Fisheries and Environment
Canada

BRIEF PRESENTED TO THE POLLUTION INQUIRY INTO THE MINING, MINE-MILLING AND SMELTING INDUSTRIES OF BRITISH COLUMBIA

Prepared By

FISHERIES AND ENVIRONMENT CANADA

August 1977

Brief presented to the pollution inquiry into the mining, mine-milling and smelting industries of British Columbia.

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INTRODUCTION AND SUMMARY

This Brief, compiled by the Environmental Protection Service (EPS), Pacific Region is divided into three sections:

Section 1 presents the legislative authorities and responsibilities of the Department of Fisheries and the Environment relevant to this Inquiry.

Section 2 includes the federal requirements developed under the legislative authorities. This Section also identifies and discusses variances between the federal requirements and Pollution Control Objectives. Recommendations with respect to Objectives are made to the Inquiry for its consideration.

Section 3 includes recently developed technology which has yet to be considered by the task forces who develop federal requirements. However, this information is presented for review by the Inquiry so that consideration may be given to its possible utilization as a basis for revisions to the Pollution Control Objectives.

The main recommendations to this Inquiry are:

1. adoption of the measurement of the <u>total</u> metal concentrations for mine/mill/smelter effluents;
2. adoption of federal limits for total metal concentrations and suspended solids as a minimum standard for mine, mill and smelter effluents;
3. elimination, when possible, of all unconfined disposal of mill tailings;
4. adoption of the federal limits for discharging radioactive substances from uranium mining and milling operations;
5. adoption of federal emission limits for asbestos;
6. adoption of federal emission limits for secondary lead smelters;

7. the addition of emission limits, as specified in the federal guidelines for coke ovens, to existing ambient air pollution control objectives;

8. when meteorologically based supplementary emissions control procedures are proposed, the air monitoring network should be designed to sample all sectors around the mine, mill and smelter operations, and that the air pollution model should be fully validated before being used as part of the control system.

9. requiring the permittee to evaluate the potential effects of long-range transport of air pollutants.

1. FEDERAL RESPONSIBILITIES AND LEGISLATION

The Department of Fisheries and the Environment (DFE) has a mandate to provide leadership at the federal level to control and abate pollution. Its responsibilities encompass the prevention of pollution; the identification of pollution problems and the development of means to overcome such problems; the development of technology to control pollution where such technology is lacking; and the detection and surveillance activities related to assessment and control of pollution.

The organization and principal functions of DFE are presented in Appendix I of this Brief.

1.1 Federal Responsibility

The federal role in resource management and environmental protection has evolved from the division of powers between Parliament and Provincial legislatures described in the British North America Act of 1867. In general, control over natural resources rests with the Provinces; while management and protection of the fishery resource and the administration of more recent legislation dealing with environmental matters and cross-boundary movement of pollutants, rests with the Federal Government. The protection of public health is a shared jurisdiction between the Provinces and the Federal Government. The Federal Government in the abatement of all pollution is striving to establish uniform minimum pollution control standards throughout Canada. The responsibilities assigned to DFE are presented in Appendix II.

1.2 Federal Legislation

Parliament has approved legislation designed to carry out federal responsibilities encompassing resource management and pollution control. The most significant federal legislation affecting the mining, mine-milling and smelting industries of British Columbia include:

(a) The Fisheries Act (R.S.C. 1970, c.F-14 as amended by R.S.C. 1970, c.17 (1st suppl.)) and recent amendments contained in Bill C-38.

(b) The Clean Air Act (Chapter 47, Statutes of Canada 1970-71-72 as amended by SOR/71-569).

(c) The Environmental Contaminants Act (Vol. 1, No. 12, Canada Gazette Part III, Chapter 72).

(d) The Canada Water Act (R.S.C. 1970, c.5 (1st suppl.)).

(e) The Ocean Dumping Control Act (Vol. 1, No. 9, Canada Gazette, Part III, Chapter 55).

DFE, and EPS in particular, as described in Appendix I in this Brief, has a direct responsibility, at the federal level, for the development and implementation of pollution control programs. Programs have been developed for the control of specific contaminants and for the discharge of mine, mill and smelter waste products into water and air regimes.

1.2.1 The Fisheries Act

According to Sections 33 and 34 of the Fisheries Act, no person is allowed to deposit or permit the deposit of a substance deleterious to fish or to man's use of fish, in waters frequented by fish. The Act defines a deleterious substance. It also gives the Minister of Fisheries and the Environment the power to require plans and specifications from any operation that may affect fish, and allows the Governor-in-Council to formulate specific regulations. The Base Metal Mining Regulations are an example of requirements designed to protect fish from effluents discharged by a specific range of industries.

The establishment of control levels, on an industry-specific basis, is based on best practicable technology (BPT). BPT is defined as technically and economically viable technology, as demonstrated by current usage. Economic viability implies that a normally healthy member of the industry can install and operate the necessary technology without undue economic disruption. Adaptation of BPT on an industry-specific basis is intended to provide a minimum national pollution control standard. The technology is defined by a joint industry/government (Federal/Provincial) Task Force.

Other sections of the Fisheries Act pertinent to the mining, milling and smelting industries are:

Section 20 - every slide, dam or other obstruction across or in any stream shall when necessary be provided with facilities for free passage of fish.

Section 28 - every water intake shall if necessary be provided with a fish guard or screen to prevent entry of fish.
Section 31 - no work or undertaking results in the harmful alteration or destruction of fish habitat.

It is recognized that the above federal requirements may be outside the "Terms of Reference" of this Inquiry.

Recent amendments to the Fisheries Act (Bill C-38) clarifies the interpretation of the requirements and also provides the administrative latitude for enforcement of the regulations developed under Section 33.

1.2.2 The Clean Air Act

Legislative authority for the DFE program related to the control of emissions to the atmosphere, is embodied in the Clean Air Act. Section 7 of this Act provides for the development of National Emission Standard Regulations, to control emissions of contaminants into the ambient air from stationary sources, in cases where:

(a) the contaminants constitute a significant danger to the health of persons, or

(b) the emissions would likely result in the violation of a term or terms of any international obligation entered into by the Government of Canada relating to the control or abatement of air pollution in regions adjacent to any international boundary.

An assessment as to whether the emission of a specific air contaminant constitutes a significant danger to the health of persons, is given by Health and Welfare Canada. To date, Health and Welfare Canada had identified five hazardous contaminants: lead, asbestos, arsenic, mercury, and vinyl chloride. Regulations limiting their discharge to the atmosphere have been, or are being developed on an industry-specific basis. Four of the contaminants are addressed in this Brief; however, vinyl chloride is not addressed because it is not directly related to the mining industry.

In the realm of air pollution, it is unfortunate that cause-effect relationships with respect to human health are often non-existent, or are poorly understood, particularly as they relate to long term effects.

It is evident, therefore, that the degree of risk to human health attributable to an air contaminant is most difficult to determine.

