Friends of the Boundary Waters Wilderness and Minnesota Center for Environmental Advocacy Comments on Application for Withdrawal and Segregation of Federal Lands; Cook, Lake, and St. Louis Counties, Minnesota

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About the Organizations

Friends of the Boundary Waters Wilderness ("Friends"), on behalf of itself and the Minnesota Center for Environmental Advocacy ("MCEA"), submits the following comments to the Bureau of Land Management ("BLM") regarding the U.S. Forest Service's Application for Withdrawal and Segregation of Federal Lands in Cook, Lake, and St. Louis Counties in Minnesota.

Friends is a nonprofit organization established over forty years ago for the purpose of protecting, preserving, and restoring the Boundary Waters Canoe Area Wilderness ("BWCAW" or "Wilderness") and the Quetico-Superior ecosystem. Our thousands of members and supporters, across Minnesota and the United States, have a profound and enduring interest in ensuring that actions proposed in and near the BWCAW protect the wilderness character and biological integrity of the Quetico-Superior ecosystem.

MCEA is a Minnesota nonprofit organization whose mission is to use the law, science, and research to preserve and protect Minnesota's natural resources, wildlife, and the health of its people. For nearly fifty years, MCEA has worked with citizens and government decision-makers to protect and improve the quality of Minnesota's environment, including work to address the threat of sulfide-ore mining in the state.

It is these missions that inform the following comments.

Experts who Contributed to this Report

Frederick K. Campbell has a B.A. in geology from Macalester College and an M.S. in geology from the University of Minnesota-Duluth. Mr. Campbell was a hydrologist at the Minnesota Pollution Control Agency for 29 years, working mainly on Superfund sites with groundwater and/or surface water contamination. Mr. Campbell was previously an economic geologist, working on mineral exploration projects in northern Minnesota and northern Wisconsin. He worked on the Teck copper-nickel deposit in the Duluth Complex, which was previously known as the Minnamax/Babbitt deposit.

Steven H. Emerman has a B.S. in mathematics from The Ohio State University, M.A. in geophysics from Princeton University, and Ph.D. in geophysics from Cornell University. Dr. Emerman was a professor of hydrology for 31 years, and has studied and worked in issues of hydrology and mining for over 40 years. Dr. Emerman has reviewed existing and proposed tailings storage facilities, including filtered tailings storage facilities, in North America, South America, Europe, Africa, Asia, and Oceania, and has testified on tailings storage facilities before the U.S. House of Representatives Subcommittee on Indigenous Peoples of the United States, the

United Nations Permanent Forum on Indigenous Issues, and the European Parliament. Dr. Emerman is one of the authors of Safety First: Guidelines for Responsible Mine Tailings Management and the Chair of the Body of Knowledge Subcommittee of the U.S. Society on Dams.

Bruce Johnson holds a BA in biology, chemistry minor, B.S. in secondary education from Winona State University, certified hazardous material manager, and 30 years of experience in water quality and waste management. Johnson served as the metal pathways field chemist for the Minnesota Regional Copper-Nickel Study, researcher with the U.S. Environmental Protection Agency, copper-nickel mining researcher with Minnesota Department of Natural Resources, team leader mining permit enforcement with Minnesota Pollution Control Agency, and supervisor of environmental compliance and research with Minnesota Department of Transportation. He has authored and co-authored a number of environmental research papers.

Amy Myrbo holds a B.A. in English and a Ph.D. in geology from the University of Minnesota (UMN). She worked for 23 years at UMN studying human impacts on lakes, wetlands, and wild rice waters, mainly in Minnesota, Wisconsin, and Montana, and is now an independent consultant and part-time scientist at the St. Croix Watershed Research Station, Science Museum of Minnesota. Dr. Myrbo was the UMN-Twin Cities principal investigator for the Minnesota Pollution Control Agency's study on the Sulfate Water Quality Standard to Protect Wild Rice, and has published several peer-reviewed papers on the results of that research.

Diana M. Papoulias has a B.A. in aquatic biology from Prescott College, M.N.S in zoology from Arizona State University, and Ph.D. in Fisheries and Wildlife from the University of Missouri. Dr. Papoulias was a research fish biologist for 25 years at the USGS Columbia Environmental Research Center where she studied the effects of contaminants on aquatic species. She currently works with the non-profit E-Tech International in South America as their aquatic toxicologist to assist indigenous and rural communities adversely impacted by extractive industries, particularly oil and mining.

Gerald J. Stahnke has a B.A. in biology from Hamline University and is an MPH candidate at the University of Minnesota in Water Hygiene. Mr. Stahnke was an Environmental Scientist at the Minnesota Pollution Control Agency for 38 years working primarily in the Superfund Program. Mr. Stahnke previously worked for 5 years as an Aquatic Biologist with Barr Engineering focusing on Mining operations and spent most of his time on the Teck copper-nickel deposit which was previously known as the Minnamax/Babbitt deposit.

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I. Introduction

The future of the BWCAW is currently under threat from proposed sulfide-ore mining in the Rainy River watershed. The U.S. Environmental Protection Agency ("EPA") has labeled heavy metals mining the most polluting industry in America as measured by chemical releases (EPA, 2019). Accordingly, heavy metals mining is prohibited within the borders of the BWCAW.

Nevertheless, Twin Metals Minnesota LLC ("TMM"), a wholly-owned subsidiary of the Chilean corporation Antofagasta Minerals, has proposed a sulfide-ore mine on the banks of Birch Lake, just upstream of the Wilderness boundary. If it were permitted, other mines in the watershed would likely follow. No precedent exists for a sulfide-ore mine that does not pollute; further, experts agree that tailings storage facilities built at these mining facilities will inevitably fail. Mine waste pollution upstream of the BWCAW would cause irreparable damage to waters, ecosystems, and human health.

