pt 36

Milwaukee Journal Sentinel
September 15, 1997

Heavy manufacturer mines for business

CEO's office is a plane, as he visits holdings in several countries

100 WISCONSIN 100
LARGEST PRIVATE COMPANIES

Editor's Note: *This is the first in an occasional series of profiles on companies listed in this year's Wisconsin 100.*

By Lee Hawkins Jr.
of the Journal Sentinel staff

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- [illegible] Millersburg, Ky.
- [illegible] Denver
- [illegible]
- [illegible] Mexico
- [illegible] Pty Ltd. Brisbane, Australia
- [illegible] Ltd. Nottinghamshire, England

MANUFACTURERS OF OTHER PRODUCTS

- [illegible] Inc. Iron River, Mich. Computer-controlled timber harvesting equipment
- [illegible] Delavan, Wis. [illegible]
- Lake Shore Inc. Iron Mountain, Mich. Heavy equipment [illegible] and the U.S. Army and Navy
- [illegible] Detroit. Heavy construction equipment

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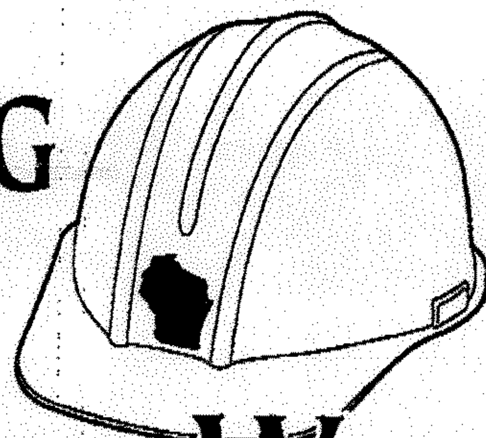
Coalition for Fair Regulation

Mining Matters to Wisconsin Workers



A mobilization kit for the Milwaukee area legislative hearing

The Coalition for Fair Regulation • [illegible]

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Please copy everyone on the attached list.

Thank You

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FAST FACTS ABOUT MINING

Every American uses an average 40,000 pounds of new minerals each year.

Mining has touched less than 1/4 of 1 percent of all the land in the United States.

Nearly 300,000 people work directly in mining throughout the United States. Employment in industries that support mining, including manufacturing, engineer, environmental and geological consultants, accounts for about three million jobs.

Processed materials of mineral origin account for 5 percent of U.S. gross domestic product.

Only 3 million acres of public land, about the size of a single county in Nevada, have gone into private ownership from mining, compared with 94 million acres granted to railroads and 288 million acres as agricultural homesteads.

Minerals account for exports worth as much as $6 billion per year. U.S. exports minerals and materials processed from minerals are worth $26 billion.

Your telephone is made of aluminum, beryllium, coal, copper, gold, iron, limestone, silica, silver, talc and wollastonite.

Without boron, copper, gold and quartz, your digital alarm clock would not work.

Everything from the carpet (limestone, selenium, lime, soda ash, zeolites, bentonite, titanium, sulfur, diatomite) under your feet to the doorknob (iron) on your door comes from mining.

The United States is the world's second-largest producer of gold, which in addition to jewelry, is used to make computer circuitry.

A television requires 35 different minerals, 40 minerals are used to make telephones and 15 minerals are needed to make a car.

America's copper mines rank second only to Chile in production. One mine alone (Phelps Dodge's Morenci) produced 1 billion pounds of copper in 1996.

The average miner makes $43,653 per year in salary, not including overtime, bonuses and benefits.

U.S. metal/nonmetal miners reported only 4.95 injuries per 100 workers in 1995, a lower rate of occupational injuries than grocery and department stores, hospitals, restaurants and even hotels.

The United States is the world's leading producer of beryllium, molybdenum, phosphate rock and salt.

Investment in technology, training and equipment has made the U.S. mining industry the safest in the world.

Minerals such as boron, clay, kaolin, sulfur, talc, titanium and trona are used to help make paper.

To return to the home page, click here.

THE IMPACTS OF MINING ON THE ECONOMY OF WISCONSIN 1995

Value of minerals mined in Wisconsin $420,901,000

Direct contribution to federal government revenues $24,595,000

Wisconsin's Direct Economic Gain from Mining $608,016,000
Including:
- Personal Income Gain of $111,568,000
- Business Income Gain In-State of 112,103,000
- Business Income Gain from Other States of 357,120,000
- State and Local Government Revenue Gain of 27,225,000

The Indirect Gain from Direct Gains $3,815,329,000
Including:
- Personal Income Gain of $698,734,000
- Business Income Gain of 2,972,212,000
- State and Local Government Revenue Gain of 144,383,000

and
Wisconsin's Indirect Gain from Interstate Income Flows $5,283,137,000
Including:
- Personal Income Gain of $1,763,835,000
- Business Income Gain of 2,276,818,000
- State and Local Government Revenue Gain of 313,387,000
- Federal Government Funds Gain of 929,097,000

Wisconsin's Combined Direct and Indirect Gain **$9,706,482,000**
Including:
- Personal Income Gain of $2,574,137,000
- Business Income Gain of 5,718,253,000
- State and Local Government Revenue Gain of 484,995,000
- Federal Government Funds Gain of 929,097,000

Total Wisconsin Jobs Gained, Directly and Indirectly **98,800**
Wisconsin Jobs Gained, Directly **2,200**

Source: Western Economic Analysis Center - Economic Impacts by State

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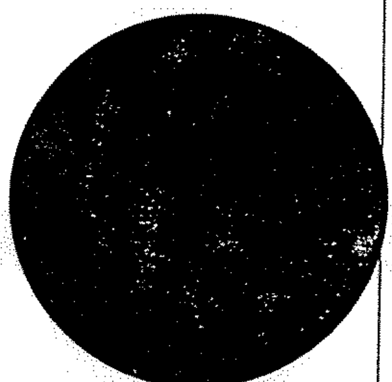

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Mineral Resources, Environmental Issues, and Land Use

Carroll Ann Hodges

Contrary to predictions from the 1950s through the mid-1980s, persistent shortages of nonfuel minerals have not occurred, despite prodigious consumption, and world reserves have increased. Global availability of raw materials is relevant to policy decisions regarding mineral development and land use. **Justification for environmental protection may exceed that for mining a specific ore body. Demand for environmental accountability is** rising worldwide, and new technologies are enabling internalization of costs. Mineral-rich developing nations plagued by inefficient state-owned mining enterprises, high population growth rates, and environmental degradation could realize substantial benefit by reforming government policies to encourage foreign investment in resources and by appropriate allocation of mineral rents.

The extent to which U.S. nonfuel minerals industries, and thereby the nation, are adversely affected by land restrictions and environmental regulations, and public advocacy thereof, has long been debated (*1–4*). A presumed consequence of such restrictions is the departure of metal mining companies to less developed nations. The relative importance of factors such as labor costs, exploration potential, political stability, and investment incentives, as well as U.S. foreign policy interests, is seldom acknowledged in this debate.

In the five decades since World War II, the volume of nonfuel minerals consumed has exceeded the sum total extracted from the Earth throughout all of human history up to mid-century (*5*). The economic growth that ensued with the rebuilding of war-torn nations after 1945 fueled massive expansion of mineral extraction and utilization, generating widespread concern that the world's mineral endowment would soon be depleted. In 1968, Park (*6*) contended that growing world population coupled with ever-increasing consumption of the world's finite resources would lead inevitably to international conflict and that if steps were not taken to address the issue of pending resource exhaustion, such conflicts could well shatter the world before the end of the 20th century. Also in 1968, Ehrlich (*7*) forecast diminishing resources unable to sustain the exponential growth of human numbers, and Hardin (*8*) emphasized the grave environmental and social consequences of uncontrolled human reproduction. Soon thereafter, the Club of Rome issued *Limits to Growth* (*9*), with its gloomy predictions about minerals exhaustion in the face of ever-growing population and industrialization.

Yet, despite the specter of resource scarcity that has prevailed throughout much of this century, no sustained mineral shortages have occurred. Even the economically disrupting oil crises of the 1970s and 1980s were brought on not by pending global exhaustion of oil but rather by political grievances. Furthermore, the demise of the resource-rich Soviet Union has added another major variable to the equation of materials supply and demand.

Historically, the rate of increase in mineral consumption has consistently outpaced the population growth rate (*10*). For example, while world population doubled between 1950 and 1990, production of six major base metals (aluminum, copper, lead, nickel, tin, and zinc) increased more than eightfold (*11, 12*). Increasing at a rate of nearly 1 billion people per decade, human population is growing faster than ever and, at its present annual rate of about 1.7% (*13*), will double from 5.7 billion to 10 or 12 billion by about the year 2035. Thus, it is inevitable that mineral consumption will continue to increase. About 95% of global population growth is occurring in the developing world (*13, 14*), where consumption is growing rapidly, but the developed world still consumes the bulk of mineral commodities. The United States, with 263 million people (4.5% of the world total), is the third most populous nation, after China and India. In 1990, U.S. consumption of 10 major ferrous and nonferrous metals (including that in goods exported) was about 10% of world production (*12*).

Historical perspective. In 1900, the United States was essentially self-sufficient in most metals. Legal codes, notably the General Mining Law of 1872, and technological innovation fostered exploitation of the land's mineral wealth so rapidly and successfully that it was widely presumed North America possessed a unique abundance of minerals (*15*). Indeed the United States remains the world's largest producer of raw minerals (*16, 17*), but it now relies increasingly on imports from a wide diversity of suppliers (Fig. 1), as do most other nations. World trade is expanding dramatically, including that in nonfuel mineral commodities (Fig. 2).

Shortly after World War II, concern about future U.S. minerals vulnerability became paramount; resources had been stretched by two world wars, and war was then flaring in Korea. In 1950, President Truman appointed the Commission on Materials Policy to assess America's position and to recommend policy necessary to meet resource needs over the next 25 years. In 1952, this commission issued its comprehensive, landmark report *Resources for Freedom* (*18*). Many of its premises are pertinent today, even though the commission's forecasts of worldwide metals usage by the year 1975 were vastly underestimated: By the mid-1970s, consumption of most key metals (aluminum, copper, zinc, chromium, iron, manganese, and nickel) was at least twice that predicted. The forecasters had failed to anticipate the incredible rebuilding and economic boom in postwar Europe and Japan (*19*). In contrast, consumption of most metals in the United States was somewhat less than predicted, partly because the industrial infrastructure in this country after World War II was undamaged and thriving. The notable exception was aluminum, consumption of which was nearly eight times the 821,000 metric tons used in 1950, compared with the predicted twofold increase; the entire free world consumption of primary aluminum was more than nine times that used in 1950 (Table 1), whereas the forecast was for only twice as much (*18, 19*).

Such appetites for the world's resources led to the proliferation of warnings of impending crises in minerals availability (*4, 6, 9, 20–22*), but despite prodigious consumption of minerals since World War II, known world reserves of most major minerals increased from the 1940s through the 1980s (Table 2) (*19, 23, 24*) and, as currently estimated (*25*), are robust (Table 3). Furthermore, the prices of most metals today have changed little, in constant dollars, over the last 150 years (*11, 24, 26, 27*). Although cyclical, the trend (Fig. 3), exemplified by copper (Fig. 4), has been level or downward since about 1850, despite accelerated production, which might have hastened depletion.

The author is with the U.S. Geological Survey, Menlo Park, CA 94025, USA.

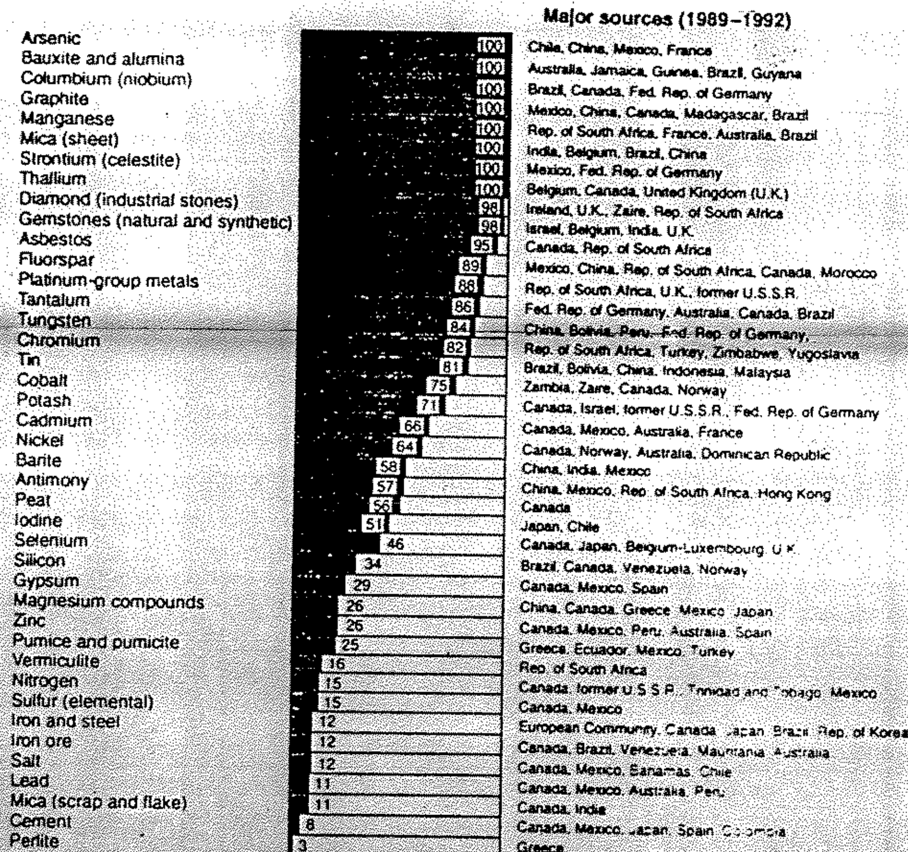

Fig. 1. Estimated U.S. net import reliance (1993) on selected nonfuel mineral materials as a percent of apparent consumption. Net import reliance = imports − exports − adjustments for government and industry stock exchanges; apparent consumption = U.S. primary + secondary production + net import reliance. [From (25)]

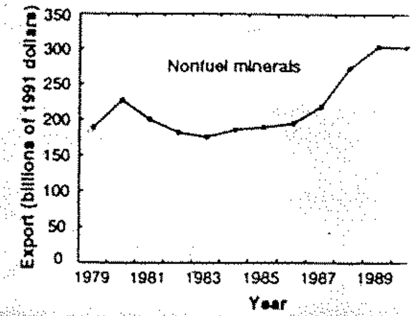

Fig. 2. World mineral commodity export [Data from (17)]

Factors Affecting Minerals Availability

Most parts of the planet have proven generously endowed with useful mineral resources, but specific minerals are not evenly distributed, as is demonstrated by well-established metallogenic concentrations. Primary mineral resources, in anomalous concentrations and accessible on our human time scale, are nonrenewable and ultimately finite; their availability depends on technological innovation, production cost, and commodity price.

