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COPPER-NICKEL MINING IMPACT OVERVIEW
Inquiry Response No. 127
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INQUIRY: How effectively can available technologies minimize the health, safety, and environmental impacts of copper and nickel development in Minnesota?

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BACKGROUND: From 1976 to 1979, the Minnesota Environmental Quality Board (MEQB) conducted a $4.3 million study of the potential environmental impacts of copper-nickel mining in the Hoyt Lakes-Ely area of northeastern Minnesota. The MEQB Regional Copper Nickel Study (RCNS) estimates that this area contains a total of 28 and 9 million metric tons of copper and nickel, respectively, of which 20 and 5 million metric tons can be recovered by existing technology. Cobalt would probably also be recovered, though in smaller quantities, estimated at 80,000 to 90,000 metric tons. At January 1981 market prices, these metals have a gross value of over $80 billion.[1]

Minnesota's 28 million metric tons of copper are approximately one-fourth of total U.S. reserves and one-twentieth of the world reserves. Minnesota's 9 million tons of nickel are 50 times larger than existing U.S. reserves and approximately one-eighth of total world reserves. [RCNS, Vol. 1, pp. 14-15]

Exploitation of this resource involves many significant public policy decisions. The Regional Copper Nickel Study (RCNS) contains a comprehensive compilation of information regarding copper-nickel development and its economic, social, and environmental effects. The RCNS was used extensively in the preparation of this inquiry response, and page references are given for the convenience of those who seek additional information.

Copper-nickel mining in Minnesota is not likely to occur in the near future; the mining company whose plans are most advanced at present is AMAX, and company officials do not anticipate beginning operations prior to 1990 or 1995. State regulatory agencies, reporting in February 1981 on their examination of the RCNS, stated that this allows the state time to develop policy towards mining, and to carry out additional research needed to develop methods to minimize adverse environmental impacts.

The following sections (1) describe mineral development (mining, processing, smelting, and refining), (2) describe key choices which strongly influence the

*A key resource is a person who knows the technical aspects of the topic being considered and has indicated a willingness to answer questions on the topic from legislators.

potential impacts of mineral development, and (3) discuss specific problems and available remedies regarding impacts of copper-nickel development to land, water, air, and human health.

RESPONSE:

1. Processes of Mineral Development

Table 1 summarizes the main components of developing copper-nickel. Major processes are discussed below; wastes produced, and other environmental and health concerns are discussed following the section on major trade-offs.

TABLE 1

MAJOR COMPONENTS OF DEVELOPING COPPER-NICKEL RESOURCE

PROCESS	PRODUCT	PRINCIPAL WASTE	MAIN HEALTH AND ENVIRONMENTAL CONCERNS
Mining	ore	waste rock lean ore overburden	water effluent from mine and waste land use dust/particulates noise worker safety
Processing	concentrate	tailings processing chemicals	land use dust/particulates water use water effluent from tailings disposal
Smelting and Refining	copper metal nickel metal other precious metals, including cobalt sulfur compounds	slag sulfur emissions dust/particulates heavy metals	air emissions (sulfur, particulates) water use water effluent

Mining is the process of breaking loose and physically removing the copper-nickel-bearing rock. Processing consists of two stages: first, crushing and grinding of the ore, and second, flotation and chemically-assisted separation of minerals into copper-rich and nickel-rich concentrates. Processing usually occurs no more than a few miles from the mine. Smelting involves drying the concentrates and burning them in a furnace at 2000 to 2400°F. (Nickel concentrates may be processed by methods alternative to smelting.) Following smelting, the refining process purifies the metal by chemical precipitation or electrorefining (a process similar to electroplating). Smelting and refining may occur at great distances from the mine and processing facility.

2. Major Trade-Offs for Copper-Nickel Development

The extent to which copper-nickel development causes adverse impacts to the environment and to human health and safety depends upon many factors. Many of these factors are not tied to the specific processes or technologies which are applied to development, but instead are tied to key decisions made prior to specific development activities. These key choices involve:

- scale and rate of copper-nickel development
- open pit or underground mining
- location of mining and milling operations
- location of smelting and refining operations

2.1 Scale and Rate of Copper-Nickel Development

The rate of development will determine whether the copper resource is exhausted within 200 years or more or within a few decades only. Compared to rapid, large-scale development, moderately-paced development will tend to reduce adverse impacts because (1) pollution is spread out over a longer period of time, which may reduce the level of pollution-related stress placed on plants and wildlife, and (2) slower development provides greater opportunity for a more thoughtful, planned, and more adequately financed response to expected impacts. [RCNS, Vol. 1, p. 87]

Below a certain rate of development, mining would be impractical due to economic considerations. It may be noted that the rate and scale of mineral development may become limited by the amount of water available in the region. [RCNS, Vol. 1, p. 51]

2.2 Open Pit or Underground Mining

Depending on the depth of the ore, its grade, and other geologic factors, open pit or underground mining methods may be used. In some cases, a combination of both is preferred.

