REVIEW OF CANADIAN AND UNITED STATES LEGISLATION RELEVANT TO DECOMMISSIONING ACID MINE DRAINAGE SITES

MEND Project 4.2.1

This work was done on behalf of MEND and sponsored by
Ontario Ministry of Environment and Energy
Homestake Canada Inc.
Hudson Bay Mining and Smelting Company

September 1993

REVIEW OF CANADIAN AND UNITED STATES LEGISLATION RELEVANT TO DECOMMISSIONING ACID MINE DRAINAGE SITES

MEND Project 4.2.1

SEPTEMBER 21, 1993

PROJECT NOS. 30266/30277

JACQUES WHITFORD ENVIRONMENT LIMITED
2781 LANCASTER ROAD
SUITE 200
OTTAWA, ONTARIO
PHONE: (613) 738-0708 FAX: (613)738-0721

Report

on

Review of Canadian and United States Legislation Relevant to Decommissioning Acid Mine Drainage Sites

Sponsored by:

Ontario Ministry of Environment and Energy
Homestake Canada Inc.
Hudson Bay Mining and Smelting Company

on Behalf of:

Mine Environment Neutral Drainage (MEND) Program

Prepared by:

Jacques Whitford Environment Limited

September 21, 1993

Project Nos. 30266/30277

EXECUTIVE SUMMARY

Jacques Whitford Environment Limited (JWEL) was selected by the Mine Environment Neutral Drainage (MEND) program to conduct a review of Canadian and United States legislation relevant to decommissioning acid mine drainage (AMD) sites. The purpose of the review was to provide government agencies, industry representatives and other organizations and individuals with an overview of the existing Canadian and United States regulatory framework relevant to decommissioning AMD sites, and to summarize the criteria used by Canadian and United States regulatory agencies to assess the performance of a decommissioning, AMD site.

This report is the result of two separate reviews financially supported by different groups. The review of Canadian legislation was sponsored by the Ontario Ministry of Environment & Energy and Homestake Canada Inc. The review of United States legislation was sponsored by Hudson Bay Mining and Smelting Company. The findings of both reviews are combined in this report for completeness.

Canada is actively involved in research on the prediction and control of AMD, particulary with respect to metal mining operations. Much of this research is fostered by the national Mine Environment Neutral Drainage (MEND) program in which the provinces of British Columbia, Saskatchewan, Manitoba, Ontario, Quebec and New Brunswick participate. Research on AMD from coal mining operations is likely further advanced in the United States.

In general, regulatory strategies specifically geared towards decommissioning sites with AMD are still in the development stage in both Canada and the United States. Overall, environmental legislation is more prescriptive in the United States than in Canada. Some of the criteria that would typically be used in assessing the success of an AMD site decommissioning are effluent quality leaving the mine site and groundwater and surface water quality downgradient from the mine site. Effluent limitations, drinking water standards and surface water quality criteria have all been developed at a federal level by the United States Environmental Protection Agency. In addition, they are all enforceable at either the federal or state level, depending on whether a particular state has a federally approved regulatory program in place.

In Canada, on the other hand, non-enforceable water quality guidelines or objectives are the norm. However, site-specific enforceable parameters, based on water quality guidelines or objectives, may be incorporated in mine operation permits or licences.

Seven states were contacted as part of this review. Idaho and Nevada have no regulations, guidelines or policies tailored specifically for licensing or decomissioning mines with AMD, or the potential for AMD. California and Montana do not have clear-cut legislation to address AMD specifically, but do

seem to have some general policies for the approach (i.e. site-specific) to be used in decommissioning AMD sites. Legislation in Colorado makes reference to AMD by stating that "acid-forming material" at operating mine sites should be handled in a manner that will protect downgradient water bodies.

Only two of the states contacted, Pennsylvania and West Virginia, have a regulatory strategy that addresses AMD directly. In both states, predictive testing for acid generation potential is mandatory prior to approval. In Pennsylvania, if a proposed mine site is shown to have the potential for AMD, it is not licensed. West Virginia requires that control technologies be adequate to meet effluent and water quality criteria. However, in neither state is there a systematic approach for decommissioning abandoned mines with AMD.

All the provinces and territories were contacted as part of this review. Two of the provinces do not have a significant AMD problem (Prince Edward Island, Alberta). The remaining provinces and the territories are at different stages of developing regulatory strategies for addressing AMD. In most jurisdictions, there are now provisions for proposed mines to complete some type of environmental impact statement. However, depending on which jurisdiction, the discretion granted to the "minister", and/or the size of the proposed mine, the complexity of the statement will vary.

Several provinces, including British Columbia, Ontario and Saskatchewan, have guidelines in place that require predictive testing to determine the acid generation potential of rock units at a proposed mine. Nova Scotia has gone a step further and requires monitoring, and sometimes predictive testing, at any development on shale of the Halifax Formation.

With respect to effluent limitations, most provinces use the federal Metal Mining Liquid Effluent Regulations, although some provinces such as British Columbia, Saskatchewan and Quebec have developed their own. Ontario is currently in the process of developing comprehensive effluent regulations for various industries, including mining, under the Municipal Industrial Strategy for Abatement (MISA) program.

For water quality criteria, many provinces use the federal Canadian Water Quality Guidelines, although provinces such as British Columbia, Alberta, Manitoba, Saskatchewan, Ontario and Quebec have developed, or are developing, their own criteria for surface water and/or groundwater quality. Both British Columbia and Manitoba seem to be taking a different approach from the other provinces. For example, with time, surface water bodies in Manitoba will be classified according to present and potential use and water quality criteria set accordingly. This approach is similar to that taken in the United States. British Columbia sets water quality objectives on a site-specific basis, taking into account such factors as water quality and water uses. This approach potentially has the flexibility to address the anomalous background water chemistry sometimes encountered at mine sites.

TABLE OF CONTENTS

TABLE OF CONTENTS (CON'T)

PAGE

1.0 INTRODUCTION

Jacques Whitford Environment Limited (JWEL) was selected by the Mine Environment Neutral Drainage (MEND) program to conduct a review of Canadian and United States legislation relevant to decommissioning acid mine drainage (AMD) sites. The MEND program is a co-operative program financed and administered by the Canadian mining industry, the Canadian government, and the governments of British Columbia, Saskatchewan, Manitoba, Ontario, Quebec and New Brunswick. MEND objectives are the following:

- to provide a comprehensive scientific, technical and economical basis for the mining industry and government agencies to predict, with confidence, the long-term management requirements for acid producing tailings and waste rock; and
- to establish techniques that will enable the operation and abandonment of acid-generating tailings and waste rock disposal areas in a predictable, affordable, timely and environmentally-acceptable manner.

This report is the result of two separate reviews financially supported by different groups. The review of Canadian legislation was sponsored by the Ontario Ministry of Environment & Energy and Homestake Canada Inc. The review of United States legislation was sponsored by Hudson Bay Mining and Smelting Company. The findings of both reviews are combined in this report for completeness.

The purpose of the report is to provide government agencies, industry representatives and other organizations and individuals with an overview of the existing Canadian and United States regulatory framework relevant to decommissioning AMD sites, and to summarize the criteria used by Canadian and United States regulatory agencies to assess the performance of a decommissioning, AMD site.

This report is a summary document. Many acts, regulations and guidance documents are referenced throughout. For complete details in a specific area, the reader is encouraged to refer to the references directly or to contact the appropriate regulatory agency. A partial listing of regulatory agencies in the United States and Canada that deal with mining and/or environmental issues is presented at the end of the report.

2.0 SCOPE OF WORK

The scope of work for this study consisted of the following four tasks:

- Task 1 - Review legislation, regulations and policies of the United States Federal Government that are relevant to decommissioning acid mine drainage (AMD) sites.

- Task 2 - Review legislation, regulations and policies of selected State Governments that are relevant to decommissioning acid mine drainage (AMD) sites. State legislation discussed in this report includes that from California, Colorado, Idaho, Montana, Nevada, Pennsylvania and West Virginia - states where AMD is a concern, and/or where environmental legislation is well-developed.

- Task 3 - Review legislation, regulations and policies of the Canadian Federal Government that are relevant to decommissioning acid mine drainage (AMD) sites
- Task 4 - Review legislation, regulations and policies of the Territorial and Provincial Governments that are relevant to decommissioning acid mine drainage (AMD) sites.

The above tasks were completed through a combination of library research, direct contact with numerous regulatory agencies and a review of in-house reports and reference material.

3.0 UNITED STATES FEDERAL LEGISLATION

Federal agencies in the United States implement three general approaches to regulation of the mining industry:

- environmental regulation of specific media regardless of the waste source;
- regulation of the impacts of mineral operations on federal and Indian land; and
- regulation of one specific type of mining on all land.

The aspects of these three approaches pertinent to this review are discussed in more detail in the following sections.

3.1 Environmental Regulation of Specific Media

The first approach, which is used by the United States Environmental Protection Agency (EPA), involves the regulation of specific environmental media such as surface water and groundwater. These regulations are promulgated under the authorities of the following:

- Federal Water Pollution Control Act, or Clean Water Act (CWA)
- Safe Drinking Water Act (SDWA)
- Resource Conservation and Recovery Act (RCRA)
- Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)

Federal Water Pollution Control Act Amendments of 1972

The principal law regulating discharge of pollutants to surface water in the United States is the Clean Water Act (CWA), formally known as the Federal Water Pollution Control Act (1). Such regulation is divided among various programs within the Act. Each of these programs may be applicable to mining operations.

CWA has been termed a technology-forcing statute because of the rigorous demands placed on those who are regulated by it to achieve higher and higher levels of pollution abatement. Industries were given until 1977 to install "best practicable control technology" (BPT) to clean up waste water discharges. The Act required greater pollutant cleanup than BPT by 1989, demanding that industry use the "best available technology" (BAT) that is economically achievable.

The Office of Science and Technology of the EPA is responsible for developing sound, scientifically defensible standards, criteria, advisories, guidelines and limitations under the Clean Water Act (and the Safe Drinking Water Act). These provide the regulatory framework for restoring and maintaining the biological, chemical, and physical integrity of water resources, for protecting public water supplies, and for achieving technology-based pollution control requirements in support of, among others, point source discharge programs, drinking water programs and geographic-specific programs (e.g. Great Lakes, coastal, estuaries). For example, the EPA issues regulations containing the BPT and BAT effluent guidelines applicable to categories of industrial sources. Specifically, the Energy Branch of the EPA establishes enforceable effluent limitations for **active** metal and coal mines. These are known as the Coal Mining Point Source Category (2) and the Ore Mining and Dressing Point Source Category (3) and are presented in Tables 1.1 and 1.2, respectively, in Appendix 1.

Certain responsibilities are delegated to the states, and CWA, like other environmental laws, embodies a philosophy of federal-state partnership in which the Federal Government sets the agenda and standards for pollution abatement while states carry out day-to-day activities of implementation and enforcement. Consequently, the effluent guidelines for metal mines are enforced for the most part at the state level through the National Pollutant Discharge Elimination System (NPDES) Permit Program. Refer to Section 3.3 for a further discussion of coal mining regulation.

NPDES requires the Federal Government, or State Governments under federally funded programs, to issue permits for the discharge of any pollutant from a point source into navigable waters, defined as "waters of the United States". Point sources are defined under CWA to include any discrete conveyance of pollutants. The courts have widely interpreted this provision to include, for example, overflows from heap leaching sumps (4). Mining operations whose pollutants eventually find navigable waters through a conveyance are required to obtain such permits. About 40 states are active in this program. In the remaining states, the effluent guidelines are enforced by the Federal Government. The states can establish effluent criteria more stringent (but not less) than federal guidelines.

Another state-delegated responsibility is that of establishing Water Quality Standards for surface water, which consist of a designated use (recreation, water supply, industrial, or other), plus a numerical or narrative statement identifying the maximum concentration of various pollutants which would not interfere with the designated use. These standards serve as the backup to federal technology-based requirements, by indicating where additional pollution controls are needed to achieve the overall goals of CWA.

Safe Drinking Water Act (SDWA)

SDWA (5) is the basis for protecting public drinking water systems from harmful contaminants. SDWA directs the EPA Administrator to develop national Primary and Secondary Drinking Water Standards which specify the concentration of pollutants allowable in public water supplies. The Primary Drinking Water Standards, referred to as Maximum Concentration Limits (MCLs), are designed to protect human health to the extent feasible, taking technology, treatment techniques, and costs into consideration. They are federally enforceable; the states can be more stringent, but not less. Secondary Drinking Water Standards are designed to protect the aesthetic qualities of the water and are not federally enforceable. They are issued for states to use as guidelines. A partial list of Primary and Secondary Drinking Water Standards is presented in Table 1.3, in Appendix 1.

In addition, SDWA directs the EPA to develop underground injection control regulations to protect underground sources of drinking water and groundwater protection grant programs for the administration of sole-source aquifer demonstration projects and for wellhead protection area programs. SDWA permits these activities to be implemented by the states.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

CERCLA (6) (or Superfund) was enacted in 1980, and substantially amended in 1986, to address the cleanup of inactive and abandoned hazardous substances sites. About 60 of the more than 500,000 abandoned mines on public and private property in the United States are so polluted that they are on the EPA's roster of Superfund sites, the list of the most hazardous waste sites in the United States. The EPA's authority to regulate mining, milling, smelting and refining wastes under CERCLA has been challenged in court in several cases; these attempts were largely unsuccessful (7). It is now clear that CERCLA applies to hazardous substances from mining operations including heavy metals found in tailings impoundments and waste rock piles as well as solvents and various other chemicals.

Due to the unique characteristics of mining sites, notably the predominantly inorganic nature of wastes, the large volume of waste generated and the size of sites, special problems arise in developing remedial plans that are both protective and cost-effective. CERCLA requires that remedial plans comply with any **A**pplicable or **R**elevant and **A**ppropriate federal and state standard **R**equirement, criterion or limitation (ARARs). An important aspect of site remediation becomes the selection of ARARs. ARARs are not intended as national cleanup standards, and, ideally, each site should be approached as a new and unique situation.

CERCLA has proven to be a powerful tool for federal, state and local governments to address virtually all pollution problems, including those created by the mining industry. Government agencies have used CERCLA extensively in an attempt to remediate both operating and non-operating mine sites. CERCLA has been interpreted to be retroactive. For example, an entirely lawful 30-year-old tailings pond or waste pile, state of the art at the time it was built, used, and closed, can trigger current liability under CERCLA.

The concept of liability in CERCLA has led to endless rounds of litigation and a high percentage of the funds allocated to the remediation of superfund sites have been spent on legal fees and court costs. There are three basic elements of liability which must be proven by a plaintiff (e.g. government agency) in order to recover response costs or to obtain natural resources damages from the responsible party. Those elements are: 1) a release or threat of release to the environment 2) of a hazardous substance 3) which causes response costs to be incurred (4).

Resource Conservation and Recovery Act (RCRA)

RCRA (8) was enacted in 1976 to address the ever increasing amount of waste being generated in the United States. RCRA identifies two major subgroups of wastes: solid waste and hazardous waste.

Solid waste is regulated under Subtitle D of RCRA which establishes environmental performance standards. The program is operated mainly by the states, with assistance from the Federal Government. Hazardous waste is addressed under Subtitle C of RCRA. Subtitle C is enforced by EPA or by states authorized by EPA to run the RCRA program.

Because mining wastes do not fall neatly into a solid waste or hazardous waste category, the characterization of mining waste has been controversial. High volume, low toxicity mining wastes have, in general, been regulated as solid waste under Subtitle D, and in 1986, the EPA decided to develop a regulatory program specifically tailored to mining waste under Subtitle D. This program is still in the development stage.