Despite an apparent limit to resources, adequate world mineral supplies have been maintained. Major new discoveries in recent decades—disseminated gold deposits in the American West, huge iron and bauxite deposits in Brazil and Australia, large ore bodies in Alaska, Ireland, Chile, and elsewhere—have resulted from advance geologic knowledge, new technologies, in the case of gold, higher real prices, the fact that little exploration occurred ing and between the world wars (19). T nological improvements in mining metal recovery have enabled massive e moving operations, extraction of l grade ores, and greater efficiency in pro tion, with attendant reductions in c Gold provides an illustrious example though its case is unique because c monetary tie and fixed dollar price 1971. World production, 47 million ounces in 1971, increased strongly afte price was allowed to float and has st high (74 million ounces in 1993) as declined over the last decade (Fig. 5) United States is now the second lea gold producer in the world (10.6 mi troy ounces in 1993), after South A (20.2 million troy ounces) [China he the world's leading gold consumer in at about 11 million troy ounces (World reserves of gold were estimated billion troy ounces in 1971 (29), and more than 20 years of rising produc world reserves now amount to more 1.35 billion troy ounces (25).

A number of factors conspired to l the growth of mineral demand afte mid-1970s throughout industrialized tions, although total consumption rea record levels by 1990 (30). Worldwide

Table 1. Free world consumption* of primary metal in 1950 (18).

Metal	Consumption (10^3 metric tons)
Aluminum	1,440
Copper	2,737
Iron ore	192,000
Lead	1,865
Nickel	120
Tin	169
Zinc	2,011

*In 1950, data were available from the Free World only; production from countries with centrally planned economies, however, represented less than 25% of the global aggregate of most commodities (30). The purpose of the President's Commission was to assess raw material supplies, irrespective of scrap consumption. Therefore, the 1950 and 1990 data (Table 3) are not truly comparable but illustrate the relative magnitude of increased consumption.

Table 2. Growth of the world [illegible] base of selected commodities (contained metal near the end relevant decade). [illegible] used by the U.S. Bureau of Mines, includes reserves, whi currently economic [illegible] resources, which are currently subeconomic and mar economic but can [illegible] to become economically available. The data are from based on that from [illegible] Mines; 1993 data are from (25).

Decade	World reserves base (millions of metric tons)			
	[illegible]	Lead	Zinc	Alum
1940s	[illegible]	[illegible] to 45	54 to 70	[illegible]
1950s	[illegible]	[illegible] to 54	77 to 86	[illegible]
1960s	[illegible]	86	106	[illegible]
1970s	[illegible]	[illegible]	240	[illegible]
1980s*	[illegible]	[illegible]	295	[illegible]
1993	[illegible]	[illegible]	330	[illegible]

*Gross weight of bauxite [illegible]

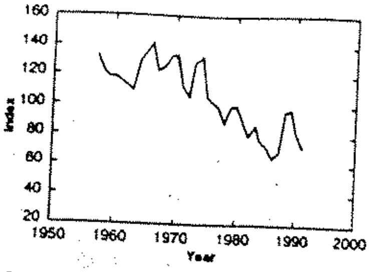

Fig. 3. Index of nonfuel mineral prices in constant (1980) dollars from 1957 to 1991. [Reprinted from (45) courtesy of Worldwatch Institute; data from International Monetary Fund and United Nations]

nomic expansion was extraordinary between 1950 and 1974 but then slowed considerably, in large part because of the oil crises; consequently, growth rates of metals consumption declined substantially (Fig. 6), resulting in worldwide surplus inventories (30, 31). The economies of Japan and western Europe leveled off after their blazing recovery from World War II. Further, the trend in both per capita use and intensity of use (volume relative to gross national product) of minerals in industrialized countries is down; mature economies with infrastructures largely in place become increasingly tied to

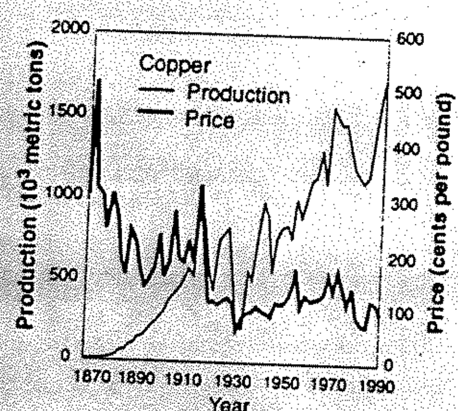

Fig. 4. U.S. copper production and price in constant 1987 dollars. [From (87)]

Table 3. Worldwide annual consumption in 1991 (13) and reserve base in 1993 (25) of selected metals [consumption includes primary and secondary (scrap) metal, except for iron, which includes only crude ore].

Metal	Annual consumption (10^3 metric tons)	Reserve base (10^3 metric tons of contained metal)
Aluminum	17,194	28,000,000*
Copper	10,714	590,000
Iron	959,609	230,000,000
Lead	5,342	130,000
Nickel	882	110,000
Tin	218	10,000
Zinc	6,993	330,000

*Bauxite (crude ore).

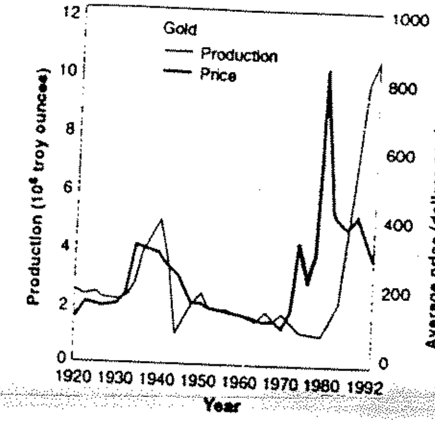

Fig. 5. U.S. gold production and world gold price in constant 1987 dollars; 1992 values are estimates. [From (87)]

high technology and service industries that require less intense use of raw materials, thanks to miniaturization, economies of scale, and substitution (19). This stage appears to represent a "structural saturation of demand" (31), not simply a temporary drop in demand. Rapid technological advances have delivered new materials and new products—ceramics and composites (derived from more abundant nonmetallic minerals), in addition to pervasive plastics—all substituting for metals to some degree (32).

Recycling has increased significantly throughout the industrialized world (31, 33) (Fig. 7); recycled scrap is generally a cheaper source of metals, because of lower energy costs, and is profitable for many, particularly aluminum, for which production from scrap uses only 5% of the energy required to win the metal from bauxite ore. Recycling steel reduces energy consumption by 61%. In the United States, one metric

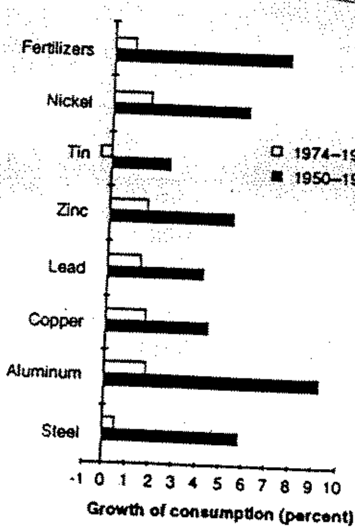

Fig. 6. Growth rates from 1950 to 1985 of world consumption of major metals and minerals. [Adapted from (31) with permission from the Natural Resources Center (CERNA), Paris]

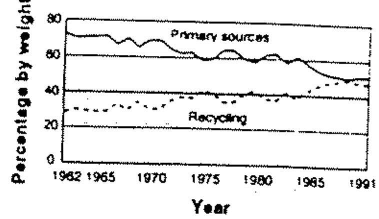

Fig. 7. U.S. metals consumption from primary resources and from recycled material. [From (33)]

ton of raw steel requires 0.60 ton of ferrous scrap. In 1990, recycled scrap accounted for a substantial fraction of total U.S. metals consumption (Fig. 8). Of all the gold ever mined, 85% is thought still to be in use, storage, or collections.

Contrary to mid-century expectations, mineral supplies, metallic and nonmetallic, are now thought to be adequate for the next 100 years or so (19, 34, 35). Markets will continue to be cyclical, but indications are that new production, recycling, substitution, and technological innovation will rise to meet the demands of a continually expanding population. In the last decade of this century, more urgent world concerns are likely to be loss of soils, water, biodiversity, and environmental degradation (27, 34–37).

Environmental Concerns

A significant factor affecting minerals availability today is the environmental conscience that has arisen over the last three decades throughout the industrialized world and, increasingly, in developing countries. It has engendered controversy and antagonism within the extraction industries. Exemplifying the dispute in the United States is the proposed Crown Butte gold mine in

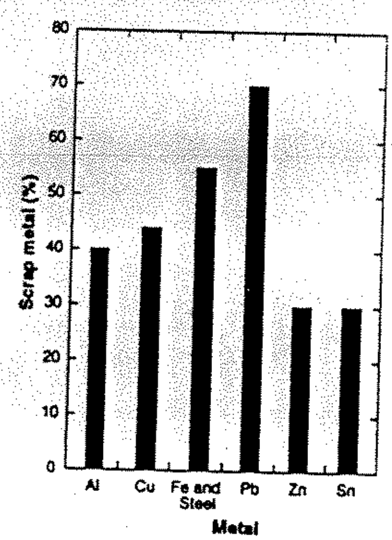

Fig. 8. Amount of scrap metal used in the United States as a percentage of total consumption. [Data from (33)]

Wyoming (4 km from Yellowstone National Park and surrounded by designated Wilderness), which has generated heated opposition and underscored arguments for Mining Law reform (*38*). Contrary to the mindset of 100 years ago, a growing segment of the U.S. population today places higher value on natural assets other than gold, particularly on public lands. Where once mining was widely regarded as the "highest and best" use of land, irrespective of its suitability for other purposes (the concept that underpins the Mining Law of 1872 still today), federal lands are now valued for multiple resources: wilderness, historic sites, wildlife, or scenery, for example (*39*, *40*). Even though metallic and nonmetallic mining operations, past and present, occupy only a small fraction of total land area in any country (0.25% of the United States as of 1980, one-tenth of which was metal mining) (*41*, *42*), the scars are long-lasting, and the environmental impact can extend well beyond the limits of disturbed ground through air pollution and water contamination. Mines are not perceived as compatible with wilderness or wildlife, and the lack of glaring shortages, together with shrinking employment in the industry [down 80% in the last 20 years (*43*)], has relegated mineral resources to a status of secondary importance in much of the public reckoning. Direct employment in metal mining in the western United States (including Alaska) now accounts for only 0.1% of total employment in the region (*40*).

Historically, environmental damage incurred in the course of extracting minerals worldwide has been largely an externality; these social costs have not been incorporated in the price of the product. For example, mining on U.S. public or patented land carries no obligation to address the environmental aftermath under the Mining Law of 1872 (although various regulations have subsequently been imposed, mainly by states). That law permits free access for exploration on public lands, filing of claims, and conveyance of title (patent) for fees of $2.50 (placer) or $5 (lode) per acre, with no subsequent royalty payments on production. These provisions, accorded for sound reasons in 1872, amount to government subsidy of mining operations on U.S. federal lands (*44*). Highlighting this legal legacy was the acquisition in May 1994 of 1800 acres in Nevada by a Canadian corporation, to whom a reluctant Secretary of the Interior conveyed title to gold resources reportedly valued at $8 billion to $10 billion, in exchange for $9000. In addition to this land and resource subsidy, federal tax law applies depletion allowances ranging from 5 to 22% to more than 50 mineral commodities. Other mining countries commonly also provide subsidies to domestic minerals industries operating at home or abroad (*44*, *45*). This legal lack of full accountability has helped to keep metals cheap on the world market.

Environmental resources—such as water, land, air, and wildlife—have constituted a public commons, seen as free and unlimited, throughout most of the world (*8*, *27*). But those commons have been visited by tragedy. In the United States, 52 abandoned mines have been designated Superfund sites by the Environmental Protection Agency (EPA), largely because of toxic effluent, notably acid mine drainage. Most are historic, but the latest case is Summitville, Colorado, where a Canadian company went bankrupt in 1992 after extracting 280,000 ounces of gold; the clean-up tab may be as high as $120 million. The total bill for all of these Superfund sites is estimated at $12.5 billion to $17.5 billion (*46*).

The mining industry's image has been damaged by its past record, but having been forced by regulation and public reaction to change its ways, and having found it cost-effective to do so, much of the industry today exhibits better environmental stewardship. The Homestake McLaughlin mine, north of San Francisco, California, is exemplary. With facilities in three different counties, Homestake required a total of 327 different permits before gold production could begin. Yet, by adopting a proactive strategy involving community members and potential adversaries at the beginning of the permitting process, only 6 years elapsed between discovery and the first bar of gold. Costs of meeting environmental requirements constituted less than 2% of the $284 million total capital cost of the mine. Furthermore, as the mine operates, reclamation is proceeding toward its final conversion to an environmental studies field station (*47*, *48*).

Improved technology has permitted great strides in the mitigation of environmental impacts. The new $880 million Kennecott smelter-refinery complex at Bingham, Utah, is both environmentally correct and cost-effective (*49*). Expected to be among the cleanest in the world, the smelter will retain 99.9% of the sulfur produced, compared with 93% today. Production costs at the new plant will be reduced by 53%, making Kennecott one of the cheapest copper producers worldwide. Innovative, dynamic companies can gain competitive advantage by preventing pollution at the source, saving costly clean-up bills and accommodating environmental constraints with new, efficient technology (*50*). Increasingly, economic incentives relying on market mechanisms are the basis for encouraging minerals industries to address environmental priorities (*50*, *51*).

If costs of environmental protection are thus internalized in the industrialized world, how likely are mineral-rich developing nations to follow suit? Are nations beset by poverty and growing populations so eager for the financial benefits of mineral export that environmental degradation is inconsequential relative to gains from resource exploitation? Indications are that demands for environmental accountability are rising among Third World nations, and they are being heard by both policy-makers and industry (*42*, *50*–*54*). In mid-1991, an international conference in Berlin on "Mining and Environment" established formal guidelines addressed to both the minerals industries and major funding agencies (*53*). Among these guidelines are (i) that all parties must "recognize environmental management as a high priority, notably during the licensing process . . ." and (ii) "Environmental accountability in industry and government must be established at the highest management and policy-making levels." There are 12 more guidelines addressed to the minerals sector and 10 to development assistance agencies, all directed toward ensuring protection of the "global environmental system."

The International Council on Metals and the Environment (ICME), comprising 27 national and multinational metal companies and representing 10 countries, was established in March 1991 "to promote sound environmental and related health policies and practices to ensure the safe production, use, recycling, and disposal of metals," to promote excellence within the global industry, and ultimately "to foster environmentally sustainable economic development" (*55*). Also in 1991, the Mining and Environment Research Network was launched in the United Kingdom, its goal being to help mineral-producing countries improve environmental management and protection by capitalizing on the lessons learned in industrialized nations (*56*). The *Mining Journal*'s Environment Supplement of 1991 (*53*) noted that neither pollution nor public opinion respects national boundaries and concluded that companies from the industrialized world will be required to adhere to environmental standards imposed by their own societies as they develop projects elsewhere around the globe, a conclusion voiced also by former EPA chief Reilly (*57*).

