MEND

THE CANADIAN PROGRAM ON ACID MINE DRAINAGE

by

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ABSTRACT

Acidic drainage is the largest single environmental problem facing the Canadian mining industry today. Technologies to prevent acidic drainage from occurring in waste rock piles and tailings sites, and on the walls of open pits, need to be developed and proven. In response to this need, the Mine Environment Neutral Drainage (MEND) program was established in Canada to initiate and coordinate research efforts. MEND is a co-operative program financed and administered by the Canadian mining industry; the Canadian government through Energy, Mines and Resources Canada (CANMET), Environment Canada, and Indian and Northern Affairs Canada; and the governments of British Columbia, Manitoba, Ontario, Quebec and New Brunswick, where most of Canada's sulphide minerals are mined.

MEND sponsored research programs have been under way since the beginning of 1988. To date, some 59 projects have been initiated. In terms of technical progress, 33 projects have been completed spanning all the research program areas. Some the most promising results have been obtained through studies into the prevention and control of acidic drainage using wet barriers and solid covers. This presentation summarizes the present, proposed and completed activities of the MEND program.

Keywords: Tailings, waste rock, sulphide oxidation, MEND, BC AMD Task Force, reactive wastes, acid mine drainage, AMD.

INTRODUCTION

For over two decades, the Canadian mining industry and the government of Canada conducted research into methods of establishing sustainable vegetative growth on tailings and waste rock. It was believed that this technology would alleviate acid drainage problems from these sites, thus allowing mining companies to abandon these sites without future liability. Very successful vegetation methods were developed, and many sites were vegetated. However after several years, the quality of drainage from vegetated sites had not improved, and mining companies are faced with the prospect of continuing to operate and maintain lime treatment plants indefinitely. Vegetation was clearly not an acceptable solution to the problem, and new reclamation technology needed to be developed and demonstrated.

In response to the need to conduct research on acidic drainage, the Canadian mining industry initiated a task force in 1986. The task force consisted of a steering committee and a technical working group, with representation from the mining industry, CANMET, Environment Canada, British Columbia, Manitoba, Ontario, Quebec and New Brunswick. The task force recommendations were published in July, 1988 (CANMET, 1988), and are being implemented by a tripartite consortium organized under the **Mine Environment Neutral Drainage (MEND)** program. A second group in Canada is also coordinating research into the problem of acidic drainage and is known as the British Columbia Acid Mine Drainage (BC AMD) Task Force.

This paper summarizes progress in acidic drainage research in Canada under MEND.

WHAT IS ACIDIC DRAINAGE ?

Like elsewhere in the world, Canadian base metal, precious metal and uranium mines contain sulphide minerals, either in the ore or the surrounding waste rock. When these sulphide minerals, particularly pyrite and pyrrhotite, are exposed to oxygen and water, a process of conversion of sulphide to sulphate takes place. Water in contact with these oxidizing minerals is made acidic, and in the absence of calcareous materials, such as calcite, the acidic water carries with it toxic metals and elevated levels of dissolved salts. As the reactions proceed, temperature and acidity increase, resulting in an increased rate of reaction. Between pH levels of 2 and 4, bacteria and ferric iron catalyze the reactions, and rates can be 20 to 100 times faster than the original chemical reaction rate (Knapp, 1987). Rainfall and snowmelt flush the toxic solutions from the waste sites into the downstream environment.

If acidic drainage is left uncollected and untreated, the drainage could contaminate groundwater and local water courses, damaging the health of plants, wildlife, and fish.

At active mine sites (and some inactive mine sites), mining companies operate comprehensive systems to collect and treat effluents and seepage from all sources. These facilities, when well operated and maintained, are sufficient to prevent downstream *environmental impact*. However, acid generation may persist for hundreds of years following mine closure. The operation of treatment plants for very long periods of time is clearly not desirable and counter to the principles and goals of sustainable development. In addition, the conventional lime treatment process produces sludges that contain a very low percentage by weight of solids. In some severe cases, in a few decades the volume of sludge will exceed the volume of tailings or waste rock producing the acidic drainage.

DIMENSIONS OF THE PROBLEM

Between 1984 and 1987, CANMET and industry co-sponsored two projects to define the extent of acid-generating mine waste at base metal mining operations (Monenco, 1984 Nolan, 1987). British Columbia, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Newfoundland, Yukon and Northwest Territories were all identified as having operating and/or abandoned acid generating waste sites, with a total area of over 15,000 hectares (37,000 acres). These wastes are largely the accumulation of the last forty years of mining. As for the future, it seems reasonable to assume that the mining of lower grade ores together with the likelihood of *increasing annual* mineral production could lead to the accumulation of an equal quantity of acidic tailings and waste rock over the next twenty years.