The RCNS estimated that over two-thirds of the copper resource exists in ores that are located at a depth of 1,000 feet or more below surface; these probably would be mined by underground rather than open pit methods.

Mining requires a substantial land area, primarily for waste disposal. An open pit mine producing 100,000 metric tons (which equals 110,000 short tons) of copper annually is estimated to need over 10,000 acres (16 square miles); an underground mine of equal production requires about 5,000 acres.

Underground mining reduces the potential for environmental harm because the volume of mine wastes and the land needed for disposal is reduced. In addition, underground mining avoids two pollution problems associated with open pits:

1. an open pit is a source of dust and particulates to the air;

2. rainwater in an open pit is likely to become contaminated with heavy metals and solids, and, if so, would cause water quality problems unless treated when pumped from the pit (during mine operation) and when the water fills and overflows the pit (several decades or more after mining operations have ceased.) Groundwater contamination from the open pit is also possible, depending on site geology.

2.3 Location of Mining and Milling Operations

Location of development is one of the key determinants of the magnitude of environmental impacts which result. The copper resource occurs sporadically along a belt 40 to 50 miles long (shaded area in Figure 1). Along this belt, there are significant changes in sensitivity to mining-related impacts. [RCNS, Vol. 1, p. 92]

This belt is bisected by the Laurentian Divide: all waters north of the Divide flow north into the Boundary Waters Canoe Area, and eventually into the Hudson Bay; waters south of the Divide flow south into the St. Louis River and into Lake Superior.