It is within this complex situation that DFE must pursue its program of safeguarding human health. DFE believes that simple prudence dictates and, that in the absence of evidence to the contrary, the release of certain air contaminants to the atmosphere should be reduced to the greatest possible extent through containment at source. In establishing how this control might be achieved, DFE has chosen as its criterion the best available control technology.

It is the determination of what constitutes best available control technology that has led DFE to make use of the wide range of expertise in government-industry task forces.

DFE acknowledges the possibility that such control might reduce emission levels to a greater extent than some consider necessary, but equally, it must be acknowledged that insufficient control could lead to a condition significantly dangerous to health. In such circumstances DFE believes its approach to be the most appropriate one to take.

DFE is also responsible for the development of National Emission Standard Guidelines. The guidelines, based on BPT, indicate quantities and concentrations above which air contaminants should not be emitted into the ambient air from sources of any class, whether stationary or otherwise. The guidelines are not legally enforceable by the Federal Government, but it is hoped that they will be adopted by the Provinces and Territories as the minimum baseline standards when developing their own regulations or objectives. DFE recognizes that more stringent limits may be imposed by the Provinces.

1.2.3 The Environmental Contaminants Act

The Environmental Contaminants Act provides the government with the mandate to obtain a systematic overview of the problem of contamination of the environment by a substance, regardless of its type, use or mode of distribution. The Act also provides appropriate controls, if necessary in those cases where other legislative authority does not exist, or is not used.

1.2.4 The Canada Water Act

The Canada Water Act provides for the establishment of Water Quality Management Areas for any waters within federal jurisdiction, if water pollution in that area is of national concern. A decision to create a Water Quality Management Area would normally be the result of an agreement to carry out studies and consultations between the Federal and Provincial Governments.

1.2.5 The Ocean Dumping Control Act

The Act defines "dumping" as the deliberate disposal of substances from ships, aircraft or platforms (Section 2(1)), and therefore does not apply to accidental discharges. Dumping does not include discharges that are incidental to the normal operation of a ship or aircraft, or discharges incidental to exploitation and off-shore processing of seabed mineral resources.

1.2.6 Federal-Provincial Agreements

It is evident that environmental matters are not solely confined within Federal or Provincial responsibilities. Cooperation is the key word in the concept, planning and implementation of resource management programs. To facilitate this cooperative approach, the Federal and Provincial Governments have agreed to the concept of Federal/Provincial Accords for the Protection and Enhancement of Environmental Quality.

These Accords are designed to ensure cooperative programs to protect the environment, while avoiding duplication of effort among agencies. Generally, the Federal Government agrees to establish national baseline effluent and emission standards for specific industrial groups and specific pollutants, and the Province agrees to establish and enforce requirements at least as stringent as those specified by the Federal Government. Both levels of government agree to cooperative monitoring programs in areas of joint interest and to the free exchange of data.

1.2.7 Environmental Assessment

Many new mining developments and their auxiliary support facilities (housing etc.), often impose numerous indirect environmental impacts beyond those related directly to the mining and milling operations. While the nature of the project and its proposed location will determine in many

respects the type of detailed information required, a broad based environmental impact statement should be considered as a prerequisite.

For mining developments involving federal lands or those for which federal funds are solicited, an environmental assessment will be required.

By a Cabinet decision of December 30, 1973, the Environmental Assessment and Review Process (EARP)[1] was established to ensure that:

(a) environmental effects are taken into account early in the planning of new federal projects, programs and activities;

(b) an environmental assessment is carried out for projects, programs and activities that are likely to have a significant effect on the environment;

(c) the results of these assessments are used in planning, decision-making and final construction and operating practice controls.

The Environmental Assessment and Review Process is administered by DFE.

All federal departments are bound by the Cabinet decisions, except proprietary Crown Corporations who are invited, rather than directed, to participate in the process.

1.2.8 National and International Requirements

Many of the activities of DFE stem from obligations arising out of national and international treaties and agreements related to the protection of water and air environments. Provincial requirements should reflect national regulations and guidelines as well as international obligations.

2. VARIANCES BETWEEN FEDERAL AND PROVINCIAL POLLUTION CONTROL LIMITS

In this section the minimum national standards for pollution limits as specified in the federal regulations and guidelines are compared to the limits prescribed in the Pollution Control Objectives of British Columbia. Recommendations are presented for review by the Inquiry.

A summary of the status of DFE's Control Regulations and Guidelines related to mining and associated industries is presented in Table I.

2.1 Requirements Under the Fisheries Act

A Fisheries Act regulation entitled "Metal Mining Liquid Effluent Regulations" was proclaimed on February 25, 1977. "Guidelines for the Control of Liquid Effluents from Existing Metal Mines" and "Guidelines for the Measurements of Acute Lethality in Liquid Effluents from Metal Mines" were proclaimed on March 19, 1977.

The regulations and guidelines were developed by the Base Metal Mining Task Force and its six working groups comprising representatives of the Environmental Protection Service; the Atomic Energy Control Board; Department of Energy, Mines and Resources; Department of National Health and Welfare; Provincial regulatory agencies, including representatives from British Columbia; and the mining industry. In all, 57 technical experts were involved in this cooperative development activity: 22 represented the mining industry and 11 were from provincial governments.

2.1.1 Metal Mining Liquid Effluent Regulations

The regulations apply to all new, expanded or reopened base metal mines and mills including uranium mines. Expanded mines are those that increase production by more than 30% of their reference mine production rate.

The regulations prescribe arsenic, copper, lead, nickel, zinc, total suspended matter, and radium 226 as deleterious substances. The regulations also set limits on the total concentrations of these substances (except for Ra 226 where a soluble limit is specified) that may be discharged in effluents from the operations area of a mine-mill complex (see Table II on page 12).

TABLE I SUMMARY OF EPS REGULATIONS/GUIDELINES COMPLETED AND IN PROGRESS, RELATED TO MINING AND ASSOCIATED INDUSTRIES.

FISHERIES ACT	STATUS
1. Metal Mining Liquid Effluent Regulations (Canada Gazette Part II, Vol. III, No. 5, March 9, 1977, SOR/77-178).	Issued
2. Metal Mining Liquid Effluent Guidelines (Canada Gazette Part I, Vol. III, No. 12, March 19, 1977).	Issued
3. Guidelines for the Measurement of Acute Lethality in Liquid Effluents from Metal Mines (Canada Gazette Part I, Vol. III, No. 12, March 19, 1977).	
4. Base Metal Smelting Regulations and Guidelines	
Part I - Aluminium	In Progress
Part II - Copper, Lead, Zinc	In Progress
5. Regulations and Guidelines for Gold Mill Effluents	In Progress
CLEAN AIR ACT	
1. Asbestos Mining and Milling Emission Standard Regulations (Canada Gazette Part II, Vol. III, No. 13, June 27, 1977).	Issued
2. Secondary Lead Smelter National Emission Standard Regulations (Canada Gazette Part II, Vol. 110, No. 14, July 9, 1976 SOR/76-464).	Issued
3. Arctic Mining Industry Emission Guidelines (Canada Gazette Part I, July, 1976, pp. 3564-3569).	Issued
4. Metallurgical Coke Manufacturing Industry National Emission Guidelines (Canada Gazette Part I, May 31, 1975, pp. 2219-2223).	Issued

Cont'd.

