Chapter 5.0. This section addresses the slope stability and liner integrity of the proposed facilities.

If incorrectly designed, constructed, and/or managed, or from other unforeseen circumstances, waste material storage facilities would have the potential to result in increased hydrologic and/or water quality effects and may be unstable (potentially leading to slope or dam failure).

The large-scale waste material storage facilities proposed for the NorthMet Project Proposed Action would require compliance with MDNR, nonferrous mining, and dam safety rules, as well as the MPCA NPDES/SDS Permit. The Dam Safety permit requires that design and safety criteria be met to reduce the risk of potential failure.

The design of geotechnical features is typically developed using an iterative design and model approach where the design is amended until modeling results meet the required minimum design criteria, including Factors of Safety and other requirements for permitting. Factor of Safety is used to describe the ratio of resisting forces to driving forces along a potential failure surface, whereby a Factor of Safety of 1.0 represents equilibrium between the estimated resisting shear strength to the applied shearing load. Systems are often designed to a Factor of Safety above 1.0 to allow for unexpected loads, unexpected operating conditions, and variations in estimated material properties.

The specific design and minimum required Factor of Safety criteria for the proposed large-scale waste materials storage facilities and the methodology applied to develop the designs of the

proposed facilities in order to meet these criteria are discussed for each facility in the respective sections below.

The potential effects of hypothetical failure scenarios have not been assessed in this SDEIS, as the risk of failure is mitigated through application of design and safety requirements including adaptive management procedures.

5.2.14.2 NorthMet Project Proposed Action

5.2.14.2.1 Waste Rock Stockpiles

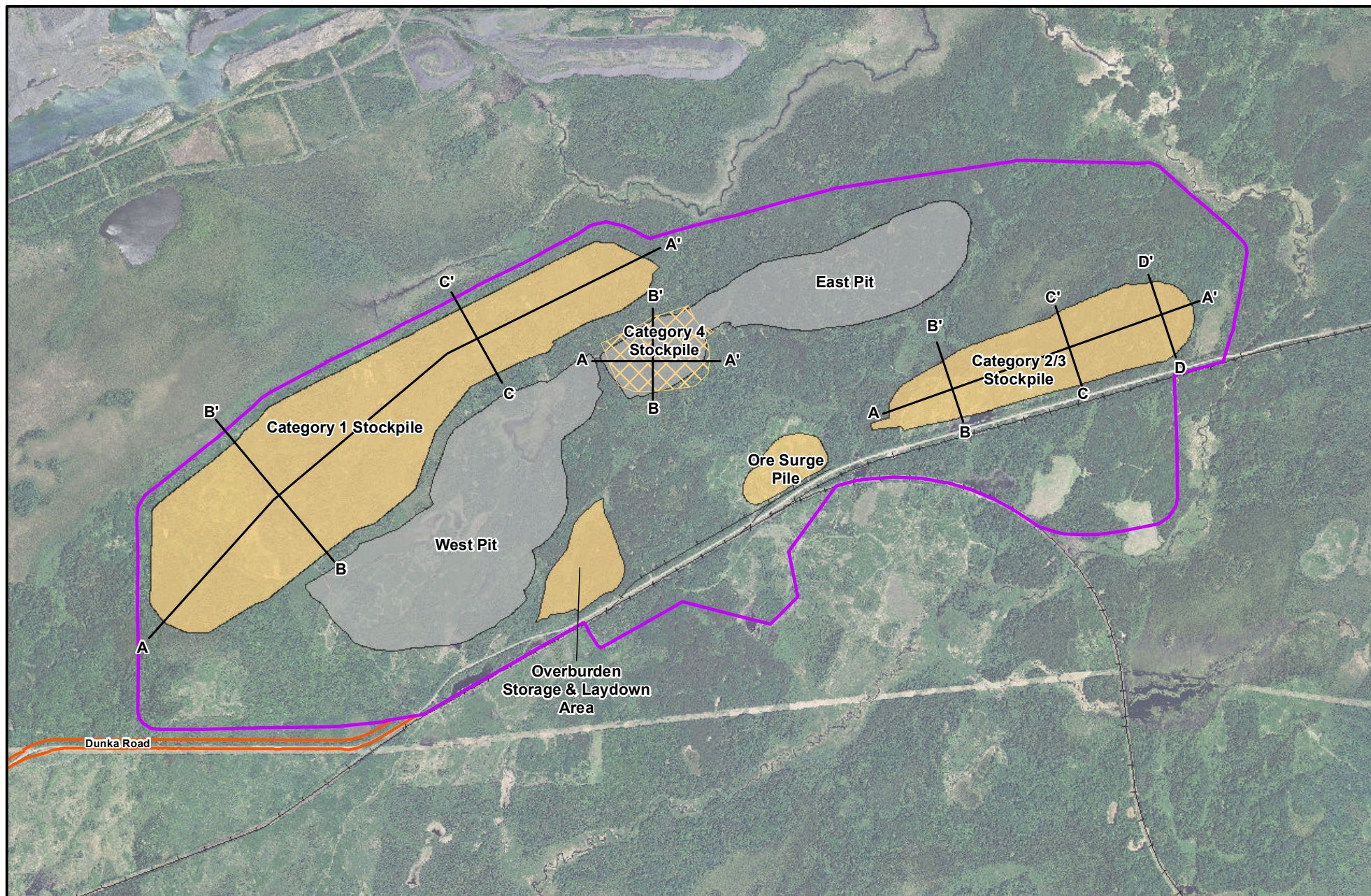
The proposed large scale waste material storage facilities at the Mine Site are:








- a permanent waste rock stockpile for Category 1 waste rock, and
- temporary stockpiles for Category 4 waste rock, combined Category 2/3 waste rock, and an Ore Surge Pile.

In addition to the stockpiles above, PolyMet would also prepare an Overburden Storage and Laydown Area that would be used for temporarily stockpiling overburden prior to its use.

PolyMet expects that the NorthMet Project Proposed Action would produce approximately 308 million tons of waste rock over the life of mine. Waste rock would be categorized and managed based on its potential to oxidize. The least reactive Category 1 waste rock would be placed into a permanent stockpile, while Category 2/3 waste rock and Category 4 waste rock would be stored in temporary stockpiles before being placed as backfill into the East Pit after year 11. The location of the stockpiles is shown in Figure 5.2.14-1. The total weight of waste rock stored in a permanent stockpile (Category 1 Stockpile) would be approximately 168 million tons (see Section 3.2.2.1.7).

The data inputs, evaluation methodology, results, and design and operating requirements for the stockpiles were reported in Geotechnical Data Package Volume 3 Version 2 (PolyMet 2012p) and reviewed by the Co-lead Agencies.



- | | |
|---|---|
|  Mine Site |  Stockpile Cross-Section |
|  Active Stockpile |  Transportation and Utility Corridor |
|  Category 4 Stockpile |  Existing Railroad |
|  Mine Pit | |

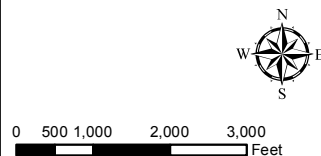


Figure 5.2.14-1
Mine Site Plan - Year 11
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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Design Criteria

Waste rock stockpiles must be designed to comply with *Minnesota Rule* 6132.2400 (stockpile slopes are required to meet *Minnesota Rule* 6132.2400 Subp. 2. B. and stockpile foundations are required to meet *Minnesota Rule* 6132.2400, Subpart 2. A. (1)). These are design requirements that have been established to attain acceptable slope stability safety factors for global stability and acceptable foundation stability, the latter of which relates to the capability of the geomembrane liner system to withstand the strain anticipated due to differential settlement that may occur in the stockpile foundation materials.

The NorthMet Geotechnical Modeling Work Plan (PolyMet 2013n, Attachment A) requires PolyMet to perform stockpile subgrade settlement analysis to predict magnitude of deformation and resulting strain in the stockpile liners for comparison to allowable strain in the liner system. Allowable strains are material-specific and would be determined from manufacturers specifications for the materials selected for the stockpile liners.

Methodology

In order to demonstrate that the design of the stockpiles would meet the geotechnical requirements, PolyMet completed the following:

- collected existing conditions data needed to support foundation design (refer to Section 4.2.14);
- configured stockpile slopes to meet or exceed the minimum dimensional requirements established by *Minnesota Rules* 6132.2400;
- conducted a stockpile subgrade settlement analysis to predict the magnitude of deformation and resulting strain in the stockpile liners for comparison to allowable strain in the liner system;
- completed slope stability analyses using RocScience's limit equilibrium program SLIDE; and
- developed the stockpile design and operating requirements necessary to maintain required slope stability safety factors and liner performance requirements.

Design

Various design specifications have been established and used for the stockpile analysis (PolyMet 2012p). The following is a summary of the design characteristics applied and considered in geotechnical evaluation.

The Category 1 Stockpile has been designed as follows:

- to be permanent;
- to have a maximum lift height of 40 ft, bench width of 30 ft, and initial slopes between benches at the angle of repose of the waste rock, as specified in *Minnesota Rule* 6132.2400;
- progressive reclamation including grading (3.75(H):1(V) regraded interbench slopes), contouring, and covering during operation; and
- a permanent geomembrane surface cover (at closure).

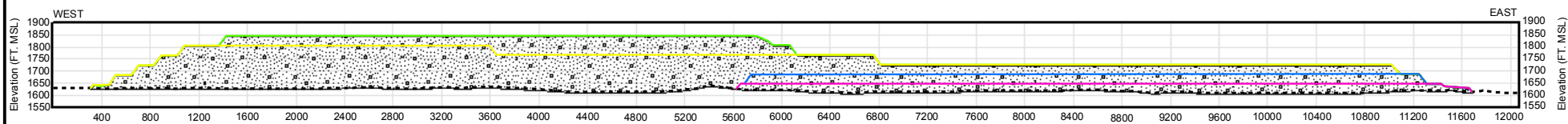
The Category 2/3 Stockpile, Category 4 Stockpile, and the Ore Surge Pile have been designed for the following:

- to be temporary;
- to be lined with a LLDPE geomembrane;
- to have an underdrain system (minimum grade of 0.5 percent), as required; and
- to have an overliner drainage system (minimum grade of 0.5 percent).

Cross sections of the proposed stockpiles are shown in Figure 5.2.14-2 and Figure 5.2.14-3.

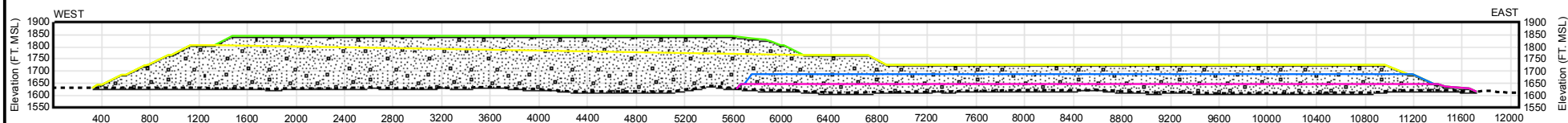
The stability model (SLIDE) assumed a geomembrane liner interface friction angle (i.e., the strength that the geomembrane possesses for resisting sliding against the adjacent earthen material) of 15.7 degrees or greater. Further geotechnical investigation and laboratory testing is required to verify the liner interface shear strength values as placed against potential borrow materials, as well as the shear strength parameters for the foundation and stockpile materials prior to construction. To mitigate associated uncertainty, PolyMet commits to remove all unsuitable foundation soils from beneath lined stockpiles and replace them (where required) with structural fill to meet strength and grade requirements (PolyMet 2013n). PolyMet also commits to undertaking further geotechnical investigations prior to the construction of the stockpiles to define the foundation management needs.

Temporary stockpiles at the Overburden Storage and Laydown Area have not been included in stability analysis given their temporary nature and relatively small size.



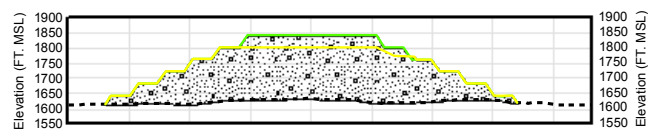
A: Operational Configuration Section

0 400 800
Horizontal Scale in Feet
2X Vertical Exaggeration



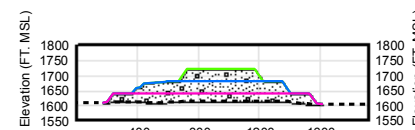
A: Reclamation Configuration Section - Interbench Slopes 3.75H:1V

0 400 800
Horizontal Scale in Feet
2X Vertical Exaggeration



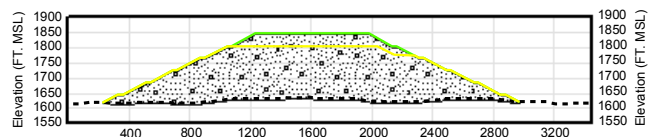
B: Operational Configuration - West Section

0 400 800
Horizontal Scale in Feet
2X Vertical Exaggeration



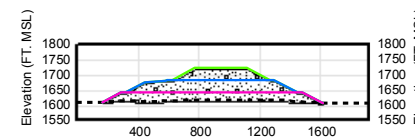
B: Operational Configuration - East Section

0 400 800
Horizontal Scale in Feet
2X Vertical Exaggeration



B: Reclamation Configuration - West Section, Interbench Slopes 3.75H:1V

0 400 800
Horizontal Scale in Feet
2X Vertical Exaggeration



B: Reclamation Configuration - East Section, Interbench Slopes 3.75H:1V

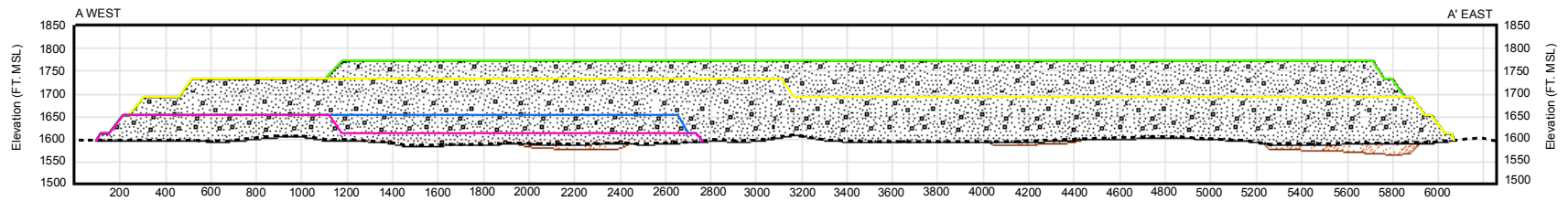
0 400 800
Horizontal Scale in Feet
2X Vertical Exaggeration

- Year 1
- Ultimate Extent
- Year 2
- Existing Ground Surface
- Year 11

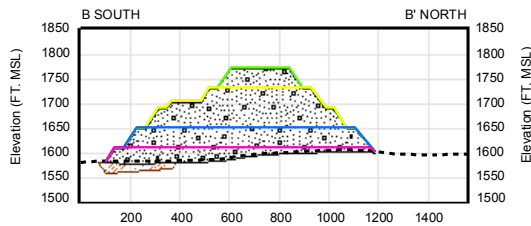


Figure 5.2.14-2
Cross Sections of the Proposed Category 1 Stockpile
NorthMet Mining Project and Land Exchange SDEIS
Minnesota

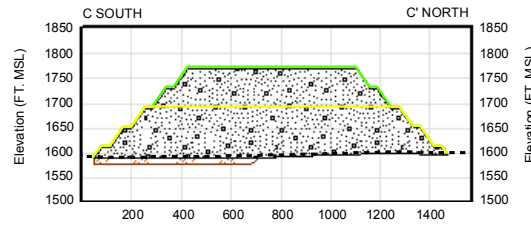
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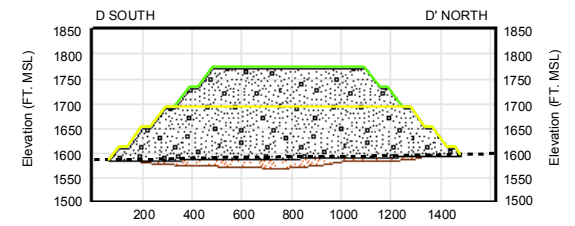
A: Category 2/3 Stockpile
2:1 Vertical Exaggeration



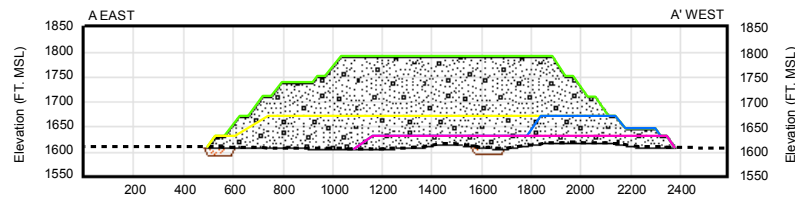
B: Category 2/3 Stockpile
2:1 Vertical Exaggeration



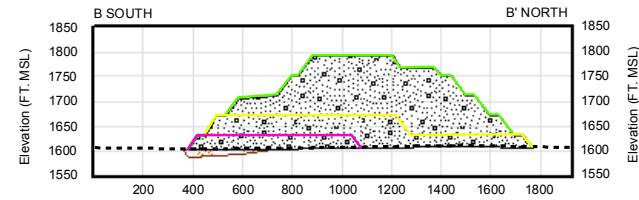
C: Category 2/3 Stockpile
2:1 Vertical Exaggeration



D: Category 2/3 Stockpile
2:1 Vertical Exaggeration



A: Category 4 Stockpile
2:1 Vertical Exaggeration



B: Category 4 Stockpile
2:1 Vertical Exaggeration

Horizontal 0 500 1000
Feet

Vertical 0 250 500
Feet

- Year 1 — Ultimate Extent
- Year 2 — Existing Ground Surface
- Year 11 — Unsuitable Soil Excavation Surface



Figure 5.2.14-3
Cross Sections of the Proposed Category 2/3 and 4
Stockpiles at Maximum Extent
NorthMet Mining Project and Land Exchange SDEIS
Minnesota

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Modeling Results

The results reported in Geotechnical Data Package Volume 3 Version 2 indicate that the proposed design of the stockpiles would meet all required Factors of Safety (PolyMet 2012p). The geotechnical evaluation is summarized below.

Stability

PolyMet undertook a stability analysis of the design cross sections developed to represent the following typical conditions at different phases of stockpile development:

- Temporary Category 2/3 Stockpile, Category 4 Stockpile, and Ore Surge Pile
 1. Initial operational configuration (single lift of waste rock placed in two stages).
 2. Operational configuration at proposed final buildout (excludes the Ore Surge Pile, which would fluctuate).
- Permanent Category 1 Stockpile
 1. Initial operational configuration (a single lift of waste rock with a maximum height of 40 ft placed at the angle of repose).
 2. Operational configuration at proposed final buildout prior to reclamation (assume four lifts of waste rock).
 3. Reclaimed configuration, interbench slopes regraded to 2.5(H):1(V).
 4. Reclaimed configuration, interbench slopes regraded to 3.0(H):1(V).
 5. Reclaimed configuration, interbench slopes regraded to 3.75(H):1(V).
 6. Assuming a liner interface (i.e., overliner material/LLDPE geomembrane liner/soil liner) friction angle of 15.7 degrees or greater.

Results indicated that all sections analyzed met the minimum required Factors of Safety.

Estimated liner strains resulting from foundation settlement are less than 1 percent; well below the 30 percent maximum strain allowed in the LLDPE geomembrane proposed for the geomembrane barrier layer component of the basal liner system for the Category 2/3 Stockpile, Category 4 Stockpile, and the Ore Surge Pile.

Proposed Monitoring, Maintenance, and Mitigation

A Rock and Overburden Management Plan (PolyMet 2012s) has been prepared by PolyMet that includes a description of the operating plans, monitoring procedures, and adaptive management approaches for the stockpiles.

The stockpile quantities would be monitored throughout the life of the mine and the stockpile heights and footprints would be monitored to verify that they are constructed as designed. Monitoring and maintenance of the Category 1 Stockpile would also continue through the post-closure period until the MDNR determines that the cover is stable. An annual compliance report would be developed each year for submittal to the MDNR to comply with the Permit to Mine requirements.

Information gained through ongoing monitoring would also be used to advise adaptive waste management requirements should the capacity of the Category 2/3 Stockpile, the Category 4 Stockpile, and/or the East Pit be insufficient for the mined volume of Category 2/3 and Category 4 waste rock generated by mining. Adaptive waste rock management could include expansion of the waste rock stockpiles. While moving all of the Category 1 waste rock into the West Pit as backfill was eliminated as a potential alternative (refer to Section 3.2.3.4.2), it may be possible to dispose of some excess waste rock or saturated overburden in the West Pit in areas where mining has ceased, if necessary as an adaptive measure.

Each year, an operating plan and annual report would be completed, as required for the Permit to Mine, to keep the Rock and Overburden Management Plan (PolyMet 2012s) current and to track changes in the mine plan, rock type schedule, and characterization of the material. Modifications to the Rock and Overburden Management Plan based on changes to the material characterization would be completed, as necessary.

5.2.14.2.2 Tailings Basin

Tailings from the beneficiation process would be disposed of in a Tailings Basin, constructed on top of Cell 1E and Cell 2E of the existing LTVSMC Tailings Basin. Figure 5.2.14-4 depicts the Tailings Basin at its proposed final elevation (year 20).

The data inputs, modeling methodology, results, and design and operating requirements for the Tailings Basin were reported in Geotechnical Data Package Volume 1 Version 4 (PolyMet 2013n) and Flotation Tailings Management Plan (PolyMet 2013m), which were reviewed by the Co-lead Agencies. The information provided in the data package informs the permitting process and is summarized below.

Design Criteria

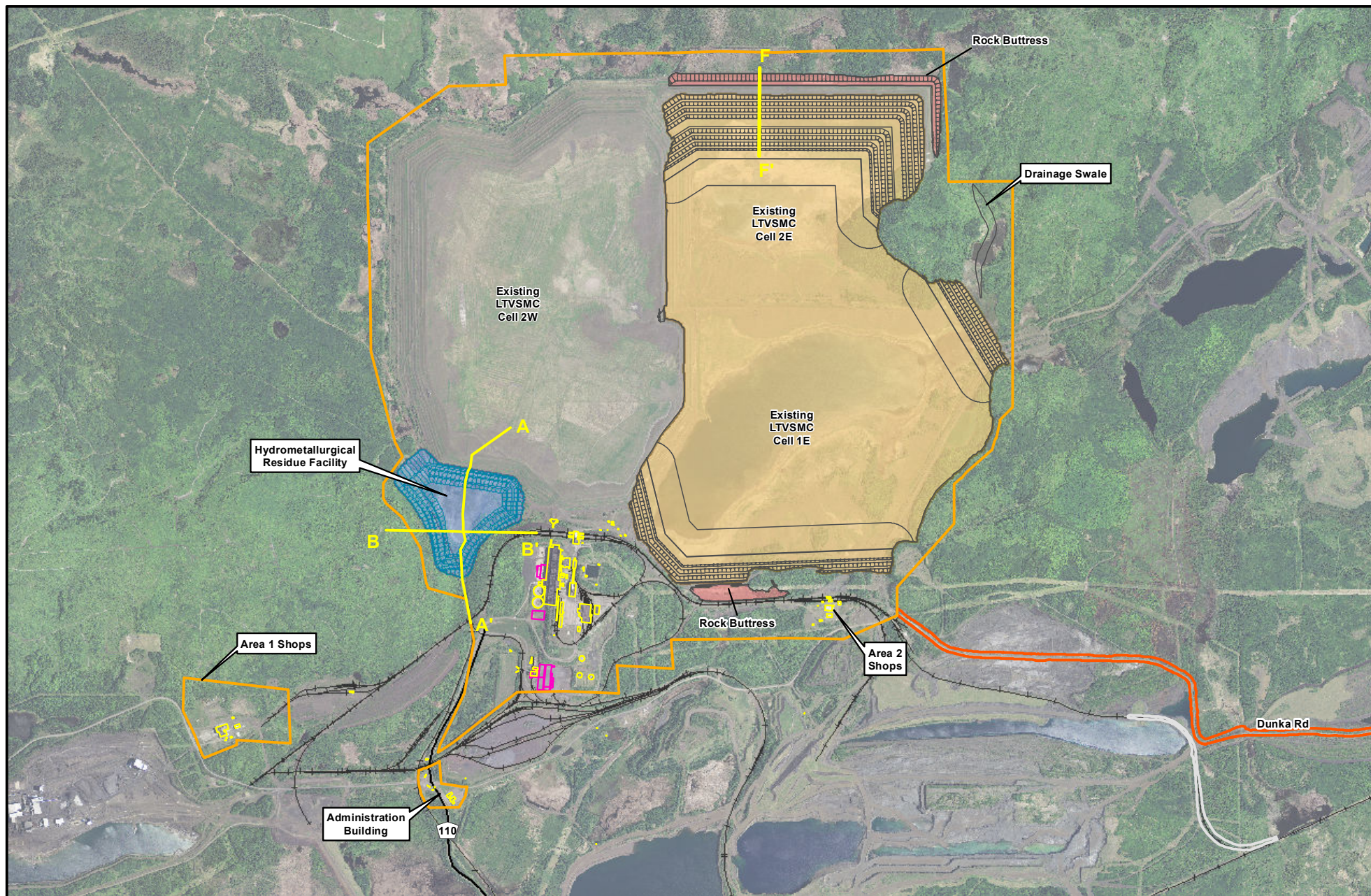
In Minnesota, dams must be constructed in accordance with applicable requirements of *Minnesota Rules* 6115.0300 through 6115.0520. In addition, under the NorthMet Geotechnical Modeling Work Plan (PolyMet 2013n, Attachment A), the Co-lead Agencies require that the critical cross section of the Tailings Basin is demonstrated to meet or exceed the following minimum Factors of Safety as required for various construction and loading scenarios:

- Factor of Safety greater than or equal to 1.5 for effective stress conditions using parameters that reflect long-term, drained strength conditions.
- Factor of Safety greater than or equal to 1.3 for short-term, undrained strength conditions for soils that are not prone to static liquefaction using undrained strength conditions.
- Liquefaction analysis of potentially liquefiable materials in undrained strength conditions including:
 - liquefaction triggering analysis Factor of Safety greater than or equal to 1.1;
 - seismic liquefaction triggering analysis (i.e., induced by seismic event) Factor of Safety greater than or equal to 1.2 (or if the results of deformation modeling is accepted by the Co-lead Agencies if Factor of Safety is greater than 1.0 and less than 1.2); and
 - liquefied scenario (assumes all saturated contractive materials have liquefied) Factor of Safety greater than or equal to 1.10.

These minimum Factors of Safety were selected with consideration for:

- the proposed construction of the Tailings Basin on top of the existing LTVSMC Tailings Basin and the known geotechnical conditions and material characteristics of the existing facility;
- the expected characteristics of the NorthMet Project tailings and construction materials and methods, including long-term wet closure; and
- similar industry standards and other large tailings dams in Minnesota.

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- | | | |
|--------------------|-------------------------------------|-------------------|
| Plant Site | Hydrometallurgical Residue Facility | Railroad Corridor |
| Tailings Basin | Rock Buttrass | Cross-Section |
| Proposed Buildings | Transportation and Utility Corridor | Existing Railroad |
| Existing Building | | |

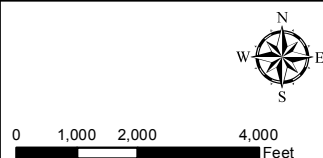


Figure 5.2.14-4
Proposed Plant Site Layout
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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Methodology

In order to demonstrate that the design of the Tailings Basin would meet the respective geotechnical requirements, PolyMet, in accordance with the NorthMet Geotechnical Modeling Work Plan (PolyMet 2013n, Attachment A) took the following steps:

1. Gathered conditions data (i.e., existing basin topography, stratigraphy, soil and tailings strength and hydraulic characteristics [see Section 4.2.14], characteristics of NorthMet tailings based on those produced during the pilot-plant processing, and other data as needed to support geotechnical modeling and Tailings Basin design).
2. Developed Tailings Basin cross sections (i.e., geometry and stratigraphy for existing and planned conditions) for the Tailings Basin for seepage and stability modeling.
3. Developed seepage and stability models using Geo-Slope International, Inc. modeling software (i.e., SLOPE/W, SEEP/W and SIGMA/W as necessary) for various construction and loading scenarios (such as various dam crest and pond surface elevations during construction and closure).
4. Established the geotechnical design data for model input including identification of hydraulic and strength parameters and the triggering potential for static and seismic events of the various tailings material types.
5. Performed modeling and results interpretation.
6. Refined the design and operating requirements necessary until modeling showed that the required slope stability Factors of Safety are achieved for the critical slope cross section.

Design

Various design specifications have been established and used for Tailings Basin geotechnical analysis (PolyMet 2013n). The following is a summary of the design characteristics applied and considered in modeling.

The Tailings Basin would be constructed using the upstream method, whereby NorthMet dam embankments would be constructed using preferentially borrowed LTVSMC tailings on top of the existing LTVSMC tailings embankment and on the spigotted tailings adjacent to the perimeter embankment. NorthMet bulk tailings would be discharged into the new basin by perimeter spigots and a pond barge pump. New dam embankments (using LTVSMC Bulk tailings) would be raised in stages on top of the existing LTVSMC tailings impoundment, and the new tailings are deposited upstream of the dam into the basin from spigots at the dam's edge. Tailings would also be discharged subaqueously in the basin via a barge.

The Tailings Basin incorporates construction of new dam embankments over the existing LTVSMC Tailings Basin Cells 1E and 2E. The design process is an iterative approach whereby various combinations of stabilization factors including slope angle, lift set-back and thickness, intermediate slope bench width, drainage layers beneath the proposed NorthMet tailings, and supporting rock buttresses were modeled to identify a design that would achieve the following:

- provide safe permanent storage of tailings generated over the proposed 20-year operating life of the NorthMet Project Proposed Action and maintain stability post-closure;

- efficiently and effectively recover process water from the surface of the Tailings Basin during operation, and contain groundwater and surface water seepage during operation and over the long term (refer to Section 4.2.2 for more information on water management);
- accommodate the planned wet cover system at closure; and
- meet project regulatory requirements (including Factors of Safety).

As shown in Figure 5.2.14-5, the proposed design consists of eight lifts with a proposed final crest elevation (selected on the basis of tailings storage capacity requirements) modeled as 1,732 ft amsl. This would be an additional 150 ft on top of the existing LTVSMC Tailings Basin Cell 2E. This proposed elevation is similar to the elevation of the existing north dam of Cell 2W, which is at a designed final elevation of 1,735 ft amsl. A schematic cross section of the Tailings Basin is shown in Section 3.2.2.3.5.

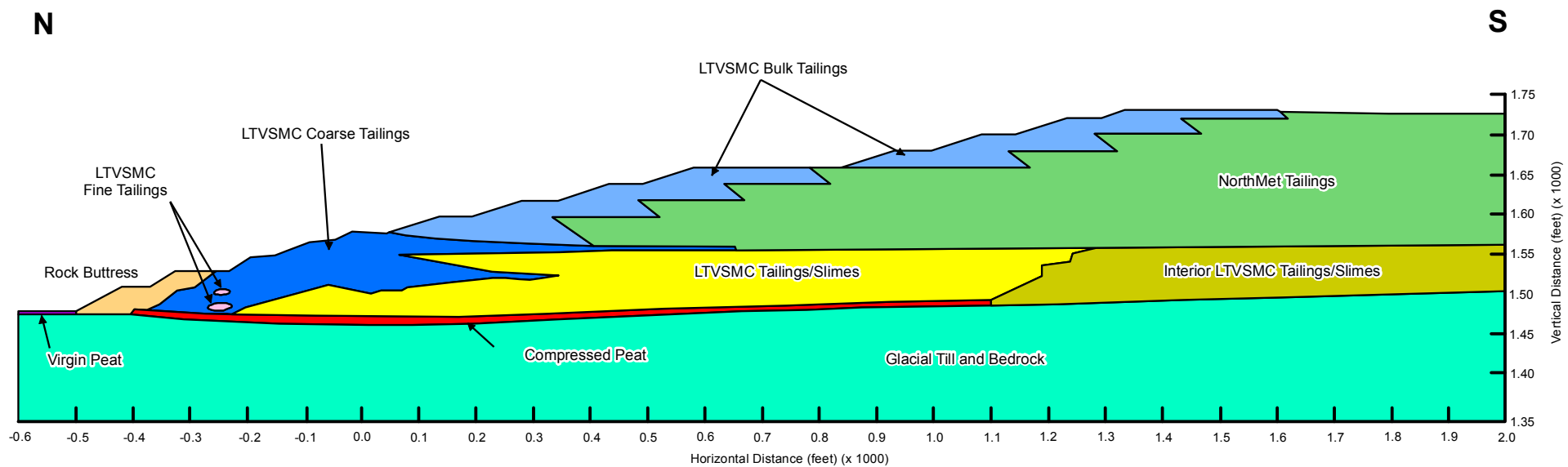
Before placement of tailings, coarse tailings sourced from the existing LTVSMC Tailings Basin would be used to construct a drainage layer to maintain a lowered phreatic surface within the new dam. A lower phreatic surface would help to prevent saturation (and weakening) of the dam embankments. Additional modeling would be conducted to ascertain if this drainage layer needs to be continuous along the length of the dam, or if narrow segments of foundation material would prove to be as effective. Rock buttresses would be placed at the northern toe of the existing Cell 2E starter dam, and at the south end of Cell 1E near the railroad fill to provide resistance to the driving forces created by the dam raises. Buttress material would likely consist of waste rock sourced from the LTVSMC Area 5 Stockpile and has been modeled as Category 1 waste rock.

The proposed dams would be constructed from mechanically placed and compacted “bulk tailings” taken from the existing LTVSMC Tailings Basin as needed to produce the desired dam lift height and geometry. LTVSMC “bulk tailings” are currently defined as a mixture of tailings from the existing LTVSMC Tailings Basin. The exterior face of the dams would be augmented with a bentonite layer to limit oxygen and rain water infiltration into the Tailings Basin.

The individual lifts would have a slope of 4.5H:1V, which, including setbacks, would provide for an overall slope of approximately 8.6H:1V. Each lift would be 20 ft high, with the exception of the final lift, Lift 8, which would be 10 ft in height. There is a 60-ft bench on top of each lift, with an additional 200-ft setback on top of Lift 4, and a 625-ft beach extending from the interior crest of dam to the edge of the Tailings Basin pond.

As dams are constructed, exterior slopes would be covered with bentonite and vegetated. Upon reaching the final proposed dam elevation (after 20 years of operation), the Tailings Basin would be closed in accordance with *Minnesota Rules* 6132.3200 and would also include the following:

- bentonite augmentation of the pond area bottom to reduce infiltration to a sufficient degree to maintain desired pond water elevations at closure;
- bentonite augmentation of the exposed embankments and beach areas; and
- mulching and planting/seeding of vegetation of upland areas (plants would be selected and monitored to limit root growth from penetrating bentonite).



- | | |
|---|---|
| Compressed Peat | LTVSMC Tailings/Slimes |
| Interior LTVSMC Tailings/Slimes | LTVSMC Fine Tailings |
| NorthMet Tailings | Rock Butress |
| LTVSMC Bulk Tailings | Virgin Peat |
| LTVSMC Coarse Tailings | Glacial Till and Bedrock |



Figure 5.2.14-5
Cross Section F of the Tailings Basin at Maximum Extent
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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Identification of the Critical Cross Section

Geotechnical conditions along the length of existing LTVSMC Tailings Basin dams have varying layers of coarse, fine, and slime tailings. Cross Section F, which intersects the northern dam of Cell 2E, as shown in Figure 5.2.14-4, was selected to represent the critical cross section for stability analysis purposes as it is the maximum section and some layers of the weaker fine and slime tailings extend close to the dam embankment, and the dam embankment is underlain by peat. Material types identified from borings in the existing LTVSMC Tailings Basin along Cross Section F are shown in Figure 4.2.14-3. Figure 5.2.14-5 shows the proposed design of the NorthMet Project Proposed Action Tailings Basin along Cross Section F at its full extent.

Cross Section F was analyzed in a sequential manner consisting of the development of the dam cross section stratigraphy for analyses, application of the material strength and permeability characteristics, and modeling of seepage conditions at the dam cross section, followed by stability analyses.

Once the preliminary Cross Section F configuration was determined, Cross Section F was evaluated with the Tailings Basin at the proposed final crest height to determine whether liquefaction would be triggered in the contractive materials, based on certain triggers prescribed in the NorthMet Geotechnical Modeling Work Plan (PolyMet 2013n, Attachment A).

Modeling Results

The results reported in Geotechnical Data Package Volume 1 Version 4 indicate that the proposed design of the Tailings Basin would meet all respective Factors of Safety as required (PolyMet 2013n). The modeling undertaken and results obtained are summarized below. Subsequent to Geotechnical Data Package Volume 1 Version 4, PolyMet evaluated the effect that the Tailings Basin groundwater containment system would have on stability. Results indicated that the groundwater containment system would not impact the stability of the Tailings Basin or the Factor of Safety results determined in Geotechnical Data Package Volume 1 Version 4 and provided below (PolyMet 2013n).

These results would be further verified before the completion of permitting.

Slope Stability

The predicted Factor of Safety values for Cross Section F at various stages of development of the Tailings Basin are summarized in Table 5.2.14-1. All slope stability factors are designed to meet the factors of safety required by the NorthMet Geotechnical Modeling Work Plan (PolyMet 2013n, Attachment A).

Table 5.2.14-1 Stability Modeling Results for the Tailings Basin

Minimum Factor of Safety Value:		1.3	1.5
Case	Slip Surface	Undrained Strength Stability Analysis (USSA _{yield}) Factor of Safety	Effective Stress Stability Analysis (ESSA) Factor of Safety
Lift 2	Grid and Radius, Optimized ¹ – Circular ²	1.94	3.66
	Grid and Radius, Optimized ¹ – Wedge ³	1.89	2.32
Lift 4	Grid and Radius, Optimized ¹ – Circular ²	1.78	3.65
	Grid and Radius, Optimized ¹ – Wedge ³	1.75	2.26
Lift 6	Grid and Radius, Optimized ¹ – Circular ²	1.82	3.64
	Grid and Radius, Optimized ¹ – Wedge ³	1.81	3.78
Lift 8 – Proposed Final Crest Height with Normal Pond	Grid and Radius, Optimized ¹ – Circular ²	1.82	3.70
	Grid and Radius, Optimized ¹ – Wedge ³	1.83	3.80
Lift 8 – Proposed Final Crest Height with Maximum Pond ⁴	Grid and Radius, Optimized ¹ – Circular ²	1.81	3.57
	Grid and Radius, Optimized ¹ – Wedge ³	1.81	3.80
Long-term Closure Conditions	Grid and Radius, Optimized ¹	NA	3.71
	Grid and Radius, Optimized ¹ – Wedge ³	NA	3.65

Source: PolyMet 2013n.

¹ Assumes that failure of a soil mass could occur in any manner.

² Assumes failure of a soil mass would occur as though it is rotating within a larger mass.

³ Assumes failure of a soil mass would occur as a large, monolithic block (wedge) sliding relative to the surrounding soil mass.

⁴ Probable Maximum Precipitation event whereby the pond level suddenly raised 4 ft in elevation, remained high long enough for steady-state conditions to apply.

Liquefaction

The potential for liquefaction, where a triggering event changes the stress state of the material such that it loses a significant amount of its strength, was assessed under different scenarios, including rapid loading and construction, ineffective underdrain resulting in increased saturation, and erosion events. Results shown in Table 5.2.14-2 indicate that the design meets the minimum Factor of Safety.

A scenario for liquefaction was evaluated whereby all contractive, saturated soils were modeled with their liquefied strengths. Table 5.2.14-3 and Table 5.2.14-4 show that if liquefaction were to fully liquefy all contractive, saturated soils at the end of operations, or 20, 200, or 2,000 years after operations, the design would meet the minimum Factors of Safety deemed acceptable by the Co-lead Agencies.

Potential for seismic activity was also analyzed and assessed. Results indicated that there is a very low likelihood of liquefaction as a result of seismic events.

Table 5.2.14-2 Results of Liquefaction Triggering Analyses for Tailings Basin

Minimum Factor of Safety Value:		1.1
Liquefaction Triggering Scenario	Factor of Safety (overall)	Average Factor of Safety (triggering)
Baseline (design conditions)	2.27	2.27
Plugged drain, Lift 8	2.27	2.27
Rapid loading – fast construction of Lift 1	1.93	2.09
Retrogressive erosion – local erosion/pipe scour	2.15	2.15
Plugged drain, Lift 1	1.85	1.85

Table 5.2.14-3 Modeled Factors of Safety for Fully Liquefied Conditions for the Tailings Basin

Minimum Factor of Safety Value:		1.1
Case	Slip Surface	Factor of Safety (overall)
All Saturated Contractive Materials Liquefied to Undrained Strength Stability ($USSR_{liq}$)	Grid and Radius, Optimized ¹ – Circular ²	1.25
	Grid and Radius, Optimized ¹ – Wedge ³	1.11

Source: PolyMet 2013n.

¹ Assumes that failure of a soil mass could occur in any manner.

² Assumes failure of a soil mass would occur as though it is rotating within a larger mass.

³ Assumes failure of a soil mass would occur as a large, monolithic block (wedge) sliding relative to the surrounding soil mass.

Table 5.2.14-4 Modeled Factors of Safety for Fully Liquefied Long-term Conditions for the Tailings Basin

Minimum Factor of Safety Value:		1.1
Case	Effective Stress Stability Analysis	
Long-term Fully Liquefied Conditions	20 years after end of operations	1.13
	200 years after end of operations	1.20
	2,000 years after end of operations	1.24

Source: PolyMet 2013n.

Long-Term Closure Stability Conditions

While it is normally preferable from a stability perspective to allow tailings facilities to drain following closure, the NorthMet Project Proposed Action involves maintaining a pond on top of the Tailings Basin for water quality management purposes.

The Tailings Basin would be covered with a bentonite-amended surface on the exterior face of the NorthMet Project dam lifts (amended during construction). After the Tailings Basin has been filled to its maximum height, the dam would be prepared for reclamation by amending the 625-ft beach of tailings and the bottom of the pond with bentonite.

Modeling was undertaken to predict the long-term stability of the Tailings Basin. As shown in Table 5.2.14-1 and Table 5.2.14-4, the long-term closure slope stability Factors of Safety are above the minimum value required under the Work Plan.

Proposed Monitoring

Geotechnical investigations would be performed on the Tailings Basin during construction and operations to confirm that the construction and performance of the dam meet design criteria. This approach is standard for large earthen structures that are developed incrementally over long periods of time.

A Flotation Tailings Management Plan (PolyMet 2013m) has been prepared by PolyMet that includes a description of the operating plans, monitoring procedures, and adaptive management approaches for the Tailings Basin. Monitoring activities include construction material sampling, geotechnical instrumentation, geotechnical investigations, and systematic dam safety inspections.

Existing and proposed geotechnical instrumentation would measure actual tailings dam performance by monitoring stability, seepage, and deformation. Monitoring instrumentation relevant to geotechnical stability would include:

- **Piezometers** to facilitate monitoring of the pore water pressure within the Tailings Basin and perimeter dams (the phreatic surface has a significant effect on slope stability), which would be compared to modeled phreatic surface.
- **Inclinometers** to facilitate monitoring of the movement of the Tailings Basin dams.
- **Survey monitoring points** to facilitate the monitoring of horizontal and vertical deformation (including settlement) of the Tailings Basin dams.

Geotechnical investigations and systematic dam safety inspections would include:

- Staff observation of the condition of the dam and the reporting of any conditions that indicate a departure from the design specifications.
- Weekly/daily routine dam inspections by staff to observe the conditions and performance of the Tailings Basin dams and associated facilities so that any changes to dam conditions could be identified and promptly addressed. These would supplement more detailed Dam Safety Inspections (below).
- Regulator Dam Safety Inspections to evaluate, on a regular basis, the current and past performance of the Tailings Basin dams and to observe potential deficiencies in their condition, performance, and/or operation.
- Semi-annual Dam Safety Inspections undertaken by an independent consultant retained specifically for dam safety expertise and a Minnesota-registered engineer.
- Inspection after unusual events to monitor and report observations.
- Routine Dam Safety Reviews every 5 years by a qualified geotechnical engineer registered in the State of Minnesota. The review would ascertain that the dam has an adequate margin of safety, based on the current Dam Safety Permit, current engineering practice, and updated operations and design input data. A Dam Safety Review may also be carried out to address a specific problem.

Annual reports on the conditions of the Tailings Basin are required under the MDNR Dam Safety Permit and Permit to Mine. Monitoring and maintenance would continue post closure in accordance with permit requirements.

