

Update on Selenium Projects at Tilden and Empire Mines

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Purpose Statement:

Cliffs Natural Resources' Michigan Operations Tilden and Empire Mines move over 60 million tons of rock annually in order to produce approximately 12 million tons of iron pellets. This large scale operation generates significant environmental interest. This newsletter will focus on selenium.

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Environmental History of Goose Lake

By: MDEQ Staff

Background

Goose Lake is located in northern Marquette County, southeast of the City of Negaunee in Richmond Township. This water body is approximately 450 acres in surface area and has a maximum depth of 15 feet. It is unique in that it has a railroad grade constructed along the southern shoreline and through part of the lake. The main tributary to Goose Lake is Partridge Creek, which drains the Empire Mine waste rock piles, the historic iron mine caving grounds, and the City of Negaunee. In the early 20th century, the untreated sewage from Negaunee was routed to Goose Lake. The Michigan Department of Environmental Quality (MDEQ) estimates that up to 20,000 pounds of phosphorus entered the lake annually until the Negaunee wastewater facility was constructed in 1953. This "fertilization" (eutrophication) has increased production of algae, insects, and fish in the lake above natural conditions. This also results in an ongoing odor problem in the summer due to blue-green algal blooms that occur especially during periods of dry, warm weather. Decaying algae depletes the

dissolved oxygen in the water. Oxygen depletion at the lake bottom has been documented and is the most likely cause of reported periodic fish kills. Monitoring in 2009 did not show any dissolved oxygen problems, which was probably a result of the cooler than normal weather.

Nutrient Studies

Goose Lake has been intensively monitored by the MDEQ since 2002. It was placed on the Federal Section 303(d) list as an impaired water body due to excessive phosphorus inputs. The MDEQ has spent over \$30,000 to characterize the magnitude of the nutrient enrichment and associated impacts such as algae blooms that cause the odor problems. Studies conducted in 2003 by White Water Associates, Inc., determined that phosphorus is being released from the sediments. The full report can be found by clicking on the "Various Studies and Reports" link found at www.michigan.gov/deqnpdes. Chlorophyll (algae), dissolved oxygen, and temperature profiles have been measured by the MDEQ biannually (spring and summer) to track lake conditions.

Fisheries Issues

Goose Lake has been known locally as having good fishing for yellow perch, northern pike, and walleye. Netting results indicate that white suckers dominate the fishery. Currently, there is a fish advisory in sport fish due to elevated polychlorinated biphenyl (PCB) levels. Fish sampling in 2008 indicated that PCBs are

still an issue although the concentrations have been declining. No PCBs were detected in sediment samples collected in 2001 so the sources are likely outside the lake. The Michigan Department of Natural Resources (MDNR) conducted a fish survey in 2009 and concluded that the fish community has not changed substantially, even though numbers have declined. Cliffs Natural Resources' Michigan Operations provided \$50,000 to the MDNR for improving the road to the Goose Lake public access site as part of the Deer Lake Amended Consent Judgment. The MDNR plans to straighten and gravel the access road in late 2010 or 2011.

Current Issues

Total selenium concentrations have recently been monitored by the MDEQ within Marquette County in the vicinity of the Tilden and Empire Mines. It has been determined that selenium levels in Goose Lake sediments, water, and fish tissue are elevated above background levels commonly found throughout the Upper Peninsula. The MDEQ report "An Assessment of Environmental Selenium Levels Around Empire and Tilden Mines" is available at <http://www.michigan.gov/deq/0,1607,7-135-3313---,00.html> under announcements. The apparent source of selenium is the drainage associated with the iron mining operations. Cliffs Natural Resources' Michigan Operations is working to control selenium discharges from the Tilden and Empire Mines, as described on Page 5 of this newsletter.

(Goose Lake – near boat launch)



What is Selenium?

By: Cliffs Natural Resources' Michigan Operations

In order to effectively manage selenium (si-lee-ne-em) once it has been identified in an ecosystem, it is necessary to understand what selenium is, where it comes from, and its associated characteristics. Selenium exists naturally in the environment and can be found in coal, shale/sedimentary rock, petroleum source rocks, and phosphate-rich rock. Some interesting selenium facts include:

- * First discovered as an element in 1817 by a Swedish chemist.
- * Present in the environment in both organic and inorganic forms.
- * Referred to as a metalloid because it has some metal characteristics and some non-metal characteristics.
- * Very rare element – ranks among the 25 least common elements in the earth's crust.