Although minerals were conspicuous by their absence at the highly publicized "Earth Summit" in Rio de Janeiro in June 1992, environmental sensitivity was not; the concept that the polluter pays for environmental damage was widely embraced (*54*). A 1993 seminar in Zimbabwe on small-scale mining further underscored demand for environmental responsibility on the part of investors in development projects (*58*). Even the World Bank has added, as of 1987, environmental assesments to its modus operandi (*59*); Bank President Preston has stated that paying too little attention to the environment was the worst mistake made by the World Bank in its first 50 years (*60*). Environmental regulation is here to stay and likely to become more widespread, more stringent, and better enforced (*42, 51, 54, 61*). Numerous mining projects throughout the globe have been canceled, deferred, shut down, or sued in the last 10 years because of environmental objections (*42, 62*).

Although worldwide environmental standards are neither feasible nor appropriate because ecological and social conditions vary, the establishment of industrywide codes of conduct could improve the industry's credibility in its efforts to demonstrate that mining is compatible with environmental protection (*61*). Standards are often minimal and poorly enforced in developing nations, but multinational firms are instituting comprehensive environmental management systems to minimize impacts in anticipation of more stringent regulation and to avoid criticism for "exporting pollution" (*42*). Newmont Mining Corporation recently announced that substantial investments will be made at their new gold mine in Indonesia to ensure that the mine operates under the same environmental standards applied to its U.S. projects (*63*). Increased emphasis worldwide will promote commercialization of innovative, "green" technologies (*54*). If major mining companies are constrained to operate in developing nations with the same expectations imposed in their home countries, broad-based internalization of the costs of sound environmental practice will be required. Improved technology may compensate for additional costs necessary for environmental protection; such costs escalate as ore grades decline, however, and higher mineral commodity prices may eventually result.

In the developing world, even in countries with existing environmental statutes, state-owned enterprises have been particularly egregious in ignoring environmental impacts, largely because of production inefficiencies, poor management, obsolete technologies, and obligations to provide social services (*30, 51, 64*). Multinational corporations in general have a far better environmental record, and competition in the global metals market encourages new technologies and efficient management (*54*). Nationalization of resource industries was extensive in emerging nations during the 1960s and 1970s, but the economic difficulties of the 1980s have led many countries to seek renewed private investment. Because of capital requirements, mining enterprises in Third World nations are likely to be increasingly operated by multinational consortia (*30*). Thus, leadership by the global mineral community in addressing environmental issues is critical.

Is the concept of sustainable development applicable to the extractive minerals industry? Can ever larger supplies of finite mineral concentrations be found and exploited without lasting damage to environmental resources, and how long can such ore bodies be sustained? According to von Below (*52*), "Sustainable development in mining can be achieved only through continuous exploration, technological innovation, and environmental rehabilitation." The first two requirements cannot be sustained over the long term without investment in the third, and all resources, environmental as well as nonrenewable, must be priced realistically in order both to accommodate the environment and to avoid wasteful production and consumption of minerals (*52*). Sustainable development requires that nonrenewable mineral resources be managed so that the wealth they generate effectively substitutes for the depleting mineral asset (*61*). Recycling is also key, contributing substantially to current supplies of most metals; greater stimulus through government policies that provide market incentives could undoubtedly increase the use of scrap. Nearly all metals can be recycled indefinitely from most uses (*23*), but even if the population were to stabilize, recycling could not meet all of society's needs.

Less Developed Countries and the Global Market

Since World War II, the overriding principle of the U.S. de facto minerals policy has been to obtain mineral supplies adequate for U.S. needs at the lowest possible cost, commensurate with the interests of friendly nations (*18*). That dictum still applies and will continue to require U.S. dependence on sources overseas. Irrespective of environmental constraints in the United States (and possible Mining Law reform), mineral development abroad is advantageous because of low labor costs, revised legal codes, and attractive exploration targets in newly accessible territory. Environmental mitigation and rehabilitation measures will increasingly be required of new mines (*51*).

The most critical environmental problem today is the inexorable growth of the human population (*65*) and attendant resource use, in both industrialized and developing worlds (Fig. 9). That reality must be of foremost concern to those charged with ensuring adequate supplies of raw materials. Some of the fastest growing populations are in less developed nations, a substantial number of which are dependent on minerals for a major share of their foreign exchange earnings (Table 4). If improved economic and social conditions (specifically the educational status of women) are incentive for reduction in fertility (*13, 14*), it may be that the minerals industries are well positioned to enhance the circumstances of minerals-rich emerging nations. However, mineral resource wealth does not have a good track record in post–World War II developing nations insofar as launching them toward economic prosperity (*66*). Low mineral prices have not helped, but the problem stems largely from the sort of political and economic difficulties so evident in many developing countries. Nonfuel mineral exports constituted 40% of the total exports from 16 "mining countries" at least once since 1975 (Fig. 10), but the economic plights of many such well-endowed nations are bleak (*66, 67*).

Consider Zaire: Not only is it the world's major supplier of cobalt, but until 1987, it was the world's largest producer of diamonds (now greatly surpassed by Australia). It also has substantial reserves of copper, tin, and tungsten, and yet, political turmoil has generated economic disaster. Its state-

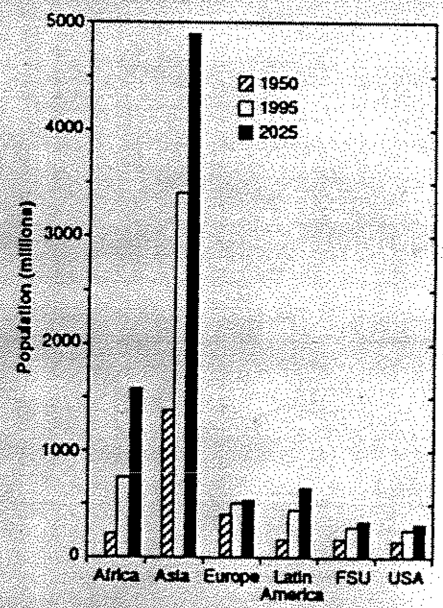

Fig. 9. Selected human populations. FSU, former Soviet Union. [Data from (*13*)]

Table 4. Population in 1995 and current growth rates in selected mining countries (*13*).

Country	Population (millions)	Growth rate (%)
Bolivia	8.07	2.4
Botswana	1.43	2.9
Guinea	6.7	3.0
Mauritania	2.34	2.9
Niger	9.10	3.3
Peru	23.85	2.0
Surinam	0.46	1.9
Zaire	43.81	3.2
Zambia	9.38	2.8

owned mining company produced over 400,000 metric tons of copper in 1989, which political interference had reduced to less than 50,000 tons by 1993 (*68*). Zambia has had a poor record as well, relying on its copper industry while permitting its agricultural infrastructure to collapse (*66*). Despite a sharp drop in mineral commodity prices in 1975, mining continued to siphon labor from agriculture throughout the 1970s; the Zambian government was forced to retain high wages for copper miners while relying on imports for necessary foodstuffs, thus consuming much of the rent acquired from mining and thereby falling victim to "Dutch Disease" (*54, 61, 69*). Today, per capita income in sub-Saharan Africa is less in constant dollars than it was in 1960 (*65*), when countries began to gain independence. A widespread decline in per capita income occurred in mining countries between 1975 and 1987 (Fig. 11) for several reasons, including the economic downturn throughout the industrialized world. More recently, these nations as a whole "have lost one-sixth of their commodity export earnings over the past two years due to falling commodity prices" (*70*). There was also the relentless increase in population. The World Bank (*71*) estimates that over the next 40 years, the population of sub-Saharan Africa will triple to 1.5 billion. The impact of these growing numbers (*72*) is cause for concern, particularly as industries strive to become competitive in the world market through increased productivity, often with consequent reduction in work force.

The former Soviet Union is an exceptional case; its extraordinary mineral endowment made it virtually self-sufficient throughout the Cold War. Yet, despite vast natural wealth (and a low population growth rate of 0.5%), Russia and most of its neighboring states have experienced economic collapse, selling off stocks of mineral commodities at bargain prices and depressing the world market in metals such as aluminum, nickel, and chromium (*17, 25, 73, 74*). The metals sector is now the biggest foreign exchange earner after oil and gas in the former Soviet Union states collectively (*75*); it is also a notorious source of pollution (*76*).

There are more exemplary nations, however. Chile has overhauled its political, economic, and legal systems to capitalize productively on its resource wealth, diversify its economy, and address environmental concerns (*13, 41, 63*). Likewise, Mexico has made important changes to attract foreign investment in the mining sector (*77, 78*), now locked in by the North American Free Trade Agreement (NAFTA) (*79*). Bolivia, which enacted its General Environmental Law in 1992, has shown increasing support for privatization of mining interests (*80*), having recently put into place a new, broad-based capitalization law that advances privatization of five major state companies, including the state-owned tin producer (*81*).

The current situation in sub-Saharan Africa (exclusive of South Africa) is perhaps least conducive to foreign investment (*82*). Dependence on state-owned enterprises for mineral production in much of Africa has been counterproductive, to a large exte because of the ancillary social services su companies have been required to provi (*82*). In those developing nations endow with a significant mineral resource bas governments must assume the obligation maximize rents derived therefrom by attrac ing foreign investment and reforming fisc and regulatory policies. Rents captured fro mineral development and export can in prove the economic well-being of impove ished nations if directed toward stimulatin more diversified economies, ensuring co tinued viability of mining industries throug the infusion of private capital, and buildir independent structures dedicated to e hancing social welfare and education (*83* Internalization of environmental costs the private sector must be required to mi gate the current environmental toll. Sou Africa and Russia, both major minerals pr ducers and both embodying elements of t First and Third Worlds, now have the o portunity to reverse the historical record mineral-dependent nations by encouragir mining enterprise and judiciously managir mineral rents for long-term national goals

Multinational mining companies a eager to explore in favorable count wherever geological, political, and soci conditions are conducive to investme (*61*). Neither environmental regulatio nor lack of sufficient infrastructure is major deterrent if other factors are opt mum, but without government stabilit security of tenure, and legal assurance fair return, investment by multination corporations in either exploration or d velopment is unlikely.

In the final analysis, it may very well in the best interests of the industrializ world for mining firms to generate jobs ar income in resource-rich developing cou tries. Transfer of technology, training, ed cation, and environmental stewardship a major steps toward mitigation of both po erty and pollution, the downstream effec of which may include eventual reduction fertility—albeit these countries constitu but a small fraction of the world populatio problem.

Conflicts and trade-offs in resource deve opment. If resource exhaustion is not like to be of serious concern globally for th foreseeable future, then established land-u priorities may need revisiting. Can th United States, and the world, afford to a sign higher priority to environmental co cerns? **Should a decision to develop an o body now take into account the global co text of both minerals availability and ec logical resources?**

To illustrate the conflicts and trade-o that can arise between resource develo ment and environmental protection, co sider the iron deposit in the Nimba Mou

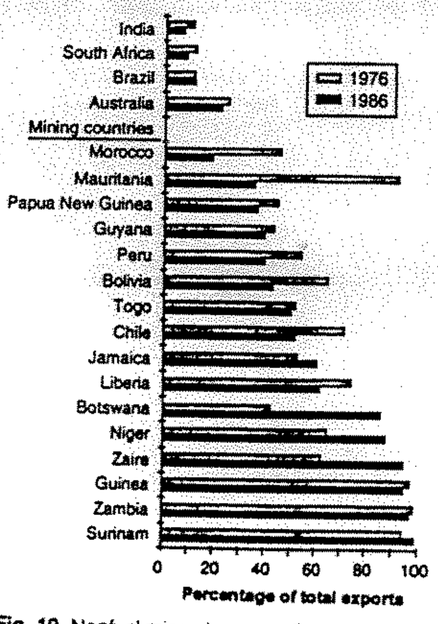

Fig. 10. Nonfuel mineral commodity exports as a percentage of total exports for selected countries. "Mining countries" are those whose nonfuel mineral exports have accounted for 40% of total exports at least once since 1975 (*66*). [Data from U.N. Conference on Trade and Development. Adapted from (*66*) with permission from Resources for the Future, Washington, D.C.]

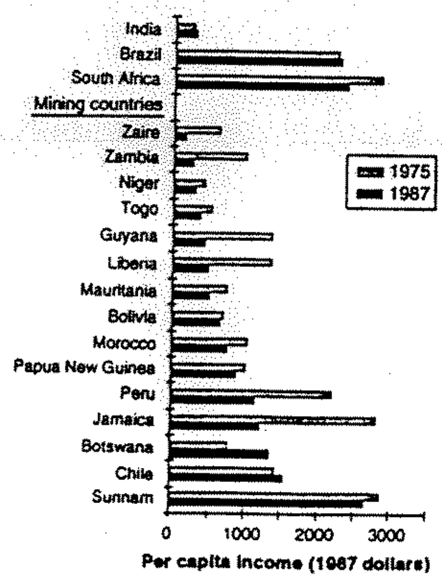

Fig. 11. Per capita income for selected countries. [Data from the World Bank; figure adapted from (*66*) with permission from Resources for the Future, Washington, D.C.]

tains of Guinea, where a large ore body has long been known. Reserves of high-grade ore (66.5% iron) are estimated at 350 million metric tons (84). A consortium of Western mining companies is eager to develop the deposit; the government of Guinea is eager for new mining rents and jobs. However, Mount Nimba, highest point (1760 meters) in the Nimba Range of West Africa, is in rain forest that harbors a number of unique species, and in 1981, the area was designated a World Heritage Site, an ecological preserve, by the United Nations (Yellowstone National Park in the United States is similarly designated). A Guinean nongovernmental organization has mounted a campaign against the project and enlisted the support of a major U.S. environmental group.

It might be asked if the world's need for iron ore is so great that mining should take precedence over ecological value. Proposed production of Mount Nimba iron ore at about 9 million metric tons per year is 1% of annual world production; China and the former Soviet Union each produce 200 million tons annually; Brazil alone produces about 150 million tons (25). The resource sought is not in short supply nor likely to be in the next century. Guinea is not bereft of other resources (84); it is the world's second largest producer of bauxite (after Australia), having almost unlimited reserves, and with significant production of gem diamonds and gold, Guinea is thought to have major geological potential for new discoveries of these minerals. Iron ore is not the country's only hope for hard currency exports.

Currently, the Mount Nimba project is on hold; the World Bank has withheld financial support, and civil war in neighboring Liberia has prevented linkage with the existing rail line to the coast. Negotiations are continuing, however, "and environmental objections to mining in Nimba National Park . . . are expected to be resolved to the satisfaction of UNESCO" (85). Indeed, the government of Guinea was successful in its appeal to the World Heritage Committee to exclude the proposed mine area from the World Heritage Site in a revised (1993) delimitation of its boundaries. The human impact on the ecological resources of the mountainous rain forest environment that would result from the project's implementation and attendant influx of population, however, would be difficult to mitigate (86). There are numerous economic, social, and environmental issues yet to be resolved, and appeals to block development are still pending.