3.2 Regulation of Mineral Operations on Federal and Indian Land

The second approach to regulation of the mining industry, which is used by the Bureau of Land Management, the National Park Service, the Bureau of Indian Affairs and the Forest Service, involves the regulation of the impacts on surface resources from mineral operations on federal and Indian land. Mineral operations on such land are regulated through issuance of the appropriate leases, permits or approvals. An approved plan of operations, containing site-specific stipulations for environmental protection and reclamation, is generally required prior to beginning mineral operations. For mining waste, these agencies implement the applicable environmental standards and criteria established by other federal and state agencies on a site-specific basis. Pending legislation seeks a reclamation fee on federally owned lands but does not extend to mines on private lands.

The National Environmental Policy Act (NEPA) (9) was enacted in an attempt to ensure careful federal consideration of the impacts of man's activities on the environment. An environmental impact statement is required where a project involves a major federal action which significantly affects the quality of the human environment. Due to the fact that mining operations on federal lands require the issuance of a permit or license from a federal agency, this may be sufficient federal involvement to trigger the NEPA process (4). However, the statutory right to mine on federal land provided in the Mining Law of 1872 and reaffirmed by the courts and in the Mining and Minerals Policy Act of 1970 limits the extent to which land management agencies can condition mining on federal land. Furthermore, the law allows miners to extract minerals on federal lands without paying any royalties to the US government. In 1992, a reform bill that would have allowed federal agencies to say no to mining in ecologically sensitive areas, and to insist that approved mine sites be cleaned up, won committee approval in the House, but the Senate refused to move the bill (10).

3.3 Regulation of One Specific Type of Mining on all Land

The third approach to regulation of the mining industry, used by the Office of Surface Mining, Reclamation and Enforcement (OSM), involves the regulation of coal mining on federal, non-federal, Indian and state land by authority of the Surface Mining Control and Reclamation Act (SMCRA) (11). SMCRA establishes a nationwide program for the protection of human health and the environment from the adverse effects of coal mining operations, current and past. The OSM administers the Act and has the authority to promulgate and enforce regulations; however, individual states which have an OSM approved regulatory program assume responsibility for enforcement and rulemaking. The state programs must be as effective as, and as consistent as, the federal SMCRA. In the event that a state has chosen not to develop a program, or the OSM has refused to approve the state program, a complete federal program for that state is developed and implemented.

A coal mining permit is required for all operations, and specific environmental protection standards must be met under conditions of the permit. SMRCA specifies that the potential for AMD must be addressed as part of the permitting process. Discharge from active coal mines must meet the effluent guidelines set forth in the Coal Mining Point Source Category (2) and presented in Table 1.2, in Appendix 1. OSM, generally, exercises no authority over metal mining operations.

4.0 STATE LEGISLATION

State environmental programs regulating the mining industry are variable, but can be separated into two general types. The first type includes state programs that simply enact federal environmental legislation such as the Clean Water Act, Safe Drinking Water Act and Surface Mining Control and Reclamation Act (SMRCA). These statutes invite the states to take over the main aspects of the programs; the states are free to design such delegated programs to be more stringent, but not less stringent, than federal minimum requirements. Some state programs comprise copies of federal programs, but with changes that reflect individualized decisions by the state legislatures enacting the statutes.

The second type of state environmental program consists of state statutes, policies and directives that address areas of concern not addressed at the federal level (e.g. metal mining). In addition, some states, such as California and Idaho, have state environmental statutes similar to the National Environmental Policy Act which apply to all activities including mining.

The following sections highlight aspects of the environmental programs relevant to AMD from seven states. The discussions vary in detail depending on the extent of the AMD problem in the individual states and the degree to which the state environmental programs go beyond federal initiatives.

4.1 California

Mining has long been, and will continue to be, an important part of California's economy. In 1989, California was the top non-fuel mineral producer in the United States.

Disposal of waste on land in California is regulated relative to protection of water quality by Subchapter 15, California Code of Regulations (12). The principal subdivisions of Subchapter 15 pertain to waste classification, siting criteria and construction standards for waste management units, water quality monitoring requirements, and site closure/post-closure maintenance requirements. Policies under Subchapter 15 are established by the State Water Quality Control Board (WQCB) and administered through regional WQCBs. The State WQCB has divided California into nine separate regions based on the natural hydrologic basins of California. Every new mine or expansion of an existing mine must file a Report of Waste Discharge with the appropriate regional WQCB office, and receive either a waiver or Waste Discharge Requirements. The Waste Discharge Requirements are generally revised when a mining operation goes from full scale operation to closure. Subchapter 15 does not specifically address AMD, however, its prevention has been addressed to varying degrees by the respective regional staffs.

California's Porter-Cologne Water Quality Control Act (13) and the federal Clean Water Act require water quality control plans for the waters of the state. The Act specifies that each regional WQCB shall establish water quality objectives. In addition, surface waters in California must be classified according to beneficial use. California's Water Quality Standards consist of the designated water use and the water quality objectives. The standards form the basis for establishing the Waste Discharge Requirements.

The following two case studies portray the decommissioning of AMD sites in California. The first example discusses the decommissioning of an active mine. The second example discusses the decommissioning of an historic, abandoned mine which is now a Superfund site.

Grey Eagle Mine

The Noranda Grey Eagle Mine in the Klamath River Basin is presently in closure. It was originally a copper producing mine during WW ll, and then was operated as a gold mine by Noranda in the 1980's. A closure and operation plan was required of Noranda at the start-up of mining under the California Water Code. Also, a financial guarantee was required under Subchapter 15. AMD, if allowed to discharge to surface water (or groundwater, then surface water) would have to meet California Water Quality Standards. However, AMD at the Grey Eagle Mine was dealt with on a **site-specific** basis, as are all AMD sites in California.

The Klamath River Basin has been classified as a "no discharge" zone (14). No "deleterious" material can be discharged to the surface waters of the Klamath River Basin, even if criteria are still below California Water Quality Standards. Therefore, treated effluent from the Grey Eagle Mine is discharged to percolation beds. Water quality consitituents which are present in the wastewater at levels of concern include cyanide, copper, iron, zinc, cadmium, mercury and nickel. In the Waste Discharge Requirements revised for closure, limits for these parameters in the treated effluent were set as follows:

Constituent	Maxiumum Concentration (mg/l)
cyanide (free)	0.2
copper	1.0
iron	0.3
zinc	0.02
cadmium	0.01
mercury	0.002
nickel	0.7

In addition, any detection above "background concentrations" of the following specific constituents, at monitoring points outside of the process containment and permitted disposal areas, constitutes a violation of the Waste Discharge Requirements:

Constituent	Background (mg/l)
cyanide (total)	less than detectable
cyanide (free)	less than detectable
copper	0.50
iron	0.30
zinc	2.0

Iron Mountain Mine

The Iron Mountain Mine is a Superfund site for which a remedial action plan has been accepted. Iron, silver, gold, copper, zinc and pyrite were mined and milled at the site from the 1860's to 1962. AMD discharges high concentrations of copper, cadmium and zinc into Slickrock and Boulder Creeks which drain the site, flow into Spring Creek, and then into the Sacramento River (approximately 8-10 kms from the site). Two cleanup criteria were developed for the site: 1) minimize off-site migration of contamination via surface water flows and seepage, and 2) minimize impacts to receiving waters of contaminants that will continue to move from the site (7). To meet these objectives, three sets of target cleanup levels (i.e. ARARs) were considered for the site:

Contaminant	EPA Water Quality Criteria (ug/l)	State Water Quality Standards (ug/l)	Background (ug/l)
copper	5.4	5.6	3.5
cadmium	0.55	0.22	0.1
zinc	47	16	14.8

Taking the ARARs - and financial considerations - into account, a final remediation plan was accepted for this site. A modeling analysis, based on the remediation plan, predicted that water quality in the Sacramento River will meet the EPA Water Quality Criteria, as well as the state Water Quality Standards for all but "worst case" years, and that the water quality between the mine and the Sacramento River should be "greatly improved".

4.2 Colorado

Colorado has different legislation for non-coal and coal mines. Non-coal mines in Colorado have a considerable AMD problem, however, coal mines generally do not. The former are regulated under the Colorado Mined Lands Reclamation Act as Amended (15). This Act establishes the authority for the state to regulate water quality at discharge areas from mines. According to the Act, "acid-forming material" shall be handled in a manner that will protect the drainage system from pollution; and disturbances to the prevailing hydrologic balance and to the quality of water in surface and groundwater systems, both during and after mining operations, shall be minimized.

Rules regarding permits, financial responsibility, reclamation performance standards and inspections, monitoring and enforcement are included in Mineral Rules and Regulations (16). Compliance with applicable federal and Colorado water quality laws and regulations is specified. According to the Clean Water Act (federal), water quality cannot be degraded below existing levels; therefore, mine sites need good baseline information for 1-2 years prior to operation to show background quality. Colorado Water Quality Control Act (17) is similar to the Clean Water Act, but requires certain standards, therefore, it is more comprehensive. The Water Quality Control Commission, by authority of the Act, has promulgated regulations which include water use classification and quality criteria for surface and groundwater (18, 19). For groundwater, inorganic standards are set according to the classification of the aquifer. For surface water, Colorado is divided into seven major drainage basins and water quality must meet that of the hub river. A partial list of Ground Water and Surface Water Quality Standards are presented in Tables 2.1 and 2.2, respectively, in Appendix 2. According to State Senate Bill 181,

mines have to meet Colorado's Water Quality Standards.

One of the most notorious abandoned mine sites in the United States is Summitville in southwestern Colorado, where cyanide was used to mine gold. Mine seepage has already killed the Alamosa River and the USEPA is spending up to $50,000 a day to prevent what it has called a "catastrophic" spillage of water contaminated with heavy metals and acids. EPA took over pumping the site when the Canadian owners - Galactic Resources Ltd. of Vancouver and its US subsidiary, Summitville Consolidated Mining Co. Ltd. - abandoned the mine and went bankrupt. Cleanup costs could cost more than $60 million and take years.

Partly due to Summitville, a major mining reform package is currently before the Colorado Legislature. The changes would subject chemical mining operations to stricter enviornmental requirements; give state regulators more time to review plans for new mining projects; allow the state to force mine operators to post higher financial bonds for reclamation; and create a new fund, finanaced by penalties on law-breaking mines, to pay for emergency state responses to mine spills.

4.3 Idaho

The Idaho Department of Health and Welfare, Division of Environmental Quality, by authority of the Idaho Environmental Protection and Health Act (1972), has primacy to ensure that all waters of Idaho are in compliance with the federal Clean Water and Safe Drinking Water Acts. Criteria used in developing state Water Quality Standards (20) for surface water are adopted directly from the Clean Water Act. A partial list of Idaho's Surface Water Quality Criteria is presented in Table 2.3, in Appendix 2.

There are no formal guidelines, policies or procedures in Idaho for preventing AMD or decommissioning AMD sites. The general approach to preventing AMD is to implement activities by the responsible party to protect groundwater and surface water. Informally, the Clean Water Act is utilized. However, Idaho does not have primacy in administering NPDES permits (21).

The approach to decommissioning mines with AMD is either site-specific or in accordance with the Clean Water Act, depending on the location of the mine and other issues. For example, one massive sulphide deposit with a stream flowing through it, located in a remote, inaccessible area, had an AMD problem. No baseline information was available. Therefore, the percentage of metals in water due to mining activity and the percentage occuring as background, was not known. Cleanup targets were established for the site, as follows: remove 60% of the metals from the water even if the remaining 40%

exceed Idaho's Water Quality Standards. However, cleanup targets for another mine located in a more accessible location, where it was thought to be easier to treat the effluent, were more stringent: zero discharge in accordance with the Clean Water Act. Colorado regulators feel that addressing AMD "where feasible" is a practical approach to decommissioning.

For operating and reclamation plans at new base metal mines, the following steps are requested, but not mandatory for licensing:

- determine probability of AMD
- do static tests
- proceed to dynamic tests and modeling
- incorporate conditions to prevent AMD
- include contingency plans

The state recommends these steps in order to remove any doubt with respect to the liability of the mine if an AMD problem occurs in the future. However, no new metal mines have opened in Idaho for several years.

4.4 Montana

AMD is a big problem in Montana, both from coal and metal mines. Coal, uranium and metal mines in Montana are regulated under the Strip and Underground Mine Reclamation Act (22) and the Metal Mine Reclamation Act (23). Mines in operation prior to promulgation of these Acts are exempt. The Acts include sections that discuss mining permits, reclamation plans and reclamation bonds. In order to be granted a permit, the operator must submit a reclamation plan. The plan must set forth in detail the steps to be taken to comply with "applicable air and water quality laws and rules and any applicable health and safety standards" during operation and decommissioning. In addition, the applicant must file a reclamation bond in an amount determined by the Montana Department of State Lands.

With respect to water quality, Montana has adopted applicable federal criteria for industrial effluent and drinking water. Surface Water Quality Standards (24) contain a classification of the surface water in the state according to water-use, adopt EPA criteria and specify water quality standards accordingly. Addressed specifically are tailings ponds and leaching pads which must be designed and operated to prevent pollution of surface waters. Montana Groundwater Pollution Control System (25) sets forth Ground Water Quality Standards, allows for mixing zones of a site-specific areal extent based on reasonable use, and specifies that discharge permits for mining operations must be in compliance with the state Strip and Underground Mine Reclamation Act and Metal Mine Reclamation Act.

Old, abandoned mines, which operated prior to the present permitting process, did not have to meet any water quality or effluent standards and did not have any closure bonds. Abandoned coal mines, whose reclamation is legislated by SMCRA (federal), are now in the early steps of decommissioning, according to the following process:

- funding for decommissioning is from a tax on Montana mined coal collected by the federal Office of Surface Mining, 50% of the tax goes back to Montana;
- mines are located and inventoried; and
- decommissioning approach is site-specific.

Montana uses the ARAR approach and/or will clean up to background if possible. The state has primacy and can be more stringent than any federal standards if they wish.

4.5 Nevada

Mining regulations are promulgated under authority of the Nevada Water Pollution Control Law (26). The Regulations Governing Design, Construction, Operation and Closure of Mining Operations (27) discuss permitting, minimum design criteria, monitoring and closure. Design criteria must ensure that there is "zero discharge"; mines are required to contain 100% of process fluids and storm water. Therefore, there are no effluent or surface water quality criteria in Nevada relevant to AMD.

With respect to groundwater, the above regulations specify the following:

- The quality cannot be "lowered below a state or federal regulation prescribing standards for drinking water". Nevada has adopted the federal Primary and Secondary Drinking Water Standards.

- The department "may establish a numerical limit for any constituent not regulated" by the federal standards "which may reasonably be expected to be discharged by the facility in sufficient volume and concentration to cause an adverse impact on human health".

- If groundwater quality already exceeds standards, the department can set new levels to protect "existing or potential" groundwater use.

The department may exempt a body of groundwater (or portion) from the standards based on the total dissolved solids content or present and potential use (e.g. not drinking water source).

In general, AMD is not a problem in Nevada due to its arid climate. However, one potential problem area is in the Humboldt River drainage area of north-central Nevada. Ten large open pit gold mines are about to commence dewatering operations. The issues of potential impacts, such as metal leaching and groundwater contamination, and remedial approach are controversial. As discussed in Ross (28), some are of the opinion that the current regulations in Nevada are so generalized and vague that they create uncertainty, and that what is required are scientific data and criteria for permitting and remediation. Furthermore, there are no performance bonds required in Nevada to ensure the maintenance of groundwater quality.