Federal and state standards prohibit any degradation of the water quality in the BWCAW due to the exceptional value of this clean water. Preventing mining within the Wilderness borders, however, will not be sufficient to protect the BWCAW and its water quality if a sulfide-ore mine opens just upstream. To ensure that these federal and state standards are met, the protections afforded to the BWCAW must be extended to the waterways that flow into the Wilderness. Water flows according to nature and does not respect lines on a map defined by human beings. What happens upstream in the watersheds will happen to the downstream areas as well.

As will be shown herein, current federal and state mining regulations will not adequately protect the BWCAW from mining pollution in the catchments (watersheds) of waterways that flow into the Wilderness. As leaders in protecting the BWCAW and Minnesota's environment for over 40 years, Friends and MCEA strongly agree that National Forest System lands in the Rainy River watershed should be withdrawn from disposition under U.S. mineral and geothermal leasing laws to ensure that the BWCAW remains pollution-free for future generations.

The BWCAW is not located solely within the Rainy River watershed. A large portion of the protected Wilderness is located in the Northwestern Lake Superior watershed (see Fig. 1). Just as in the Rainy River watershed, these waters are "interconnected through the unique hydrology in the region," as described in the BLM Notice of Application for Withdrawal and Segregation of Federal Lands ("Notice"). And just as pollution in the Rainy River watershed would affect the parts of the BWCAW in that watershed, pollution in the Northwestern Lake Superior watershed would affect the parts of the BWCAW in *that* watershed. Therefore, we urge BLM to consider withdrawal of federal lands not only in the Rainy River Headwaters watershed but also in the Northwestern Lake Superior watershed (HUC 040101).

Additional analysis of the manifold threats of sulfide-ore mining to the ecological and social systems of the BWCAW and northern Minnesota can be found in the comments of the Friends and MCEA on the environmental review support documents submitted by Twin Metals Minnesota in December 2019 (Friends and MCEA, 2020).

II. Exceptional Wilderness Character and Clean Water of the BWCAW

The wilderness character and high-quality waters of the BWCAW are unmatched even within the extraordinary landscape of northern Minnesota. The Wilderness is largely roadless; motorized usage is restricted; the number of visitors is limited; and logging, mining, and dam construction are prohibited. Ecologically, the BWCAW is located within the boreal forest, a biome that stretches across North America, Europe, and Asia, and that provides vast carbon storage, mitigating the effects of climate change. The Wilderness is part of the Mississippi Flyway, a critical migration route for over 325 species of birds (USFWS, nd.) and some 60% of migrating birds in North America (MDNR, 2021). The wilderness character of the BWCAW thus contributes to global biodiversity and ecological resilience.

The BWCAW consists of more than one million acres and 1,100 lakes connected by an intricate network of rivers, streams, and portage trails. It is the most visited Wilderness Area in America, hosting more than 150,000 visitors each year. The BWCAW is thus a national resource – just as Wyoming has Yellowstone, and Arizona has the Grand Canyon, Minnesota has the BWCAW. Between the BWCAW and Lake Superior, northeastern Minnesota has become one of the premier clean water destinations in the world. The water of the BWCAW is still clean because of the protections provided by federal law.

The BWCAW became part of a National Wilderness Preservation System with the signing of the 1964 Wilderness Act. According to the Act, *wilderness* is "an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain" (PL 88-577). The intent of the Act was to establish wilderness areas that would remain undeveloped "for the use and enjoyment of the American people in such a manner as will leave them unimpaired for future use and enjoyment as wilderness."

President Carter signed the Boundary Waters Canoe Area Wilderness Act (PL 95-495) on October 21, 1978, adding acreage, establishing the adjacent Mining Protection Area, and amending the national Wilderness Act of 1964, in order to:

1) Protect and manage fish and wildlife "to enhance public enjoyment and appreciation of the unique biotic resources";
2) Protect and enhance the natural values and environmental quality of the lakes, streams, shorelines, and associated forest areas;
3) Maintain high water quality; and
4) Minimize, "to the maximum extent possible . . . the environmental impacts associated with mineral development."

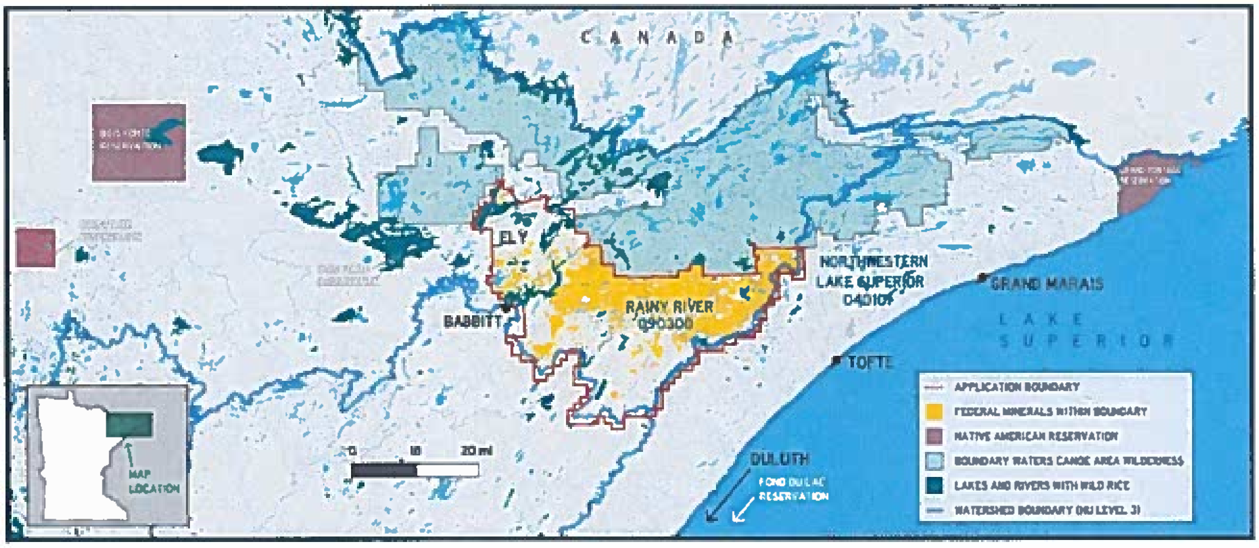

Figure 1. Map of northeastern Minnesota showing the proposed mineral withdrawal area, in close proximity to the Boundary Waters Canoe Area Wilderness (BWCAW). Water bodies shaded in dark green have verified populations of wild rice growing in them. Reservation lands of the Bois Forte Band of Lake Superior Chippewa and Grand Portage Band of Lake Superior Chippewa are shown; the Fond du Lac Band of Lake Superior Chippewa Reservation is off the map to the south. The entire area of Minnesota shown in this map is part of the 1854 Ceded Territory, within which these three Bands retain rights to hunt, fish, and gather. Note that the eastern part of the BWCAW lies within the Northwestern Lake Superior watershed.