Perhaps the potential conflict over mineral deposits and environmental resources is a matter for arbitration, if not by the United Nations, then perhaps by a corporate, multinational organization such as the International Council on Metals and the Environment. Such a self-policing role would seem to fall squarely within the Environmental Charter agreed to by members of that group. The Mount Nimba project represents the sort of dilemma the mining industry and developing nations are likely to confront with increasing frequency as hinterlands continue to disappear around the world.

Summary

Minerals essential to industrial economies are not now in short supply, nor are they likely to be for the next several generations. Accordingly, given the lack of pending crises in raw materials availability, mining can no longer presume de facto acclaim as the best of all possible uses for land; it must compete with compelling demands for alternative uses. Current debate regarding the disposition of U.S. public lands exemplifies this point, as do conflicts elsewhere. Environmental protection and rehabilitation are fast becoming high priorities throughout the world, no longer confined to industrialized nations. Human population growth is the most critical environmental problem facing the entire planet, and 95% of that growth is occurring in the developing world. Investment in mineral deposits of developing nations offers some hope of improving economic and social conditions in those countries that rely on mineral rents for hard currency, but realization hinges on reform and the implementation of long-range government policies for applying those rents to domestic welfare and ensuring environmental sustainability.

As world tensions among major powers diminish and trade expands in the aftermath of the Cold War, concerns about self-sufficiency and minerals security of the United States are no longer overriding. Of greater importance may be the contribution of mineral resource development to the economic rescue of emerging nations, and the consequent hope for an eventual reduction in population growth, without which environmental concerns in these nations are ultimately irrelevant.

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88. I thank numerous colleagues for provocative discu sions, particularly E. A. Thiers, J. J. Schanz, C. Frippel, G. Nash, W. P. Blacutt, and S. Straus all of whom offered valuable commentary. Form reviewers S. D. Ludington, J. J. Rytuba, and E. Thiers were particularly helpful in their suggestior for improving the manuscript, as were H. R. So and B. R. Lipin. Comments by B. J. Skinner, Brandon, A. Cendrero, and two anonymous reviev ers were most beneficial. K. Horta provided inform tion regarding the Mount Nimba project. S. Garc crafted the illustrations. The basic concept of th paper is a product of my year's affiliation (1992) wi Stanford University, where I developed a course o "Minerals and World Affairs" as a visiting professc in the School of Earth Sciences, under the Nationa Science Foundation's Visiting Professorships fo Women program. I thank the U.S. Geological Surve for permitting me to continue this research

RESEARCH ARTICLE

Mutagenesis and Laue Structures of Enzyme Intermediates: Isocitrate Dehydrogenase

Jill M. Bolduc, David H. Dyer, William G. Scott, Paul Singer, Robert M. Sweet, Daniel E. Koshland Jr., Barry L. Stoddard*

Site-directed mutagenesis and Laue diffraction data to 2.5 Å resolution were used to solve the structures of two sequential intermediates formed during the catalytic actions of isocitrate dehydrogenase. Both intermediates are distinct from the enzyme-substrate and enzyme-product complexes. Mutation of key catalytic residues changed the rate determining steps so that protein and substrate intermediates within the overall reaction pathway could be visualized.

Standard x-ray crystallography is usually performed on inactivated enzymes or inhibited enzyme complexes in order to prevent the rapid reaction of substrate and time-dependent averaging of electron density. However, polychromatic Laue crystallography, a technique whereby the x-ray source is a synchrotron, provides an increased rate for data collection so that the structural details of intermediate complexes can be visualized (*1–5*). Such Laue studies demonstrate the possibility of visualizing rate-limited enzyme-substrate complexes with very long lifetimes, but do not address the problem of transient intermediate species that normally are not rate-limited.

Determination of the structure of an enzyme-bound intermediate on a path of several intermediates requires a method of inducing the homogeneous synchronized accumulation of that particular species throughout the crystal, during which time diffraction data may be collected. One successful strategy has consisted of triggering an initial, synchronized turnover cycle in the crystal with a caged-type compound (usually a chemically modified substrate molecule that can be released by flash photolysis). During the first round of catalysis after photolysis, rate-limited intermediates accumulate and then decay, provided that the rate of all steps between the initial absorption of photons and the formation of the rate-limited intermediate complex are sufficiently fast. As an alternative strategy we now present the use of site-directed mutagenesis of key catalytic residues to create kinetic bottlenecks at specific catalytic steps in the overall reaction pathway that may then be used to determine the structure of distinct intermediates. Such complexes represent steady-state species that accumulate and persist in the crystal in vast excess of other catalytic states during the course of slow turnover and data collection.

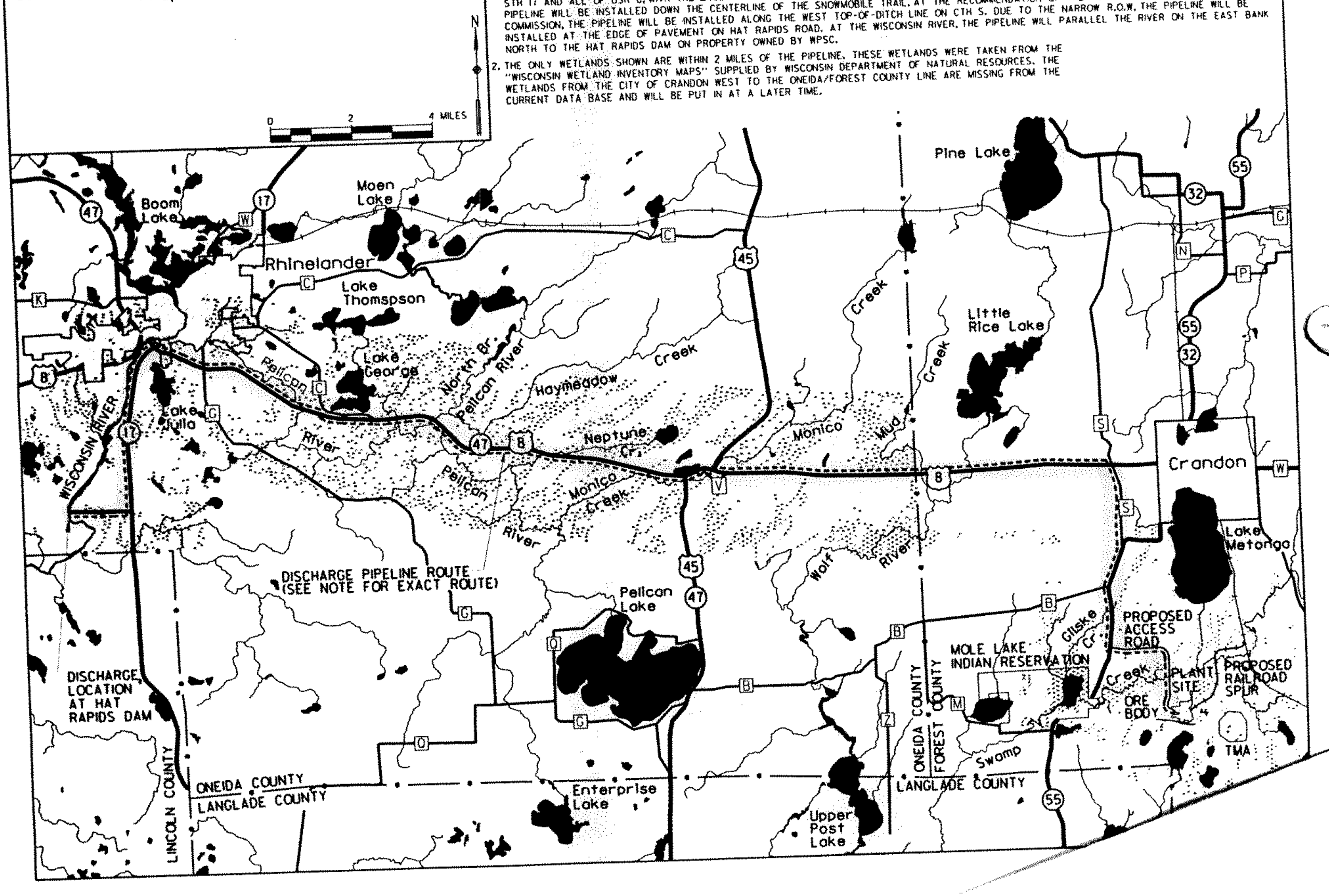
Figure 2-2. Proposed Pipeline Route For Wisconsin River Discharge

-------------- Proposed Pipeline Route

NOTES:

1. THE DISCHARGE PIPELINE ROUTE BEGINS AT THE CRANDON PROJECT SITE, FOLLOWS THE PROPOSED PLANT SITE ACCESS ROAD TOWARD THE NORTHWEST
TO STATE TRUNK HIGHWAY (STH) 55, APPROXIMATELY 1/2 MILE SOUTH OF AIRPORT ROAD, THEN NORTH ON STH 55 TO COUNTY TRUNK HIGHWAY
(CTH) S, THEN NORTH ON CTH S TO U.S. ROUTE (USR) 8, THEN WEST ON USR 8 TO STH 17. FROM THE INTERSECTION OF USR 8 AND STH 17, THE
ROUTE FOLLOWS STH 17 SOUTH TO HAT RAPIDS ROAD AND THEN WEST ON HAT RAPIDS ROAD TO THE HAT RAPIDS DAM. PER DISCUSSIONS WITH THE
WISCONSIN DEPARTMENT OF TRANSPORTATION (WISDOT), THE PIPE WILL GENERALLY BE PLACED 25 FEET FROM THE EDGE OF PAVEMENT ALONG STH 55,
STH 17 AND ALL OF USR 8, WITH THE EXCEPTION OF THE PORTION RUNNING ALONG A SNOWMOBILE TRAIL NORTH OF USR 8 FROM CTH S TO CTH V. THE
PIPELINE WILL BE INSTALLED DOWN THE CENTERLINE OF THE SNOWMOBILE TRAIL. AT THE RECOMMENDATION OF THE FOREST COUNTY HIGHWAY
COMMISSION, THE PIPELINE WILL BE INSTALLED ALONG THE WEST TOP-OF-DITCH LINE ON CTH S. DUE TO THE NARROW R.O.W. THE PIPELINE WILL BE
INSTALLED AT THE EDGE OF PAVEMENT ON HAT RAPIDS ROAD. AT THE WISCONSIN RIVER, THE PIPELINE WILL PARALLEL THE RIVER ON THE EAST BANK
NORTH TO THE HAT RAPIDS DAM ON PROPERTY OWNED BY WPSC.

2. THE ONLY WETLANDS SHOWN ARE WITHIN 2 MILES OF THE PIPELINE. THESE WETLANDS WERE TAKEN FROM THE "WISCONSIN WETLAND INVENTORY MAPS" SUPPLIED BY WISCONSIN DEPARTMENT OF NATURAL RESOURCES. THE WETLANDS FROM THE CITY OF CRANDON WEST TO THE ONEIDA/FOREST COUNTY LINE ARE MISSING FROM THE CURRENT DATA BASE AND WILL BE PUT IN AT A LATER TIME.



significant long-term environmental impacts would be expected from construction of the pipeline and outfall structure.

The groundwater alternative would require the disturbance of a total of approximately 80 to 150 acres or more for construction of the seepage cells, berms, roadways, and ancillary facilities. Because the seepage cells would be used throughout operation and closure of the Crandon Project, impacts would continue during operation and closure. Therefore, construction and continued operation of the seepage cells would result in a greater impact than construction of the pipeline for the Wisconsin River alternative. The seepage cell locations would all be upland sites, so there would be no significant disturbance of wetlands during seepage cell construction.

5.3.2 Economic Considerations

The three alternatives were evaluated with respect to costs, including capital costs for construction of the treatment and discharge facilities, annual operation and maintenance costs for treatment and discharge during operation and closure, and total present worth costs over the life of the Crandon Project. The estimated capital, O & M, and present worth costs for each alternative are summarized in Table 5-4.

Table 5-4

Present Worth Analysis for Discharge Alternatives

Discharge Alternative	Capital Cost	Annual O&M Cost	Present Worth Cost
Wisconsin River	$18,300,000	$449,000/year	$23,400,000
Swamp Creek	$24,700,000	$1,140,000/year	$37,600,000
Groundwater	$30,300,000	$861,000/year	$39,900,000

Prepared by: HJA
Checked by: PAK

In order to evaluate the relative cost of each discharge alternative, capital and operating costs were developed based on conceptual process designs. These designs were based on satisfying the design wastewater flows, wastewater loads, and effluent limitation requirements. Capital costs include equipment and materials, installation, engineering, and a contingency, and are based on budget quotations from equipment vendors, quantity takeoffs using typical unit prices, and miscellaneous costs typical for construction projects. Operation and maintenance costs are based on estimated requirements for power, labor, chemicals, and maintenance based on vendor information and treatment plant experience.

For each discharge alternative, a present worth cost was determined by calculating the present worth of the operation and maintenance costs and adding this value to the capital cost. An eight percent per year present worth rate and a thirty year design period were used in the present worth evaluation.

The costs for each of the alternatives include a base treatment system consisting of lime treatment, pH adjustment, sulfide treatment, and filtration. All three alternatives use this identical base treatment system. Additionally, all three discharge alternatives utilize an identical discharge lagoon system. The differences in the costs are associated with the advanced treatment and discharge systems used for each alternative.

For the Wisconsin River alternative, the base treatment system would provide a level of treatment adequate to meet discharge limitations, and consequently the costs for an advanced treatment would not be incurred. For the Swamp Creek and groundwater alternatives, the costs include the reverse osmosis and evaporation/crystallization technologies required to meet the discharge limitations.

For the Wisconsin River and Swamp Creek alternatives, the costs include capital and operation and maintenance costs associated with the discharge pipeline. The approximate pipeline distances are 38.3 miles and five miles, respectively. For the groundwater discharge alternative, the costs associated with effluent discharge include capital and operation and maintenance costs associated with the seepage cells.

5.3.3 Other Considerations

The base treatment system which would be used for all three alternatives is proven wastewater treatment technology, with a high degree of reliability. This technology has been used at numerous industrial facilities including the Flambeau Mining Company in Ladysmith, Wisconsin. The advanced treatment system for the Swamp Creek and groundwater alternatives includes reverse osmosis, evaporation, and crystallization processes. These treatment processes are also proven technologies which have been used to produce high-purity water in a variety of water and wastewater applications. These processes also have a high degree of reliability. However, because the Wisconsin River alternative would require only the base treatment while the Swamp Creek and groundwater alternative would require advanced treatment processes, the treatment system for the Wisconsin River alternative would have a somewhat higher level of reliability than the treatment systems for the Swamp Creek and groundwater alternatives because it would be a simpler system to operate and maintain.