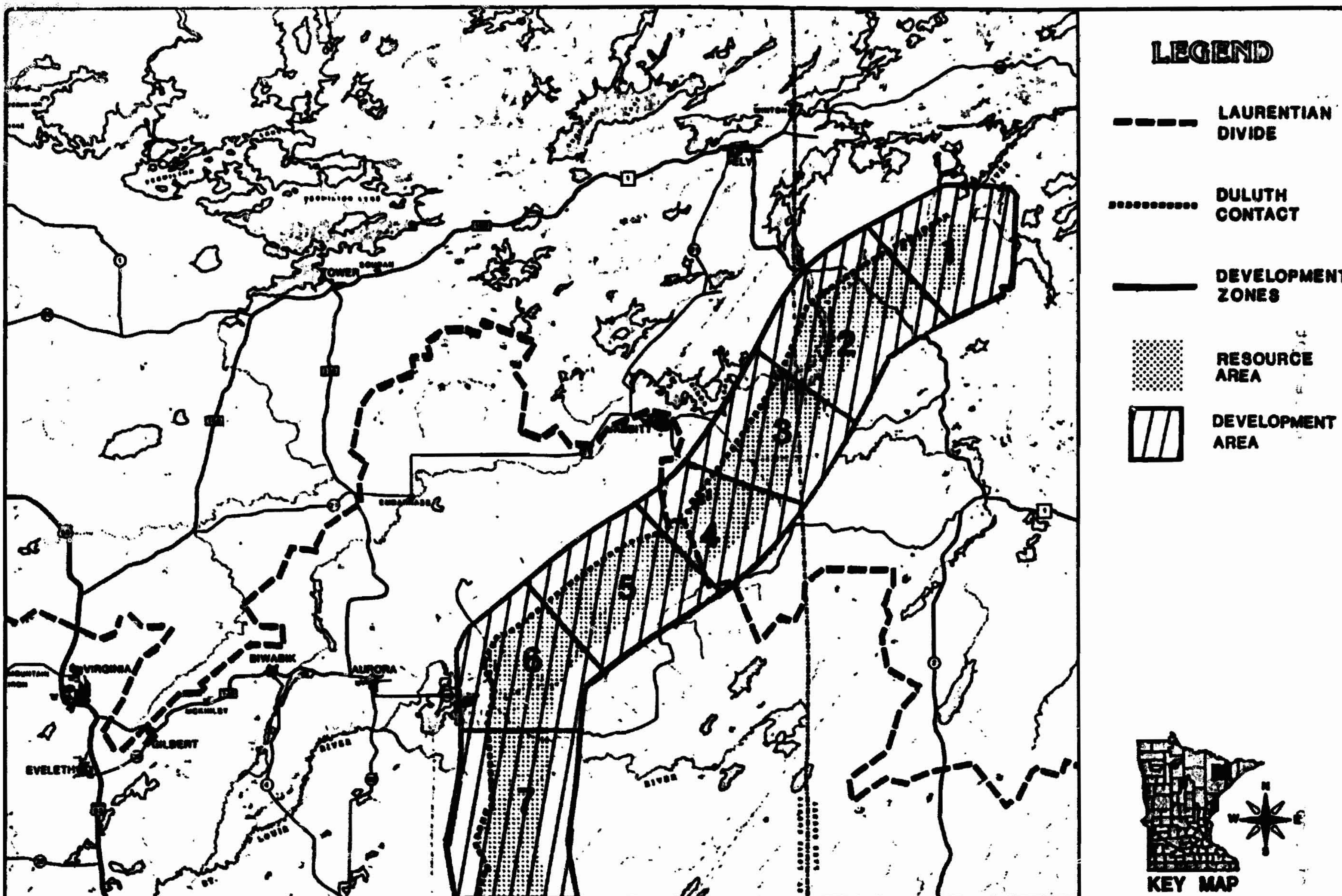

FIGURE 1 **MEQB REGIONAL COPPER-NICKEL STUDY**

MN CU-NI DEVELOPMENT AND RESOURCE ZONES

The region north of the Divide contains about 88 percent of the identified minable copper-nickel resource.[2] Concerning potential environmental impacts, development north of the Divide is clearly less desirable than development to the south for several reasons.[3] These are:

- impact to wildlife may be more significant, since the northeast part of the study area (north of the Divide) contains a forest type which is less prevalent in the region. This forest type is inhabited by many animals of state and national interest; impacts there could reduce or eliminate these populations; [RCNS, Vol. 4, Ch. 2, pp. 5, 11-12]
- soils are shallower and more easily eroded north of the Divide, making reclamation efforts extremely difficult; [RCNS, Vol. 4, Ch. 2, p. 139]
- there is more surface water north of the Divide, which makes these waters more susceptible to air pollution impacts, particularly sulfur oxides and heavy metals;
- for the most part, the area north of the Divide is currently unspoiled by industrial development, whereas south of the Divide, there is considerable taconite development; and
- the area north of the Divide is closer to the Boundary Waters Canoe Area (BWCA), and development there would be more likely to impinge on air, water, and noise quality in the BWCA.

Should mining occur north of the Divide, stricter controls may be necessary to reduce or prevent adverse impacts.[4] In a few cases, some potential impacts of mining north of the Divide can be reduced by placing waste rock and lean ore piles adjacent to the Divide or south of the Divide, with engineering designs which ensure that water runoff flows into the southern watershed.

2.4 Location of Smelting and Refining Operations

Smelting could occur nearby the mine and processing facilities, elsewhere in Minnesota, or outside of the state. The major disadvantage of a smelter in the processing area is increased regional air pollution, particularly sulfur dioxide and particulates containing heavy metals (copper, nickel, cobalt). [RCNS, Vol. 1, pp. 89-91] The degree that smelting emissions can be controlled is discussed below at the section on air quality. The major environmental advantage of locating smelting operations in the mining/processing area is that minimizing the transportation of the concentrate also minimizes the risk of accidental spillage. Such accidents have caused environmental damage in other parts of the U.S. (Locating a smelter in the mining area may also have advantages in terms of cost savings and tax revenue to the state, but these issues are outside the scope of this report.)

3. Specific Copper-Nickel Development Impacts to Land, Air, Water, and Human Health

The following sections discuss the main impacts of development to land, water quality, air quality, and human health, with emphasis on available technologies for minimizing potential impacts. In order to estimate impacts, it is assumed that mining operations are of the size which produces 100,000 metric tons of copper per year, and about 2.4 million metric tons over 30 years. Several separate mines may be involved. (This size of operation was chosen as representative by the RCNS; See RCNS, Vol. 1, pp. 22-27 for additional discussion.)