According to the U.S. Department of Agriculture ("USDA"), the federal government's intent to protect the BWCAW's wilderness characteristics was the motivation behind the protections that the BWCAW currently receives as a federal Wilderness Area. To ensure that this irreplaceable Wilderness remains free from pollution as originally intended, the waterways that flow into the BWCAW and their associated watersheds, including the Rainy River and Northwestern Lake Superior watersheds, must also remain free from pollution. As described in the Notice, "[d]evelopment of sulfide-bearing mineral resources present in the withdrawal area could lead to permanently stored waste materials and other conditions upstream of the BWCAW and the MPA with the potential to generate and release effluent with elevated levels of acidity, metals, and other potential contaminants." To prevent heavy metal, sulfate, and acid pollution of these wilderness areas, sulfide-ore mining must be prohibited in these watersheds.

III. Sulfide-Ore Mining Poses an Extreme Threat to the BWCAW

The environmental danger posed by sulfide-ore mining in the Rainy River and Northwestern Lake Superior watersheds is acute because such mining exposes the fragile and vital ecosystems of the BWCAW to the threat of irreversible environmental harm. Acid mine drainage and metal leaching ("AMD/ML") could cause devastation through the discharge of toxic metals and sulfate pollution. Additionally, the potential release of other harmful materials through surface water, groundwater, and dust is a serious threat to surrounding ecosystems and human health.

Sulfide-ore mining has a long history of causing environmental degradation. This process produces sulfuric acid. In addition to acidifying lakes and rivers, sulfuric acid leaches out heavy metals such as mercury, lead, arsenic, and other toxins from rocks to produce AMD/ML. This type of mining is so problematic that there has never been a sulfide mine in the United States or Canada that has not contaminated surrounding water resources. In northeastern Minnesota itself, the Dunka Pit mine, where sulfide-rich Duluth Complex ores were excavated in the process of taconite iron-ore mining, water containing copper, nickel, other metals, sulfate, and salts greatly exceeding Minnesota water quality standards continue to discharge into previously fresh and clean water bodies (WaterLegacy, 2011; Lapakko and Olson, 2015; *Timberjay,* 2019).

In addition to AMD/ML, sulfide-ore mining utilizes myriad other chemicals and releases them into the environment, where they negatively affect water quality, plants, animals, and human health. Sulfate discharge to freshwaters unleashes a cascade of damaging ecosystem effects (Myrbo et al. 2017a and -b). Biologically active and undesirable metals present in the ore, including arsenic, cadmium, chromium, manganese, mercury, and nickel, could be released into the environment through tailings and wastewater. In addition, toxic beneficiation reagents (used in the metal extraction process), dust-control chemicals (sprayed on the land), and salt (used for de-icing roads) could all enter the clean soil and waters of the BWCAW downstream. Some of these chemicals degrade further into other toxic compounds. Finally, dust containing sulfur, heavy metals, and possibly asbestos minerals could be blown by the wind to areas near and distant from the mine, including the BWCAW.

The extreme threat to the Wilderness from sulfide-ore mining was confirmed by a 2016 U.S. Forest Service ("USFS") study that found that the risks associated with the proposed TMM mine were so great that USFS denied the project's permit application based on the best available scientific evidence (USDA, 2016). The risk of catastrophic pollution from TMM or other proposed sulfide-ore mines is far too great to be allowed upstream of the exceptional natural resources of the BWCAW.

A. History of Disaster

Sulfide-ore mining has a long history of pollution and disaster across the globe. The potential threat of catastrophe from these mines has been evidenced by horrific events, including the tailings dam collapse at Mount Polley, a copper and gold mine in British Columbia, Canada, that resulted in the discharge of around 24 million cubic meters of wet tailings (Larrauri and Lall, 2018) into Polley Lake, Hazeltine Creek and Quesnel Lake, causing significant degradation. The Mount Polley tragedy caused the loss of one of North America's premier salmon spawning habitats and destroyed local businesses that depended on the area's clean water.

Another example of the destruction caused by sulfide-ore mining is the Gold King mine in Colorado, where EPA remediation efforts inadvertently caused the release of at least three million gallons of toxic heavy-metal-laden water into rivers and groundwater used for human and animal drinking and agricultural irrigation, leading to disaster declarations in Colorado and New Mexico (Finley and McGhee, 2015) and significant economic losses for the Navajo Nation. The states of New Mexico and Utah filed suits alleging millions of dollars in damages. If such a catastrophic release occurred in northeastern Minnesota, it would be devastating to the surrounding water-rich environment, would violate tribal treaty rights, and could also have international consequences, because Canada's Quetico Provincial Park is downstream of the BWCAW within the Rainy River watershed.

Catastrophic releases of concentrated pollution, while dramatic, are only one of the means by which sulfide-ore mines contaminate. Chemical leaks and "smaller" spills are also highly likely to occur from sulfide-ore mining. A 2012 report analyzed 14 copper porphyry mines accounting for 89% of all U.S. copper production. The report found that 100% of those mines suffered spills and that 13 of the mines (92%) faced issues with water treatment systems not being adequate to handle the water contamination (Gestring, 2012). In one of the worst examples highlighted by the report, a spill from the Morenci copper-sulfide mine in Arizona polluted a tributary of the San Francisco River with 186,000 gallons of corrosive sulfuric-acid-based solution.