Other problem areas are several old mine sites which operated prior to the current regulations and, as a result, have AMD discharging from the sites. Two of these are Rio Tinto and Buckskin National, both Superfund sites overseen by the Forest Service. At this time, only sampling and problem definition has been completed and cleanup criteria have not been set yet.

4.6 Pennsylvania

Pennsylvania's mineral resources consist primarily of coal. The state has a primacy program for coal mining embodied in the state Surface Mining Reclamation and Control Act (29) which is similar to the federal Act, although accompanying regulations can be more stringent than federal regulations - at the state's discretion.

AMD is addressed primarily at the permitting stage (for new mines). The state has a Cumulative Hydrologic Impact Assessment (CHIA) program under SMCRA. As part of this program, a hydrogeological assessment is done prior to permitting proposed mines to document water quality in the area and to determine the acid generating potential of strata to be mined. Pertinent information from adjacent mining operations is reviewed at this time and analytical tests such as overburden analysis are performed. If there is a potential for generating AMD, the mine is not permitted. Draft guidelines outlining the CHIA program are in preparation, but are not yet available for review.

The principle state legislation relevant to AMD are SMCRA and The Clean Streams Law (30). These Acts allow the state to enforce effluent limits and water quality criteria which are set in coal mining regulations (31) and Water Quality Standards (32). Under the Clean Streams Act, degrading of surface water to any extent is not allowed. The state also has a NPDES program. Effluent and water quality criteria are "drainage basin specific", as opposed to site-specific or state-wide. Mines must meet the same criteria during decommissioning as during operation. Pennsylvania is active in treatment technology and abatement research focused on AMD.

Pennsylvania has a lot of abandoned underground adits that generate AMD and impact large stretches of streams, but they are difficult and costly to remediate due to a large number of sites with low discharges. Some sites are presently being remediated with various treatment technologies, but there is no state-wide program for remediating these sites.

4.7 West Virginia

AMD is a big problem in West Virginia due to the high sulphur content of the coal. Little metal mining is done in West Virginia, and there is not a significant AMD problem associated with it.

Coal mine permitting is regulated by the West Virginia Surface Mining Control and Reclamation Act which is the state's version of SMCRA (federal). As part of the permitting process, the potential for AMD must be addressed both qualitatively (e.g. expert opinion) and quantitatively. If it is shown that AMD is likely, the state then makes a decision whether to permit the mine. This decision is based on the mine's ability to deal with the problem and to prevent adverse environmental impacts. Permitting has been a controversial topic. One school of thought is that any mines with potential AMD should not be permitted (e.g. see Pennsylvania, Section 4.6). However, West Virginia has taken the approach that permits will be given as long as it can be shown that AMD will be dealt with in an acceptable manner to meet water quality and effluent standards. A reclamation plan is also required as part of the permitting process. A flat-rate bond per acre covers reclamation costs at closure which includes addressing water quality issues.

Requirements Governing Water Quality Standards (33) apply to the discharge of sewage, individual wastes and other wastes into surface water and establish water quality standards for surface water. Surface Water Quality Standards are enforceable under West Virginia Water Pollution Control Act (34) which is based on the Clean Water Act (federal). West Virginia does not have any groundwater quality standards yet. They are currently before the legislature.

The West Virginia Department of Natural Resources implements the federal NPDES program. West Virginia follows the federal effluent guidelines for mines at a minimum, but can be more stringent, if necessary. For example, if federal effluent guidelines result in downstream water quality which exceeds West Virginia's Water Quality Standards, then West Virginia can set water quality based effluent limits. This is done on a site-specific basis depending on the size of the mine and amount of discharge. The NPDES program is self-monitoring: mines submit results and the state has inspectors.

The scientific community in West Virginia is actively involved in research concerning AMD. Much of this research is referenced in a report by Skousen et al. (35) which provides general information on current research and new technology in order for surface mine operators to select appropriate procedures to limit acid mine drainage.

5.0 CANADIAN FEDERAL LEGISLATION

Federal jurisdiction over decommissioning tends to be more restricted than provincial jurisdiction (see Section 7.0). The Constitution Act (1867) grants specific federal power over coastal and inland fisheries, navigable interprovincial rivers and migratory birds. However, recent federal environmental legislation such as the Canadian Environment Protection Act and the Canadian Environmental Assessment Act represents an increasing federal government role in the environmental regulatory field previously dominated by the provinces. Federal legislation and guidelines relevant to decommissioning AMD sites are discussed in the following sections.

Fisheries Act

The intent of the Fisheries Act (36) is to protect fish, marine mammals, and their habitats. This responsibility is shared between the Ministers of Environment and Fisheries and Oceans. The Act prohibits the deposit of a "deleterious substance" directly into water frequented by fish or in a place where the substance may enter such water. Therefore, this Act would apply to most mining operations that discharge effluent, for example AMD, into rivers, lakes or the ocean. The Act also prohibits any work that results in the harmful alteration or destruction of fish habitat (e.g. tailings ponds).

The Metal Mining Liquid Effluent Regulations and Guidelines (37), under authority of the Fisheries Act, contain enforceable effluent regulations for new, expanded and reopened mines and non-enforceable effluent guidelines for existing mines. The guidelines have the same numerical values as the regulations. The guidelines provide flexibility for mine operators and the Minister to negotiate a compliance schedule. The limits in the regulations/guidelines are "specified for those parameters which are known to occur commonly in base metal mining effluent in sufficient amounts to be deleterious to fish and for which demonstrated practicable technology exists to reduce these substances to low levels". The effluent limitations are presented in Table 3.1, in Appendix 3.

Canadian Environmental Protection Act (CEPA)

CEPA (1988) is administered by the Department of the Environment. The Minister of National Health and Welfare provides advice on human health aspects. CEPA is a prevention-oriented statute which outlines a comprehensive scheme for the control and regulation of toxic chemicals. Therefore, heavy metals found in AMD could potentially be regulated under CEPA. However, it is more probable that AMD will continue to be regulated under the Fisheries Act which has adequate legal authority (38).

One aim of CEPA is to establish nationally consistent levels of environmental quality. CEPA provides that federal regulations with respect to toxic substances will not apply in provinces where equivalent provisions are already in force.

Canadian Environmental Assessment Act

The Canadian Environmental Assessment Act (1992), administered by Environment Canada, is to ensure that the environmental consequences of all federal projects and activities are assessed before final decisions are made. The Act identifies four categories of federal involvement which could trigger an Environmental Assessment (EA). They are when the Federal Government:

- is the proponent of a project;
- makes federal funds available for a project;
- makes federal lands available for a project;
- evokes a statutory or regulatory provision which allows a project to proceed.

When a federal authority is required to conduct an EA, screening is one of several procedural options to follow. Projects requiring a more intensive level of assessment will undergo a comprehensive study. The types of projects likely to require a comprehensive study based on their likelihood to cause significant adverse environmental effects are listed in the discussion draft: Comprehensive Study List (39). This list may be established by regulation at a later date by authority of the Act.

Of interest to the issue of AMD is the inclusion on the Comprehensive Study List of "a metal mine with a mill capacity greater than 10,000 tonnes/day". This will cover most major ferrous metal and major new non-ferrous metal mines (39). The comprehensive study will be required to show that no significant adverse effects are expected, or that such effects can be mitigated, for the project to proceed. The question of how to handle small-scale, potentially high-impact mines (e.g. gold mines), and coal and industrial mineral mines, remains unresolved.

Interim Canadian Environmental Quality Criteria for Contaminated Sites

The Canadian Council of Ministers of the Environment (CCME) inititated the National Contaminated Sites Remediation Program (NCSRP) for remediation of high priority contaminated sites in Canada. To promote consistency in the assessment and remediation of sites under NCSRP, CCME adopted the Interim Canadian Environmental Quality Criteria for Contaminated Sites (40) from existing guidelines and criteria currently in use in various jurisdictions across Canada. A partial list of the criteria is presented in Table 3.2, in Appendix 3. Many of the criteria do not have a complete set of supporting rationale and, therefore, are considered "interim". Criteria are assessed and modified as required to reflect current knowledge of the environmental and human health effects of contaminants. The criteria do not constitute values for uniform environmental quality at all contaminated sites, and their use is site-specific. Although they are non-enforceable, they may serve as a basis for site-specific enforceable parameters incorporated in mine operation permits or licences.

6.0 TERRITORIAL LEGISLATION

The territorial governments have the authority to enact legislation; however, territorial legislation is subject to federal legislation and may be limited in scope where there is a contradiction. Territorial environmental legislation commonly mirrors federal legislation and may use federal environmental controls as a baseline for territorial standards.

The federal government owns and controls most of the lands and resources in the territories and, therefore, most mining activities require federal permits and licences. The Territorial Lands Act (TLA), administered by the Department of Indian Affairs and Northern Development (DIAND), addresses concerns with respect to the abandonment and decommissioning of mines in the territories. The TLA is administered under two sets of regulations governing surface use: the Territorial Land Use Regulations (TLUR) and the Territorial Land Regulations (TLR). Typically, a prospective mining company will be issued a permit under the TLUR and will register a mining claim under the Canada Mining Regulations. The latter regulations grant authority to the Minister of DIAND to order the owner of a mining operation that is discharging a "harmful" substance to treat the substance prior to discharge, limit the discharge, or cease the operations causing the discharge. The relevant control mechanisms for abandonment and decommissioning of mines are the TLR and the leases issued pursuant to these regulations.

The federal Northern Inland Waters Act has recently been replaced by the Northwest Territories Waters Act and the Yukon Waters Act, promulgated in 1993. The Northwest Territories Waters Act, administered by the NWT Water Board and DIAND, regulates the use of water and the disposal of waste into waters of the Northwest Territories. A mining company that wishes to operate a mine must first obtain a water licence by satisfying the following conditions: any waste produced by the mining

operation will be treated and disposed of in the appropriate manner under prescribed effluent standards, and the financial responsibility of the applicant is adequate for completion of the undertaking as well as any required mitigation, maintenance or restoration. If present restoration technology will not satisfactorily prevent long term degradation of the environment, a water licence may not be issued. The Water Board may require an applicant to furnish and maintain a security with the Minister to compensate users who are entitled to compensation or to recover the Crown's costs incurred in counteracting, mitigating or remedying adverse effects. Industrial licences generally contain conditions requiring abandonment and restoration plans and their implementation. If the approved abandonment and restoration plan is not satisfactorily implemented, the security deposit or a portion of it may be withheld by the Water Board.

The NWT Water Board has published guidelines to provide the mining industry with direction in developing abandonment and restoration plans (41b). The guidelines include a discussion of design features (e.g. tailings and containment structures, cover treatments, waste rock piles), plan development (e.g.abandonment scenarios) and monitoring. The maximum acceptable concentrations for selected substances in discharges from abandoned tailings areas are from the Metal Mining Liquid Effluent Regulations, but lower values may be considered for environmentally sensitive areas.

The Water Resources Division of Northern Affairs administers and enforces the Yukon Waters Act, and is responsible for licensing. The Water Board processes and issues the licenses. The Act is similar to the NWT Waters Act. A mining company needs a license to operate. Conditions included in the license include provisions for monitoring, collection and treatment and closure. The Minister has the authority to take the necessary action to mitigate or remedy adverse effects caused by the operation and a security deposit to cover this eventuality is incorporated into the license.

Other relevant federal environmental legislation includes the Arctic Waters Pollution Prevention Act, which regulates effluent disposal in arctic waters, and the Fisheries Act, the Canadian Environmental Assessment Act and the Canadian Environmental Protection Act, which were discussed in Section 5.0.

6.1 Northwest Territories

The mineral industry in the Northwest Territories (NWT) accounts for a major portion of the territorial economy. Almost one-quarter of Canada's lead and zinc production originates in the NWT, which also produces gold, cadmium and silver (41a).

There is no legislation in the NWT directly affecting prospecting, exploration and mining. Environmental legislation includes the territorial Environmental Protection Act and the Environmental Rights Act, both administered by the NWT Department of Renewable Resources. The former provides general protection from contamination by hazardous substances. For example, it prohibits the discharge of contaminants to the environment and holds the party responsible for a spill liable for clean-up and damages. The latter is primarily concerned with the release of contaminants and gives residents of the NWT the right to take certain actions to protect the environment.

The NWT Department of Energy, Mines and Petroleum Resources has prepared a guide to legislation affecting the mineral industry in the territories (42). It provides a comprehensive look at laws and regulations which affect exploration, development and mining.

6.2 Yukon

The Yukon mining industry comprises mineral exploration, hardrock mining and placer mining. Zinc, lead and gold are the most important minerals.

Mining in the Yukon is regulated under the Yukon Quartz Mining Act (1924). The Act does not have any specific regulations governing land use activities on mining claims. An amended Act and regulations have been proposed by the Yukon Mining Advisory Committee, which includes representatives from government and industry. It is expected to encompass exploration, development, production, mine closure, financial security and penalties (43). A production license will be required for any producing mine. The licence application would trigger review under the Canadian Environmental Assessment Act.

7.0 PROVINCIAL LEGISLATION

Most of the legislative power relating to decommissioning of AMD sites falls within provincial jurisdiction because the provinces exercise proprietary rights over vast areas of Crown land and minerals; have legislative authority in relation to the development, conservation and management of mineral resources; and have powers over property and civil rights which provide a basis for the regulation of land use and mining activities, including reclamation work. Provincial jurisdiction in these areas is expressed in provincial legislation relating to environmental assessment and licensing, land-use planning, water rights and mineral tenure and mining, all which directly affect decommissioning activities. Provincial legislation and guidelines relevant to decommissioning AMD sites are discussed in the following sections.

7.1 Alberta

Alberta's mineral endowment lies mainly in petroleum and natural gas, coal and oil sands. Metallic minerals are not mined in Alberta. Because the coal that is mined is low in sulphur, AMD is not a major problem in Alberta.

The Alberta Clean Water Act legislates the licensing of coal mines. The effluent criteria are site-specific and incorporated into the operating license for the mine. Some criteria for licencing are contained in the Coal Guidelines, which are in "updated draft form". For example, the pH of wastewater discharged must be within the range of 6.0 - 9.5 based on grab sampling. In addition, criteria from the Alberta Surface Water Objectives (44) or the Canadian Water Quality Guidelines (CWQG) (45) are used for licencing. CWQG are being used more frequently in preference to the Alberta Surface Water Objectives.

The authority for imposing reclamation requirements on Alberta mining operations is found primarily in the Land Surface Conservation and Reclamation Act, the Coal Conservation Act, and the Public Lands Act (46). Authority governing the reclamation of coal operations is shared by the Energy Resources Conservation Board (ERCB) and Alberta Environment with the former responsible for coordinating the numerous approvals required to engage in coal mining in Alberta.

Because AMD is not a significant problem in Alberta, there is no legislation, policy, or criteria specific to AMD. In addition, there are no case studies of decommissioning an AMD site.

Therefore, a more detailed discussion of Alberta's regulatory framework with respect to coal mining is beyond the scope of this review.

7.2 British Columbia

Mineral products constitute over one-fifth of the province's total exports. Coal and copper are British Columbia's most important minerals, followed by zinc, gold and silver (41). AMD occurs at six of the sixteen operating metal mines, and none of the eight operating coal mines in British Columbia (47). British Columbia is a participant in the MEND program.