For the groundwater alternative, limited investigations were conducted at five locations for potential seepage cell sites. Two sites had preliminary indications that the soil types could be suitable for construction of seepage cells. For both of these locations, extensive excavation of upper soil strata would be required in order to expose underlying soils which potentially possess the hydraulic characteristics required for a seepage cell system. Even if this were accomplished, it is uncertain whether seepage cells constructed on these two sites would have sufficient capacity to dispose of the treated effluent at the maximum flow rate of approximately 1,200 gallons per minute. For purposes of this evaluation it was assumed that the seepage cells at these two sites would have sufficient capacity. However, more detailed evaluations of the capacity of seepage cells at these two sites would be needed before this alternative could be selected.

5.4 Alternative Selection

Based on the evaluation of environmental and economic considerations, a discharge to the Wisconsin River is the recommended alternative. The reasons for this recommendation are summarized as follows:

- A discharge to the Wisconsin River would have no significant adverse environmental effects on the Wisconsin River.

- The Wisconsin River alternative does not result in the generation and disposal of solids which are produced by the advanced treatment systems required for the Swamp Creek and groundwater alternatives.

- The Wisconsin River alternative would have the lowest present worth cost of the three alternatives evaluated.

- Effluent limitations for discharge to the Wisconsin River would be met without the use of advanced treatment systems. The lime and sulfide treatment processes used for this alternative are proven technologies with a high degree of reliability. The Swamp Creek and groundwater alternatives would require advanced treatment before discharge. Although these advanced treatment processes are proven technologies with a high degree of reliability, the treatment system for the Wisconsin River alternative would have a higher degree of reliability because it would be a simpler system to operate and maintain.

- The technical feasibility of the groundwater discharge alternative is presently unknown due to the uncertainty whether seepage cells with sufficient capacity could be constructed and operated to dispose of the maximum wastewater flow rate.

CORRESPONDENCE/MEMORANDUM

State of Wisconsin

DATE: March 14, 1997

FILE REF:

TO: Paul Didier WA/3

FROM: Paulette Harder - WT/2

SUBJECT: Funding for Automonitoring at Hat Rapids Dam

The Crandon mine discharge is presently proposed to enter the Wisconsin River at the Hat Rapids Dam. The Wisconsin River in this area is wasteload allocated with all of the assimilative capacity assigned to existing dischargers. Some past data indicates that the river may actually be slightly over allocated and in need of revisions prior to the Department being able to approve the Crandon Mine discharge. The attached memo explains the tie between the proposed Crandon discharge and the wasteload allocation.

The Department has operated an automatic monitoring station at the Hat Rapids site between 1984 and 1995. Loss of GPR funds caused us to shut down this station in June 1995. Because we will have to redo the wasteload allocation during the Crandon mine review process, restarting the Hat Rapids monitor is a priority. I am requesting support from the Mining Fund to operate the monitor for a 1 year period starting July 1, 1997 through June 30, 1998. Our cost estimates indicate that it should cost between $4000 and $6000 to operate for a 1 year period. All equipment is presently moth-balled at the site and merely needs to be restarted and maintained.

It is especially important that the monitor be operating during field work Watershed Management has scheduled for this summer to support the update of the waste load allocation. Please let me know if use of the Mining Fund is possible for this purpose. You can contact Dale Patterson (6-0155) of my staff with any questions or concerns.

Thank you for considering this request.

c. Lois Aide WT/2
Bill Tans SS/6
Tom Bashaw NOR

Appendix B

PILOT STUDY DATA

The Crandon Mining Company conducted treatability studies to evaluate treatment processes and optimum treatment conditions. Synthetic wastewater was generated from actual rock, ore, and groundwater from the mine site. This wastewater was treated in bench scale (large beakers as treatment vessels) pilot tests at the Foth & Van Dyke laboratory where the effectiveness of various treatment processes were evaluated. The effluent was analyzed to the characterize the expected discharge quality. Bench scale tests can accurately simulate full scale processes. The following effluent sample from the bench scale treatability pilot study was collected on April 26, 1995. (DNR split sample analysis done by the State Lab of Hygiene.)

PARAMETER	CONCENTRATION
Total Solids	1,430 mg/L
COD*	17 mg/L
Hardness	830 mg/L
Alkalinity	14 mg/L
pH	7.14 su
Conductivity	1600 μmhos/cm
Ammonia N	0.804 mg/L
Nitrate N	0.217 mg/L
Total Kjeldahl N	1.0 mg/L
Chloride	41 mg/L
Fluoride	0.21 mg/L
Phosphorus	0.026 mg/L
Boron	0.046 mg/L
Cyanide	<0.01 mg/L
Aluminum	61.7 μg/L
Antimony	<2 μg/L
Arsenic	0.3 μg/L
Barium	150 μg/L
Beryllium	0.005 μg/L
Cadmium	0.03 μg/L
Calcium	190 mg/L
Chromium	0.38 μg/L
Copper	5.7 μg/L
Iron	50 μg/L
Lead	0.016 μg/L
Magnesium	87 mg/L
Manganese	4.7 μg/L
Mercury	40 ng/L
Molybdenum	4 μg/L
Nickel	4.9 μg/L
Potassium	14 mg/L
Selenium	110 μg/L
Silver	0.024 μg/L
Sodium	51 mg/L
Sulfate	900 mg/L
Thallium	<1 μg/L
Zinc	2.9 μg/L

* COD stands for chemical oxygen demand. COD will always be a larger number than BOD (biochemical oxygen demand). No results were obtained from the BOD analysis due to problems in running the test.

(7)

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

WISCONSIN DEPT. OF NATURAL RESOURCES

Tommy G. Thompson, Governor
George E. Meyer, Secretary
Dale T. Urso, District Director

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February 6, 1997

Mr. Mark Patulski
6730 Prune Lake Road
Rhinelander, Wisconsin 54501

Dear Mark:

This letter is in response to your question about the biochemical oxygen demand (BOD) analysis conducted during the Crandon Mining Company treatability studies. Specifically, you noted in Appendix B regarding the pilot study data (June 28, 1996 "Public Concerns Regarding the Proposed Crandon Mine Discharge into the Wisconsin River") that there were no results obtained for the BOD_5 analysis due to problems running the test.

The problem which occurred in the Department of Natural Resources split sample analysis done by the State Lab of Hygiene (SLH) was one of decreasing BOD_5 results with increasing sample volumes within a set of dilutions for a single sample. Given this circumstance, SLH rejected the analysis. Normally BOD_5 results remain similar as sample volume changes.

The SLH analysis had this remark relative to this BOD_5 test, "Toxic- 25 milliliters, 37 BOD, 5 milliliters, 60 BOD". The word "toxic" in the SLH's report is SLH's way of informing the reviewer a "toxic effect" was observed in the conducting of the BOD_5 test. It is not to imply conclusively the sample was toxic, but that a toxic effect was observed and the BOD could not be accurately determined.

Additional testing including whole effluent toxicity (WET) testing conducted by Crandon Mining Company appears to show the Crandon Mining Company effluent will not be toxic. The Wisconsin Pollution Discharge Elimination System Permit, if and when issued, will regulate the discharge of toxic pollutants and require regular WET testing.

This information was provided to me by Mr. Steve Ohm, Wastewater Engineer, here in Rhinelander. If you have any questions concerning this, please contact Steve (365-8939) or me (365-8947).

Sincerely,

Jim Kreitlow

Jim Kreitlow
Water Resources Specialist

JK:da

cc: Steve Ohm, Rhinelander
Tom Bashaw, Rhinelander
Archie Wilson, Rhinelander
Bill Jaeger, Rhinelander
Mike Witt, WT/2
Dave Webb, WT/2
Paul Luebke, WT/2
Bill Tans, SS/6
Jim Schmidt, WT/2

occurred in the late 1970s and early 1980s before disinfection of effluent. Recent data has shown that elevated coliform levels have not been a concern.

Fish in the Upper Wisconsin River main stem appear relatively free of harmful levels of toxic constituents. Northern pike taken from the Wisconsin River at Lake Alice in Lincoln County are on the Health Advisory for mercury concentrations greater than 0.5 ppm. Walleye from the Rainbow Flowage are also on the advisory for mercury. Further information about toxic pollutants in fish for other surface waters can be found in **Table 4** and in a joint WDNR/Division of Health publication: *Health Advisory For People Who Eat Sport Fish From Wisconsin Waters* (PUBL-IE-019-96REV), as well as from district WDNR water quality staff.

Hazardous substances (PCPs, PAHs) have been discharged in the Merrill area (Watson 1995). Further sampling of river sediment should be conducted adjacent to these facilities to assess conditions.

No major industries discharge to the main stem Wisconsin River between Lac Vieux Desert and Rhinelander. This portion of the river remains relatively free of pollution problems. Between Rhinelander Dam and Grandfather Dam, which includes the cities of Rhinelander and Tomahawk, the river receives inputs of effluent from point sources (**Table 9**). This section of the river is wasteload allocated (referred to as segment A from Hat Rapids Dam down to Grandfather Dam, 36 river miles). Point sources in Rhinelander include Rhinelander Paper Company and the city of Rhinelander WWTP, which discharges to the Pelican River. In the Tomahawk area, Tenneco Packaging, Inc., is a major discharger to the Wisconsin River at Lake Mohawksin. The city of Tomahawk WWTP and T.R.C. Inc., when in operation, are also significant point source dischargers. The violation of water quality standards of 5.0 ppm for dissolved oxygen in a warm water fishery justifies the need for revising the model for wasteload allocation for Segment A – Rhinelander Dam To Grandfather Dam (Fenske). The river cannot assimilate the current biochemical oxygen demand (BOD) loading and still maintain the 5.0 ppm dissolved oxygen standard.

Phosphorus (P) loading in the Wisconsin River, via WWTP effluent, is another water quality concern. Phosphorus is an essential plant nutrient, but in excess can cause nuisance blue-green algal blooms and dense growths of aquatic macrophytes (rooted plants). These problems in downstream main stem reservoirs already hinder recreational uses. Phosphorus loading should be reduced in the future as a result of the adoption of Wisconsin Administrative Code NR 217, which requires both industrial and municipal WWTPs to remove phosphorus from their effluent and maintain specific effluent limits.

Under Wisconsin Administrative Codes NR 105 and NR 106, water quality standards have been developed for toxic chemicals in surface waters; appropriate discharge limits will be included in WPDES permits for the protection of aquatic life, human health, and wild and domestic animals. To determine if toxins are a concern, some municipal and industrial facilities will be required to test their effluent. If toxins are a concern, appropriate water quality standards will be set for specific surface waters and effluent limits established.

Owners of the proposed Crandon Mine (to be located in the Upper Wolf River and Post Lake Watershed of the Wolf River Basin near Crandon) are considering piping process wastewater to the Wisconsin River for discharge above Hat Rapids Dam. The proposed mine is a zinc-copper sulphide deposit. Groundwater pumped from the mine shafts would be treated and discharged to surface water.

NORTH CENTRAL DISTRICT

Water-body Name (Priority)	Water-body ID Code	Watershed ID Code	Length of stream (miles) or Lake Drainage area (sq. mile)	Start of stream segment (River Miles)	End of Stream Segment (River Miles)	Stream Classi-fication	Standards Violation/ Impairment	Suspected Pollutants	Potential Sources
Wis. R. near Rhinelander (HIGH)	1179900	Main Stem WI - 171	36.0	343.0	307.0	WWSF	DO, Bacteria	BOD, SS	Point S., NPS
Petenwell Fl. (HIGH)	1377100	main stem WI-171	21.1 miles 5970 sq. miles	195.9	174.8	WWSF	Fish Advisory DO Stds. Violation	Mercury, Dioxin, PCBs, Nutrients	Point Sources, Industry, NPS runoff
Castle Rock Fl. (HIGH)	1345600	Mainstem WI-171	15.1 miles 7056 sq. miles	144.8	159.7	WWSF	Fish Advisory, DO Stds. Violation	Mercury, Dioxin, PCBs, Nutrients	Point Sources, Industry, NPS runoff
Big Eau Pleine River (HIGH)	1427200	UW-17 UW-18	26 miles/363 sq. mi.	17	43	WWSF	DO & Bacteria Stds. Violation	Nutrients	Point Sources, NPS
Big Eau Pleine Fl. (HIGH)	1427300	UW-17	363 sq. miles or/17.0 river miles	0	17	WWSF	DO & Bacteria Stds. Violation	Nutrients	Point Sources, NPS
Mill Creek (HIGH)	1398600	UW-11	47 miles, 165 sq. miles	0	47	LAL, WWSF	DO Stds. Violation	Nutrients	Municipal and Industrial point Sources, NPS
Yellow R. (MEDIUM)	1352800	UW-02 UW-05	99 miles, 458 sq. miles	0	99	WWSF	Bacteria Stds. Violation	Nutrients, Bacteria	Point and NPS

Interim Final 303 (d) List; December 13, 1996

Sr. #	Water-body Name	Prio-rity	Water-body ID Code	Water-shed ID Code	Length of stream (mi)	Start of stream segment (River Miles)	End of Stream Segment (River Miles)	Stream Classi-fication	Standards Violation/ Impairment
1	Plum Creek	High	0125100	LF03	19	0	19	WWSF	Habitat Impairment, Temperature
2	Kankapot Creek	Low	0126800	LF03	9	0	9	LFF	Habitat Impairment
3	Mud Creek	Low	0129500	LF04	8	0	8	WWSF	Habitat Impairment
4	Fond du Lac River	High	0133700	UF03	2	0	2	WWSF	Toxics, Fish Advisories
5	Wisconsin River near Rhinelander	High	1179900	Main stem	36	307	343	WWSF	Dissolved Oxygen, Waste Load Allocation Review
6	Yellow River	Med	1352800	UW02, UW05	39	0	39	WWSF	Bacteria
7	Yellow River	Med	1352800	UW02, UW05	60	39	99	WWSF	Bacteria
8	Dodge Branch	Low	910800	SP06	14.1	0	14.1	WWSF	Fisheries, Habitat
9	Dodge Branch	Low	910800	SP06	7.2	14.1	21.3	COLD	Fisheries, Habitat
10	Dodge Branch	Low	910800	SP06	0.7	21.3	22	LFF	Fisheries, Habitat
11	W. Br. Sugar River	Med	886100	SP16	2.5	0	2.5	WWSF	Fisheries, Habitat
12	W. Br. Sugar River	Med	886100	SP16	5.5	2.5	8.0	WWSF	Fisheries, Habitat
13	W. Br. Sugar River	Med	886100	SP16	13	8	21	WWSF	Fisheries, Habitat
14	Rowan Creek	Low	1263700	LW19	8	0	8	COLD	Fisheries, Habitat

WWSF=Warm Water Sport Fish; LFF=Limited Forge Fish; FAL=Full Aquatic Life; WWFF=Warm Water Forge Fish; COLD=Cold F.

(12)

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

WISCONSIN DEPT. OF NATURAL RESOURCES

Tommy G. Thompson, Governor
George E. Meyer, Secretary
Dale T. Urso, District Director

North Central District Headquarters
PO Box 818, 107 Sutliff Ave.
Rhinelander, WI 54501-0818
TELEPHONE 715-365-8900
FAX 715-365-8932
TDD 715-365-8957

January 23, 1997

Mr. Mark Patulski
6730 Prune Lake Road
Rhinelander, Wisconsin 54501

Dear Mark:

Thank you for attending the public hearing for the Upper Wisconsin River Water Quality Management Plan (Northern Sub-Basin) held on December 17, 1996. At that time you made a public statement for the record. This letter serves as a response to your comments/questions expressed during the hearing.