3.1 Land Use

3.1 (a) Principal Impacts. Mining excludes other uses of the land occupied by the mine and by wastes disposal. [RCNS, Vol. 1, p. 31] Ninety percent of the area likely to be consumed by new mining is now forested. Open pit mining, in particular, may consume areas which are currently lakes or streams.

Most of the land is needed for stockpiling of lean ores and for waste disposal. The total land requirement for production of about 2.4 million metric tons of copper over 30 years is estimated at 5,000 acres for underground mining and 10,000 acres for open pit mining. [RCNS, Vol. 1, p. 24] Lean ore and waste rock piles for an open pit mine proposed by AMAX would be 500 to 600 feet high and cover 3,400 acres.[5]

The disturbed land is a potential source of contaminants to air, surface waters, and groundwater. These problems are discussed further in the following sections.

A related issue, not discussed in this report, is changes in land use due to human settlements which result from mineral development. [See RCNS, Vol. 1, pp. 33-34]

3.1 (b) Technology to Reduce Impacts. New methods or technology do not appear likely to substantially reduce the land requirements of copper-nickel development, but the choice of mining method (underground or open pit) is very significant.

3.2 Water

There are two principal classes of impacts to water due to copper-nickel development: (1) those impacts due to water use and, (2) those due to water contamination.

3.2.1 WATER USE--(a) Impacts. Development would require large quantities of water. For an open pit mine producing 100,000 metric tons of copper annually, mining and milling is estimated to require about 2.1 billion gallons per year. An underground mine of equal production would require about 1.3 billion gallons annually. For comparison, current municipal, rural domestic, and irrigation uses in the region are about 1 billion gallons annually, and current taconite mine operations (excluding mine dewatering) use about 5 to 6 billion gallons annually. [RCNS, Vol. 3, Ch. 4, pp. 49-50]

In addition to mining and milling, smelting and refining operations would require between 1.6 and 24.8 billion gallons of water annually, depending upon the extent of water recycling. Assuming that mining, milling, smelting, and refining operations are well-designed to conserve water and maximize its re-use, there would still be a need for makeup water to replace losses. For an operation of the size mentioned (100,000 metric tons annual copper production) this makeup water is estimated to be 760 to 1,000 million gallons per year. [RCNS, Vol. 1, p. 50] Much of this water can be provided from collection of rain (runoff) from within the mining area, but appropriation of water from area streams and lakes is likely, particularly in dry years. Because the demand for water is fairly constant and the supply fluctuates, storage on the order of 3 to 5 billion gallons (10,000 to 15,000 acre-feet) will be necessary.

Water appropriation is likely to entail some loss of fish and other aquatic life in affected streams. Losses due to flow changes may occur while mine and mill are operating, but recovery appears likely within several years of return to normal flow. Channelization and diversion of streams could result in significant and long-term losses unless mitigation measures are applied. [RCNS, Vol. 4, Ch. 1, p. 93] Discharge of warm water could reduce trout and other cold-water fish populations in affected steams.

Water use by copper mining could conflict with the need for water by existing or expanded taconite mining in the region.[6]

<u>3.2.1 WATER USE--(b) Technology to Reduce Impacts</u>. Impacts of water appropriation to lake and stream life is reduced when the re-use of water is maximized (as was assumed in the discussion above), and by other measures to ensure that water appropriation does not cause extreme low flows in the affected steams. These measures may include selection of water sources large enough to meet needs with little flow change, use of runoff as a water source, and phased construction of tailing basins and stockpiles. Impacts of channelization and diversion can be minimized by building curved channels, placing substrate such as large rocks in streams, revegetating stream banks, and restricting the length of channels. [RCNS, Vol. 4, Ch. 1, pp. 87-98] Thermal pollution can be reduced by use of cooling towers or by using the waste heat for other purposes.

<u>3.2.2 WATER CONTAMINATION--(a) Impacts</u>. What may be the most significant environmental issue related to copper-nickel development is contamination of surface water from lean ore and waste rock piles.[7] Contamination of water is also possible from an open pit.

Of major concern is the release of heavy metals (also sometimes referred to as "toxic metals" or "trace metals") into surface waters. Copper, nickel, cobalt, and zinc are of main concern because they are likely to be present at much higher concentrations than other toxic heavy metals (such as silver, lead, cadmium, and arsenic).