The Mine Development Assessment Act (48) provides the legal framework for comprehensive environmental assessments of proposed mine developments. It is intended to dovetail with the Canadian Environmental Assessment Act. Mine developments subject to the Act are termed "reviewable mine developments" and include new coal or mineral mines capable of producing 10,000 tonnes per year, or other mines designated by the Chief Inspector of Mines where potential impacts warrant an integrated review. An application for a mine development certificate must contain an environmental protection plan approved by the Minister of Energy, Mines and Petroleum Resources with the concurrence of the Minister of the Environment. A mine development certificate must be obtained before a "reviewable mine development" can be constructed. As part of the approval process, the government requires testing to identify potentially acid producing materials and requires assurance that all sources of potential acid generation have been identified and that prevention and control measures have been incorporated into the plan, if appropriate. The Ministers may refer the application to an assessment panel or accept, modify or reject an application. The assessment panel may recommend amendments to the certificate which overrule existing permits even if those permits were obtained in compliance with applicable legislation.

The Mines Act (49) governs all mining activities including exploratory drilling, excavation, processing, concentrating, waste disposal and site reclamation. Before commencing work on a mine, proponents are required to outline the proposed work plan and a program for the protection and reclamation of the land and watercourses affected by a mine, and to obtain a Reclamation Permit. Disturbed land and water resources must be reclaimed to a level of productivity not less than that which existed previously, and water released from the minesite must meet long term water quality standards. A security deposit may be required for reclamation purposes. The inspectors appointed under the Act may do work around a closed or abandoned mine to abate pollution and a charge may be registered against the mineral title.

The Mines Act also established the Health, Safety and Reclamation Code for Mines in British Columbia (50). The code is subject to an annual review. Compliance with the code, which covers worker health and safety, mechanical/electrical and reclamation requirements, is necessary. Proposed mines must submit reclamation plans if a surface disturbance is likely to result. The Chief Inspector of Mines decides when exploration work is likely to cause a significant surface disturbance and exercises broad discretion with respect to requiring and approving reclamation programs (46). Reclamation plans should include: 1) location and extent of the mine, 2) present land uses, 3) nature of the mine, with special reference to "prediction of acid generation for all strata and deposits, including static and, if necessary, kinetic tests", 4) reclamation plan for construction and operational phases of mining operation, and 5) final reclamation plan. Mine reclamation standards are also specified in the code and include returning the land and watercourses to a productive land use, ensuring that impoundment structures and waste rock dumps are stable over the long-term, and ensuring that water quality released from a mine site is of an acceptable standard. With respect to acid generating material, the mine reclamation standards specify that "all potential acid generating material shall be placed in a manner which minimizes the production and release of AMD to a level that assures protection of environmental quality".

The Pollution Control Objectives (51) contain objectives for discharges to air, water and land. The objectives provide for a wide range of discharge concentrations depending on the needs of particular receiving environments. The more stringent values apply to sensitive environmental situations, the less stringent where it can be shown that unacceptably deleterious changes will not follow. The objectives are intended to apply province-wide, but in special circumstances the Director of Pollution Control may apply more, or less stringent requirements. The objectives for final effluent are presented in Table 4.2, in Appendix 4.

British Columbia does not have any province-wide water quality objectives. BC Environment develops objectives on a site-specific basis using scientific guidelines, or criteria (52). For example, if an area has very high copper, objectives for copper would be set for this area. Each objective and criteria is published in a separate report. There are presently reports on 33 objectives and 15 criteria. Objectives may serve as a guide for mine permitting and may help to assess the Ministry's performance in protecting water uses. Neither criteria nor objectives are based on any legislation, therefore, they are non-enforceable. However, these guidelines are used in the review of a mine development certificate and failure to comply may result in significant delays. Furthermore, each mine site has site specific parameter concentrations specified in their waste management permits.

The Victoria-based Reclamation Advisory Committee (RAC) has developed a series of working policies and technical initiatives to deal with AMD. These have recently been released as an "Interim Policy" for public comment (47). The interim policy reflects the RAC's current philosophy of preventing

AMD generation through prediction and design, wherever possible avoiding long term treatment. The policy contains sections dealing with prediction, prevention, collection and treatment, reclamation permitting, bonding, monitoring, historic sites, existing mines, commercial leaching and exploration. Many of these issues are discussed in detail in a guidance document sponsored by the British Columbia Acid Mine Drainage Task Force (53). The objectives of the document are to provide guidance and recommendations in the application of state-of-the-art technology in prediction, control and monitoring of AMD.

Of the sixteen metal mines currently operating in British Columbia, six are presently producing AMD and several more have the potential to do so. These six mines are currently collecting and treating all acidic drainage. Of the eight operating coal mines, none are presently generating AMD. Although one coal mine has acid generating potential, it has been designed to prevent AMD. For proposed new mines, government policy is to approve only those mines which develop plans that prevent or control AMD (54).

Existing mines with AMD which commenced operation prior to present legislation are required to submit detailed closure plans. For example, the Equity Silver Mine in the central interior of British Columbia has scheduled closure and developed detailed closure plans. At this time, the water quality objectives are not yet available. British Columbia also has at least six historic mine sites with AMD and new policies pertaining to them are currently under development. One such site is the Mt. Washington Mine on Vancouver Island which is undergoing reclamation. However, water quality objectives are in the early draft stage and not yet available.

7.3 Manitoba

Next to agriculture, mining is the leading primary resource industry in Manitoba. Nickel, copper and zinc are the major metallic minerals produced in the province. Manitoba is a participant in the MEND program. There are some serious AMD sites in Manitoba, but not many compared to other provinces participating in MEND. There are no readily available case studies of AMD sites that have been decommissioned.

Manitoba has a new Mines and Minerals Act (55) which contains improved environmental safeguards for mining operations. There are two sections relevant to decommissioning AMD sites:

- new and existing mining operations must file closure plans which address the "protection of the environment during the life of the project" and rehabilitation of the site upon mine closure; and

- mining operations must put up security for performance of rehabilitation work.

However, the practical details of the closure and rehabilitation requirements are still to be worked out and developed into regulations. A target date for development of regulations has not been set.

Prior to commencing operation of a mine, an environmental impact statement must be completed to comply with the Environment Act. In Manitoba, the Clean Environment Commission (CEC) holds hearings and gathers evidence from any "concerned individuals" including the public, the government Environmental Department, and the proponent. Following this, the CEC issues a report with recommendations which the Director of the Environment Department uses in setting terms and conditions of an Environmental License. The Director is not bound by the CEC recommendations, but must indicate why any such recommendations are rejected. Any issued License is subject to an appeal process. The mine license includes limitations on effluent. Federal effluent limitations are sometimes used, but in general, criteria are set on a site-specific basis using the following approach.

Surface waters in Manitoba are classified from 1 to 6. Manitoba Environment assesses the potential impact area of the proposed mine and, if the surface waters in the vicinity have not been previously classified, makes an assumption as to water classification. As can be expected, the class of surface waters for the entire province has not been determined yet. Public hearings are required to set the classification, therefore, during mine licensing only an initial assumption is made. Manitoba Environment then selects the most stringent surface water quality objectives applicable, based on the assumed classification, and sets effluent limitations such that the loading to the surface water can be accomodated without exceeding the water quality objectives. At times, this approach results in criteria more stringent than the federal mine effluent limitations.

Details on surface water classification and water quality objectives are contained in the following three documents: Surface Water Quality Objectives, The Development and Use of Water Quality Objectives (56) and Watershed Classifications (57). Manitoba does not have any groundwater standards yet, but they are in the development stage.

7.4 New Brunswick

Mining is New Brunswick's second-largest industry. The most valuable minerals are zinc, potash, lead, silver, coal, antimony and peat, with zinc accounting for over 50 percent of the total value of production (41). AMD is an overwhelming problem in New Brunswick, but very few (if any) AMD sites have been decommissioned at this time. New Brunswick is a participant in the MEND program.

The Mining Act (58) provides the authority for the imposition of reclamation requirements on mining operations. As part of the mine approval process, an application must be made to the Minister of Natural Resources and Energy in satisfaction of the requirements of the Mining Act. Requirements for closure and reclamation are regulated under the General Regulation (59) which specifies that a reclamation program for the protection, reclamation and rehabilitation of the environment be submitted as part of the application for a mining lease. In addition, mining lease applicants are required to provide security for the costs of reclamation work conducted both during and after mining operations. A mining lease will not be granted until the Minister has approved the reclamation program.

The approvals process for a new mine may commence with an environmental impact assessment (EIA) if, in the Minister's opinion, the proposed mining operation will result in a significant environmental impact. New Brunswick has a standing committee consisting of members from the Department of Natural Resources and Ministry of the Environment who oversee the EIA process by authority of the Environmental Impact Assessment Regulation (60). This regulation does not specifically deal with mine decommissioning, but the feasibility of mine reclamation would likely be addressed in the EIA.

The Water Quality Regulation (61) prohibits anyone, without approval, from permitting a source to discharge a contaminant such that it may cause water pollution. The Clean Water Act (62) gives authority to the Minister of Health and Community Services to prescribe the maximum concentration of any contaminant or waste that is permissible in potable water and to the Minister of the Environment for water that is not potable. However, there are no compliance numbers in either the Clean Environment Act or its regulations, or in the Clean Water Act. Criteria for water quality and effluent are usually taken from federal sources such as the CCME criteria and the Metal Mining Liquid Effluent Regulations, but criteria are negotiable and site-specific.

7.5 Newfoundland

Iron ore accounts for over 80 percent of the provincial mineral industry; the other two leading minerals are zinc and asbestos. Newfoundland does not have a significant AMD problem.

The Environmental Assessment Act (63) governs the approval of new mines in Newfoundland and provides the authority to impose reclamation conditions on these operations. It does not apply to mines already in operation when the Act was passed. The Act requires proponents to notify the Minister of the Environment prior to proceeding with the final design of an "undertaking" defined as an activity which, in the opinion of the Minister, may have a significant environmental impact. In addition, a schedule of activities that must be registered under the Act are provided in Environmental Assessment Regulations, and include metal and non-metal mines over 10 ha in area.

Once a proposed mining operation is registered, the Minister determines if an EIA is required. If it is, the proponent is required to provide a description of the effects that may be expected to be caused to the environment and actions necessary to prevent or mitigate the effects, and a proposed set of control or remedial measures to minimize the effects. If the proposed mining operation is approved, the Minister may attach conditions that the proponent "restore the affected environment to ecologically and socially acceptable levels".

Mining operations are regulated under The Department of Mines and Energy Act (1989). In addition, the Environment and Lands Act specifies that any building or construction requires a discharge permit from the Minister of Environment. The Minister issues a discharge permit to mines before they can start and effluent limits are set at this point. Newfoundland utilizes the federal Metal Mining Liquid Effluent Regulations, the Canadian Water Quality Guidelines and any other regulations or criteria on a site-specific basis. In addition, the pH of any effluent can be set under the Water and Sewage Regulations.

There are no regulations or policies specific to AMD in Newfoundland. The Newfoundland Department of Mines and Energy deals with AMD problems at the point when the mining company wants to terminate its lease and return the land back to the province. The mining company must show that the mine site will not pose any environmental liability. Effluent data is reviewed by relevant provincial and federal agencies and a decision made on a site-specific basis whether the mine poses a problem or not. One mine returned to the province does have an AMD problem. As part of the remedial assessment, the province is reviewing stream geochemical data collected previously by the Newfoundland Geological Survey for prospecting purposes. The province plans to utilize the data to establish background concentrations of parameters of concern.

7.6 Nova Scotia

Coal and industrial minerals constitute the bulk of mining in Nova Scotia. Coal is Nova Scotia's most

important mineral resource, followed by gypsum. Canadian primary tin production came from one open-pit mine in East Kemptville until 1991 (41). Nova Scotia has a significant AMD problem due to the fact that pyrite-rich Halifax Formation slate underlies many areas of the province.

Many aspects of mining operations are regulated under the new Mineral Resources Act (64), administered by the Nova Scotia Department of Natural Resources. It deals primarily with land management issues such as mining leases, mining permits, reclamation and bonding. The department is currently developing guidelines for reclamation (65).

Mining operations are also affected by the Environmental Protection Act (66) which requires industry to apply for an industrial discharge permit at the commencement of operations. Effluent criteria are determined on a case-by-case basis as part of the permitting. As a result, the Department of Natural Resources, who have jurisdition over permitting, works closely with the Department of Environment, who has jurisdiction over effluent quality. Nova Scotia does not have their own water quality objectives or effluent guidelines. They use objectives from other jurisdictions including the federal Metal Mining Effluent Regulations.

The Environmental Protection Act also requires industry to propose close-out plans and put-up security at the same time. The close-out plans tend to be very general, for example: "a reclamation plan will be available 1 year prior to closure".

Mine decommissioning may be influenced in some cases by the Environmental Assessment Act (67). This Act requires proponents to register proposed mining activities with the Minister of the Environment. The Minister then decides if the activity has the potential to have a significant environmental impact, in which case an environmental assessment report would be required. Based on the report and input from government agencies and the public, the Minister has the authority to grant approval for the proposed operation and to place conditions on the approval. Specific authority is provided in the Act for conditions requiring reclamation research and rehabilitation to a level acceptable to the Minister. The Act also requires that owners register abandonment of particular operations. Based on input from government agencies and the public, it is decided whether a complete environmental assessment is required.

Of relevance to more than just the mining industry are the Guidelines for Development on Slates in Nova Scotia (68), jointly prepared by the Nova Scotia Department of Environment and Environment Canada. The objective of the guidelines is to protect aquatic habitat and water resources from acid runoff from disturbed Halifax Formation slate. The guidelines apply to all developments on, or disposal of, mineralized slates where a total volume greater than 1000 m^3 is to be disturbed. The guidelines require

monitoring effluents and groundwater at all development sites for pH, arsenic, iron, sulphate, copper, aluminum, total acidity, alkalinity and conductivity. No compliance criteria are given; they are determined on a site-specific basis. The guidelines also include protocols for the sampling and evaluation of bedrock and overburden with respect to acid generation potential.

Recently, Nova Scotia initiated a review and overhaul of the province's environmental laws. The process will culminate in a consolidation of 16 pieces of environmental legislation into a single act, titled the Nova Scotia Environment Act. Among legislation included in the review will be the Environmental Protection and Environmental Assessment Acts.

7.7 Ontario

Ontario accounts for one-third of total Canadian mineral production: two-thirds of Canada's nickel and salt, almost half its gold, a third of its sand and gravel, cement, copper and uranium, and over a quarter of its silver and zinc (41). Four minerals: gold, nickel, copper and uranium, constitute over half the value of Ontario's production. Ontario is a participant in the MEND program.

Activities specific to mining operations are regulated by authority of the Mining Act (69) which was amended in 1991 to include Part VII. Part VII and accompanying regulations (70) address mine closure and rehabilitation. Any mining company that plans advanced exploration, mine production, expansion or alteration of a project, or temporary suspension or closing out of a project must follow the rehabilitation requirements outlined in an accepted closure plan or the rehabilitation standards set out in the Regulations. Part VII also gives the Director of Mines Rehabilitation the ability to demand closure plans for properties already abandoned when the Act came into force and where the owner can be found.

To assist proponents in dealing with the requirements of Part VII pertaining to closure, the Ontario Ministry of Northern Development and Mines has issued extensive guidelines that include details on: closure plans, the Regulations, closure technology, closure components, monitoring, costing and financial assurance (71). Some items from the guidelines that are relevant to this review follow.

