Environmental Risk to the Boundary Waters Wilderness & Voyageurs National Park from Sulfide-Ore Copper Mining

Introduction

The natural beauty and quiet wilderness character of the Boundary Waters Canoe Area Wilderness (Boundary Waters or Wilderness) are under threat from sulfide-ore copper mines proposed within its watershed. While federal and state laws prohibit mining activities directly within the Boundary Waters and adjacent Mining Protection Area, the laws are not protective enough to limit impacts and encroachment from activities that occur outside of the wilderness boundaries. Northeastern Minnesotans for Wilderness has a number of scientific reports that show that sulfide-ore mining on lands adjacent to rivers and lakes that flow directly into the Boundary Waters and Voyageurs National Park (Voyageurs) would impact not only the surrounding waters and forest, but would also affect the Wilderness and Voyageurs themselves.

Scientific Support

Acid mine drainage (AMD) is produced by exposing sulfide minerals present in ore bodies and rock overburden to air and water. Oxidation and hydrolysis reactions turn otherwise benign minerals into toxic materials, including acid, metals (e.g., mercury, copper, nickel, lead, and zinc), and sulfates (Jennings et al. 2008). Acidic conditions further catalyze these reactions, making them proceed at faster rates than would otherwise occur (Jennings et al. 2008). AMD can affect fish populations and aquatic ecosystems both through direct toxicity and by indirect effects on the food chain and habitat availability. For instance, high acidity (low pH) can alter gill membranes and cause hypoxia among fish (Jennings et al. 2008), and pH below 6.5[1] can have negative effects on fish reproductive success (Jennings et al. 2008). Indirect effects to fish include direct toxicity to food sources (e.g., insects and other macroinvertebrates that live in streambeds), reduction of habitat, and coating of gravel beds used for spawning (Jennings et al. 2008). Episodes of acute toxicity can kill thousands of fish in rivers much larger than the South Kawishiwi River, where the Twin Metals Minnesota project is proposed. For example, a thunderstorm event in 1989 caused enough acidification and elevated copper concentrations within 20 minutes to kill over 5,000 salmonids in Montana's Clark Fork River (Jennings et al. 2008), a river with twice the annual flow as the South Kawishiwi River (MT DNRC 2004, USGS 2015).

Despite advances in the mining permitting process that require estimation of acidic mine drainage potential, the scientific protocols used to estimate acidic generating potential are uncertain at best. The Environmental Protection Agency standardized protocols for the entire US using techniques developed in

[1] A pH of 7 is considered neutral, as it is in the middle of the 0-14 logarithmic scale used to measure acidity (0 is most acidic, and 14 is most basic or alkaline).

sedimentary rock mined for coal in the eastern US, and it is unknown whether it is appropriate to apply those principles to igneous rock mined for minerals in the rest of the country (Jennings et al. 2008). Additionally, those techniques are called into question by research showing that 11% of 56 mines did not conform to the expected acid generating potential based on standard techniques (Jennings et al. 2008). In fact, four sites predicted to generate alkaline water (the opposite of acidic water) eventually produced acidic material (Jennings et al. 2008). Furthermore, sites predicted to have "no acid generating potential" often use short-term studies that do not consider the extended length of time material will be exposed to oxidizing conditions (Sherlock 1995). In one case, it took three years of continued kinetic testing of tailings in humidity cells for acid rock drainage conditions to manifest (Sherlock 1995). According to Jennings et al. (2008, p. 8):

> Recurrence of inaccurate interpretations between laboratory and field data has caused investigators to reexamine the adequacy of the analytical methods. Because of the challenges inherent in interpreting laboratory data and predictive models, forecasting future water quality impacts from AMD should not be considered routine and robust, rather they should be considered an area of uncertainty and on-going research.

Based on the technical documents submitted by Duluth Metals for the Twin Metals Minnesota project, their acidic generating potential prediction is based short time-frame assessments using the traditional techniques implicated by the Jennings et al. (2008) and Sherlock (1995). Claims by the mining companies that their mines carry low risk of acid generating potential thus carry a large degree of uncertainty and cannot be treated as fact.