The above surveys do not represent the entire Canadian inventory, since they did not include gold, coal, uranium or any kind of abandoned mine site for which responsibility has reverted to the Crown. The two provinces with the most extensive mining base, Ontario and Quebec, have recently completed surveys of their abandoned mine sites. In Ontario, over 2000 abandoned mine sites were identified and many may pose an acidic drainage problem. Twenty sites have been well documented and they contain 55,000,000 tonnes (60,000,000 tons) of reactive sulphide tailings over a surface area of 830 hectares (2030 acres). In Quebec, about 107 abandoned mine sites exist. Twenty-one (21) of these sites have been classified as hazardous waste sites because of acidic drainage, and the total area was estimated at 4500 hectares (11,110 acres).

The cost of stabilizing reactive wastes is highly site specific, and thus will vary greatly from site to site. Under the most difficult conditions and applying existing, but unproven technology, the costs of stabilizing some sites have been estimated to be as high as $410,000 per hectare. Applying an average cost of $125,000 per hectare to the existing and future accumulation of acid generating waste, the Costs of reclamation at non-ferrous metal mine sites is $3 billion over the next twenty years. Funds required to deal with abandoned sites where liability cannot be established, and where the mineral rights have reverted to the crown, are estimated to be about $1 billion.

THE MEND PROGRAM

MEND is a cooperative research organization sponsored, financed and administered by the Canadian mining industry, the Government of Canada, and the provinces of British Columbia, Manitoba, Ontario, Quebec and New Brunswick. The MEND organizational structure includes a Board of Directors, a Management Committee and six Technical Committees.

The overall objectives of MEND are:

1. to provide a comprehensive scientific, technical and economical basis for the mining industry and governmental agencies to predict, with confidence, the long-term management requirements for reactive tailings and waste rock, and
2. 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.

The six technical committees that were established and brief resum6s of their mandates are:

1. Prediction
   Develop improved analytical protocols to identify acid generating waste materials and to predict the concentration of pollutants to be expected in drainage waters from these wastes. Initiate research into the fundamental chemistry and reaction mechanisms of sulphide waste materials.

2. Prevention and Control
   Demonstrate the suitability of various closure alternatives for preventing acidic drainage formation in tailings and waste rock. Examine closure systems that will include the use of wet barriers and dry barriers. Keep up to date and develop new technology for treatment and prevention of AMD.
3. Treatment
   Examine and demonstrate the feasibility of new effluent treatment systems for use during operations and upon closure of a waste site. Passive treatment systems, such as wetlands, may be used downstream of decommissioned waste sites, but fundamental research is required before these systems can be proven effective and reliable. Examine advanced treatment methods and methods for stabilizing heavy metal hydroxide sludges.
4. Monitoring
   Examine all aspects of site monitoring, *including advanced* methods and develop field sampling manuals.
5. Technology Transfer
   Communicate research results to industry, government agencies and the public. Maintain, through the Library and Documentation Services Division of CANMET, a computerized database of acidic drainage literature and distribute this literature on request. organize seminars and workshops across Canada, and ensure that information bulletins are being published in the CIM Journal.
6. International Liaison
   Interface with international organizations, collect information on international acidic drainage research and review and disseminate this information to MEND participants. Expand on established contacts with the USBM, Australia, Finland, Sweden and Norway.

In order to meet the objectives of MEND, the Management Committee estimated that $12.5 million in expenditures was required to complete the work program. The original (1988) financial plan called for the research work to be spread over 5 years. and to be allocated by technical committee as shown in Table 1.

Table 1
SUMMARY OF MEND PROJECTS

1. Prediction	$ 3,765,000
2. Prevention and Control	$ 5,705,000
3. Treatment	$ 1,285,000
4. Monitoring	$ 385,000
5. Technology Transfer	$ 225,000
Contingency	$ 1,135,000
Total Program	$12,500,000

Research is being conducted through contracts issued to universities and consultants, and through the contribution of work-in-kind credits from government research labs and mining companies. MEND program results are made available to MEND participants and the public through the CANMET publications department.

Supporting the national MEND program, while serving provincial objectives are the acid mine drainage technical and management committees in Quebec, Ontario and in British Columbia, and these committees cooperate closely with ***MEND***. In addition to this cooperation, British Columbia conducts an active research program, termed the British Columbia Acid Mine

Drainage Task Force. The interest of this Provincial task force stems from the high percentage of acidic drainage originating from waste rock in British Columbia. 80% of all Canadian acid producing waste rock in located in British Columbia versus only 4% of all acid producing tailings.