Proposed Maintenance and Mitigation

Typical maintenance of the facility would include repairing eroded surfaces and repair and replacement of damaged monitoring and operational infrastructure. The majority of the non-mechanical maintenance work at the Tailings Basin would be carried out on an as-required basis, rather than on a scheduled basis because it is driven by weather events rather than hours of operation.

Where monitoring or model updates indicate that the Factor of Safety for the Tailings Basin no longer meets design criteria, appropriate modifications to the Tailings Basin would be considered, modeled, and, if necessary, undertaken. Modifications could include but are not limited to: modification of bench widths between lifts of the dam, modification of lift heights, and modification of slope angles. Other modifications could include increasing the size of the rock buttress, improving the performance of underdrains, and increasing mid-slope setbacks.

A Contingency Action Plan has been prepared as part of the Flotation Tailings Management Plan (PolyMet 2013m). The plan provides guidance to on-site personnel and emergency responders in the case of unplanned occurrences at the Tailings Basin. The plan defines three levels of hazardous and emergency conditions response:

1. Level 1 is defined as unusual conditions that do not warrant an emergency response but require prompt investigation and resolution.
2. Level 2 is defined as conditions that represent a potential emergency, if sustained or allowed to progress, but no emergency situation is imminent. The first action in the event of a Level 2 emergency condition is to discuss and define a response plan.
3. Level 3 is defined by either imminent failure of the Tailings Basin or a significant component thereof. The first actions in the event of any Level 3 condition are to check all persons who could potentially be affected are safe, initiate the appropriate chain of communications, and immediately undertake appropriate response actions.

5.2.14.2.3 Hydrometallurgical Residue Facility

As shown in Figure 5.2.14-4, hydrometallurgical residue would be disposed of in a new Hydrometallurgical Residue Facility that would be located at the site of the existing LTVSMC Emergency Basin, adjacent to the southern extent of existing LTVSMC Tailings Basin Cell 2W.

The data inputs, modeling methodology, results, and design and operating requirements for the Hydrometallurgical Residue Facility were reported in Geotechnical Data Package Volume 2 Version 3 (PolyMet 2012a) and reviewed by the Co-lead Agencies. The information provided in the data package informs the permitting process and is summarized below.

Design Criteria

The design of the Hydrometallurgical Residue Facility must meet the applicable requirements of *Minnesota Rules* 6115.0300 through 6115.0520 and the requirements of the NorthMet Geotechnical Modeling Work Plan (PolyMet 2013n, Attachment A) which include the following:

- the ability of the most sensitive slope cross section to meet a global slope stability factor of 1.5;
- the ability of the composite liner system to comply with infinite slope stability safety factor of 1.5, and
- the capability of the composite liner system to withstand the longitudinal strain anticipated due to differential settlement that may occur in the facility foundation materials.

Methodology

PolyMet took the steps listed below in order to demonstrate that the design of the Hydrometallurgical Residue Facility would meet the respective geotechnical requirements and would be in accordance with the NorthMet Geotechnical Modeling Work Plan (PolyMet 2013n, Attachment A):

1. Gathered existing conditions data (i.e., facility foundation material stratigraphy and strength data, hydrogeological data, characteristics of NorthMet Project Proposed Action residues based on those produced during the pilot-plant processing, and other data as needed to support geotechnical modeling of the Hydrometallurgical Residue Facility) (see Section 4.2.14).
2. Developed residue facility layout and cross sections (i.e., geometry and stratigraphy for existing and planned conditions) for proposed residue facility stability and deformation modeling.
3. Developed seepage and stability models using Geo-Slope International, Inc. modeling software (i.e., SLOPE/W, SEEP/W and SIGMA/W as necessary) for maximum facility dam height with minimum and maximum pond elevation, and post-closure – cover effective with minimum pond elevation the maximum.
4. Established the geotechnical design data for model input including identification of strength parameters and the triggering potential for static and seismic events.
5. Ran the models to determine Factors of Safety, and the potential for slope failure and deformation of the foundation and liner.
6. Refined the design and operating requirements necessary to maintain required slope stability safety factors and deformation requirements for the critical slope cross section.

Design

Various design specifications have been established and used for the Hydrometallurgical Residue Facility geotechnical analysis (PolyMet 2012a). The following is a summary of the design characteristics applied and considered in modeling.

The Hydrometallurgical Residue Facility has been designed as a single cell structure with a design capacity of 6,400,000 cubic yards to be located on top of the existing LTVSMC Emergency Basin. The perimeter would have an irregular shape consisting of the north dam (a portion of the existing southern LTVSMC Tailings Basin Cell 2W dam), natural high ground, and new dams (see Figure 5.2.14-4).

The maximum height of the proposed dams is approximately 85 ft, with a crest elevation of 1,650 ft amsl and an additional 3-ft minimum freeboard (14-ft maximum freeboard at a residue surface slope of 0.5 percent). The exterior, downstream face of the dam would be constructed at a slope of 4 horizontal to 1 vertical (4:1). The interior of the Hydrometallurgical Residue Facility would be sloped at 4H:1V and 30-ft horizontal benches would be placed at elevations of 1,600 and 1,630 ft amsl.

Prior to construction of the dams, PolyMet would perform the following tasks:

1. install a granular drainage layer at the existing LTVSMC Emergency Basin, as needed to facilitate wick drain installation and operation;
2. install wick drains; and
3. place, monitor, and remove a surcharge load fill in the existing LTVSMC Emergency Basin to pre-consolidate existing material, thereby reducing future anticipated settlements to mitigate the potential future strains.

A geosynthetic liner system would be installed with the following components, listed in order from top to bottom:

1. upper geomembrane;
2. geocomposite (geonet) (for leakage collection and recovery);
3. lower geomembrane; and
4. geosynthetic clay liner.

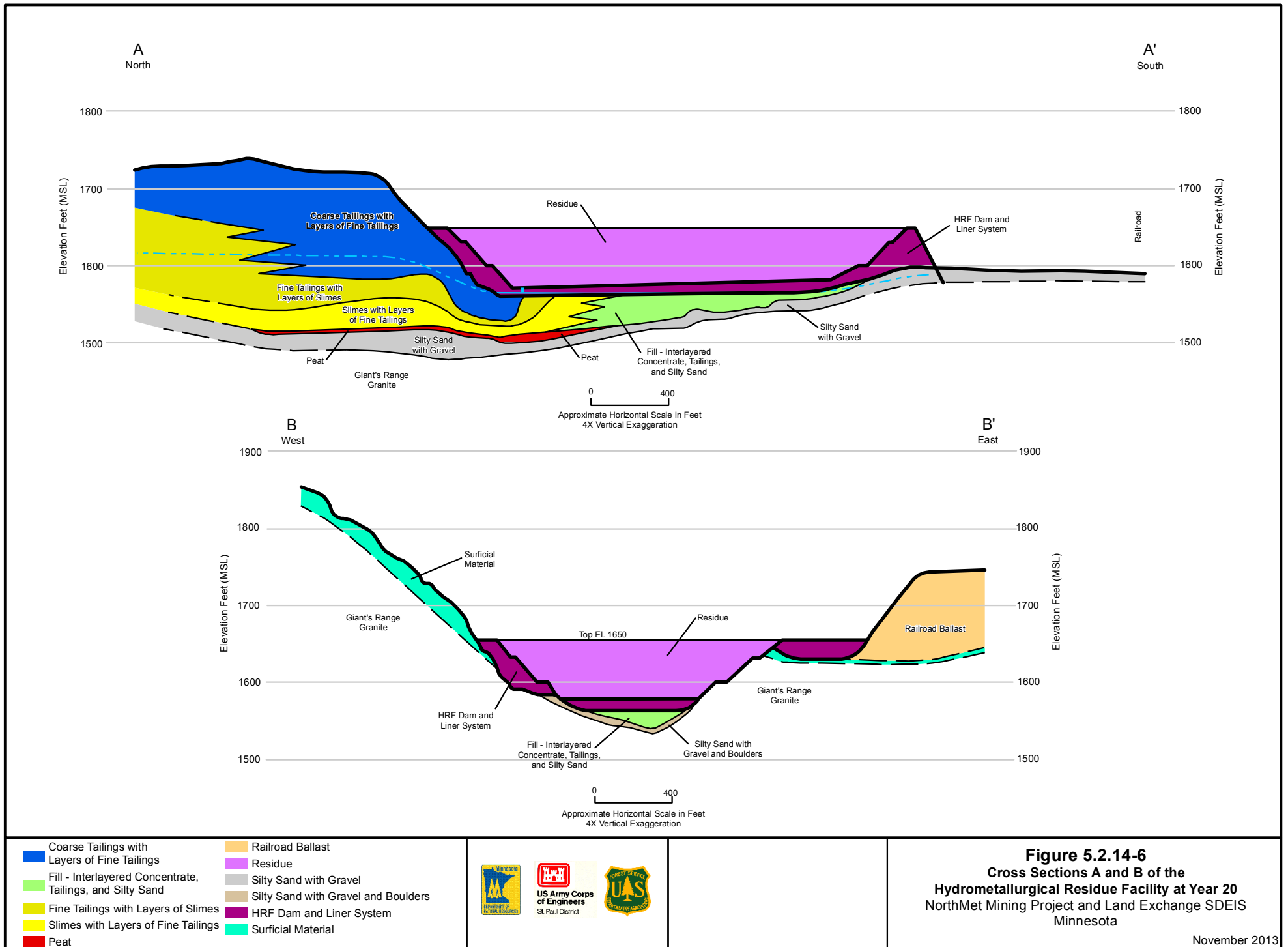
The dams would be constructed using downstream construction methods that involve constructing a smaller starter dam first and then raising the dam upward and outward over the downstream shell of the dam as additional capacity is needed. Construction material would be sourced from natural soil and quarried bedrock between the high ground and south dam. Some LTVSMC coarse tailings may also be utilized for dam construction. While the material is placed, it would be compacted to the design density.

Identification of the Design Cross Section

Cross Section A, depicted in Figure 5.2.14-4, has been identified as the design cross section. It approximates the base of a former ravine, beginning south of the future south dam and terminating near the crest of the Hydrometallurgical Residue Facility north dam. It is considered as the design cross section, as it incorporates the thickest sections of LTVSMC slimes. Fine tailings and slimes in the Emergency Basin are the thickest at approximately 50 ft at Node A located 280 ft away from the toe of the south dam. A cross section of the Hydrometallurgical Residue Facility at its maximum extent along cross sections A and B is shown in Figure 5.2.14-6.

The global slope stability discussed below was assessed along Cross Section A.

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Modeling Results

The results reported in Geotechnical Data Package Volume 2 Version 3 indicate that the proposed design of the Hydrometallurgical Residue Facility would meet all respective factors of safety as required (PolyMet 2012a). The modeling undertaken and results are summarized below.

Stress Deformation and Strain in the Liner System

A surcharge load would be placed on the existing LTVSMC Emergency Basin to consolidate the existing material before construction of the Hydrometallurgical Residue Facility. Wick drains would be used to help accelerate the consolidation time. Some portion of this load would be removed before construction, and the remaining material would be graded to provide sufficient drainage slope, considering the underdrain and leakage collection systems, and provide a suitable foundation material for the facility. The material would rebound a small amount after the surcharge load is removed. The aggregate settlement at a representative location within the Emergency Basin, considering the maximum anticipated tailings thickness in the foundation, is estimated to be 3.9 ft. The material at this location is modeled to consolidate an additional 1.4 ft by the end of operations of the Hydrometallurgical Residue Facility.

Residue consolidation is modeled as beginning after the cessation of residue discharge to the Hydrometallurgical Residue Facility. Over time, the rate of consolidation would decrease with the greatest amount of consolidation occurring before pore-water pressure reaches hydrostatic equilibrium (approximately 10 years following closure). Total settlement in areas with the greatest depth of residue is estimated to be on the order of 9.6 ft. As the depth of residue decreases near the edge of the Hydrometallurgical Residue Facility, less settlement would occur. The resulting deformed surface of the Hydrometallurgical Residue Facility would be concave with the greatest deformation in areas of greatest residue thickness.

Strain in the Hydrometallurgical Residue Facility liner system would result from differential settlement between points along the liner. The maximum strain in the liner system is estimated to be 0.20 percent. This value is well within acceptable limits of most geosynthetics, which range from 1 to 19 percent.

Global Slope Stability

Analysis of the new dams (i.e., those not supported by the existing LTVSMC Tailings Basin or natural topography) at their greatest height (at year 20) resulted in a computed Factor of Safety for the ESSA of 2.32, which is greater than the required minimum of 1.5. Because the friction angle for the dam fill material (approximately 30 degrees) is greater than the proposed dam downstream slope angle (18 degrees), surficial slope failures are not expected.

Liquefaction analysis was not applicable and not performed because the material proposed in the constructed dams would be well-compacted and the Hydrometallurgical Residue Facility liner system would limit leakage through the dams.

Infinite Slope Stability

The components of the double liner system are designed to act as hydraulic barriers to leakage; not as structural members of the dam system. Therefore, the liner layers must not be allowed to slide relative to one another. Evaluation of this potential for sliding was performed using infinite slope stability analyses. The minimum infinite slope stability safety factor for all

Hydrometallurgical Residue Facility liner system components is 1.5. On the basis of the interface friction angles used in the analysis, the design proposed for the Hydrometallurgical Residue Facility achieves a computed safety factor of 2.94.

The interior slope angle for the Hydrometallurgical Residue Facility and the geosynthetic materials of the liner that would directly contact the underlying soils used for dam construction must be selected to produce a stable liner system—a system that would not slide down-slope during operations. In addition, each successive layer of the liner system must have an adequate interface-friction angle with the adjacent layer to prevent down-slope movement of any layer of the liner system. Infinite slope stability for the liner system layer interface configurations currently expected is shown in Table 5.2.14-5. Computed factors of safety shown in Table 5.2.14-5 are based on commonly reported interface friction angles between the materials anticipated to be used for the Hydrometallurgical Residue Facility liner. Any variation from the anticipated material types warrants project-specific interface shear testing to confirm that the friction angles are equal to or greater than those used in this analysis.

Table 5.2.14-5 Infinite Slope Stability Analysis Results for the Hydrometallurgical Residue Facility

Interface Number	Material Types	Slope Angle, (deg)	Predicted friction Angle, (deg)	Minimum required Factor of Safety	Predicted Factor of Safety
4	Textured Geomembrane above Geocomposite Drainage Net	15.95	28	1.5	1.86
3	Geocomposite Drainage Net above Textured Geomembrane	15.95	28	1.5	1.86
2	Textured Geomembrane above Geosynthetic Clay Liner	15.95	28	1.5	1.86
1	Geosynthetic Clay Liner above Granular Soil	15.95	24	1.5	1.56

Proposed Monitoring, Maintenance, and Mitigation

A Hydrometallurgical Residue Management Plan (PolyMet 2012e) prepared by PolyMet includes a description of the operating plans, monitoring procedures, and adaptive management approaches for the Hydrometallurgical Residue Facility.

Monitoring and maintenance for the Hydrometallurgical Residue Facility would be similar to that discussed for the Tailings Basin above.

5.2.14.3 NorthMet Project No Action Alternative

Under the No Action Alternative, no waste rock stockpiles, or expanded Tailings Basin, or Hydrometallurgical Residue Facility would be created. The existing geotechnical conditions are discussed in Section 4.2.14. The existing LTVSMC Tailings Basin as discussed in Section 4.2.14 would remain at the site and monitoring and inspection would continue under the LTVSMC site closure plan and the MDNR Dam Safety regulations.

5.3 LAND EXCHANGE

5.3.1 Land Use

The Land Exchange Proposed Action represents a transfer of surface rights of 6,495.4 acres from the Superior National Forest to PolyMet to eliminate the conflict between federal surface and private mineral estate. This action would remove those acres from Superior National Forest management and public use. The Land Exchange Proposed Action would remove these acres, which are part of the 1854 Ceded Territory, from lands available to the Bands to exercise reserved 1854 Treaty rights. Given the existing lack of overland public access and actual use of the federal lands, as well as historic use of this area for mineral exploration (see Section 4.2.9), the Land Exchange Proposed Action represents little to no change in the actual level of recent or current use of the federal lands. At the same time, the Land Exchange Proposed Action brings as many as 7,075.0 acres of private land into the public domain, making it available for the Bands to exercise 1854 Treaty rights (see Section 4.3.9).

When compared with the Land Exchange No Action Alternative, the Land Exchange Proposed Action and the Land Exchange Alternative B would provide a slight improvement in key indicators described in Section 5.3.1.1. The Land Exchange Proposed Action provides for more of an improvement in overall indicators than under the Land Exchange Alternative B. The Land Exchange Proposed Action and the Land Exchange Alternative B are both compatible with adjacent zoning and management area designations.

There is no current legacy contamination on the non-federal parcels. Past legacy contamination concerns are discussed in Section 4.3.1.

5.3.1.1 Methodology and Evaluation Criteria

The area of analysis for land use effects from the Land Exchange Proposed Action included the federal and non-federal tracts, as well as properties abutting the tracts, which provide the basis for determining compatibility of land uses on the federal and non-federal parcels. The temporal analysis is based on the time of change in ownership. Management areas and subsequent land uses would be established at the time of the ownership change.

The analysis of the land use resources affected by the Land Exchange Proposed Action was guided by evaluation criteria that were developed by the USFS and the other Co-lead Agencies. The following impact indicators identify anticipated outcomes of the Land Exchange Proposed Action alternatives being considered for the NorthMet Project Proposed Action:

- net change in the number of acres controlled by the USFS on the Superior National Forest;
- net change in the length of the boundary around USFS-controlled land in the Superior National Forest (including internal boundaries around private in-holdings) to be managed under each of the proposed alternatives;
- net change in the level of land fragmentation, expressed as a ratio of linear boundary-to-area (linear miles per acre) of the USFS-controlled portions of the Superior National Forest under each of the proposed alternatives;

- the degree of access to lands owned by the USFS in the Superior National Forest, as determined through the identification of public access points via road or trail;
- degree of compatibility between USFS management areas and zoning or land use designations (in the absence of zoning) of adjacent areas;
- potential for mineral development within the parcels, assessed by the USFS based on mineral ownership, the type of mineral, and the precedent/history for exploitation of this mineral within Minnesota; and
- quality of title within each of the parcels being considered. Quality was evaluated by the USFS according to outstanding encumbrances on the parcels considered for each of the Land Exchange Proposed Action alternatives, including mineral ownership and development potential.

Quantitative criteria, such as boundary length and land area, were calculated using GIS. Evaluations of mineral development potential were conducted by third party professional geologists (Barr 2011c). The risk of conflict between mineral interests and USFS surface management and quality of title were assessed by a USFS Forest Realty Specialist.

5.3.1.2 Land Exchange Proposed Action

5.3.1.2.1 Forest Available for Public Access and Use

Through the Land Exchange Proposed Action, 6,495.4 acres of federal lands in the Superior National Forest would be transferred to PolyMet in exchange for up to approximately 7,075.0 acres of non-federal lands presently in private ownership. This would result in a net increase of up to 579.6 acres for the Superior National Forest.

All of the non-federal lands are within the 1854 Ceded Territory and would thus be subject to Treaty rights reserved by the Bands as a result of the Land Exchange Proposed Action. This would result in a net increase of up to 579.6 acres of publicly owned land in the 1854 Ceded Territory. Table 5.3.1-1 shows the Management Area designations that the USFS would apply to the non-federal lands under the Land Exchange.

Table 5.3.1-1 Management Area Allocations under the Land Exchange Proposed Action

Tract	Acreage by Management Area ¹			cRNA ⁵	Total ⁶
	General Forest	General Forest-Longer Rotation	Riparian Emphasis Areas		
Federal Lands²	355.3	6,140.1	0.0	0.0	6,495.4
Non-federal Lands³					
Tract 1	4,619.3	0.0	0.0	306.9	4,926.2
Tract 2	0.0	161.0	220.9	0.0	381.9
Tract 3	1,450.0	125.8	0.0	0.0	1,575.8
Tract 4	0.0	160.2	0.0	0.0	160.2
Tract 5	0.0	30.8	0.0	0.0	30.8
Subtotal, Non-federal Lands	6,069.3	477.8	220.9	306.9	7,075.0
Net Increase/(Decrease)⁴	5,714.0	(5,662.3)	220.9	306.9	579.6

¹ See definitions of USFS Management Areas in Section 4.2.3.

² Source: USFS 2011a.

³ Source: USFS 2011b.

⁴ Calculated as (non-federal) minus (federal).

⁵ Candidate Research Natural Area (see Section 4.2.3).

⁶ Totals may not match overall NorthMet Project area acreages due to rounding.

The 6,495.4 acres of federal lands are not accessible for public use via land (see Section 4.2.11), while substantial portions of the non-federal lands do have public access via public roads or hiking trails. This distinction is a factor in evaluating land use effects because public access defines the degree to which the lands in question can actually be used—either by the public for recreational purposes, by forestry interests for economic purposes, or for research and conservation purposes (in the case of Riparian Emphasis and cRNA management areas, defined in Section 4.3.1). Tract 1 has direct public access via existing county roads (see Figure 5.3.1-1), and Tract 4 has public access via other roads (see Figure 5.3.1-2). Tracts 2 and 3 have no direct public access (see Figure 5.3.1-1). When considered collectively, public access to, and therefore use of the Superior National Forest, would be increased under the Land Exchange Proposed Action.

Table 5.3.1-2 shows the effect of the Land Exchange Proposed Action on the total acreage within the Superior National Forest that is controlled by the USFS, the boundary of the USFS-controlled land (see Section 5.3.1.2.2), and the fragmentation ratio (see Section 5.3.1.2.3). The Land Exchange Proposed Action would increase the federal estate by adding a net of 385.1 acres to the 2,171,603.9 acres of USFS-controlled land within the Superior National Forest.

Table 5.3.1-2 Superior National Forest Boundary, Acreage, and Fragmentation under the Land Exchange Proposed Action

	Baseline / Land Exchange No Action Alternative	Land Exchange Proposed Action	
		Predicted Value	Net Increase/ (Decrease) ¹
Acreage in Superior National Forest controlled by USFS	2,171,603.9	2,171,989.0	385.1
Boundary length (linear miles)	10,054.8	10,021.6	(33.2)
Fragmentation (linear miles per acre)	0.005	0.005	0.00

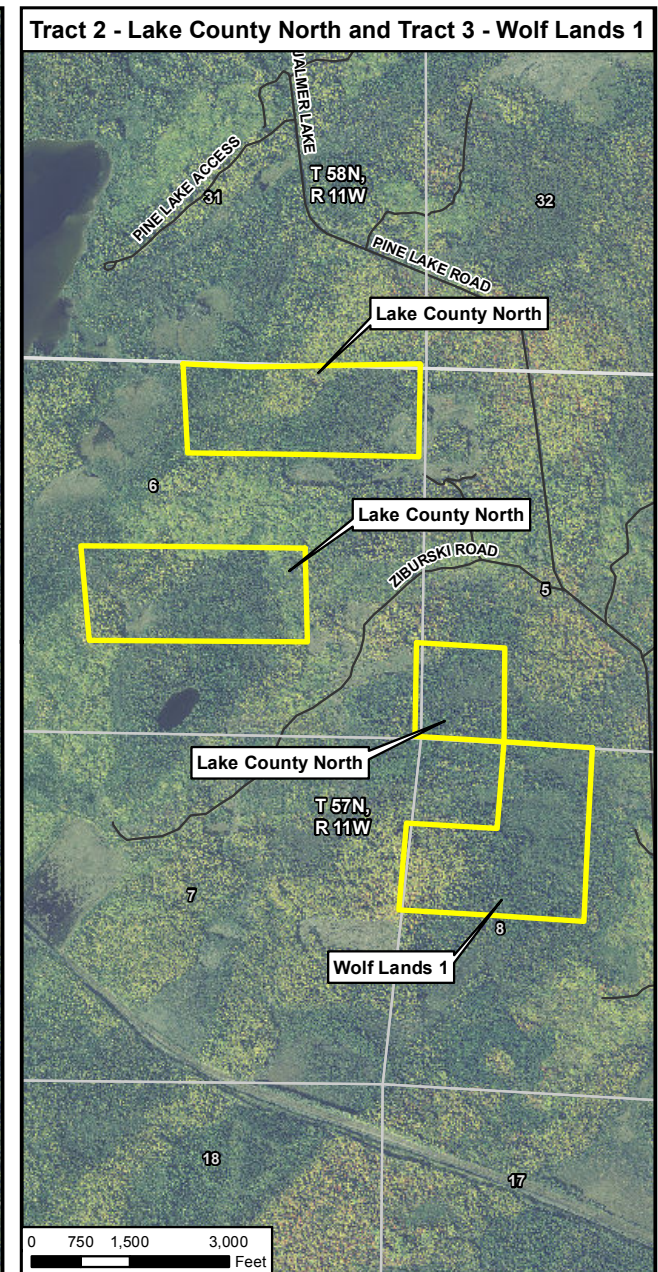
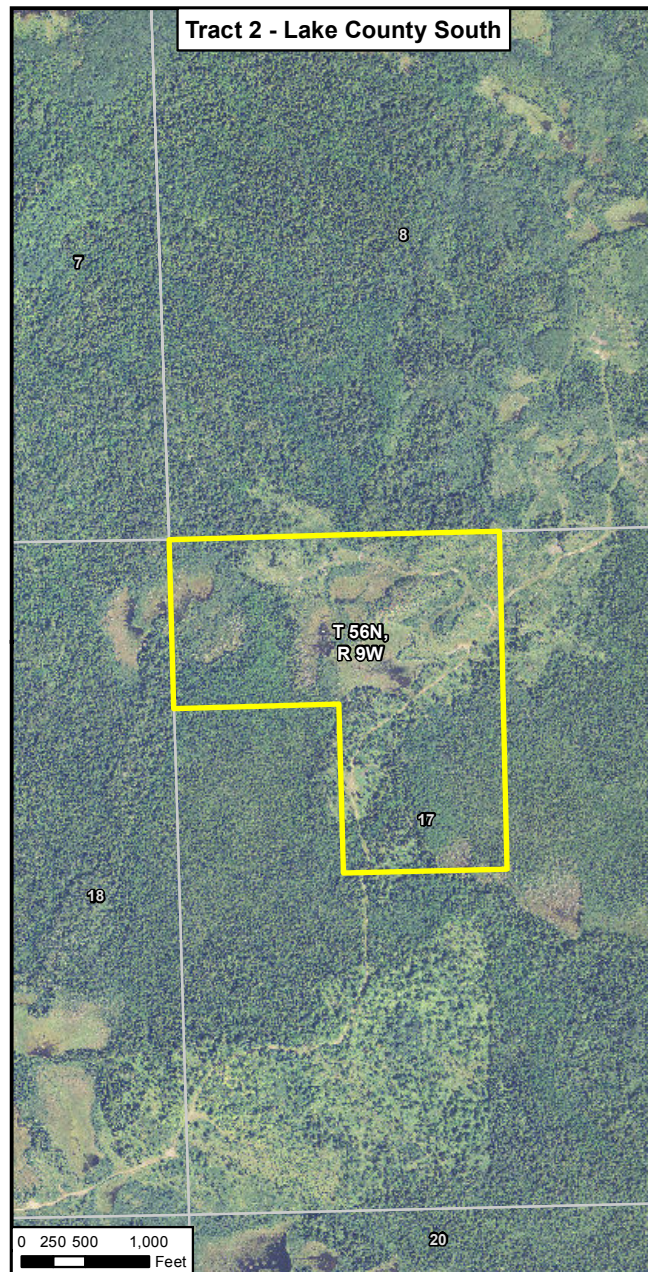
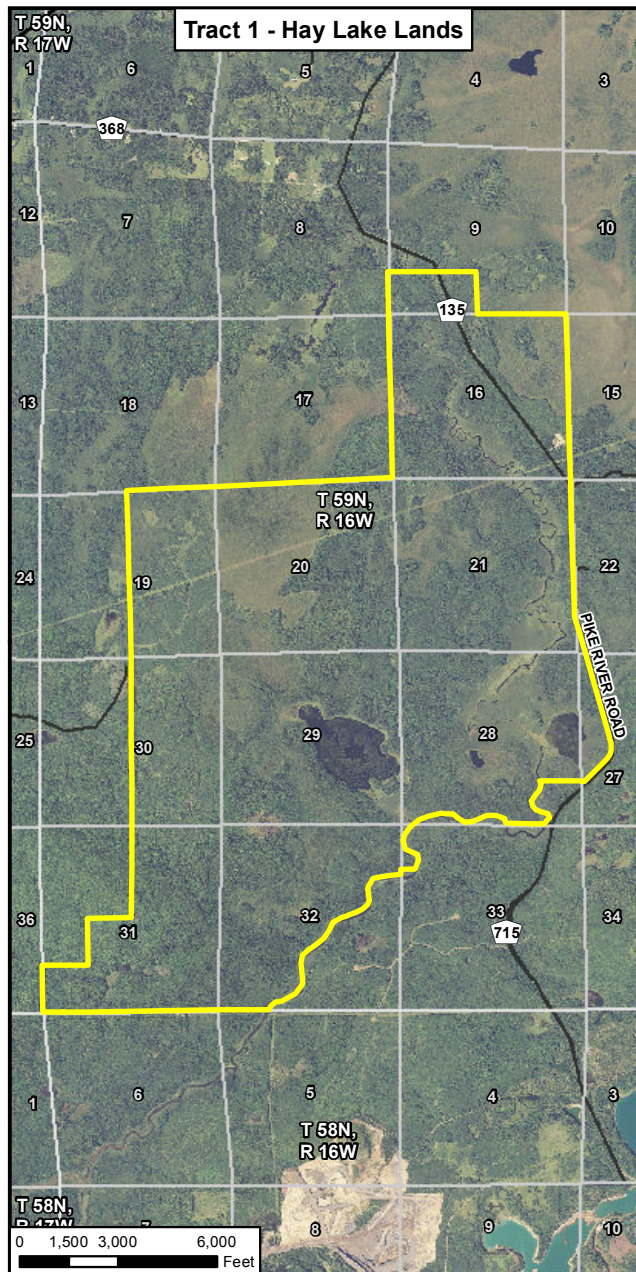
¹ Totals differ from acreage reported in Section 5.3.1.2.1 (579.6 acres) due to inconsistencies in GIS data and because Mud Lake (30.5 acres) would continue to be managed by the MDNR.

5.3.1.2.2 Boundary Managed

A reduced boundary length is more desirable for the USFS, because it reduces the difficulty of accessing and managing the forest. The Land Exchange Proposed Action would result in a 33.2-mile net reduction of the perimeter around the USFS-controlled portions of the Superior National Forest (see Table 5.3.1-2).

5.3.1.2.3 Forest Fragmentation

The underlying assumption regarding land fragmentation of USFS-controlled portions of the Superior National Forest is that a lower ratio of boundary to area is more desirable, because it reduces the difficulty of accessing and managing the forest in addition to increasing the forest's overall quality and function. All of the non-federal parcels are contiguous with National Forest System lands, thus decreasing the ratio of boundary to area. The Land Exchange Proposed Action would not alter the existing ratio of fragmentation in the Superior National Forest of approximately 0.005 linear mile of boundary per acre of USFS-controlled Superior National Forest land (see Table 5.3.1-2).

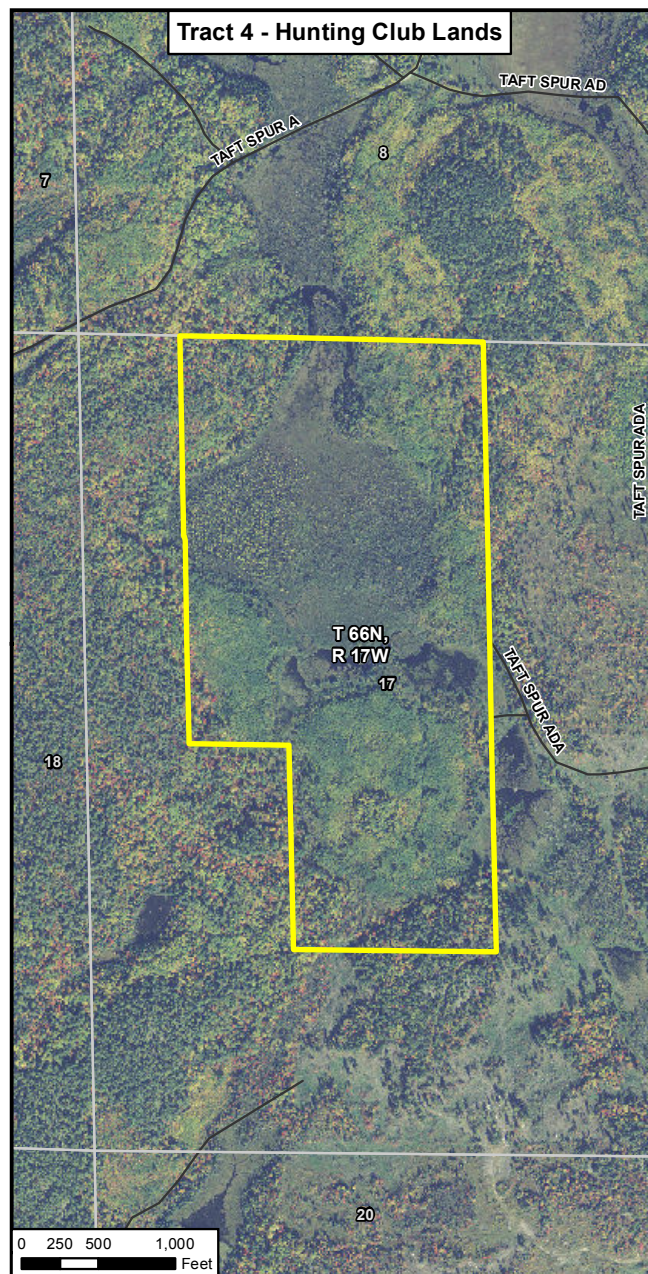
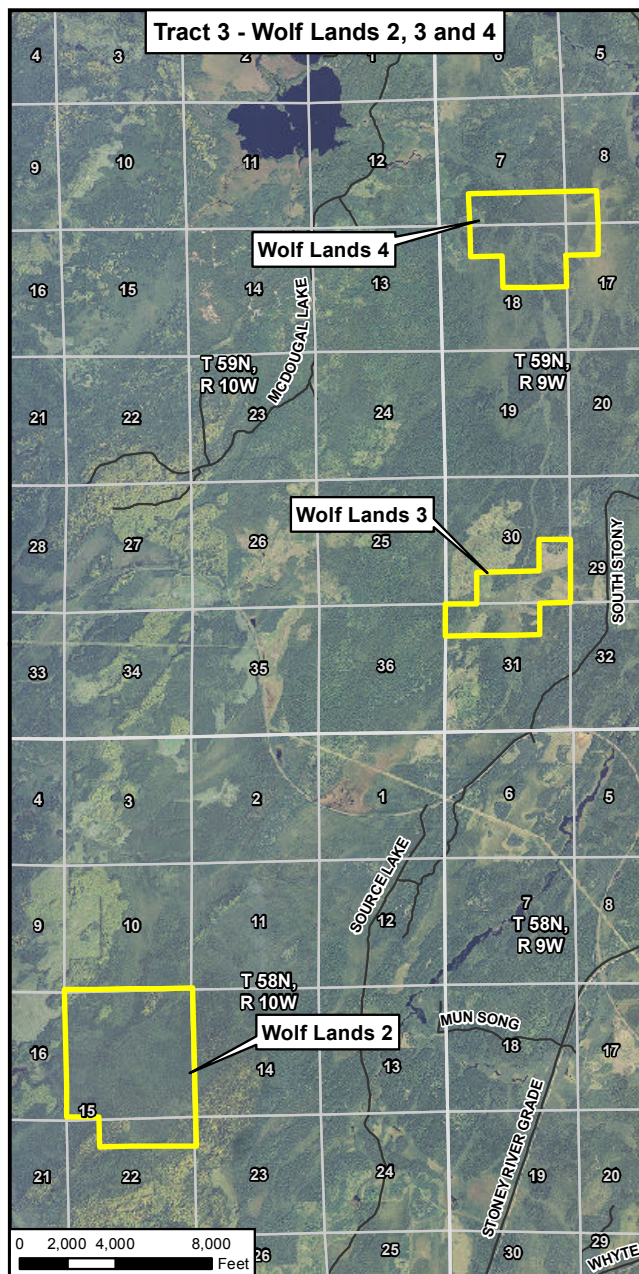


- Non-federal Lands
- Section Boundary
- Section Label
- Road



Figure 5.3.1-1
Tracts 1, 2 and 3 Roads
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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- Non-federal Lands
- Section Boundary
- 1 Section Label
- Road



Figure 5.3.1-2
Tracts 3, 4 and 5 Roads
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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5.3.1.2.4 Zoning Compatibility

Management area designations provide guidance regarding public use of National Forest System lands (e.g., recreation, scenic resources, and facilities). Section 4.3.1 provides definitions of the intended uses of the management area designations that apply to the federal and non-federal tracts, as well as surrounding areas within the Superior National Forest.

Zoning in areas adjacent to the non-federal lands outside of the Superior National Forest and compatibility with the management area designations of non-federal lands are summarized below:

- Zoning on privately owned (“non-forest”) lands adjacent to Tract 1 is split among multiple zoning districts, including residential, wild rice production, timber, and hunting (St. Louis County 2011). With the exception of residential development and timber, these uses are generally compatible with the proposed General Forest Management Area designation of Tract 1. Recreational uses such as personal-use riding and hunting would be consistent with the cRNA designation. Non-forest lands to the east and south of Tract 1 are in the Multiple-Use Non-Shoreland (MUNS-4) district (St. Louis County 2011), which is generally compatible with the General Forest and cRNA management areas.
- Non-forest lands adjacent to Tracts 2 and 3 are in the Forest-Recreation district, as defined by the Lake County Zoning Ordinance (Nelson, Pers. Comm., October 10, 2011). This is compatible with the proposed General Forest, General Forest – Longer Rotation, and Riparian Emphasis Area Management Area designations.
- Non-forest lands adjacent to Tract 4 to the west and southeast are within the St. Louis County FAM-1 zoning district, which emphasizes forestry, agricultural, and recreational uses (St. Louis County 2011). These uses are generally compatible with the proposed General Forest – Longer Rotation Management Area designation.
- Privately owned lands adjacent to Tract 5 to the north and southeast are within Cook County’s Recreational Development zoning district (Cook County 2011), which is generally compatible with the proposed General Forest – Longer Rotation Management Area.

Overall, the management area designations of the non-federal lands are compatible with surrounding zoning. The Land Exchange Proposed Action would be compatible with the USFS Management Areas and zoning/land use designations of adjacent lands.

5.3.1.2.5 Mineral Development Potential and Quality of Title

The Land Exchange Proposed Action would remove from the Superior National Forest 6,495.4 acres of land with privately held, minable mineral development potential and USFS-held surface rights, in exchange for up to 7,075.0 acres of non-federal land with a low mineral development potential. As described in Section 3.3, the Land Exchange would eliminate conflict between mineral estate and surface rights by transferring the federal surface to the holder of the private mineral rights, fulfilling the USFS’s purpose and need.

Table 5.3.1-3 summarizes the risk of conflict between mineral potential and the USFS surface management objectives on each of the non-federal parcels, as well as the overall quality of title to the land.

Table 5.3.1-3 Mineral Interests and Quality of Title for Non-Federal Lands

Tract/Parcel	Risk of Conflict Between Mineral Interests and USFS Surface Management ¹	Quality of Title ^{2,3}
1: Hay Lake	Moderate	Moderate
2: Lake County North	Low	Moderate
2: Lake County South	Low	Moderate
3: Wolf Lands 1	Low	Moderate
3: Wolf Lands 2	Low	Moderate
3: Wolf Lands 3	Low	Moderate
3: Wolf Lands 4	Low	Moderate
4: Hunting Club	Low	High
5: McFarland Lake	Low	Moderate

Source: USFS 2011c.

¹ Low is the best and high is the worst, as defined in USFS 2011c and Barr 2011c.

² Condition of title represents review as of December 21, 2011 -- may be revised per specialist investigation or advice of USDA, Office of General Counsel.

³ High is the best and poor is the worst, as defined in USFS 2011c.

The risk of conflict determination in Table 5.3.1-3 expresses the degree to which “split estate” conditions could complicate achievement of USFS management goals and objectives. Split estate refers to situations where private ownership of mineral rights would occur on land whose surface is owned by the Superior National Forest after the Land Exchange Proposed Action. This concern notwithstanding, the USFS allows exploration, development, and production of mineral resources on National Forest System lands under conditions where the activities “are conducted in an environmentally sound manner so that they may contribute to economic growth and national defense” (USFS 2004b).

The “moderate” risk of conflict on Tract 1 reflects the presence of potential surficial aggregate resources in the far northeastern corner of the tract. There are also some potential surficial aggregate resources near Greenwood Lake in Tract 3, but development of these resources is constrained due to the presence of wetlands, which may limit or prohibit access (Barr 2011c). For all other tracts, the risk of conflict is low due to the low potential for mineral development.

The quality of title determination assesses existing uncertainties in surface ownership, title insurance, or other encumbrances that may be transferred to the USFS in the event of the Land Exchange moving forward, as well as the risk of conflict defined above. Details of the quality of title determination are presented below by tract (USFS 2011c):

- Tract 1: Moderate, due to the presence of surficial aggregate resources in the northeastern portion of the site and certain title encumbrances that may be cured by endorsements in the final title insurance policy.
- Tract 2: Moderate, due to the presence of privately held mineral exploitation rights. This potential is constrained by the low potential presence of subsurface mineral resources and the absence of surficial deposits.
- Tract 3: Moderate, due to the presence of privately held mineral exploitation rights on portions of all Tract 3 parcels and the presence of private timber rights for one parcel. Mining potential is constrained by the low potential presence of subsurface mineral resources, the absence of surficial deposits, and the presence of wetlands that may make mineral exploitation difficult.

- Tract 4: High, because the mineral estate was never severed from this parcel.
- Tract 5: Moderate, due to the potential for privately held mineral exploitation rights. This potential is constrained by the low potential presence of subsurface mineral resources and the absence of surficial deposits. The timber reservation is rendered benign when it expires on December 13, 2013.

By comparison, the risk of conflict between mineral and surface rights on the federal lands is high due to the presence of privately owned mineral rights and economically developable minerals and USFS surface ownership. The Land Exchange Proposed Action would reduce this risk by exchanging the high-risk federal lands for predominantly low-risk non-federal lands. The risk of conflict on the non-federal lands may be reduced and title quality further improved through subsequent arrangements with holders of mineral rights on the non-federal lands or affirmative title insurance coverage. Thus, the overall effect of the Land Exchange Proposed Action improves the quality of title and reduces the complexity of title to the federal and non-federal lands.

5.3.1.3 Land Exchange Alternative B

5.3.1.3.1 Forest Available for Public Access and Use

Under the Land Exchange Alternative B, 4,752.6 acres of federal lands would be transferred to private ownership in exchange for up to approximately 4,926.3 acres of land (Tract 1 only), as determined by appraisals. This land is currently in private ownership, resulting in a net increase of approximately 173.6 acres for the Superior National Forest. The federal lands transferred out of the Superior National Forest in this scenario have poor public access (see Section 4.3.11). The smaller federal parcel would leave an isolated island of federal lands to the west of the Mine Site. These federal lands would be difficult to access because the railroad and road are private property. Access points managed by the USFS to the isolated area are limited. The non-federal tract has relatively good public access. Land Exchange Alternative B would result in a net increase of 173.6 acres for the Superior National Forest. All of Tract 1 is within the 1854 Ceded Territory and would thus be subject to 1854 Treaty rights reserved by the Bands. Table 5.3.1-4 shows the Management Area designations that the USFS would apply to Tract 1 under Land Exchange Alternative B.

Table 5.3.1-4 Management Area Allocations under Land Exchange Alternative B

Tract	Acreage by Management Area ¹			cRNA ⁵	Total ⁶
	General Forest	General Forest- Longer Rotation	Riparian Emphasis Areas		
Federal lands²	355.3	4,397.3	0.0	0.0	4,752.6
Non-federal lands³					
Tract 1	4,619.3	0.0	0.0	306.9	4,926.2
Net Increase/(Decrease)⁴	4,264.0	(4,397.3)	0.0	306.9	173.6

¹ See definitions of USFS Management Areas in Section 4.2.3.

² Source: USFS 2011a.

³ Source: USFS 2011b.

⁴ Calculated as (non-federal) minus (federal).

⁵ Candidate Research Natural Area (see Section 4.2.3).

⁶ Totals may not match overall project area acreages due to rounding.