Water which moves over or through waste rock piles or lean ore piles will collect metals and other materials. This process is called leaching. As a result, metals may be present in the drainage water at 500 to several thousand times their concentration in natural surface water. [RCNS, Vol. 1, pp. 62-65] Surface water in the region typically contains heavy metals in extremely small (trace) amounts (2 micrograms per liter or less). Increasing this natural metals concentration as little as 15 times has at least some potential for causing adverse impacts on aquatic life over time. [RCNS, Vol. 4, Ch. 1, p. 79]

Models developed by the RCNS indicated that uncontrolled discharge of water leached from a lean ore pile to surface waters, would contain several different metals and could be acutely toxic to all aquatic organisms. The RCNS estimated that this discharge would be equivalent in toxicity to about 8,000 micrograms of copper per liter of water (this is roughly equivalent to one-thousandth of an ounce of copper per gallon of water). With a discharge of this magnitude, the RCNS estimated that all aquatic life would either move away from the pollution source, or die. [RCNS, Vol. 1, pp. 64-65] Once metals concentrations were reduced through dilution by a factor of 3 to 4, some fish could survive, but few, if any, other aquatic animals (principally invertebrates) would be available for food. When the metals concentration is reduced by a factor of 10 to 20 (to 800-400 micrograms per liter) some additional aquatic life will survive; but not until metals concentration is reduced by a factor of 80 to 90 will relatively large numbers of fish and invertebrates be found. The area of watershed needed to provide this degree of dilution is around 50 square miles. For the impacts to be too slight to measure, reduction by a factor of 200 to 300 is needed, requiring about 100 square miles of watershed. [RCNS, Vol. 4, Ch. 1, pp. 77-80]

This example, and other examples developed by the RCNS, is based upon the assumption that silicate minerals present in waste rock and lean ore piles will prevent acidic conditions from forming. However, if acidic conditions do occur, the release of metals will greatly exceed the amounts estimated above, resulting in even more severe impacts if uncontrolled. The Minnesota Department of Natural Resources (DNR) and the U.S. Bureau of Mines are jointly studying the leaching problem. Whether acidic conditions will occur cannot be determined with the data currently available.[8]

<u>3.2.2 WATER CONTAMINATION--(b) Technology to Reduce Impacts</u>. During the period of active mine and mill operation, runoff from lean ore and waste rock stockpiles, and water from mine dewatering, can be collected and treated to remove heavy metals. The RCNS concluded that it may be prohibitively expensive to treat large amounts of runoff to reduce metals concentration to the levels found in undisturbed surface waters of the region. [RCNS, Vol. 1, p. 63] Thus, some degradation of water quality may occur, though it may be within limits established by state regulations.

However, leaching does not go away when the mine goes away. Waste rock piles covering several square miles (in the case of an open pit mine) will be there indefinitely, and have the potential for leaching for hundreds of years.[9] Ideally, land reclamation techniques would be able to permanently control water contamination from waste rock and lean ore piles, and from an open pit. However, at present, no proven reclamation techniques have been demonstrated. The DNR and Bureau of Mines research is aimed at developing methods for removing metals from runoff water, and they say the results to date look promising. Additional studies are planned or proposed.[10]

If no reclamation techniques are found to be adequate, collection and treatment of runoff may be necessary for many, perhaps hundreds, of years. Ensuring that mining companies provide such treatment would be difficult.

In addition to the problem of toxic heavy metals, four additional water contamination problems have been identified: (1) the groundwater exposed by mining may in some cases contain high concentration of salts, and could pollute surface waters when pumped from the mine, (2) suspended solids may enter waters from land disturbed by construction, (3) mineral fibers may be released by mine wastes, and (4) processing chemicals from milling operations may be a source of water pollution. High salt (saline) groundwater is best handled by site-specific studies if it is encountered. Suspended solids can be avoided by use of sediment traps and prompt revegetation of disturbed land. Release of mineral fibers could cause health problems, but there is considerable disagreement on this. Processing chemicals vary greatly in toxicity and persistence (i.e., the time before they are broken down to nontoxic compounds), and some chemicals should not be used because of their toxicity. [RCNS, Vol. 3, Ch. 4, pp. 190-192]

<u>3.3 Air</u>

Copper-nickel development potentially could degrade air quality in several ways. The most significant is through sulfur emissions from smelting operations. Other potential problems arise from dust and particulates and associated heavy metals. These two issues are discussed in sections 3.3.1 and 3.3.2 below.