TABLE I (continued)

5.	Guidelines for the Thermal Power Industry	In Progress
6.	Non-Ferrous Smelters Guidelines	In Progress
7.	Arsenic Regulations for Gold Roasting Operation	In Progress
8.	Arsenic Regulations for Non-Ferrous Smelters	In Progress
9.	Arsenic Regulations for Iron Ore Processing	In Progress
10.	Guidelines for the Fertilizer Industry	In Progress

TABLE II - AUTHORIZED LEVELS OF SUBSTANCES IN MINE EFFLUENTS

SUBSTANCE	MAXIMUM AUTHORIZED CONCENTRATION		
	Monthly Arithmetic Mean	Composite Sample	Grab Sample
Arsenic	0.5 mg/l	0.75 mg/l	1.0 mg/l
Copper	0.3 mg/l	0.45 mg/l	0.6 mg/l
Lead	0.2 mg/l	0.30 mg/l	0.4 mg/l
Nickel	0.5 mg/l	0.75 mg/l	1.0 mg/l
Zinc	0.5 mg/l	0.75 mg/l	1.0 mg/l
Total Suspended Matter	25.0 mg/l	37.50 mg/l	50.0 mg/l
Radium	10.0 pCi/l	20.0 pCi/l	30.0 pCi/l

NOTE: All 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.

Parameter:	Minimum Authorized Monthly Arithmetic Mean Value of pH	Minimum Authorized pH in a Composite Sample	Minimum Authorized pH in a Grab Sample
	6.0	5.5	5.0

The regulations further specify that any quantity or quality of deleterious substances may be deposited into a tailings impoundment that has been approved by the Minister. Disposal areas are defined as areas confined by natural or manmade structures.

2.1.2 Guidelines for the Control of Liquid Effluents from Existing Metal Mines

The guidelines accompanying the regulations are not, in themselves, legal instruments; and they are subject to a compliance schedule to be negotiated with industry on a site-specific basis. The guidelines are an expression of what DFE considers to be compliance with the spirit of the general prohibition of discharges of deleterious materials found in the Fisheries Act, which is applicable in the absence of specific regulations.

2.1.3 Total Versus Dissolved Metals

In the British Columbia Pollution Control Objectives, the concentration of metals in effluents is considered only in terms of dissolved values. Dissolved is defined in Table IV of the Pollution Control Objectives as "that portion of the effluent as discharged which passes through an approved 0.45 micron pore-sized filter". As the primary function of a regulatory agency is to protect the environment by limiting effluent discharges, careful consideration must be given to the form in which chemical species are discharged.

Metals cations are more toxic than their complexes. The chemistry of complexation is so intricate and the stability of the complexes so variable, that a detailed chemical study may be needed in each case to estimate the extent to which each metal ion has been complexed, and to assess the significance of any other interaction or synergistic effect on the aquatic life. Studies of this type would be expensive, time consuming and, perhaps, academic rather than practical.

As a further complication, chemical species change with time (oxidation/reduction mechanisms) and, even though the kinetics of the reaction may be so slow as to be virtually insignificant, there could be cases in which metal cations are released quickly (i.e. a change of metal hydroxide to its ionic form by a drop of pH).

Total metals of an undiluted sample, according to the federal regulations, refers to the complete chemical analysis of the filterable

and non-filterable residue of the sample. To avoid discrepancies in the test results originating from different chemical methods of analysis, acceptable test methods are prescribed in Schedule 3 of the Base Metal Liquid Effluent Regulations and Guidelines. Other environmental protection agencies that utilize the total metal concentration approach for effluent discharges, are the Ministry of the Environment of Ontario and the United States Environmental Protection Agency.

The problems have been addressed repeatedly in the past and perhaps can be best summarized with a quotation by G.F. Lee[2].

> "there is considerable debate among the regulatory agencies on whether water quality criteria should be established for soluble or total concentrations of the transition metals. The problem arises from the fact that the interactions of some transition metals with certain types of particulate matter result in making the potentially toxic species unavailable to the aquatic organism. On the other hand the interactions with the same metals but other types of particulate matter, resulting in the formation of an insoluble species, may have little effect on the availability of the element to the organism. At the present time our understanding of the aqueous environmental chemistry of most elements in natural waters is such that it is impossible to make <u>a priori</u> predictions of availability without detailed chemical studies. Consideration must be given to both the abiotic and biotic chemistry of the element in the specific waters under consideration.

It is felt that the <u>most reasonable approach for establishing</u> meaningful water quality standards <u>is one where the standards are based on the total of the chemical species</u>. In those instances where the alleged violator of the standard feels that is is inappropriate to apply the standard based on the total composition of its waste, he should be given the opportunity to conduct, in cooperation with a regulatory agency, bioassay tests to determine in fact whether or not a substantial part of the total is currently unavailable to key aquatic organisms in the receiving waters. The chemical environment of the receiving waters must be considered from

not only the current conditions but those that might be encountered in the reasonably foreseeable future."

The rationale used by the Mining Task Force for regulating total metals in effluents rather than dissolved values, is based on the ultimate availability of metals in the environment. To overcome the difficulties with chelated species, synergistic effects and lengthy baseline studies on river basins, the total metal concentration approach reflects a more prudent measure to avoid undesirable conditions that "might be encountered in the reasonably foreseeable future".

For this reason and to achieve uniformity throughout Canada, DFE considers that the most prudent measure to protect aquatic life would be to provide controls based on the total metals in an effluent in preference to only the dissolved portion. This approach has been incorporated in the Metal Mining Liquid Effluent Regulations.

Recommendation

It is recommended that the Inquiry considers and adopts the total metal concentration approach as prescribed in the Federal Regulations and Guidelines to achieve the optimum protection of the fisheries resources and the environment.

2.1.4 Total Suspended Solids

Removal of suspended solids from mill tailings is commonly achieved by sedimentation. Fine particles settle in quiescent waters at a rate proportional to their size and density. Well designed clarifiers and tailings ponds are used to remove mill solids, with, or without, the use of flocculating agents. Impoundment of tailings is done to avoid pollution of streams, and to prevent damage to fish habitat as well as to recover the supernatant after settling the solids, or to save the solids for possible treatment at a later date.

Most mines in British Columbia do not have a decant and recycle the tailings pond supernatant within the mill. The few mines which have a decant have no difficulty achieving the present limit of 50 ppm of suspended solids required by provincial permits. In fact, it has been amply demonstrated through existing BPT that considerably lower levels of suspended solids can be achieved. The Ontario Ministry of

Environment, in its Provincial Guidelines[3], has set a limit of 15 ppm of suspended solids in a mining effluent. The mining industry has been able to achieve these limits for the last twenty years[4]. Any deviation from this value has almost always been attributable to factors such as improper tailings pond design and operation and/or inadequate control of surface runoff.