Table 5.3.1-5 shows the effect of the Land Exchange Alternative B on the total acreage within the Superior National Forest that is controlled by the USFS, the boundary of the USFS-controlled land (see Section 5.3.1.4.2), and the fragmentation ratio (see Section 5.3.1.4.3). The Land Exchange Alternative B would increase the federal estate by a net of 38.7 acres to the 2,171,603.9 acres of USFS-controlled land within the Superior National Forest.

Table 5.3.1-5 Superior National Forest Boundary, Acreage, and Fragmentation for Land Exchange Alternative B

	Baseline/ Land Exchange No Action Alternative	Land Exchange Alternative B	
		Predicted Value	Net Increase/(Decrease) ¹
Acreage in Superior National Forest controlled by USFS	2,171,603.9	2,171,642.6	38.7
Boundary length (linear miles)	10,054.8	10,046.2	(8.6)
Fragmentation (linear miles per acre)	0.005	0.005	0.00

¹ Totals differ from acreage reported in Table 5.3.1-4 (173.6 acres) due to inconsistencies in GIS data and because Mud Lake (30.5 acres) would continue to be managed by the MDNR.

5.3.1.3.2 Boundary Managed

The Land Exchange Alternative B would result in an 8.6-mile net reduction of the perimeter around the USFS-controlled portions of the Superior National Forest (see Table 5.3.1-5).

5.3.1.3.3 Forest Fragmentation

The Land Exchange Alternative B would not change the fragmentation ratio in USFS-controlled portions of the Superior National Forest (see Table 5.3.1-5).

5.3.1.3.4 Zoning Compatibility

Under the Land Exchange Alternative B, the forest lands that would become isolated under this alternative to the west of the smaller federal parcel would remain within the Superior National Forest, and would retain their General Forest – Longer Rotation Management Area designation.

This management area is compatible with nearby mining activity. There is no existing public access to this portion of the Superior National Forest, and it is reasonable to expect that permission of the private landowner to access via historical methods would be restricted, for health and safety reasons, for the anticipated life of the mine.

The proposed management area designation for Tract 1 under the Land Exchange Alternative B would be the same as in the Land Exchange Proposed Action (see Section 5.3.1.2.4). The Land Exchange Alternative B would be compatible with the USFS management areas and zoning/land use designations of adjacent lands.

5.3.1.3.5 Mineral Development Potential and Quality of Title

The Land Exchange Alternative B would remove 4,752.6 acres of forest lands with proven mineral development potential from the Superior National Forest, in return for up to 4,926.3 acres with moderate mineral development potential, except for potential surficial aggregate resources in the far northeastern corner of Tract 1 (Barr 2011c). The risk of conflict and quality of title for the Land Exchange Alternative B is the same as for Tract 1 in the Land Exchange Proposed Action (see Table 5.3.1-3).

As with the Land Exchange Proposed Action, the Land Exchange Alternative B would result in a reduced risk of conflict and improved quality of title. The Land Exchange Alternative B would result in relinquishing the federal parcel with severed, private mineral rights and known, economically developable minerals and acquiring parcels with low to moderate risk of conflict and moderate to high title quality. The risk of conflict and title quality may be further improved through subsequent arrangements with holders of mineral rights on the non-federal lands or affirmative title insurance coverage. Thus, the Land Exchange Alternative B would also benefit efforts to manage the Superior National Forest, although to a lesser degree than the Land Exchange Proposed Action.

Mineral rights to the Mine Site are held by PolyMet, while surface rights are held by USFS, creating a conflict between surface and mineral rights. As described in Section 3.3, the USFS's Purpose and Need is to resolve the conflict between surface and mineral rights (see Section 5.3.1).

The Land Exchange Alternative B would be consistent with this Purpose and Need, as well as existing land use designations surrounding the Mine Site. Therefore, the Land Exchange Alternative B would have no adverse effect on land use at the Mine Site. Effects on recreational and natural resource use at the Mine Site are addressed in other sections of this chapter.

5.3.1.4 Land Exchange No Action Alternative

The Land Exchange No Action Alternative represents no change to current land use on the federal and non-federal lands. There would be no change in the amount of forest boundary managed, level of forest fragmentation, or acres available for public access and use.

Under the Land Exchange No Action Alternative, interest in development of mineral potential on the federal lands could continue, and would be compatible with relevant local zoning ordinances and planning designations. The Land Exchange No Action Alternative is also compatible with the General Forest and General Forest – Longer Rotation Management Area classifications. However, the mineral rights would remain severed from federal ownership. The potential

conflict between mineral interests and USFS surface management of the federal parcel would remain.

The presence of a privately owned road (Dunka Road) and rail on the southern border of the federal lands would continue to limit public access to and use of the federal lands, as envisioned by the management area designations.

5.3.2 Water Resources

This section describes the potential effects and compares the resource value of the Land Exchange Proposed Action on water resources of the federal and non-federal lands to be exchanged, as well as for Land Exchange Alternative B and the Land Exchange No Action Alternative. The effects on the federal and non-federal lands are discussed together to facilitate comparison between the water resources of the lands exchanged. The total yield and quality of surface and groundwater currently leaving the non-federal tracts and flowing into the federal estate would not be altered by any of the Land Exchange alternatives. Under the Land Exchange Proposed Action and alternatives, the Superior National Forest would retain its ongoing responsibility for managing water resources on USFS lands in accordance with the Forest Plan. Table 5.3.2-1 shows the effects of the Land Exchange Proposed Action and Land Exchange alternatives on acreage of surface water and wild rice beds.

Under the Land Exchange Proposed Action, a net increase of 95.2 acres of MDNR-designated public water lakes (2.1 miles of shoreline) and 4.6 miles of public water streams would be added to the federal estate. By comparison, under Land Exchange Alternative B, a net increase of 116.8 acres of public water lakes (2.6 miles of shoreline) and 3.6 miles of public water streams would be added to the federal estate. One difference is that, under the Land Exchange Proposed Action, all of Mud Lake (30.5 acres) would be exchanged for the private lands, while under Land Exchange Alternative B only about 8.9 acres of Mud Lake would be included in the land exchange. Both the Land Exchange Proposed Action and Land Exchange Alternative B would result in a net increase of wild rice beds to the federal estate. Hay Lake Lands (Tract 1) contain known wild rice beds (approximately 126 acres).

Table 5.3.2-1 Net Change in Surface Water and Wild Rice Beds to the Federal Estate under the Land Exchange Proposed Action and Alternatives

Alternative	Net Increase/(Decrease) of Water Resources			
	Public Water Lakes acres	Public Water Lakes miles of shoreline	Public Water Streams miles	Wild Rice Beds acres
Land Exchange Proposed Action	95.2	2.1	4.6	>125.7 ⁽¹⁾
Land Exchange Alternative B	116.8	2.6	3.6	>125.7 ⁽¹⁾
Land Exchange No Action Alternative	0	0	0	0

¹ Excludes area of wild rice beds in Pike River. Presence of wild rice in the Pike River, which runs through Rice Lake, was noted in Barr's surveys (Barr 2010a; 2011a; 2012a), but the area of rice was not calculated.

There is limited groundwater or surface water quality data available for the non-federal tracts, with the exception of sulfate data for the Hay Lake Lands. There are, however, no known reasons to suspect surface water or groundwater contamination of any of the tracts from human activities. In general, water quality is expected to reflect natural conditions as similar to that found from MPCA regional studies (see Section 4.3.2.2.3).

5.3.2.1 Methodology and Evaluation Criteria

The area of analysis for water resource effects of the Land Exchange alternatives included the federal and non-federal tracts proposed for the exchange.

Since the Land Exchange Proposed Action would not actually result in any direct effects, as there are no construction or other activities proposed that would affect water resources, this assessment focuses on a comparison of the net change in the quantity and quality of water resources between the federal and non-federal tracts involved in the exchange.

5.3.2.1.1 Groundwater Evaluation Criteria

Groundwater resource evaluation criteria for the Land Exchange Proposed Action include a qualitative assessment of potential for groundwater contamination of the non-federal properties using MDNR and MPCA groundwater quality data.

5.3.2.1.2 Surface Water and Wild Rice Evaluation Criteria

Surface water evaluation criteria for the Land Exchange Proposed Action include a comparison of the length of public water streams/rivers, public water lake acreage, and shoreline length between the federal and non-federal lands. This was used to determine the net change in quantity of waterbodies. In addition, a qualitative assessment of surface water quality was conducted taking into consideration available water quality data, aerial photographs, and GIS information.

Wild rice evaluation criteria include a comparison in the amount of known or potential wild rice beds between federal and non-federal lands. This was used to determine the potential change in acres of wild rice on the federal estate. Information that was used in the analysis of wild rice beds included available field data, aerial photographs, and GIS layers.

5.3.2.2 Land Exchange Proposed Action

The Land Exchange Proposed Action would involve the transfer of 6,495.4 acres of federal lands from public to private ownership, and up to 7,075.0 acres of private land to public ownership (see Figure 3.3-1).

5.3.2.2.1 Groundwater

The Land Exchange Proposed Action would not directly result in a change in groundwater quantity or quality presently at the non-federal tracts. Evaluation of existing hydrogeologic data did not suggest the potential for groundwater contamination from human activity from any of the tracts. Therefore, there does not appear to be any substantive difference in the quality of groundwater resources between the federal and non-federal tracts.

5.3.2.2.2 Surface Water and Wild Rice

The Land Exchange Proposed Action would not directly result in a change in surface water quantity or quality at the non-federal tracts. There would be a net increase to the federal estate of 4.6 miles of public water streams, 95.2 acres of public water lakes (including 2.1 miles of additional shoreline), and at least 125.7 acres of wild rice beds under the Land Exchange Proposed Action.

Table 5.3.2-2 summarizes the federal and non-federal surface water resources and shows the net changes in these resources to the federal estate that would result from the Land Exchange Proposed Action. The Hay Lake lands (Tract 1) account for the majority of the net gain in surface water and wild rice beds to the federal estate from all the non-federal lands.

Table 5.3.2-2 Net Change in Surface Water and Wild Rice Beds to the Federal Estate under the Land Exchange Proposed Action

	Surface Water Resource			
	Public Water Lakes, acres	Public Water Lakes, miles shore	Public Water Streams, miles	Wild Rice Beds, acres
Lands Conveyed				
Federal Lands	30.5	0.9	4.5	0.0
Lands Acquired				
Tract 1 – Hay Lake	125.7	2.8	8.1	>125.7 ⁽¹⁾
Tract 2 – Lake County	0.0	0.0	0.0	0.0
Tract 3 – Wolf Lands	0.0	0.0	1.0	0.0
Tract 4 – Hunting Club	0.0	0.0	0.0	0.0
Tract 5 – McFarland Lake	0.0	0.2	0.0	0.0
Subtotal: Non-federal Lands	125.7	3.0	10.5	>125.7 ⁽¹⁾
Net Increase/(Decrease)	95.2	2.1	4.6	>125.7⁽¹⁾

¹ Excludes area of wild rice beds in Pike River.

5.3.2.3 Land Exchange Alternative B

Under the Land Exchange Alternative B, 4,752.6 acres of federal lands would be transferred from public to private ownership, and 4,926.3 acres of land from private to public ownership, for a net increase in 173.7 acres in the federal estate (see Figure 3.3-2).

5.3.2.3.1 Groundwater

The Land Exchange Alternative B would not directly result in a change in groundwater quantity or quality at the non-federal tracts. Evaluation of existing hydrogeologic data did not suggest the potential for groundwater contamination from human activity from any of the tracts. Therefore, there does not appear to be any substantive difference in the quality of groundwater resources between the federal and non-federal tracts.

5.3.2.3.2 Surface Water and Wild Rice

The Land Exchange Alternative B would not directly result in a change in surface water quantity or quality at the non-federal tracts. There would be a net increase to the federal estate of about 3.6 miles of public water streams, under Land Exchange Alternative B. There would also be a net increase of about 116.8 acres of public water lake area (including 2.6 miles of shoreline) and at least 125.7 acres of wild rice beds under the Land Exchange Alternative B.

Table 5.3.2-3 summarizes the federal and non-federal surface water resources and shows the net changes in these resources to the federal estate that would result from the Land Exchange Alternative B.

Table 5.3.2-3 Net Change in Surface Water and Wild Rice Beds to the Federal Estate under Land Exchange Alternative B

	Surface Water Resource			
	Public Water Lakes, acres	Public Water Lakes, miles shore	Public Water Streams, miles	Wild Rice Beds, acres
Lands Conveyed				
Federal Lands	8.9	0.2	4.5	0.0
Lands Acquired				
Tract 1	125.7	2.8	8.1	>125.7 ⁽¹⁾
Net Increase/(Decrease)	116.8	2.6	3.6	>125.7 ⁽¹⁾

¹ Excludes area of wild rice beds in Pike River.

5.3.2.4 Land Exchange No Action Alternative

Under the Land Exchange No Action Alternative, the Land Exchange Proposed Action would not take place and would result in no changes in existing water resources under federal ownership. The Superior National Forest would have an ongoing responsibility for managing water resources on the federal lands in accordance with the Forest Plan. The Land Exchange No Action Alternative would not change the USFS responsibility for managing water resources.

5.3.3 Wetlands

This section describes the potential environmental consequences of the Land Exchange Proposed Action on wetland resources that occur on the federal and non-federal lands. In this section, effects on the federal and non-federal lands are discussed together, to facilitate calculation of net changes to wetland resources. Under the Land Exchange Proposed Action and alternatives, the Superior National Forest would retain its ongoing responsibility for managing wetland resources on Forest Service lands in accordance with the Forest Plan.

Overall, the Land Exchange Proposed Action would result in an increase to the federal estate of wetland acreage by up to 505.5 acres through the acquisition of up to 7,075.0 acres of non-federal lands in exchange for 6,495.4 acres of federal land, and thus would be in conformity with EO 11990 (see Table 5.3.3-1). The Land Exchange Proposed Action would result in a net decrease to the federal estate of 1,401.0 acres of floodplains (see Table 5.3.3-1); however, these floodplains are not Federal Emergency Management Agency (FEMA) regulatory floodplains. There would be no decrease in the amount of regulatory floodplain or increase in the flood damage potential associated with the Land Exchange Proposed Action. The effects on the ecological function of the floodplain wetlands would be mitigated through the Section 404 Permit and the proposed mitigation described in Section 4.2.3. The Land Exchange Proposed Action would also increase the wetlands within the federal estate. The Land Exchange Proposed Action would be in conformance with EO 11988 (FSH 5409.13 § 33.43c). The Land Exchange Proposed Action would result in an increase of coniferous swamp, hardwood swamp, open water, shallow marsh, and shrub swamp wetland resources to the federal estate, but would result in a decrease of coniferous bog, open bog, and sedge/wet meadows wetland resources to the federal estate (see Table 5.3.3-2). In addition, the Land Exchange Proposed Action would result in an increase in waterway acreage and frontage to the federal estate (see Table 5.3.3-3).

Due to the reduced land area involved, Land Exchange Alternative B would result in a lesser degree of wetlands, floodplains, and other water resources exchanged to the federal estate as the proposed Land Exchange Proposed Action. Overall, Land Exchange Alternative B would increase wetland areas to the federal estate by 69.9 acres (see Table 5.3.3-1) through the acquisition of up to 4,926.3 acres of the non-federal lands in exchange for 4,752.6 acres of federal land, and would thus be in conformity with EO 11990. The Land Exchange Alternative B would decrease the amount of floodplains to the federal estate by 1,036.7 acres (see Table 5.3.3-1); however, these floodplains are not FEMA regulatory floodplains. There would be no decrease in the amount of regulatory floodplain or increase in the flood damage potential associated with the Land Exchange Alternative B. The effects on the ecological function of the floodplain wetlands would be mitigated through the Section 404 Permit and the proposed mitigation described in Section 4.2.3. The Land Exchange Alternative B would also increase the wetlands within the federal estate. The Land Exchange Alternative B would be in conformance with EO 11988 (FSH 5409.13 § 33.43c). Land Exchange Alternative B would result in an increase of coniferous swamp, open water, shallow marsh, and shrub swamp wetland resources to the federal estate but would result in a decrease to coniferous bog, hardwood swamp, open bog, and sedge/wet meadows wetland resources to the federal estate (see Table 5.3.3-2). In addition, Land Exchange Alternative B would result in an increase of waterway acreage and frontage to the federal estate (see Table 5.3.3-3).

Table 5.3.3-1 Net Increase or Decrease of Wetland and Floodplain Acres on the Federal Estate from the Land Exchange Proposed Action and Alternatives

Alternative	Increase (or Decrease) of Wetland and Floodplain Acres	
	Wetlands (Acres)	Floodplains (Acres)
Land Exchange Proposed Action	505.5	(1,401.0)
Land Exchange Alternative B	69.9	(1,036.7)

Table 5.3.3-2 Net Increase or Decrease of Wetland Resource Types on the Federal Estate from the Land Exchange Proposed Action and Alternatives

Alternative	Increase (or Decrease) of Wetland Resource Types (Acres)								
	Coniferous Bog	Coniferous Swamp ¹	Deep Marsh	Hardwood Swamp ²	Open Bog	Open Water (includes shallow, open water, and lakes)	Sedge/Wet Meadow	Shallow Marsh ³	Shrub Swamp (includes alder thicket and shrub-carr)
Land Exchange Proposed Action	(1,961.4)	1,954.6	0.0	36.9	(202.4)	151.7	(35.7)	20.5	541.3
Land Exchange Alternative B	(1,677.0)	1,477.8	0.0	(5.7)	(172.9)	168.0	(34.9)	3.2	311.4

¹ Coniferous bogs on the non-federal lands were grouped with coniferous swamps during field data collection.

² Hardwood swamps on the non-federal lands may contain coniferous tree species.

³ Shallow marsh areas on the non-federal lands may contain deep marshes.

Table 5.3.3-3 Net Increase or Decrease of Frontage of Waterways on the Federal Estate from the Land Exchange Proposed Action and Alternatives

Alternative	Increase (or Decrease) of Frontage of Waterways					
	Lake			River/Stream/Creek		
	Acres	Frontage (ft)	Length of Lake Frontage/Acre	Miles	Frontage (linear ft)	Length of River Frontage/Acre
Land Exchange Proposed Action	99.1	12,864.0	34.9	3.8	27,456.0	34.0
Land Exchange Alternative B	120.7	15,224.0	3.2	2.8	16,896.0	3.5

Source: Data from Section 4.3.3.

Based on a qualitative assessment, the Land Exchange Proposed Action and Land Exchange Alternative B would appear to result in an increase to the federal estate of wetlands rated as high for vegetation diversity/integrity, wetland water quality, fish habitat, and amphibian habitat. Land Exchange Alternative B would also appear to result in an increase to the federal estate of wetlands rated as high for hydrology and wildlife habitat. The Land Exchange Proposed Action

would result in an increase to the federal estate of moderate and low rated wetlands for amphibian habitat, as where Land Exchange Alternative B would also result in an increase to the federal estate of wetlands rated low for amphibian habitat. The Land Exchange Proposed Action would have similarly rated hydrology, flood attenuation, downstream water quality, wildlife habitat, and aesthetics/education/cultural functions. Land Exchange Alternative B would result in a decrease to the federal estate of wetlands rated high and moderate for flood attenuation and downstream water quality and would not result in a change to aesthetics/education/cultural functions.

5.3.3.1 Methodology and Evaluation Criteria

The potential effect that the Land Exchange Proposed Action and alternatives would have on wetland resources was evaluated using two types of criteria: 1) criteria assessing conformity to EOs 11990 and 11988, which requires a wetland acre-for-acre analysis and a floodplain acre-for-acre analysis of the federal estate, and 2) criteria used in an analysis of wetlands and floodplain habitat, as well as other water resource indicators.

As previously discussed, to satisfy the requirements of EOs 11990 and 11988, the USFS policy is to use the following three conditions (FSH 5409.13 § 33.43c): 1) the value of the wetlands or floodplains for properties received and conveyed is equal (balancing test) and the land exchange is in the public interest; 2) reservations or restrictions are retained on the unbalanced portion of the wetlands and floodplains on the federal lands when the land exchange is in the public interest but does not meet the balancing test; and 3) the federal property is removed from the exchange proposal when the conditions described in the preceding paragraphs 1 or 2 cannot be met.

In addition to evaluating wetlands in accordance with the two EOs, analysis of the Land Exchange included information on wetland community types as well as ecological floodplains.

To evaluate conformity to the EOs, the following evaluation criteria were used:

- comparative difference in acres of wetland between the federal and non-federal parcels; and
- comparative difference in acres of floodplain between the federal and non-federal parcels.

Other wetland resources indicators that were used are the following:

- comparative difference in acres of wetland types between the federal and non-federal parcels;
- a MnRAM assessment of wetland function and value;
- change in flood damage potential on the parcels and to the surrounding parcels;
- a MnRAM assessment of floodplain assets; and
- comparative difference of length of streams, rivers, and lake frontage between the federal and non-federal parcels.

The spatial area of analysis for wetland resource effects from the Land Exchange Proposed Action and alternatives included the federal and non-federal tracts proposed for the exchange, while the temporal area of analysis assessed was the point in time at which the change in ownership would occur.

The analysis of the wetland resources affected by the Land Exchange Proposed Action and alternatives was guided by evaluation criteria that were developed by the USFS and other Co-

lead Agencies, which included a comparison of wetland resource acreages, wetland resources types, wetland function and values, floodplain acreages, and other water resources acreages. GIS data and field observations were used and then compared over an area of analysis that included the federal and non-federal lands.

5.3.3.1.1 Wetlands and Floodplains

The federal lands contain 4,164.4 acres of wetlands (see Table 5.3.3-4). By comparison, the five non-federal land tracts contain 4,669.9 acres of wetlands. The Land Exchange Proposed Action would result in a net increase of up to 505.5 acres of wetlands to the federal estate if all five tracts are exchanged (see Table 5.3.3-4). The Land Exchange Proposed Action would increase wetland acreage to the federal estate by up to 505.5 acres through the acquisition of up to 7,075.0 acres of non-federal lands in exchange for 6,495.4 acres of federal land, and thus would be in conformity with EO 11990. The Land Exchange Proposed Action would result in a net decrease to the federal estate of 1,401.0 acres of floodplains; however, these floodplains are not FEMA regulatory floodplains. There would be no decrease in the amount of regulatory floodplain or increase in the flood damage potential associated with the Land Exchange Proposed Action. The effects on the ecological function of the floodplain wetlands would be mitigated through the Section 404 Permit and the proposed mitigation described in Section 4.2.3. The Land Exchange Proposed Action would also increase the wetlands within the federal estate. The Land Exchange Proposed Action would be in conformance with EO 11988 (FSH 5409.13 § 33.43c).

Table 5.3.3-4 Wetland and Floodplain Acres for the Land Exchange Proposed Action

Parcel		Acres of Wetlands	Acres of Floodplains
Lands Conveyed			
Federal Lands		4,164.4	1,889.4
Lands Acquired			
Tract 1		2,930.8	376.2
Tract 2	Lake County North	209.3	0.0
	Lake County South	73.6	0.0
Tract 3	Wolf Lands 1	90.4	0.0
	Wolf Lands 2	706.2	0.0
	Wolf Lands 3	233.2	32.8
	Wolf Lands 4	362.8	79.4
Tract 4		63.6	0.0
Tract 5		0.0	0.0
Subtotal: Non-federal lands		4,669.9	488.4
Net Change			
Net Increase/(Decrease)		505.5	(1,401.0)

As part of the increase in total wetland acreage, the Land Exchange Proposed Action would result in a net increase to the federal estate of the following wetland resource types (see Table 5.3.3-5): coniferous swamp (1,954.6 acres), hardwood swamp (36.9 acres), open water (151.7 acres), shallow marsh (20.5 acres), and shrub swamp (541.3 acres). However, the Land Exchange Proposed Action would result in a net decrease to the federal estate of the following wetland resource types: coniferous bog (1,961.4 acres), open bog (202.4 acres), and sedge/wet meadow (35.7 acres).

Table 5.3.3-5 Wetland Resource Types for the Land Exchange Proposed Action

Parcel	Acres of Wetland Resource Types								
	Coniferous Bog	Coniferous Swamp ¹	Deep Marsh	Hardwood Swamp ²	Open Bog	Open Water (includes shallow, open water, and lakes)	Sedge/Wet Meadow	Shallow Marsh ³	Shrub Swamp (includes alder thicket and shrub-carr)
Lands Conveyed									
Federal Lands	1,961.4	1,287.8	0.0	21.1	209.5	30.8	35.7	97.0	521.1
Lands Acquired									
Tract 1	0.0	1,953.9	0.0	8.0	2.1	176.6	0.0	84.1	706.1
Tract 2	Lake County North	0.0	135.0	0.0	34.7	1.8	0.2	0.0	2.5
	Lake County South	0.0	32.4	0.0	9.9	0.0	2.5	0.0	12.3
Tract 3	Wolf Lands 1	0.0	75.4	0.0	0.0	3.0	0.0	0.0	12.0
	Wolf Lands 2	0.0	627.4	0.0	5.0	0.0	0.4	0.0	73.0
	Wolf Lands 3	0.0	82.6	0.0	0.0	0.0	0.0	5.2	145.4
	Wolf Lands 4	0.0	320.3	0.0	0.0	0.2	0.0	0.0	42.3
Tract 4	0.0	15.4	0.0	0.4	0.0	2.8	0.0	13.0	32.0
Tract 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal: Non-federal lands	0.0	3,242.4	0.0	58.0	91.2	182.5	0.0	33.4	1,062.4
Net Change									
Net Increase/(Decrease)	(1,961.4)	1,954.6	0.0	36.9	(202.4)	151.7	(35.7)	20.5	541.3

¹ Coniferous bogs on the non-federal lands were grouped with coniferous swamps during field data collection.

² Hardwood swamps on the non-federal lands may contain coniferous tree species.

³ Shallow marsh areas on the non-federal lands may contain deep marshes.

5.3.3.1.2 Wetland Functional Assessment

Based on a qualitative assessment, the Land Exchange Proposed Action would appear to result in an increase to the federal estate of the following high rated wetland functions: vegetation diversity/integrity, wetland water quality, fish habitat, and amphibian habitat. The Land Exchange Proposed Action would result in an increase to the federal estate of moderate- and low-rated wetlands for amphibian habitat. The Land Exchange Proposed Action would have similarly rated hydrology, flood attenuation, downstream water quality, wildlife habitat, and aesthetics/education/cultural functions.

5.3.3.1.3 Frontage of Waterways

The Land Exchange Proposed Action would result in a net increase of other water resources to the federal estate (see Table 5.3.3-6). A net increase of 99.1 acres of lake and 3.8 miles of rivers will be added to the federal estate from the Land Exchange Proposed Action. These increases would result in additional frontage of lakes and rivers to the federal estate.

Table 5.3.3-6 Frontage of Waterways for the Land Exchange Proposed Action

Lake				Rivers/Creeks/Streams		
Parcel	Acres	Frontage (ft)	Length of Lake Frontage/Acre	Miles	Frontage (linear ft)	Length of River Frontage/Acre
Lands Conveyed						
Federal Lands	30.5	4,550.0	0.7	5.3	55,968.0	8.6
Lands Acquired						
Tract 1	129.6	16,424.0	3.5	8.1	72,864.0	15.3
Tract 2	0.0	0.0	0.0	0.0	0.0	0.0
Tract 3	Wolf Lands 1	0.0	0.0	0.0	0.0	0.0
	Wolf Lands 2	0.0	0.0	0.0	0.0	0.0
	Wolf Lands 3	0.0	0.0	0.0	1,056.0	3.8
	Wolf Lands 4	0.0	0.0	0.0	9,504.0	23.5
Tract 4	0.0	0.0	0.0	0.0	0.0	0.0
Tract 5	0.0	990.0	32.1	0.0	0.0	0.0
Subtotal: Non-federal lands	129.6	17,414.0	35.6	9.1	83,424.0	42.6
Net Change						
Net Increase/(Decrease)	99.1	12,864.0	34.9	3.8	27,456.0	34.0

Source: Data from Section 4.3.3.

5.3.3.2 Land Exchange Alternative B

5.3.3.2.1 Wetlands and Floodplains

The smaller federal parcel contains 2,860.9 acres of wetlands (see Table 5.3.3-7). By comparison, the non-federal lands contain 2,930.8 acres of wetlands. The Land Exchange Alternative B would result in a net increase of 69.9 acres of wetlands to the federal estate. The

Land Exchange Alternative B would increase wetland areas to the federal estate by 69.9 acres through the acquisition of up to 4,926.3 acres of the non-federal lands in exchange for 4,752.6 acres of federal land, and would thus be in conformity with EO 11990. The Land Exchange Alternative B would result in a net decrease to the federal estate of 1,036.7 acres of floodplains; however, these floodplains are not FEMA regulatory floodplains. There would be no decrease in the amount of regulatory floodplain or increase in the flood damage potential associated with the Land Exchange Alternative B. The effects on the ecological function of the floodplain wetlands would be mitigated through the Section 404 Permit and the proposed mitigation described in Section 4.2.3. The Land Exchange Alternative B would also increase the wetlands within the federal estate. The Land Exchange Alternative B would be in conformance with EO 11988 (FSH 5409.13 § 33.43c).

Table 5.3.3-7 Wetland and Floodplain Acres for Land Exchange Alternative B

	Acres of Wetlands	Acres of Floodplains
Lands Conveyed		
Smaller Federal Parcel	2,860.9	1,412.9
Lands Acquired		
Tract 1	2,930.8	376.2
Net Change		
Net Increase/(Decrease)	69.9	(1,036.7)

As part of the increase in wetland acreage, Land Exchange Alternative B would result in a net increase to the federal estate of the following wetland resource types (see Table 5.3.3-8): coniferous swamp (1,477.8 acres), open water (168.0 acres), shallow marsh (3.2), and shrub swamp (311.4 acres). However, the Land Exchange Alternative B would result in a net decrease to the federal estate of the following wetland resource types: coniferous bog (1,677.0 acres), hardwood swamp (5.7 acres), open bog (172.9 acres), and sedge/wet meadow (34.9 acres).

Table 5.3.3-8 Wetland Resource Types for Land Exchange Alternative B

Parcel	Acres of Wetland Resource Types								Shrub Swamp (includes alder thicket and shrub-carr)
	Coniferous Bog	Coniferous Swamp ¹	Deep Marsh	Hardwood Swamp ²	Open Bog	Open Water (includes shallow, open water, and lakes)	Sedge/Wet Meadow	Shallow Marsh ³	
Lands Conveyed									
Smaller Federal Parcel	1,677.0	476.1	0.0	13.7	175.0	8.6	34.9	80.9	394.7
Lands Acquired									
Tract 1	0.0	1,953.9	0.0	8.0	2.1	176.6	0.0	84.1	706.1
Net Change									
Net Increase/(Decrease)	(1,677.0)	1,477.8	0.0	(5.7)	(172.9)	168.0	(34.9)	3.2	311.4

¹ Coniferous bogs on the non-federal lands were grouped with coniferous swamps during field data collection.

² Hardwood swamps on the non-federal lands may contain coniferous tree species.

³ Shallow marsh areas on the non-federal lands may contain deep marshes.

5.3.3.2.2 Wetland Functional Assessment

The Land Exchange Alternative B would result in an increase to the federal estate of wetlands rated as high for vegetation diversity/integrity, hydrology, wetland water quality, wildlife habitat, fish habitat, and amphibian habitat. There would be a decrease to the federal estate of wetlands rated high and moderate for flood attenuation and downstream water quality. The Land Exchange Alternative B would also result in an increase to the federal estate of wetlands rated low for amphibian habitat. The Land Exchange Alternative B would not result in a change to aesthetics/education/cultural functions to the federal estate.

5.3.3.2.3 Frontage of Waterways

The Land Exchange Alternative B would result in a net increase of other water resources to the federal estate (see Table 5.3.3-9). A net increase of 120.7 acres of lake and 2.8 miles of rivers will be added to the federal estate from the Land Exchange Alternative B. These increases would result in additional frontage of lakes and rivers to the federal estate.

Table 5.3.3-9 Frontage of Waterways for Land Exchange Alternative B

Parcel	Acres	Lake		Rivers/Creeks/Streams		
		Frontage	Length of	Miles	Frontage	Length of
		(ft)	Lake		(linear ft)	River
Lands Conveyed						
Smaller Federal Parcel	8.9	1,200.0	0.3	5.3	55,968.0	11.8
Lands Acquired						
Tract 1	129.6	16,424.0	3.5	8.1	72,864.0	15.3
Net Change						
Net Increase/(Decrease)	120.7	15,224.0	3.2	2.8	16,896.0	3.5

Source: Data from Section 4.3.3.

5.3.3.3 Land Exchange No Action Alternative

Under the Land Exchange No Action Alternative, the Superior National Forest would have an ongoing responsibility for managing wetland resources, floodplains, and surface waters on the federal lands in accordance with the Forest Plan. The Land Exchange No Action Alternative would not change USFS's responsibility for managing wetland resources, floodplains, and surface waters and would result in no further effects on these resources.

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5.3.4 Vegetation

This section provides an evaluation of the effects of the Land Exchange Proposed Action on vegetation, including comparisons of MDNR GAP land cover types, native plant community types, MBS Sites of Biodiversity Significance, MIH types, age classes, threatened and endangered plant species, and biodiversity between the federal and non-federal lands. Table 5.3.4-1 provides a summary of these data on a net increase or decrease basis to the federal estate.

When comparing the total acres of the federal and non-federal lands, the federal estate would have an increase of 579.6 acres of MDNR GAP land cover types (see Table 5.3.4-1) as a result of the Land Exchange Proposed Action. The shrublands (1,199.4 acres) would increase the most and the upland conifer forests (919.5 acres) would decrease the most (see Table 5.3.4-2). There would be an acreage increase of upland forest (MIH 1) with lesser amounts of lowland black spruce-tamarack forest (MIH 9) and aquatic habitat (MIH 14), but a decrease of upland conifer forest (MIH 5) to the federal estate (see Table 5.3.4-1). There would be an increase to the federal estate of immature forest stands with lesser amounts of young stands, but a decrease in mature forest stands.

There would be a decrease to the federal estate of up to approximately 6,025.8 acres of MBS Sites of High Biodiversity Significance and an increase of up to 767.9 acres of MBS Sites of Moderate Biodiversity Significance under the Land Exchange Proposed Action (see Table 5.3.4-1). There would be a decrease to the federal estate of three native plant communities that are “imperiled,” “imperiled-vulnerable,” or “vulnerable,” as well as others that are ranked as “apparently secure” or “widespread and secure,” in exchange for one native plant community that is ranked as “vulnerable” and two that are ranked as “apparently secure.” There would be a decrease to the federal estate of up to 2,016.6 acres in the Jack Pine-Black Spruce landscape ecosystem, and an increase of up to 994.7 acres in the Lowland Conifer landscape ecosystem and 558.7 acres in the Mesic Red and White Pine landscape ecosystem. Additionally, the USFS would increase representation in the Dry-Mesic Red and White Pine, Mesic Birch-Aspen-Spruce-Fir, Lowland Hardwood, and Sugar Maple landscape ecosystems. Overall, there would be an increase to the federal estate of 625.2 acres of landscape ecosystems as a result of the Land Exchange Proposed Action.

There would be a decrease to the federal estate of 13 populations of 11 state-listed ETSC plant species on the federal lands in exchange for two populations of two known state-listed ETSC plant species on the non-federal lands. Though the 11 state-listed plant species on the federal lands are not known to occur on the non-federal lands, the Land Exchange Proposed Action would result in an increase to the federal estate of most habitats important to them. Drawing from the MIH exchange, RFSS plants associated with upland forest (MIH 1), lowland black spruce-tamarack forest (MIH 9), and aquatic habitat (MIH 14) could potentially exist on or spread to the habitats on the non-federal parcels. There would also be a gain of Rove Formation cliff microhabitats to the federal estate, which are important for a variety of RFSS plants in the Superior National Forest.

Rulemaking was conducted with the intent to update the list of ETSC species (*Minnesota Rules*, parts 6134.0100 to 6134.0400), with new listings becoming effective on August 19, 2013. The FEIS will consider any new listings, or changes in the previous listings, associated with the updated list. The FEIS will also consider any federal listing changes, should they occur.

A Biological Evaluation (containing further information about RFSS species) has been prepared and is posted on the USFS website (<http://www.fs.usda.gov/goto/superior/northmet>). The organization of the methodologies and discussion in the Biological Evaluation may be different from the SDEIS. The document also contains determinations of effect for the species discussed.

Table 5.3.4-1 Vegetation and Cover Type Increase or Decrease to the Federal Estate Due to Land Exchange Proposed Action and Alternatives

Category		Net Increase/(Decrease)		
		Land Exchange Proposed Action	Land Exchange Alternative B	Land Exchange No Action Alternative
Habitat Types (acres)	MDNR GAP Land Cover Types	579.6	173.6	0.0
	MIH 1 (Upland Forest)	1,364.5	1,411.8	0.0
	MIH 5 (Upland Conifer Forest)	(1,172.5)	(1,084.6)	0.0
	MIH 9 (Lowland Black Spruce-tamarack Forest)	248.3	(261.1)	0.0
	MIH 14 (Aquatic Habitat)	226.7	206.2	0.0
	Lowland Shrub	(160.1)	(272.1)	0.0
	Lowland Emergent	200.2	249.6	0.0
	Upland Grass	43.3	0.0	0.0
	Young Forest Stands	507.1	262.7	0.0
	Immature Forest Stands	2,000.5	1,933.9	0.0
	Mature Forest Stands	(2,029.6)	(2,114.5)	0.0
MBS Sites (acres)	High Biodiversity Sites	(6,025.8)	(4,573.1)	0.0
	Moderate Biodiversity Sites	767.9	(0.3)	0.0
	Imperiled (S2)	(1.0)	0.0	0.0
	Imperiled/Vulnerable (S2-3)	(1.0)	(1.0)	0.0
Native Plant Communities		(1) and +1 other	(1.0)	0.0
	Vulnerable (S3)			
		(6) and +2 others	(2.0)	0.0
	Apparently Secure (S4)			
Landscape Ecosystems (acres)	Widespread and Secure (S5)	(6.0)	(4.0)	0.0
	Dry-Mesic Red and White Pine	683.0	589.2	0.0
	Jack Pine-black Spruce	(2,016.6)	(1,411.6)	0.0
	Lowland Conifer	994.7	486.2	0.0
	Lowland Hardwood	66.5	0.0	0.0
	Mesic Birch-aspen-spruce-fir	302.2	0.9	0.0
	Mesic Red and White Pine	558.7	528.0	0.0
ETSC Species (number of species)	Sugar Maple	36.7	0.0	0.0
		(11) species +2 different species	(11) species	
Management Area (acres)	State-listed Plant Species			
	General Forest	5,714.1	4,264.0	0.0
	General Forest – Longer Rotation	(5,658.0)	(4,397.3)	0.0
	cRNA	306.9	306.9	0.0
	Riparian Emphasis Area	220.9	0.0	0.0

5.3.4.1 Methodology and Evaluation Criteria

The vegetation assessment area for the Land Exchange Proposed Action would involve 6,495.4 acres of federal lands transferred from public to private ownership, and up to 7,075.0 acres of land transferred from private to public ownership. The spatial and temporal area of analysis for vegetation as part of the Land Exchange Proposed Action included direct and indirect effects resulting from the change in ownership of the federal and non-federal lands, including the extent of landscape ecosystems as defined in the Forest Plan or the extent of similar landscape ecosystems on the abutting forest lands.

An evaluation was conducted to determine the potential effect that the Land Exchange Proposed Action would have on the following vegetation resources:

- the quality and quantity of forest resources/lands (change in forest types and age classes);
- change in state-listed ETSC plant species and RFSS plants (individuals, habitat, and/or populations);
- change in biodiversity or overall vegetation and habitat; and
- the introduction and spread of invasive non-native species.

The analysis of the vegetation resources affected by the Land Exchange Proposed Action was guided by evaluation criteria that were developed by the USFS and other Co-lead Agencies, which included a comparison of the MDNR GAP land cover types, native plant communities, MBS Sites of Biodiversity Significance, MIH types (MIH 1, 5, 9, and 14, as well as lowland shrublands, lowland emergent wetlands, and upland grass), age classes (young, immature, and mature), large mature forest patches, landscape ecosystems, management areas, threatened and endangered plant species, RFSS plants, and invasive non-native plant species. GIS data for these categories were gathered to the extent possible, and then compared over an area of analysis that included the federal and non-federal lands, and also the surrounding landscape ecosystems of the Superior National Forest or ecological subsections. MIH types and age classes have also been compared within the context of landscape ecosystems to reveal how many acres of each MIH and age class would be increased or decreased on the federal estate by the Land Exchange Proposed Action within each landscape ecosystem. MIH type and age class data for the non-federal lands were interpreted from field survey maps, aerial maps, surrounding federal MIH data, topographic maps, and USFS review. These were then compared to the federal lands MIH data to determine MIH type and age class increases or decreases of acreage to the federal estate. Additionally, all of the data types mentioned have been compared to summarize the vegetative biodiversity of the federal and non-federal lands.

5.3.4.2 Land Exchange Proposed Action

5.3.4.2.1 Cover Types

Cover types consist of several categories of classification, including MDNR GAP land cover types, USFS management areas, USFS ELTs, and USFS MIH types.

Habitat Types

The Land Exchange Proposed Action would result in an increase to the federal estate of up to 579.6 acres of MDNR GAP land cover designations, with the greatest increase in shrubland acreage of 1,199.4 acres and the greatest decrease in upland conifer forest of 919.5 acres (see Table 5.3.4-2). The decrease of upland conifer forest is contrary to a goal of the 2004 Forest Plan. The Forest Plan calls for an increase in the acreage of red, white, and jack pine habitats (and a decrease in the acreage of aspen vegetation communities). In addition, the Land Exchange Proposed Action would support other Forest Plan goals to maintain acreage of lowland deciduous habitats and non-forested wetlands. The Land Exchange Proposed Action would result in a small increase to the federal estate of lowland deciduous forests, an increase in aquatic habitats, and a large increase of shrublands.

Table 5.3.4-2 Net Increase or Decrease to the Federal Estate of MDNR GAP Land Cover Types under the Land Exchange Proposed Action

Cover Types	Federal Land Acres	Non-federal Land Acres	Net Increase/ (Decrease) Acres
Shrubland	645.6	1,845.0	1,199.4
Aquatic environments	60.1	266.6	206.5
Upland deciduous forest	1,091.8	1,232.9	141.1
Upland conifer-deciduous mixed forest	20.9	50.4	29.5
Cropland/grassland	6.2	31.7	25.5
Lowland deciduous forest	9.5	28.6	19.1
Lowland coniferous forest	2,978.6	2,920.5	(58.1)
Disturbed	63.8	0.0	(63.8)
Upland coniferous forest	1,618.9	699.4	(919.5)
Total ¹	6,495.4	7,075.0	579.6

Source: MDNR 2006b.

¹ Total acres may be more or less than presented due to rounding.

Culturally Important Plants

The Land Exchange Proposed Action would result in additional wild rice beds by the acquisition of Tract 1. Tract 1 contains Little Rice Lake, which supports a continuous population of wild rice. Wild rice also grows along the Pike River south of Little Rice Lake and in isolated populations on Hay Lake. Section 4.3.4.2.5 provides further discussion of wild rice on Tract 1. Wild rice does not currently grow within the proposed federal land boundaries. As a result, the public would have better opportunities for wild rice harvesting on Tract 1, where there is currently no opportunity to harvest wild rice directly on the federal lands (i.e., no known wild rice populations) despite the public water access onto the federal lands. A carry-down boat launching access is located on Tract 1, which may provide private access for wild rice harvesting on the Tract 1 lands. Access to wild rice beds on the federal lands would not be lost as a result of the Land Exchange Proposed Action, but access to wild rice beds on Tract 1 would be gained.

Natural resources culturally important to the Bands are discussed in Section 4.2.9.

Minnesota Biological Survey

The Land Exchange Proposed Action would result in a decrease to the federal estate of 6,142.7 acres of MBS Sites of High Biodiversity Significance in the Laurentian Uplands subsection, and an increase of 116.9 acres of MBS Sites of High Biodiversity Significance in the North Shore Highlands subsection. Furthermore, the Land Exchange Proposed Action would result in an increase to the federal estate of 767.6 acres of MBS Sites of Moderate Biodiversity Significance in the Laurentian Uplands subsection.

Native plant community rankings are largely unavailable for the non-federal lands, with the exception of Lake County South, which has one site ranked as “vulnerable” and others ranked as “apparently secure.” Section 4.3.4.2.6 provides further discussion of native plant community types on the Lake County South parcel. The Land Exchange Proposed Action would result in a decrease to the federal estate of three native plant communities on the federal lands that are ranked as “imperiled” to “vulnerable” in the state. A native plant community increase or decrease comparison cannot be accurately made since rankings are unavailable for much of the non-federal lands.