B. Designed to Contaminate

In the case of the proposed TMM mine, catastrophic release of mining wastewater is not just a theoretical possibility, it is a part of the design. Specifically, water used in processing, or that has contacted ore, waste rock, tailings or other mine materials, would be stored in surface ponds. This water would be untreated, since the TMM design does not include a water treatment plant. All of TMM's stormwater infrastructure is designed to accommodate a 100-year storm or 100-year snowpack. Thus, the probability of an uncontrolled overflow of stored wastewater is 1% in any given year.

The likelihood of TMM releasing wastewater during the 20-year proposed operation period of the mine is significant. Without factoring in the expected increase of extreme weather events as a result of climate change, the probability of a 100-year storm occurring at least once over 5 years, 10 years, and 25 years, is 4.9%, 9.6%, and 22.2%, respectively. In other words, the release of mine water, all of which will be untreated, should be expected. The Minnesota Department of Natural Resources ("MDNR") has not objected to TMM's proposed design, suggesting that the agency would also permit such a design for other sulfide-ore mines proposed in this exceptional and ecologically fragile region.

C. Inevitability of Failure of Tailings Storage Facilities

On its website, TMM touts the proposed "dry stack" tailings storage facility (which would actually contain 13-16% water and for which the standard terminology is "filtered tailings"; Ulrich and Coffin 2017) as a safe alternative to tailings basins: "Dry stacking filtered tailings means there is no need for a dam – dam failure is impossible . . . There's no need for a dam to hold them in place, no possibility of dam failure, and no long-term storage issues" (TMM nd.). Contrary to TMM's assertion, filtered tailings stacks do require an outer shell of compacted tailings (called the structural zone), which serves the same function as a dam (Klohn Krippen Berger 2017, Crystal et al., 2018). The failure and slumping of the Cachoeirinha filtered tailings stack onto a highway in January 2022, for which the Brazilian government fined the French mining company Vallourec the equivalent of $51.6 million (Reuters 2021), clearly demonstrates this method's long-term storage issues.

Typically, a tailings storage facility is expected to confine the toxic tailings in perpetuity, although normally the inspection and maintenance of the dam cease at some point after the end of the mining project. By comparison, a water-retention dam cannot simply be abandoned or it will eventually fail at an unpredictable time. For this reason, a water-retention dam must be completely dismantled at the end of its useful life, or when it is no longer possible to inspect and maintain it. In contrast, a tailings storage facility cannot be dismantled unless the tailings can be moved to another location, such as an abandoned open pit.

Such storage facilities inevitably fail. In a conference presentation, Dr. Steven Vick (the author of the only textbook on tailings dams [Vick 1990], and generally regarded as the world expert on the subject) concluded that "[s]ystem failure probabilities much less than 50/50 are unlikely to be achievable over performance periods greater than 100 years … system failure probability approaches 1.0 after several hundred years" (Vick 2014a). Vick (2014a) continued, "[f]or closure, system failure is inevitable … so closure risk depends solely on failure consequences." In the accompanying conference paper, Vick (2014b) elaborated:

> Regardless of the return period selected for design events, the cumulative failure probability will approach 1.0 for typical numbers of failure modes and durations.

This has major implications. For closure conditions, the likelihood component of risk becomes unimportant and only the consequence component matters. The two-dimensional matrices of Figures 3 and 5 collapse to one dimension. This counterintuitive result for closure differs so markedly from operating conditions that it bears repeating. In general, reducing failure likelihood during closure - through more stringent design criteria or otherwise - does not materially reduce risk, simply because there are too many opportunities for too many things to go wrong. In a statistical sense, all it can do is to push failure farther out in time. System failure must be accepted as inevitable, leaving reduction of failure consequences as the only effective strategy for risk reduction during closure. (Vick 2014b)

D. Northeastern Minnesota is Geologically Vulnerable to Both Pollution Creation and Pollution Migration

Several aspects of the geology of northeastern Minnesota would make sulfide-ore mining there particularly likely to cause severe environmental damage. First, the stratigraphy and mineralogy of the host rocks, the Duluth Complex, are highly heterogeneous over very short distances (Severson, 1994). The variability in metal and sulfide content, as well as in other associated elements and minerals, means that mining would encounter rapidly changing compositions over short distances (i.e., less than 10 feet). This in turn would prevent mining companies from effectively segregating highly reactive material from more benign waste rock. These differences in the product the mining companies would be processing over short periods of time, along with the overall low grade of the ores, could also require the companies to use more beneficiation chemicals (many of which are toxic), and use variable processing methods, making processing more expensive. This heterogeneity will also make it very difficult for TMM to control the water content of the filtered tailings, with consequences for the stability of tailings storage facilities.

Second, the climate of northeastern Minnesota is wet, and its abundant lakes, streams, rivers, and wetlands are intimately connected to both the shallow and deep groundwater. The abundance of precipitation, and the flow between these water bodies, make the area highly susceptible to pollution. Wetting and drying of tailings by rain, snow, and sun, and associated fluctuations in oxygen and pH in the fluids in contact with the tailings, increase leaching and dissolution. Once pollution is generated, the hydrological connections and flow between water bodies allow contaminants to be readily transported and spread. Accordingly, the Notice recognizes the "unique hydrology" of the region and the interconnected nature of the protected areas in northeastern Minnesota and adjoining parts of Canada.