The Federal Metal Mining Liquid Effluent Regulations limit the discharge of total suspended matter to 25 mg/l, while the EPA "Effluent Guidelines and Standards for Ore Mining and Dressing" specify a limit of 20 mg/l[5].

Recommendation

Level A of the Pollution Control Objectives sets the minimum limit for total suspended solids at 50 mg/ℓ. The Base Metal Mining Regulations have established a limit of 25 mg/ℓ. It is recommended that this Inquiry adopt the minimum limit of 25 mg/ℓ.

2.1.5 Unconfined Disposal of Mine Tailings

According to the "Metal Mining Liquid Effluent Regulations" and based on the conclusion of the Task Force:

> "The operator of a mine may deposit the deleterious substances prescribed in Section 4 in any quantity or concentration into a tailings impoundment area designated in writing by the Minister".

A tailings impoundment area is defined in the above regulations as:

> "A limited disposal area that is confined by man made or natural structures or by both".

The use of a tailings impoundment minimizes the deleterious effects of turbidity and the smothering of fish habitat by sedimentation, as well as other possible impacts on the life cycle of aquatic organisms. These direct impacts include:

(a) clogging and compaction of spawning habitat caused by sedimentation;

(b) the loss of fish, shellfish and invertebrate habitats in the area affected by the discharge;

(c) various deleterious effects upon the food chain organisms, such as:

(i) the effects of turbidity on all aquatic life processes, primarily photoproductivity,

(ii) the smothering of aquatic habitat,

(iii) the smothering of invertebrates,

(iv) the abrasion of algae, invertebrates and fish,

(v) the release of toxic contaminants, derived from process reagents and through acid generation and the leaching of tailings, which may exhibit both lethal and adverse sub-lethal effects,

(vi) an uptake of heavy metals by fauna and flora in, and near, the tailings deposits.

A recent marine environmental study related to mine waste disposal into Rupert Inlet, British Columbia[6] showed that unconfined disposal of mine tailings and rock waste is resulting in considerable negative impact on the natural habitat and biota of the area. In addition, if an environmental problem develops as a result of unconfined disposal at depth, it is unlikely that any corrective actions could be undertaken to reverse existing damage.

Recommendation

On the basis of the evidence presented above, it is recommended that unconfined disposal of mill tailings be avoided.

2.1.6 Radioactive Waste

2.1.6.1 Review by DFE Task Force

Pollution problems related to the mining and milling of radioactive ores require additional control steps beyond the basic control considerations encountered in base metal mining. The DFE Base Metal Mining Task Force established a Radioactive Sub-group to investigate these

areas of concern in order to prepare appropriate recommendations. The objectives of the sub-group were to:

(a) Examine the state of the art in treatment technology and recommend best practicable technology for effluent treatment.

(b) Recommend concentration limits (standards) for those radioactive contaminants of major concern in the final effluents.

(c) Recommend frequency of sampling and analysis of final effluents.

(d) Describe analytical methods for measurement of the radionuclides of importance.

In the unpublished report of the Radioactive Sub-group to the Base Metal Mining Task Force, the Sub-group recommended that:

(i) Best practicable technology for the treatment of effluents from uranium mine/mill operations consists of pH adjustment with lime or limestone/lime to pH 8-9 (except in the case of carbonate leaching, where this step is unnecessary); sedimentation in tailings impoundment areas must result in the lowest suspended solids level possible (less than 10 mg/l); barium chloride should be added to the tailings pond decant; and final sedimentation of the barium-radium-sulphate precipitate in the treatment lagoon, must result in lowest practicable level possible.

(ii) Based on the diligent application of best practicable technology, a maximum average monthly standard of 10 pCi/l Ra226 in dissolved form should be adopted for federal regulations and guidelines. This agrees with the philosophy of the International Commission on Radiation Protection, which states that the level of all radioactive contaminants should be maintained as low as practicable at all times.

2.1.6.2 Rationale for the Discharge Standards

The current practice of storing barium-radium-sulphate precipitate in treatment lagoons is regarded as an unsuitable long-term solution. This is because the material may redissolve during the post-abandonment period and further contaminate the receiving waters. No long-term solution was proposed by the Sub-group, except that precipitate disposal in abandoned underground workings may provide the best approach. The Radioactive Sub-group also recognized the inadequacy of current base data for use in the setting of pollution control standards, or to ascertain if such standards are warranted for Th230, Th232, and Pb210. Analysis of effluents for these radionuclides should be carried out to assess whether additional standards are necessary.

2.1.6.3 Total Versus Dissolved Concentrations of Ra226

The recommended limit for Ra226 is based on dissolved values only, since most analytical data has been derived from filtered samples. However, the Sub-group felt that standards should be set on total concentration, rather than only dissolved levels (this approach is consistent with that for base metal mines), therefore, analyses should consist of both total and dissolved values for Ra226, Th230, Th232 and Pb210. A 3-micron filter should be used for sample filtration. DFE is currently attempting to correlate these data in order to provide needed comparisons.

The desirability of setting a standard for total radium 226 is also recognized by the AECB, who have asked all Canadian uranium mines to submit both total and dissolved values of their effluents. AECB will then consider the feasibility of developing a standard based on total radium 226 concentration.

Recommendations

The Pollution Control Objectives do not address the disposal of radioactive materials. Therefore, it is recommended that the Inquiry consider the adoption of a minimum limit of 10 pCi/l (monthly arithmetic mean) for dissolved Ra226 in effluents from uranium mining and milling operations.

2.1.7 Guidelines for the Measurement of Acute Lethality in Liquid Effluents from Metal Mines

These toxicity guidelines describe a bioassay test in which test fish are exposed to samples of 100% effluent. The effluent is considered to have passed the test if 50% of the test fish survive the 96-hour exposure period. Although the acute lethality test is believed to be compatible with the application of BPT, the toxicity requirement is presented as a guideline since it is felt that the level of confidence in the effluent meeting the test objectives is not as high as for the analytical parameters.

Recommendation

Level A of the Pollution Control Objectives coincides with the federal requirements in the measurement of acute toxicity in mining effluents. Therefore, it is recommended that no changes be made to the present Pollution Control Objectives.

2.1.8 Environmental Code of Practice for Mines

DFE has developed, with the assistance of the Mining Effluent Task Force, an "Environmental Code of Practice for Mines." This code is meant to indicate sound environmental management practices which can be followed to meet both the intent and substance of the environmental requirements of the Metal Mining Liquid Effluent Regulations and Guidelines and is intended to serve as a useful supplement to these documents. The Code emphasizes effective pollution control measures that should be considered at all stages of a mine-mill development from initial planning to abandonment. Topics covered include minimization and treatment of waterborne wastes, waste rock and mill tailings disposal, monitoring, contingency planning and rehabilitation. The "Code" is included with the regulations and guidelines in the report, EPS-1-WP-77-1[7].