Management Areas

In conjunction with landscape ecosystem objectives, the USFS has developed desired future conditions and objectives, based on management areas, which describe what is desired socially and economically (USFS 2004b). The majority of the non-federal lands (86 percent) would be allocated to the General Forest Management Area upon completion of the Land Exchange Proposed Action. This management area provides a wide variety of goods, uses, and services, including wood products, scenic quality, recreation opportunities, and habitat types (USFS 2004b). The remaining non-federal lands would be allocated to the General Forest – Longer Rotation Management Area (7 percent), Potential/cRNA (4 percent), and Riparian Areas Management Area (3 percent). Section 5.3.1 provides a discussion of management area allocations on the non-federal lands for the Land Exchange Proposed Action.

Through the acquisition of Tract 1, the Land Exchange Proposed Action would result in a gain of a large contiguous block of land and lakeshore/river frontage. The majority of this tract (94 percent) would be allocated to the General Forest Management Area, with the balance allocated as a cRNA (6 percent). Two cRNA lands abut Tract 1 (USFS 2011b) and, upon completion of the Land Exchange Proposed Action, these two cRNA lands would be extended onto the parcel. The Pike Mountain cRNA is located at the southwestern corner of Tract 1. Approximately 135 acres of Tract 1 are proposed to be added to the Pike Mountain cRNA because it is an extension of the northern hardwood uplands with a high sugar maple component. The Loka Lake cRNA is located at the northeastern corner of Tract 1. Approximately 172 acres of the parcel are proposed to be added to the Loka Lake cRNA because it is an extension of the high-quality lowland black spruce and tamarack swamp.

The Land Exchange Proposed Action would result in Tract 2 being allocated as Riparian Areas (83 percent) and General Forest – Longer Rotation Management Area (17 percent) (USFS 2011b). The Riparian Emphasis Area Management Area provides protection to diverse age classes, but generally for older-growth forest stands along sensitive riparian areas.

The majority of Tract 3 would be allocated to the General Forest Management Area (92 percent), with the remaining 8 percent allocated to the General Forest – Longer Rotation Management Area (USFS 2011b).

All of Tracts 4 and 5 would be allocated to the General Forest – Longer Rotation Management Area (USFS 2011b). Obtaining Tract 5 would result in a gain of lakeshore property.

Overall, there would be a large increase to the federal estate in the General Forest Management Area (5,714.1 acres) and smaller increases in the cRNA (306.9 acres) and Riparian Areas (220.9 acres) Management Areas as a result of the Land Exchange Proposed Action (see Table 5.3.4-3). There would be a decrease to the federal estate of 5,662.3 acres of the General Forest – Longer Rotation Management Area. The lands to be acquired as part of the Land Exchange Proposed Action would be managed in accordance with Forest Plan standards and guidelines. Section 5.3.1 describes the management areas in detail.

Table 5.3.4-3 Net Increase or Decrease to the Federal Estate of Management Areas under the Land Exchange Proposed Action

Category	Federal Lands		Non-federal Lands		Net Increase/ (Decrease)
	Acres	%	Acres	%	Acres
General Forest	355.3	5	6,069.4	86	5,714.1
General Forest – Longer Rotation	6,140.2	95	477.8	7	(5,662.3)
Potential/cRNAs	0.0	0	306.9	4	306.9
Riparian Areas	0.0	0	220.9	3	220.9

Source: USFS 2011j.

Ecological Land Types

The Land Exchange Proposed Action would result in an increase to the federal estate of seven ELTs, including ELT 3, 4, 10, 11, 14, 17, and 18. Five of these ELTs are upland soils and two are lowland soils. The USFS would not lose representation of any ELTs currently on the federal lands, based on available data.

Management Indicator Habitats

The Land Exchange Proposed Action would result in an increase to the federal estate of upland forest (MIH 1; 1,364.5 acres), lowland black spruce-tamarack forest (MIH 9; 248.3 acres), and aquatic habitat (MIH 14; 226.7 acres), and a decrease of upland conifer forest (MIH 5; 1,172.5 acres) (see Table 5.3.4-4). The Land Exchange Proposed Action would also result in a decrease to the federal estate of lowland shrub habitat (160.1 acres), but an increase in lowland emergent (200.2 acres) and upland grass (43.3 acres) habitat types. While not considered MIH types, these are important habitats for several wildlife species. The fact that aquatic habitat (MIH 14) is not mapped on the federal lands results in an apparent increase to the federal estate in these categories, even though this habitat type does occur on the federal lands.

The Land Exchange Proposed Action would result in an increase to the federal estate of 2,507.6 acres of young and immature forest stands. However, it would result in a decrease to the federal estate of 2,029.6 acres of mature forest types. The Land Exchange Proposed Action would not result in a change to the federal estate of large patches (stands over 300 acres) of mature upland

forests (MIH 13), as none exist on the federal lands (USFS 2012c) and the patches of mature forest on the non-federal lands are not part of the USFS Patch layer.

Table 5.3.4-4 Net Increase or Decrease to the Federal Estate of MIH Types and Age Classes under the Land Exchange Proposed Action

Category	Federal Land Acres ²	Non-federal Land Acres ^{1,2}	Net Increase/ (Decrease) Acres
MIH Types			
MIH 1 (Upland Forest)	1,330.0	2,694.5	1,364.5
MIH 5 (Upland Conifer Forest)	1,252.4	79.9	(1,172.5)
MIH 9 (Lowland Black Spruce-tamarack Forest)	3,060.2	3,308.5	248.3
MIH 14 (Aquatic Habitat)	0.0	226.7	226.7
Lowland Shrub	492.3	332.2	(160.1)
Lowland Emergent	185.5	385.7	200.2
Upland Grass	0.0	43.3	43.3
Age Classes			
Young	271.1	778.2	507.1
Immature	1,539.2	3,539.7	2,000.5
Mature	3,854.2	1,824.6	(2,029.6)

Source: USFS 2010b.

¹ According to non-federal lands cover type table (see Table 4.3.4-3).

² Total acres may be more or less than presented due to rounding.

Landscape Ecosystems

The Land Exchange Proposed Action would result in a decrease to the federal estate of 2,016.6 acres of the Jack Pine-Black Spruce landscape ecosystem (0.65 percent decrease), but there would be an increase of 994.7 acres in the Lowland Conifer landscape ecosystem (0.08 percent increase) and 558.7 acres of the Mesic Red and White Pine landscape ecosystem (0.73 percent increase). The Superior National Forest, as part of the Land Exchange Proposed Action, would have increased representation in the Dry-Mesic Red and White Pine landscape ecosystem (682.9 acres; 0.11 percent increase), Mesic Birch-Aspen-Spruce-Fir landscape ecosystem (302.2 acres; 0.04 percent increase), Lowland Hardwood landscape ecosystem (66.5 acres; 0.01 percent increase), and the Sugar Maple landscape ecosystem (36.7 acres; 0.04 percent increase), and there would be an overall increase to the federal estate of 625.1 acres.

Within the Superior National Forest, the USFS tracks acreage of MIH types and age classes within each landscape ecosystem to better manage them within the broader ecological context. As a result of the Land Exchange Proposed Action, there would be an increase to the federal estate in acreage of MIH types and age classes within some landscape ecosystems and a decrease in others (see Table 5.3.4-5). The greatest percentage increase to the federal estate in MIH acreage within a landscape ecosystem is lowland black spruce-tamarack forest (MIH 9) in the Mesic Birch-Aspen-Spruce-Fir landscape ecosystem, while the greatest decrease is upland conifer forest (MIH 5) in the Jack Pine-Black Spruce landscape ecosystem. The greatest percentage increase to the federal estate in age class acreage within a landscape ecosystem is the immature age class in the Lowland Conifer landscape ecosystem, while the greatest decrease is the immature and mature age classes in the Jack Pine-Black Spruce landscape ecosystem. Overall, the Lowland Conifer landscape ecosystem would have the highest acreage increase to

the federal estate in MIH types and age classes, while the Jack Pine-Black Spruce landscape ecosystem would have the highest acreage decrease in MIH types and age classes.

Table 5.3.4-5 Net Increase or Decrease to the Federal Estate of MIH Types and Age Classes within Landscape Ecosystems in the Superior National Forest under the Land Exchange Proposed Action

Landscape Ecosystem Name		Dry-Mesic Red and White Pine	Jack Pine- Black Spruce	Lowland Conifer	Lowland Hardwood	Mesic Birch- Aspen- Spruce- Fir	Mesic Red and White Pine	Sugar Maple
Category		Net Increase/(Decrease)						
MIH Types	MIH 1	Acres ¹	517.0	(1,374.7)	289.0	10.1	140.8	527.1
		% ²	2	(4)	2	2	0	1
	MIH 5	Acres ¹	15.5	(1,089.3)	(121.2)	3.2	7.6	11.6
		% ²	0	(8)	(2)	2	0	0
	MIH 9	Acres ¹	26.2	(390.7)	928.9	17.1	134.7	13.8
		% ²	1	(7)	2	1	4	0
	MIH 14	Acres ¹	115.5	2.2	97.8	9.1	0.3	0.8
		% ^{2,3}	NA	NA	NA	NA	NA	NA
	Lowland Shrub	Acres ¹	3.0	(95.0)	(113.0)	24.0	19.0	0.0
		% ²	0	(4)	(1)	4	1	0
	Lowland Emergent	Acres ¹	6.0	(62.3)	348.1	3.2	0.0	2.4
		% ²	1	(7)	5	1	0	0
	Upland Grass	Acres ¹	0.0	(0.2)	15.4	0.0	0.0	0.0
		% ²	0	0	5	0	0	0
Age Classes	Young	Acres ¹	250.8	(21.5)	188.0	5.6	51.1	9.3
		% ²	15	(1)	18	7	2	0
	Immature	Acres ¹	178.7	(700.3)	2,170.2	2.3	50.4	298.9
		% ²	1	(4)	28	1	0	1
	Mature	Acres ¹	129.2	(1,079.0)	(1,559.6)	22.5	181.6	247.1
		% ²	1	(4)	(2)	1	1	1

Source: USFS 2010b; USFS 2011g.

¹ Total acres may be more or less than presented due to rounding.

² Percentage of acres increased or decreased on the federal estate within the entire landscape ecosystem.

³ MIH 14 is not tracked on the federal lands; thus, percentage is NA (not applicable).

5.3.4.2.2 Invasive Non-native Plants

The Land Exchange Proposed Action would result in a reduction of occurrences of invasive non-native species on the federal lands, but an increase to the federal estate of similar occurrences of invasive non-native species on Tracts 1, 2, and 3, including common tansy, orange hawkweed, ox-eye daisy, and thistles. Tracts 4 and 5 would not have an increase of any occurrences of invasive non-native species.

5.3.4.2.3 Threatened and Endangered Plant Species

Endangered, Threatened, and Special Concern Plant Species

There are fewer occurrences of state-listed ETSC plant species on the non-federal lands (two species on Tract 5) than on the federal lands (11 species), so the USFS would have fewer populations as a result of the Land Exchange Proposed Action (see Table 5.3.4-6). The two species gained in the exchange are *Woodsia scopulina* and *Saxifraga paniculata*. Section 4.3.4.2.9 provides a discussion of these species. There are no federally listed plant species in St. Louis, Lake, or Cook counties (USFWS 2012). Rulemaking was conducted with the intent to update the list of ETSC species (*Minnesota Rules*, parts 6134.0100 to 6134.0400), with new listings becoming effective on August 19, 2013. The FEIS will consider any new listings, or changes in the previous listings, associated with the updated list.

Though the 11 known state-listed ETSC plant species on the federal lands are not known to occur on the non-federal lands, the Land Exchange Proposed Action would result in an increase to the federal estate of most habitats important to them. The Land Exchange Proposed Action would result in additional grassland habitat, which *Botrychium campestre* and *Botrychium pallidum* occupy. The Land Exchange Proposed Action would also result in an increase to the federal estate of upland deciduous and mixed forest habitats, used by *Botrychium pallidum*, *Botrychium rugulosum*, and *Botrychium simplex*. There would be an increase to the federal estate of aquatic habitats (open water or wetlands) for *Caltha natans*, *Eleocharis nitida*, *Juncus stygius* var. *americanus*, *Sparganium glomeratum*, and *Torreyochloa pallida*. According to the MIH analysis, the Land Exchange Proposed Action would result in an increase to the federal estate of lowland black spruce or tamarack habitats, which could mean more habitats for *Platanthera clavellata*, *Pyrola minor*, and *Ranunculus lapponicus*.

Table 5.3.4-6 Increase or Decrease to the Federal Estate of State-listed ETSC Plant Populations under the Land Exchange Proposed Action

Plant Species (State Status/ Global Status ¹)	Federal Lands Populations		Non-federal Lands Populations		Net Species Increase/ (Decrease)
	Total Populations ^{2,3}	Total Individuals ³	Total Populations ^{2,3}	Total Individuals ³	
<i>Botrychium pallidum</i> (E/G3)	1	2	0	NA	(1)
<i>Botrychium rugulosum</i> (T/G3)	1	4	0	NA	(1)
<i>Botrychium simplex</i> (SC/G5)	3	905	0	NA	(1)
<i>Caltha natans</i> (E/G5)	1	29	0	NA	(1)
<i>Eleocharis nitida</i> (T/G4)	1	~486 ft ²	0	NA	(1)
<i>Juncus stygius</i> var. <i>americanus</i> (SC/G5)	1	1	0	NA	(1)
<i>Platanthera clavellata</i> (SC/G5)	1	5	0	NA	(1)
<i>Pyrola minor</i> (SC/G5)	1	10	0	NA	(1)
<i>Ranunculus lapponicus</i> (SC/G5)	1	~919 ft ²	0	NA	(1)
<i>Sparganium glomeratum</i> (SC/G4)	1	28	0	NA	(1)
<i>Torreyochloa pallida</i> (SC/G5)	1	~25 ft ²	0	NA	(1)
<i>Woodsia scopulina</i> (T/G5)	0	NA	1	2	1
<i>Saxifraga paniculata</i> (T/G5)	0	NA	1	1,000	1
Total	13	NA	2	NA	(9)

Source: MDNR 2013a.

¹ The state status is E – Endangered; T – Threatened; and SC – Species of Concern. The global ranks range from G1 to G5. A lower global ranking (e.g., G3) indicates a species at higher global risk than higher ranking (e.g., G5) (NatureServe 2011).

² Populations are interpreted from MDNR NHIS data using Element Occurrence; this differs from the DEIS, which used colonies as the population estimate.

³ Data included here were provided by the Division of Ecological Resources, MDNR, and were current as of March 13, 2013. These data are not based on an exhaustive inventory of the state. The lack of data for any geographic area shall not be construed to mean that no significant features are present.

Regional Foresters Sensitive Species

The USFS RFSS data layer indicates there are no RFSS plants on the federal lands. However, several state-listed ETSC plant species that occur on the federal lands are also listed as RFSS plants, including *Botrychium pallidum*, *Botrychium rugulosum*, *Botrychium simplex*, *Caltha natans*, *Eleocharis nitida*, *Juncus stygius* var. *americanus*, and *Pyrola minor*. The USFS would have a decrease to the federal estate in these RFSS plant species as a result of the Land Exchange Proposed Action. *Saxifraga paniculata* is a state-listed ETSC plant species that is also listed as a RFSS plant on the Tract 5 lands. The USFS would gain this RFSS plant species under the Land Exchange Proposed Action.

As with the NorthMet Project Proposed Action, the Land Exchange Proposed Action would not affect 20 RFSS plants on the Superior National Forest. In addition, the Land Exchange Proposed Action may affect individuals, but would not be likely to cause a trend to federal listing or loss of viability for the remaining 38 RFSS plants on the Superior National Forest. Please see the Biological Evaluation listed on the USFS website (<http://www.fs.usda.gov/goto/superior/northmet>) for more information about effects to RFSS plants.

There would be the greatest increase to the federal estate in acres of lowland black spruce-tamarack forest (MIH 9; see Table 5.3.4-4) as a result of the Land Exchange Proposed Action, which means there is the highest chance to gain the RFSS plants listed under that category in Table 4.2.4-5, as long as the suitable habitats exist on the non-federal lands. There would be smaller acreage increases of both upland forest (MIH 1) and aquatic habitat (MIH 14), meaning the RFSS plants in those categories could also be gained. The largest acreage decrease to the federal estate would be upland conifer forest (MIH 5). There are no RFSS plants specifically listed under upland conifer forest (MIH 5); however, it is likely that some RFSS plants that occupy upland forest (MIH 1) habitats would also occupy upland conifer forest (MIH 5) habitats and the USFS could therefore have a decrease to the federal estate in RFSS plant species that prefer coniferous upland habitats. There would also be a gain of Rove Formation cliff microhabitats, which are important for a variety of RFSS plants in the Superior National Forest.

5.3.4.2.4 Biodiversity

Biodiversity is described in the Forest Plan as the “variety of life and its ecological processes ... [as well as] ecosystems, which comprise both the communities of organisms within particular habitats, and the physical conditions under which they live” (USFS 2004b). Biodiversity is important to consider for managing natural communities in a sustainable and ecological manner. Several data sources mentioned above and in Section 4.2.4 were compared on an increase or decrease basis to the federal estate to measure or estimate the biodiversity of both the federal and non-federal lands.

The federal land contains a high level of biodiversity because the majority of the parcel has been classified for inclusion in two Sites of High Biodiversity Significance. Additionally, several different native plant communities exist on it, as do 11 state-listed ETSC plant species. Because the non-federal lands have not been fully studied yet, they contain less biodiversity classification since they lack MBS Sites of High Biodiversity Significance and native plant communities. Table 5.3.4-1 provides a summary of the various data used to estimate biodiversity.

In summary, the non-federal lands contain 116.9 acres of MBS Sites of High Biodiversity Significance in the North Shore Highlands subsection and 767.9 acres of MBS Sites of Moderate Biodiversity Significance in the Laurentian Uplands subsection. The Land Exchange Proposed Action would result in a decrease to the federal estate of 6,142.7 acres of MBS Sites of High Biodiversity Significance in the Laurentian Uplands subsection, and an increase of 116.9 acres of MBS Sites of High Biodiversity Significance in the North Shore Highlands subsection. Furthermore, the Land Exchange Proposed Action would result in an increase to the federal estate of 767.6 acres of MBS Sites of Moderate Biodiversity Significance in the Laurentian Uplands subsection. Overall, there would be a decrease to the federal estate of 6,025.8 acres of MBS Sites of High Biodiversity Significance and an increase of 767.6 acres of MBS Sites of Moderate Biodiversity Significance under the Land Exchange Proposed Action. However, several of the non-federal lands have preliminary classifications of Sites as Moderate, High, or Outstanding Biodiversity Significance, which, if approved by the MDNR MBS program, would help balance the exchange.

Native plant community rankings are largely unavailable for the non-federal lands, with the exception of Lake County South, which has one site ranked as “vulnerable” and others ranked as “apparently secure.” Section 4.3.4.2.6 provides further discussion of native plant community types on the Lake County South parcel. The Land Exchange Proposed Action would result in a

decrease to the federal estate of three native plant communities on the federal lands that are ranked as “imperiled” to “vulnerable” in the state. A native plant community increase or decrease comparison cannot be accurately made since rankings are unavailable for much of the non-federal lands.

Endangered, Threatened, and Special Concern Plant Species

As previously stated, the federal lands support 11 known state-listed ETSC plant species, while the non-federal lands currently support two known state-listed ETSC plant species. This would be a decrease to the federal estate in known state-listed species as a result of the Land Exchange Proposed Action.

5.3.4.3 Land Exchange Alternative B

5.3.4.3.1 Cover Types

The effects of Land Exchange Alternative B would be comparable to those from the Land Exchange Proposed Action, although to a lesser extent. A smaller portion of the federal lands (approximately 4,752.6 acres) would be transferred into private ownership for the non-federal Tract 1 lands (approximately 4,926.3 acres), which would be conveyed into USFS ownership. Under this alternative, the USFS would retain a smaller federal parcel located on the northwestern and western sides of the current federal lands, which would create additional linear boundaries for the USFS to maintain (see Section 5.3.1).

Habitat Types

This alternative would result in an overall increase to the federal estate of 173.6 acres of MDNR GAP land cover types. As under the Land Exchange Proposed Action, the greatest increase to the federal estate would be shrubland acreage (1,227.7 acres), and upland conifer forest would have the greatest acreage decrease (928.8 acres), as shown in Table 5.3.4-7 below.

Table 5.3.4-7 Net Increase or Decrease to the Federal Estate of MDNR GAP Land Cover Types under Land Exchange Alternative B

Cover Types	Alternative B: Smaller Federal Parcel Acres	Tract 1 Acres ¹	Net Increase/ (Decrease) Acres
Shrubland	436.9	1,664.6	1,227.7
Aquatic environments	26.3	251.1	224.8
Upland deciduous forest	804.7	999.9	195.2
Cropland/grassland	2.2	31.7	29.5
Lowland deciduous forest	4.7	17.4	12.7
Upland conifer-deciduous mixed forest	17.8	0.0	(17.8)
Disturbed	29.1	0.0	(29.1)
Lowland coniferous forest	2,064.8	1,524.2	(540.6)
Upland coniferous forest	1,366.1	437.3	(928.8)
Total ²	4,752.6	4,926.2	173.6

Source: MDNR 2006b.

¹ According to Tract 1 land cover type table (see Table 4.3.4-11).

² Total acres may be more or less than presented due to rounding.

Culturally Important Plants

As with the Land Exchange Proposed Action, Land Exchange Alternative B would result in additional wild rice beds from the acquisition of Tract 1. Section 5.3.4.2 provides additional information on wild rice.

As with the Land Exchange Proposed Action, see Section 4.2.9 for a discussion of natural resources culturally important to the Bands.

Minnesota Biological Survey

Land Exchange Alternative B would result in a decrease to the federal estate of 4,573.1 acres of MBS Sites of High Biodiversity Significance and a decrease of 0.3 acre of MBS Sites of Moderate Biodiversity Significance within the Laurentian Uplands subsection (see Table 5.3.4-1). Portions of the west end of One Hundred Mile Swamp would remain in federal ownership. Furthermore, Land Exchange Alternative B would result in removal from the Superior National Forest of three native plant communities that are ranked as “imperiled” to “vulnerable” in the state. As previously discussed, Tract 1 does not contain any MBS Sites of Biodiversity Significance or native plant communities, so, unlike the Land Exchange Proposed Action, the federal estate would not have an increase of either MBS sites or native plant communities under this alternative.

Management Areas

Lands included as part of Land Exchange Alternative B are currently managed under the General Forest – Longer Rotation Management Area (93 percent) and the General Forest Management Area (7 percent) (see Table 5.3.4-8). The majority of Tract 1 (94 percent) would be allocated to the General Forest Management Area upon completion of Land Exchange Alternative B, and the remaining area would be managed under the cRNA Management Area (6 percent). Land

Exchange Alternative B would be comparable to the Land Exchange Proposed Action in that cRNA lands would be increased on the federal estate, but Riparian Areas would not be. Section 5.3.1 describes the management areas in detail.

Table 5.3.4-8 Net Increase or Decrease to the Federal Estate of Management Areas under Land Exchange Alternative B

Category	Alternative B: Smaller Federal Parcel		Tract 1		Net Increase/ (Decrease)
	Acres	%	Acres	%	Acres
General Forest	355.3	7	4,619.3	94	4,264.0
General Forest - Longer Rotation	4,397.3	93	0.0	0	(4,397.3)
Potential/candidate Research Natural Areas	0.0	0	306.9	6	306.9
Riparian Areas	0.0	0	0.0	0	0

Source: USFS 2011j.

Ecological Land Types

Land Exchange Alternative B would result in a decrease to the federal estate of five ELTs, including ELT 1, 2, 6, 13, and 16, which are currently located on the proposed smaller federal parcel. The ELTs are unavailable for Tract 1, and so a comparison cannot be made.

Management Indicator Habitats

Land Exchange Alternative B would result in an increase to the federal estate in upland forest (MIH 1; 1,411.8 acres) and aquatic habitat (MIH 14; 206.2 acres); however, there would be a decrease of upland conifer forest (MIH 5; 1,084.6 acres) and lowland black spruce-tamarack forest (MIH 9; 261.1 acres) (see Table 5.3.4-9). Though not considered MIH types, there would be a decrease to the federal estate of lowland shrubland habitat (272.1 acres) and an increase of lowland emergent wetlands (249.6 acres). Similar to the Land Exchange Proposed Action, the aquatic habitat (MIH 14) type is not fully mapped on lands that are part of Land Exchange Alternative B, resulting in an apparent increase to the federal estate in this category; however, this habitat type does occur on these lands.

There would be a large increase to the federal estate of immature forest stands (1,933.9 acres) with lesser amounts of young stands (262.7 acres), corresponding to a decrease of mature forest stands (2,114.5 acres). Land Exchange Alternative B would not result in a change to the federal estate of large patches (stands over 300 acres) of mature upland forest, as none exist on the Alternative B: Smaller Federal Parcel lands (USFS 2012c) and patch data does not exist for the Tract 1 lands.

Table 5.3.4-9 Net Increase or Decrease to the Federal Estate of MIH Types and Age Classes under Land Exchange Alternative B

Category	Alternative B: Smaller Federal Parcel Acres²	Tract 1 Acres^{1,2}	Net Increase/ (Decrease) Acres
MIH Types			
MIH 1 (Upland Forest)	954.2	2,366.0	1,411.8
MIH 5 (Upland Conifer Forest)	1,138.8	54.2	(1,084.6)
MIH 9 (Lowland Black Spruce-tamarack Forest)	2,078.7	1,817.6	(261.1)
MIH 14 (Aquatic Habitats)	0.0	206.2	206.2
Lowland Shrubland	385.4	113.3	(272.1)
Lowland Emergent	115.4	365.0	249.6
Upland Grass	0.0	0.0	0.0
Age Classes			
Young	271.1	533.8	262.7
Immature	1,325.9	3,259.8	1,933.9
Mature	2,574.7	460.2	(2,114.5)

Source: USFS 2010b.

¹ According to Tract 1 lands MIH table (see Table 4.3.4-3).

² Total acres may be more or less than presented due to rounding.

Landscape Ecosystems

Land Exchange Alternative B would result in a decrease to the federal estate of 1,411.6 acres of the Jack Pine-Black Spruce landscape ecosystem (0.46 percent decrease), but result in an increase of 486.2 acres of the Lowland Conifer landscape ecosystem (0.04 percent increase). Furthermore, there would be an increase in representation in the Dry-Mesic Red and White Pine landscape ecosystem (589.2 acres; 0.10 percent increase), Mesic Red and White Pine landscape ecosystem (528.0 acres; 0.69 percent increase), and the Mesic Birch-Aspen-Spruce-Fir landscape ecosystem (0.9 acres; less than 0.01 percent increase), and an overall increase to the federal estate of 192.7 acres.

Similar to the Land Exchange Proposed Action, Land Exchange Alternative B would result in an increase to the federal estate in acreage of MIH types and age classes within various landscape ecosystems, and a decrease in acreage in others (see Table 5.3.4-10). The greatest percentage increase to the federal estate in MIH acreage within a landscape ecosystem is upland forest (MIH 1) in the Lowland Conifer and Dry-Mesic Red and White Pine landscape ecosystems, while the greatest decrease is upland conifer forest (MIH 5) in the Jack Pine-Black Spruce landscape ecosystem. The largest percentage increase to the federal estate in age class acreage within a landscape ecosystem is the immature age class in the Lowland Conifer landscape ecosystem, while the largest decrease is in the immature age class in the Jack Pine-Black Spruce landscape ecosystem and the mature age classes within the Jack Pine-Black Spruce and Lowland Conifer landscape ecosystems. Overall, the Dry-Mesic Red and White Pine landscape ecosystem would have the highest acreage increase to the federal estate of MIH types and age classes and the Jack Pine-Black Spruce landscape ecosystem would have the highest acreage decrease of MIH types and age classes.

Table 5.3.4-10 Net Increase or Decrease to the Federal Estate of MIH Types and Age Classes within Landscape Ecosystems in the Superior National Forest under Land Exchange Alternative B

Landscape Ecosystem Name			Dry-Mesic Red and White Pine	Jack Pine- Black Spruce	Lowland Conifer	Lowland Hardwood	Mesic Birch- Aspen- Spruce- Fir	Mesic Red and White Pine	Sugar Maple
Category			Net Increase/(Decrease)						
MIH Types	MIH 1	Acres ¹	437.8	(1,007.1)	340.3	0.0	0.9	501.1	0.0
		% ²	2	(3)	2	0	0	1	0
	MIH 5	Acres ¹	6.0	(998.2)	(100.1)	0.0	0.0	7.7	0.0
		% ²	0	(7)	(2)	0	0	0	0
	MIH 9	Acres ¹	26.2	(290.9)	(10.5)	0.0	0.0	13.9	0.0
		% ²	1	(6)	0	0	0	0	0
	MIH 14	Acres ¹	114.2	2.2	89.6	0.0	0.0	0.2	0.0
		% ^{2,3}	NA	NA	NA	NA	NA	NA	NA
	Lowland Shrub	Acres ¹	0.0	(66.4)	(207.3)	0.0	0.0	0.1	0.0
		% ²	0	(3)	(1)	0	0	0	0
Lowland Emergent	Acres ¹	5.0	(23.5)	265.7	0.0	0.0	2.4	0.0	
	% ²	1	(3)	4	0	0	0	0	
Upland Grass	Acres ¹	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	% ²	0	0	0	0	0	0	0	
Age Classes	Young	Acres ¹	229.4	(21.5)	45.5	0.0	0.0	9.3	0.0
		% ²	14	(1)	4	0	0	0	0
	Immature	Acres ¹	148.5	(528.7)	2,014.3	0.0	0.9	298.9	0.0
		% ²	1	(3)	26	0	0	1	0
	Mature	Acres ¹	92.1	(726.1)	(1,709.8)	0.0	0.0	217.1	0.0
		% ²	1	(3)	(3)	0	0	1	0

Source: USFS 2010b; USFS 2011g.

¹ Total acres may be more or less than presented due to rounding.

² Percentage of acres increased or decreased on the federal estate within the entire landscape ecosystem.

³ MIH 14 is not tracked on the federal lands; thus, percentage is NA.

5.3.4.3.2 Invasive Non-native Plants

Land Exchange Alternative B would result in a reduction of occurrences of invasive non-native species on the smaller federal parcel, but in an increase to the federal estate of similar occurrences of invasive non-native species on Tract 1, including common tansy, orange hawkweed, and ox-eye daisy.

5.3.4.3.3 Threatened and Endangered Plant Species

Endangered, Threatened, and Special Concern Plant Species

Under Land Exchange Alternative B, a smaller portion of the federal lands would be exchanged for Tract 1. The same 11 ETSC plant species would be exchanged as for the Land Exchange Proposed Action, but fewer colonies would be exchanged. There are no known state-listed ETSC plant species located on Tract 1. Overall, 13 populations of 11 different species on the smaller

federal parcel would be exchanged for none on Tract 1 (see Table 5.3.4-11). Rulemaking was conducted with the intent to update the list of ETSC species (*Minnesota Rules*, parts 6134.0100 to 6134.0400), with new listings becoming effective on August 19, 2013. The FEIS will consider any new listings, or changes in the previous listings, associated with the updated list.

Table 5.3.4-11 Increase or Decrease to the Federal Estate of State-listed ETSC Plant Populations under Land Exchange Alternative B

Plant Species (State Status/ Global Status ¹)	Alternative B: Smaller Federal Parcel Populations		Tract 1 Populations		Net Species Increase/ (Decrease)
	Total Populations ^{2,3}	Total Individuals ^{3,4}	Total Populations ^{2,3}	Total Individuals ³	
<i>Botrychium pallidum</i> (E/G3)	1	2	0	NA	(1)
<i>Botrychium rugulosum</i> (T/G3)	1	4	0	NA	(1)
<i>Botrychium simplex</i> (SC/G5)	3	905	0	NA	(1)
<i>Caltha natans</i> (E/G5)	1	29	0	NA	(1)
<i>Eleocharis nitida</i> (T/G4)	1	~486 ft ²	0	NA	(1)
<i>Juncus stygius</i> var. <i>americanus</i> (SC/G5)	1	1	0	NA	(1)
<i>Platanthera clavellata</i> (SC/G5)	1	3	0	NA	(1)
<i>Pyrola minor</i> (SC/G5)	1	10	0	NA	(1)
<i>Ranunculus lapponicus</i> (SC/G5)	1	~919 ft ²	0	NA	(1)
<i>Sparganium glomeratum</i> (SC/G4)	1	28	0	NA	(1)
<i>Torreyochloa pallida</i> (SC/G5)	1	~25 ft ²	0	NA	(1)
Total	13	NA	0	NA	(11)

Source: MDNR 2013a.

¹ The state status is E – Endangered; T – Threatened; and SC – Species of Concern. The global ranks range from G1 to G5. A lower global ranking (e.g., G3) indicates a species at higher global risk than higher ranking (e.g., G5) (NatureServe 2011).

² Populations are interpreted from MDNR NHIS data using Element Occurrence; this differs from the DEIS, which used colonies as the population estimate.

³ Data included here were provided by the Division of Ecological Resources, MDNR, and were current as of March 13, 2013. These data are not based on an exhaustive inventory of the state. The lack of data for any geographic area shall not be construed to mean that no significant features are present. NA = Not Applicable.

⁴ Where the number of individuals could not be determined without damaging the population, then patch size was used as a representative abundance measure.

Regional Foresters Sensitive Species

The USFS RFSS data layer indicates there are no RFSS plants on the federal lands, which includes the smaller federal parcel. However, several state-listed ETSC plant species occur on the smaller federal parcel that are also RFSS plants, including *Botrychium pallidum*, *Botrychium rugulosum*, *Botrychium simplex*, *Caltha natans*, *Eleocharis nitida*, *Juncus stygius* var. *americanus*, and *Pyrola minor*.

As with the Land Exchange Proposed Action, the Land Exchange Alternative B would not affect 20 RFSS plants on the Superior National Forest. In addition, the Land Exchange Alternative B may affect individuals, but would not be likely to cause a trend to federal listing or loss of viability for the remaining 38 RFSS plants on the Superior National Forest. Please see the Biological Evaluation listed on the USFS website (<http://www.fs.usda.gov/goto/superior/northmet>) for more information about effects to RFSS plants.

There would be an increase to the federal estate in acres of upland forest (MIH 1) and aquatic habitat (MIH 14) as a result of Land Exchange Alternative B (see Table 5.3.4-9), which means there would be the greatest opportunity to gain the RFSS plants listed under those categories in Table 4.2.4-5. There would be a decrease to the federal estate in acreage of upland conifer forest (MIH 5) and lowland black spruce-tamarack forest (MIH 9), which means the RFSS plant species that prefer these habitat types and have suitable microhabitats may also be decreased on National Forest System lands.

5.3.4.3.4 Biodiversity

The smaller federal parcel contains a high level of biodiversity because the majority of the parcel has been classified for inclusion in two MBS Sites of High Biodiversity Significance. Additionally, several different native plant communities exist on it, as well as 11 state-listed ETSC plant species. Because Tract 1 has not been fully studied, it is assumed to contain less biodiversity because it lacks MBS Sites of High Biodiversity Significance and native plant communities. However, inclusion of the preliminary Site of Outstanding Biodiversity Significance on Tract 1 would balance the exchange, if not make it more biodiverse than the smaller federal parcel. Table 5.3.4-1 provides a summary of the various data used to estimate biodiversity.

Land Exchange Alternative B would result in a decrease to the federal estate of 4,573.1 acres of MBS Sites of High Biodiversity Significance and a decrease of 0.3 acres of MBS Sites of Moderate Biodiversity Significance within the Laurentian Uplands subsection (see Table 5.3.4-1). Portions of the west end of One Hundred Mile Swamp would remain in federal ownership.

Furthermore, Land Exchange Alternative B would result in removal from the Superior National Forest of three native plant community sites that are ranked as “imperiled” to “vulnerable” in the state. As previously discussed, Tract 1 does not contain any MBS Sites of Biodiversity Significance or native plant communities, so, unlike the Land Exchange Proposed Action, the federal estate would not have an increase of either MBS Sites or native plant communities under this alternative.

5.3.4.4 Land Exchange No Action Alternative

Under the Land Exchange No Action Alternative, the Superior National Forest would have an ongoing responsibility for managing vegetation resources on the federal lands in accordance with the Forest Plan. The Land Exchange No Action Alternative would not change the USFS’s responsibility for managing vegetation resources and would result in no further effects on existing vegetation.

5.3.4.4.1 Cover Types

Under the Land Exchange No Action Alternative, the current federal lands would remain in federal ownership and the lands would continue to be managed under the General Forest – Longer Rotation Management Area and the General Forest Management Area. Direct and indirect effects of the Land Exchange No Action Alternative on cover types would be unchanged, as the management of these forests has occurred on site in the past. None of the federal lands currently have any vegetation management actions planned in the near future, regardless of whether the Land Exchange Proposed Action were to occur.

5.3.4.4.2 Invasive Non-native Plants

Non-native species may still invade the federal lands as a result of logging, mineral exploration, vehicle traffic, and natural disturbances, but are likely to do so much more slowly than they would under the Land Exchange Proposed Action. The proximity of the federal lands to the already-disturbed Plant Site may put the federal lands at risk of eventual colonization by invasive non-native species.

5.3.4.4.3 Threatened and Endangered Plant Species

Under the Land Exchange No Action Alternative, timber harvests are expected to continue to occur on the federal lands, though there are not any planned in the near future. Effects on ETSC plant species and RFSS plants, for different management techniques, are addressed in the Forest Plan (USFS 2004b). As discussed in the Biological Evaluation, the Land Exchange No Action Alternative would not have effects on RFSS species.

5.3.4.4.4 Biodiversity

The Land Exchange No Action Alternative would not result in any change to biodiversity on the federal lands.

5.3.5 *Wildlife*

This section describes the environmental consequences of the Land Exchange Proposed Action to wildlife on the federal and non-federal lands. Effects from the change in federal ownership could be either beneficial or adverse, based on the change in species occurrences, habitat, and habitat connectivity on land that is under direct federal control. Effects due to the NorthMet Project Proposed Action are discussed in Section 5.2.5.

Rulemaking was conducted with the intent to update the list of ETSC species (*Minnesota Rules*, parts 6134.0100 to 6134.0400), with new listings becoming effective on August 19, 2013. The FEIS will consider any new listings, or changes in the previous listings, associated with the updated list. The FEIS will also consider any federal listing changes, should they occur.

A Biological Assessment (with further information on federally listed species) and a Biological Evaluation (containing further information about RFSS species) have been prepared and are posted on the USFS website (<http://www.fs.usda.gov/goto/superior/northmet>). The Biological Assessment analyzes impacts to the Canada lynx and the gray wolf, in the event that the gray wolf is re-listed. Land Exchange alternatives were not analyzed in the Biological Assessment. The organization of the methodologies and discussion in the Biological Assessment and Biological Evaluation may be different from the SDEIS. Both documents also contain determinations of effect for the species discussed.

The Land Exchange Proposed Action would have mixed effects for the Canada lynx. It would result in an increase in suitable habitat for lynx and for snowshoe hare (prey species) on the federal estate (although the amount of unsuitable lynx habitat would also increase). It would also result in a decrease of denning habitat and a decrease to the federal estate within designated LAUs. Critical lynx habitat would not change regardless of ownership.

Overall, the Land Exchange Proposed Action would result in an increase (to the federal estate) of the number of occurrences and habitat availability for four state-listed species, which include the gray wolf, the bald eagle, the Laurentian tiger beetle, and the trumpeter swan. The Land Exchange Proposed Action is not expected to result in changes to the three additional state-listed species, which include the wood turtle, the eastern heather vole, and the yellow rail.

Under the Land Exchange Proposed Action, one additional state-listed species and 22 additional SGCN would be affected due to their presence on the federally held lands. The Land Exchange Proposed Action would result in an increase of up to 579.6 acres of habitat within the federal state in the Superior National Forest. While forested habitat would be decreased, shrubland/grassland and aquatic habitats would be increased as part of the Land Exchange Proposed Action. Under the Land Exchange Proposed Action, lands to be acquired would be managed by the USFS in accordance with the current Forest Plan. No activities are planned on these lands.

Under the Land Exchange Alternative B, one additional state-listed species but one less SGCN would be affected because they occur within the federal estate. Forest habitat under federal ownership would also decrease, though by a smaller amount than under the Land Exchange Proposed Action. Similarly, the Land Exchange Alternative B would result in an increase of 173.6 acres of habitat to the federal estate, with a distribution of habitat similar to the Land Exchange Proposed Action. As with the Land Exchange Proposed Action, lands acquired under

the Land Exchange Alternative B would be managed by the USFS in accordance with the current Forest Plan. There are no activities planned on these lands.

As discussed in the Biological Evaluation, the USFS determined that the Land Exchange Proposed Action and Land Exchange Alternative B may affect individuals but are not likely to cause a trend to federal listing or loss of viability for 18 RFSS terrestrial wildlife species on the Superior National Forest.

Under the Land Exchange No Action Alternative, no action would be taken. No lands would be exchanged and no changes in wildlife species on the federal estate would be anticipated. As discussed in the Biological Evaluation, the Land Exchange No Action Alternative would have no effect on RFSS species.

Table 5.3.5-1 Increase or Decrease of Special Status Wildlife Species on the Federal Estate Resulting from the Land Exchange Proposed Action and Alternatives

Alternative	Increase or (Decrease) of Special Status Wildlife Species			
	Federally Listed Species	State-listed Species	Regional Forester Sensitive Species	Species of Greatest Conservation Need
Land Exchange Proposed Action	0	1	0	22
Land Exchange Alternative B	0	1	0	(1)
Land Exchange No Action Alternative	0	0	0	0

Table 5.3.5-2 Increase or Decrease of Key Habitat Types on the Federal Estate Resulting from the Land Exchange Proposed Action and Alternatives

Alternative	Increase or (Decrease) of Acres ¹ of Key Habitat Types				
	Mature Upland Forest, Continuous Upland/Lowland Forest (MIH1-13)	Open Ground, Bare Soils (no MIH)	Grassland and Brushland, Early Successional Forest (no MIH)	Aquatic Environments (MIH 14)	Total Net Increase or (Decrease)
Land Exchange Proposed Action	(787.9)	(63.8)	1,224.9	206.5	579.6
Land Exchange Alternative B	(1,279.3)	(29.1)	1,257.2	224.8	173.6
Land Exchange No Action Alternative	0	0	0	0	0

Source: Tables 5.3.4-2 and 5.3.4-7.

¹ Total acres may be more or less than presented due to rounding.

5.3.5.1 Methodology and Evaluation Criteria

Evaluation was conducted to determine the potential effect that the Land Exchange Proposed Action would have on wildlife on the federal estate species from the following:

- a change in federal and state-listed ETSC, SGCN, RFSS, and other wildlife species; and
- a change in habitat availability, prey species habitat availability, habitat connectivity, and adjacent land use.

Analysis of wildlife species affected by the Land Exchange Proposed Action was guided by evaluation criteria that were developed by the USFS and other Co-lead Agencies, which included a comparison of the vegetation land cover and habitat types, forest age classes (young, immature, and mature), large mature forest patches, road and trail densities, federal and state-listed ETSC, SGCN, RFSS, and other wildlife species. GIS data and field observations for these categories were gathered to the extent possible and then compared over an area of analysis that included the federal and non-federal lands and LAU.

5.3.5.2 Land Exchange Proposed Action

5.3.5.2.1 Federally Listed Species

Canada Lynx

The federal lands of the Land Exchange Proposed Action include lynx habitat and habitat for lynx prey species. Lynx habitat includes a wide variety of upland and lowland habitats and forest types/ages, shrubland, and grasslands, but excludes aquatic environments and disturbed areas. Preferred denning habitat is typically found in mature forest and is generally more dependent on forest age classes, with trees older than saplings and with a dbh greater than 5 inches (immature and mature age classes; see Table 4.3.4-3). Snowshoe hare are the primary prey species for the Canada lynx, and hare habitat includes all types and age classes of forest and shrubland, but not aquatic environments, disturbed areas, or grassland/croplands (see Table 5.3.5-3).