The closure plans should provide data on ore mineralogy and on the acid generating potential of the ore and host rock. They should provide data to assess potential water quality impacts adjacent to and downstream from the site. Predicted downstream water quality should be compared with Provincial Water Quality Objectives. The closure plan should also provide details on the chemical monitoring program to be carried out during closure including the location of the monitoring points, the parameters

to be measured and sampling frequency. Parameters to be measured will be determined on a site-specific basis and will depend on the mineralogy of the particular site, results of the predicted downstream water quality, and relevant provincial and/or federal effluent and water quality criteria.

Policies and implementation procedures regarding the management of surface and groundwater quality and quantity are contained in Water Management - Goals, Objectives, Policies and Implementation Procedures of the Ministry of the Environment (72). The document sets Provincial Water Quality Objectives which represent a desirable level of water quality that the Ministry of Environment and Energy (MOEE) strives to maintain in Ontario's surface waters. A partial list is presented in Table 4.4, in Appendix 4. The document also contains objectives for groundwater quality including Ontario's Drinking Water Objectives, which have been recently updated (73), and water quality criteria for agricultural use. A partial list is presented in Table 4.5, in Appendix 4.

No effluent criteria are set in the above document, although there is a discussion of how they are determined. However, Ontario is currently in the midst of implementing the Municipal Industrial Strategy for Abatement (MISA) which is a regulatory program initiated by the MOEE to tighten standards which must be met by mines and other industries that discharge effluent into surface waters. Initially, each of nine major industrial sectors have been subject to a monitoring regulation which requires them to identify, measure and report concentrations of toxic chemicals in the effluents that they discharge into surface waters. After one year of monitoring, the MOEE will review the results and develop regulations that specify the concentrations of toxic pollutants permitted in the effluent of each operation. Effluent limits will generally be established on a sector-by-sector basis, but more stringent limits may be set for a particular operation in order to protect sensitive waterbodies. MOEE will set effluent limits that are attainable by using the "best available technology economically achievable".

Draft Clean Water Regulations for the Metal Mining Sector have recently been released for public review (Sept., 1993). The final regulations will be enforceable and will be at least as stringent as the federal Metal Mining Liquid Effluent Regulations, but will likely include more parameters.

MISA's legislative authority is based on the Environmental Protection Act (EPA) (74). The purpose of the Act is to protect and conserve the air, land and water of Ontario. It prohibits discharges that contaminate the environment, and enables the MOE to require that certain discharges be stopped or controlled, preventive measures taken and damage repaired. The Ontario Water Resources Act (OWRA) (75) also prohibits discharges of materials that may impair water quality, and enables the MOEE to require measures to be taken to prevent or reduce water quality impairment. The general purpose of the OWRA is to protect and conserve the lakes, rivers, streams and groundwater of Ontario. There is some overlap between the EPA and OWRA, but the Acts complement each other

and are both administered by the MOE.

Ontario also has an Environmental Assessment Act. Proposed mining operations in Ontario have generally not been subject to the Environmental Assessment process, although MOEE is considering requiring that all proposed private sector mining undertakings undergo some form of environmental assessment and approval process (76).

7.8 Prince Edward Island

As Canada's smallest province, Prince Edward Island has limited mineral activity. Although the presence of uranium has been recorded at various points on the island, the only minerals with current commercial value are sand and gravel (41). Therefore, existing mining and environmental legislation and policies for Prince Edward Island were not considered relevant to this review.

7.9 Quebec

Over half the value of Quebec's mineral production is derived from gold, iron ore, asbestos and copper (41). Mining has traditionally been a major source of employment in the northeastern, north-central and Gaspe regions of the province. Quebec has a significant AMD problem and is a participant in the MEND Program. A comprehensive environmental report on Quebec's mining industry was released in 1991 (77).

The Mining Act (78) sets out requirements for exploration licences and for operators involved in mining activities and, due to recent amendments, ensures the rehabilitation and restoration of land affected by mining activities. The Ministry of Energy and Resources is responsible for developing mineral resources in the public domain and has control over the restoration of mining sites. Mine operators are required to submit a rehabilitation and restoration plan for approval before exploration or mining activities begin (for new mines), or within a set period of time (for existing mines), meet the requirements of the plan and furnish a financial guarantee. The content of restoration plans will be site-specific. Acid generation tests can be requested to determine if there is a danger of AMD and restoration plans will be stricter when acid tailings are present (79). Rehabilitation and restoration plans are subject to consultation with the Ministry of the Environment.

In cases of non-compliance, the Minister has authority to order the work done at the operator's expense. The amendments also give the Minister authority to order an operator having already ceased

his mining activities to perform rehabilitation and restoration work due to the presence of tailings, even if the operation predates the amendments.

Mining activities are subject to the Environmental Quality Act (80) which requires that certificates of authorization be obtained from the Ministry of the Environment prior to the commencement of any mining activity which may change the environment. A certificate is also necessary for any modifications. Procedures and requirements for obtaining the certificate of authorization are outlined in Directive 019 (81), a guidance document which addresses aspects of the Environmental Quality Act applicable to the mining industry. For example, it contains criteria for final effluent from mines, derived largely from the federal Metal Mining Liquid Effluent Regulations, which are presented in Table 4.6, in Appendix 4. The directive applies to both new and existing mines.

Drinking Water Regulation (82) contains enforceable drinking water quality criteria. A partial list is presented in Table 4.7, in Appendix 4. Quebec does not have any regulations containing surface water quality criteria.

7.10 Saskatchewan

About 40 percent of world exports of potash are produced in Saskatchewan. The province also contains some of the highest-grade reserves of uranium known in the western world. Other metals and minerals produced in Saskatchewan include coal, sodium sulphate, special clays, copper, zinc, gold, silver, cadmium, selenium and tellurium (41). Newer uranium ore bodies, which are located in the sulphide-bearing Athabasca Sandstone, tend to have a greater AMD problem than older ones located in sulphide-poor basement rocks. Saskatchewan has a fairly arid climate and AMD can take awhile to manifest itself. Saskatchewan has recently become involved in the MEND program.

Prior to licensing, new mines in Saskatchewan must go through the Environmental Impact Assessment (EIA) process by authority of the Environmental Assessment Act (83). Once the Minister of the Environment is satisfied that the proponent has met the requirements of the Act, he will decide whether to approve the development. The Minister may impose any terms and conditions on the approval that he considers necessary or advisable. For example, in the case of major coal mine operations, conditions have been placed on the approvals requiring compliance with the reclamation program described in the Environmental Impact Statement (part of the EIA process) or with area specific reclamation guidelines (46).

The Mines Pollution Control Branch of the Department of Environment is responsible for licensing mines by authority of the Environmental Management and Protection Act (84), which the Branch administers. The Branch provides input during the EIA process, but its primary role lies in approving and ensuring compliance with the site specific reclamation plans required as part of the EIA process. Security deposits are generally not required. Abandonment of a mine site rquires approval by the Minister.

Effluent criteria for mines are site-specific. Some criteria are contained in the Mineral Industry Environmental Protection Regulations (85), but these are very broad-based and apply to all types of mining. They are presented in Table 4.8, in Appendix 4. Effluent criteria are generally determined by considering the Surface Water Quality Objectives (86) which are incorporated into the EIA prior to approval. A partial list of these objectives is presented in Table 4.9, in Appendix 4.

Saskatchewan Environment and Public Safety, with input from a committee of industry and regulatory representatives, has published guidelines for the design and control of mine effluent quality (87). The objectives of the guidelines are to provide a summary of the processess which control effluent quality and to provide guidance and recommendations for the state of the art in prediction, control and monitoring of AMD and metal leaching. The guidelines were written for the uranium mining industry in Saskatchewan in particular, although the general philosophy and approach are used throughout the mining industry (35, 53).

8.0 SUMMARY

In general, regulatory strategies specifically geared towards decommissioning sites with AMD are still in the development stage in both Canada and the United States. Overall, environmental legislation is more prescriptive in the United States than in Canada. Some of the criteria that would typically be used in assessing the success of an AMD site decommissioning are effluent quality leaving the mine site and groundwater and surface water quality downgradient from the mine site. Effluent limitations, drinking water standards and surface water quality criteria have all been developed at a federal level by the United States Environmental Protection Agency. In addition, they are all enforceable at either the federal or state level, depending on whether a particular state has an approved regulatory program in place. In Canada, on the other hand, non-enforceable water quality guidelines, or objectives are the norm. However, site-specific enforceable parameters, based on water quality guidelines or objectives, may be incorporated in mine operation permits or licences.

Seven states were contacted as part of this review. Idaho and Nevada have no regulations, guidelines or policies tailored specifically for licensing or decomissioning mines with AMD, or the potential for AMD. Nevada does not have a significant problem with AMD due to its arid climate, and legislation in Idaho has not been developed to the level of detail to include AMD sites. These states do not have any AMD sites that have been decommissioned.

California and Montana do not have clear-cut legislation to address AMD specifically, but do seem to have some general policies for the approach to be used in decommissioning AMD sites. In both states,

decommissioning of mine sites with AMD is done in a site-specific manner, as exemplified by some case studies discussed in this report.

Legislation in Colorado loosely makes reference to AMD by stating that "acid-forming material" at operating mine sites should be handled in a manner that will protect downgradient water bodies. A major mining reform package is currently before the Colorado Legislature.

Only two of the states contacted, Pennsylvania and West Virginia, have a regulatory strategy that addresses AMD directly. In both states, predictive testing for acid generation potential is mandatory prior to approval. Furthermore, in Pennsylvania, if a proposed mine site is shown to have the potential for AMD, it is not licensed. On the other hand, West Virginia will license a mine with AMD potential, but requires that control technologies be adequate to meet effluent and water quality criteria. The fact that the regulatory system in these states addresses AMD specifically is likely due to the importance and high visibility of coal mining in both these states, and the problem of AMD associated with it. However, even in these two states, there is no systematic approach for decommissioning abandoned mines with AMD.

Canada is actively involved in research on the prediction and control of AMD, particulary with respect to metal mining operations. Much of this research is fostered by the national Mine Environment Neutral Drainage (MEND) program in which the federal government, the Canadian mining industry and the provinces of British Columbia, Saskatchewan, Manitoba, Ontario, Quebec and New Brunswick participate. Research on AMD from coal mining operations is likely further advanced in the United States.

All the provinces and territories were contacted as part of this review. Two of the provinces do not have a significant AMD problem (Prince Edward Island, Alberta). The remaining provinces and the territories are at different stages of developing regulatory strategies for addressing AMD. In most jurisdictions, there are now provisions for proposed mines to complete some type of environmental impact statement. However, depending on which jurisdiction, the discretion granted to the "minister", and/or the size of the proposed mine, the complexity of the statement will vary.

Several provinces, including British Columbia, Ontario and Saskatchewan, have guidelines in place that require predictive testing, prior to approval, to determine the acid generation potential of rock units at a proposed mine. Nova Scotia has gone a step further and requires monitoring at any development on shale of the Halifax Formation, and predictive testing for acid generation potential in certain instances.

With respect to effluent limitations, most provinces use the federal Metal Mining Liquid Effluent

Regulations, although some provinces such as British Columbia, Saskatchewan and Quebec have developed their own. Ontario is currently in the process of developing comprehensive effluent regulations for various industries, including netal mining, under the Municipal Industrial Strategy for Abatement (MISA) program.

With respect to water quality, many provinces use the federal Canadian Water Quality Guidelines, although provinces such as British Columbia, Alberta, Manitoba, Saskatchewan, Ontario and Quebec have developed, or are developing, their own criteria for surface water and/or groundwater quality. Both British Columbia and Manitoba seem to be taking slightly different approaches from the other provinces to developing water quality management programs. For example, with time, surface water bodies in Manitoba will be classified according to present and potential use and water quality criteria set accordingly. This approach is similar to that taken in the United States. British Columbia sets water quality objectives on a site-specific basis, taking into account such factors as water quality and water uses. This approach potentially has the flexibility to address the anomalous background water chemistry sometimes encountered at mine sites.

REFERENCES

1. Federal Water Pollution Control Act Amendments of 1972, 33 United States Code, Section 1251, et seq.

2. Ore mining and dressing point source category, Code of Federal Regulations, Title 40, Part 440, 1992.

3. Coal mining point source category, Code of Federal Regulations (CFR), Title 40, Part 434, 1992.

4. Eddy RM, Gilbert AJ, Erwin TP, 1990. An overview of environmental laws impacting the mining industry. In: Proceedings of the Western Regional Symposium on Mining and Mineral Wastes, Berkeley, California: 3-9.

5. Safe Drinking Water Act, 42 United States Code, Section 300f-300j-11, 1974.

6. Comprehensive Environmental Response, Compensation, and Liability Act, 42 United States Code, Section 9601, et seq., 1980.

7. Berg MG, Callaway RJD, 1989. Consideration of mining issues at Superfund sites. In: Proceedings of the 6th National Conference on Hazardous Wastes and Hazardous Materials, New Orleans, Louisiana: 624-629.

8. Resource Conservation and Recovery Act, 42 United States Code, Section 6901, et seq., 1976.

9. National Environmental Policy Act, 42 United States Code, Section 4321, et seq., 1969.

10. Hamilton J, 1993. Fields of Dust. Sierra, 78(1):50-53.

11. Surface Mining Control and Reclamation Act, 30 United States Code, Section 1201, et seq., 1977.

12. State Water Resources Control Board, Discharges of Waste to Land, California Code of Regulations, Title 23, Subchapter 15. Register 84, No. 49-12-8-84.

13. Porter-Cologne Water Quality Control Act, California Water Code, Division 7, Chapters 1-15.

14. North Coast Regional Water Quality Control Board (California), 1988. Water quality control plan for the North Coast Region.

15. Colorado Mined Land Reclamation Act as Amended, Colorado Revised Statutes, Title 34, Article 32, 1973.

16. Colorado Mined Land Reclamation Board, 1977. Mineral rules and regulations. Department of Natural Resources, Mined Land Reclamation Division.

17. Colorado Water Quality Control Act, Colorado Revised Statutes, Title 25, Article 8, Section 101, et seq.

18. Colorado Department of Health (Water Quality Control Commission), 1991. The basic standards and methodologies for surface water.

19. Colorado Department of Health (Water Quality Control Commission), 1991. The basic standards for groundwater.

20. Idaho Department of Health and Welfare, Water quality standards.

21. Nautch IM, 1990. Development and evaluation of regulations for cyanide heap and vat leaching operations in Idaho. In: Proceedings of the Western Regional Symposium on Mining and Mineral Processing Wastes, Berkeley, California: 21-29.

22. Strip and Underground Mine Reclamation Act, R.C. Montana, Title 82, Chapter 4, Section 201, et seq.

23. Metal Mine Reclamation Act, R.C. Montana, Title 82, Chapter 4, Section 301, et seq.

24. Surface Water Quality Standards, Administrative Rules of Montana, Title 16, Chapter 20, Subchapter 6.

25. Montana Groundwater Pollution System, Administrative Rules of Montana, Title 16, Chapter 20, Subchapter 10.

26. Water Pollution Control Law, Nevada Revised Statutes, Chapter 445.

27. Regulations governing design, construction, operation and closure of mining operations, Nevada Administrative Code, 1989.

28. Ross C, 1992. Gold mining affects ground water. Ground Water Monitoring Review, 12(4):100-102.

29. The Surface Mining Conservation and Reclamation Act, 52 Pennsylvania Statutes, 1396.1 et seq., 1945.

30. The Clean Streams Law, 35 Pennsylvania Statutes, 691.1 et seq., 1937.

31. 25 Pennsylvania Code, Environmental Resources, Chapters 86-90, 1990.