Finally, bedrock faults (some with a displacement of 100 feet or more; Severson, 1994) and fractures are abundant in the areas of interest (i.e., the Birch Lake fault zone) and would act as conduits for the movement of groundwater and other fluids. Blasting in the course of mining could further displace and dilate these conduits. Connectivity between these faults is poorly understood: dye tests of water entering conduits are often unable to trace where that water "daylights" or exits. Faults and fractures are also associated with mineral alteration (e.g., serpentinized) zones. Several published articles (e.g., Miller et al., 2002) have concluded that some of the copper, nickel, and precious metal deposits in the Duluth Complex are present due to the leaching of metals by fluids that migrated along faults and re-deposited the metals in and near fault and fracture zones. Chloride-rich fluids are documented in the Duluth Complex (e.g. Dahlberg and Saini-Eidukat, 1991). Under certain conditions (e.g. high acidity), these fluids could leach and transport the metals that are concentrated in these fractures, which would thereby have an adverse impact on groundwater and surface water.

E. Generation and Release of Acid Mine Drainage

Most, if not all, sulfide-ore mining projects throughout the world have produced AMD/ML (Kuipers et al., 2006), and this would be no different in Minnesota. Even TMM, which has sometimes claimed that all AMD will be neutralized by the bedrock of northern Minnesota, concedes that: (1) some of the ore is potentially acid-generating (10% of the ore, according to TMM [2019b, lines 2623-2625]); and (2) the buffering capacity of the region's silicate rocks to neutralize the acidity of the AMD would last for only "decades" for "rock with low sulfur content" (TMM 2019b, lines 3502-3504).

Laboratory experiments (humidity cell testing) have been conducted on waste rock (Eger and Lapakko, 1980; Morin, 2000; Scharer, 2000; MDNR, 2004; Lapakko and Olson, 2015; Wenz, 2016) and tailings (Lapakko, 2003, 2013). Computer modeling of water quality is required to scale up these results to simulate field conditions and provide confidence that AMD/ML would not be produced (Maest et al., 2005). Additionally, the work of Hobart et al. (2018, 2020) on the microbial acceleration of sulfide mineral dissolution and acid generation in Duluth Complex rocks demonstrates the large knowledge gaps that still exist in our understanding of the potential for pollution from sulfide-ore mining in Minnesota.

The dangers of AMD/ML are not limited to its low pH: this waste material also carries high levels of toxic heavy metals and high concentrations of sulfate. The contention that AMD/ML can be "neutralized" either naturally (by the bedrock) or artificially (by adding limestone or other materials to raise the pH of the wastewater) does not take into consideration either heavy metals or sulfate. Even if the acidity of the AMD/ML were completely neutralized, sulfide-ore mining would still discharge mine wastewater contaminated with toxic heavy metals and dissolved sulfate into clean, oligotrophic, low-sulfate lakes, rivers, wetlands, and groundwater-surface water systems.

The findings of Kuipers et al. (2006), that Environmental Impact Statements usually greatly underestimate water quality degradation from mining, are a sobering reminder that we should err on the side of caution when permitting polluting activities in sensitive environments. Based on both the history of sulfide-ore mining and the lack of evidence that the acidity and other damaging consequences of AMD/ML could be controlled in this wet region, any sulfide-ore mine in the Rainy River watershed should be expected to produce AMD/ML that will flow downstream into the BWCAW.

F. Dangers of Sulfate Pollution: Wild Rice Extirpation, Eutrophication, Mercury, Methylmercury

Sulfate contamination of aquatic ecosystems presents three distinct and substantial dangers to environmental and human health (Figure 2): (1) sulfate harms wild rice (*Zizania palustris*) and other rooted aquatic plants (Pastor et al., 2017; Myrbo et al., 2017a and references therein) because sulfate is converted to toxic sulfide in the mud of the plant rooting zone; (2) sulfate addition causes the soils of lake beds, wetlands, and riverbeds to release inorganic mercury, as well as nitrogen, phosphorus, and dissolved inorganic and organic carbon, which individually and collectively can have significant and undesirable effects on algae growth, water clarity, and pH (Gilmour et al., 2007; Myrbo et al. 2017b); and (3) sulfate enhances the growth of existing microbes that make methylmercury, the highly toxic form of mercury that accumulates in fish and other life forms (Gilmour et al., 1992; Myrbo et al., 2017b).