You were concerned over a pile of soil located near the Highway 8 bypass and if it was contaminated. This material is dredge spoil taken out of the river. It has been tested for heavy metals. Metals have been detected but are not at a level of concern. I have enclosed the data for your review.

You also asked about mercury levels in sediment within the Wisconsin River between Hat Rapids and Lake Alice. I have enclosed a report that summarizes the sampling that occurred in 1995. We have continued to monitor through 1996 and into 1997. This data is not yet available. As soon as I receive it, I will forward it to you. If you have any questions concerning the 1995 report, please contact me.

I acknowledge the fact that you are in favor of placing the automatic monitoring station back into service at Hat Rapids. At the present time, the DNR is looking at options available to try and re-establish this monitoring site. We are also looking into using mining dollars as you suggested.

Although the technology may be available to treat the Crandon Mine effluent to the point where it is able to be discharged into the Wolf River, they (Crandon Mining) are required only to meet the criteria of the surface water they discharge to. In this case the law states that the water quality criteria and effluent limitations are based upon a warmwater sport fishery classification (Wisconsin River) instead of outstanding resource water classification (Wolf River). The DNR does not have statutory authority to tell wastewater producers where to discharge their effluent but the Department does have authority to regulate the quality of that effluent so that water quality standards are met.

I hope this letter addresses your concerns that you made at the public hearing. Feel free to contact me if you would like to discuss this further at 365-8947.

Sincerely,

Jim Kreitlow
Water Resources Specialist

JK:da
Enc.
cc: A. Wilson, Rhinelander
D. Webb, WT/2
B. Tans, SS/6
T. Bashaw, Rhinelander
K. Markart, Rhinelander

(14)

CORRESPONDENCE/MEMORANDUM

State of Wisconsin

Date: January 24, 1996

To: Archie Wilson, Rhinelander
Ken Markart, Rhinelander
Tom Janisch, WR/2
Terry McKnight, Rhinelander
Larry Maltbey, Rhinelander
Linda Talbot, WR/2
Bill Tans, EA/6
Bob Martini, Rhinelander

From: Jim Kreitlow, NCD

Subject: Summary of Wisconsin River Sediment Sample Collection, Wisconsin River and Hat Rapids Flowage

Introduction

In September of 1995, five sediment samples were collected from the Wisconsin River (two samples in Hat Rapids Flowage, three samples below Hat Rapids Dam) for the purpose of gathering baseline streambed sediment data (see attached memos for details on exact site locations). Samples were analyzed for metals, nutrients, pesticides, total PCB's, total organic carbon, and particle size. The monitoring results are attached to this summary for your review. Field sheets are available upon request.

Purpose

The purpose of this sampling was to gather baseline streambed sediment data for the purpose of establishing existing conditions. The Department felt that this sampling was necessary because of the "potential" Crandon Mine wastewater discharge at Hat Rapids Dam.

Methods

See attached October 4, 1995, memo which outlines the sampling methods used to collect the samples.

Analytical Results

It's difficult to evaluate the results because of lack of streambed sediment standards or criteria. To reach some sort of conclusion, I compared the results to the "old" solid waste sediment contamination levels for beach and inland water disposal. I also normalized each sample environmental variable (mg of metal per kilograms of silt/clay) so that comparisons could be conducted between the sample locations (see Table 1).

Particle Size

Please see the attached memo which lists the percent sand, silt and clay for all five sampling locations.

Metals

Field samples #1 and #2 (Wisconsin River above Hat Rapids Dam) appear to have elevated levels of cadmium, copper, lead, mercury, selenium and zinc compared to the downstream field samples #3, #4, and #5. These samples were collected from the depositional zone above the dam. The percent of silt and clays are also higher. A core sampling device was also used to collect these samples at greater depth than samples #3, #4 and #5. Because of the dam, I believe there is less scouring and more contaminants have settled above the dam.

The downstream samples (below the dam) are below the solid waste (beach and in-water) disposal guidelines, with the exception of site #4 (mercury, .26 part per million).

Pesticide/PCB's

Site #2 was the only location that had any detectable quantities of pesticides and PCB's. I feel these quantities are low.

Nutrients

Total Kjeldahl Nitrogen (TKN) and total phosphorus (TP) sediment values are high in the pooled portion of Hat Rapids Flowages (Sites #1 and #2). Again, this is probably characteristic of a depositional zone higher in silt and clays. Nutrient values from Sites #3, #4 and #5 are much lower.

Normalization of the Data

The five sample locations were normalized to allow direct comparison of the results between site locations. This can be done by using the following formula:

$$\frac{\text{mg of metal/kg of sediment}}{\text{\% silt, clay fraction expressed as a decimal}} = \text{mg of metal/kg of silt clay fraction.}$$

Again (Table 1), the results show higher levels of metals in the samples above Hat Rapids Dam.

Discussion

The purpose of this sampling was to gather baseline data. Some minor conclusions have been stated about the data. More detailed analysis of the results could be conducted by Central Office if needed. They could provide information on how these results compare to others around the state. Are these values considered background levels or are they elevated above background or are they at a level of concern? For more information please contact Linda Talbot or Tom Janisch, Water Resources Management, Madison.

JK:da
Attach.
cc: Joe Ball, WR/2

TABLE 1: Metals Concentrations (mg/Kg), and Concentrations Normalized (Mg of metal/Kg of silt, clay)

	Field #1		Field #2		Field #3		Field #4		Field #5	
	mg/kg	mg/kg (Silt, clay)	mg/kg	mg/kg (silt, clay)	mg/kg	mg/kg (silt, clay)	mg/kg	mg/kg (silt, clay)	mg/kg	mg/kg (silt, clay)
Aluminum	12,000	15,789	21,000	30,434	1,600	32,000	4,800	13,333	3,500	21,875
Arsenic	4.23	5.56	6.45	9.35	.38	7.6	1.17	3.25	.39	2.43
Barium	84	110	68	98.5	15	300	51	141.6	28	175
Cadmium	* 2.3	3.0	* 2.5	3.62	.09	1.8	.28	.77	.15	.937
Chromium	25	33	57	82.6	4.7	94	18	50	10	62.5
Copper	*180	237	*130	188.4	3.5	70	10	27.7	4.2	26.25
Lead	*170	223	*120	173.9	** 2.69	53.8	14	38.8	4.9	30.6
Manganese	240	310	150	217.4	110	2,200	0	--	210	1,312
Mercury	* 1.2	1.58	* 4.1	5.94	.020	.4	* .26	.72	.070	.437
T.K.N.	9,300		12,000		380		2,700		900	
Nickel	11	14.47	11	15.94	2	40	7	19.4	4	25
TP	1,700		3,300		160		530		220	
Selenium	* 1.58	2.08	* 1.27	1.87	-.05	--	.35	.97	.25	1.56
Zinc	*260	342	* 220	318.8	13	260	47	130.5	25	156.2
T.O.C.	90,400		108,000		5,950		27,400		8,900	

** Analysis Rejected
* Exceeds standard for beach and in-water disposal.

How to Use this Mercury Advisory

An important note regarding fish on the mercury portion of this advisory. *Mercury is distributed throughout a fish's muscle tissue (the part you eat) rather than in the fat and skin. The only way to reduce mercury intake is to reduce the amount of contaminated fish you eat.*

Meal advice for mercury is presented slightly differently than for PCBs. The advice is based on the following groups:

Group 1

Pregnant women should eat no more than one meal a month of Group 1 fish.

Everyone else may eat unlimited amounts of Group 1 fish. Fillets average 0.5 ppm mercury or less.

Group 2

Pregnant or breastfeeding women, women who plan to have children, and children under 15 should not eat Group 2 fish.

Everyone else should eat no more than 26 meals of Group 2 fish a year. Eat no more than 13 of these in any one month. Space the remaining 13 meals over the rest of the year at rate of one or two meals a month. Fillets average 0.5 to 0.75 ppm mercury.

Group 3

Pregnant or breastfeeding women, women who plan to have children, and children under 15 should not eat Group 3 fish.

Everyone else should eat no more than 13 meals of Group 3 fish a year. Eat no more than 7 of these meals in any one month, and space the remaining 6 meals over the rest of the year at a rate of one meal a month. Fillets average 0.75 to 1.0 ppm mercury.

Group 4

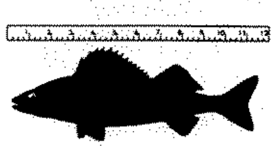
No one should eat Group 4 fish.

Skin-on fillets average above 1.0 ppm mercury.

Example: You are on a family vacation, fishing on Lots-o-Fish Lake in Chippewa County. You catch a 25-inch northern.

First

Measure your fish from the tip of the nose to the end of the tail and determine what type of fish it is.



Then

Go to the table and find Chippewa County; then find Lots-o-Fish Lake.

Then

The advisory group for your fish is under the size category for the fish you've caught.

A 25-inch northern from Lots-o-Fish Lake in Chippewa County is a Group 2 fish. If you decide to keep the fish for eating, follow the advice for a Group 2 fish at the top of the mercury tables on page 30.

County/Water	Fish Species	Length (in inches) <10	10–12	12–15	15–18	18–22	22–26	26–30	>30
Chippewa County ◄ *Tip! Find the county and the water where you caught your fish here.*									
Lots-o-Fish Lake	Northern Pike	•	•	•	1	1	2	2	•

Tip! Find the type of fish you've caught here.

Tip! Find the meal advice for the fish you've caught here. The number refers to the groups at the top of this table.

County/Water	Fish Species	Length (in inches) <10	10-12	12-15	15-18	18-22	22-26	26-30	>30
Wisconsin River at Lake Alice. See Adams, Juneau, Sauk, and Wood Counties also.	Northern Pike	1	1	1	1	2	2	•	•
	Walleye	1	1	1	2	3	•	•	•

(18)

From: DNRNC::JAEGEW "BILL JAEGER, RHINELANDER, (715)365-8971" 6-NOV-1996 13:04:50.47
To: MARTIRE
CC:
Subj: fyi'

From: DNRVAX::TANSW "Bill Tans EA/6" 6-NOV-1996 11:22:31.66
To: DNRNC::WILSOA, CARLSC, DNRNC::JAEGEW
CC: WITTM, WEBBD, ALBRIG,TANSW
Subj: Mercury Releases from the Crandon Project

There have been several discussions with staff regarding the proposed discharge of treated wastewater into the Wisconsin River and how we will handle that in the permit. Today we reviewed this issue with Susan Sylvester, Paulette Harder and Maryann Sumi and have developed a strategy for mercury in the discharge.

We plan to put a limit on mercury in the discharge permit of 2 ng/L. This could be reduced to 1.3 ng/L if the standard changes, or could go up to background levels (almost 4 ng/L) if the company successfully argues this. We also plan to require the company to use ultra low level techniques to monitor for mercury in its effluent.

Because our split sample from the pilot plant treatability studies came out at 40 ng/L for the proposed effluent, the company could not meet the limit. This assumes that the one sample we have adequately represents the true effluent quality. As a result, we will need to obtain from the company alternative methods that could be used to treat the effluent and remove most of the mercury. The company may also have to request a variance from the limit if it could not meet it. There may be ways of segregating its wastewater streams and using a more powerful treatment technology on the stream with the most mercury. Perhaps such a technology could be used in conjunction with a surface water mitigation plan.

Staff in Watershed Management Bureau are reviewing this regulatory stance with EPA, and assuming it agrees, we will then inform CMC of how we are going to proceed. I suspect that CMC will want to meet with us to discuss this further.

In related issues, mercury coming from the TMA and moving through the groundwater ultimately will reach Hemlock Creek and other downstream locations. We are getting some assistance from Dave Krabbenhoft of the USGS, who will attempt to sample groundwater near Hemlock Creek for mercury concentrations. He may be able to perform that work in November. Dave Webb will work with Jim Hurley to conduct an estimate of the mercury that will move into Hemlock Creek, but will first need the groundwater mercury data, and source term data for the TMA leachate, and then can make some estimations of how much mercury might reach Hemlock Creek. Increased levels of sulfate reaching surface waters also could affect the availability of mercury in the stream, and that has to be factored in also. Bill.

(19)

State of Wisconsin

CORRESPONDENCE/MEMORANDUM

DATE: December 13, 1995

TO: Jim Hurley - Research - Monona
David Webb - WR/2
Chris Carlson - SW/3
Larry Lynch - SW/3
Archie Wilson - NCD (by conference phone)

FROM: Bill Tans - EA/6

SUBJECT: Mercury Issues Related to the Crandon Mining Project

Recently Chris Carlson initiated discussions with you concerning mercury as it relates to the Crandon project. To follow-up with those discussions, I have scheduled a meeting for **Tuesday December 19, 9:00 a.m. in room 511, GEF II.**

The two main issues are as follows:

Evaluating the Impacts on Mercury Availability from Increased Sulfates in Surface Waters
Because there will be leachate leakage out of the tailings management area (TMA), groundwater with increased levels of sulfates would be discharged to nearby streams and springs. According to Jim Hurley's earlier memo, increased levels of sulfate could increase the methylization of mercury in the sediments, thus making mercury much more bio-available. We will have better projections of the level of sulfate in the groundwater and the increase in sulfates in Hemlock Creek after we have completed our review of the groundwater modeling. However, we know there are 4-10 mg/L sulfates in Hemlock Creek now, and in our 1986 final EIS on the Exxon proposal, we said this about the TMA impacts on sulfates in Hemlock Creek: *"The mixing zone concentration of sulfate downstream from the groundwater contribution is predicted to be 6.9 mg/L."*

This raises a number of questions for our analysis in the environmental impact statement:

1. Assuming we can project the increased sulfate in Hemlock Creek and calculate the increase in methylmercury in the sediments, does this translate into a comparable increase of methylmercury in the water column?

2. Can we readily evaluate impacts of increased methylmercury on aquatic biota?

3. Will an increase in the sediment methylmercury mean increased uptake by the aquatic life in the sediment and increased uptake by aquatic life in the stream?

4. How far down stream would the increase in methylmercury be propagated (e.g., to the Wolf River about 15 stream-miles downstream)?

5. Is there some level of methylmercury in the sediment that would translate into resultant fish consumption advisories for humans?

6. The Sokaogon Chippewa reservation is several miles downstream from the project site. Swamp Creek flows through the project site and through Rice Lake on the reservation and ultimately into the Wolf River. Would there be any effect on the wild rice populations in Rice Lake (6-7 miles downstream)?

Evaluating the Effects of Mercury from the Tailings Management Area

There may be mercury in the pore waters within the tailings ponds, some of which may move with the leachate that exfiltrates. Ultimately this could reach surface waters and exacerbate the mercury availability to stream biota.

1. Can we sample leachate from the ongoing waste characterization studies to get an idea of the mercury levels?

2. Archie Wilson suggested a that it could be useful to sample leachate from the Flambeau site as a means to evaluate mercury concentrations. Comments?