SUMMARY OF PROJECTS UNDERWAY AND RESULTS

Thirty-three projects have been completed spanning all of the research program areas. Some of the most promising results have been obtained during the studies into the prevention and control of acidic drainage using wet barriers and solid covers. For example, the studies into the effects of depositing reactive tailings into 4 Canadian lakes (2 in British Columbia and 2 in Manitoba) have shown that tailings do not react underwater, that the dissolution of heavy metals from the tailings and overlying sediments is minimal, that uptake of metals into the flora and fauna is negligible and that the lakes can and do support thriving biological systems. Reducing conditions in the bottom of one lake were sufficiently established to identify the formation of framboidal pyrite.

The research into dry cover technology has resulted in the construction of laboratory equipment to measure the performance of various cover system designs by monitoring moisture content and oxygen flux. This significant achievement will allow the testing of locally available cover materials to establish the beat cover design configuration. The companion field project will demonstrate the performance of layered cover systems for comparison with laboratory data. The combined results of the two studies will provide the technical basis for designing covers on tailings, demonstrate the benefits of the technology in preventing or reducing the generation of acidic drainage and provide the necessary information for optimization of cover design.

MEND continuos to generate considerable interest from the Canadian research community as demonstrated by the number of new and innovative proposals approved in 1991. One such proposal, for example, involves the microbial plugging of tailings to prevent the formation of acidic drainage in tailings. The project uses starved indigenous microorganisms which, when exposed to nutrients, reproduce and excrete polymers. The polymers fill the void spaces in the tailings, effectively preventing the mouvement of oxygen and water through the tailings mass.

Summary listings for the research projects are given in Tables 2, 3 and 4 accoording to their status: Completed, Active or Recommended. Table 5 is a listing of MEND Reports that are available.