32. Water Quality Standards, 25 Pennsylvania Code, Chapter 93.

33. West Virginia Water Resources Board, 1990. Requirements governing water quality standards, Legislative Rules, Title 46.

34. West Virginia Water Pollution Control Act, West Virginia Code, Chapter 20, Article 5(a), Section 1, et seq.

35. Skousen JG, Sencindiver JC, Smith RM, 1987. A review of procedures for surface mining and reclamation in areas with acid-producing materials. West Virginia University Energy and Water Research Center, Publication EWRC871.

36. Fisheries Act, Revised Statutes, Chapter F-14, Section 1, 1985.

37. Environment Canada, 1977. Metal Mining Liquid Effluent Regulations and Guidelines. Report EPS 1-WP-77-1.

38. Perrier R, MacLatchy JE, 1991. The federal regulatory perspective in Canada on acid mine drainage. In: Proceedings of Second International Conference on the Abatement of Acidic Drainage, Montreal, Quebec.

39. FEARO (Federal Environmental Assessment Review Office), 1991. Comprehensive Study List: Discussion Draft.

40. CCME (Canadian Council of Ministers of the Environment), 1991. Interim Canadian Environmental Quality Criteria for Contaminated Sites. Report CCME EPC-CS34.

41a. McAllister ML, Schneider TF, 1992. Mineral policy update, 1985-1989: Policy and program changes affecting the Canadian mineral industry. Centre for Resource Studies, Queen's University.

41b. Northwest Territories Water Board, 1990. Guidelines for Abandonment and Restoration Planning for Mines in the Northwest Territories.

42. Government of the Northwest Territories (Department of Energy Mines and Petroleum Resources), 1991. A guide to legislation affecting exploration and mining in the Northwest Territories.

43. McIntyre RL, 1992. Amendments to the Yukon's Mining law. In: Proceedings from the Prospectors and Developers Association of Canada Annual Meeting, Toronto, Ontario: 133-140.

44. Alberta Environment (Water Quality Branch), 1977. Alberta surface water quality objectives.

45. CCREM (Canadian Council of Resource and Environmental Ministers), 1987. Canadian Water Quality Guidelines.

46. Scarth J, 1989. Mine reclamation law in Canada.

47. Ministry of Energy, Mines and Petroleum Resources, 1993. Interim policy for acid rock drainage at mine sites. Issued for comment and discussion by the British Columbia Reclamation Advisory Committee.

48. Mine Development Assessment Act, Statutes of British Columbia, Chapter 55, 1990.

49. Mines Act, Statutes of British Columbia, Chapter 56, 1989.

50. Ministry of Energy Mines and Petroleum Resources (Resource Management Branch), 1992.

Health, Safety and Reclamation Code for Mines in British Columbia.

51. BC Environment, 1979. Pollution Control Objectives for the Mining, Smelting and Related Industries of British Columbia.

52. BC Environment (Water Management Division), 1986. Principles for preparing water quality objectives in British Columbia.

53. British Columbia Acid Mine Drainage Task Force, 1989. Draft acid rock drainage technical guide . BiTech Publishers Ltd., Vancouver.

54. Ministry of Energy Mines and Petroleum Resources, 1991. Mine Reclamation in British Columbia: Policy Overview.

55. Mines and Minerals Act, Revised Statutes of Manitoba, Chapter M-162, 1991.

56. Williamson DA, 1990. The development and use of water quality objectives in Manitoba. Manitoba Department of Environment, Water Standards Section Report #90-2.

57. Williamson DA, 1983. Surface water quality management proposal. Volume 2: Watershed classifications. Manitoba Department of Environment and Workplace Safety and Health, Water Standards and Studies Report #83-3.

58. Mining Act, Revised Statutes of New Brunswick, Chapter M-14.1, 1985.

59. General Regulation - Mining Act, New Brunswick Regulation 86-98, 1986.

60. Environmental Impact Assessment Regulation - Clean Environment Act, New Brunswick Regulation 87-83, 1987.

61. Water Quality Regulation - Clean Environment Act, New Brunswick Regulation 82-126, 1982.

62. Clean Water Act, Statutes of New Brunswick, Chapter C-6.1, 1989.

63. The Environmental Assessment Act as Amended, Statutes of Newfoundland, Chapter 3, 1980.

64. Mineral Resources Act, Statutes of Nova Scotia, 1991.

65. Ratcliffe R, 1992. The new Mineral Resources Act and Department of Natural Resources in Nova Scotia. In: Proceedings from the Prospectors and Developers Association of Canada Annual Meeting, Toronto, Ontario: 141-146.

66. Environmental Protection Act as Amended, Statutes of Nova Scotia, Chapter 6, 1973.

67. Environmental Assessment Act, Statutes of Nova Scotia, Chapter 11, 1988.

68. Nova Scotia Department of Environment and Environment Canada, 1990. Guidelines for development on slates in Nova Scotia.

69. Mining Act, Revised Statutes of Ontario, Chapter M.14, 1990.

70. Mine Development and Closure under Part VII of the Act, Ontario Regulation 114/91, 1991.

71. Ontario Ministry of Northern Development and Mines, 1991. Rehabilitation of mines: Guidelines for proponents.

72. Ontario Ministry of the Environment (MOE), 1984. Water Management - Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment.

73. Ontario Ministry of the Environment (MOE), 1992. Ontario's Drinking Water Objectives.

74. Environmental Protection Act as Amended, Revised Statutes of Ontario, 1980.

75. Ontario Water Resources Act, Revised Statutes of Ontario, Chapter 361, 1980.

76. Osler Hoskin & Harcourt, 1990. Environmental legislation manual for the mineral industry in Ontario. Ontario Mining Association.

77. Association miniere du Quebec, 1991. Les mines et l'environnement.

78. Mining Act, Revised Statutes of Quebec, Chapter M-13.1, 1992.

79. Marcoux L, 1992. New environmental legislation on the rehabilitation and restoration of land affected by mining activities in Quebec. In: Proceedings from the Prospectors and Developers Association of Canada Annual Meeting, Toronto, Ontario: 63-71.

80. Environmental Quality Act as Amended, Revised Statutes of Quebec, Chapter Q-2, 1977.

81. Environnement Quebec, 1989. Industries minieres. Directive No. 019.

82. Reglement sur l'eau potable, R.R.Quebec, c. Q-2, r.4.1.

83. The Environmental Assessment Act, Statutes of Saskatchewan, Chapter E-10.1, 1979.

84. The Environmental Management and Protection Act as Amended, Statutes of Saskatchewan, 1983.

85. Saskatchewan Environment and Public Safety, 1991. The Mineral Industry Environmental Protection Regulations. Chapter E-10.2 Reg 5.

86. Saskatchewan Environment and Public Safety (Water Quality Branch), 1988. Surface Water Quality Objectives. Document WQ 110.

87. Saskatchewan Environment and Public Safety, 1992. Mine Rock Guidelines: Design and Control of Drainage Water Quality. Report No. 93301.

88. United States Environmental Protection Agency, 1989. Risk Assessment Guidance for Superfund. EPA/540/1-89/002.

LIST OF CONTACTS

CANADA

Alberta

Alberta Environment
Standards and Approvals Division
4th Floor, 9820-106 Street
Edmonton, Alberta T5K 2J6

British Columbia

BC Environment
Water Management Division
Water Quality Branch
765 Broughton Street, 3rd Floor
Victoria, British Columbia V8V 1X5

Ministry of Energy, Mines and Petroleum Resources
Resource Management Branch
525 Superior Street, Room 105
Victoria, British Columbia V8V 1X4

Ministry of Environment, Lands and Parks
Industrial Waste and Hazardous Contaminants Branch
Technical Services and Special Wastes
1106-1175 Douglas Street
Victoria, British Columbia V8V 1X4

Manitoba

Energy and Mines
555-330 Graham Avenue
Winnipeg, Manitoba R3C 4E3
Department of Environment
Manitoba

New Brunswick
Ministry of Natural Resources
New Brunswick

Water Quality Group
Ministry of Environment
New Brunswick

Newfoundland
Industrial Environmental Engineering Division
Department of Environment and Lands
Newfoundland

Mineral Development Engineering
Department of Mines and Energy
Newfoundland

Northwest Territories
Department of Renewable Resources
P.O. Box 1320
Yellowknife, NWT X1A 2L9

Nova Scotia
Department of the Environment
Nova Scotia

Ontario
Ministry of Environment and Energy
135 St. Clair Street
Toronto, Ontario M4V 1P5

Ministry of Northern Development and Mines
159 Cedar Street
Sudbury, Ontario P3E 6A5

Quebec
Department of Mining Exploitation Titles
Quebec Ministry of Energy and Resources
5700 - 4^{e} Avenue ouest
Charlesbourg (Québec)

Saskatchewan
Saskatchewan Environment and Public Safety
Mines and Pollution Control
Saskatchewan

Yukon Territory
Department of Economic Development
211 Main Street, P.O. Box 2703
Whitehorse, Yukon Y1A 2C6

Department of Renewable Resources
211 Main Street, P.O. Box 2703
Whitehorse, Yukon Y1A 2C6

UNITED STATES

California
CA Regional Water Quality Control Board
North Coast Region
5550 Skylane Boulevard, Suite A
Santa Rosa, California 95403

Colorado
Water Quality Control Commission
4210 East 11th Avenue
Denver, Colorado 80220

Department of Health
Office of Environment
Water Quality Control Division
Groundwater and Standards Section
4300 Cherry Creek Drive, South
Denver, CO 80222-1530

Department of Natural Resources
Mined Land Reclamation Division
1313 Sherman Street, Room 215
Denver, Colorado 80203

Idaho
Department of Health and Welfare
Water Quality Bureau
Division of Environmental Quality
SW Idaho Regional Office
1420 North Hilton
Boise, Idaho 83706-1260

Montana
Department of State Lands
Capitol Station
Helena, Montana 59620

Department of Health and Environmental Sciences
Environmental Sciences Division
Water Quality Bureau
Helena, Montana 59620

Nevada
Department of Conservation and Natural Resources
Division of Environmental Protection
Mining Regulation and Reclamation
Capitol Complex
333 W. Nye Lane
Carson City, Nevada 89710

Pennsylvania
Department of Environmental Resources
Bureau of Mining and Reclamation
Harrisburg, Pennsylvania

West Virginia
Department of Natural Resources
Division of Environmental Protection
Office of Mining and Reclamation
10 McJunkin Road
Nitro, West Virginia 25143-2506

Cooperative Extension Service
U.S. Department of Agriculture
West Virginia University
1090 Agricultural Sciences Building
P.O. Box 6108
Morgantown, West Virginia 26506-6108

File Nos. 30266/30277

May 3, 1993

Hudson Bay Mining and Smelting Co., Ltd.
P.O. Box 1500
Flin Flon, Manitoba R8A 1N9

Dear Mr. W. Fraser:

RE: REVIEW OF CANADIAN AND UNITED STATES LEGISLATION RELEVANT TO DECOMMISSIONING ACID MINE DRAINAGE SITES

Please find enclosed one copy of the above-captioned report. We trust the information provided in this report meets your present requirements. If you have any questions or require additional information, please do not hesitate to contact the undersigned, or Mr. Geoffrey Parker, Manager, Environmental Operations.

Yours truly,

JACQUES WHITFORD ENVIRONMENT LIMITED

Ingrid Reichenbach, M.Sc.
Project Officer

File Nos. 30266/30277

May 3, 1993

Mr. W. Napier
Homestake Canada

Dear Mr. Napier:

RE: REVIEW OF CANADIAN AND UNITED STATES LEGISLATION RELEVANT TO DECOMMISSIONING ACID MINE DRAINAGE SITES

Please find enclosed one copy of the above-captioned report. We trust the information provided in this report meets your present requirements. If you have any questions or require additional information, please do not hesitate to contact the undersigned, or Mr. Geoffrey Parker, Manager, Environmental Operations.

Yours truly,

JACQUES WHITFORD ENVIRONMENT LIMITED

Ingrid Reichenbach, M.Sc.
Project Officer

File Nos. 30266/30277

May 3, 1993

Mr. Bak Chauhan
Ontario Ministry of Environment & Energy
135 St. Clair Avenue West, 5th Floor
Toronto, Ontario M4V 1P5

Dear Mr. Chauhan:

RE: REVIEW OF CANADIAN AND UNITED STATES LEGISLATION RELEVANT TO DECOMMISSIONING ACID MINE DRAINAGE SITES

Please find enclosed one copy of the above-captioned report. We trust the information provided in this report meets your present requirements. If you have any questions or require additional information, please do not hesitate to contact the undersigned, or Mr. Geoffrey Parker, Manager, Environmental Operations.

Yours truly,

JACQUES WHITFORD ENVIRONMENT LIMITED

Ingrid Reichenbach, M.Sc.
Project Officer

TABLE 1.1

ORE MINING AND DRESSING POINT SOURCE CATEGORY (1992)

EFFLUENT CHARACTERISTICS	EFFLUENT LIMITATIONS (BPT)		EFFLUENT LIMITATIONS (BAT)		EFFLUENT LIMITATION (NSPS)	
	Maximum for any 1 day	Average of daily values for 30 consecutive days	Maximum for any 1 day	Average of daily values for 30 consecutive days	Maximum for any 1 day	Average of daily values for 30 consecutive days
Iron Ore[1]						
TSS	30	20	-	-	30.0	20.0
Fe (dissolved)	2.0	1.0	2.0	1.0	2.0	1.0
pH	6.0-9.0	6.0-9.0	-	-	6.0-9.0	6.0-9.0
Aluminum Ore						
TSS	30	20	-	-	30.0	20.0
Fe	1.0	0.5	1.0	0.5	1.0	0.5
Al	2.0	1.0	2.0	1.0	2.0	1.0
pH	6.0-9.0	6.0-9.0	-	-	6.0-9.0	6.0-9.0
Uranium, Radium and Vanadium Ore[2]						
TSS	30(30)	20(20)	-	-	-	-
COD	200(-)	100(500)	200	100	200	100
As	-(1.0)	-(0.5)	-	-	-	-
Zn	1.0(1.00)	0.5(0.5)	1.00	0.5	1.0	0.5
Ra226 (dissolved)[3]	10(10)	3(3)	10.0	1.0	10.0	3.0
Ra226 (total)[3]	30(30)	10(10)	30.0	10.0	30.0	10.0
U	4(-)	2(-)	4.0	2.0	4.0	2.0
NH_3	-(-)	-(100)	-	-	-	-
pH	6.0-9.0	6.0-9.0	-	-	6.0-9.0	6.0-9.0

EFFLUENT CHARACTERISTICS	EFFLUENT LIMITATIONS (BPT)		EFFLUENT LIMITATIONS (BAT)		EFFLUENT LIMITATION (NSPS)	
	Maximum for any 1 day	Average of daily values for 30 consecutive days	Maximum for any 1 day	Average of daily values for 30 consecutive days	Maximum for any 1 day	Average of daily values for 30 consecutive days
Mercury Ore[4]						
TSS	30	20	-	-	30.0	20.0
Hg	0.002	0.001	0.002	0.001	0.002	0.001
Ni	0.2	0.1	-	-	-	-
pH	6.0-9.0	6.0-9.0	-	-	6.0-9.0	6.0-9.0
Titanium Ore[5]						
TSS	30	20	-	-	30.0	20.0
Fe	2.0	1.0	2.0	1.0	2.0	1.0
Zn	1.0	0.5	1.0	0.5	1.0	0.5
Ni	0.2	0.1	-	-	-	-
pH	6.0-9.0	6.0-9.0	-	-	6.0-9.0	6.0-9.0
Tungsten Ore[6]						
TSS	30(50)	20(30)	-	-	30.0	20.0
Cd	0.10	0.05	0.10	0.05	0.10	0.05
Cu	0.3	0.15	0.30	0.15	0.30	0.15
Zn	1.0	0.5	1.0	0.5	1.0	0.5
Pb[7]	0.6	0.3	-	-	-	-
As	1.0	0.5	-	-	-	-
pH	6.0-9.0 (6.0-9.0)	6.0-9.0 (6.0-9.0)	-	-	6.0-9.0	6.0-9.0