3. What is the best way to evaluate/model movement and impacts of mercury from the Tailings Management Area through the groundwater and into Hemlock Creek?

I would greatly appreciate your help on these and similar problems dealing with mercury. We will need to address mercury issues in our EIS. Thank you.

cc: Bob Grefe - SW/3

print in the unshaded areas only

EPA ID Number (copy from Item 1 of Form 1)

Form Approved
OMB No. 2040-0086
Approval expires 7-31-88

EPA New Sources and New Dischargers Application for Permit to Discharge Process Wastewater

I. Outfall Location

For each outfall, list the latitude and longitude, and the name of the receiving water

Outfall Number (list)	Latitude Deg	Latitude Min	Latitude Sec	Longitude Deg	Longitude Min	Longitude Sec	Receiving Water (name)
007	(see Figure 3 for the location of the outfall)						Wisconsin River

Note: Outfalls 001-006 and 008-012 will dishcarge only construction and non-contact runoff at the facility. A "Notice of Intent for Storm Water Discharges Associated with Construction Activities Under a General WPDES Permit", (Wisconsin DNR Form 3400-161) has been submitted to the Wisconsin DNR. Refer to this "Notice of Intent" for information concerning Outfalls 001-006 and 008-012.

II. Discharge Date (When do you expect to begin discharging?)

(see Attachment 2)

III. Flows, Sources of Pollution, and Treatment Technologies

A. For each outfall, provide a description of (1) All operations contributing wastewater to the effluent, including process wastewater, sanitary wastewater, cooling water, and stormwater runoff; (2) The average flow contributed by each operation; and (3) The treatment received by the wastewater. Continue on additional sheets if necessary.

Outfall Number	1. Operations Contributing Flow (list)	2. Average Flow (include units)	3. Treatment (Description or List Codes from Table 2D-1)
007	• mine shaft development and underground mining	560 gallons/minute (total discharge flow rate)	(see Attachment 2)
	• ore milling & beneficiation, including disposal of waste rock and tailings		
	• operaton of sanitation facilities for mine and mill employees		
	• ancillary operations needed for mine & mill operations/maintenance		

V. Effluent Characteristics

A, and B: These items require you to report estimated amounts *(both concentration and mass)* of the pollutants to be discharged from each of your outfalls. Each part of this item addresses a different set of pollutants and should be completed in accordance with the specific instructions for that part. Data for each outfall should be on a separate page. Attach additional sheets of paper if necessary.

22

General Instructions *(See table 2D-2 for Pollutants)*

Each part of this item requests you to provide an estimated daily maximum and average for certain pollutants and the source of information. Data for all pollutants in Group A, for all outfalls, must be submitted unless waived by the permitting authority. For all outfalls, data for pollutants in Group B should be reported only for pollutants which you believe will be present or are limited directly by an effluent limitations guideline or NSPS or indirectly through limitations on an indicator pollutant.

1. Pollutant	2. Maximum Daily Value *(include units)*	3. Average Daily Value *(include units)*	4. Source *(see instructions)* (see Attachment 2)
Flow Rate	1,200 gallons per minute	560 gallons per minute	Design Capacity of the WWTS (maximum flow) Water Balance (average flow)
5-Day Biochemical Oxygen Demand	10 mg/L	5 mg/L	Treatability Testing
Chemical Oxygen Demand	20 mg/L	< 10 mg/L	Treatability Testing
Total Organic Carbon	10 mg/L	< 5 mg/L	Best Professional Judgement
Total Suspended Solids	20 mg/L	< 5 mg/L	Best Professional Judgement
Ammonia (as N)	9 mg/L	3.3 mg/L	Best Professional Judgement
Temperature (winter)	50^{o} F	35^{o} F	Best Professional Judgement
Temperature (summer)	85^{o} F	60^{o} F	Best Professional Judgement
pH	9.0 (max.) 6.0 (min.)	8.0	Best Professional Judgement
Fluoride	0.5 mg/L	0.2 mg/L	Best Professional Judgement
Nitrate + Nitrite (as N)	22 mg/L	8.2 mg/L	Best Professional Judgement
Oil and Grease	15 mg/L	< 5 mg/L	Best Professional Judgement
Total Phosphorus	0.2 mg/L	0.05 mg/L	Treatability Testing
Sulfate (as SO_4)	1,500 mg/L	1,000 mg/L	Best Professional Judgement 800
Sulfide (as S)	5 mg/L	< 2 mg/L	Best Professional Judgement
Sulfite (as SO_3)	< 1 mg/L	< 1 mg/L	Best Professional Judgement
Total Aluminum	0.3 mg/L	0.12 mg/L	Treatability Testing
Total Barium	0.06 mg/L	0.03 mg/L	Leaching Testing
Total Cobalt	1.0 mg/L	0.5 mg/L	Leaching Testing
Total Iron	0.1 mg/L	0.02 mg/L	Treatability Testing
Total Magnesium	75 mg/L	30 mg/L	Leaching Testing

(continued on Page 3B of 5)

CONTINUED FROM THE FRONT	EPA ID Number *(copy from Item 1 of Form 1)*	Outfall Number 007

V. Effluent Characteristics

A, and B: These items require you to report estimated amounts *(both concentration and mass)* of the pollutants to be discharged from each of your outfalls. Each part of this item addresses a different set of pollutants and should be completed in accordance with the specific instructions for that part. ~~Data for~~ each outfall should be on a separate page. Attach additional sheets of paper if necessary. (23)

General Instructions *(See table 2D-2 for Pollutants)*

Each part of this item requests you to provide an estimated daily maximum and average for certain pollutants and the source of information. Data for all pollutants in Group A, for all outfalls, must be submitted unless waived by the permitting authority. For all outfalls, data for pollutants in Group B should be reported only for pollutants which you believe will be present or are limited directly by an effluent limitations guideline or NSPS or indirectly through limitations on an indicator pollutant.

1. Pollutant	2. Maximum Daily Value *(include units)*	3. Average Daily Value *(include units)*	4. Source *(see instructions)* (see Attachment 2)
Total Manganese	0.2 mg/L	0.06 mg/L	Best Professional Judgement
Total Antimony	0.1 mg/L	<0.05 mg/L	Treatability Testing
Total Chromium	0.01 mg/L	<0.005 mg/L	Treatability Testing
Total Lead	0.006 mg/L	<0.003 mg/L	Treatability Testing
Total Nickel	0.04 mg/L	<0.02 mg/L	Treatability Testing
Total Silver	0.002 mg/L	<0.001 mg/L	Treatability Testing
Total Zinc	0.10 mg/L	0.02 mg/L	Treatability Testing
Total Arsenic	0.01 mg/L	<0.004 mg/L	Treatability Testing
Total Cadmium	0.002 mg/L	0.0015 mg/L	Treatability Testing
Total Copper	0.080 mg/L	0.010 mg/L	Treatability Testing
Total Mercury	N.D.[1]	N.D.[1]	Treatability Testing
Total Selenium	0.29[2] mg/L	0.09 mg/L	Leachate Testing
Total Thallium	0.02 mg/L	<0.01 mg/L	Treatability Testing
Total Cyanide	0.53 mg/L[3]	0.08 mg/L	Best Professional Judgement
Hardness	1,000	700	Best Professional Judgement

1 N.D. = Not detectable. The detection level for mercury using approved analytical methods for the WPDES permit program is approximately 0.0002 mg/L. Crandon Project effluent when tested is expected to show a no detect.

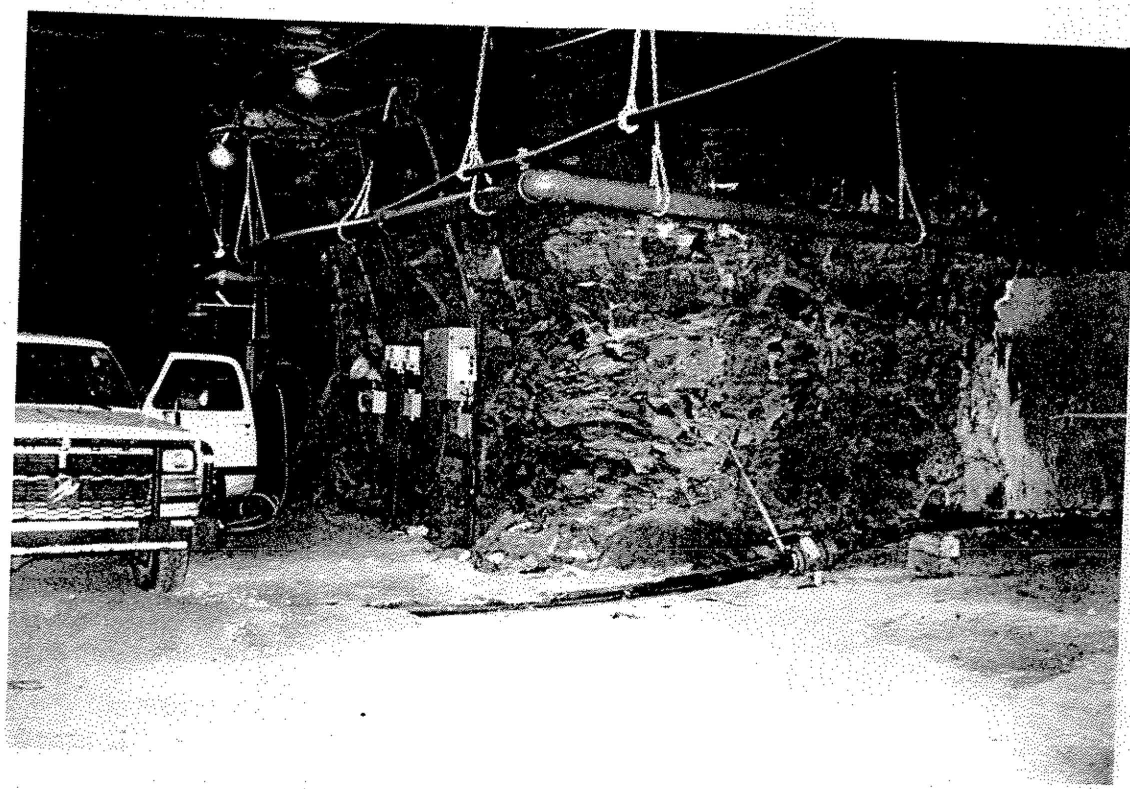
2 Maximum concentration when treated effluent consists solely of treated excess mill process water. Normal maximum concentration when treated effluent includes treated mine drainage is estimated to be 0.24 mg/L.

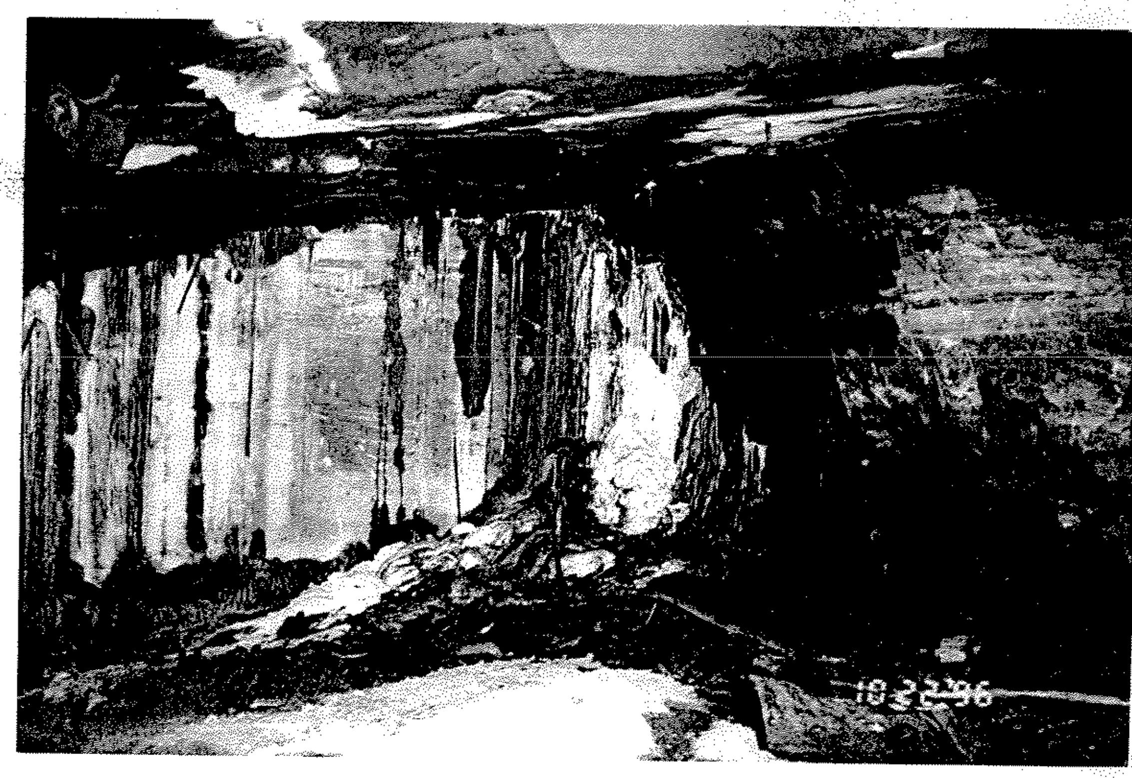
3 Maximum concentration when treated effluent consists solely of treated excess mill process water. Normal maximum concentration when treated effluent includes treated mine drainage is estimated to be 0.13 mg/L.