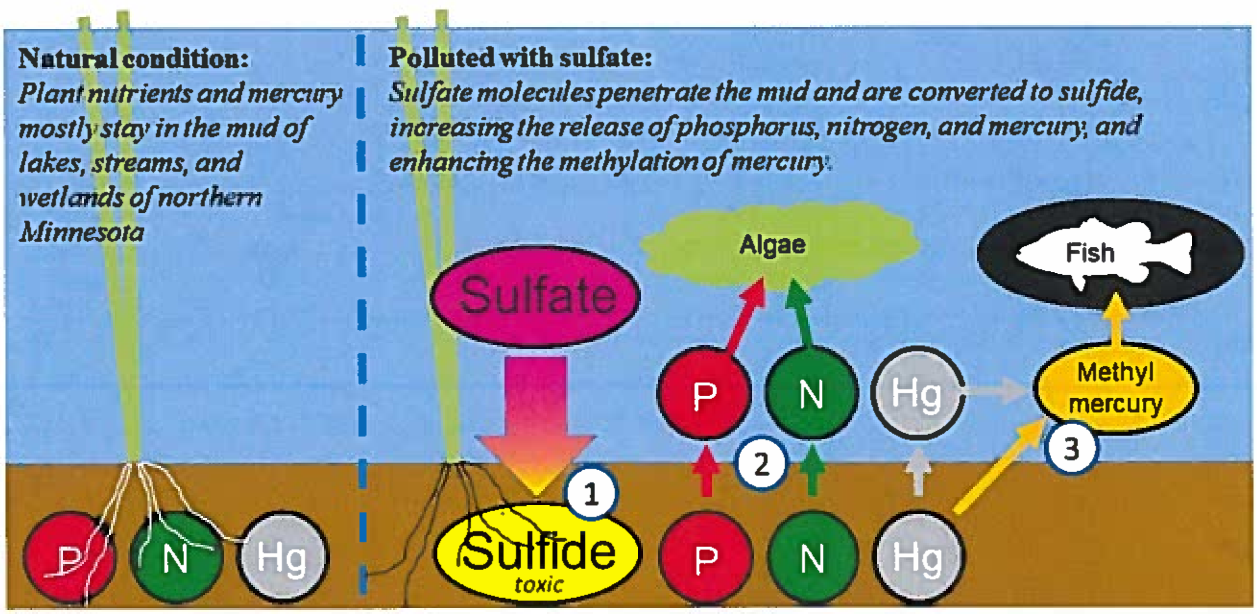

Figure 2. Effects of sulfate pollution of northern Minnesota waters. Sulfate pollution would increase eutrophication and mercury bioavailability (ability for mercury to get into food webs) in the low-sulfate systems of northern Minnesota, and could wipe out entire populations of rooted aquatic plants. (1) The sulfate is changed to toxic sulfide in the mud, and can poison aquatic plants (including wild rice) through the roots. (2) Sulfate pollution enhances the decomposition of organic matter in mud, releasing the constituents that would have stayed buried. Phosphorus (P) and nitrogen (N) are released into the overlying water, feeding more

algae growth, which decreases water clarity. (3) Sulfate pollution not only releases mercury (Hg) from the mud, but additionally increases the conversion of mercury to methylmercury, the only form that contaminates fish.

Dangers (1) and (2) "may severely influence the plant species composition of freshwater wetlands" (Lamers et al., 1998) and thus could have disastrous effects on the biodiverse ecosystems of the BWCAW. Danger (2) could also lead to eutrophication (excess nutrient levels) and harmful algal blooms in these ecosystems. Danger (3) could lead to increased health threats from methylmercury. The combined effects of dangers (2) and (3) - release of mercury plus methylation of that mercury and other mercury deposited from the atmosphere - could dramatically increase methylmercury in not only fish, otters, eagles, and other fish-eating wildlife, but also, of course, the human consumers of fish from impacted waters. Current Minnesota fish consumption guidelines already advise that pregnant women, women who could become pregnant, and children under age 15 limit consumption of Minnesota-caught fish (bass, catfish, lake trout, northern pike, and walleye) to no more than one serving per month due to mercury contamination (MDH, 2020). Increasing sulfate discharge could significantly increase the mercury content in fish. Those who fish for subsistence, including Native Americans, would be dramatically affected, and their treaty rights to fish in the ceded territory violated. Higher mercury in fish in the BWCAW, where families often fish for their dinners, would be a serious danger.

Wild rice is Minnesota's state grain and is culturally highly significant to many Native Americans in the region. Usufructuary (hunting, fishing, gathering) rights under the 1854 Treaty between the Chippewa and the U.S. government would be violated by the degradation of wild rice waters by mining activities. In Minnesota, wild rice is protected by a rule limiting sulfate discharge to no more than 10 mg/l. For comparison, in a three-year field study by the MDNR, Duluth Complex tailings were processed using a similar beneficiation process as is proposed by PolyMet and TMM. The tailings were placed in a lined basin, and leachates from natural precipitation were collected for three years. During that time leachate sulfate concentrations averaged 1750 mg/l (MDNR, 2004). Extensive field research shows that, for about half the wild rice lakes in Minnesota, even levels of 10 mg/l sulfate would produce too much sulfide for wild rice to survive (MPCA, 2017; based on data in Myrbo et al., 2017a). Numerous sensitive wild rice waters lie in both the Rainy River and Northwest Lake Superior watersheds (see Figure 1 above), and those waters would be contaminated with sulfate from sulfide-ore mining, even if the acidity of the AMD/ML were neutralized.

There is currently no treatment for waste from sulfide-ore mining that will meet Minnesota's water quality standards. Sulfate salts are highly soluble, and the removal of dissolved sulfate from mining water is challenging and expensive, requiring reverse osmosis and/or multiple chemical treatments, which in turn creates the problem of disposal of the solid or liquid products removed, such as sulfate brines and precipitated minerals. The Minnesota Pollution Control

Agency ("MPCA") has already determined that treatment of mine wastewater with reverse osmosis is not feasible because of a lack of economically viable disposal options and problems associated with disposing of the filtered waste, resulting in a regulatory variance (MPCA, 2010).

G. Myriad Other Dangerous Chemical Pollutants

Mine operations, post-mine closure, and winter road de-icing would produce a number of environmental contaminants of potential concern. Minerals occurring along with ores can be toxic to humans and other species at very low concentrations either alone or as mixtures. And when the ores are crushed during the mining process, these minerals are reduced to a fine powder that exposes them to prolonged weathering and dissolution. Such minerals include arsenic, mercury, manganese, and fluoride. The ores themselves include the metals copper, nickel, cobalt, palladium, platinum, gold, silver, vanadium, and titanium as products or by-products. Mine water would contain dissolved or suspended constituents similar to those found in the ore body itself. In addition to the elements already listed, there may also be traces of aluminum, antimony, beryllium, cadmium, chromium, selenium, and zinc (USGS, 1973). Toxicity among these elements varies greatly, and effects often differ among terrestrial and aquatic species.

Mine operations can also be expected to directly or indirectly result in accidental or intentional releases of mine water with ammonia, chloride, nitrate, nitrite, silica, and sulfate. Such releases could have direct negative effects on aquatic biota and could affect the bioavailability of metals (their uptake by organisms). Beneficiation chemicals used during the process of separating the metals of interest would likely include calcium oxide, carbonates, carboxymethylcellulose, copper sulfate, dextrin starch glue, methyl isobutyl carbinol, phosphates, silicates, sodium diisobutyl dithiophosphinate, sodium isopropyl xanthates, sodium sulfite, sulfuric acid, and triethylenetetramine. Sodium xanthate and potassium xanthate have been identified as toxic to aquatic life at low levels and break down to carbon disulfide, which is also toxic (Alto, 1977; Lind, 1978). Road salt and dust suppression chemicals (e.g., lignosulfonates) would also contribute to potential environmental pollutants (Eastern Research Group, 2016; Herb et al., 2017). These chemicals, along with any reaction or degradation products, would be part of potential environmental leachate releases to unsaturated soils, groundwater, and surface water.