EFFLUENT CHARACTERISTICS	EFFLUENT LIMITATIONS (BPT)		EFFLUENT LIMITATIONS (BAT)		EFFLUENT LIMITATION (NSPS)	
	Maximum for any 1 day	Average of daily values for 30 consecutive days	Maximum for any 1 day	Average of daily values for 30 consecutive days	Maximum for any 1 day	Average of daily values for 30 consecutive days
Nickel Ore[6]						
TSS	30(50)	20(30)	-	-	-	-
Cd	0.10	0.05	-	-	-	-
Cu	0.3	0.15	-	-	-	-
Zn	1.0	0.5	-	-	-	-
Pb[7]	0.6	0.3	-	-	-	-
As	1.0	0.5	-	-	-	-
pH	6.0-9.0 (6.0-9.0)	6.0-9.0 (6.0-9.0)	-	-	-	-
Vanadium Ore[6]						
TSS	30(50)	20(30)	-	-	-	-
Cd	0.10	0.05	-	-	-	-
Cu	0.3	0.15	-	-	-	-
Zn	1.0	0.5	-	-	-	-
Pb[7]	0.6	0.3	-	-	-	-
As	1.0	0.5	-	-	-	-
pH	6.0-9.0	6.0-9.0	-	-	-	-
Copper, Lead, Zinc, Gold, Silver & Molybdenum Ores[8,9]						
TSS	30	20	-	-	30.0	20.0
Cu	0.30	0.15	0.30	0.15	0.30	0.15
Zn	1.5(1.0)	0.75(0.5)	1.5(1.0)	0.75(0.5)	1.5	0.75
Pb	0.6	0.3	0.6	0.3	0.6	0.3
Hg	0.002	0.001	0.002	0.001	0.002	0.001
Cd	-(0.10)	-(0.05)	0.10(0.10)	0.05(0.05)	0.10	0.05
pH	6.0-9.0	6.0-9.0	-	-	6.0-9.0	6.0-9.0

EFFLUENT CHARACTERISTICS	EFFLUENT LIMITATIONS (BPT)		EFFLUENT LIMITATIONS (BAT)		EFFLUENT LIMITATION (NSPS)	
	Maximum for any 1 day	Average of daily values for 30 consecutive days	Maximum for any 1 day	Average of daily values for 30 consecutive days	Maximum for any 1 day	Average of daily values for 30 consecutive days
Molybdenum Ores[6,9,10]						
TSS	30(50)	20(30)	-	-	30.0	20.0
Cd	0.10	0.05	0.10	0.05	0.10	0.05
Cu	0.3	0.15	0.30	0.15	0.30	0.15
Zn	1.0	0.5	1.5(1.0)	0.75(0.5)	1.5	0.75
Pb[7]	0.6	0.3	0.6	0.3	0.6	0.3
As	1.0	0.5	-	-	-	-
Hg	-	-	0.002	0.001	0.002	0.001
pH	6.0-9.0 (6.0-9.0)	6.0-9.0 (6.0-9.0)	-	-	6.0-9.0	6.0-9.0

NOTES:

BPT = best practicable control technology
NSPS = new source performance standards
All units are mg/L unless otherwise noted.

BAT = best available technology economically achievable
Effluent limitation are applicable to discharge from both mines and mills except as noted.
- = not given

1. Effluent limitations (BPT,BAT,NSPS) stipulate no discharge to surface water from mills using magnetic and physical methods in the Mesabi Range.
2. Effluent limitations (BPT and NSPS) exclude mills using the acid, alkaline, or combined leach process; ( ) = effluent limitations (BPT) for mines using these leach methods; NSPS stipulate no discharge to surface water for mills using these leach processes.
3. Values in picocuries per litre (pCi/ℓ).
4. Effluent limitations (BPT,BAT,NSPS) are applicable to discharges from mines; effluent limitations (BPT,BAT,NSPS) stipulate no discharges to surface water from mills using gravity separation or froth flotation methods.
5. Effluent limitations (BPT,BAT,NSPS) for TSS,Fe,pH apply to mine drainage; effluent limitations (BPT,BAT,NSPS) for TSS,Zn,Ni,pH apply to discharges from mills beneficiating ores by electrostatic, magnetic and physical, or flocculation methods.
6. Effluent limitations (BPT) for mines producing less than 5000 metric tons or discharged from mills processing less than 5000 metric tons, per year, are prescribed for pH and TSS only (see values in brackets).
7. Effluent limitations (BPT) for Pb are applicable to discharges from mines only.
8. Effluent limitations (BPT,BAT) are for discharges from mines and for discharges from mills which employ the froth flotation process (N.B. Zn & Cd limitations for mills differ from mines and are shown in brackets); effluent limitations (BPT,BAT) stipulate no discharge to surface water from mills using dump, heap, in-situ or vat leach, or cyanidation processes.
9. NSPS only apply to mine drainage; NSPS stipulate no discharge to surface water from mills that use the froth flotation process; dump, heap, in-situ or vat leach processes; cyanidation process.
10. Effluent limitations (BAT) are for discharges from mines and from mills which employ the froth flotation process (N.B. Zn limitations for mills differ from mines and are shown in brackets).

TABLE 1.2

COAL MINING POINT SOURCE CATERGORY (1992)

POLLUTANT PROPERTY	EFFLUENT LIMITATIONS (BPT)		EFFLUENT LIMITATIONS (BAT)		EFFLUENT LIMITATION (NSPS)	
	Maximum for any 1 day	Average of daily values for 30 consecutive days	Maximum for any 1 day	Average of daily values for 30 consecutive days	Maximum for any 1 day	Average of daily values for 30 consecutive days
Acid or Ferruginous Mine Drainage[1]						
Iron, total	7.0	3.5	7.0	3.5	6.0	3.0
Manganese, total	4.0	2.0	4.0	2.0	4.0	2.0
TSS	70.0	35.0	-	-	70.0	35.0
pH	6.0-9.0	6.0-9.0	-	-	6.0-9.0	6.0-9.0
Post - Mining Areas						
Settleable Solids[2]	0.5 mℓ/ℓ	0.5 mℓ/ℓ	0.5 mℓ/ℓ	0.5 mℓ/ℓ	0.5 mℓ/ℓ	0.5 mℓ/ℓ
pH[2,3]	6.0-9.0	6.0-9.0	-	-	6.0-9.0	6.0-9.0
Iron, total[3]	7.0	3.5	7.0	7.0	6.0	3.0
manganese, total[3]	4.0	2.0	4.0	4.0	4.0	2.0
TSS[3]	70.0	35.0	-	-	70.0	35.0

NOTES:

BPT = best practicable control technology
BAT = best available technology economically achievable
NSPS = new source performance standards
All units are mg/L unless otherwise noted.
- = not given

1. Applicable to acid or ferruginous mine drainage from an active mining area resulting from coal mining.
2. Applicable to discharges from reclamation areas until SMCRA bond has been released.
3. Applicable to discharges from underground workings of underground mines until SMCRA bond release.

TABLE 1.3

PRIMARY AND SECONDARY DRINKING WATER STANDARDS (USEPA, 1992)

	PRIMARY DRINKING WATER STANDARDS	SECONDARY DRINKING WATER STANDARDS
	MCL	Suggested Levels
General Parameters		
pH	-	6.5-8.5
Total Dissolved Solids	-	500
Inorganic Parameters		
Aluminum	-	0.05-0.2
Antimony	0.006	-
Arsenic	0.05	-
Barium	2	-
Beryllium	0.001	-
Cadmium	0.005	-
Chromium (total)	0.1	-
Copper	(TT)	1
Iron	-	0.3
Lead	0.05 (TT)	-
Manganese	-	0.05
Mercury	0.002	-
Nickel	0.1	-
Radium 226	5 pCi/L	-
Selenium	0.05	-
Silver	-	0.1
Zinc	-	5

NOTES:

MCL = Maximum Contaminant Level
All units are mg/ℓ unless otherwise noted.
TT = treatment technique requirement in effect

TABLE 2.1
GROUND WATER QUALITY STANDARDS (Colorado Department of Health, 1991)

	HUMAN HEALTH STANDARDS (mg/L)	SECONDARY DRINKING WATER STANDARDS (mg/L)	AGRICULTURAL STANDARDS (mg/L)
General Parameters			
pH	-	6.5-8.5	6.5-8.5
Inorganic Parameters			
Aluminum	-	-	5.0
Arsenic	0.05	-	0.1
Barium	1.0	-	-
Beryllium	-	-	0.1
Cadmium	0.010	-	0.01
Chromium	0.05	-	0.1
Cobalt	-	-	0.05
Copper	-	1.0	0.2
Iron	-	0.3	5.0
Lead	0.05	-	0.1
Manganese	-	0.05	0.2
Mercury	0.002	-	0.01
Nickel	-	-	0.2
Selenium	0.01	-	0.02
Silver	0.05	-	-
Vanadium	-	-	0.1
Zinc	-	5	2.0

TABLE 2.2

SURFACE WATER QUALITY STANDARDS FOR METALS, COLORADO

METAL[1]	AQUATIC LIFE [1][3][4]	AGRICULTURE[2]	DRINKING WATER-SUPPLY[2]
Aluminum	Acute = 750 Chronic = 87		
Antimony			14 (30-day)
Arsenic	Acute = 360 Chronic = 150	100 (30-day)	50 (1-day)
Barium			1,000(E) (1-day)
Beryllium		100 (30-day)	0.0076 (30-day)
Cadmium	Acute = $e^{(1.128[\ln(\text{hardness})]-2.905)}$ *(Trout) = $e^{(1.128[\ln(\text{hardness})]-3.828)}$ Chronic = $e^{(0.7852[\ln(\text{hardness})]-3.490)}$	10 (30-day)	10 (1-day)
Chromium III[5]	Acute = $e^{(0.819[\ln(\text{hardness})]+3.688)}$ Chronic = $e^{(0.819[\ln(\text{hardness})]+1.561)}$	100 (30-day)	50 (1-day)
Chromium VI[5]	Acute = 16 Chronic = 11	100 (30-day)	50 (1-day)
Copper	Acute = $\frac{1}{2}e^{(0.9422[\ln(\text{hardness})]-0.7703)}$ Chronic = $e^{(0.8545[\ln(\text{hardness})]-1.465)}$	200	1,000 (30-day)
Iron	Chronic = 1,000(tot.rec.)		300(dis) (30-day

TABLE 2.2 (con't)

METAL(1)	AQUATIC LIFE (1)(3)(4)	AGRICULTURE(2)	DRINKING WATER-SUPPLY(2)
Lead	Acute = $\frac{1}{2}e^{(1.6148[\ln(\text{hardness})]-2.1805)}$ Chronic = $e^{(1.417[\ln(\text{hardness})]-5.167)}$	100 (30-day)	50 (1-day)
Manganese	Chronic = 1,000	200 (30-day)	50(dis) (30-day)
Mercury	Acute = 2.4 Chronic = 0.1 FRV(fish) (6) = 0.01 (Total)		2.0 (1-day)
Nickel	Acute = $\frac{1}{2}e^{(0.76[\ln(\text{hardness})]+4.02)}$ Chronic = $e^{(0.76[\ln(\text{hardness})]+1.06)}$	200 (30-day)	
Selenium	Acute = 135 Chronic = 17	20 (30-day)	10 (30-day)
Silver	Acute = $\frac{1}{2}e^{(1.72[\ln(\text{hardness})]-6.52)}$ Chronic = $e^{(1.72[\ln(\text{hardness})]-9.06)}$ "(Trout) = $e^{(1.72[\ln(\text{hardness})]-10.51)}$		50 (1-day)
Thallium	Chronic = 15		0.012 (30-day)
Uranium	Acute = $e^{(1.1021[\ln(\text{hardness})]+2.7088)}$ Chronic = $e^{(1.1021[\ln(\text{hardness})]+2.2382)}$		
Zinc	Acute = $e^{(0.8473[\ln(\text{hardness})]+0.8604)}$ Chronic = $e^{(0.8473[\ln(\text{hardness})]+0.7614)}$	2000 (30-day)	5000 (30-day)

NOTE:

Numbers in parentheses refer to Table III footnotes.

TABLE 2.2 FOOTNOTES

(1) Metals for aquatic life use are stated as dissolved unless otherwise specified.

(2) Metals for agricultural and domestic uses are stated as total recoverable unless otherwise specified.

(3) Hardness values to be used in equations are in mg/l as calcium carbonate. The hardness values used in calculating the appropriate metal standard should be based on the the lower 95 per cent confidence limit of the mean hardness value at the periodic low flow criteria as determined from a regression analysis of site-specific data. Where insufficient site-specific data exists to define the mean hardness value at the periodic low flow criteria, representative regional data shall be used to perform the regression analysis. Where a regression analysis is not appropriate, a site-specific method should be used. In calculating a hardness value, regression analyses should not be extrapolated past the point that data exist.

(4) Both acute and chronic numbers adopted as stream standards are levels not to be exceeded more than once every three years on the average.

(5) Unless the stability of the chromium valence state in receiving waters can be clearly demonstrated, the standard for chromium should be in terms of chromium VI. In no case can the sum of the instream levels of Hexavalent and Trivalent Chromium exceed the water supply standard of 50ug/l total chromium in those waters classified for domestic water use.

(6) FRV means Final Residue Value and should be expressed as "Total" because many forms of mercury are readily converted to toxic forms under natural conditions. The FRV value of 0.01 ug/liter is the maximum allowed concentration of total mercury in the water that will present bioconcentration or bioaccumulation of methylmercury in edible fish tissue at the U.S. Food and Drug Administration's (FDA) action level of 1 ppm. The FDA action level is intended to protect the average consumer of commercial fish; it is not stratified for sensitive populations who may regularly eat fish.

A 1990 health risk assessment conducted by the Colorado Department of Health indicates that when sensitive subpopulations are considered, methylmercury levels, in sport-caught fish as much as one-fifth lower (0.2 ppm) than the FDA level may pose a health risk.

In waters supporting populations of fish or shellfish with a potential for human consumption, the Commission can adopt the FRV as the stream standard to be applied as a 30-day average. Alternatively, the Commission can adopt site-specific ambient based standards for mercury in accordance with Section 3.1.7(1)(b)(ii) and (iii). When this option is selected by a proponent for a particular segment, information must be presented that (1) ambient water concentrations of total mercury are detectable and exceed the FRV, (2) that there are detectable levels of

mercury in the proponent's discharge and that are contributing to the ambient levels and (3) that concentrations of methylmercury in the fish exposed to these ambient levels do not exceed the maximum levels suggested in the CDH Health Advisory for sensitive populations of humans. Alternatively or in addition the proponent may submit information showing that human consumption of fish from the particular segment is not occurring at a level which poses a risk to the general population and/or sensitive populations.