2.2 Legislation Under the Clean Air Act

The Act provides the authority to implement regulations to reduce emission of substances (lead, asbestos, arsenic, and mercury) hazardous to human health. Regulations in progress or issued, relating to industry-specific operation within the mining industry, are presented in Table I on page 10.

2.2.1 Asbestos Mining and Milling Emission Standard Regulations

The Federal Department of Health and Welfare designated asbestos as being "A significant hazard to the health of persons". As a result, the development of "Regulations Prescribing National Emission Standards in Respect of Asbestos Mines and Mills" was undertaken by DFE. The Asbestos Task Force included representatives from DFE regional offices, provincial governments and private industry.

Pollution control technology information relating to asbestos emissions can be found in EPS Report No. 3-AP-76-6[8]. In summary a series of emission tests were carried out during the development of the standard methods, which demonstrated that a proposed limit of 2 fibres/cm^3 was achievable for emissions in exhaust gases from high efficiency fabric filters in the asbestos industry.

Measurements of fibre concentration will be determined using the standard methods for source testing, as prescribed in "Measurement of Asbestos from Asbestos Mining and Milling Operation[9].

The federal regulations, promulgated on June 27, 1977, set the emission limit at 2 fibres/cm^3, where fibres are greater than 5 microns in length and have a length to breadth ratio of 3:1 or more.

The federal regulations will apply to the four principal sources of particulate emission: crushing, drying, milling, and dry rock storage.

An amendment to the present regulations will include asbestos emissions from dry drilling operations in open-pit mining. Measurements will be taken using a standard method, presently being developed by the Asbestos Task Force.

Recommendations

The Pollution Control Objectives do not specify any emission limits for asbestos. It is therefore recommended that this Inquiry adopt the same limit as that specified in the federal regulations; that is, 2 fibres/cm^3 for fibres greater than 5 microns in length and have a length to breadth ratio of 3:1 or more.

2.2.2 Secondary Lead Emission Standards

Secondary Lead Smelter National Emission Standard Regulations were published in the Canada Gazette on July 9, 1976. The standards limit the quantities of particulate matter emitted into the ambient air from various operations involved in secondary lead production. The standards summarized in Table III, specify that the lead content of the allowable particulate emissions should not exceed 63% by weight, subject to conditions specified in an additional sub-section. When the lead content exceeds 63%, the quantities of allowable particulate emissions are reduced so that the quantity of lead emitted is equivalent to 63% by weight of the originally specified limits.

These standards are based on the fact that control technology is available to limit emissions from blast and reverberatory furnaces to a very high degree; efficiencies of up to 99.5% have been quoted[10].

Control systems usually consist of bagfilters or high energy scrubbers. However, when fabric filters are used to control blast furnace emissions, the filters are normally preceded by an afterburner to incinerate oily materials which would otherwise blind the fabric; secondly, an afterburner converts carbon monoxide to carbon dioxide. An afterburner may not be needed for a reverberatory furnace. Baghouses and scrubbers are also used to control secondary lead emission from pot furnaces.

2.2.2.1 Results of Emission Tests

Investigations in the United States[10] revealed that particulates from blast furnaces (cupola) can be controlled to a low level, averaging between 0.009 and 0.013 gr/dscf. These levels were obtained at blast furnaces utilizing the following control equipment:

(a) afterburner and baghouse
(b) afterburner, baghouse, and venturi scrubber
(c) venturi scrubber

Productions rates for the furnaces tested varied between 20 and 80 tons/day.

The results of particulate emission tests made on three other blast furnaces, averaged 0.001, 0.005, and 0.012 gr/dscf. One test on a

TABLE III - SUMMARY OF AIR EMISSION REGULATIONS AND GUIDELINES

REGULATIONS	EMISSION LIMITS
ASBESTOS MINING AND MILLING	
Crushing, Drying, Milling and Dry Rock Storage, (fibres/cc)	2
SECONDARY LEAD INDUSTRY	
Type A[1]) Furnaces, g/Nm^3 (gr/scf)	0.046 (0.020)
Type B[1]) Furnaces, g/Nm^3 (gr/scf)	0.023 (0.010)
Lead in Particulate, (%w)	63[2]
Particulate from Storage of Lead-bearing Materials	None Permitted
GUIDELINES	
ARCTIC MINING	
Mining, Crushing, Concentrating and Drying, g/Nm^3 (gr/scf)	0.040 (0.017)
Mining, Crushing, Concentrating and Drying, opacity, (%)	20
SO_2 from Fuel Oil Combustion, g/1000 Kcal (lb/MM BTU)	1.1 (0.61)
METALLURGICAL COKE MANUFACTURING	
Charging, g/1000kg (lb/ton)	100 (0.20)
Pushing, g/Nm^3 (gr/scf)	0.046 (0.20)
Battery Stacks, g/Nm^3 (gr/scf)	0.069 (0.030)
SO_2 from Combustion of Coke Oven gas, g/1000kg coke (lb/ton)	1300 (2.60)[3]

(1) Furnace types are defined in the regulation.
(2) Can be exceeded if the total particulate is correspondingly reduced.
(3) Equivalent to 50gr H_2S/100 scf of coke oven gas.

reverberatory furnace averaged 0.003 gr/dscf.

The U.S. Environmental Protection Agency's test results for emissions from three controlled reverberating furnaces averaged 0.003 gr/dscf. These furnaces were production-rated at 20, 40 and 65 tons/day, and all were equipped with high efficiency fabric filters.

For melting kettle or pot furnaces, the overall lead emissions are much lower, the reported calculated values varying between 0.15 and 0.4 pounds of lead per ton of lead processed.

2.2.2.2 Emission from Lead-bearing Scrap Storage

The Secondary Lead Smelter National Emission Standard Regulations also state: "No particulate matter may be emitted into the ambient air from lead-bearing scrap or lead-bearing material stored in or about a secondary lead smelter". This statement is intended to ensure that dust from fugitive sources located at secondary smelters is minimized to insignificant levels. The most practical way of achieving low levels is to have such raw material and fugitive dust sources enclosed in buildings, so that emissions within the building are controlled by conventional hooding, ducting and air pollution control equipment.

A "Standard Reference Method for the Determination of Lead in Airborne Particulates", has been published by Fisheries and Environment Canada[11].

Recommendation

It is recommended that the Inquiry adopt the range of particulate emission as specified in the federal regulations presented in Section 2.2.2 of this Brief.

2.2.3 Arctic Mining Industry Emission Guidelines

Arctic Mining Industry Emission Guidelines were published in the Canada Gazette on July 17, 1976.

The guidelines limit the emission of particulate matter into the ambient air to 40 mg/Nm^3; and the emission of SO_2, resulting from the combustion of fuel oil in drying concentrates, to 1.1 grams per 1000 kilocalories. DFE recognizes that these limits do not apply to B.C. mining operations; however, the guidelines demonstrate the Federal

Government desire to have uniform standards throughout Canada.

2.2.4 Metallurgical Coke Manufacturing Industry National Emission Guidelines

Coke Oven emission guidelines were published in the Canada Gazette, on May 31, 1975.