Table 5.3.5-3 Increase or Decrease in Suitable Habitat Types for Canada Lynx and Prey Species on the Federal Estate Resulting from the Land Exchange Proposed Action and Alternatives

Parcel	General Suitable Lynx Habitat (Acres¹)	Suitable Denning Habitat (Acres¹)	Suitable Snowshoe Hare Forage Habitat (Acres¹)	Unsuitable Lynx Habitat (Acres¹)
Land Exchange Proposed Action				
Federal Lands	6,371.5	5,393.4	6,365.3	123.9
Non-Federal Lands Total	6,808.4	5,364.3	6,776.7	250.8
Tract 1 – Hay Lake	4,675.1	3,720.0	4,643.4	251.1
Tract 2 – Lake County North	263.3	219.5	263.3	1.8
Tract 2 – Lake County South	112.8	48.4	112.8	4.0
Tract 3 – Wolf Lands 1	125.9	113.9	125.9	0.0
Tract 3 – Wolf Lands 2	767.9	683.8	767.9	0.0
Tract 3 – Wolf Lands 3	277.4	96.7	277.4	0.0
Tract 3 – Wolf Lands 4	404.7	359.7	404.7	0.0
Tract 4 – Hunting Club	150.7	92.2	150.7	9.6
Tract 5 – McFarland Lake	30.6	30.1	30.6	0.2
Net Increase/(Decrease)	436.9	(29.1)	411.4	126.9
Land Exchange Alternative B				
Smaller Federal Parcel	4,697.2	3,912.9	4,695.0	55.4
Tract 1 – Hay Lake	4,675.1	3,720.0	4,643.4	251.1
Net Increase/(Decrease)	(22.1)	(192.9)	(51.6)	195.7

Source: Tables 5.2.5-5, 4.3.4-3, and 4.3.4-8.

¹ Total acres may be more or less than presented due to rounding.

As shown in Table 5.3.5-3, the federal lands of the Land Exchange Proposed Action include 6,371.5 acres of suitable general habitat for lynx. The non-federal lands include a total of 6,808.4 acres of potentially suitable habitat, which is an increase of 436.9 acres. Aquatic environments and disturbed areas are considered unsuitable habitat, along with lowlands with dead trees (though this habitat was not specifically called out in habitat/cover data). The Land Exchange Proposed Action would also result in an increase to the federal estate of 411.4 acres of hare habitat. However, the Land Exchange Proposed Action would result in a decrease to the federal estate of 29.1 acres of denning habitat and an increase of 126.9 acres of unsuitable lynx habitat.

Lynx utilize snow packed trails and roads as travel corridors. The federal lands do not contain any established snow packed trails (such as snowmobile trails) but are crossed by 6.9 miles of road surface. The non-federal lands are crossed by 0.03 mile of snow packed trail (snowmobile trail) and 2.2 miles of roads. The Land Exchange Proposed Action would result in a decrease to the federal estate of 4.7 miles of road and an increase to the federal estate of 0.03 mile of snow packed trails available for lynx use (see Table 5.3.5-4).

Table 5.3.5-4 Increase or Decrease of Lynx Travel Corridors on the Federal Estate Resulting from the Land Exchange Proposed Action and Alternatives

Travel Corridor Type	Established Snow Pack Trails (Miles)	Established Roads (Miles)
Land Exchange Proposed Action		
Federal Lands	0.0	6.9
Non-Federal Lands Total	0.03	2.2
Tract 1 – Hay Lake	0.0	2.2
Tract 2 – Lake County North	0.0	0.0
Tract 2 – Lake County South	0.0	0.0
Tract 3 – Wolf Lands 1	0.0	0.0
Tract 3 – Wolf Lands 2	0.0	0.0
Tract 3 – Wolf Lands 3	0.03	0.0
Tract 3 – Wolf Lands 4	0.0	0.0
Tract 4 – Hunting Club	0.0	0.0
Tract 5 – McFarland Lake	0.0	0.0
Net Increase/(Decrease)	0.03	(4.7)
Land Exchange Alternative B		
Smaller Federal Parcel	0.0	6.9
Tract 1 – Hay Lake	0.0	2.2
Net Increase/(Decrease)	0.0	(4.7)

Source: USFS 2011e.

Land ownership immediately adjacent to the federal lands is a mix of private, state, and federal. The proximity of private lands and disturbance to the north and west may limit lynx passage and utilization of habitat on the federal lands.

Overall, the land ownership patterns surrounding the non-federal lands are mixed. Federal land proximity and, thus potential habitat connectivity, is marginal on Tract 1. Connectivity on the other tracts is generally more favorable. Located in less developed areas of the Superior National Forest, these tracts are generally bordered by federal, state, or county lands and are intended to reduce fragmentation. As such, the Land Exchange Proposed Action is likely to result in generally improved habitat connectivity overall.

Because all federal and non-federal lands are located within lynx critical habitat and would remain so regardless of ownership, the Land Exchange Proposed Action would not result in a change to lynx critical habitat to the federal estate. As previously discussed, LAU were identified for purposes of analysis and development of conservation measures for lynx (USFS 2004b). The federal lands are located within LAU 12 and the non-federal lands are located in LAU 4, 16, 21, 22, and 42. Tract 1 is not located within an LAU. The USFS indicated that no development or activities are planned on the non-federal lands, which means that there would be no increase in unsuitable habitat due to the Land Exchange Proposed Action (see Table 5.3.5-5). As such, the percentage of currently unsuitable habitat in the overall LAU is not expected to change, nor would it affect the Forest Plan condition that unsuitable habitat not exceed 30 percent of the LAU (USFS 2013).

Table 5.3.5-5 Increase or Decrease in Lynx Analysis Units on the Federal Estate Resulting from the Land Exchange Proposed Action and Alternatives

Parcel	Lynx Analysis Unit	Total Acres ¹ of Proposed Land Exchange Federal/Non-Federal Land Within LAU	Overall Lynx Analysis Unit Acreage ¹	Current Percentage (%) of LAU Unsuitable (Determined by USFS)
Land Exchange Proposed Action				
Federal Parcel	12	6,495.4	70,980.5	4.0
Non-Federal Lands Subtotal		2,149.7		
Tract 1 – Hay Lake	No LAU	NA	NA	NA
Tract 2 – Lake County North	16	265.2	76,108.3	4.4
Tract 2 – Lake County South	22	116.9	58,154.2	1.6
Tract 3 – Wolf Lands 1	16	126.0	76,108.3	4.4
Tract 3 – Wolf Lands 2	21	768.0	73,265.8	4.2
Tract 3 – Wolf Lands 3	21	277.5	73,265.8	4.2
Tract 3 – Wolf Lands 4	21	404.8	73,265.8	4.2
Tract 4 – Hunting Club	4	160.4	55,071.4	4.9
Tract 5 – McFarland Lake	42	30.9	32,305.4	1.9
Net Increase/(Decrease)		(4,345.7)		
Land Exchange Alternative B				
Smaller Federal Parcel	12	4,752.7		
Tract 1 – Hay Lake	No LAU	NA	NA	NA
Net Increase/(Decrease)		(4,752.7)		

Source: 2009 USFS SNF Monitoring and Evaluation Report.

¹ Total acres may be more or less than presented due to rounding.

The Land Exchange Proposed Action would have mixed effects for the Canada lynx. It would result in an increase to the federal estate of overall suitable habitat for lynx and for snowshoe hare (prey species) to the federal estate (although the amount of unsuitable lynx habitat would also increase). It would also result in a decrease to the federal estate of denning habitat and a decrease of federal lands within designated LAU. Critical lynx habitat would not change regardless of ownership. Effects on the Canada lynx and its critical habitat will be described in more detail in the Biological Assessment.

5.3.5.2.2 State-listed Species

Gray Wolf

The federal lands are likely part of a territory occupied by a single pack of wolves. The federal lands are dominated by trees that range in age from immature to mature, which is adequate cover habitat for wolves. Approximately 271 acres of young forest are present for forage opportunities (see Section 4.2.4.1) on the federal lands and 778 acres are present on the non-federal lands (see Table 4.3.4-3). There are 5,393.4 acres of cover habitat on the federal lands and 5,364.3 acres on the non-federal lands. Gray wolves or their sign were observed on Tracts 1, 2, 3, and 5.

Table 5.3.5-6 Increase or Decrease in Gray Wolf Habitat on the Federal Estate Resulting from the Land Exchange Proposed Action and Alternatives

Parcel	Forage Habitat (Acres)	Cover Habitat (Acres¹)
Land Exchange Proposed Action		
Federal Lands	271.1	5,393.4
Non-Federal Lands Total	778.2	5,364.3
Tract 1 – Hay Lake	533.8	3,720.0
Tract 2 – Lake County North	24.4	219.5
Tract 2 – Lake County South	43.3	48.4
Tract 3 – Wolf Lands 1	2.2	113.9
Tract 3 – Wolf Lands 2	7.6	683.8
Tract 3 – Wolf Lands 3	130.4	93.7
Tract 3 – Wolf Lands 4	9.5	359.7
Tract 4 – Hunting Club	27.0	92.2
Tract 5 – McFarland Lake	0.0	30.1
Net Increase/(Decrease)	507.1	(29.1)
Land Exchange Alternative B		
Smaller Federal Parcel	271.1	3,912.9
Tract 1 – Hay Lake	533.8	3,720.0
Net Increase/(Decrease)	262.7	(192.9)

The amount of cover habitat is similar between the federal and non-federal lands, but the non-federal lands include more potential forage habitat; therefore, the Land Exchange Proposed Action would result in a very small decrease (29.1 acres) to the federal estate of cover habitat but would result in an increase to the federal estate of forage habitat (507.1) for the gray wolf.

Bald Eagle

As discussed in Section 5.2.5.2.2, eagles may utilize the area around the federal lands. The federal lands are located between the Embarrass and Partridge rivers, which eagles may use for foraging. Mud Lake may also be used for foraging. The nearest known nesting sites are more than 2 miles (5.8 miles south-southwest of the federal lands) from the federal lands and optimal habitat for nesting is not present. Eagles may utilize Mud Lake for nesting, though they tend to utilize larger lakes for nesting. Though optimal nesting and foraging habitat are not present in the federal lands, eagles may still utilize these areas.

Eagle habitat is present on several of the non-federal lands. Though they are smaller waterbodies than are optimal for eagles, Tract 1 includes the Pike River, Hay Lake, and Rice Lake. Tracts 2 and 3 are located near large lakes such as Pine and Greenwood. Tract 5 borders McFarland Lake, which is connected to other lakes within the BWCAW. With the exception of Tract 1, these lands are also further from developed mining areas and disturbances are less likely than on the federal lands.

Wood Turtle

The only known population of wood turtles on the federal lands is downstream from the Mine Site, along the southern border of the federal lands. Though there is no known suitable habitat for wood turtles on the federal lands and no individuals are known to occur, wood turtles may use

adjacent areas to the south of the federal lands. Similarly, no wood turtles or optimal wood turtle habitat was identified on the non-federal lands.

Given that no wood turtles or wood turtle habitat were identified on either the federal or non-federal lands, the Land Exchange Proposed Action would not result in an increase or decrease of individuals, populations, or suitable habitat.

Eastern Heather Vole

The eastern heather vole has not been observed during field surveys within 10 miles of the federal lands. Approximately 1,764.5 acres of potentially suitable habitat (upland deciduous forest, upland mixed forest, shrubland, and cropland/grassland) exists on the federal lands (see Table 4.3.4-1), so the eastern heather vole could be present, but, if so, likely in very small numbers. The eastern heather vole was not identified on the non-federal lands by surveys or in the NHIS, but the non-federal lands contain 2,597.4 acres of habitat. As such, the Land Exchange Proposed Action would result in an increase to the federal estate of up to 832.9 acres of habitat.

Yellow Rail

The yellow rail was not found during surveys and was not reported in the NHIS database within 10 miles of the federal lands. As previously mentioned, small, scattered areas of its preferred habitat are present on the federal lands (35.7 acres), but not the minimum nesting patch size (54 acres) needed for the species (see Table 4.3.3-1). No yellow rails or yellow rail habitat were identified on the non-federal lands. The Land Exchange Proposed Action would not result in a net change to the species or habitat.

Laurentian Tiger Beetle

The lack of suitable habitat and any recorded observations for the Laurentian tiger beetle suggest that the species does not occur on the federal lands. However, the habitat for the Laurentian tiger beetle is present at Tract 1, in an area formerly used as a sand and gravel mine. No disturbance activities are currently planned on the non-federal lands, so this potential habitat would be preserved. As such, the Land Exchange Proposed Action would result in an increase of suitable habitat for this species.

Trumpeter Swan

Trumpeter swans were observed on Tract 1 during surveys in 2009. A pair of adults with young was seen on Little Rice Lake. The species has not been observed on the federal lands. Because the species has been observed on the non-federal lands and not on the federal lands, the Land Exchange Proposed Action would result in an increase of the occurrence of this listed species within the federal estate.

5.3.5.2.3 Species of Greatest Conservation Need

Sections 4.3.5.1.1 and 4.3.5.2 discuss the SGCN in the context of their habitat. The federal lands include a wide variety of habitat types, grouped into key habitat types and MIH types (see Table 5.3.5-7).

Some acreage of some key habitat types, MIH types, and cover types within the federal estate would increase through the Land Exchange Proposed Action, while others would decrease. The

key habitat types that would increase or decrease under the Land Exchange Proposed Action are listed in Table 5.3.5-7. Species dependent on these habitat types are listed by ecological subsection in Tables 4.3.5-1 through 4.3.5-5.

Table 5.3.5-7 Increase or Decrease of Habitat Types on the Federal Estate Resulting from the Land Exchange Proposed Action

Key Habitat Type and Management Indicator Habitat	Federal Lands Acres	Non-Federal Lands ^{1,2}					Net Increase or (Decrease) Acres
		Tract 1 – Hay Lake Lands Acres	Tract 2 – Lake County Lands Acres	Tract 3 – Wolf Lands Acres	Tract 4 – Hunting Club Lands Acres	Tract 5 – McFarland Lake Lands Acres	
Mature Upland Forest, Continuous Upland/Lowland Forest (MIH1-13)	5,719.7	2,978.8	337.2	1,479.4	105.7	30.6	(788.0)
Open Ground, Bare Soils (no MIH)	63.8	0.0	0.0	0.0	0.0	0.0	(63.8)
Grassland and Brushland, Early Successional Forest (no MIH)	651.8	1,696.3	38.9	96.5	45.0	0.0	1,224.9
Aquatic Environments (MIH 14)	60.1	251.1	5.8	0.0	9.6	0.2	206.6
Total	6,495.4	4,926.2	381.9	1,575.9	160.3	30.8	579.7

¹ According to non-federal land cover type summary tables (see Tables 4.3.4-1, 4.3.4-12-20).

² Total acres may be more or less than presented due to rounding.

The Land Exchange Proposed Action would result in a decrease of 788.0 acres of forest habitat and 63.8 acres of open ground/bare soil to the federal estate. In addition, the Land Exchange Proposed Action would result in an increase of 1,224.9 acres of grassland/brushland and 206.6 acres of aquatic environment to the federal estate. Overall, the Land Exchange Proposed Action would result in an increase of up to 579.7 acres of habitat to the federal estate, though there would be a decrease of forest and open ground habitat. As such, forest-dependent species are more likely to be affected through habitat decrease by the Land Exchange Proposed Action. Grassland and brushland species (mostly bird species and one species of insect) would have more habitat available under the Land Exchange Proposed Action, as would species dependent on aquatic environments (bird species, reptile/amphibian species, and insect species). Overall, the Land Exchange Proposed Action would result in an increase of SGCN habitat to the federal estate.

5.3.5.2.4 Regional Forester Sensitive Species

A Biological Evaluation containing further information about RFSS species has been prepared and is posted on the USFS website (<http://www.fs.usda.gov/goto/superior/northmet>). Similar to the Biological Assessment, the organization of the methodologies and discussion in the

Biological Evaluation may be different from the SDEIS. The Biological Evaluation also contains determinations of effect for RFSS species.

The USFS determined that the Land Exchange Proposed Action and Land Exchange Alternative B may affect individuals but are not likely to cause a trend to federal listing or loss of viability for 18 RFSS terrestrial wildlife species on the Superior National Forest.

Of the 18 terrestrial RFSS on the 2011 list for the Superior National Forest, the gray wolf, bald eagle, wood turtle, and eastern heather vole are discussed above as federally or state-listed species. Seven additional RFSS (the boreal owl, olive-sided flycatcher, bay-breasted warbler, Connecticut warbler, taiga alpine, Freija's grizzled skipper, and Nabokov's blue) are included as SGCN and are also discussed above. Effects on the RFSS will be described in more detail in the Biological Assessment.

Habitat for the three RFSS bats, the northern myotis, eastern pipistrelle, and little brown bat, may be present on the federal lands, though no hibernacula have been observed. Similarly, both forage and hibernation habitat may be present on the non-federal lands, though no hibernation sites have been observed. Bats were observed, though not identified to species, on Tract 1 during field studies in 2009. The Land Exchange Proposed Action would result in a net decrease of mature forest habitat to the federal estate, but an increase in grassland/brushland, which constitutes a slight increase in overall bat habitat within the federal estate for the RFSS bats. Because bat species have been identified on the non-federal parcel, the Land Exchange Proposed Action may result in an increase of known RFSS bat species to the federal estate.

The northern goshawk may be occasionally present since goshawk nests have been observed on the federal parcel. Northern goshawk individuals and nests have also been identified on Tract 1, and an active goshawk territory has been identified and is being monitored by the MDNR. More forested habitat for the species is present on the federal lands than the non-federal lands (see Table 5.3.5-6). As such, the Land Exchange Proposed Action would result in a decrease of forested habitat available for the northern goshawk on the federal estate.

Though not observed during call surveys, the great gray owl may be occasionally present on the federal lands. Because owl calling surveys (ENSR 2005) found no great gray owls, populations in the area are likely small and/or occasional. No observations of great gray owls have been made on the non-federal lands. However, because the species utilizes forested habitat and the Land Exchange Proposed Action would result in a decrease of 788.0 acres of forested habitat, the Land Exchange Proposed Action would result in a decrease of this species' habitat on the federal estate.

A three-toed woodpecker was identified on the federal lands during surveys in 2000 and was observed on the parcel again in 2007. Area populations are expected to be low, and these habitat specialists require standing dead or dying trees where they can forage for bark beetles. The species has not been observed on the non-federal lands. As such, the Land Exchange Proposed Action would result in a decrease of this species' occurrence. Since the Land Exchange Proposed Action would result in a decrease of approximately 788.0 acres of forest, the Land Exchange Proposed Action would also result in a habitat decrease for this species on the federal estate.

The Quebec emerald dragonfly can inhabit wet meadow/sedge meadow. Approximately 36 acres of this habitat type are present on the federal lands. There has only been one documented occurrence of this species in Minnesota (Lake County in 2006), and that occurrence was not on

either the federal or non-federal lands. The non-federal lands do not contain any sedge/wet meadow wetlands. The Land Exchange would result in a decrease of potential habitat used by this species on the federal estate.

Other factors, such as lower disturbance levels and increase of contiguous habitat, would potentially increase RFSS utilization of the non-federal lands. The federal lands contain two stands of contiguous forest habitat greater than 300 acres (340.6 acres and 1,352.3 acres) while the non-federal lands include one forest stand greater than 300 acres (598.2 acres – Tract 3, Wolf Lands 2). The Land Exchange Proposed Action would result in a net decrease of 1,094.7 acres of contiguous habitat stands greater than 300 acres to the federal estate.

5.3.5.2.5 Other Wildlife Species

Other regionally common wildlife species, such as ravens, grouse, beaver, wolves, white-tailed deer, moose, fox, marten, and snowshoe hare, have been observed on both the federal and non-federal lands. Effects on wildlife species important to the Bands are discussed in Section 5.2.9 on a connected ecosystems level. Similar to SGCN, habitat for some other species of wildlife would increase via the Land Exchange Proposed Action while habitat would decrease for others. As previously discussed, forested habitat would decrease via the Land Exchange Proposed Action, but grassland/shrubland habitat and aquatic habitat would increase. Grassland and brushland species would have more habitat available under the Land Exchange Proposed Action, as would species dependent on aquatic environments. The Land Exchange Proposed Action would result in 579.7 additional acres of wildlife habitat to the federal estate.

Game species such as white-tailed deer, bear, and moose are of significant concern to the Bands. As mentioned above, forested habitat on the federal estate would decrease under the Land Exchange Proposed Action, but grassland and brushland and aquatic habitat would increase. The Land Exchange Proposed Action would result in increased hunting opportunities on the federal estate, as the non-federal lands would become available for use while the federal lands, which currently have limited access, would become private.

5.3.5.3 Land Exchange Alternative B

Under the Land Exchange Alternative B, a smaller federal parcel would be exchanged for only one non-federal parcel, Tract 1. The effects that would result from this alternative are similar to those of the Land Exchange Proposed Action.

5.3.5.3.1 Federally Listed Species

Canada Lynx

As shown in Table 5.3.5-3, the smaller federal parcel includes 4,697.2 acres of suitable general habitat for lynx. Tract 1 has a total of 4,675.1 acres of habitat potentially suitable for the Canada lynx, which would result in a decrease of 22.1 acres to the federal estate. The Land Exchange Alternative B would also result in a decrease of 192.9 acres of denning habitat. Snowshoe hare habitat would increase by 51.6 acres, but there would also be an increase of 195.7 acres of unsuitable lynx habitat to the federal estate under the Land Exchange Alternative B.

The smaller federal parcel does not contain any established snow packed trails (such as snowmobile trails) but is crossed by 6.9 miles of road surface. Tract 1 is crossed by 2.2 miles of

roads and no established snow trails. Since lynx use snow packed trails and roads as travel corridors, the Land Exchange Alternative B would result in a decrease to the federal estate of 4.7 miles of road use for lynx.

Land ownership under the Land Exchange Alternative B would be similar to the Land Exchange Proposed Action, but the smaller federal parcel would be bordered to the west by USFS-managed federal lands. Tract 1 is bordered by federal lands to the north, west, and partially east, but the area is generally surrounded by private lands and developed areas. Habitat connectivity to Tract 1 is marginal. The Land Exchange Alternative B is likely to result in limited habitat connectivity overall. Similar to the Land Exchange Proposed Action, the smaller federal parcel and non-federal lands are located within lynx critical habitat and would remain so regardless of ownership; the Land Exchange Alternative B would not result in a change to lynx critical habitat. As shown in Table 5.3.5-5, the Land Exchange Alternative B would result in the decrease of 4,753 acres of land within an LAU because the federal parcel is within an LAU, but the Tract 1 lands are not.

The Land Exchange Alternative B would have mixed habitat effects for the Canada lynx. It would result in a decrease of overall suitable habitat for lynx and denning habitat, but would result in an increase of suitable snowshoe hare habitat. It would also result in a decrease of federal lands within designated LAUs. Critical lynx habitat would not change regardless of ownership. As such, the Land Exchange Alternative B is not likely to have either a net increase or decrease on Canada lynx on the federal estate.

5.3.5.3.2 State-listed Species

Gray Wolf

Gray wolves have been observed on both the smaller federal parcel and on Tract 1. Approximately 271 acres of forage habitat is present on the smaller federal parcel (young age class on Table 5.3.4-4) and 533.8 acres are present on Tract 1. There are 3,912.9 acres of cover habitat on the smaller federal parcel (immature and mature age classes) and 3,720.0 acres on Tract 1. This would result in an increase of 262.8 acres of forage habitat but also in a decrease of 192.9 acres of cover habitat on the federal estate.

Bald Eagle

As under the Land Exchange Proposed Action, the smaller federal parcel and surrounding areas may be utilized by bald eagles. Similar to the Land Exchange Proposed Action, the smaller federal parcel is also located between the Embarrass and Partridge rivers, which eagles may use for foraging. However, the smaller federal parcel excludes a portion of Mud Lake. The nearest known nesting sites are greater than 2 miles (5.8 miles south-southwest of the smaller federal parcel) from the federal lands and optimal habitat for nesting is not present.

Tract 1 contains waterbodies (Pike River, Hay Lake, and Rice Lake) and large trees, which eagles may use for nesting, though no nests have been observed. The nearest known eagle nest is approximately 4 miles southwest of the parcel.

Wood Turtle

No wood turtles or optimal wood turtle habitat were identified on Tract 1 or the smaller federal parcel. As such, the Land Exchange Alternative B would not result in an increase or decrease of habitat for the species on the federal estate.

Eastern Heather Vole

The eastern heather vole has not been observed during field surveys within 10 miles of the federal lands. There are 1,261.6 acres of potentially suitable habitat on the smaller federal parcel (see Table 4.3.4-6). Eastern heather voles were not identified on the non-federal lands by surveys or in the NHIS, but Tract 1 contains 2,133.6 acres of habitat, which would result in an increase of 872.0 acres of habitat for the eastern heather vole on the federal estate. As such, the Land Exchange Alternative B would result in an increase of habitat for this species.

Yellow Rail

The yellow rail was not found during surveys and was not reported in the NHIS database within 10 miles of the federal lands. As previously mentioned, small, scattered areas of its preferred habitat are present on the federal lands (34.9 acres), but not the minimum nesting patch size (54 acres) needed for the species. Similar to the Land Exchange Proposed Action, the Land Exchange Alternative B would not result in a net change to the species or its habitat on the federal estate.

Laurentian Tiger Beetle

Similar to the Land Exchange Proposed Action, the lack of suitable habitat and any recorded observations for the Laurentian tiger beetle suggest that the species does not occur on the smaller federal parcel. However, habitat for the Laurentian tiger beetle is present on Tract 1, in an area formerly used as a sand and gravel mine. No disturbance activities are currently planned on Tract 1, so this potential habitat would be preserved. As such, the Land Exchange Alternative B, similar to the Land Exchange Proposed Action, would result in an increase of suitable habitat for the species on the federal estate.

Trumpeter Swan

Trumpeter swans were observed on Tract 1 during surveys in 2009. A pair of adults with young was seen on Little Rice Lake. The species has not been observed on the smaller federal parcel. Similar to the Land Exchange Proposed Action, because the species has been observed on Tract 1 but not on the smaller federal parcel, the Land Exchange Alternative B would result in an increase of the occurrence of this listed species within the federal estate.

5.3.5.3.3 Species of Greatest Conservation Need

Like the Land Exchange Proposed Action, the SGCN for the Land Exchange Alternative B are discussed in the context of their habitat. The smaller federal parcel also includes a wide variety of habitat types, grouped into key habitat types and MIH types (see Table 5.3.5-8).

Similar to the Land Exchange Proposed Action, the Land Exchange Alternative B would result in a decrease of forest habitat (1,279.3 acres) and open ground/bare soil (29.1 acres) on the federal estate. The Land Exchange Proposed Action, however, would result in an increase of grassland/brushland (1,257.2 acres) and aquatic environments (224.8 acres) on the federal estate.

Overall, the Land Exchange Proposed Action would result in an increase of up to 173.6 acres of habitat to the federal estate, though there would be a decrease of forest and open ground habitat. As such, forest-dependent species are more likely to be affected through habitat decrease under the Land Exchange Alternative B. Grassland and brushland species (mostly bird species and one species of insect) would have more habitat available under the Land Exchange Alternative B, as would species dependent on aquatic environments (bird species, reptile/amphibian species, and insect species). Overall, the Land Exchange Alternative B would result in an increase of SGCN habitat to the federal estate.

Table 5.3.5-8 Increase or Decrease of Habitat Types on the Federal Estate Resulting from Land Exchange Alternative B

Key Habitat Type and Management Indicator Habitat	Smaller Federal Parcel (Acres)	Non-Federal Land Tract 1 (Acres)	Net Increase or (Decrease) (Acres)
Mature Upland Forest, Continuous Upland/Lowland Forest (MIH1-13)	4,258.1	2,978.8	(1,279.3)
Open Ground, Bare Soils (no MIH)	29.1	0.0	(29.1)
Grassland and Brushland, Early Successional Forest (no MIH)	439.1	1,696.3	1,257.2
Aquatic Environments (MIH 14)	26.3	251.1	224.8
Total¹	4,752.6	4,926.2	173.6

¹ Total acres may be more or less than presented due to rounding.

5.3.5.3.4 Regional Forester Sensitive Species

Habitat for the three RFSS bats, the northern myotis, eastern pipistrelle, and little brown bat, may be present on the smaller federal parcel, though no hibernacula have been observed. Bats were observed, though not identified to species, on Tract 1 during field studies in 2009. Because habitat has, but no significant hibernation locations have, been identified on the smaller federal parcel or Tract 1, the Land Exchange Alternative B would not result in a net change of bat habitat within the federal estate for the RFSS bats. However, because bats have been identified on Tract 1, the Land Exchange Alternative B may result in an increase of known RFSS bat species to the federal estate.

The northern goshawk may be occasionally present on the federal lands since a goshawk nest has been observed. Northern goshawk individuals and nests have also been identified on Tract 1. More forested habitat for the species is present on the smaller federal parcel than on Tract 1 (see Table 5.3.5-8). As such, the Land Exchange Alternative B would result in a decrease of forested habitat available for the northern goshawk on the federal estate.

Though not observed during call surveys, the great gray owl may be occasionally present on the smaller federal parcel. No observations of great gray owls have been made on Tract 1. However, because the species utilizes forested habitat and the Land Exchange Alternative B would result in a decrease of 1,279.3 acres of forested habitat, the Land Exchange Alternative B would result in a decrease of this species' habitat on the federal estate.

Three-toed woodpeckers were observed on or near the smaller federal parcel in 2000 and again in 2007. Area populations are expected to be low, and the species has not been observed on Tract 1. As such, the Land Exchange Alternative B would result in the decrease of this species' occurrence. Since the Land Exchange Alternative B would result in a decrease of 1,279.3 acres of forest, this would result in a habitat decrease for this species on the federal estate.

The Quebec emerald dragonfly has not been identified on the smaller federal parcel, as there has only been one documented occurrence of this species in Minnesota in Lake County in 2006 (Minnesota Odonata Survey Project 2012). Tract 1 does not contain any sedge/wet meadow wetlands, and so the Land Exchange Alternative B would result in a decrease of potential habitat used by this species on the federal estate.

Other factors, such as lower disturbance levels and increase of contiguous habitat, would potentially increase RFSS utilization of Tract 1 lands. The smaller federal parcel contains two stands of contiguous forest habitat greater than 300 acres (340.6 and 926.1 acres) while there are no stands greater than 300 acres on Tract 1.

5.3.5.3.5 Other Wildlife Species

Similar to the Land Exchange Proposed Action, forested habitat within the federal estate would decrease under the Land Exchange Alternative B, but grassland/shrubland habitat and aquatic habitat would be increased. Grassland and brushland species would have more habitat available under the Land Exchange Alternative B, as would species dependent on aquatic environments. The Land Exchange Alternative B would result in 173.6 additional acres of wildlife habitat on the federal estate.

5.3.5.4 Land Exchange No Action Alternative

Under the Land Exchange No Action Alternative, the current federal lands would remain in federal ownership and would continue to be managed under the General Forest – Longer Rotation Management Area and the General Forest Management Area. Wildlife would be directly affected by logging, mineral exploration, vehicle traffic, natural disturbances, and thinning activities, which would occur as planned by the USFS, and would be indirectly affected by changes in habitat caused by forest management. However, these activities would affect wildlife to a lesser degree than under the Land Exchange Proposed Action. Section 5.2.4.3.1 provides further discussion of the effects on management of cover types and habitat on the federal lands. Under the Land Exchange No Action Alternative, the USFS has an ongoing responsibility for managing wildlife resources on Superior National Forest lands in accordance with the Forest Plan (USFS 2004b). The Land Exchange No Action Alternative would not change the Forest Service's responsibility for managing wildlife resources and would result in no change in anticipated effects on existing wildlife.

Under the Land Exchange No Action Alternative, the non-federal lands would not go into USFS ownership, and land use would be determined by the private land owners. Effects on wildlife species are difficult to predict given the uncertainty of future potential land use. Lands may be developed, resulting in potential effects on individuals and local populations, habitat decrease, and effects on wildlife travel corridors.

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5.3.6 Aquatic Species

This section describes the environmental consequences of the Land Exchange alternatives on aquatic biota, using comparisons of the existing conditions presented in Sections 4.2.6 and 4.3.6 to conditions after the Land Exchange alternatives in terms of net increase or decrease in aquatic species resources for the federal and non-federal lands.

The Land Exchange Proposed Action would result in a net increase to the federal estate of surface waters (MIH 14), including 99.1 acres of lakes and 3.8 miles of rivers. Additionally, it would result in a decrease to the federal estate of 0.3 miles of first-order streams and 4.0 miles of second-order streams, and an increase to the federal estate in 8.1 miles of third-order streams. The Land Exchange Proposed Action would result in an increase in watershed riparian connectivity and aquatic connectivity for the federal estate. Based on available data, the Land Exchange Proposed Action would potentially result in an increase of nine additional fish species to the federal estate, while the macroinvertebrate assemblage would be similar. The Land Exchange Proposed Action could result in an increase to the federal estate of six new potential SGCN species, based on ecoregion data.

Land Exchange Alternative B would result in a net increase to the federal estate of surface waters (MIH 14), including 120.7 acres of lakes and 2.8 miles of rivers. Additionally, it would result in a decrease to the federal estate of 1.3 miles of first-order streams and 4.0 miles of second-order streams, and an increase to the federal estate of 8.1 miles of third-order streams. Land Exchange Alternative B would result in an increase in watershed riparian connectivity and aquatic connectivity for the federal estate. Based on available data, Land Exchange Alternative B would potentially result in a decrease to the federal estate of four fish species, while the macroinvertebrate assemblage would likely be similar. Land Exchange Alternative B would result in no net change of SGCN species, based on ecoregion data.

The Land Exchange No Action Alternative would not result in any increase or decrease of aquatic habitats or SGCN species to the federal estate.

Rulemaking was conducted with the intent to update the list of ETSC species (*Minnesota Rules*, parts 6134.0100 to 6134.0400), with new listings becoming effective on August 19, 2013. The FEIS will consider any new listings, or changes in the previous listings, associated with the updated list. The FEIS will also consider any federal listing changes, should they occur.

A Biological Evaluation (containing further information about RFSS species) has been prepared and is posted on the USFS website (<http://www.fs.usda.gov/goto/superior/northmet>). The organization of the methodologies and discussion in the Biological Evaluation may be different from the SDEIS. This document also contains determinations of effect for the species discussed.

5.3.6.1 Methodology and Evaluation Criteria

The criteria used to describe the direct and indirect effects of the Land Exchange alternatives focused on the ecological integrity of the aquatic systems present at the federal lands and non-federal lands where physical, chemical, and biological characteristics that are important to biotic quality were considered. The spatial and temporal area of analysis for aquatic resources included the federal and non-federal lands that are proposed for the exchange based on current conditions.

The methodology used for analysis of the Land Exchange alternatives included review and evaluation of available literature, aerial photography review, and GIS analysis of all surface waters and aquatic species habitat present within the Land Exchange areas. Both quantitative and qualitative analyses were used. The analysis of the aquatic resources affected by the Land Exchange alternatives was guided by evaluation criteria that were developed by the USFS and other Co-lead Agencies as follows:

- change in the amount of Superior National Forest MIHs (MIH 14 [aquatic habitat]) available for species on the federal and non-federal lands;
- changes in the length of stream segments;
- changes in the area of lake or deepwater wetland;
- qualitative determination of community habitat and ecological value;
- qualitative assessment of the aquatic connectivity (network created by streams, rivers, and lakes as they flow into one another) and the potential for barriers to fish passage; and
- net change in aquatic species.

5.3.6.2 Land Exchange Proposed Action

5.3.6.2.1 Surface Water Features (MIH 14)

Comparing the footprints of the surface water features present within the federal and non-federal lands provides a direct assessment of the increase or decrease to the federal estate in aquatic environments that support aquatic biota and associated habitats. This comparison was made by analyzing the linear shoreline frontage and frontage index of the surface water features within the federal and non-federal lands, where the frontage index indicates the linear feet of lake and shoreline frontage per acre of land.

The Land Exchange Proposed Action would result in a net increase of surface water resources to the federal estate (see Table 5.3.6-1). A net increase of 99.1 acres of lake and 3.8 miles of rivers would be added to the federal estate from the Land Exchange Proposed Action. For both lakes and streams, the frontage index would increase substantially by 34.0 shoreline/acre units as a result of the exchange.

Table 5.3.6-1 Federal and Non-federal Land Surface Water Comparisons

Parcel	Lake			Miles	Rivers/Creeks/Streams	
	Acres	Frontage (ft)	Frontage Index (shoreline/acre)		Frontage (linear ft) ¹	Frontage Index (shoreline/acre) ²
Lands Conveyed						
Federal Lands	30.5	4,550.0	0.7	5.3	55,968.0	8.6
Lands Acquired						
Tract 1 – Hay Lake	129.6	16,424.0	3.5	8.1	72,864.0	15.3
Tract 2 – Lake County	0.0	0.0	0.0	0.0	0.0	0.0
Tract 3 – Wolf Lands						
Wolf Lands 1	0.0	0.0	0.0	0.0	0.0	0.0
Wolf Lands 2	0.0	0.0	0.0	0.0	0.0	0.0
Wolf Lands 3	0.0	0.0	0.0	0.1	1,056.0	3.9
Wolf Lands 4	0.0	0.0	0.0	0.9	9,504.0	23.5
Tract 4 – Hunting Club	0.0	0.0	0.0	0.0	0.0	0.0
Tract 5 – McFarland Lake	0.0	990.0	32.1	0.0	0.0	0.0
Total Non-federal lands	129.6	17,414.0	35.6	9.1	83,424.0	42.6
Net Change						
Net Increase/(Decrease)	99.1	12,864.0	34.9	3.8	27,456.0	34.0

Note: Surface water shoreline distance calculated by GIS analysis.

¹ Includes shoreline distance on both sides of streams.

² Frontage Index calculated by dividing total acres of parcel by total shoreline within parcel.

5.3.6.2.2 Differences of Strahler Stream Orders and Habitat

For the purposes of this SDEIS, the Strahler Order (USEPA 2011a) is used to describe the hierarchical ordering of streams, where a first-order stream describes a headwater type stream with no branching. Where two first-order streams meet, they become larger second-order streams and where two second-order streams meet, they become larger third-order streams, etc. A quantitative comparison of the Strahler Stream Order indicates the Land Exchange Proposed Action would result in a decrease of 0.3 miles of first-order headwater streams and 4.0 miles of second-order streams, and an increase in 8.1 miles of third-order streams to the federal estate (see Table 5.3.6-2).

The net increase of third-order streams and decrease in second-order streams would likely add more habitat diversity to the Superior National Forest since, generally, stream habitat diversity increases with higher-order streams. No significant habitat changes would likely occur associated with the slight increases in first-order, headwater streams acquired as a result of the Land Exchange Proposed Action.

Table 5.3.6-2 Increase or Decrease of Stream Orders from the Land Exchange Proposed Action

Parcel (Stream)	Stream Distance (miles)		
	1 st Order	2 nd Order	3 rd Order
Lands Conveyed			
Federal Lands (Yelp Creek and Partridge River)	1.3	4.0	0.0
Lands Acquired			
Tract 1 – Hay Lake (Pike River)	0.0	0.0	8.1
Tract 2 – Lake County	0.0	0.0	0.0
Tract 3 – Wolf Lands			
Wolf Lands 1	0.0	0.0	0.0
Wolf Lands 2	0.0	0.0	0.0
Wolf Lands 3 (Coyote Creek)	0.1	0.0	0.0
Wolf Lands 4 (Coyote Creek)	0.9	0.0	0.0
Tract 4 – Hunting Club	0.0	0.0	0.0
Tract 5 – McFarland Lake	0.0	0.0	0.0
Total Non-federal Lands	1.0	0.0	8.1
Net Increase/(Decrease)	(0.3)	(4.0)	8.1

Note: Surface water shoreline distance calculated by GIS analysis.

5.3.6.2.3 Watershed Level Riparian and Aquatic Connectivity

Riparian Connectivity

Intact riparian areas are an important factor contributing to diverse and productive aquatic ecosystems and function to maintain available water quality and physical habitat. The streams present on the federal and non-federal lands (Partridge River, Pike River, and Coyote Creek) are each part of a web of streams, creeks, and rivers that makes up a larger watershed. The connections between these surface water features are affected by the vegetated, undisturbed riparian edges bordering these water bodies. A comparison of the watersheds using the RCI is presented in Table 5.3.6-3. The index was developed from GIS analysis of vegetative cover along riparian areas where agriculture and land development have affected natural riparian vegetative cover.

The Land Exchange Proposed Action would result in a slight increase in watershed riparian connectivity, which indicates that the streams on both the federal and non-federal lands are located within watersheds with existing high-quality riparian connectivity.

Table 5.3.6-3 Watershed Riparian Connectivity Index Comparison

Surface Water	Tract	Watershed	Percent Agriculture in Riparian Zone	Percent Development in Riparian Zone	RCI Score ¹
Lands Conveyed					
Partridge River/Yelp Creek	Federal Lands	St. Louis	0	5	95
Lands Acquired					
Pike River	1 - Hay Lake	Vermilion	0	1	99
Coyote Creek	3 - Wolf Lands 3 and 4	Rainy River- Headwaters	0	0	100
Net Increase/(Decrease)²			0	(4)	4.5

Adopted from MDNR 2012k.

¹ RCI score calculated with MDNR formula using Percent Agriculture and Percent Development in Riparian Zone; scale is from 0 to 100 where 100 indicates excellent riparian conductivity.

² Non-federal lands RCI score averaged to determine net increase/decrease.

Aquatic Connectivity

Structures within streams, such as dams, bridges, and culverts reduce the longitudinal and lateral connectivity of the watershed. These structures can degrade the aquatic habitat in the watershed by slowing stream flow, increasing sedimentation, incising stream channels, changing the depth, and disconnecting portions of streams from the floodplain. The ACI was developed from GIS analysis of number of structures per stream mile for each watershed, and the watershed ACI scores were used to provide a comparison of each watershed.

The Land Exchange Proposed Action would result in the Superior National Forest acquiring streams located in watersheds with better aquatic connectivity values (see Table 5.3.6-4).

Table 5.3.6-4 Watershed Aquatic Connectivity Index Comparison

Surface Water	Tract	Watershed	Aquatic: Bridges and Culverts (miles stream/# structures)	Aquatic: Dams (miles stream/# structures)	ACI Score ¹
Lands Conveyed					
Partridge River/Yelp Creek	Federal Lands	St. Louis	15	6	11
Lands Acquired					
Pike River	1 - Hay Lake	Vermilion	41	11	26
Coyote Creek	3 - Wolf Lands 3 and 4	Rainy River-Headwaters	89	19	54
Net Increase/(Decrease)²			50	9	29

Adopted from MDNR 2012l.

¹ ACI score calculated by dividing total miles of streams and ditches per watershed by total number of culverts, bridges, and dams; scale is from 0 to 100 where 100 indicates free flowing streams (no structures) and 0 indicates one structure for every 20 miles of flowing water.

² Non-federal lands averaged to determine net increase/decrease.

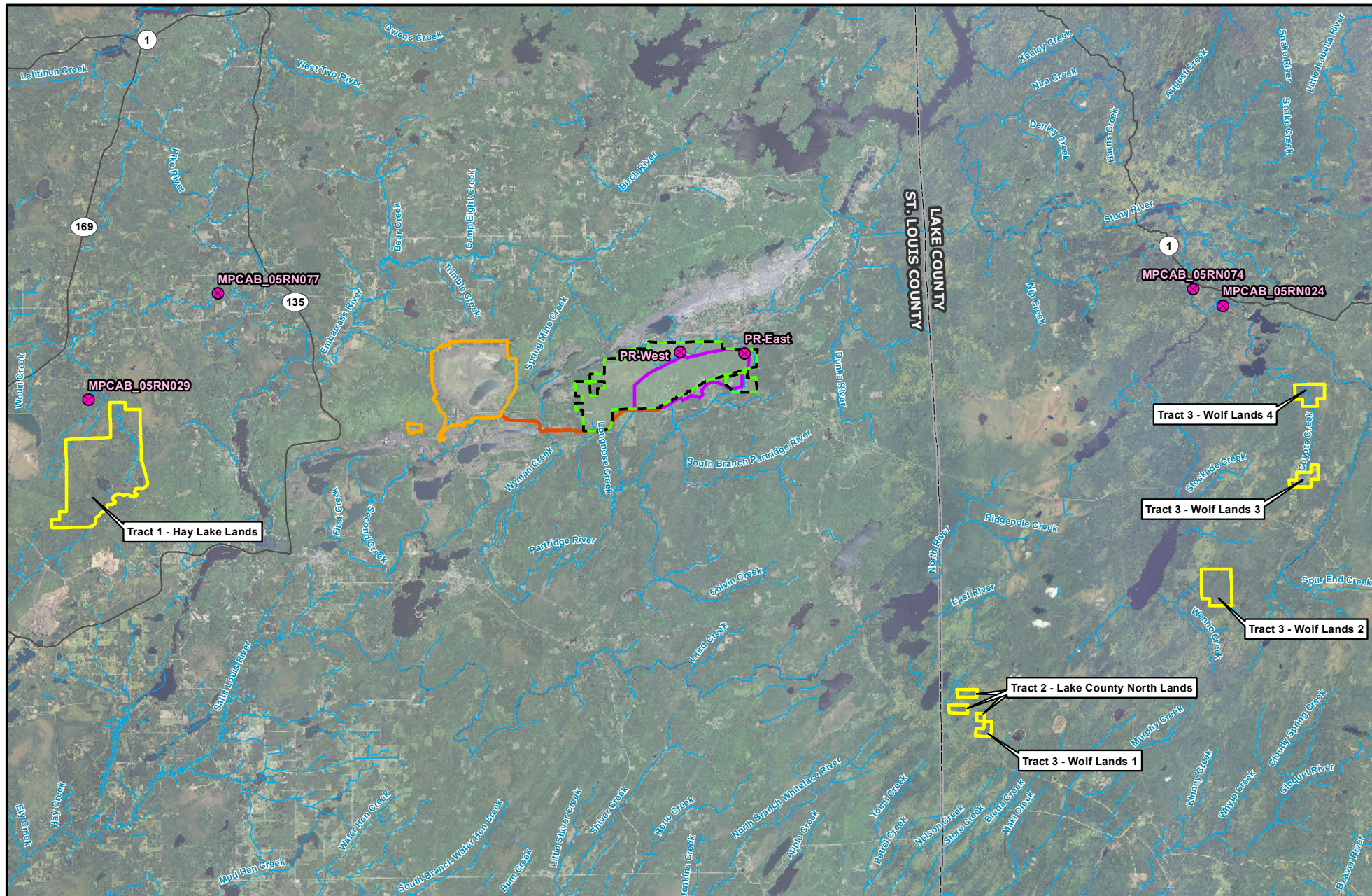
5.3.6.2.4 Aquatic Species

A complete quantitative comparison of the net increase or decrease of aquatic species cannot be made for the purposes of the Land Exchange Proposed Action due to the absence of complete baseline information. Only the federal lands had aquatic biota and habitat sampling sites within the parcel boundaries. However, a semi-quantitative comparison can be made for species located within the vicinity of the non-federal parcel boundaries since representative survey sites located in the vicinity of the parcels were likely similar to the existing aquatic habitats present at each parcel (see Section 4.2.6).