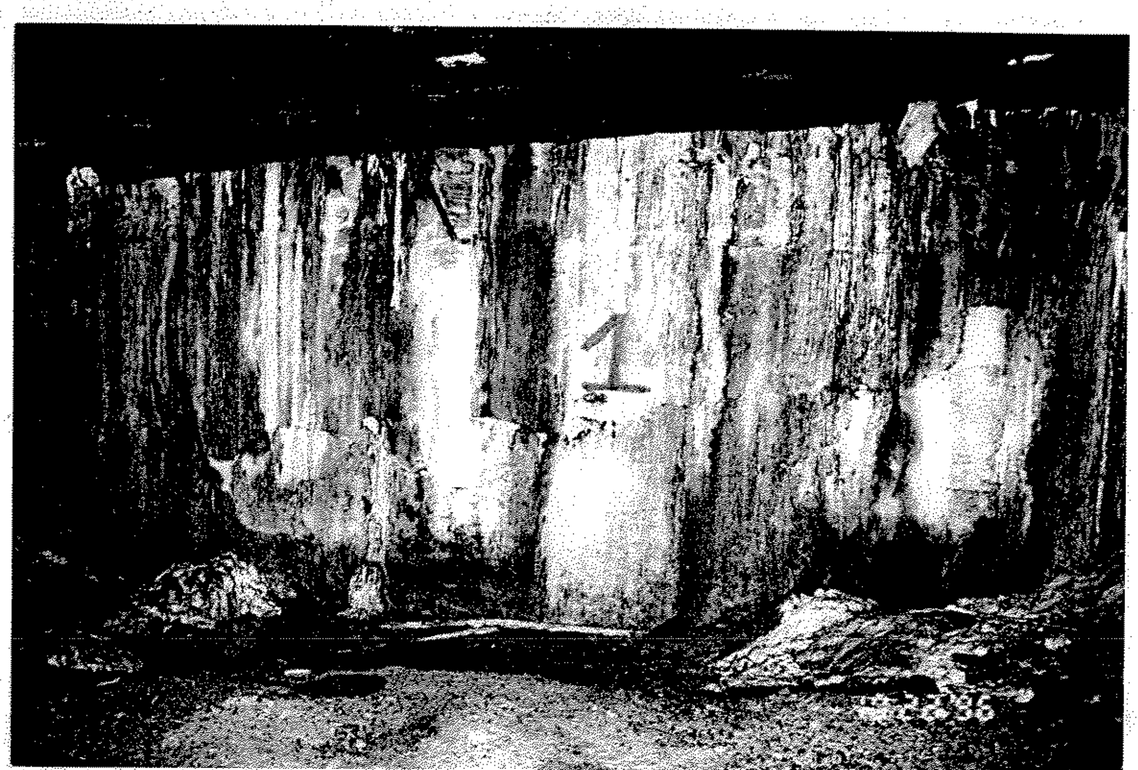
SULFATE (as SO_4)

G.P.M.	G.P.D		MG/L					P.P.D.		TON'S A DAY
560	806,400	×	1000 =	806.4	× 8.34	=		6725	÷ 2 =	3.3
1200	1,728,000	×	1500 =	2.592	× 8.34	=		21'617	÷ 2 =	10.8

Frank K. Koehn
P.O. Box 3
Herbster, WI
54844



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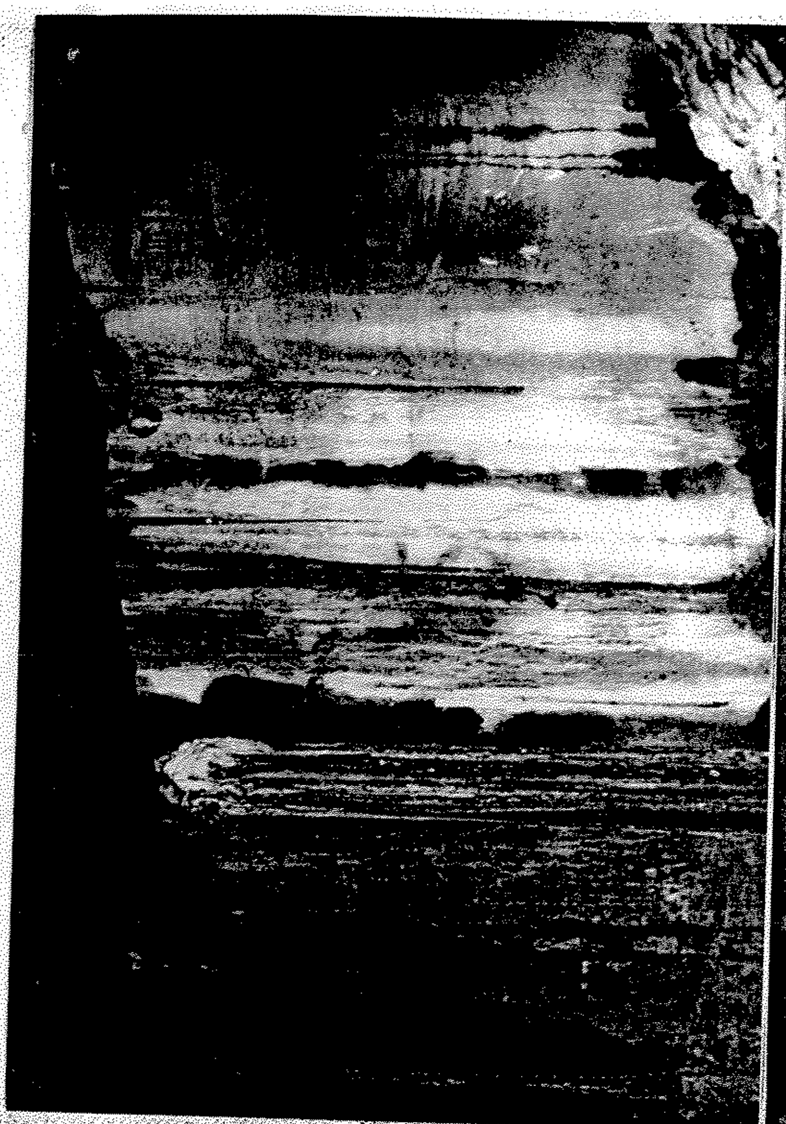
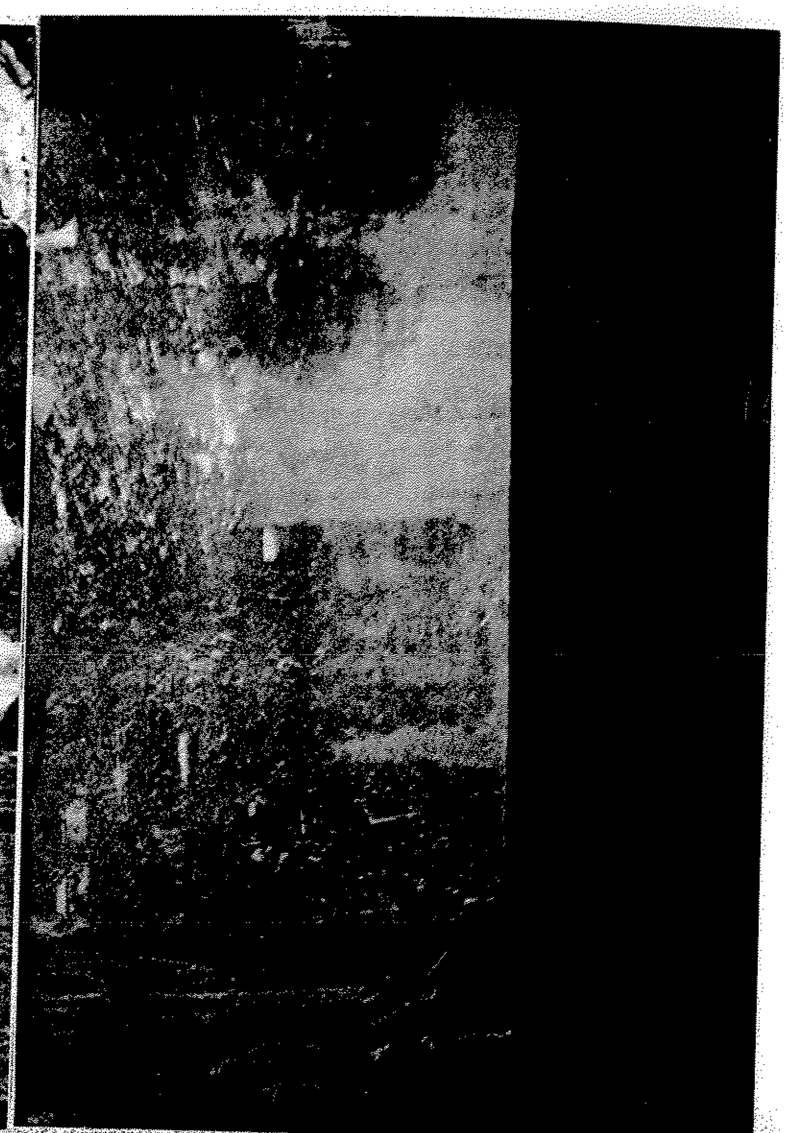


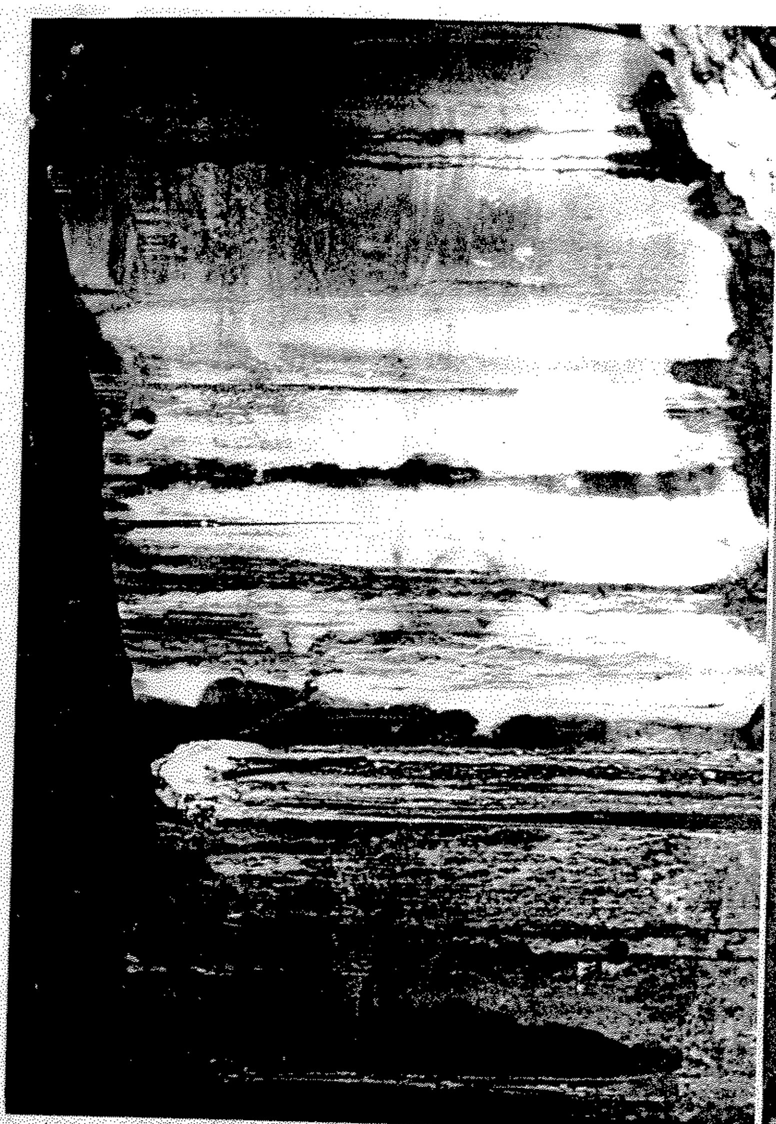

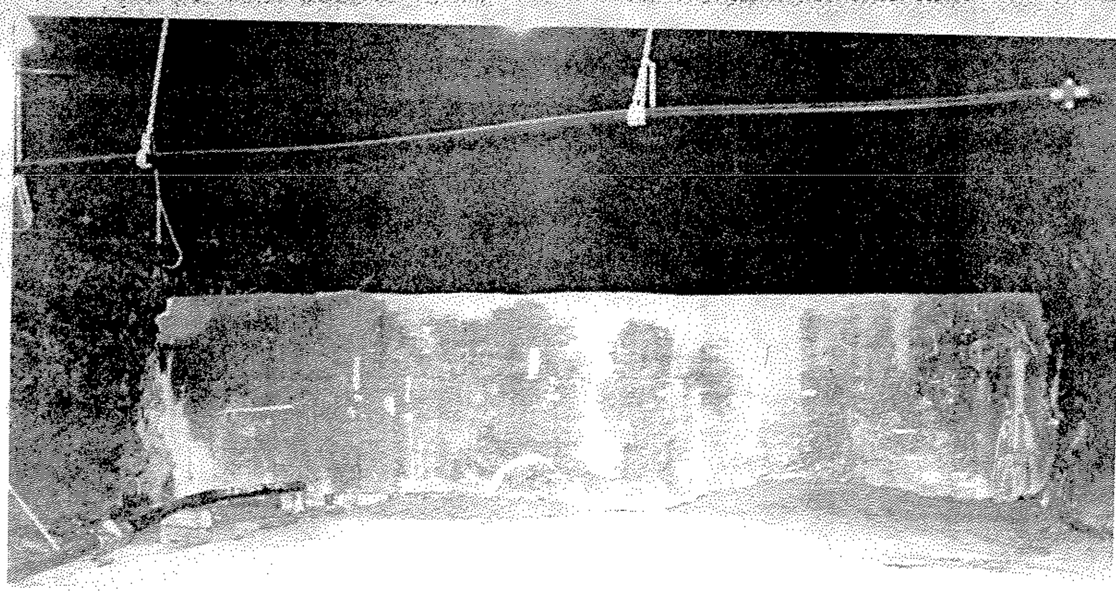

Mining Impact Coalition of Wisconsin Inc.

— committed to research and education about the social, economic and environmental impacts of metallic sulfide mining —

Critique of the Society for Mining, Metallurgy, and Exploration Inc. survey, *Environmentally Responsible Mining: Results and Thoughts regarding a survey of North American Metallic Mineral Mines,* 1997, J.W. Todd, and D.W. Struhsacker. This survey was commissioned by Exxon and Rio Algom's Crandon Mining Company (CMC).

The CMC survey was conducted ostensibly to answer the question of whether or not there are environmentally safe metallic sulfide mines operating in North America. Unfortunately it fails answer the most important question: does the mining industry have a reliable track record of successful closure and reclamation? The Wisconsin state legislature is debating the Metallic Mining Moratorium bill (SB 3), which would prohibit metallic sulfide mines in Wisconsin, only until the mining industry demonstrates an example of a metallic sulfide mine in geology similar to that of northern Wisconsin which has operated safely for at least 10 years <u>and</u> been closed and reclaimed safely for 10 years without causing water pollution. CMC's survey fails to demonstrate any examples of mines that would meet this simple test. Despite this fact, mining proponents are misleading the public by calling the survey proof that CMC's proposed mine would be safe.

On March 11, 1997, the Wisconsin State Senate passed an amended SB 3 with a 29 to 3 vote. One of the amendments to the bill stipulates that a mining operation used to satisfy the requirements of SB 3 must be, "...in a sulfide ore body *which is not capable of neutralizing acid mine drainage* of similar geologic characteristics..." (added language italicized.) With this amendment, at least two examples used in this survey could not be used to satisfy SB 3. They are the Viburnum No. 27 and any of the mines that operated in the southwest Wisconsin lead-zinc district. Although they are now irrelevant to the debate, discussion of their use in the survey is still worthwhile as illustrations of specific problems with the survey.

The survey cites 6 mines plus the historic Wisconsin lead-zinc district.

1. <u>The Henderson Mine and Mill</u> The mine and mill are each located in different locations at least 15 miles apart (Empire, Colorado-mine, Parshall, CO-mill). This example is <u>not yet closed or successfully reclaimed.</u> This example is <u>highly flawed</u>-see attached report for detail.

2. <u>The Cannon Mine, Wenatchee, WA</u> This gold mine closed only one year ago. It operated for 9 years, but has yet to demonstrate any successful closure and reclamation.

3. <u>The McLaughlin Mine, Lower Lake, CA</u> This project is an open-pit gold mine. It is <u>neither closed nor reclaimed.</u>

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