- * Exists in many possible oxidation states thereby making it a very complex element to understand, manage, and isolate.

Today, selenium finds a wide variety of industrial and commercial uses as a result of its electrical and physical properties. Mining of selenium due to its rarity is not economically feasible; it is primarily produced as a by-product from the mining/refining of other metals (e.g. copper, nickel, and lead ores). Major producers of selenium in the world include Japan, Canada, Belgium, the U.S., Russia, and Germany. World-wide annual production is around 600 tons (2007). The two most important uses of selenium are glass-making and electronics (accounting for approximately 60 to 70 percent of all selenium produced each year). Specific uses include:

- * Plain paper photocopiers and laser printers.
- * X-ray systems for medical equipment.
- * Photovoltaic ("solar") cells.
- * Active ingredient in some dandruff shampoos.
- * Pigment (coloring agent) for paints, plastics, glazes, and ceramics.
- * Additive in various metal alloys (e.g. stainless steel).
- * Agricultural soil amendment and animal feed supplement (approximately 5 percent of annual selenium production).

In addition to the industrial/commercial uses, selenium is an essential micronutrient in bacteria, plants, and animals. Its necessity for mammalian life was discovered in 1957 and is

considered an antioxidant in humans at low doses. Plant foods are considered the major dietary source of selenium in most countries throughout the world. Examples of selenium-rich foods include (in descending order):

- * Dried Brazil nuts.
- * Light canned tuna in oil.
- * Cooked beef.
- * Light meat roasted turkey.
- * Cooked cod.

The actual selenium levels in various food types can be affected by the selenium-richness of their source area.

Recommended Dietary Allowances (RDA) for adults (19+ years) is 55 ug/day and the tolerable upper intake level for adults is 400 ug/day. A narrow band exists between selenium concentrations considered safe and those considered harmful. Interestingly, selenium is available for purchase as a human vitamin supplement.

In the environment, selenium transports easily without much bonding or sorption, the degree of movement being dependent upon its oxidative state. Selenium can be released into the air and subsequently deposited into the environment from the burning of coal. It is capable of undergoing bioconcentration and bioaccumulation. Accurate assessments of selenium in the environment are important because of its effect on reproduction in aquatic birds and fish. Because of the complexity of selenium's behavior in the environment due to its many chemical states and transport

mechanisms, there remains some uncertainty over acceptable discharge levels. This is further discussed in "Proposed U.S. EPA Selenium Water Quality Standard" which immediately follows this news article.

(Picture of Selenium Crystal)



Proposed US EPA Selenium Water Quality Standard

By: MDEQ Staff

Selenium is essential to life, but can be toxic in excess, reducing survival and reproduction of fish and water-dependent birds. In other states, selenium has also built up in fish to levels dangerous for human consumption.

Selenium is a bioaccumulative chemical which means it will accumulate in fish and other aquatic life at levels greater than in the surrounding water. Selenium also accumulates in aquatic sediments where it can cycle with overlying water and aquatic life for

an extended period. The primary source of selenium to aquatic life is through the diet.

However, unlike mercury, the concentration of selenium does not increase with increasing food chain level (biomagnifications).

Water quality criteria are legal limits of the concentration of the chemical. Acute criteria protect aquatic life from rapid, severe harm. Chronic criteria protect aquatic life, humans, and wildlife from long-term harm. The current Michigan selenium water quality criteria are 120 ug/l (acute criterion) and 5 ug/l (chronic criterion) in water.

New research shows that selenium bioaccumulation rates vary from water body to water body. Consequently, the United States Environmental Protection Agency (US EPA) has proposed to issue selenium water quality criteria based on selenium concentrations in the bodies of fish (tissue-based criteria). By using direct measures of selenium inside the fish, the draft criterion avoids the uncertainty that arises from predicting fish uptake rates from water. This approach potentially provides the best overall protection from chronic harm to aquatic life.

The proposed US EPA chronic criterion is 7.91 parts per million in fish tissue. To help regulate selenium in water discharges, the US EPA is also considering factors to convert water concentrations of selenium to fish tissue concentrations.

The US EPA chronic criterion also protects human health from exposure to selenium from

eating fish. Michigan does not commonly screen fish tissue for selenium because it has not been a contaminant of concern for human health in Michigan.