Fish Assemblages

Two survey sites were analyzed within the vicinity of the federal lands while four survey sites were analyzed among the non-federal lands (in the vicinity of Pike River and Coyote Creek; see Figure 5.3.6-1). The federal and non-federal lands had 11 species in common (see Table 5.3.6-5). The Land Exchange Proposed Action would potentially result in an increase to the federal estate of 12 additional species, including two pollution-intolerant species and two pollution-tolerant species (see Tables 5.3.6-5 and 5.3.6-7). There would be a decrease to the federal estate of one different pollution-intolerant species and one different pollution-tolerant species. Given the fact that representative survey sites were used for non-federal lands, it is possible that some species are more or less prevalent than is noted here.

The fish assemblages located at each survey site indicate that the Land Exchange Proposed Action would result in minimal change to the fish assemblages for the streams the Superior National Forest would acquire. Additionally, the dominant fish species present at each site (see Table 5.3.6-6) indicate that the stream characteristics were consistent with slower moving, glide pool features with the exception of the segment on the Stony River where the MCAB_05RN024 survey site was located. This site exhibited dominant longnose dace populations which indicated riffle-run habitats were likely present as described in Section 4.2.6.



- ✕ Study Site
- Plant Site
- Federal Lands
- Non-federal Lands
- Mine Site
- Transportation and Utility Corridor
- Streams/Rivers
- Existing Road



0 1.5 3 6
Miles

Figure 5.3.6-1
Federal and Non-federal Lands Aquatic Study Area
NorthMet Mining Project and Land Exchange SDEIS
Minnesota

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Table 5.3.6-5 Increase or Decrease of Stream Fish Assemblage for the Land Exchange Proposed Action

Species	Common Name	Tolerance Designation ¹	Federal Land Parcel	Non-federal Land Parcels
<i>Catostomus commersonii</i>	White sucker	Tolerant	X	X
<i>Luxilus cornutus</i>	Common shiner	Intermediate	X	X
<i>Notemigonus crysoleucas</i>	Golden shiner	Tolerant		X
<i>Notropis heterolepis</i>	Blacknose shiner	Intolerant		X
<i>Notropis hudsonius</i>	Spottail shiner	Intermediate		X
<i>Notropis volucellus</i>	Mimic shiner	Intolerant		X
<i>Etheostoma nigrum</i>	Johnny darter	Intermediate	X	X
<i>Perca flavescens</i>	Yellow perch	Intermediate		X
<i>Sander vitreus</i>	Walleye	Intermediate		X
<i>Percina caprodes</i>	Logperch	Intermediate		X
<i>Lota lota</i>	Burbot	Intermediate	X	X
<i>Ambloplites rupestris</i>	Rock bass	Intermediate		X
<i>Micropterus dolomieu</i>	Smallmouth bass	Intermediate		X
<i>Esox lucius</i>	Northern pike	Intermediate	X	X
<i>Phoxinus eos</i>	Northern redbelly dace	Tolerant	X	
<i>Culaea inconstans</i>	Brook stickleback	Intermediate	X	X
<i>Phoxinus neogaeus</i>	Finescale dace	Intermediate		X
<i>Rhinichthys atratulus</i>	Blacknose dace	Intolerant	X	
<i>Rhinichthys cataractae</i>	Longnose dace	Intolerant	X	X
<i>Semotilus margarita</i>	Pearl dace	Intermediate	X	
<i>Noturus gyrinus</i>	Tadpole madtom	Intermediate	X	X
<i>Umbra limi</i>	Central mudminnow	Tolerant	X	X
<i>Hybognathus hankinsoni</i>	Brassy minnow	Intermediate	X	
<i>Pimephales promelas</i>	Fathead minnow	Tolerant	X	X
<i>Cottus bairdii</i>	Mottled sculpin	Intolerant	X	X
<i>Semotilus atromaculatus</i>	Creek chub	Tolerant		X
<i>Coregonus clupeaformis</i>	Lake whitefish	Intermediate		X
Total Species			15	23
# Intolerant Species			3	4
# Tolerant Species			4	5
Net Increase or Decrease Species			(8)	8
Net Increase or Decrease Intolerant Species			(1)	1
Net Increase or Decrease Tolerant Species			(1)	1

¹ Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish - Second Edition EPA 841-B-99-002 (USEPA 2012b).

Table 5.3.6-6 Dominant Fish Species Present at Study Sites

Attributes	Federal Land (within parcel)		Non-federal Land (study areas within vicinity of Tract 1)		Non-federal Land (study areas within vicinity of Tract 3- Wolf Lands 3 and 4)	
Study site	PR-west	PR-east	MPCAB- 05RN029	MPCAB- 05RN077	MPCAB- 05RN024	MPCAB- 05RN074
Dominant Species	Brook stickleback	Northern redbelly dace	White sucker	White sucker	Longnose dace	Blacknose shiner

Adopted from Barr 2011b and MPCA 2011c.

Table 5.3.6-7 Increase or Decrease of Stream Fish Assemblage for the Land Exchange Proposed Action

Combined Studies Within, or Within Vicinity of, Surface Water	Tract	Total Species (#)	Pollution- Intolerant Species (#)	Pollution- Tolerant Species (#)
Lands Conveyed				
Partridge River	Federal Lands	15	3	4
Lands Acquired				
Pike River	Tract 1	11	0	4
Coyote Creek	Tract 3 - Wolf Lands 3 and 4	18	4	4
Total Non-Federal Lands		21 ¹	4	5 ²
Net Increase/(Decrease)		12 species (4) other species	1	1

Adopted from Section 4.3.6.

¹ Species would overlap between Tract 1 and Tract 3; thus, 21 species are distinct number of species for combined non-federal lands.

² Does not equal sum of non-federal lands since some species overlap or vary between Tract 1 and Tract 3.

Benthic Macroinvertebrate Assemblages

Macroinvertebrate baseline surveys completed within and in the vicinity of the federal lands ranked macroinvertebrate assemblages as fair within the second-order stretches of the Partridge River, as indicated by the HBI (see Table 5.3.6-8). The first-, third-, and fourth-order segments of the streams within the vicinity of the non-federal lands indicated macroinvertebrate assemblages ranging from good to fair. A qualitative comparison using the attributes of HBI, stream order, total families (diversity), and percent pollution-tolerant organisms indicate that the macroinvertebrate assemblages likely would remain the same under the Land Exchange Proposed Action. This qualitative comparison assumes the habitat and associated macroinvertebrate assemblages are similar in the stream segments within the non-federal lands boundaries including the third-order segment of the Pike River on Tract 1 and the first-order segments of Coyote Creek within Tract 3 (see Figure 5.3.6-1).

Table 5.3.6-8 Stream Macroinvertebrate Assemblage Comparisons for the Land Exchange Proposed Action

Attributes	Federal Parcel (within parcel)		Non-federal Land (study areas within vicinity of Tract 1)		Non-federal Land (study areas within vicinity of Tract 3- Wolf Lands 3 and 4)	
	PR-west	PR-east	MPCAB- 05RN029	MPCAB- 05RN077	MPCAB- 05RN024	MPCAB- 05RN074
Study site						
Stream order	2	2	1	4	3	4
HBI score	6.4	6.0	5.7	5.1	5.9	5.2
HBI ranking	Fair	Fair	Fair	Good	Fair	Good
Total families	11	10	11	31	23	27
Percent pollution-tolerant	8	18	3	5	10	26

Adopted from Barr 2011b and MPCA 2011c.

5.3.6.2.5 Aquatic Species of Greatest Conservation Need

The MDNR and USFS have developed the ECS for ecological mapping and landscape classification (MDNR 2011a), which defines uniform ecological features within a mapped area. The federal and non-federal lands are located in the Northern Superior Uplands Section of the Laurentian Mixed Forest Province. These lands are further divided into several subsections. The federal lands include the Laurentian and Nashwauk Uplands subsections while the non-federal lands include these two subsections and the Border Lakes subsection.

As discussed in Section 4.2.6.1.4, SGCN aquatic species are associated with these ecological subsections based on occurrence and habitat considerations. Using the approach of comparing SGCN species by subsection association only, the Land Exchange Proposed Action could result in an increase of six new potential SGCN species (see Table 5.3.6-9). Of these, the spoonhead sculpin, lake chub, and longear sunfish have the highest potential to be found near the shoreline habitat of Tract 5 (within the Border Lakes subsection).

Regardless of the potential indicated by subsection association, no SGCN species were identified within the boundaries of the federal or non-federal lands during field surveys. While habitat is present in at least some locations within these boundaries for SGCN species, the surveys performed within the vicinity of the federal lands found no SGCN aquatic species, suggesting that SGCN species are likely not present on the federal lands. Conversely, occurrences of the creek heelsplitter, an SGCN species, have been documented within the vicinity of the non-federal lands on segments of the Pike River (downstream of Tract 1) and the Stony River (downstream of Tract 3) as discussed in Section 4.3.6.2. The predominant sand substrate documented in survey areas within the vicinity of these SGCN occurrence locations and the possibility that similar substrates exist within the boundaries of Tract 1 and Tract 3 indicate the creek heelsplitter may exist within the river segments of these non-federal lands. A qualitative review of these data indicates the Land Exchange Proposed Action may result in the added presence of the creek heelsplitter.

The USFS determined that the Land Exchange Proposed Action would not affect three RFSS aquatic species on the Superior National Forest, which include lake sturgeon, nipigon cisco, and shortjaw ciscoe. In addition, the Land Exchange Proposed Action may affect individuals, but would not be likely to cause a trend to federal listing or loss of viability for the remaining six RFSS aquatic species on the Superior National Forest. Please see the Biological Evaluation listed

on the USFS website (<http://www.fs.usda.gov/goto/superior/northmet>) for more information about effects on RFSS aquatic species.

Table 5.3.6-9 Ecoregion SGCN Species Comparisons for the Land Exchange Proposed Action

SGCN Species	Common Name	Federal Land (Laurentian and Nashwauk Uplands)	Non-federal Lands (Laurentian Uplands, Nashwauk Uplands, Border Lakes)
Fish			
<i>Acipenser fulvescens</i>	Lake sturgeon		X
<i>Coregonus nipigon</i>	Nipigon cisco		X
<i>Coregonus zenithicus</i>	Shortjaw cisco		X
<i>Cottus ricei</i>	Spoonhead sculpin		X
<i>Couesius plumbeus</i>	Lake chub		X
<i>Ichthyomyzon fossor</i>	Brook lamprey	X	X
<i>Lepomis megalotis</i>	Longear sunfish		X
Mussels			
<i>Lasmigona compressa</i>	Creek heelsplitter	X	X
<i>Ligumia recta</i>	Black sandshell	X	X
Total species		3	9

Adopted from Section 4.3.6.

5.3.6.3 Land Exchange Alternative B

5.3.6.3.1 Surface Water Features (MIH 14)

Land Exchange Alternative B would result in a net increase of lake and river surface water features to the federal estate (see Table 5.3.6-10). A net increase of 120.7 acres of lake and 2.8 miles of rivers would be added to the Superior National Forest under this alternative. The increase in lake and river frontage would provide a net increase to the federal estate of habitat for aquatic species (MIH 14). The frontage index would increase in the federal estate for both lakes and streams as a result of Land Exchange Alternative B.

Table 5.3.6-10 Frontage of Waterways for Land Exchange Alternative B

Parcel	Lake			Rivers/Creeks/Streams		
	Acres	Frontage (ft)	Frontage Index (shoreline/acre)	Miles	Frontage (linear ft) ¹	Frontage Index (shoreline/acre) ²
Lands Conveyed						
Land Exchange Alternative B	8.9	1,200.0	0.3	5.3	55,968.0	11.8
Lands Acquired						
Tract 1	129.6	16,424.0	3.5	8.1	72,864.0	15.3
Net Change						
Net Increase/(Decrease)	120.7	15,224.0	3.2	2.8	16,896.0	3.5

Note: Surface water shoreline distance calculated by GIS analysis.

¹ Includes shoreline distance on both sides of streams.

² Frontage Index calculated by dividing total acres of parcel by total shoreline within parcel.

5.3.6.3.2 Differences of Strahler Stream Orders and Habitat

A quantitative comparison of the Strahler Stream Order indicates that Land Exchange Alternative B would result in a decrease of 1.3 and 4.0 miles of first- and second-order streams, respectively, and an increase of 8.1 miles of third-order streams to the federal estate (see Table 5.3.6-11).

As with the Land Exchange Proposed Action, the net increase of third-order streams and decrease in first- and second-order streams would likely add more habitat diversity to the Superior National Forest. The net decrease to the federal estate of first-order streams would slightly reduce the amount of available spawning habitat for some aquatic species as headwater streams provide specialized spawning habitat for some species.

Table 5.3.6-11 Increase or Decrease of Stream Orders from Land Exchange Alternative B

Parcel (Stream)	Stream Distance (miles)		
	1 st Order	2 nd Order	3 rd Order
Lands Conveyed			
Federal Lands (Yelp Creek and Partridge River)	1.3	4.0	0.0
Lands Acquired			
Tract 1 – Hay Lake (Pike River)	0.0	0.0	8.1
Net Increase/(Decrease)	(1.3)	(4.0)	8.1

Note: Surface water shoreline distance calculated by GIS analysis.

5.3.6.3.3 Watershed Level Riparian and Aquatic Connectivity

Riparian Connectivity

A comparison of the watersheds containing streams present on the federal lands (Partridge River) and Tract 1 (Pike River) using the RCI is presented in Table 5.3.6-12. The index was developed from GIS analysis of vegetative cover along riparian areas where agriculture and land development have affected natural riparian vegetative cover.

Under Land Exchange Alternative B, there would be a slight increase to the federal estate in watershed riparian connectivity. The streams on both the federal lands and Tract 1 are located within watersheds with existing high quality riparian connectivity.

Table 5.3.6-12 Watershed Riparian Connectivity Index Comparison

Surface Water	Tract	Watershed	Percent Agriculture in Riparian Zone	Percent Development in Riparian Zone	RCI Score ¹
Lands Conveyed					
Partridge River/Yelp Creek	Federal Lands	St. Louis	0	5	95
Lands Acquired					
Pike River	1 - Hay Lake	Vermilion	0	1	99
Net Increase (Decrease)			0	(4)	4.0

Adopted from MDNR 2012k.

¹ RCI score calculated with MDNR formula using *Percent Agriculture and Percent Development in Riparian Zone*; scale is from 0 to 100 where 100 indicates excellent riparian conductivity.

Aquatic Connectivity

Land Exchange Alternative B would result in the Superior National Forest acquiring streams located in watersheds with significantly better aquatic connectivity values, indicating increased aquatic habitat.

Table 5.3.6-13 Watershed Aquatic Connectivity Index Comparison

Surface Water	Tract	Watershed	Aquatic: Bridges and Culverts (miles stream/# structures)	Aquatic: Dams (miles stream/# structures)	ACI Score ¹
Lands Conveyed					
Partridge River	Federal Lands	St. Louis	15	6	11
Lands Acquired					
Pike River	1 - Hay Lake	Vermilion	41	11	26
Net Increase (Decrease)			26	5	15

Adopted from MDNR 2012l.

¹ ACI score calculated by dividing total miles of streams and ditches per watershed by total number of culverts, bridges, and dams; scale is from 0 to 100 where 100 indicates free flowing streams (no structures) and 0 indicates one structure for every 20 miles of flowing water.

5.3.6.3.4 Aquatic Species

As with the Land Exchange Proposed Action, a semi-quantitative comparison of the net increase or decrease to the federal estate of aquatic species was made for species located within the vicinity of the Tract 1 parcel boundaries since representative survey sites located in the vicinity of the parcel are likely similar to the existing aquatic habitats present at the parcel (see Section 4.2.6).

Fish Assemblages

Two survey sites were analyzed within the vicinity of both the smaller federal parcel and within the vicinity of Tract 1. The smaller federal parcel and Tract 1 had six species in common. Land Exchange Alternative B would potentially result in a net decrease to the federal estate of four species, including two pollution-intolerant species (see Table 5.3.6-14). Given the fact that only representative survey sites were used for Tract 1, it is possible that some species are more or less prevalent than is noted here. The attributes of the fish assemblages located at each survey site indicate that Land Exchange Alternative B would result in minimal change to the fish habitat for the portions of the river the Superior National Forest would acquire. The dominant fish species present at each site indicate that the stream characteristics were consistent with slower-moving, glide pool features.

Table 5.3.6-14 Increase or Decrease of Stream Fish Assemblage for Land Exchange Alternative B

Combined Studies Within, or Within Vicinity of, Surface Water	Tract	Total Species (#)	Pollution-Intolerant Species (#)	Pollution-Tolerant Species (#)
Lands Conveyed				
Partridge River/Yelp Creek	Federal Lands	15	4	4
Lands Acquired				
Pike River	Tract 1	11	2	4
Net Increase (Decrease)		(4)	(2)	0

Adopted from Section 4.2.6.

Benthic Macroinvertebrate Assemblages

Macroinvertebrate baseline surveys completed within, and in the vicinity of, the smaller federal parcel ranked macroinvertebrate assemblages as fair within the second-order stretches of the Partridge River, as indicated by the HBI pollution index (see Table 5.3.6-15). The first- and fourth-order segments of the streams within the vicinity of Tract 1 indicated macroinvertebrate assemblages ranging from good to fair. A qualitative comparison using the attributes of HBI, stream order, total families (diversity), and percent pollution-tolerant organisms indicate that the macroinvertebrate assemblages would likely be similar under Land Exchange Alternative B. This qualitative comparison assumes the habitat and associated macroinvertebrate assemblages are similar in the stream segments within the third-order segment of the Pike River on Tract 1.

Table 5.3.6-15 Stream Macroinvertebrate Assemblage Comparisons for Land Exchange Alternative B

Attributes	Federal Lands		Non-federal Lands (study areas within vicinity of Tract 1)	
	PR-west	PR-east	MPCAB-05RN029	MPCAB-05RN077
Study site				
Stream order	2	2	1	4
HBI score	6.4	6.0	5.7	5.1
HBI ranking	Fair	Fair	Fair	Good
Total families	11	10	11	31
Percent pollution-tolerant	8	18	3	5

Adopted from Barr 2011b and MPCA 2011c.

5.3.6.3.5 Aquatic Species of Greatest Conservation Need

The smaller federal parcel includes the Laurentian and Nashwauk Uplands ecological subsections, while Tract 1 includes only the Nashwauk Uplands.

As discussed in Section 5.3.6.2.5, SGCN species are associated with these ecological subsections based on occurrence and habitat considerations. Using the approach of comparing SGCN species by subsection association only, Land Exchange Alternative B would likely result in no net change to the federal estate of SGCN species (see Table 5.3.6-16).

Regardless of the potential indicated by subsection association, no SGCN species were identified within the boundaries of the smaller federal parcel. Habitat is present in at least some locations within these boundaries for SGCN species. Although no surveys were completed within the boundaries of Tract 1, occurrences of the creek heelsplitter, an SGCN species, have been documented within the vicinity of Tract 1 on segments of the Pike River (downstream of Tract 1). The predominant sand substrate documented in survey areas within the vicinity of this SGCN occurrence location and the possibility that similar substrates exist within the boundaries of Tracts 1 indicate the creek heelsplitter may exist within the Pike River segments of Tract 1. A qualitative review of these data indicates that Land Exchange Alternative B may result in the added presence to the federal estate of the creek heelsplitter.

Table 5.3.6-16 Ecoregion SGCN Species Comparisons for Land Exchange Alternative B

SGCN Species	Common Name	Federal Lands (Laurentian and Nashwauk Uplands)	Tract 1 (Nashwauk Uplands only)
Fish			
<i>Ichthyomyzon fossor</i>	Brook lamprey	X	X
Mussels			
<i>Lasmigona compressa</i>	Creek heelsplitter	X	X
<i>Ligumia recta</i>	Black sandshell	X	X
Total species		3	3

Adopted from Section 4.3.6.

5.3.6.4 Land Exchange No Action Alternative

Under the Land Exchange No Action Alternative, the Superior National Forest would have an ongoing responsibility for managing aquatic resources on the federal lands in accordance with the Forest Plan. The Land Exchange No Action Alternative would not change the USFS responsibility for managing aquatic resources and would result in no further effects on existing aquatic species or habitats.

Fish and other aquatic life on the federal lands would be exposed to the water quality, hydrologic, and physical habitat conditions that currently exist as a result of past mining activities. There would be no change from existing conditions, although it is expected that the water quality of the Embarrass River may improve as a result of corrective actions potentially required by the reissuance of existing NPDES/SDS permits in the NorthMet Project area. Future actions conducted under the Cliffs Erie Consent Decree may also change these conditions.

The non-federal lands would not go into USFS ownership, and land use would be determined by the private land owners. Effects to aquatic resources are difficult to predict given the uncertainty of future potential land use. Some lands may be developed, resulting in potential effects to aquatic species at the individual and local population levels, decreases in habitat, and adverse effects on habitat connectivity.

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5.3.7 *Air Quality*

Because there are no current operations or activities on the non-federal parcels that would result in a change to ambient air quality, the Land Exchange Proposed Action (and alternatives) would not result in new effects on the federal estate. Indirect effects from the NorthMet Project Proposed Action on the non-federal parcels are considered under Class I area modeling and are discussed in Section 5.2.7.

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5.3.8 Noise and Vibration

Evaluation of potential noise, vibration, and airblast effects in the areas of the Land Exchange Proposed Action used the same methodologies and criteria that were described previously for the NorthMet Project Proposed Action. The results of the modeling indicate that noise, vibration, and airblast levels that would be experienced at or by sensitive receptors would be below the Minnesota standards. Therefore, operations at the Mine Site and Plant Site would not have a significant effect on human receptors within the federal and non-federal lands, including people that may use the non-federal lands for recreational activities such as hunting and hiking (if the Land Exchange Proposed Action were to occur and the non-federal lands were added to the Superior National Forest). As discussed in Section 5.2.8, tribal users of archaeological sites (Spring Mine Lake Sugarbush, *Mesabe Widjiu*, and BBLV Trail; see Section 4.2.9) in the immediate vicinity of the Mine Site and Plant Site could experience some effects from noise. The non-federal land tracts are approximately 10 to 90 miles from operations at the Mine Site and Plant Site; tracts located 50 to 90 miles away from the federal lands are outside the area of analysis for noise modeling and would be not affected by noise from operations at the Mine Site and Plant Site.

5.3.8.1 Methodology and Evaluation Criteria

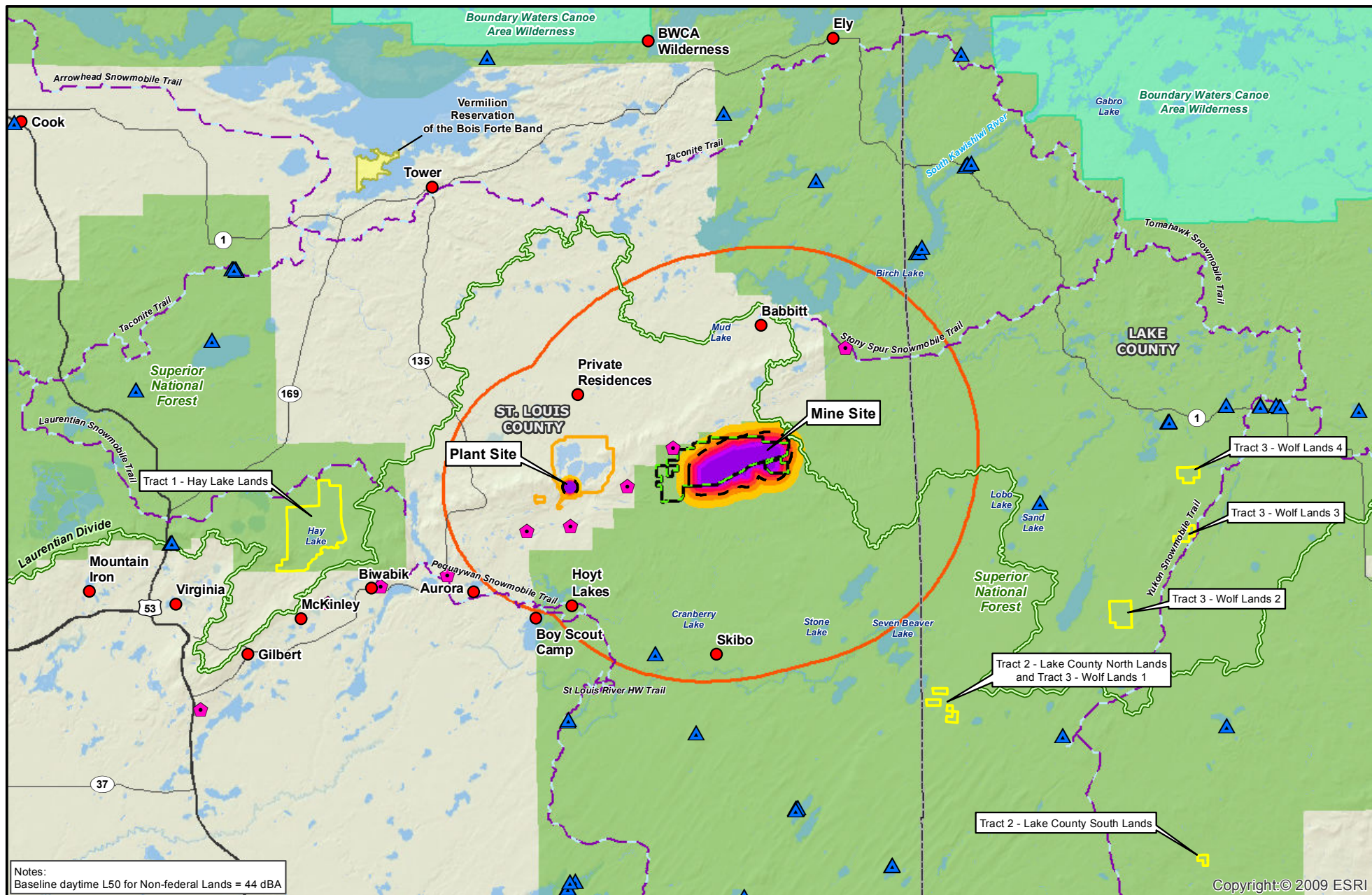
The noise and vibration impact assessment area for the Land Exchange Proposed Action would involve transferring 6,495.4 acres of federal lands from public to private ownership, and up to 7,075.0 acres of land from private to public ownership. The spatial and temporal area of analysis assessed for noise, vibration, and airblast as part of the Land Exchange Proposed Action included the indirect effects resulting from the mining activities; therefore, the area of analysis is the same as that described in Section 5.2.8.1. As indicated before, three desktop computer models (ISO 9613-2 sound-propagation model, the Site Law formula, and the Terrock model) were used to evaluate noise, ground vibration, and airblast effects, respectively, on the federal and non-federal lands.

5.3.8.2 Land Exchange Proposed Action

5.3.8.2.1 Federal Lands

The topography and land cover of the federal lands are similar to those of the Mine Site previously discussed, but include additional area to the west and northwest that are mostly wetland. NorthMet Project Proposed Action-related activities that would result in noise, vibration, or airblast would not occur on the additional federal lands (3,776.1 acres) situated west and northwest of the Mine Site, so no additional noise, vibration, or airblast effects would occur in this area. It should be noted that the federal land excludes private lands (295.2 acres) situated south of Dunka Road. There are no residential areas or individual houses within the federal lands that could be affected by the NorthMet Project Proposed Action's noise and vibration-related activities (see Figures 5.3.8-1 to 5.3.8-4). As discussed in Section 5.2.8.2, noise and vibration levels from the Mine Site would be too low to significantly affect the recreational use of the federal land (i.e., minor effects in 11,456 acres around the Mine Site).

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<ul style="list-style-type: none"> Noise Sensitive Receptor Non-federal Lands Federal Lands Plant Site Mine Site Wildlife Travel Corridor 	<ul style="list-style-type: none"> Recreational Site Native American Reservation Boundary Waters Canoe Area Wilderness National Forest 	<ul style="list-style-type: none"> MN L50 Daytime Noise Standard: 60 dBA L50 Audibility Limit L50 dBA Levels 50-54.9 55-59.9 60-64.9 65-69.9 70-74.9 75-79.9 80+ 			<p>Figure 5.3.8-1 Predicted Daytime L50 Noise Contours at Non-federal Tracts (Includes Baseline L50 Levels) NorthMet Mining Project and Land Exchange SDEIS Minnesota</p> <p>November 2013</p>
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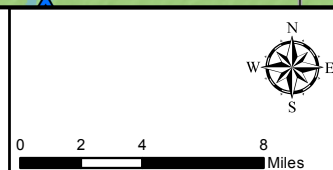
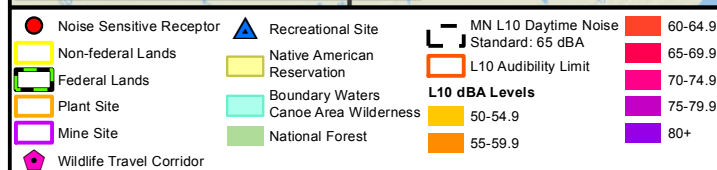
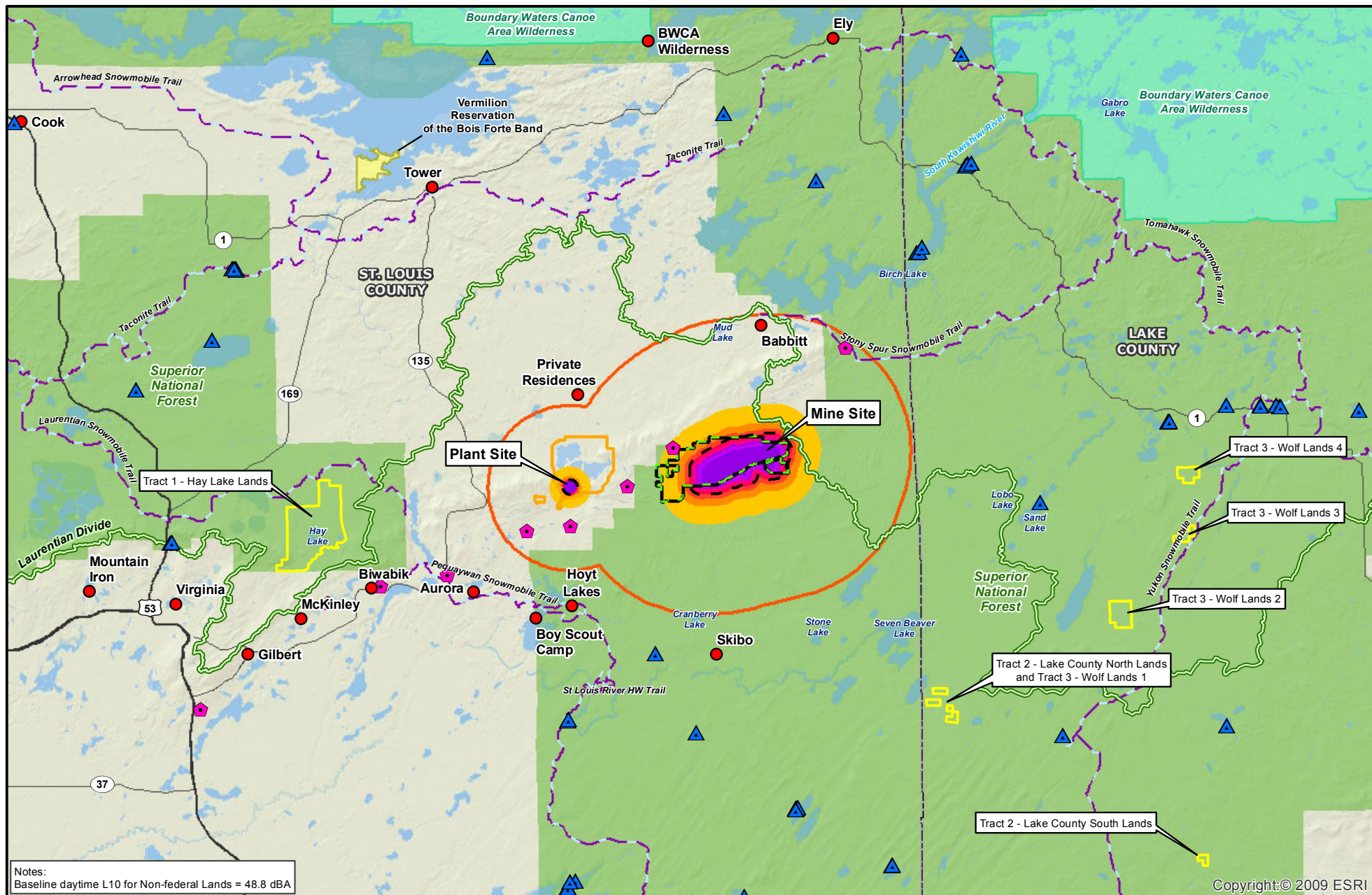


Figure 5.3.8-2
Predicted Daytime L10 Noise Contours at Non-federal Tracts (Includes Baseline L10 Levels)
NorthMet Mining Project and Land Exchange SDEIS
Minnesota

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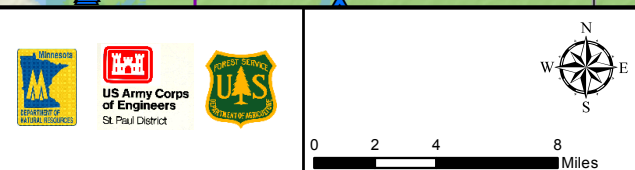
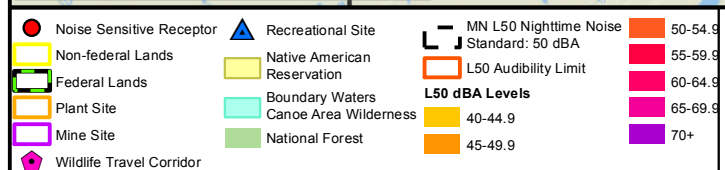
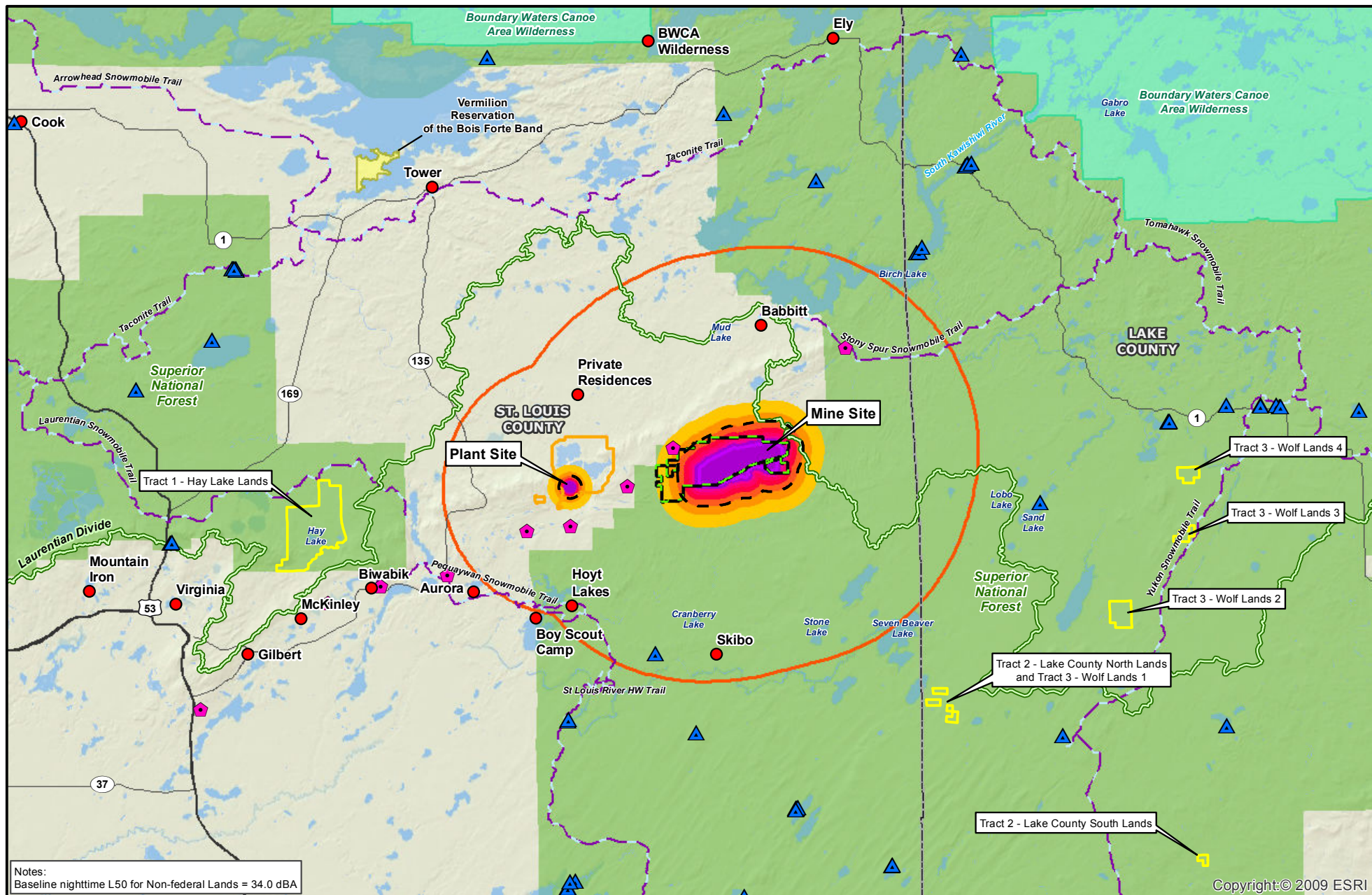
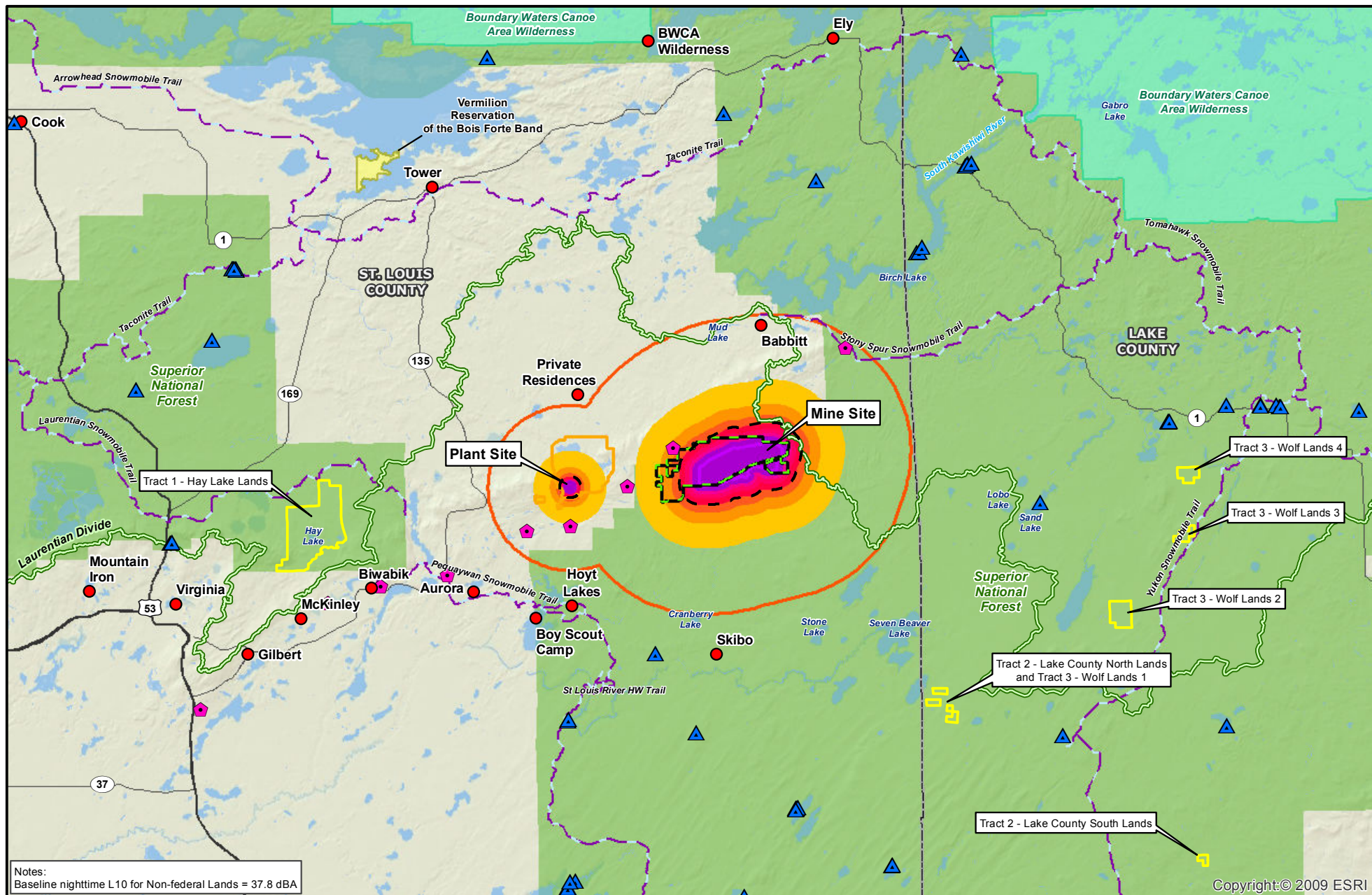


Figure 5.3.8-3
Predicted Nighttime L50 Noise Contours at Non-federal Tracts (Includes Baseline L50 Levels)
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota
 November 2013

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0 2 4 8 Miles

Figure 5.3.8-4
Predicted Nighttime L10 Noise Contours at Non-federal Tracts (Includes Baseline L10 Levels)
NorthMet Mining Project and Land Exchange SDEIS
Minnesota

November 2013

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5.3.8.2.2 Non-federal Lands

The non-federal lands would be managed consistent with the adjacent forest lands management (see Section 4.3.1). No direct effects from the Land Exchange Proposed Action are anticipated since the USFS currently has no plans for operations on the non-federal lands and no NorthMet Project Proposed Action-related activity (e.g., drilling, blasting, excavation work, material haulage via trucks, and ore crushing) would occur within the non-federal lands.

Review of the most-up-to-date aerial maps indicates that there are no human or residential receptors within or adjacent to the non-federal lands (Tracts 1 to 5). If the Land Exchange Proposed Action were to occur and the non-federal lands were added to the Superior National Forest (i.e., if the tracts became federal lands), public recreational use such as hiking and hunting would likely occur on these tracts.