The guidelines, based on BPT, have been developed in consultation with representatives of provincial governments and of metallurgical coke manufacturing, to control the emission of particulate matter and sulphur dioxide as indicated in Table III on page 23.

Recommendations

It is recommended that the federal guidelines be adopted by this Inquiry.

2.2.5 Meteorologically Based Supplementary Emission Control

Ambient air monitoring is an integral part of air quality management. However, when meteorologically based supplementary emission control procedures are proposed, ambient air monitoring plays a much more significant role.

Recommendation

It is recommended that the monitoring network should be designed to sample all areas affected by the mine/mill/smelting operation. These areas will include those where meteorological and topographical influences may combine to produce high concentrations over a particular area which may result in unacceptable environmental impacts.

Air pollution models can be used to supplement the monitoring stations required. However, in British Columbia, the diverse topography is a complicating factor. Models developed for flat terrain do not apply and each location requires individual consideration. *It is recommended that air pollution models be fully validated before being used as part of an air pollution control system.*

2.2.6 Regional Transport of Air Pollution

Ground-level ambient air pollution near emission sources is covered by current ambient air objectives. However, it should be recognized that pollutants can be transported and deposited over long

distances, and even with low concentrations significant cumulative effects can occur.

In British Columbia, topography and weather patterns combine and contribute to significant pollution effects remote from the source. The mountainous terrain in British Columbia is the main factor controlling spatial variability of precipitation and, since atmospheric pollution is washed out by precipitation, the orographic effect is to concentrate pollutant washout in areas many miles from the emission source. It has been shown[12] that "acid rain" originating from distant SO_2 emission sources can have deleterious effects to fish populations. Sulphur is not the only substance of concern. Trace elements and persistent organic contaminants are also part of the problem.

Since current ground-level ambient air objectives do not adequately deal with this problem, special control strategies should be established to ensure that regional and long-range transport of pollution does not result in irreversible damage to the environment.

DFE recently initiated a comprehensive Long Range Transport of Air Pollution (LRTAP) Program to develop a better understanding of the occurrence and effects of such transport within and into Canada.

Recommendation

Since new information is continually becoming available, it is recommended that if a permit is issued for a large pollution source (eg. thermal generating plant), the permittee must be required to evaluate continuously the effects of long range transport of pollutants.

3. ADDITIONAL AVAILABLE TECHNOLOGIES RELATED TO THE MINING INDUSTRY

The development of technology to control pollution of the aquatic and air environments, including that of solids waste discharge, is a dynamic process. Where regulations have been based on best practicable technology, the technology currently practicable may not be adequate to protect the environment.

A number of best practicable and available technologies are included in this Section of the Brief for consideration by the Inquiry.

3.1 Gravel Removal, Gravel Washing and Placer Mining Operations

3.1.1 Introduction

The gravel removal, gravel washing, and placer mining industries are three of the major unnatural contributors of suspended solids to watercourses. Suspended sediments from these operations generally originate from two sources: (i) earth disturbance resulting in accelerated erosion and elevated suspended solid levels, and (ii) silt-laden process waste waters from gravel washing and placer operations. Since, at the present time, there does not appear to be a distinct set of objectives under which these discharges can be restricted, and since they are similar to the tailings releases of mining effluents, it is proposed that they should be included under the Objectives for the Mine, Mine-Milling and Smelting Industries of British Columbia.

As outlined in Section 2.1.5, the effect of turbidity and sedimentation on aquatic organisms can be very detrimental. For example, in relation to gravel washing in British Columbia, Langer (1974)[13], in a presentation to the Faculty of Forestry, University of British Columbia, referred to an experiment on survival of chum salmon egg plants in the Coquitlam River. He found that a small increase in suspended solids (12 per cent), resulting from a known sediment release, increased gravel sediment levels which caused a very disproportionate (55 per cent) decrease in egg survival. However, it was also pointed out that although sediment probably causes the greatest reduction of salmonid production due to egg mortality and death of alevin stages of development, all life forms are

linked together by food chains so that any deleterious effect on algae will affect aquatic invertebrate and fish that depend on food produced in the stream. Such data and opinions clearly indicate the need for strict control measures on discharges from gravel removal, gravel washing and placer mining operations.

3.1.2 Gravel Washing

DFE is of the opinion that the best solution to the disposal of process water from gravel washing operations should involve a system of total process water recycling with no positive discharge. The predominant treatment practice for solids removal is the use of one or more settling ponds; however, in some instances, non-toxic flocculating agents are necessary to settle the finer fractions.

In addition to the need for treatment of gravel wash water, silt-laden runoff water from gravel pit areas must be collected and clarified. Depending upon the source and conditions (i.e. suspended solid concentrations), pit area streams or excessive runoff waters may be diverted around excavation surfaces or may be collected and treated using settling ponds.

Recommendation

It is recommended that the minimum requirements of 25 mg/l suspended solids as specified in the Base Metal Mining Regulations be adopted as a minimum standard for gravel washing operations.

3.1.3 Placer Mining

Placer mining practices such as working stream beds with bulldozers, front-end loaders and suction dredges, and depositing tailings into water courses are of particular concern to the fisheries resource agencies. At present the Pollution Control Objectives for the Mining, Mine-Milling and Smelting Industries do not address these problems and, consequently, are inadequate to ensure the protection of water quality adjacent to placer mining operations.

During the past few years the B.C. Fish and Wildlife Branch and the Fisheries and Marine Service of DFE, in cooperation with the B.C. Ministry of Mines, developed a set of provisions to protect fisheries streams and to allow the Ministry of Mines to administer and process placer lease applications. Streams within designated placer areas are grouped into three categories which are referred to as green, yellow and red coded streams according to their fishery value(14). For each of these three colours, a set of provisions (Schedule "B"), when applied to the operation, are sufficient to safeguard the fishery resource in adjacent water courses. The Chief Inspector of Mines can refer to a predetermined mapping of the streams involved and can then apply the appropriate colour coded Schedule "B" provisions.

These provisions for placer development are believed to be a reasonable set of conditions to impose on the industry to ensure responsible water resource use. In most cases, common sense, minimal effort and little expense or technology are needed to meet these requirements. The provisions leave a great deal of latitude to the individual to design a system so as to avoid problems.

Recommendation

It is recommended that this Inquiry address the problem of placer mining operations and adopt the water pollution abatement provisions of the Stream Colour Code Catalogue and Schedule "B" provisions.

3.2 Mercury Pollution Control Technology

The Federal Government has not yet produced a comprehensive set of regulations to control mercury from all industrial sources. To date, only the chlor-alkali industry is regulated.

The effects of bioaccumulations of mercury and the resulting Minimata disease are well documented. In 1972, Jonasson and Boyle(15) investigated the geochemistry of mercury and the origins of natural contamination of the environment. They reported average mercury levels of 0.2 ppb in lakes and rivers, and 161 ppb in mineralized formations. In

1976, the Water Quality Branch of the Inland Waters Directorate, published a report[16] which stated that mercury levels in some of the rivers in south-eastern British Columbia were equal to or exceeded 2 ppb.