3.3.1 SULFUR EMISSIONS--(a) Impacts. The major pollutant emitted by the copper-nickel industry is sulfur dioxide (SO_2). Smelting of 100,000 metric tons of copper per year would generate on the order of 200,000 to 400,000 metric tons of sulfur dioxide annually. If released to the environment, this volume of pollutant would approximately double the sulfur emissions released in Minnesota.[11]

Northeastern Minnesota is probably the region of the state most susceptible to the potential impacts of sulfur emissions. [RCNS, Vol. 1, p. 36] Sulfur pollutants are harmful to life, and could damage animal and human lung tissue, forests, vegetation, soils, and fish and other aquatic life. Sulfur emissions can also cause corrosion or deterioration of metals, limestone, marble, and other building materials. Impacts are discussed in more detail below.

3.3.1 SULFUR EMISSIONS--(b) Technologies to Reduce Impacts. Considerable advances have been made in recent years in technology to control sulfur oxide emissions (primarily sulfur dioxide, but also sulfate). Instead of emitting between 200,000 and 400,000 metric tons sulfur dioxide each year, technology can enable a modern smelter and refinery complex to lower its sulfur dioxide emissions by 95 percent to over 99 percent [RCNS, Vol. 2, Ch. 4, p. 5]: as a result, projected emissions are within the range of other regional sulfur dioxide sources (taconite and paper industries), and less than, for example, a proposed 800-megawatt power plant at Floodwood, Minnesota.

To assess the impact of sulfur emissions, the RCNS modeled three smelter complexes, with sulfur dioxide emissions of 12,300 metric tons per year, 5,500 metric tons per year, and 2,000 metric tons per year, respectively. The smelter complex emitting 12,300 metric tons per year would not meet current federal new source (air quality) performance standards, but was modeled to assess impacts which could occur if these standards were not in effect.[12] The other two smelter models would meet new source performance standards. Within this range of expected sulfur dioxide emissions, no direct measurable effects to land animals of the region are expected to occur, though indirect effects due to changes in vegetation and soils are possible. Sulfur dioxide emissions within this range may cause subtle damage to vegetation over time, such as damage to leaves or reduced growth. However, knowledge of these impacts is very limited at present. More severe damage to vegetation would occur, however, should pollution control equipment fail for even short periods of time. [RCNS, Vol. 4, Ch. 2, pp. 141-142, 153-154] For example, a three-hour failure of pollution control equipment would release sulfur dioxide sufficient to cause visible injury to nearly all major forest tree species within six miles downwind of the facility. The extent of damage is reduced if wind and meteorological conditions promote greater dispersion of the released sulfur dioxide. Equipment failures are considered to be likely to occur during the life of the facility. [RCNS, Vol. 1, p. 90] It is possible, though costly, to install backup equipment which would treat sulfur emissions when the primary control equipment fails.

In the immediate vicinity of a smelter, sulfur emissions (specifically sulfate) released during normal operation could have detrimental effects on aqautic life. The RCNS estimated that a smelter releasing 12,000 tons of sulfur dioxide and associated sulfate annually could overload the buffering capacity (ability to neutralize acids) of streams and lakes nearby (within 3 miles). This would be a problem particularly during snowmelt in the spring, and noticeable decreases in fish populations could occur. Impacts are reduced substantially if emissions are controlled to the levels of the other two smelter models. The potential for damage is highly variable according to the sensitivity of surface waters to acidification, and may or may not be a problem depending upon the choices of smelter location. [RCNS, Vol. 1, pp. 55-56]

The extent that projected levels of sulfur emissions would contribute to the regional problem of acid rain is difficult to determine. Sulfur emissions from a smelter would at least aggravate the existing acid rain problem. Aside from direct contribution of sulfate, sulfur dioxide from a smelter combines with atmospheric oxygen and moisture to form additional sulfate, which may be deposited to surface waters and to soils in an acidic form. Of particular concern is the faster-than-normal loss of nutrients from forest soils, which appears to be due to acid rain, and that lakes and streams of the area may be becoming more acidic. Long-term changes in aquatic communities may already be occurring due to the general increase in acidity of rain (and thus surface water) of the region. [RCNS, Vol. 1, p. 43]

The demand for approximately 150 megawatts of electricity for mining, milling, smelting, and refining would require additional power production, which also could entail increased sulfur emissions in the region. The RCNS estimated that smelting and refining would be responsible for roughly half of this electrical demand. [RCNS, Vol. 1, p. 25] In this regard, locating smelting or refining facilities and their power source outside the region could reduce potential air pollution to the region by shifting the pollution sources to another location.