To determine the indirect effect of operations at the Mine Site and Plant Site on people that may use the non-federal lands for recreational activities such as hiking and hunting, the modeled area was expanded to a 20-mile radius from both the Mine Site and the Plant Site. Daytime and nighttime noise contours (L_{50} and L_{10}) generated from the modeling are shown in Figures 5.3.8-1 through 5.3.8-4. During the daytime, all potential receptors within the non-federal lands were outside the 50-dBA (L_{50} and L_{10}) noise contours. During the nighttime, all potential receptors within the non-federal lands were outside the 40-dBA (L_{50} and L_{10}) noise contours. This shows that the predicted daytime and nighttime noise levels at the non-federal lands due to operations at the Mine Site and Plant Site are well below Minnesota's noise standards. The results of the noise assessment indicate that operations at the Mine Site and Plant Site would add no perceptible noise (0 dBA) to the current baseline levels experienced at the non-federal lands. Non-federal Tracts 4 and 5 are approximately 50 and 90 miles away, respectively, from the federal lands and are outside the area of analysis for noise modeling; neither tract would be affected by noise from operations at the Mine Site and Plant Site.

Based on the information above, it is anticipated that noise from typical mining and hauling operations at the Mine Site and ore-crushing operations at the Plant Site would not affect the people that may use the non-federal lands for recreational activities such as hiking and hunting under the Land Exchange Proposed Action. However, as discussed in Section 5.2.8, tribal users of archaeological sites (Spring Mine Lake Sugarbush, *Mesabe Widjiu*, and BBLV Trail; see Section 4.2.9) in the immediate vicinity of the Mine Site and Plant Site could experience some effects from noise. The non-federal lands are far from the Mine Site and Plant Site (10 to 90 miles away), so indirect vibration levels from operations at both locations would not affect potential receptors within the non-federal lands that would be acquired under the Land Exchange Proposed Action.

5.3.8.3 Land Exchange Alternative B

Under the Land Exchange Alternative B, 4,752.6 acres would be conveyed to PolyMet. The type, quantity, and location of noise- and vibration-related sources (i.e., drilling, blasting, excavation work, haul trucks, trains, and crushers) for the Land Exchange Alternative B would be the same as that for the Land Exchange Proposed Action. Therefore, the Land Exchange Alternative B would not change noise and vibration levels experienced at the federal lands or modify noise and vibration effects on nearest receptors. If the 4,752.6 acres of land were to become privately owned, public recreational use currently associated with the smaller federal parcel would no

longer occur on that portion of the federal lands (i.e., the Land Exchange Alternative B would have no effects associated with public recreational use on that portion). Sections 5.2.8.2.1 and 5.2.8.2.2 provide a discussion of the noise and vibration effects on the federal lands.

Under the Land Exchange Alternative B, Tract 1 (4,926.3 acres) would be acquired by the USFS. The type, quantity, and location of noise- and vibration-related sources (i.e., drilling, blasting, excavation work, haul trucks, trains, and crushers) for this alternative would be the same as that for the Land Exchange Proposed Action. Therefore, the Land Exchange Alternative B would not change noise and vibration levels experienced at the non-federal lands or modify noise and vibration effects on the nearest receptors.

As indicated above, during the daytime, all modeled potential receptors within Tract 1 were outside the 50-dBA (L_{50} and L_{10}) noise contours (see Figure 5.3.8-1 and 5.3.8-2). Similarly, during the nighttime, all potential receptors within Tract 1 were outside the 40-dBA (L_{50} and L_{10}) noise contours (see Figure 5.3.8-3 and 5.3.8-4). The predicted daytime and nighttime noise levels at Tract 1 due to operations at the Mine Site and Plant Site are well below Minnesota's noise standards. The results of the noise assessment indicate that operations at the Mine Site and Plant Site would add no additional noise (0 dBA) to the current baseline levels experienced at Tract 1.

5.3.8.4 Land Exchange No Action Alternative

Under the Land Exchange No Action Alternative, the transfer of lands would not occur and there would be no increase in noise and vibration levels at the federal and non-federal lands. Therefore, there would be no change in noise and vibration levels at the nearest receptors.

5.3.9 Cultural Resources

This section describes the environmental consequences of the Land Exchange Proposed Action on historic properties that are present on the federal and non-federal lands. Under the Land Exchange Proposed Action and alternatives, the Superior National Forest would retain its ongoing responsibility for managing cultural resources on Superior National Forest lands in accordance with the Forest Plan. At this time, environmental consequences on historic properties have not been completed. Results will be added to this document when received from the federal Co-lead Agencies.

5.3.9.1 Methodology and Evaluation Criteria

Effects associated with the Land Exchange Proposed Action would be the potential destruction of historic properties and the loss of the historic information and cultural significance that these properties could represent. An additional effect would be the loss of federal protection for any unknown historic properties, such as those provided under the NHPA, the Archaeological Resource Protection Act, and the Native American Graves and Repatriation Act. The methodology and evaluation criteria used to determine potential effects on cultural resources from the Land Exchange Proposed Action are similar to those used for the NorthMet Project Proposed Action (see Section 5.2.9).

The analysis of cultural resources was performed based on readily available information, and no additional field work was performed. Intensive analysis is only needed for the federal parcel leaving federal ownership. The non-federal lands that would be going into federal ownership would not be of primary concern since future management of these lands would be per Forest Plan direction for heritage resources.

The spatial area of analysis for Land Exchange Proposed Action effects on cultural resources included the boundaries of the federal tracts proposed for the exchange, while the temporal area of analysis was the point in time at which the change in ownership would occur. The geographic extent is appropriate because it includes all cultural resources that would be affected by a change in site protection. In a temporal sense, the change in ownership is appropriate because this is when there would be a gain or loss of legal protections.

The analysis of the cultural resources affected by the Land Exchange Proposed Action was guided by effects criteria that were developed by the USFS and the USACE. The analysis included a review of known and recorded heritage resources (i.e., historic structures, artifacts, TCPs) within or immediately adjacent to the federal and non-federal lands and a qualitative assessment to determine if there were portions of the federal and non-federal lands that have not been surveyed previously and would have a high probability to yield heritage resources.

5.3.9.2 Land Exchange Proposed Action

5.3.9.2.1 Federal Lands

The cultural resources analysis has not been completed at this time; however, the federal Co-lead Agencies are currently working with the SHPO and the Bands to make final determinations and will present the results of the effects and appropriate mitigation in the FEIS.

Cultural resources located on private lands being transferred to federal ownership would not be considered as adversely affected, but would be considered to have greater preservation protection under federal law.

The 1854 Treaty resources located within the Land Exchange Proposed Action would be similar to the Mine Site portion of the NorthMet Project area previously discussed in Section 4.2.9. Section 4.2.9 provides further discussion of the existing conditions on the Mine Site and associated federal lands. The Land Exchange Proposed Action represents an exchange of private and federal land, but it also represents an exchange of access to natural resources expressed in treaties made between the United States and Bands of Ojibwe Indians in the 19th Century. Due to the nature of a land exchange, therefore, the effects would be limited to access to such resources versus direct or indirect effects, as would be the case with the Land Exchange Proposed Action.

An analysis of effects on 1854 Treaty resources, as described and discussed in Section 4.2.9, is limited by the lack of available information concerning the use of such resources. Determining how the Bands have traditionally conducted their usufructuary rights on or near the Land Exchange area would only be available through a detailed ethnographic study of individual Band members and their families. The cultural resources investigations included Band member interviews with Bois Forte, Fond du Lac, and Grand Portage, although only Bois Forte's results were made available. The results of the interviews and the cultural resources investigation did not find any natural resources that would be considered a TCP or other traditional cultural place.

There is also no quantitative analysis of current use of treaty resources in or near the Land Exchange area. This lack of data also precludes the analysis of how Band members would be quantitatively affected socioeconomically by effects on 1854 Treaty resources, further discussed in Section 5.2.10. The primary source of data for assessing effects on treaty resources is from the analysis of the environment in other chapters of this SDEIS as discussed in Section 4.2.9.4 and 5.2.9.2.2.

As discussed above, the Land Exchange Proposed Action could have effects on 1854 Treaty resources—i.e., lack of access to those areas and species that are traditionally or culturally important to the Bands. Band members' use of the Land Exchange area is not well-defined through research at this time and did not emerge through interviews. A good faith effort was made on the part of the federal Co-lead Agencies to identify use areas in or adjacent to the Land Exchange area; however, those efforts resulted in little specific information concerning historic subsistence use and no information regarding recent subsistence activity within the Land Exchange area. As such, cultural effects on the Bands would be difficult to quantify in regards to such incremental increases below standards or effects on species where appropriate mitigation is used.

5.3.9.2.2 Non-federal Lands

There are no known cultural resources on the non-federal lands. Cultural resources located on private lands being transferred to federal ownership would not be considered adversely affected, but would be considered to have greater preservation protection under federal law.

The Land Exchange Proposed Action represents an exchange of private and federal land, but it also represents an exchange of access to natural resources expressed in treaties made between the United States and Bands of Ojibwe Indians in the 19th Century. Due to the nature of a land exchange, therefore, the 1854 Treaty resources would be available for resource gathering and

subsistence use by the Bands and would receive greater protection under federal law than they are currently receiving.

5.3.9.3 Land Exchange Alternative B

5.3.9.3.1 Federal Lands

All of the cultural resources and 1854 Treaty resources identified and discussed in Section 5.3.9 are located within the Land Exchange Alternative B. Effects on these resources would be the same as discussed in Section 5.3.9.

5.3.9.3.2 Non-federal Lands

There are no known cultural resources on the non-federal lands. Cultural resources located on private lands being transferred to federal ownership would not be considered adversely affected, but would be considered to have greater preservation protection under federal law.

The Land Exchange Alternative B represents an exchange of private and federal land, but it also represents an exchange of access to natural resources expressed in treaties made between the United States and Bands of Ojibwe Indians in the 19th Century. Due to the nature of a land exchange, therefore, the 1854 Treaty resources would be available for resource gathering and subsistence use by the Bands and would receive greater protection under federal law than they are currently receiving.

5.3.9.4 Land Exchange No Action Alternative

There would be no effects on cultural resources or 1854 Treaty resources under the Land Exchange No Action Alternative.

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5.3.10 Socioeconomics

This section describes the potential socioeconomic consequences of the Land Exchange Proposed Action. Overall, the Land Exchange Proposed Action would have the following socioeconomic effects:

- positive economic effects due to the value of forestry products made available on the non-federal lands, as well as jobs and revenue due to increased visitation of the non-federal lands;
- undetermined effects for EJ populations and subsistence activities, due to the net increase in the amount of land available for subsistence activities, but unknown changes in the type and extent of subsistence resources on the federal and non-federal lands; and
- negligible effects on other socioeconomic considerations.

5.3.10.1 Methodology and Evaluation Criteria

As discussed in Section 5.2.10, the study area for socioeconomics differs from the study area used for much of the rest of the SDEIS. It includes Cook, Lake, and St. Louis counties. This includes, where appropriate, the St. Louis County municipalities listed in Section 4.2.10. The primary issues related to socioeconomics on and near the non-federal lands, and therefore the potential for effects, would include the following:

- the amount of annual property taxes lost to the county from non-federal lands going to federal ownership;
- the potential change in payment in lieu of taxes to the county from the Land Exchange Proposed Action;
- the differences in assessed market values of federal lands compared to non-federal lands proposed for exchange;
- the difference between present values of recently harvested (past 10 years) products from the federal parcels and the value of products from the federal parcels;
- the difference between present and future values of potential forest products in Land Exchange Proposed Action parcels;
- the change in forestry employment on federal and non-federal parcels (estimated);
- a qualitative assessment of public visitation to the federal tract and estimated/potential visitation to non-federal tracts;
- the difference between present and future estimated spending on recreational tourism;
- the difference between present and future amounts of treaty resources in Land Exchange Proposed Action parcels; and
- a qualitative assessment of tribal use of the federal parcels and estimated/potential use of the non-federal parcels.

5.3.10.2 Land Exchange Proposed Action

This section describes the potential socioeconomic effects of the Land Exchange Proposed Action on communities in the socioeconomics study area. The Land Exchange Proposed Action would create moderate positive economic effects through increased opportunity for forestry and recreation and associated employment, earnings, and revenue. The Land Exchange Proposed Action would have negligible negative effects on other socioeconomic factors, including housing, public facilities and services, EJ populations, and subsistence.

5.3.10.2.1 Economic Activity

There is no current economic activity (e.g., forestry, etc.) on the federal lands, although harvesting of forest products is permitted by the Forest Plan. More importantly, the federal lands are not accessible to the public for economically measurable use, such as forestry or recreation (see Section 5.2.11). Thus, while the federal lands may hold some theoretical economic value for timber harvest, their practical economic value is zero. Table 5.3.10-1 lists data and observations relevant to the economic value of the federal and non-federal lands.

Tax Payments

Implementation of the Land Exchange Proposed Action would transfer ownership of the federal lands to PolyMet, and would result in an active mining operation that would generate federal, state, and local tax revenue, in addition to employment. As described in Section 5.2.10.2.3, total annual direct tax payments from the NorthMet Project Proposed Action during operations are expected to be in the range of \$37 to \$80 million, a positive economic effect, both on an absolute basis and when compared with the minimal current economic activity within the NorthMet Project area.

The amount of property taxes that would be paid to St. Louis County for the federal lands has not yet been determined; however, property taxes would be included in the overall taxes paid by PolyMet, shown in Table 5.2.10-3. For the non-federal lands, increases to federal payments in lieu of taxes to study area counties as a result of the Land Exchange Proposed Action would be negligible (compared to the current payment in lieu for the federal lands).

Table 5.3.10-1 Economic Value of Federal and Non-federal Lands (in 2012 dollars)

Land	Acreage	Annual Property Tax¹	Annual Payment in Lieu of Taxes (PILT)²	Market Value of Land³	Other Economic Value
<i>Federal Lands</i>	6495.4	NA ³	\$2,273.39	TBD	NA
Tract 1	4,926.3	\$20,714.68	\$1,724.10	TBD	Potential recreational value due to the presence of Hay Lake (boating, fishing), existing trails, evidence of ongoing hunting, and other recreational activity (see Section 4.3.11).
Tract 2	381.9	\$2,563.54	\$133.70	TBD	NA
Tract 3	1,575.8	Unknown	\$551.60	TBD	NA
Tract 4	160.2	\$739.30	\$56.00	TBD	NA
Tract 5	30.8	\$1,938.00	\$10.85	TBD	Potential recreational value. Former site of a cabin and camp site owned by Carleton College. Adjacent to highly scenic McFarland Lake (boating, fishing, access to BWCAW) (see Section 4.3.11).
<i>Subtotal, Non-Federal Lands</i>	7,075.0	\$25,995.52	\$2,476.25	TBD	NA
Net Change⁵	579.6	NA	\$202.86	TBD	NA

¹ Source: Orehek, PolyMet, Pers. Comm., April 17, 2012.

² Source: DOI 2012

³ See Market Value section below.

⁴ Table 5.2.10-3 describes total estimated taxes that PolyMet expects to pay for the federal lands. The amount specifically anticipated for property taxes has not been determined.

⁵ Calculated as (non-federal) minus (federal).

TBD = To be determined

Market Value

Federal regulations governing land exchanges, contained in 36 CFR 254.12, require that the assessed value of non-federal land being exchanged be equal to or within 25 percent of the assessed value of the federal land being exchanged. Assessment data will be updated and included in the FEIS.

Recreation Value

Tracts 1 and 5 also have the potential for recreational use (whereas the federal lands are not easily accessible for any purpose). To the degree that the USFS manages these lands (and the other non-federal lands) for active recreational activity, the Land Exchange Proposed Action could increase economic activity associated with recreation and tourism. The non-federal lands comprise less than half of 1 percent of the 2,171,603.9 acres of Superior National Forest that are managed by USFS, so any such increase would be small.

Timber

There is no ongoing forestry activity on the federal lands, and no evidence of recent past forestry activity. Portions of Tracts 2, 3, and 4 show some evidence of timber harvesting, and a timber harvest agreement is in place through 2013 for the Wolf Lands 3 parcel (see Section 4.3.1). Likely USFS management area designations for the non-federal lands would allow timber harvesting on 6,547.1 acres of the non-federal lands (the lands designated General Forest or General Forest – Longer Rotation; see Table 5.3.1-1). Thus, the Land Exchange Proposed Action could increase timber production in Superior National Forest.

On average, 1 percent of timber land in Superior National Forest is harvested each year, with an estimated value of \$400 (gross) per harvested acre (Deckard 2012). Timber harvesting on the non-federal lands (and any other USFS lands) would occur only after completion of forest planning, when acres that are eligible for harvest are identified and the offered for sale. For planning purposes, if 1 percent of the non-federal lands would therefore generate gross proceeds of approximately \$26,188 per year. This represents approximately 2 percent of the \$1,435,900 value of timber harvests in Superior National Forest in 2011 (Deckard 2012), although the markets for timber, and thus the value of harvested timber, can change dramatically. This additional activity would be estimated to generate fewer than 20 new jobs in the region. Minnesota averages approximately one forestry job (including logging and primary manufacturing) per 350 acres of annual harvest, and each direct forestry job generates another 3.6 indirect and induced jobs (Deckard 2012). Using these estimates, the Land Exchange Proposed Action could generate four direct and 12 indirect jobs. As of 2009, forestry activities employed approximately 1,287 individuals in the study area (Headwaters Economics 2009).

Environmental Justice and Subsistence

Potential EJ populations, as well as the EJ and subsistence effects of the Land Exchange Proposed Action on the federal lands, are described in Section 5.2.10.2.7. Although tribal entities possess usufructuary rights to hunt, fish, and gather throughout the 1854 Ceded Territory, the federal lands are not easily accessible for such subsistence activities. The Land Exchange Proposed Action would involve the transfer of 6,495.4 acres of inaccessible federal lands from public to private ownership, and up to 7,075.0 acres of publicly accessible land from private to

public ownership. To the degree that increased availability of publicly accessible land improves property value and generates revenue (see above) in the study area, the Land Exchange Proposed Action could have positive effects on EJ populations.

As a result of the Land Exchange Proposed Action, the current federal lands would become unavailable for subsistence use. Resource-specific sections of the SDEIS address the degree to which subsistence species and resources are likely to be available on the non-federal lands. As described in Section 5.2.9, subsistence has both economic and cultural components; for the Bands, the harvest of a particular animal or plant is intrinsically linked to the place and nature in which it was harvested. Thus, a “net change” in subsistence activity associated with the Land Exchange Proposed Action cannot be calculated in the same way as, for example, the net change in employment or income. The Land Exchange Proposed Action would result in the loss of subsistence resources and opportunities on the federal lands, and a gain in subsistence resources and opportunities on the non-federal lands.

Other Socioeconomic Considerations

The Land Exchange Proposed Action would result in slight increases in demand for public safety services to assist recreational or other users of the non-federal lands. This is a demand that currently does not exist on the inaccessible federal lands. The non-federal lands represent 0.2 percent of the Superior National Forest. Thus, any such increased demand would be marginal. No new housing (and thus no increased demand for educational facilities) is anticipated on the non-federal lands. Any utilities extended to the non-federal lands (such as electricity) would likely be minimal in nature (given the ROS categories assigned to the non-federal lands—see Section 5.3.11). Thus, the Land Exchange Proposed Action would have negligible effects on other socioeconomic considerations.

The Land Exchange Proposed Action would result in a loss of some of the ecosystem functions provided by the forest, wetland, and other natural habitats on the federal lands, particularly the portions of the federal lands (i.e., the Mine Site) where habitat would be replaced by mine facilities. Some of these functions could be restored during the post-closure period, when the federal lands (as well as the Plant Site) are revegetated. In exchange, the Land Exchange Proposed Action would enable the USFS to directly manage the ecosystems functions on the non-federal lands.

5.3.10.3 Land Exchange Alternative B

Under the Land Exchange Alternative B, 4,752.6 acres of federal lands would be exchanged for the 4,926.3-acre Tract 1. The remainder of the federal lands would remain inaccessible by land. The Land Exchange Alternative B would generate economic benefits through forestry and recreational activities (see Table 5.3.10-1); however, these benefits would be less than from the Land Exchange Proposed Action. Similarly, the Land Exchange Alternative B would create benefits for EJ and subsistence activities, although less so than the Land Exchange Proposed Action. Negative socioeconomic effects from the Land Exchange Alternative B would be minimal.

5.3.10.4 Land Exchange No Action Alternative

Under the Land Exchange No Action Alternative, the NorthMet Project Proposed Action would not be developed, there would be no change to the federal lands, and the non-federal lands would remain inaccessible to the public (including tribal entities). Given other private ownership (e.g., the Dunka Road and railroad), the federal and non-federal lands would remain generally inaccessible to the public. Therefore, there would be no direct or indirect effects on socioeconomics.

5.3.11 Recreation and Visual Resources

This section describes the potential environmental consequences of the Land Exchange Proposed Action on recreational facilities and activities that typically take place on the federal and non-federal lands. In this section, effects on the federal and non-federal lands are discussed together, to facilitate calculation of net changes in recreation and scenic classes. Under the Land Exchange Proposed Action and Land Exchange Alternative B, the Superior National Forest would retain its ongoing responsibility for managing recreational resources on National Forest System lands in accordance with the Forest Plan.

Overall, the Land Exchange Proposed Action would increase opportunities for recreational activity through the acquisition of up to 7,075.0 acres of publicly accessible land (the non-federal lands) in exchange for 6,495.4 acres of federal land that are not publicly accessible, and thus cannot be used for recreation. The Land Exchange Proposed Action would also increase the amount of land controlled by the USFS in the Superior National Forest with Moderate and High SIOs.

The Land Exchange Alternative B would have a lesser degree of the same type of benefits for recreation and visual resources as the Land Exchange Proposed Action, due to the reduced land area involved.

Table 5.3.11-1 shows the effects of the Land Exchange Proposed Action and the Land Exchange Alternative B on acreage of various ROS classes; Table 5.3.11-2 shows the effects on SIO classes.

Table 5.3.11-1 Net Increase or Decrease of Recreation Opportunity Spectrum Classes

Alternative	Increase (Decrease) of ROS Class (Acres)			Total
	Semi-Primitive Motorized	Semi-Primitive Non-Motorized	Roaded Natural	
Land Exchange Proposed Action	(2,243.3)	2,309.9	513.0	579.6
Land Exchange Alternative B	(2,972.7)	2,162.2	984.2	173.7

Table 5.3.11-2 Net Increase or Decrease of Scenic Integrity Objectives

Alternative	Increase (Decrease) of Scenic Integrity Objective (Acres)			Total ¹
	High	Moderate	Low ¹	
Land Exchange Proposed Action	136.3	1,644.6	(1,170.8)	610.1
Land Exchange Alternative B	20.4	1,315.4	(1,153.2)	182.6

¹ Mud Lake would not be managed by the USFS, and therefore does not have an SIO.

5.3.11.1 Methodology and Evaluation Criteria

5.3.11.1.1 Recreation

The primary issues related to recreational facilities and activities associated with the Land Exchange Proposed Action on and near the federal lands and non-federal lands include the following:

- change in areas of ROS classes within the Superior National Forest; and
- qualitative difference in recreation opportunities, as measured using ROS classes, between outgoing federal land and non-federal lands to be acquired.

ROS classes were defined by the USFS (1982) and ROS classes for the non-federal lands were mapped to match the existing mapped ROS Spectrum areas on surrounding adjacent federal lands. GIS analysis was employed to determine the net change in acreage by ROS class. ROS classes are discussed in Section 4.2.11.1.1.

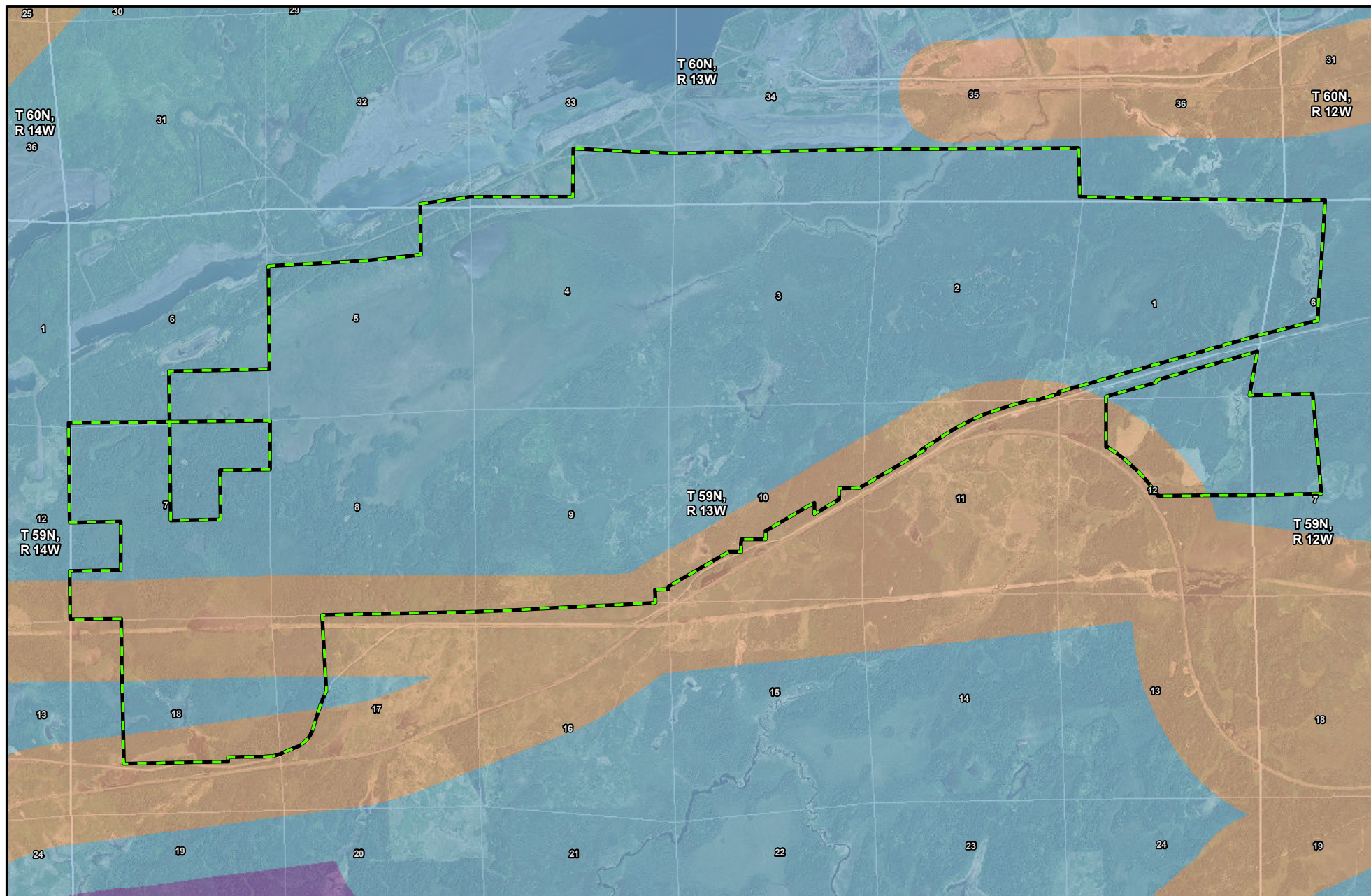
5.3.11.1.2 Visual Resources

The primary issue related to visual resources on and near the non-federal lands is the change in acreage of High, Moderate, and Low SIO classified land within Superior National Forest lands. SIOs were provided by USFS (1995), and as with ROS classes, SIOs for the non-federal lands were mapped to match the existing mapped SIOs on surrounding adjacent federal lands. GIS analysis was employed to determine the net change in acreage by SIO. SIOs are discussed in section 4.2.11.1.2. This quantitative analysis was supplemented by a qualitative description of loss of scenery opportunities on federal lands that would be conveyed to PolyMet and the gain of scenery opportunities on non-federal lands to be acquired and managed by USFS.

5.3.11.2 Land Exchange Proposed Action

5.3.11.2.1 Recreation

ROS classes for the federal lands are shown on Figure 5.3.11-1; the classes that would be applied to the non-federal lands are also shown on Figures 5.3.11-2 and 5.3.11-3. These classifications are summarized in Table 5.3.11-3. No developed recreational sites or opportunities are planned at this time. All of the tracts would be open for non-motorized, dispersed recreational activities. The federal lands in the Land Exchange Proposed Action consist of 967.0 acres designated as Roaded Natural and 5,528.4 acres designated Semi-Primitive Motorized (see Table 5.3.11-3). As described in Sections 4.2.11 and 4.3.11, the Semi-Primitive (Motorized and Non-Motorized) classes indicate areas where interaction between visitors is rare, but where human activities may be visible. The Roaded Natural class indicates an area where evidence of human activity and interactions are more frequent, and occasionally prevalent.



- | | |
|--|------------------------------|
| Federal Lands | Semi-Primitive Non-motorized |
| Section Boundary | Primitive |
| Section Label | Roaded Natural |
| Recreation Opportunity Spectrum | |
| Semi-Primitive Motorized | Rural |
| Urban | |

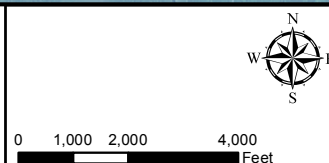
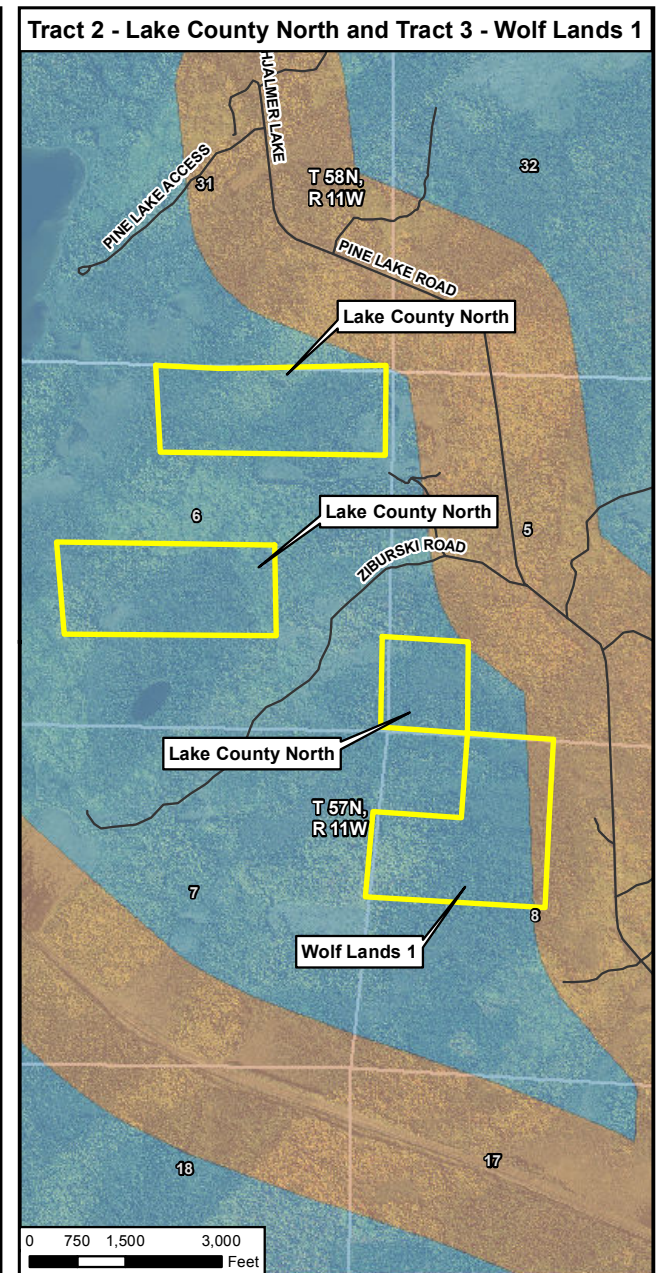
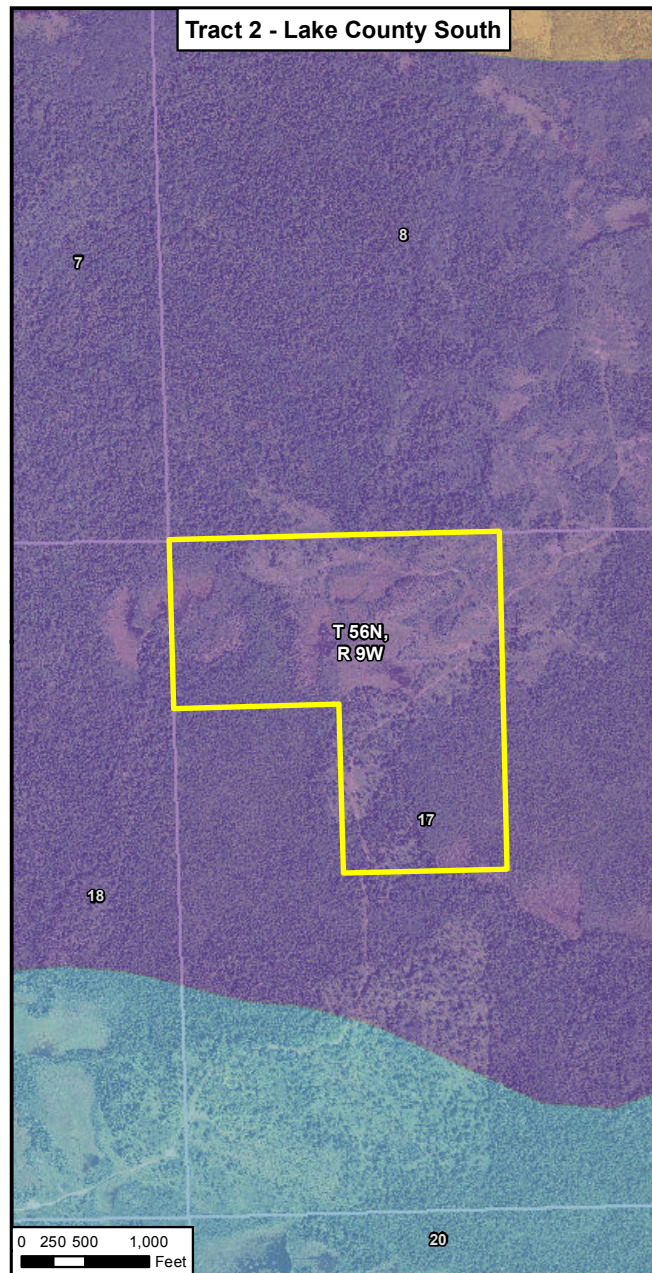
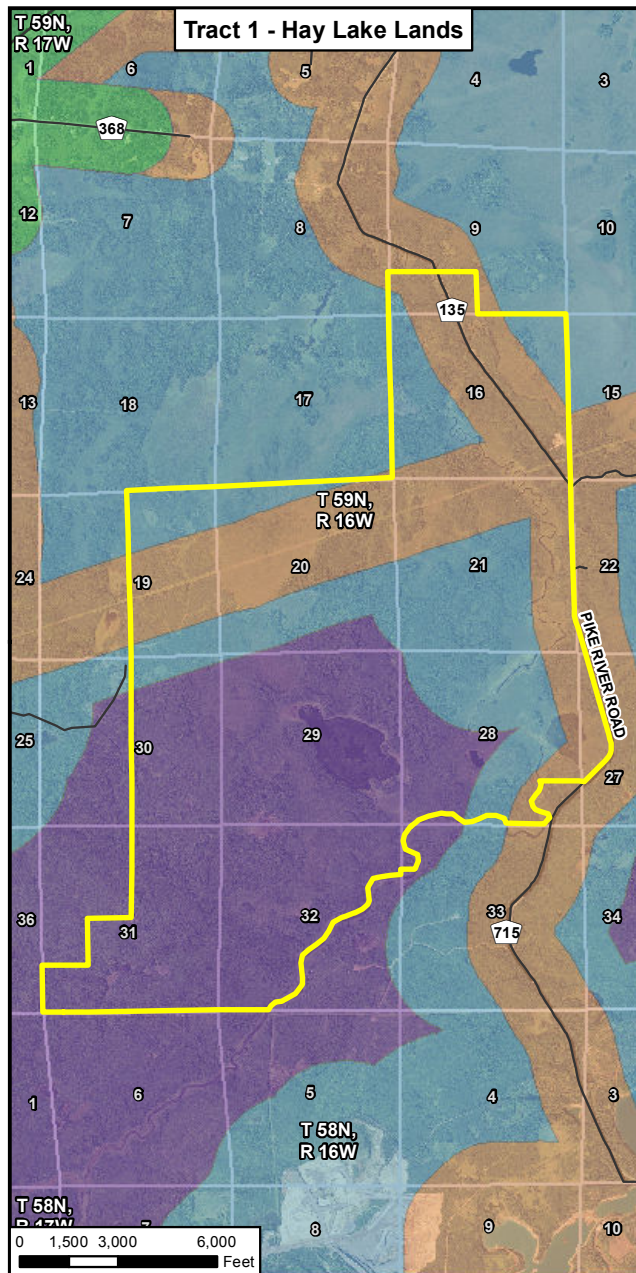


Figure 5.3.11-1
Recreation Opportunity Spectrum
Federal Lands
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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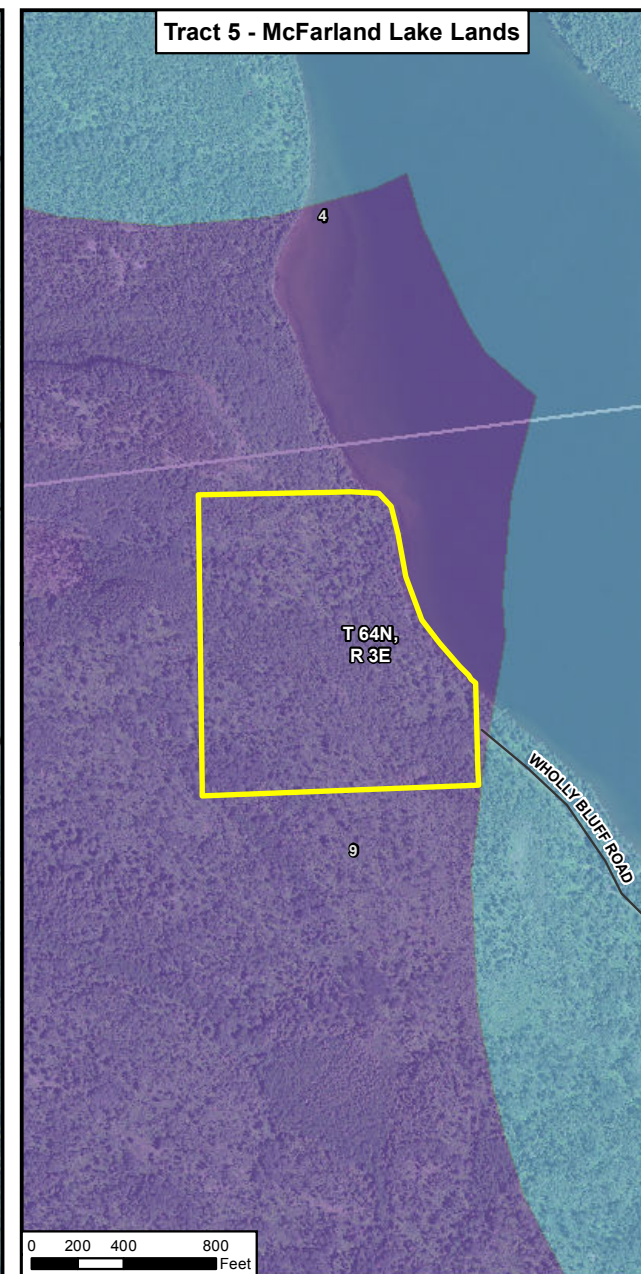
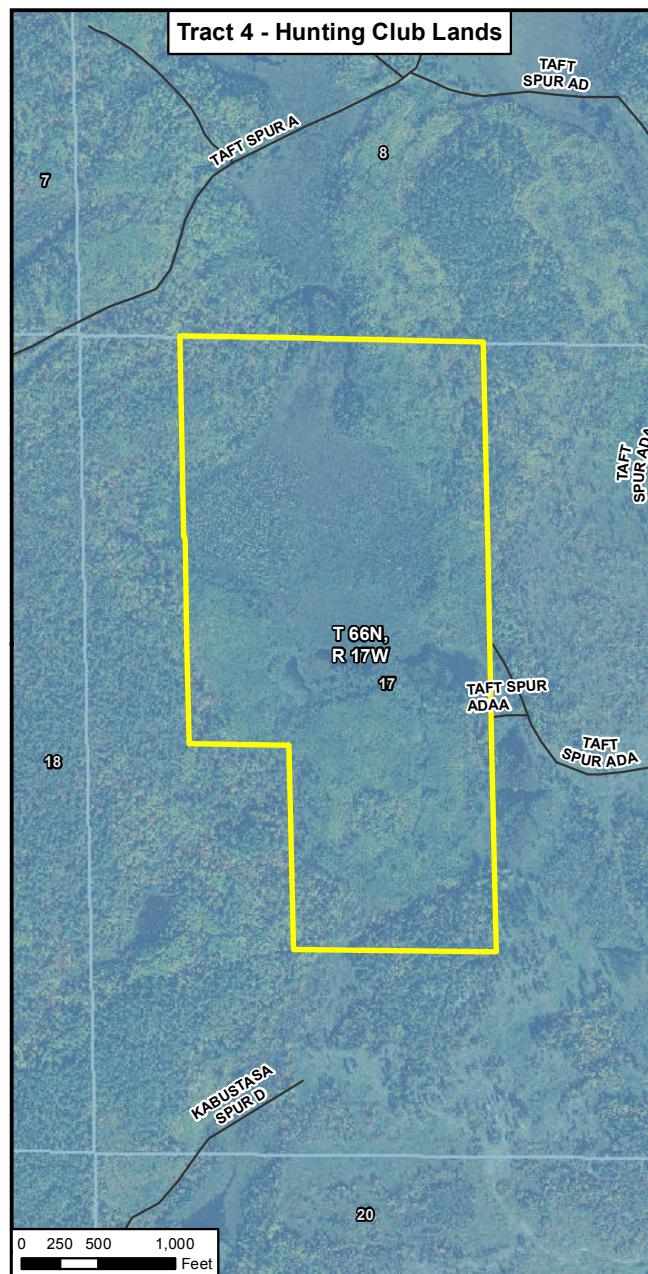
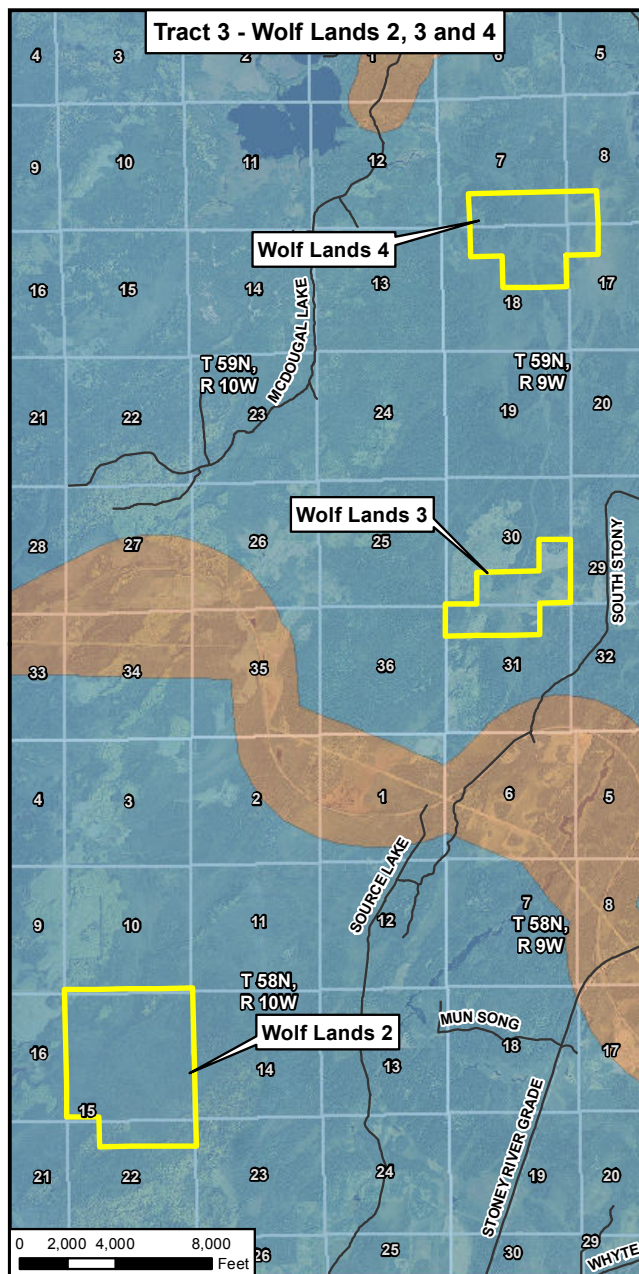


- | | |
|--|------------------------------|
| Non-federal Lands | Semi-Primitive Non-motorized |
| Section Boundary | Primitive |
| Section Label | Roaded Natural |
| Recreation Opportunity Spectrum | |
| Semi-Primitive Motorized | Rural |
| Urban | |



Figure 5.3.11-2
Recreation Opportunity Spectrum
Tracts 1, 2 and 3
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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- | | |
|--|------------------------------|
| Non-federal Lands | Semi-Primitive Non-motorized |
| Section Boundary | Primitive |
| Section Label | Roaded Natural |
| Recreation Opportunity Spectrum | |
| Semi-Primitive Motorized | Rural |
| Urban | |



Figure 5.3.11-3
Recreation Opportunity Spectrum
Tracts 3, 4 and 5
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

November 2013

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Table 5.3.11-3 Recreation Opportunity Spectrum Classifications of Federal and Non-Federal Lands (Land Exchange Proposed Action)

Parcel	Acres of ROS Class			Total
	Semi-Primitive Motorized	Semi-Primitive Non-Motorized	Roaded Natural	
Lands Conveyed				
Federal lands	5,528.4	0.0	967.0	6,495.4
Lands Acquired				
Tract 1 - Hay Lake	1,303.8	2,162.2	1,460.3	4,926.3
Tract 2 - Lake County North	265.0	0.0	0.0	265.0
Tract 2 - Lake County South	0.0	116.9	0.0	116.9
Tract 3 - Wolf Lands 1	106.1	0.0	19.7	125.8
Tract 3 - Wolf Lands 2	767.9	0.0	0.0	767.9
Tract 3 - Wolf Lands 3	277.4	0.0	0.0	277.4
Tract 3 - Wolf Lands 4	404.7	0.0	0.0	404.7
Tract 4 - Hunting Club	160.2	0.0	0.0	160.2
Tract 5 – McFarland Lake	0.0	30.8	0.0	30.8
Subtotal: Non-federal Lands	3,285.1	2,319.9	1,480.0	7,075.0
Net Change				
Net Increase/(Decrease)	(2,243.3)	2,309.9	513.0	579.6

Source: Duffy and Ness, USFS, Pers. Comm., November 2011.