Table 2: Completed Projects

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Project	Title	Budget	Expenditures	Variance	Sponsors
1.11.1	AMD from Waste Rock - Literature Review	$ 50,000	$ 50,000	$ 000	Env. Can. ($25k), Teck ($25k)
1.14.1	Field Evaluation Rock Hydrogeochemistry - Mine Doyon	$ 362,000	$ 362,000	$ 000	CRM ($94k), LAC ($134k), Cambior ($134k)
1.15.1	AMD from Open Pits - Equity Silver	$ 55,000	$ 53,000	$ 2,000	BC ($10k), CANMET ($10k), Equity Silver ($33k)
1.16.1(a)	Evaluation of Prediction Techniques - Tailings & Waste Rock	$ 70,000	$ 63,000	$ 7,000	CANMET ($63k)
1.16.1(b)	Manual of Chemical Evaluation Procedures	$ 23,000	$ 23,000	$ 000	CANMET ($23k)
1.16.1(c)	Development of Static Evaluation Procedures	$ 40,000	$ 21,000	$ 19,000	CANMET ($21k)
1.17.1	Hydrogeochemical Investigation - Waite Amulet	$ 235,000	$ 285,000	$ (50,000)	CANMET ($117k), Noranda ($168k)
1.21.1(a)	Evaluate RATAP, BMT Capabilities	$ 30,000	$ 30,000	$ 000	CANMET ($30k)
1.21.1(b)	Workshop of Modelling Techniques - Tailings	$ 70,000	$ 73,000	$ (3,000)	CANMET ($63k), Falconbridge ($10k)
1.21.1(c)	RATAP - User's Manual	$ 30,000	$ 19,000	$ 11,000	Env. Can. ($19k)
1.24.1	Development of Preliminary Modelling of Seepage Quality from Acid Generating Waste Rock Dumps	$ 285,000	$ 21,000	$ 264,000	DIAND ($21k)
2.11.1(a)	Evaluation of Existing Underwater Disposal Sites	$ 210,000	$ 220,000	$ (10,000)	BC ($50k), CANMET ($70k), HBM&S ($65k), Env. Can. ($35k)
2.11.1(b)	Evaluation of Existing Underwater Disposal Sites	$ 250,000	$ 136,000	$ 114,000	BC ($5k), CANMET ($5k), HBM&S ($50k), Env. Can. ($26k), Placer Dome ($50k)
2.14.1	Establish Vegetative Wetlands Over Tailings	$ 100,000	$ 30,000	$ 70,000	Falconbridge ($25k), CANMET ($5k)
2.21.1	Engineered Dry Covers for Tailings -	$ 230,000	$ 216,000	$ 14,000	Env. Can. ($61k), CANMET ($35k), DSS ($120k)
2.22.1	Assessment of Hardpan	$ 150,000	$ 100,500	$ 49,500	Manitoba ($100k)
2.23.1	Documentation of Disposal Methods for Tailings & Waste Rock	$ 75,000	$ 75,000	$ 000	BC ($38k), CANMET ($37k)
2.24.1	Vegetation Manual	$ 35,000	$ 33,500	$ 1,500	CANMET ($34k)
2.31.1(a)	Dry Covers on Waste Rock - Heath Steele	$ 400,000	$ 312,000	$ 88,000	BM&S ($172k), New Brunswick ($140k)
3.11.1(a)	Treatment of Acidic Seepage Employing Wetland Ecology and Microbiology	$ 230,000	$ 281,000	$ (51,000)	INCO ($166k), CANMET ($40k), Denison ($25k) Env. Can. ($50k)
3.11.1(b)	Treatment of Acidic Seepage Employing Wetland Ecology and Microbiology	$ 250,000	$ 273,400	$ (23,400)	INCO ($83k), CANMET ($90k), Denison ($30k) Env. Can. ($70k)
3.12.1(a)	Assessment of Existing Natural Wetlands	$ 40,000	$ 40,000	$ 000	Env. Can. ($40k)
3.21.1(a)	Metals Recovery from AMD	$ 25,000	$ 25,000	$ 000	CANMET ($10k), Env Can ($15k)
4.1.1	Field Methods Manual - Tailings	$ 20,000	$ 29,000	$ (9,000)	CANMET ($29k)
4.3.1	Standard Reference Materials - Tailings	$ 50,000	$ 50,000	$ 000	CANMET ($50k)
4.7.1	Optimum Sampling Frequency	$ 27,000	$ 27,000	$ 000	BC ($13.5k), CANMET ($13.5k)
4.7.2	Biological Monitoring of AMD	$ 21,000	$ 21,000	$ 000	BC ($10.5k), CANMET ($10.5k)
4.7.3(a)	Aquatic Invertebrate Monitoring (1989/90)	$ 53,000	$ 53,000	$ 000	BC ($33k), CANMET ($20k)
4.7.4	AMD Sediment Monitoring	$ 6,500	$ 6,500	$ 000	BC ($4k), CANMET ($2.5k)
5.5.1	Preliminary MEND Research Plan	$ 25,000	$ 25,000	$ 000	CANMET ($25k)
	Totals	$3,447,500	$2,953,900	$ 493,600	