Pearson et al. (2019) detail the human health risks and costs of sulfide-ore mining near the BWCAW, concluding that "[t]he overall health and wellness of this region will very likely be negatively affected by SOCN [sulfide-ore copper-nickel] mining, and economic costs will predictably outweigh benefits." Among the numerous contaminants of concern, mercury and arsenic in particular have extremely toxic impacts on people. Mercury is a chemical of particular concern in northeastern Minnesota. Mercury endangers not only clean water as a whole, but also the health of the area's residents. The Minnesota Department of Health found that 1 in 10 babies born in Minnesota along the north shore of Lake Superior is born with unsafe, elevated mercury levels (MDH, 2012). These levels are likely to be increased by sulfide-ore mining.

H. Damage to the Ecosystems of Northeastern Minnesota

The waters of northeastern Minnesota are naturally very low in dissolved nutrients, sulfate, salts, hardness, and metals (Thingvold, 1979) and have low biological productivity (oligotrophic), mostly due to the thin soils and sparse anthropogenic (human-caused) impacts. Native species have evolved to live under these oligotrophic conditions, and therefore relatively slight changes to the water chemistry can be toxic to the species inhabiting these waters (Thingvold, 1979; Minn. R. 7050.0150, subp. 3; 7050.0222, subp. 4; Johnson and Johnson, 2015; Cormier, 2016). For example, because natural sulfate concentrations are very low (below 5 mg/l and mainly below 1 mg/l; Myrbo et al., 2017a, Fig. 1), "ecologically significant changes may occur even when SO_4 [sulfate] concentrations are elevated only modestly" (Myrbo et al., 2017b).

Chemical constituent releases from sulfide-ore mines globally, both historic and contemporary, have had and continue to have adverse effects on fish and wildlife abundance and health (Alpers et al., 1992; Gray, 1998; Lin et al., 2007; Powell, 2017). These include acute or chronic effects on terrestrial and aquatic species from exposure to the potential toxins released in mining operations, habitat loss, habitat fragmentation, displacement, mortality, and the effects of noise and lights. The terrestrial and aquatic wildlife (including aquatic invertebrates), plants, and habitats at risk include not only the many threatened and endangered species in the region, but also many resident, transient, and migratory species, including birds migrating along the Mississippi Flyway. The Flyway is just one of the ways northern Minnesota's unique ecosystems contribute to global environmental health and conservation.

A wide diversity of fish is found in the BWCAW providing important recreational fishing opportunities. An extreme release of contaminated mine waters would likely have an immediate lethal effect on stream aquatic species and littoral lake species. The toxicity of dissolved metals to invertebrates and fish would be relatively high in the waters of northeastern Minnesota, due to the low natural hardness of those waters (e.g. Pyle et al., 2002; Borgmann et al., 2005). Indeed, MPCA standards for copper, nickel, chromium, and cadmium are hardness-dependent (Minn. R. 7050.0222). Contaminants that do not degrade or enter the trophic cycle will eventually fall to the bottom as sediment. Lakes in northern Minnesota are mainly dimictic, i.e., their surface and deep waters mix in spring and fall each year. This process re-suspends sediment, metals, and other contaminants into the water column (Sarmiento et al., 2008). Therefore, an extreme release event can have adverse consequences on lake biota for many years into the future, as is seen in lakes that have received acute spills of mine waste such as the previously pristine Quesnel Lake in British Columbia, described above (Hamilton et al., 2020).

The BWCAW is located within the boreal forest. Found across the northern latitudes of Europe, Asia, and North America, boreal forests provide carbon storage and clean water. In addition, boreal forests are home to large and varied wildlife populations and large unlogged areas which, due to their biodiversity, may be more resilient to the impacts of climate change than disturbed areas. In addition to its value as an ecosystem, the boreal forest is iconic of northern Minnesota. As described in detail by Frelich (2019), the impact of sulfide-ore mining on the surrounding boreal forest would be felt most directly on the mining site. Destruction of forest, plant life, and habitat within and along the mining facilities would interrupt historic wildlife migration patterns, and cause fragmentation of the forest, which has additional deleterious effects, such as higher temperatures and increased vulnerability to invasive species. Fragmentation effects can be expected to last for decades after the mining operation ends.

Some amounts of both the imported chemicals and the released chemicals would migrate (via surface water, groundwater, or air-borne dust) to the surrounding forest areas. Given the close relationship between a boreal forest and its supporting water system, any negative impact on the water would result in negative impacts in the surrounding forest.

Streams, wetlands, and lakeshores produce a vast array of aquatic-terrestrial interfaces. The boreal forest in northeastern Minnesota is best understood as a thin membrane of soil and the organisms it supports lying on top of bedrock with water flowing through a vast network of tree and plant roots. Changes to water flow and water table depth (caused by roads and culvert systems for the mining project) and water chemistry (also caused by mining) could upset the balance among the various vegetation types. Sulfide-ore mining contributes to anthropogenic climate change, which in turn affects precipitation regimes. Extreme rainfall events, which are expected in Minnesota with increasing frequency owing to the warming climate (MDNR 2022), could lead to large inputs of AMD/ML moving into swamp forests downstream from the plant site.

The BWCAW has become a resource for studying ecosystem processes. As such, it provides a baseline for understanding how adjacent areas are affected by logging, mining, roads, and other human activities. Future sulfide-ore mines in the region, by imperiling a range of conditions within the BWCAW, threaten the utility of BWCAW for use as a baseline against which to measure the effects of human activity across northeastern Minnesota and the greater boreal forest biome.