Dr. Tom Myers, a professional hydrologist from Reno, Nevada, with extensive experience with sulfide-ore mining, found that waters that would receive contamination from proposed sulfide-ore copper mines are of extremely high quality and have very low buffering capacity (Myers 2013). The many streams, wetlands, lakes, and aquifers downstream of mine sites are massively interconnected, which would make it difficult to stop and contain contamination should it leak, spill, or seep from mine sites (Myers 2013). Dr. Myers also developed a numerical hydrogeologic model that evaluates contaminant transport mechanisms between the proposed mine sites, proposed Twin Metals Minnesota concentrator site, and the Boundary Waters. Using the model, Dr. Myers found, "If sulfide mines are developed in the Rainy Headwaters [part of the Boundary Waters watershed], it is not a question of whether, but when, a leak will occur that will have major impacts on the water quality of the Boundary Waters Canoe Area Wilderness" (Myers 2014, p. 4). Dr. Myers has recently extended his qualitative analysis to consider sulfide-ore mining west of Ely, but still in the Rainy River Watershed, and he shows significant potential for risks to Voyageurs especially considering the already elevated mercury levels in the streams that flow into the park (Myers 2015).

Dr. Lawrence A. Baker, University of Minnesota Professor of Environmental Engineering, found high potential ecological impacts from sulfide-ore mining in the watershed of the Boundary Waters. Dr. Baker described an ecologically sensitive area that would be subject to loss of fish species if waters became acidic from mine runoff, leaching of heavy metals that would impact fish and aquatic life, impacts to wild rice and other rooted aquatic plants, and elevated methylation of mercury due to increased sulfate from mine waste runoff (Baker 2013). Dr. Baker also found that potential acid mine drainage and associated contamination could affect a large number of shallow, easily contaminated drinking wells in the area around proposed mines (Baker 2013). These potential aquatic impacts could work synergistically, especially if mine contamination impacted the smaller aquatic organisms and rooted aquatic vegetation that provide a foundation for the whole aquatic ecosystem.

Other studies have shown the severe effect of bioaccumulation of toxins that could result from copper-nickel sulfide-ore mining, such as methylmercury, up the food chain. For instance, the Common Loon is a "powerful indicator of local aquatic system health, especially in relation to mercury and acid precipitation" (Tozer et al. 2012, p. 1). Elevated methylmercury levels create neurological and physiological problems for loons, including increased lethargy, reduced food-seeking behavior, and reduced ability to avoid predators (Tozer et al. 2013). In a study of loons affected by methylmercury in New Hampshire and Maine, a research team found that the highest risk loons had 41% fewer fledged young than the reference group of lower risk loons (Evers et al. 2008). Data collected over 18 years across Canada showed a relationship between smaller lakes with higher methylmercury exposure and low pH and reduced loon reproductive success, and the study suggested that "mercury and acid precipitation are among the most important drivers of Common Loon reproductive success in southern Canada" (Tozer et al. 2013, p. 9). Increased mercury contamination from sulfide-ore copper mining operations in the Boundary Waters and Voyageurs watersheds could thus significantly affect loon reproductive success, which in turn indicates decreased health of the whole aquatic ecosystem.

Dr. Lee Frelich, Director of the University of Minnesota Center for Forest Ecology and preeminent forest ecologist, found that proposed mining would affect both the direct footprint underneath mine facilities and a larger secondary footprint that would extend into the Boundary Waters itself. Specifically, mining activities would reduce total forest acreage, fragment the forest, disrupt the intricate web of water connecting soil and roots, allow for increased dispersal of invasive plant and animal species, and alter wildlife migration and residence patterns (Frelich 2014). Dr. Frelich also indicated that mining could have additive and synergistic effects with climate change and could ultimately reduce the resilience of the forest ecosystem to disturbances (Frelich 2014). Reduced resiliency would not only affect the natural world, but could also affect timber extraction in the Superior National Forest and recreation and tourism opportunities in the Boundary Waters.

The sulfide-ore copper mining industry has a disastrous track record. A peer-reviewed report prepared by Earthworks, a mining watchdog non-governmental organization, studied fourteen sulfide-ore copper mines representing 89% of current US copper production (Earthworks 2012). Of those fourteen mines, all had experienced some sort of pipeline spill or other accidental release (Earthworks 2012). Thirteen of the fourteen (92%) had experienced water collection and treatment failures that resulted in significant impacts to water quality (Earthworks 2012). The tailings dam failure at the Mount Polley Mine in British Columbia in August 2014 shows the catastrophic potential for such failures, though run-of-the-mill pipeline leaks and seepages from underground mine sites are also serious vectors for contamination as shown by Myers (2014).