Mercury is present in most sulphide concentrates and is liberated by roasting and smelting. Effective mercury recovery from smelter gases, in recovery systems operating in Finland and Sweden, was motivated by mounting environmental pressure to minimize airborne mercury emissions, and by a need to reduce the mercury content of sulphuric acid produced from contaminated gases.

The dual challenge was to find an efficient and economical method of lowering mercury content in the gases to 1 mg/Nm^3 or less. This value is more stringent than the 1 mg/m^3 of Level A in the Pollution Control Objectives.

A listing of the major processes and a summary of their major operating principles follow:

(a) Outokumpu Process

This process was developed by Outokumpu Oy in Finland and applied commercially to zinc roaster offgases in 1970[17]. In the process, roaster offgases are scrubbed with concentrated sulphuric acid in a packed tower after dust removal by cyclones and electrostatic precipitators. The gas flows to the sulphatizing tower at a rate of approximately 33,000 Nm^3/hr and contains up to 100 mg/Nm^3 particulate, 40-80 mg/Nm^3 mercury and 60 g/Nm^3 water vapour, at a temperature of 350°C.

The sulphatizing tower is brick-lined and contains acid-proof ceramic packing. Sulphuric acid at 40°C is circulated through the towers and contacts the gas which flows countercurrently. Mercury is converted to mercuric sulphate and remains in the circulating acid; this has limited solubility and forms a sludge. The acid is treated in a thickener and solids periodically withdrawn and processed to recover mercury. The acid is cooled in a heat exchanger prior to recirculation.

Gases exit the packed tower at 180°C and contain less than 0.2 mg/Nm^3 mercury, corresponding to a removal efficiency

of more than 99.5% in the sulphatizer.

Concentrated sulphuric acid is required for effective operation. The temperature in the tower is controlled, to avoid water vapour condensing and diluting the acid. The mercury content of the gas is reduced as a result of the acid binding it as mercuric sulphate.

The waste water from the plant is directed to a sedimentation pond of 214,000 m^3 capacity which also treats water from the combined smelter-refinery complex. The permits limit the total mercury emissions in water from the pond to 0.8 Kg/month or 4 Kg/year.

(b) Boliden Chloride Process[18]

Boliden have developed a mercuric chloride scrubbing process which is incorporated in a zinc smelter that includes a 250 tpd acid plant at the Norzinc Smelter, Odda, Norway. Dust is recovered from fluid bed roaster offgases using cyclones and an electrostatic precipitator. The gas is then scrubbed with mercuric chloride solution ($HgCl_2$) in a packed tower. The inlet gas contains about 22 mg/Nm^3 mercury.

The mercuric chloride reacts with mercury vapour in the gas to form a fine solid precipitate, mercurous chloride (Hg_2Cl_2). The operation is controlled to obtain a gas temperature between 30-40°C at the scrubber outlet. The exit gas contains between 0.55 and 1.1 mg/Nm^3 mercury.

Part of the solution from the tower bottom is recirculated and another part treated in a sludge separator. The solution from the separator is recirculated, while part of the solids is treated in an oxidation plant, where it is converted to $HgCl_2$ using gaseous chlorine. $HgCl_2$ is then used as make-up reagent. The balance of the solids are either stored or treated to recover mercury.

(c) Boliden Dry-Selenium Filter [18]

Boliden have developed and applied Dry Selenium Filters

to recover mercury from smelter gases containing between 4-5% SO_2 and an average of 0.92 mg/Nm^3 mercury, at 30°C. Mercury is absorbed as mercuric selenide (HgSe) which has a very low vapour pressure. The plant treats approximately 66,000 Nm^3/hr. gas. The cleaned gas contains about 0.092 mg/Nm^3 mercury and is used to produce liquid sulphur dioxide.

Absorption takes place in a vertical radial reactor tower, which is filled with an inert porous material impregnated with activated selenium. The gases enter the centre of the tower and diffuse radially outwards. Mercury is absorbed on the selenium. Removal efficiencies of approximately 90% are usually obtained; spent selenium filters are not utilized presently to recover mercury.

The filter requires a clean dry gas, and the gas temperature is heated to 55°C to prevent water vapour condensing because condensation would de-activate the filter. The selenium process is preferred to that of chloride in cases where the mercury content of the inlet gas is low and very low outlet levels are desired.

(d) Activated Carbon Filters

Boliden also operate three activated Carbon Filters[18] adsorbing mercury from gas which contains about 0.22 mg/Nm^3 mercury. Each filter has a capacity of 44,000 Nm^3/hr. gas. The carbon filters reduce the mercury content to about 0.01 mg/Nm^3. The filters, similar in design to the selenium filter, utilize gas which is first dried with concentrated sulphuric acid to remove water vapour. The carbon filters require a clean, dry gas with a uniform SO_2 composition.

The Boliden Selenium and Activated Carbon Filter processes are utilized in cases where mercury concentrations are relatively low and very low mercury contents are desired. The plants are sensitive to temperature and gas compositions. Wide fluctuations cannot be tolerated. The towers have a total collection efficiency of approximately 90%.

(e) St. Joe B Process

Another mercury removal process used in industry is the St. Joe B Process. This process developed by St. Joe Minerals Corporation is used to absorb mercury from zinc multi-hearth roaster offgases at their Monca, Pennsylvannia Smelter(19). The principle of the operation is to inject hydrogen sulphide (H_2S) into the gas stream. This reacts with mercury forming HgS which has a low vapour pressure. The HgS is absorbed on coke filters, or in wet scrubbers of the conventional acid plants.

Each of five operating filters treat about 41,000 Nm^3/hr. Mercury removal efficiencies of 90% are obtained, and the cleaned gas contains between 2-5 mg/Nm^3 mercury. The sulphuric acid manufactured from the gas contains about 4 mg/Kg of mercury (4ppm). This is treated with potassium iodide using the Toho Zinc MAK process, which reduces the mercury content to below 0.5 mg/Kg.

Recommendation

It is recommended that this Inquiry consider these processes to determine the most appropriate mercury emission limit applicable to British Columbia mining operations.

3.3 Fugitive Emissions and Leachate from Mineral Stock Piles

In reviewing the Provincial Pollution Control Objectives on mining and smelting, DFE realizes that the control of particulate emissions and leachates from mineral storage areas at terminals has not been addressed.

DFE's present input is limited to an expression of concern for this problem and to ask this Inquiry to identify and consider this issue in the immediate future.

3.4 Fugitive Emissions during Transportation

Control of fugitive emissions from unit trains carrying coal from the mine sites to the terminals has been the subject of a recent industry/government cooperative study(20).

The parameters investigated during field studies of coal trains from coal mines included various loading profiles and spray applications

of various chemical binders. The results obtained showed that crust coverages of up to 95% were obtainable, but the most frequent coverages were in the order of 85%.

Recommendation

It is recommended that this Inquiry consider the adoption of a minimum coverage of 85% to be applied to the upper coal surfaces of coal cars during transportation.