I. Damage to the Regional Economy of Northeastern Minnesota

A clean and healthy BWCAW is the backbone of northeastern Minnesota's thriving $100 million/year outdoor recreation economy. Thousands of Minnesota families support themselves every year with proceeds from this industry. Yet this clean water and outdoor recreation economy would be put under extreme threat if sulfide-ore mining were to be allowed in the watersheds. A Harvard economics study predicts only a very short (about five-year) economic benefit from the proposed TMM project. This benefit would be wiped out in a few more years, due to the effects of the mine's presence and its environmental damage, and the region would then be economically worse off than before (Stock and Bradt, 2020):

> Initially, mining is economically beneficial because of the new mining jobs, the income they produce, and their spillovers to the local economy. Over time, however, the net effect of the mining jobs erodes because of the growth of productivity in mining, the stagnation or decline of amenity-based in-migration, and the decline in wilderness-based recreation as a result of impacts of mining on the recreation industry. (Stock and Bradt 2020, p. 5)

IV. Precedents and Analogies for Protection of Watersheds of Protected Areas

Restricting activities in all or a portion of a watershed around a protected area is not a new concept. There are numerous examples of restrictions against mining on the edges of national parks. For example, in October 2018, then-Secretary of the Interior Ryan Zinke signed a 20-year mineral withdrawal protecting 30,000 acres north of Yellowstone from new mining claims, and in early 2019, Congress permanently protected these lands from mining (National Parks Conservation Association, 2022). Nearly all of the thousands of gateway communities on the edges of national parks restrict development in some way, including prohibiting mining, in order to protect both the national parks and the tourist and recreational economy that is based upon the national parks.

In fact, nearly every municipality in North America prohibits mining within its municipal boundaries and, in some states, municipalities have the right to establish watershed protection districts and to prohibit mining and other potentially polluting activities within those districts. For example, in the state of Colorado, cities have the power to restrict activities up to five miles above the point on the water source where the city collects drinking water.[1] Crested Butte is one of many communities that has taken advantage of the Colorado statute. According to the Town of Crested Butte (2022), "Construction activities within any waters in the Watershed Protection

[1] *See* Colo. Rev. Stat. § 31-15-707 (2020) ("The governing body of each municipality has the power . . . . (b) To construct or authorize the construction of such waterworks without their limits and, for the purpose of maintaining and protecting the same from injury and the water from pollution, their jurisdiction shall extend over the territory occupied by such works and all reservoirs, streams, trenches, pipes, and drains used in and necessary for the construction, maintenance, and operation of the same and over the stream or source from which the water is taken for five miles above the point from which it is taken and to enact all ordinances and regulations necessary to carry the power conferred in this paragraph (b) into effect . . . .").

District are prohibited except Town authorized streambank reinforcement or repair water diversion placement or repair or stream crossings." In South Dakota, there is an initiative to protect the entire watershed of Rapid Creek above Rapid City (Rapid Creek Watershed Action, 2022).

In some cases, regular zoning laws have been used to prohibit mining or other development within the watersheds of municipalities. For example, San Miguel County, Colorado, has established a High Country Zone District, in which new development is strictly prohibited in the upper basins outside towns, and which includes multiple watersheds in the protected area. This zoning district was specifically designed to protect the historic character of the land and to allow for traditional mining, while simultaneously making it impossible for a modern mine to develop. This distinction was made possible by prohibiting the building of new roads or the upgrading of existing roads within the entire zone district and by restricting any new building to a maximum size of 800 square feet, thus essentially restricting mining to whatever can be accomplished with burro and pickaxe (San Miguel County, 2021).

As a final analogy, there are many jurisdictions that have recognized "environmental personhood" or the "rights of nature." In some cases, the environmental feature for which rights have been recognized includes the entire watershed of the feature. For example, in 2019, voters in Toledo, Ohio, passed the Lake Erie Bill of Rights, which provides, in part:

> We the people of the City of Toledo declare that Lake Erie and the Lake Erie watershed comprise an ecosystem upon which millions of people and countless species depend for health, drinking water and survival. ... Lake Erie, and the Lake Erie watershed, possess the right to exist, flourish, and naturally evolve. The Lake Erie Ecosystem shall include all natural water features, communities of organisms, soil as well as terrestrial and aquatic sub ecosystems that are part of Lake Erie and its watershed.

(University of Toledo, 2019). A similar Great Lakes Bill of Rights is currently in committee in the New York State Assembly (New York State Senate, 2021). According to New York State Assembly Bill A3604A:

> The Great Lakes, and the watersheds that drain into the Great Lakes and their connecting channels, shall possess the unalienable and fundamental rights to exist, persist, flourish, naturally evolve, regenerate and be restored by culpable parties, free from human violations of these rights and encumbered by legal privileges vested in property, including corporate property. The Great Lakes ecosystem shall include all natural water features, communities of organisms, soil as well as terrestrial and aquatic sub ecosystems that are part of the Great Lakes and their watersheds and connecting channels ... the people of the state of New York, as well as the Great Lakes ecosystem, and the watersheds that drain into the Great

> Lakes and their connecting channels, shall possess a fundamental and unalienable right to the integrity of their bodies, ecosystems and physical aspects, and to be free from toxic trespass upon or within them; therefore, the right to be free from toxic trespass shall not be violated. (New York State Senate, 2021).

V. Protections Extended to the Northwestern Lake Superior Watershed

As mentioned above, a sizable portion of the BWCAW is located not in the Rainy River watershed, but in the Northwestern Lake Superior watershed (see Figure 1 above). Therefore, a sulfide-ore mine in the headwaters of the Northwestern Lake Superior watershed would also have the potential to degrade water quality in the BWCAW. To ensure the complete protection of the BWCAW, it is therefore critical that the protections be extended to all watersheds that are home to portions of the BWCAW.

VI. Conclusion

Withdrawing the federal lands from mineral development, as proposed by USFS, would protect the vital and fragile natural resources and wilderness in the BWCAW from the threat of sulfide mining, preserve treaty-protected resources including fish and wild rice that are critical to the culture and well-being of local Ojibwe tribes, and avoid public health risks from pollution of the region's air and waters. For all of the reasons stated above, Friends and MCEA urge the BLM to withdraw these lands from disposition under U.S. mineral and geothermal leasing laws for the proposed 20-year period.

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