In contrast to mining industry claims of advanced technology, methods to prevent, treat, and mitigate water contamination at modern copper mines have not significantly improved since the mines reviewed by Earthworks were constructed. Dr. Dave Chambers of the Center for Science in Public Participation reviewed the state-of-the-art technologies and standards currently available to modern copper mine construction, and he found that they could not eliminate all risk to downstream waters (CSPP 2014). Dr. Chambers noted that uncertainties based in the inherent complexity of natural materials and their environments prevents our ability to make clear predictions, which prevents the conclusion that a mine will have only insignificant impacts (CSPP 2014). Additionally, he noted that the difficulties of adjusting water treatment and seepage collection technologies to meet real-world chemical composition, geomorphology, and water cycle variation are much greater than suggested by assumptions within the environmental assessment process (CSPP 2014). Judging from analogous mine records, the aggregate potential for at least one failure of a waste water treatment plant or incomplete waste water collection is high, and the U.S. EPA has observed that mines continue to operate even if they know their treatment does not meet established water quality standards (CSPP 2014). Even if water treatment technologies work as designed, no significantly new water treatment technologies have been developed in recent decades (CSPP 2014). Dr. Chambers reviewed the four leading water treatment technologies, including reverse osmosis, and found that the most complete systems are highly expensive and require their own follow-up treatment systems (CSPP 2014). After mine closure, the mining company no longer is directly responsible for maintaining or repairing water treatment facilities. In terms of specific pollution prevention technologies, Dr. Chambers observed that no tailings storage facility seepage collection system is perfect ("all liners leak"), and disposing of tailings or waste rock in an old facility would likely use an unlined system (CSPP 2014, p. 4). Dr. Chambers concluded, "It is not feasible, given today's or tomorrow's technology, to reduce the risk of impacting waters downstream from a copper/nickel mine in a sulfide ore body to zero" (CSPP 2014, p. 10).

In 2014, a team of researchers from Michigan State University, Oregon State University, the USGS Great Lakes Science Center, and the International Joint Commission Great Lakes Regional Office published a study in the peer-reviewed *Ecological Indicators* journal that showed the potential for mines to be sources of regional stress on fish assemblages (groups of fish that co-occur in an ecosystem) over large spatial scales. Daniel et al. (2014) built on an established body of research showing local negative impacts to fish habitats, fish species diversity, and fish size and survival in streams and their immediate basins in close proximity to coal and mineral mines. This team, however, broadened their inquiry to assess relationships between mine density and indicators of fish assemblage health on a regional scale, across multiple streams and catchments (Daniel et al. 2014).[2] While this study did not address mines in northern Minnesota, it did look at three broad ecoregions (Northern Appalachian Ecoregion, Southern Appalachian Ecoregion, and Temperate Plains Ecoregion) and showed consistent trends of negative, cumulative impact from mines to fish assemblages across all of them at the regional/multi-catchment scale (Daniel et al. 2014). The researchers found,

> "Disturbance from mines may be underestimated when only looking at local spatial scales. In all ecoregions, threshold responses were the strongest (most significant thresholds) at the network catchment scale. Mine impacts may be disproportionate to the area they encompass, because a few mines have the potential to cause very low threshold points. The numerous network catchment threshold responses suggest a cumulative effect of mines as a regional source of disturbance. As mine density increases, and associated disturbances accumulate downstream, fish assemblages respond with negative wedge-shaped declines in abundance" (Daniel et al. 2014, p. 58).

This study supports Dr. Myer's manuscript submitted to the *Hydrogeological Journal* that suggests that larger scale analysis of mining risks could be used to make siting decisions in order to prevent ecological damage to sensitive places. Daniel et al. (2014, p. 58-59) conclude,

> "There is also an opportunity for agencies and managers to consider the landscape influence of mining and improve fisheries habitat through actions including restoration, mitigation and preservation. When monitoring mined catchments, managers should include baseline ecological and environmental research not only at locally impacted reaches but at downstream reaches to account for the network alteration to fish assemblages. Mining should be excluded from ecologically- and culturally-significant catchments, since we did not detect negative fish assemblage responses in only the largest size classes of rivers with low densities of mines. When managing for game fish in streams, managers should consider landscape scale influences of mines upstream, because mines at low densities have the potential to negatively impact downstream fisheries."

[2] A catchment is essentially the same as a watershed, and it is the term more often in academic work to describe the area drains water into a stream or lake.

Conclusion

Due to the spectacular quality of the Boundary Waters, the likelihood of contamination outside its borders reaching its interior, and the unsatisfactory track record of the sulfide-ore copper mining industry, it is clear that the watershed of the Boundary Waters is no place for sulfide-ore copper mining operations. The Boundary Waters Canoe Area Wilderness and Voyageurs National Park watersheds deserve permanent protection to ensure that no sulfide-ore mining operations are allowed to threaten these national treasures.

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