TABLE 2.3
SURFACE WATER QUALITY CRITERIA (Idaho Department of Health and Welfare)

	FRESHWATER		HUMAN HEALTH
	Criterion Maximum (µg/L)	Criterion Continuous (µg/L)	(µg/L)
Inorganic Parameters			
Antimony	-	-	14
Arsenic	360	190	0.018
Beryllium	-	-	-
Cadmium	3.9	1.1	-
Chromium (III)	1700	210	-
Chromium (IV)	16	11	-
Copper	18	12	-
Lead	82	3.2	-
Mercury	2.4	0.012	0.14
Nickel	1400	160	610
Selenium	20	5	-
Silver	4.1	-	-
Thallium	-	-	1.7
Zinc	120	110	-

TABLE 2.4
SURFACE WATER QUALITY CRITERIA, (West Virginia Water Resources Board, 1990)

	UNITS	WARMWATER	TROUTWATER	RECREATION	PUBLIC
General Parameters					
pH		6-9	6-9	6-9	6-9
Inorganic Parameters					
Aluminum	mg/L		05		
Antimony	µg/L				146
Arsenic	µg/L	190	190	190	2.2ng/L
Barium	mg/L				1
Beryllium	ng/L	117	117		6.8
Cadmium	µg/L	X (c)	X (b)	X (c)	X (a)
Copper	µg/L	X (d)	X (d)		1000
Chromium IV	µg/L	10	7.2		50
Iron	mg/L	1.5 (e)	0.5		1.5
Lead	µg/L	X (f)	X (f)		50
Manganese	mg/L	1 (e)	1		1
Mercury (total)	µg/L	0.012	0.012	0.14	0.14
Nickel	µg/L	X (g)	50		510
Selenium	µg/L	5	5		10
Silver	µg/L	x (i)	X (h)		x (h)
Thallium	µg/L				13

NOTES:

a)

hardness mg/L as CaCO3	Soluble Cd µg/L
0-35	1
36-75	2
76-150	5
>150	10

b) Not to exceed 0.4 µg/L where hardness is less than 75 mg/L as CaCO3 and 1.2 µg/L in water where hardness is greater than 75 mg/L as CaCO3.

c) The concentration of cadmium shall not exceed the criteria determined by the equation:

$$Cd\ (\mu g/L) = e^{(0.7852\ [\ln(\text{hardness})] - 3.490)}$$

d)

hardness mg/L as CaCO3	Total Recoverable Copper (µg/L)
50	6
100	11
200	20
300	29
400	38
500	46
600	55
700	63

e) Effluent limitations which may result in a concentration of up to 3.5 mg/L total iron (2.0 mg/L manganese) in the stream are allowable upon a demonstration to the Chief by the applicant that such concentration will not have an adverse impact upon designated stream uses. The demonstration is subject to EPA approval and must show either; (1) that the stream is supporting designated uses while containing total iron (manganese) concentrations higher than the applicable criteria or (2) the stream does not have an aquatic life use to protect. Notwithstanding Series 1, Section 4 of the board's rules, this demonstration shall be the only demonstration required before the Chief and the Board with respect to water quality related effluent limitations. This exception does not apply to Trout Waters.

f) Concentrations of lead shall not exceed the criteria determined by the equation:

$$Pb\ (\mu g/L) = e^{(1.273\ [\ln(\text{hardness})] - 4.705)}$$

g) Concentrations of nickel shall not exceed the criterion determined by the following equation:

$$Ni(\mu g/L) = e^{(0.846\ [\ln(\text{hardness})] + 1.1645)}$$

h)

hardness	silver (µg/L)
0-50	1
51-100	4
101-200	12
>201	24

i)

hardness	silver (µg/L)
0-50	1
51-100	4
101-200	12
201-400	24
401-500	30
501-600	43

TABLE 3.1
METAL MINING LIQUID EFFLUENT REGULATIONS (Environment Canada, 1977)

	MAXIMUM AUTHORIZED MONTHLY ARITHMETIC MEAN CONCENTRATION/pH	MAXIMUM AUTHORIZED CONCENTRATION/pH IN A COMPOSITE SAMPLE	MAXIMUM AUTHORIZED CONCENTRATION/pH IN A GRAB SAMPLE
General Parameters			
pH (unitless)	6.0	5.5	5.0
Total Suspended Matter	25.0	37.5	50.0
Inorganic Parameters			
Arsenic	0.5	0.75	1.0
Copper	0.3	0.45	0.6
Lead	0.2	0.3	0.1
Nickel	0.5	0.75	1.0
Zinc	0.5	0.75	1.0
Radium 226	10.0 pCi/L	20.0 pCi/L	30.0 pCi/L

NOTES:

1. All units are mg/ℓ unless otherwise stated.
2. The concentrations are given as total values with the exception of Radium 226 which is a dissolved value after filtration of the sample through a 3 micron filter.

3. The acceptable levels of substances in the Metal Mining Liquid Effluent Guidelines have the same numerical values at the authorized levels of deleterious substances prescribed in the Metal Mining Liquid Effluent Regulations.

TABLE 3.2
REMEDIATION CRITERIA FOR WATER (CCME, 1991)

	FRESHWATER AQUATIC LIFE[2]	IRRIGATION[2,3]	LIVESTOCK WATERING[2]	DRINKING WATER[4,5,2]
General Parameters				
pH (unitless)	6.5-9.0	-	-	6.5-8.5
total dissolved solids	-	500-3500 mg/ℓ	3000 mg/ℓ	≤500 mg/ℓ[6]
Inorganic Parameters				
aluminum	5-100[7]	5000	5000	-[6]
arsenic	50	100	500-5000	25[8]
barium	-	-	-	1000[8]
beryllium	-	100	100[9]	-
cadmium	0.2-1.8	10	20	5
chromium (total)	2-20	100	1000	50
cobalt	-	50	1000	-
copper	2-4[10]	200-1000[11]	500-5000	≤1000[6]
iron	300	5000	-	≤300[8]
lead	1-7[10]	200[9]	100	10[8]
manganese	-	200	-	≤50[8]
mercury	0.1	-	3	1
molybdenum	-	10-50	500	-
nickel	25-150[10]	200	1000	-
radium 226	-	-	-	1 Bq/ℓ[6]
selenium	1	20-50	50	10
silver	0.1	-	-	-
uranium	-	10[9]	200	100
vanadium	-	100	100	-
zinc (total)	30[9]	1000-5000[12]	50 000	≤5000[8]

NOTES:
All units μg/ℓ unless otherwise noted.

1. Guidelines for freshwater aquatic life, irrigation, and livestock watering are taken from the Canadian Water Quality Guidelines (CWQG) (CCREM 1987). The CWQG also recommends guidelines for recreational uses and several industrial uses, which are not included in this table. Guidelines for drinking water are taken from the Guidelines for Canadian Drinking Water Quality (GCDWQ) (Health and Welfare Canada 1989).
2. Guidelines for heavy metals and trace ions are reported as total concentrations in an unfiltered sample.
3. Applies to all soils; for details on neutral to alkaline soils, refer to CCREM (1987).
4. Drinking water guidelines are expressed as maximum acceptable concentrations (MAC), and are for unfiltered samples at the point of consumption.
5. Several parameters also have aesthetic objectives; these are indicated by a "≤" symbol.
6. Guideline under review for addition to the GCDWQ or possible changes to the current value. Refer to the latest edition of the GCDWQ.
7. Guideline varies with pH, calcium, and dissolved organic carbon concentrations.
8. A modification to the previous guideline is proposed. If after one year, no evidence is presented that questions the suitability of this proposal, it will be adopted as the guideline. Refer to the latest edition of the GCDWQ.
9. Tentative water quality guideline because of insufficient evidence; refer to the latest edition of the CWGQ or GCDWQ.
10. Guideline changes with hardness.
11. Guideline varies depending on crop.
12. Guideline changes with pH.

TABLE 4.1

SURFACE WATER QUALITY OBJECTIVES (Alberta Environment, 1977)

	MAXIMUM CONCENTRATION
General Parameters	
Suspended Solids[1]	-
pH (unitless)[2]	6.5-8.5
Inorganic Parameters	
Arsenic	0.01
Barium	1.0
Cadmium	0.01
Chromium	0.05
Copper	0.02
Iron	0.3
Lead	0.05
Manganese	0.05
Mercury	0.0001
Radium 226	3 pCi/L
Selenium	0.01
Silver	0.05
Zinc	0.05

NOTES:

All units are mg/ℓ unless otherwise noted.

1. Not to be increased by more than 10 mg/ℓ over background value.
2. Not to be atlered by more than 0.5 pH from background value.

TABLE 4.2

OBJECTIVES FOR THE DISCHARGE OF FINAL EFFLUENTS TO MARINE AND FRESH WATERS (BC Environment, 1979)

	RANGE	
General Parameters		
pH (unitless)	6.5-8.5	6.5-10
Total Suspended Solids[1]	25	75
Total Dissolved Solids	2500	5000
Inorganic Parameters		
Aluminum	0.5	1.0
Antimony	0.25	1.0
Arsenic (as trivalent As)	0.05	0.25
Arsenic (total dissolved)	0.10	1.0
Cadmium	0.01	0.1
Chromium	0.05	0.3
Cobalt	0.5	1.0
Copper	0.05	0.3
Iron	0.3	1.0
Lead	0.05	0.2
Manganese	0.1	1.0
Mercury (Total)[2]	Nil	0.005
Molybdenum	0.5	5.0
Nickel	0.2	1.0
Radium 226	10 pCi/ℓ	100 pCi/ℓ
Selenium	0.05	0.5
Silver	0.05	0.5
Zinc	0.2	1.0

NOTES:

All units are mg/ℓ dissolved in effluent unless otherwise stated. Analysis for total elements in tailings may be required prior to and during operations and the Director would give consideration to this information when issuing a permit.

1. Variances may be allowed during periods of excess runoff.
2. Natural background concentration of total mercury will be assessed.

TABLE 4.4

SURFACE WATER QUALITY OBJECTIVES (Ontario MOE, 1984)

	MAXIMUM CONCENTRATION
General Parameters	
pH	6.5-8.5
Inorganic Parameters	
Arsenic	100
Cadmium	0.2
Chromium	100
Copper	5
Iron	300
Lead	5-25
Mercury (dissolved)	0.2
Nickel	25
Radium 226	1 Bq/ℓ
Selenium	100
Silver	0.1
Zinc	30

NOTES:

1. All units are ug/ℓ unless otherwise noted.
2. Maximum concentrations (except for mercury) are based on the total concentration of an unfiltered water sample.
3. Objective for lead changes with alkalinity.
4. Mercury is classified as a substance with a "zero tolerance limit" and any release should be completely eliminated.

TABLE 4.5

GROUND WATER QUALITY CRITERIA (Ontario MOE, 1984, 1992)

	DRINKING WATER	LIVESTOCK WATERING	IRRIGATION WATER
General Parameters			
pH (unitless)	6.5-8.5[1]	-	-
Total Dissolved Solids	500[2]	-	-
Inorganic Parameters			
Aluminum	0.1[1]	5.0	5.0/20.0
Arsenic	0.025	0.2	0.10/2.0
Barium	1.0	-	-
Beryllium	-	-	0.10/0.50
Cadmium	0.005	0.05	0.010/0.05
Chromium	0.05	1.0	0.10/1.0
Cobalt	-	1.0	0.050/5.0
Copper	1.0[2]	0.5	0.20/5.0
Iron	0.3[2]	-	5.0/20.0
Lead	0.01	0.1	5.0/10.0
Manganese	0.05[2]	-	0.20/10.0
Mercury	0.001	0.01	-
Nickel	-	1.0	0.20/2.0
Radium 226	1 Bq/ℓ	1 Bq/ℓ	-
Selenium	0.01	0.05	0.020/0.020
Uranium	0.1	-	-
Vanadium	-	0.1	0.10/1.0
Zinc	5.0[2]	25.0	2.0/10.0

NOTES:

All units mg/ℓ unless otherwise noted.

All drinking water objectives are health-related unless otherwise noted; arsenic objectives are interim only.

Objectives for irrigation water are for waters used continuously on all soils, and for use up to 20 years on fine textured soil of pH 6.0 to 8.5, respectively.

1. Operational objectives.
2. Aesthetic objectives.

TABLE 4.6
QUALITY CRITERIA FOR FINAL EFFLUENT (Environnement Québec, 1989)

	MAXIMUM ACCEPTABLE CONCENTRATION FROM A GRAB SAMPLE OF NON-DILUTED FINAL EFFLUENT (monthly arithmetic mean)
General Parameters	
pH (unitless)	authorized values from 6.5-9.5
Total Suspended Solids	25.0
Inorganic Parameters	
Arsenic	0.50
Copper	0.30
Nickel	0.50
Lead	0.20
Zinc	0.50
Iron	3.00

NOTES:

1. All units are mg/ℓ unless otherwise noted.
2. The concentrations are given as total values.
3. The sum of individual concentrations measured for copper, nickel, lead and zinc cannot exceed 1.0 mg/L.

TABLE 4.7

DRINKING WATER QUALITY CRITERIA (Environnement Québec)

	MAXIMUM CONCENTRATION PERMITTED
Inorganic Parameters	
Arsenic	0.050
Barium	1.0
Cadmium	0.0050
Chromium (total)	0.050
Lead	0.050
Mercury	0.0010
Radium 226	1.0 Bq/ℓ
Selenium	0.010
Uranium	0.020

Notes:

All units mg/L unless otherwise noted.

TABLE 4.8

AUTHORIZED CONCENTRATION OF POLLUTANTS IN LIQUID EFFLUENT (Saskatchewan)

POLLUTANT	MAXIMUM MONTHLY ARITHMETIC MEAN CONCENTRATION	MAXIMUM GRAB SAMPLE CONCENTRATION
Total Arsenic	0.5	1.0
Total Copper	0.3	0.6
Total Lead	0.2	0.4
Total Nickel	0.5	1.0
Total Uranium	2.5	5.0
Total Zinc	0.5	1.0
Total Radium - 226	0.37 Bq/L	1.11 Bq/L
Total Thorium - 230	1.85 Bq/L	3.7 Bq/L
Total Lead - 210	0.92 Bq/L	1.84 Bq/L
Total Cyanide	1.0	2.0
Un-ionized Ammonia*	0.5	1.0

NOTES:

All units mg/ℓ unless otherwise noted.

The pH level of water discharged to the environment shall be between 6.0 and 9.5 in 75% of samples during any month, and the pH level of grab samples shall never be less than 5.0 or greater than 10.0.

*Un-ionized ammonia is the portion of total ammonia nitrogen that is in the form NH_3.

TABLE 4.9

SURFACE WATER QUALITY OBJECTIVES
(Saskatchewan Environment and Public Safety, 1988)

	CONCENTRATION
Inorganic Parameters	
Arsenic	0.05
Barium	1.0
Cadmium	0.001
Chromium	0.020
Copper	0.01
Cyanide	0.01
Iron	1.0
Lead	0.02
Mercury	0.0001
Nickel	0.025 where hardness $\leq$ 100 mg/ℓ ($CaCO_3$) 0.100 where hardness $>$ 100 mg/ℓ ($CaCO_3$)
Radium 226	0.11 Bq/ℓ
Selenium	0.01
Silver	0.01
Zinc	0.05

NOTES:

1. All units are mg/ℓ unless otherwise noted.
2. The concentrations are given as total values.
3. Radium 226 objective is taken from the Saskatchewan General Surface Water Quality Objectives.