There is no public access to and no opportunity for recreational activity on the federal lands, and the federal lands would remain inaccessible after completion of the Land Exchange Proposed Action. By comparison, the non-federal lands would be accessible to varying degrees, and therefore could host recreational activities, as defined by their respective ROS class. Tract 1 is the most accessible and therefore has the greatest potential for public recreational use. Tract 5 would likely be accessible from adjacent Superior National Forest land and/or the lake itself, while Tract 4 is also accessible via road and trail. Tracts 2 and 3 would be more difficult to access.

As Table 5.3.11-3 shows, the Land Exchange Proposed Action would result in a net decrease to the federal estate of 2,243.3 acres of land designated Semi-Primitive Motorized, an increase to the federal estate of 2,309.9 acres of land designated Semi-Primitive Non-Motorized, and an increase to the federal estate of 513.0 acres of Roaded Natural land. Although there would be a decrease of Semi-Primitive Motorized land to the federal estate, the Land Exchange Proposed Action overall would affect less than one-quarter of one percent of the total area of the Superior National Forest (approximately 3 million acres), and the reduction to the federal estate of this ROS type would be exceeded by the increase to the federal estate in other ROS types.

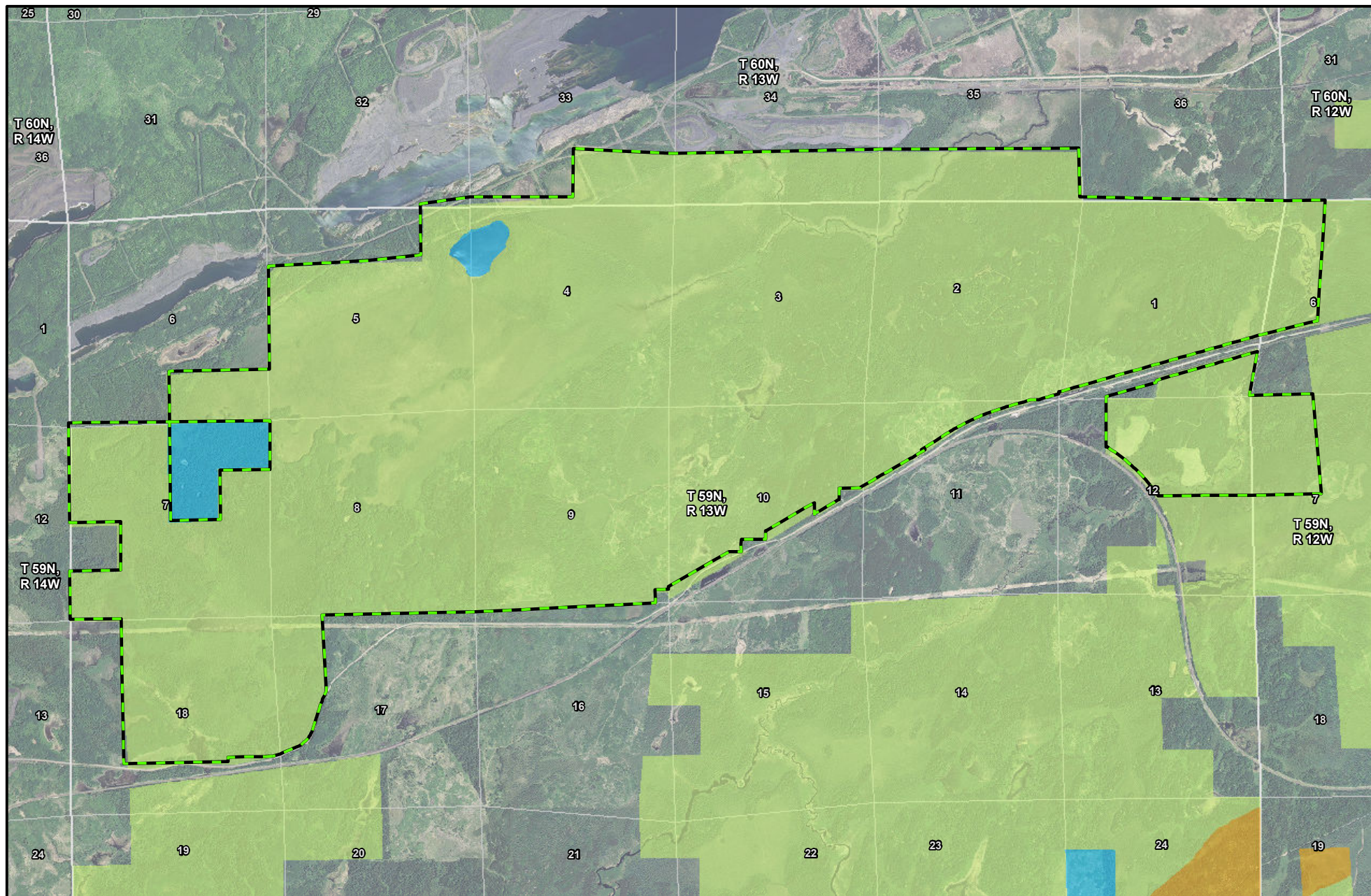
Because the federal lands are not accessible to the public, the Land Exchange Proposed Action represents an addition to the amount of potential publicly accessible land in the Superior National Forest. As a result, the Land Exchange Proposed Action would increase opportunities for hunting, fishing, and other recreational activities.

5.3.11.2.2 Visual Resources

SIOs for the federal lands are shown on Figure 5.3.11-4, while the SIOs that would be applied to the non-federal lands are shown in Figures 5.3.11-5 and 5.3.11-6. These are summarized in Table 5.3.11-4. The Low SIO of the federal lands indicates that the area may be dominated by management activities. Effects on visual resources on the federal lands are similar to those at the Mine Site, as discussed in Section 5.2.11.2.1.

The non-federal lands are only somewhat visible from public roads, few of which are elevated enough to afford views of the tracts themselves. Still, transfer of the non-federal lands to Superior National Forest ownership would generally help to preserve the scenic quality of those parcels. The NorthMet Project area would not be visible from any of the Land Exchange Proposed Action parcels.

The Land Exchange Proposed Action would result in a net decrease to the federal estate of 1,170.8 acres of land with a Low SIO and an increase to the federal estate of 136.3 acres of land with a High SIO and 1,644.6 acres of land with a Moderate SIO (see Table 5.3.11-4). This change in the composition of the visual character of the Superior National Forest, which affects less than one-quarter of one percent of the total area of the forest, has generally positive aspects. The addition of land with Moderate and High SIO (in lieu of land with a Low SIO) could affect the types of forestry and management activities that can occur on those lands. The USFS would acquire land with a wider diversity of SIOs (i.e., the addition of land with Moderate and High SIOs) and the Land Exchange Proposed Action would result in a net increase to the federal estate.



- Federal Lands**
- Federal Lands
 - Section Boundary
 - Section Label
- Scenic Integrity Objective**
- High
 - Moderate
 - Low
 - N/A



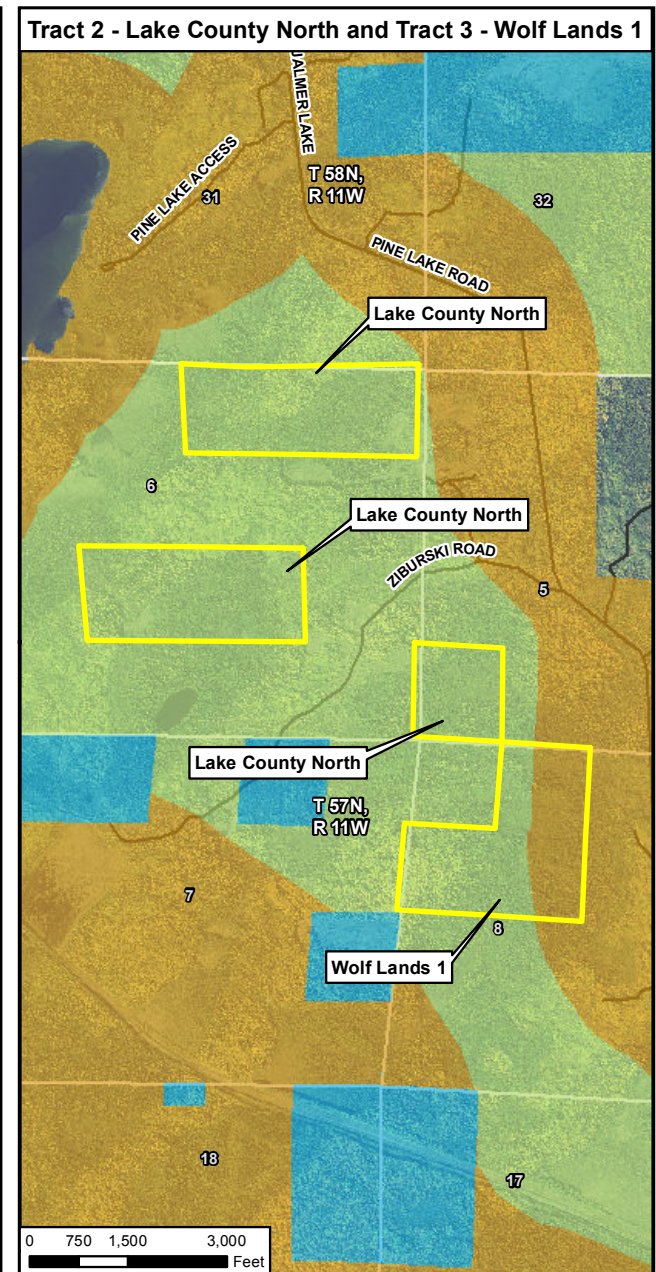
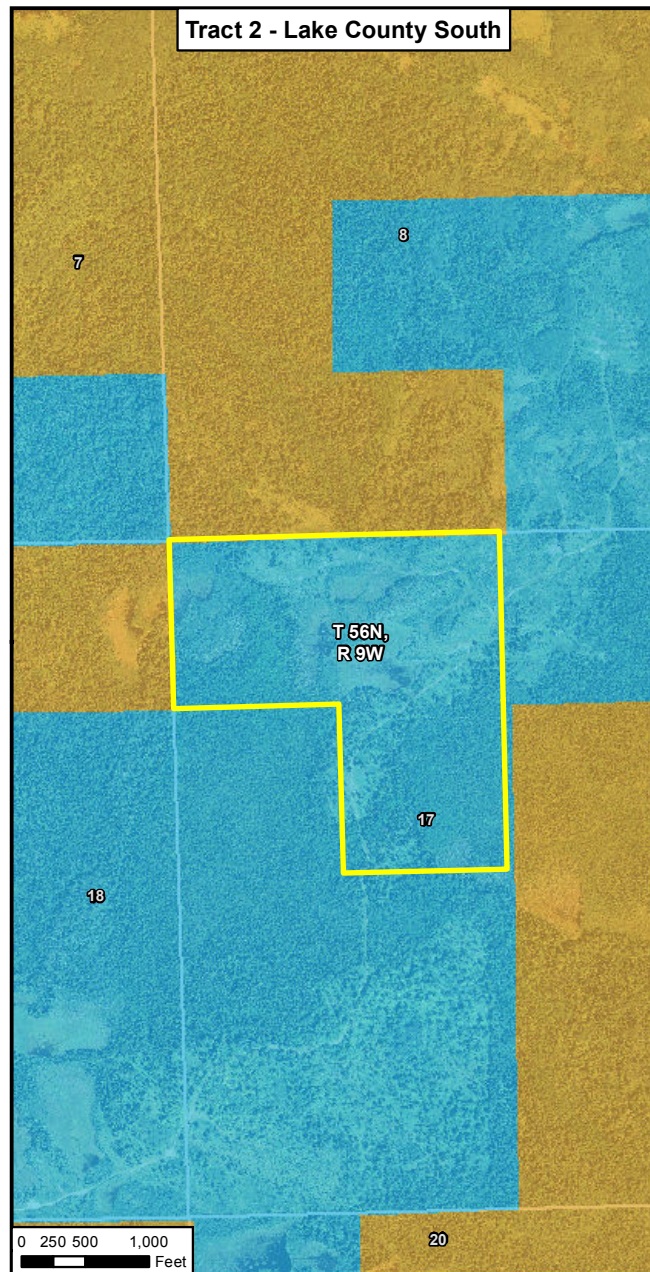
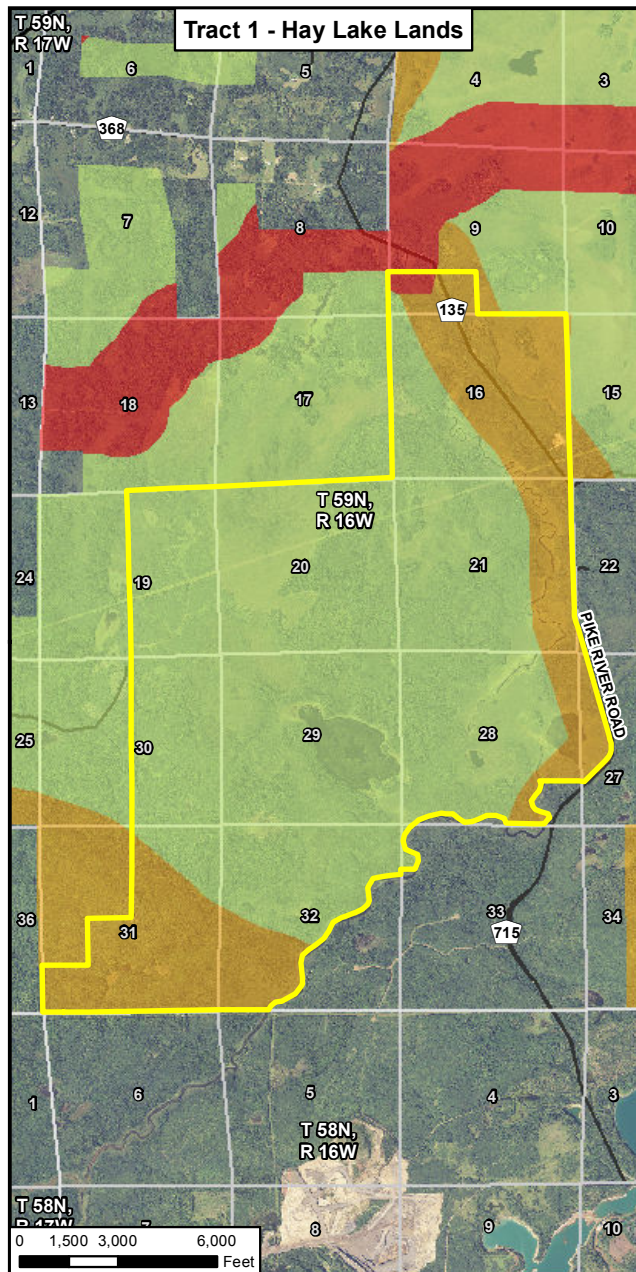
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Figure 5.3.11-4
Scenic Integrity Objective
Federal Lands
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

November 2013

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- Non-federal Lands**
- Scenic Integrity Objective**
- High
 - Moderate
 - Low
 - N/A
- Section Boundary**
- Section Label**



Figure 5.3.11-5
Scenic Integrity Objective
Tracts 1, 2 and 3
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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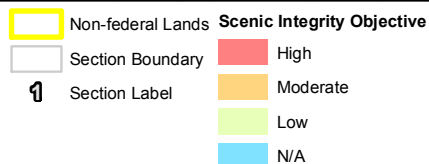
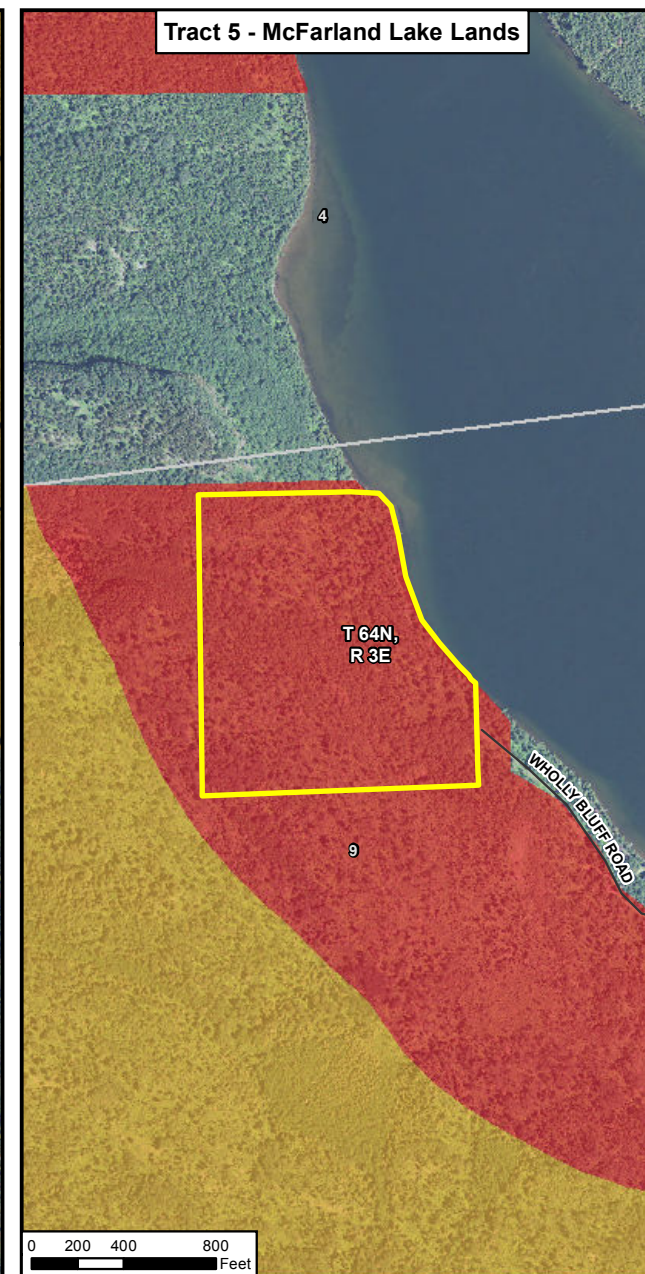
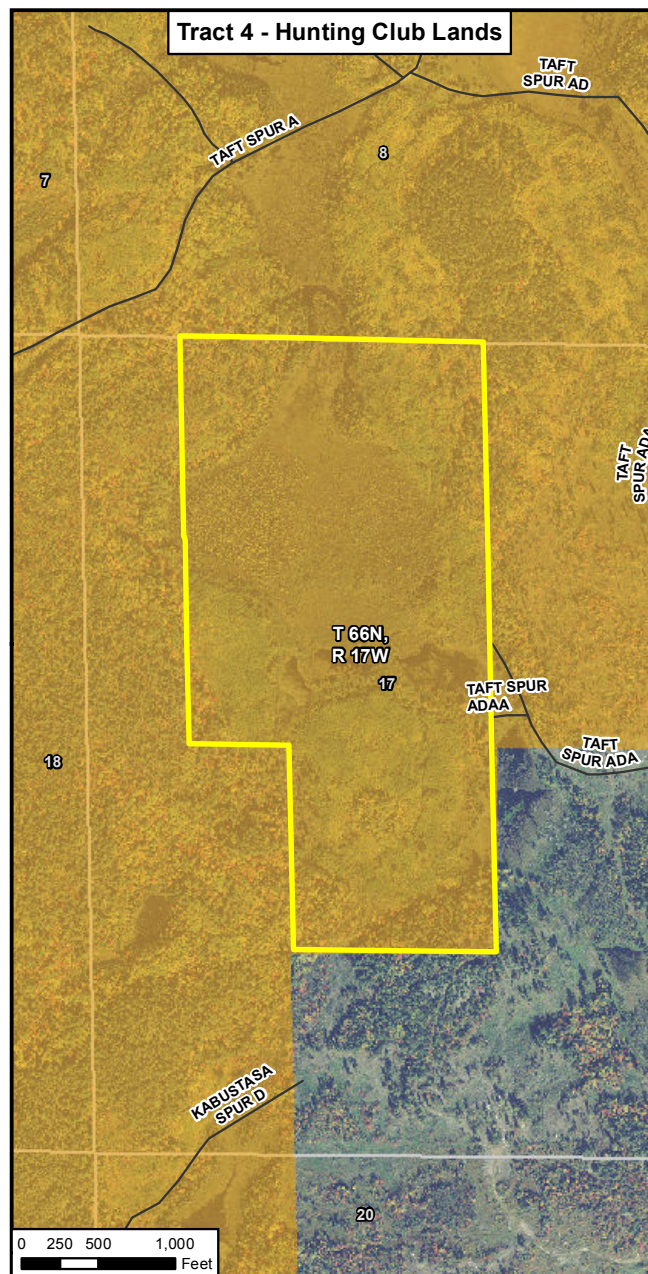
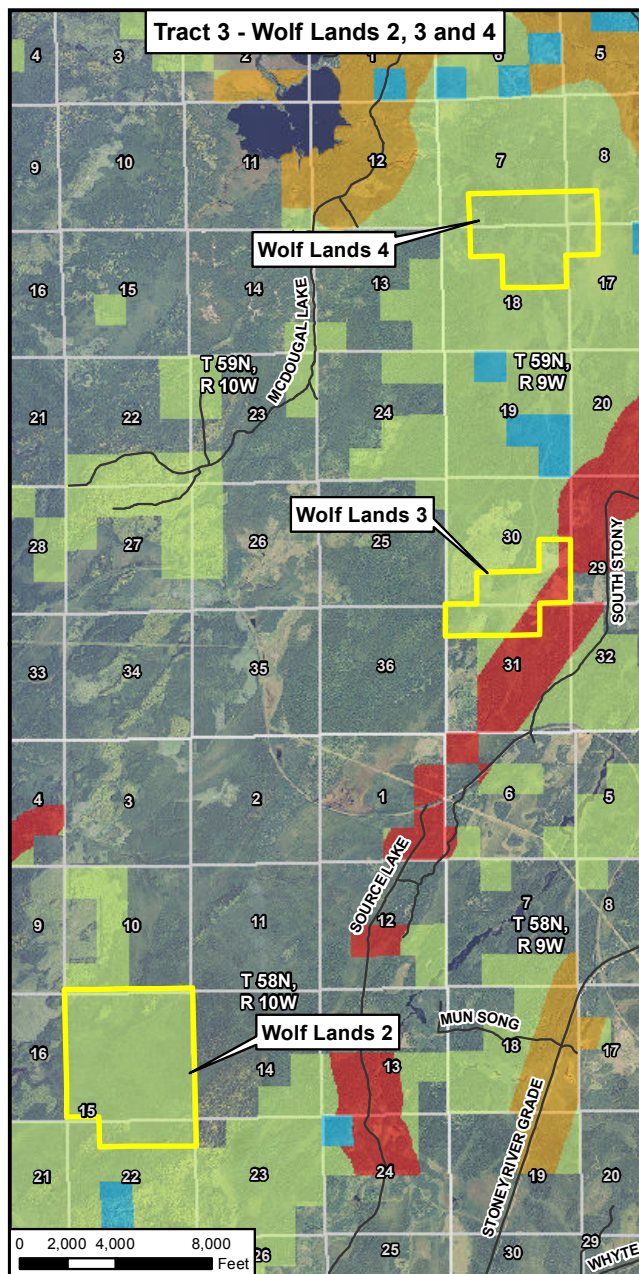


Figure 5.3.11-6
Scenic Integrity Objective
Tracts 3, 4 and 5
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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Table 5.3.11-4 Scenic Integrity Objectives of Federal and Non-Federal Lands (Proposed Action)

	Acres of Scenic Integrity Objective			
Parcel	High	Moderate	Low	Total
Lands Conveyed				
Federal lands	0.0	0.0	6,464.9 ⁽¹⁾	6,464.9 ⁽¹⁾
Lands Acquired				
Tract 1 - Hay Lake	20.4	1,315.4	3,590.5	4,926.3
Tract 2 - Lake County North	0.0	0.0	265.0	265.0
Tract 2 - Lake County South	0.0	116.9	0.0	116.9
Tract 3 - Wolf Lands 1	0.0	52.1	73.7	125.8
Tract 3 - Wolf Lands 2	0.0	0.0	767.9	767.9
Tract 3 - Wolf Lands 3	85.1	0.0	192.3	277.4
Tract 3 - Wolf Lands 4	0.0	0.0	404.7	404.7
Tract 4 - Hunting Club	0.0	160.2	0.0	160.2
Tract 5 – McFarland Lake	30.8	0.0	0.0	30.8
Subtotal: Non-federal Lands	136.3	1,644.6	5294.1	7,075.0
Net Change				
Net Increase/(Decrease)	136.3	1,644.6	(1,170.8)	610.1

Source: Duffy and Ness, USFS, Pers. Comm., November 2011.

¹ Mud Lake (comprising 30.5 acres of the 6,495.4 acres in the federal lands) would not be managed by USFS, and therefore does not have a SIO.

5.3.11.3 Land Exchange Alternative B

5.3.11.3.1 Recreation

Under the Land Exchange Alternative B, 4,752.6 acres of federal lands would be exchanged for the 4,926.3-acre Tract 1. ROS classes for the federal lands portion of the Land Exchange Alternative B are shown on Figure 5.3.11-7 (Tract 1 classes would remain unchanged from the Land Exchange Proposed Action). Table 5.3.11-5 summarizes the ROS classes of these lands.

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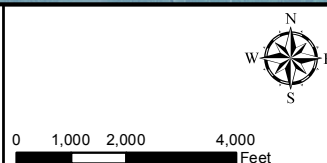
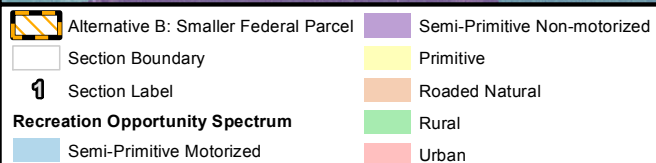
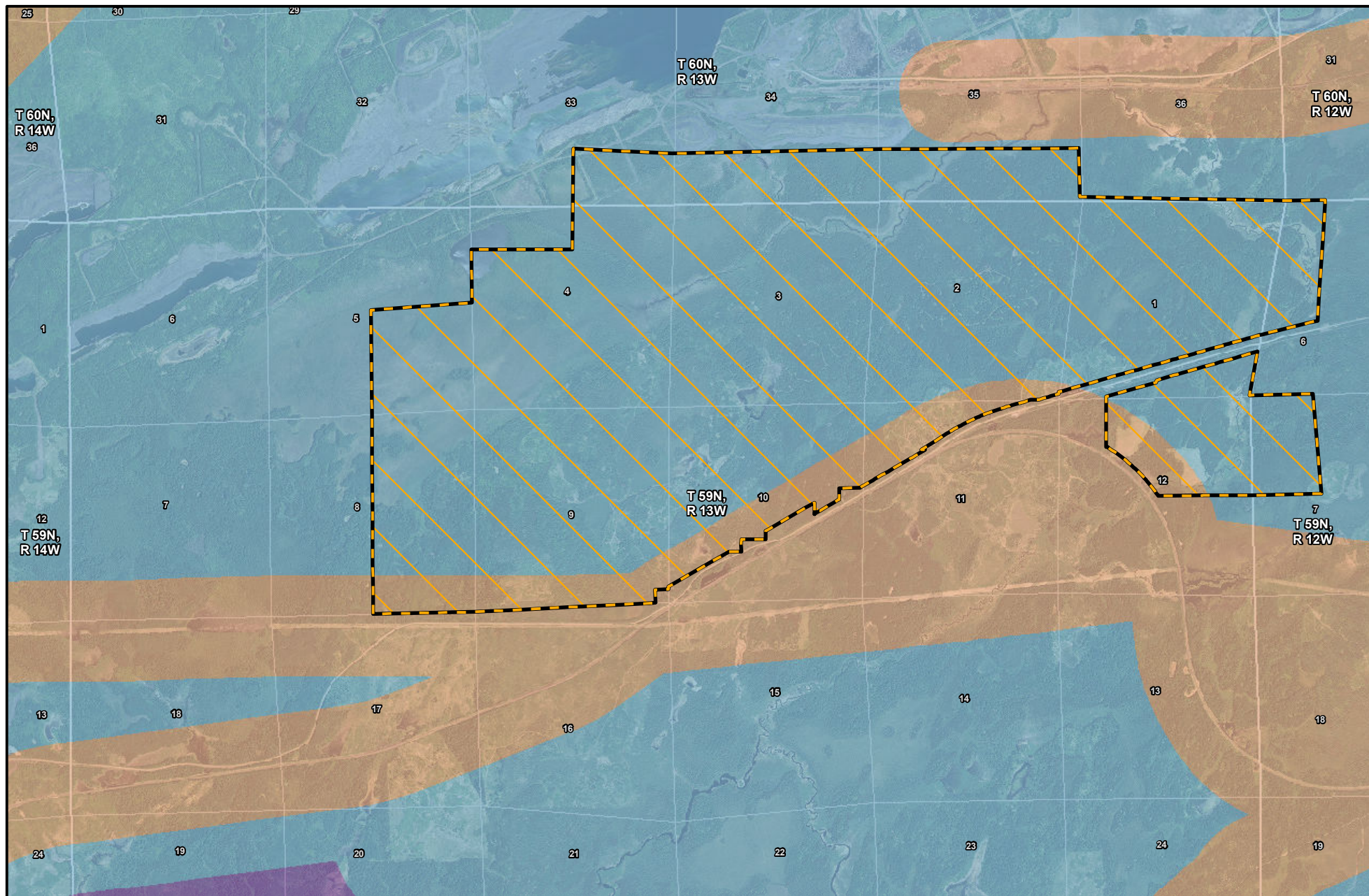


Figure 5.3.11-7
Recreation Opportunity Spectrum
Alternative B: Smaller Federal Parcel
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

November 2013

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**Table 5.3.11-5 Recreation Opportunity Spectrum Class of Federal and Non-federal Lands
(Land Exchange Alternative B)**

Parcel	Acres of ROS Class			Total
	Semi-Primitive Motorized	Semi-Primitive Non-Motorized	Roaded Natural	
Lands Conveyed				
Alternative B	4,276.5	0.0	476.1	4,752.6
Lands Acquired				
Tract 1 - Hay Lake	1,303.8	2,162.2	1,460.3	4,926.3
Net Change				
Net Increase (Decrease)	(2,972.7)	2,162.2	984.2	173.7

Source: Duffy and Ness, USFS, Pers. Comm., November 2011.

Similar to the Land Exchange Proposed Action, there is no public access to and no opportunity for recreational activity on the federal lands, and the smaller federal parcel would remain inaccessible after completion of the Land Exchange Alternative B. By comparison, the non-federal lands (Tract 1) would be accessible (to varying degrees), and therefore would be capable of hosting recreational activities, as defined by their respective ROS classes. Tract 1 is accessible and therefore would result in the greatest potential for public recreational use.

As Table 5.3.11-5 shows, the Land Exchange Alternative B would result in a net decrease to the federal estate of 2,972.7 acres of land designated as Semi-Primitive Motorized, which would be offset by an increase to the federal estate of 2,162.2 acres of Semi-Primitive Non-Motorized land and 984.2 acres of Roaded Natural land. Although there would be a decrease of Semi-Primitive Motorized land, the Land Exchange Alternative B overall would affect less than one-quarter of one percent of the total area of the Superior National Forest, and the reduction to the federal estate of this ROS class would be exceeded by the increase to the federal estate in other ROS classes.

As with the Land Exchange Proposed Action, because the federal lands are not accessible to the public, the Land Exchange Alternative B represents an addition to the amount of potential publicly accessible land in the Superior National Forest. As a result, the Land Exchange Alternative B would increase opportunities for hunting, fishing, and other recreational activities. Overall, the effects of the Land Exchange Alternative B on recreation are similar to those of the Land Exchange Proposed Action, but smaller in magnitude, due to the reduced amount of land involved.

5.3.11.3.2 Visual Resources

SIO classifications for the smaller federal parcel are shown on Figure 5.3.11-8 (Tract 1 classifications would remain unchanged from the Land Exchange Proposed Action) and are summarized in Table 5.3.11-6. As with the Land Exchange Proposed Action, the Land Exchange Alternative B has a Low SIO, indicating the lands may be dominated by management activities; however, Tract 1 would only be somewhat visible from public roads and would generally help to preserve the scenic quality of the parcel. The NorthMet Project area would not be visible from Tract 1.

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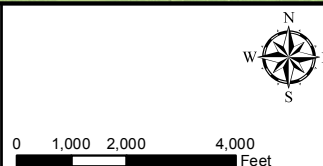
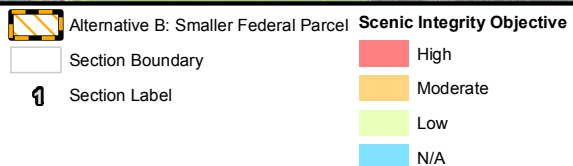
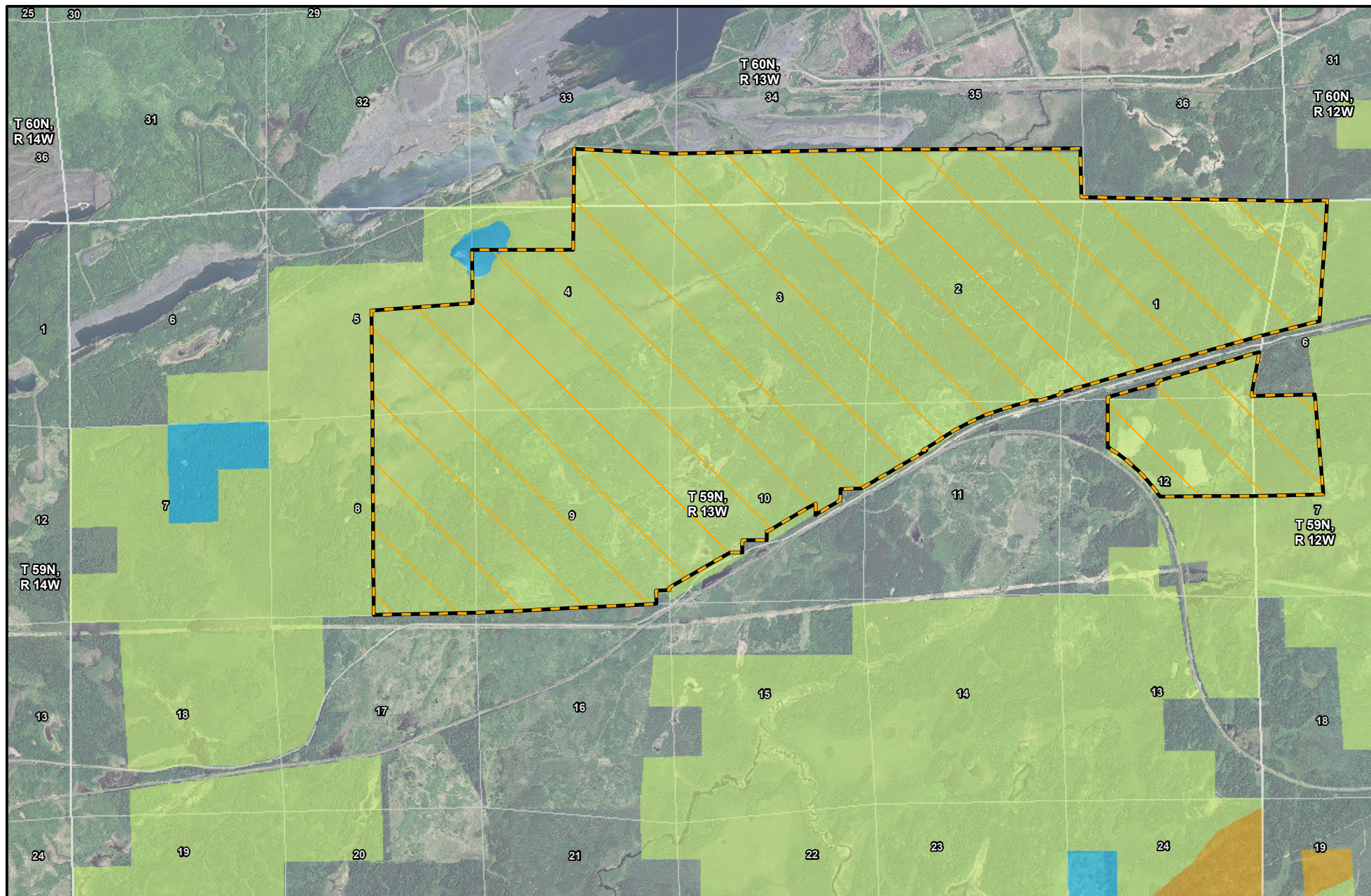


Figure 5.3.11-8
Scenic Integrity Objective
Alternative B: Smaller Federal Parcel
 NorthMet Mining Project and Land Exchange SDEIS
 Minnesota

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The Land Exchange Alternative B would result in a net decrease to the federal estate of 1,153.2 acres of land with a Low SIO, in exchange for an increase to the federal estate of 20.4 acres of land with a High SIO and 1,153.2 acres of land with a Moderate SIO. This change in the composition of the visual character of the Superior National Forest, which affects less than one-tenth of one percent of the total area of the Superior National Forest, has generally positive aspects. The addition of land with Moderate and High SIOs (in lieu of land with a Low SIO) could affect the types of forestry and management activities that can occur on those lands. The USFS would acquire land with a wider diversity of SIOs and the Land Exchange Alternative B would result in a net increase to the federal estate, although less than in the Land Exchange Proposed Action.

Table 5.3.11-6 Scenic Integrity Objectives of Federal and Non-federal Lands (Land Exchange Alternative B)

Parcel	Acres of Scenic Integrity Objective Classification			
	High	Moderate	Low	Total
Lands Conveyed				
Alternative B	0	0	4,743.7 ⁽¹⁾	4,743.7 ⁽¹⁾
Lands Acquired				
Tract 1 - Hay Lake	20.4	1,315.4	3,590.5	4,926.3
Net Change				
Net Increase (Decrease)	20.4	1,315.4	(1,153.2)	182.6

Source: Duffy and Ness, USFS, Pers. Comm., November 2011.

¹ Mud Lake (comprising 8.9 acres of the 4,752.6 acres in the smaller federal parcel), would not be managed by USFS, and therefore does not have a SIO.

5.3.11.4 Land Exchange No Action Alternative

5.3.11.4.1 Recreation

Under the Land Exchange No Action Alternative, the federal and non-federal lands would remain generally inaccessible to the public for recreation or other uses.

5.3.11.4.2 Visual Resources

Under the Land Exchange No Action Alternative, the visual appearance of the federal and non-federal lands would remain unchanged.

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5.3.12 Wilderness and Other Special Designation Areas

This section describes the potential environmental consequences of the Land Exchange Proposed Action on wilderness and other special designation area resources that are on or near the federal and non-federal lands.

The Land Exchange Proposed Action would not result in a net increase or decrease in any wilderness areas. However, the Land Exchange Proposed Action would result in a net increase of 306.9 acres of cRNAs to the federal estate. Land Exchange Alternative B would result in the same net changes as the Land Exchange Proposed Action.

The Land Exchange No Action Alternative would not affect wilderness or special-designation areas as the Land Exchange would not occur.

5.3.12.1 Methodology and Evaluation Criteria

An evaluation was conducted to determine the potential effect that the Land Exchange Proposed Action would have on the wilderness character of the area. Potential effects on noise, water resources, and recreation and visual resources were evaluated. The analysis of the wilderness character affected by the Land Exchange Proposed Action was guided by evaluation criteria that were developed by the USFS and other Co-lead Agencies.

Estimated ambient noise levels at each of the sensitive receptor sites adjacent to the federal lands were compared with modeled noise levels to determine effects. An appropriate noise propagation model was used to generate noise contours from the Mine Site and Plant Site. To determine effects on water resources, in addition to available information from field efforts already performed by PolyMet for the NorthMet Project Proposed Action, analysis of air photos and available GIS layers for federal and non-federal lands included data layers and other collected data such as NWI maps, soil maps/ecological land type maps, and FEMA floodplain maps. Scenic quality and integrity of lands being acquired and conveyed was determined based on desktop study and limited field observations where necessary. The Forest Plan uses a nationally recognized classification system, the ROS, to describe different recreation settings, opportunities, and experiences. Reviewing existing information and consultation with area land managers provided the information needed to understand the existing and potential recreation opportunities.

5.3.12.2 Land Exchange Proposed Action

The Land Exchange Proposed Action would result in a net increase of cRNAs to the federal estate. As indicated in Section 5.3.1, the USFS has determined that Tract 1 would have the following management area designations: General Forest and cRNA. Therefore, the Land Exchange Proposed Action would include the Pike Mountain and Loka Lake cRNAs (southwest corner and northeast corner of the tract, respectively). The addition of Tract 1 into the federally managed areas would extend the Pike Mountain cRNA by 135.7 acres of primarily hardwoods plant community, and would extend the Loka Lake cRNA by 171.2 acres of lowland black spruce and tamarack swamp. The remaining 4,619.3 acres would be allocated to General Forest.

Tracts 2, 3, 4, and 5 would not result in a net change to wilderness or other special designation areas.

5.3.12.3 Land Exchange Alternative B

The Land Exchange Alternative B would result in the same net increase of cRNAs to the federal estate as the Land Exchange Proposed Action. The Land Exchange Alternative B would not result in a net change to any wilderness area.

5.3.12.4 Land Exchange No Action Alternative

Under the Land Exchange No Action Alternative, the Superior National Forest would have an ongoing responsibility for managing the wilderness and other special designations on or near the federal lands in accordance with the Forest Plan. The Land Exchange No Action Alternative would not change the USFS's responsibility for managing these resources and would result in no further effects on existing wilderness areas or other special designated areas.

5.3.13 Hazardous Materials

The Land Exchange Proposed Action and the Land Exchange Alternative B would not include operations or activities that involve the use of hazardous materials on federal or non-federal lands beyond those activities specific to the NorthMet Project Proposed Action described in Section 5.2.13. AOCs associated with legacy contamination by hazardous materials from former activities and operations on these lands are discussed in Section 5.3.1.

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5.3.14 Geotechnical Stability

Geotechnical stability considerations for the proposed stockpiles that would be located on federal land subject to the Land Exchange Proposed Action or Land Exchange Alternative B within the NorthMet Project area are discussed in Section 5.2.14. There are no other existing or proposed large-scale waste material storage facilities on land subject to the Land Exchange Proposed Action or Land Exchange Alternative B.

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