The bioaccumulative nature of selenium influences its chronic toxicity, but the acute toxicity of selenium is much like that of other substances. Therefore, the US EPA has proposed water-only acute toxicity criteria for selenium. The Michigan acute criteria of 120 ug/l was developed using a similar method as US EPA is proposing.

The US EPA acute and chronic criteria are still in draft form. Michigan's current chronic Water Quality Standard for selenium is for water only and mirrors the US EPA's "Great Lakes Initiative", which required all Great Lakes States to use 5 ug/l. After the draft US EPA selenium criteria are finalized, they cannot be implemented in Michigan until:

1. The US EPA changes the Great Lakes Initiative selenium standard and
2. The Michigan's Water Quality Standards are changed to incorporate the new Great Lakes Initiative standard.

The MDEQ will monitor the development of the US EPA's draft selenium standard and consider it when determining appropriate control measures for selenium discharges.



Empire and Tilden Selenium Management Activities

By: Cliffs Natural Resources' Michigan Operations

Since 2007, the environmental and engineering professionals at Cliffs Natural Resources' Michigan Operations, which includes the Empire and Tilden mines, have been working to determine what needs to be done in response to the results of this investigation. Staffs at the mines and their team of environmental experts have been meeting with the Michigan Department of Environmental Quality (MDEQ) water quality specialists and geologists to review existing information and work on the details of plans for further investigation. While selenium occurs naturally in rocks and soil, it has become important to know how mining operations may alter its availability and impact on the environment. Investigation efforts to date have focused on materials used in mining, the geological environment at the mines, surface water, groundwater and biological resources, particularly fish and the things that fish eat.

Management of selenium begins with developing an understanding of the source of selenium and whether the mining process affects selenium in the ore body and, if so, how it may be transported and released during ore processing and pellet production. Investigations are planned to extend into 2010, including collecting key information about the ecological environment. However, planning has already begun concerning how the

investigation results will be put to use in managing/controlling the impacts of selenium in the environment. These plans focus on ways to control the amount of selenium that may come on to the mine property from outside sources, control of mining processes and ways to control the amount of selenium that leaves the mine property, particularly in surface water. This means looking into ways that raw material use could be changed, recycling alternatives and other reductions of selenium coming on to the property. For selenium in water discharges, the company is looking at ways to effectively decrease the amount of selenium leaving the property.

Design and engineering work for selenium control plans started in 2009 and will continue through 2011, incorporating what is learned through ongoing investigations. While many steps must be completed to arrive at a final plan for addressing selenium at the Empire and Tilden mines, the process is well under way. There is a fundamental agreement with the MDEQ about the approach and schedule for important milestones. The company looks forward to a productive investigation process and moving forward on efforts to address selenium.

(Empire Mine – aerial photograph)



(Tilden Mine – aerial photograph)



Ground Water Characterization Surrounding Empire and Tilden Mine Operations

By: MDEQ Staff

Necessary components of iron mining are tailings basins and waste rock storage piles. Storm waters and snow melt waters can

remove naturally occurring substances, including selenium from tailings basins and waste rock piles, and transport the dissolved materials to surface drainages and ground water. Recognizing this, the Michigan Department of Environmental Quality (MDEQ) and Cliffs Natural Resources' Michigan Operations (CNR) are characterizing runoff and developing a hydro geological study at the Empire and Tilden mining areas in central Marquette County, Michigan.

Specifically, CNR and the MDEQ will investigate selenium and other possible impacts to overall ground water quality in and around the active mine facilities. The MDEQ Water Bureau has already researched existing data on selenium content in Marquette County area water wells. The selenium concentrations are less than 5 micrograms per liter (ug/l) in all sampled wells not owned and operated by CNR. This naturally occurring selenium in Marquette County ground water is less than ten percent of the public water supply maximum contaminant level of 50 ug/l. The MDEQ report on selenium in ground water near the Empire and Tilden mines can be found by clicking on the "Various Studies and Reports" link found at

www.michigan.gov/deqnpdes.

This newsletter was developed and distributed by the Michigan Department of Environmental Quality with cooperation from Cliffs Natural Resources. It is intended to assist the public with information on the activities in and around the Empire and Tilden mines. If you have any questions, suggestions or would like to be added to the electronic mailing list, please contact Steve Casey by e-mail at caseys@michigan.gov.