3.3.1 SULFUR EMISSIONS--(c) Regulatory Issues. Existing federal air pollution regulations classify the Boundary Waters Canoe Area as a Class I Prevention of Significant Deterioration (PSD) area with regard to sulfur dioxide. The RCNS predicts that, even if a smelter is not built in the copper-nickel development area, existing and planned sulfur dioxide sources (primarily from taconite and electrical power production) will degrade air quality to the maximum allowable amount, given the development area's proximity to the BWCA. Thus, it may be difficult to site a smelter in the region, and if a smelter is built, it could preclude other development in the area.[13]

3.3.2 PARTICULATES AND HEAVY METALS--(a) Impacts. Heavy metals were described earlier with regard to water impacts from materials leached from waste and storage piles. Heavy metals are also an air quality concern, as airborne metals, particularly copper, nickel, and cobalt, are released from a smelter. Assuming the smelter has moderate particulate emission controls, the accumulation of air-deposited metals is expected to affect soils and vegetation within 12 miles of the smelter,[14] after a period of 25 to 50 years. These effects include a slowing of the rate of forest leaf decomposition (and thus nutrient recycling) and reduced seed germination, which would affect natural patterns of forest growth and species change. [RCNS, Vol. 1, pp. 58-59]

In addition to the smelter, particulates (and associated heavy metals) are released from an open pit mine, from the mill, and from blasting, haul roads, and blow-off from waste rock piles and tailing basins. Concerning impacts to the land environment, these particulates are the most important and widespread air pollutant associated with mining (exclusive of smelting). With open pit mining, particulates from haul roads and waste disposal may be particularly important because these sources expose a large area to direct impact. As with particulates from a smelter, the main environmental effects are due to the presence of heavy metals. [RCNS, Vol. 4, Ch. 2, p. 142]

Another concern is that copper-nickel development (and smelting in particular) would be the source of airborne mineral fibers. The fibers released would include little of the asbestos-like fibers associated with taconite development. Nonetheless, the fibers are potentially a significant health hazard, though health implications are poorly understood at present.

3.3.2 PARTICULATES AND HEAVY METALS--(b) Technologies to Reduce Impacts. As with control of sulfur dioxide, the technology exists to remove metals from smelter gases. Good gas collection systems can minimize non-stack ("fugitive") emissions, and devices such as fabric filters and electrostatic precipitators can remove over 99 percent of the particles in a gas stream. Devices used to remove sulfur dioxide also remove particulates and metallic vapors. The area experiencing significant air-deposition of heavy metals could be reduced to within 1.5 miles of the smelter.

The release of particulates from non-smelter sources (roads, waste piles) can often be reduced on a short-term basis through the use of water and/or chemical dust suppressants, and over a long term by revegetation (particularly of waste piles and tailing basins).

As with sulfur emissions, existing federal air pollution regulations address regional particulate concentrations, and would be a factor in decisions regarding location of mining operations.

3.4 Human Health

Workers are the population most likely to have their health affected by copper-nickel development. Historically, disabling injuries have occurred due to underground mining worldwide at a rate two to three times that for open pit operations handling an equivalent amount of ore. However, this figure may be biased by the record of older operations not representative of new safety technology. [RCNS, Vol. 1, p. 88] Nickel dusts from nickel refineries have been a cause of lung cancer. Because cancer usually develops only after 20 to 30 years after the initial exposure, the effectiveness of existing controls is unknown. Dusts, sulfur dioxide, and sulfuric acid mist have caused chronic respiratory diseases in workers at other U.S. copper developments.

The RCNS examined seven U.S. counties where copper or nickel mines and/or smelters are operating, and found indications of increased death rates from respiratory cancer, accidents, and cardiovascular diseases. The actual causes of these increases have not been determined.