3.5 Coal-Fired Thermal Power Plants

It is our understanding that discharges from large, coal-fired boilers, such as used for electrical generation, will be considered at the Inquiry and that pollution control objectives will be established. Although DFE personnel have participated in an examination of the many aspects of B. C. Hydro's Hat Creek Project, the only proposed facility in British Columbia to which the objectives would currently apply, DFE does not have a summary position to present at this time that recommends discharge objectives. There are two reasons for this:

1. We were unaware that discharges from coal-fired generating stations would be considered at the Inquiry.

2. Air emission objectives for thermal generating plants are under development and, while these are not now available, they should be available for us to present at the Inquiry.

3.6 Solid Waste Management

3.6.1 Waste and Tailings Disposal

Failure of waste embankments have occurred throughout the world, some with the loss of life[21]. In Canada, based on the results of the 1968 Energy Mines and Resources Mining Questionnaire, approximately 35% of tailings dams and 20% of waste embankments have suffered some degree of instability. Furthermore, the questionnaire shows that stability investigations were performed on only 26% of the tailings dams and 23% of the waste dumps reported in the survey. Despite this evidence, present mining regulations in Canada often do not specify that a detailed evaluation of stability must be undertaken prior to construction.

The need for a Design Guide for use by mining engineers and federal and provincial officials responsible for the operation and inspection of mining projects, was identified by the Department of Energy, Mines and Resources. A "Tentative Design Guide for Mine Waste Embankments in Canada", (EMR Technical Bulletin TB 145) was completed in March 1972. This Guide has now been revised and published by the CANMET Division of the Department of Energy Mines and Resources in 1977 as Chapter 9 (Waste Embankments of "The Pit Slope Manual". The primary purpose of the Chapter was to outline the general aspects relating to stability, the more common types of instability problems which may develop, and investigations necessary to evaluate each of these problems. It was recommended that the Chapter should include site investigation methods, design requirements and specifications, construction techniques, inspection procedures and general guidelines related to the evaluation of facilities.

The Chapter is a significant contribution to the mining industry, principally for increasing the industry's knowledge of waste embankment stability and the retention of liquids within them.

There is also the additional benefit that, by implementing best engineering practice, as outlined in the Chapter, certain aspects of associated pollution and reclamation problems will be minimized.

Pollution problems related to the carryover of suspended solids are minimized through the appropriate design and location of the tailings inlet system, decant and spillway structures. These mechanical features, however, will not influence the discharge of dissolved substances originating from either acid leaching conditions or from unconsumed mill reagents. These substances can constitute a pollution hazard mainly through the presence of heavy metals, unoxidized thiosalts, sulphates, and the complete range of flotation reagents. Such materials frequently exhibit synergistic effects with respect to fish toxicity[22].

In 1976, DFE supported an unsolicited proposal made to Supply and Services Canada by Klohn Leonoff Consultants Ltd., to prepare a simplified procedure for assessing the safety of sand-filled mine tailings dams against failure due to liquefaction caused by earthquakes. The method of evaluating the effects of earthquakes on porewater pressures, is described in the Klohn Leonoff report[23].

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APPENDIX I

ORGANIZATION OF THE
DEPARTMENT OF FISHERIES
AND THE ENVIRONMENT, CANADA

APPENDIX I DEPARTMENT OF FISHERIES AND THE ENVIRONMENT - CANADA

1 DEPARTMENT STRUCTURE

The Department of Fisheries and the Environment (DFE) is organized into operational units, each concerned with a broad element of the natural environment: The atmosphere; the oceans; the fishery; the forests; or, with the management of human activities as they interact with these elements - that is, environmental protection.

DFE comprises two main operational components - the Environmental Services, and the Fisheries and Marine Service.

2 ENVIRONMENTAL SERVICES

This component has administrative responsibilities for Environmental Management, Environmental Protection, and Atmospheric Environment.

2.1 Environmental Management Service (EMS)

This Service is responsible for mission oriented research, direction of service projects, management of fresh water resources, development of land-use, and the preservation of wildlife. These functions are carried out by four resource directorates: Canada Forestry Service, Inland Waters Directorate, Lands Directorate, Canadian Wildlife Service.

2.2 Atmospheric Environment Service (AES)

This Service provides and disseminates weather observation and climatological information through a large communication network. In addition, the Service conducts atmospheric research; consultative services in hydro-meteorology, fire-risk weather predictions, air quality, wind wave forecasting, and weather data related to environmental impact studies.

2.3 Environmental Protection Service (EPS)

This Service is responsible for developing and enforcing environmental protection regulations, guidelines, and other protection and control instruments used to implement federal environmental legislation. It has developed regulations under the Fisheries and Clean Air Acts controlling discharges of effluents and emissions of specific contaminants from specific industrial wastes. Regulations under the Environmental Contaminants Act

control the use and distribution of certain hazardous pollutants. Implementation of programs is carried out by five regional offices - Atlantic; Quebec; Ontario; Northwest; and Pacific.

3 FISHERIES AND MARINE SERVICE

This Service is responsible for fisheries development and fisheries operations on both coasts and in inland waters, and for fisheries research, oceanography, hydrography, and the administration of small craft harbours. Fisheries research extends to all factors affecting the conservation and utilization of marine and freshwater fisheries, flora and fauna, including the relevant aspects of water pollution.

APPENDIX I I

THE GOVERNMENT ORGANIZATION

ACT OF 1970

APPENDIX II

THE GOVERNMENT ORGANIZATION

ACT OF 1970

The responsibilities of DFE are as follows:

The duties, powers and functions of the Minister of the Environment (now Minister of Fisheries and the Environment) extend to and include all matters over which the Parliament of Canada has jurisdiction, not by law assigned to any other department, branch or agency of the Government of Canada, relating to

(a) sea coast and inland fisheries;

(b) renewable resources, including

(i) the forest resources of Canada,

(ii) migratory birds, and

(iii) other non-domestic flora and fauna;

(c) water;

(d) meteorology;

(e) the protection and enhancement of the quality of the natural environment, including water, air and soil quality;

(f) technical surveys within the meaning of the Resources and Technical Surveys Act relating to any matter described in paragraphs (a) to (e); and

(g) notwithstanding paragraph (f) of Section 5 of the Department of National Health and Welfare Act, the enforcement of any rules or regulations made by the International Joint Commission, promulgated pursuant to the treaty between the United States of America and His Majesty, King Edward VII, relating to boundary waters and questions arising between the United States of America and Canada, so far as the same relates to pollution control.

The Minister of the Environment, in exercising his powers and carrying out his duties and functions shall

(a) initiate, recommend and undertake programs and coordinate programs of the Government of Canada, that are designed to

promote the establishment or adoption of objectives or standards relating to environmental quality, or to control pollution; and

(b) promote and encourage the institution of practices and conduct leading to the better protection and enhancement of environmental quality, and cooperate with provincial governments or agencies thereof, or any bodies, organizations or persons, in any programs having similar objectives.