The RCNS estimated that anticipated smelter release of sulfur dioxide and sulfates is not expected to have significant effects on human health. Short-term breakdown of pollution control equipment could cause discomfort to nearby populations, and could cause problems to sensitive individuals.

Release of heavy metal particulates from a smelter could result in increased levels of metals in body tissues of persons living nearby. The health implications, if any, are not well understood, except in the case of lead (which is not expected to be released by a Minnesota smelter in appreciable amounts).

The RCNS concluded that a new smelter may avoid many of the health problems documented with regard to existing smelters, due to existing federal laws and regulations. [RCNS, Vol. 1, pp. 67-69]

PRINCIPAL REFERENCES:

1. Minnesota Environmental Quality Board, The Minnesota Regional Copper-Nickel Study 1976-1979, Volume 1, Executive Summary (St. Paul, MEQB: August 31, 1979).

Also: Vol. 2, Ch. 1-5 - Technical Assessment; Vol. 3, Ch. 3 - Air Resources; Vol. 3, Ch. 4 - Water Resources; Vol. 4, Ch. 1 - Aquatic Biology; Vol. 4, Ch. 2 - Terrestial Biology; Vol. 5, Ch. 2 - Public Health

2. Susan Tertell, Index to the Regional Copper-Nickel Study, (Minneapolis: Environmental Conservation Library, Minneapolis Public Library and Information Center, November 1980).

FOOTNOTES:

1. The gross value of recoverable copper, nickel, and cobalt was calculated using per pound prices of $0.87, $3.45, and $25.02, respectively for each metal. These are January 1981 average U.S. producer prices, from Engineering and Mining Journal, vol. 182, no. 2 (February 1981).
2. Minnesota State Planning Agency, Minnesota Pollution Control Agency, Minnesota Department of Natural Resources, Minnesota Department of Health, 1981 Report to the Legislature on Copper-Nickel Development, Prepared Pursuant to Minnesota Laws 1980, Ch. 614, Sec. 181 (St. Paul: State Planning Agency, et al., February 1981), p. 25.
3. See also RCNS, Vol. 1, pp. 91-93; RCNS, Vol. 4, Ch. 2, pp. 105-116 and sections 2.8-2.12; and
   Minnesota Legislature, House, "Unedited Transcript, Testimony of Mr. Robert Poppe on the Regional Copper-Nickel Study, Presented to the House Environment and Natural Resources Committee, Thursday, October 18, 1979." (St. Paul: Minnesota Legislature, undated), pp. 2-3.
4. Paul Eger, Division of Minerals, Minnesota Department of Natural Resources, St. Paul, written communication, received March 27, 1981.
5. Minnesota State Planning Agency, op. cit., p. 13.
6. Ibid., pp. 21-23, and RCNS, Vol. 1, p. 51.
7. Technical Advisory Committee on Copper-Nickel Mining, Report to the Environmental Quality Board from the Technical Advisory Committee on Copper-Nickel Mining (St. Paul: Minnesota Environmental Quality Board, June 1980), p. 4.
8. Kim Lapakko, Grad Engineer I, Division of Minerals, Department of Natural Resources, St. Paul, statement during telephone conversation, April 6, 1981.
9. Minnesota Legislature, House, "Unedited Transcript, Testimony of Mr. Robert Poppe," op. cit., p. 5; and statement by Paul Eger, Division of Minerals, Minnesota Department of Natural Resources, St. Paul, telephone conversation, March 3, 1981.
10. Minnesota State Planning Agency, op. cit., p. 14.
11. A 1974 estimate is that Minnesota sources generate 300,000 metric tons of sulfur dioxide annually [RCNS, Vol. 3, Ch. 3, p. 85].
12. Dr. Ingrid Ritchie, Research Scientist, Health Risk Assessment, Division of Environmental Health, Minnesota Department of Health, Minneapolis, statement during telephone conversation, April 3, 1981.
13. Minnesota State Planning Agency, op. cit., p. 10.
14. Airborne heavy metals from a smelter which meets federal new source performance standards was estimated by the RCNS to increase the background copper concentration in soils (estimated at 14 parts per million) by 2 to 40 times after 25 years. Highest deposition of metals occurs at 3 miles from the smelter; lowest of the range given, at 25 miles. Background nickel concentration was estimated to be about 7 parts per million; air deposition was estimated to increase this concentration by 2 to 500 times, depending on distance from the smelter. From Ingrid Ritchie, op. cit.

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