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Table 3: Active Projects

Project	Title	MEND Approved Budget	Expenditures	Variance	Sponsors
1.12.1	Compile AMD Prediction Data - Tailings & Waste Rock	$ 35,000	$ 19,000	$ 16,000	BC MDA ($24k)
1.19.1	Kinetic Tests for Cinola Gold Project	$ 120,000	$ 50,000	$ 70,000	Env.Can. ($46k), BC ($15k), City Res. ($2.4k)
1.22.1	ANSTO Model at Heath Steele	$ 145,000	$ 000	$ 145,000	Not funded in 1991 NB ($25k?)
1.23.1	Compilation of Rules for the Prediction of AMD	$ 30,000	$ 10,000	$ 20,000	BC MDA ($10k)
1.25.1(a)	Development of a Soil Flux Model to Design Tailings Covers	$ 49,500	$ 12,000	$ 37,500	CANMET ($55k)
1.26.1(a)	Development of Modelling Methodology for Prediction of Seepage from Acid Generating Waste Rock	$ 90,000	$ 000	$ 90,000	Env. Can. ($30k), MEMPR ($60k)
1.31.1	Fundamental Reaction Kinetics - SIMS	$ 94,600	$ 20,000	$ 74,600	Echo Bay ($5k), DIAND ($18k), Ontario ($54k), (INCO?)
1.32.1	Prediction and Prevention of ARD - A Geological & Mineralogical Approach	$ 73,000	$ 35,000	$ 38,000	Env. Can. ($55k), Teck ($3k), HBM&S ($3k), BHP ($3k), Placer Dome ($3k), Cominco ($3k)
2.11.1(c)	Evaluation of Existing Underwater Disposal Sites	$ 50,000	$ 52,000	$ (2,000)	Placer Dome ($52k)
2.11.1(d)	Peer Review on the Subaqueous Disposal of Tailings	$ 45,000	$ 35,000	$ 10,000	CANMET ($37.5k), Placer Dome ($4k), HBM&S ($3.5k)
2.13.1	Flooding of Existing Tailings Sites - Quirke Lake	$ 835,000	$ 835,000	$ 000	Rio Algom ($502k), CANMET ($333k)
2.13.2	Flooding of Existing Tailings Sites - Solbec Cupra	$ 260,000	$ 133,000	$ 127,000	Cambior ($46k), CANMET ($30k), CRM ($57k)
2.21.2	Engineered Dry Covers for Tailings - Noranda	$ 348,000	$ 419,000	$ (71,000)	CANMET ($136k), Noranda ($157k), CRM ($126k)
2.23.2	Thickened Tailings Disposal System	$ 60,000	$ 60,000	$ 000	Falconbridge ($60k)
2.23.3(a)	Porous Envelope - Falconbridge	$ 97,000	$ 26,000	$ 71,000	Falconbridge ($97k)
2.31.1(b)	Dry Covers on Waste Rock - Heath Steele	$ 219,700	$ 175,000	$ 44,700	BM&S ($72.5k), New Brunswick ($54.9k), CANMET ($92.3k)
2.32.1	Blending & Segregation of Waste Rock - Kutcho Creek	$ 140,000	$ 140,000	$ 000	Sumac ($110k), BC ($15k), CANMET($15k)
2.32.2(a)	Co-disposal of Tailings and Waste Rock - Mines Selbaie	$ 96,000	$ 85,000	$ 11,000	CRM ($76k), CANMET ($20k)
2.35.2(a)	Lysimeter Covers for Waste Rock	$ 80,500	$ 80,000	$ 500	Noranda ($65k), CRM ($16k)
2.41.1(a)	Electrochemical Oxidation/Passivation of Sulphides	$ 60,000	$ 60,000	$ 000	HB&S ($10k), LAC ($10k), Noranda ($5k), CANMET ($35k)
2.42.1(a)	Synthetic Polymers	$ 83,000	$ 15,000	$ 68,000	INCO ($22.5k), Ontario ($22.5k)
2.44.1	Microbial Plugging	$ 100,000	$ 75,000	$ 25,000	CANMET ($60k), INCO ($10k), Noranda ($20k), Teck ($10k)
3.11.1(c)	Treatment of Acidic Seepage - Microbiology	$ 208,000	$ 125,000	$ 83,000	Env Can ($27k), CANMET ($27k), CRM ($30k), INCO ($25k), Denison ($16k)
3.12.2	Evaluation of Panel Wetlands	$ 45,000	$ 40,000	$ 5,000	CANMET ($22.5k), Ontario ($22.5k)
4.5.1	Field Methods Manual for Waste Rock (Phase I & II)	$ 100,000	$ 000	$ 100,000	CANMET ($24k)
5.6.1	Second International Conference on the Abatement of Acidic Drainage, 1991	$ 40,000	$ 112,000	$ (72,000)	CANMET ($15k), Teck ($8k), Env Can ($15k), Cominco ($5k), Rio Algom ($4k), Falconbridge ($4k), Placer Dome ($4k), INCO ($11k), Noranda ($20k), Cambior ($4k), Mitec ($7k), HBM&S ($3k), Ontario ($7k), BC ($3k), MAC ($2k)
	Totals	$3,504,300	$2,613,000	$ 891,300	

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Table 4: Projects Recommended for Board Approval

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Project	Title	Recommended Budget	Funds Needed	Sponsors/Comments	Future Costs
1.14.2	Monitoring & Modelling AMD from Waste Rock - Mine Doyon Phase II	$ 450,000	$ 150,000	LAC ($75k), Cambior ($75k), CRM ($150k) $150k needed over 2 years	
1.21.1(d)	Beta Evaluation of RATAP	$ 15,000	$ —	CANMET ($15k)	
2.23.3(a)	Porous Envelope - Falconbridge	$ 26,000	$ —	Falconbridge ($13k), Ontario ($13k) (increase in scope, budget to $123,000)	
2.31.1(b)	Dry Covers on Waste Rock - Heath Steele	$ 148,000	$ —	BM&S ($48.8k), CANMET ($62.2k), New Brunswick ($37k) (for years 2 to 4)	
2.32.2(b)	Co-disposal of Tailings and Waste Rock - Mines Selbaie	$ 184,000	$ —	CRM ($19k), Selbaie ($95k), CANMET ($70k)	
2.35.2(b)	Lysimeter Covers of Waste Rock	$ 64,500	$ —	Noranda ($64.5k) (for years 2 and 3)	
2.	ARD Experience in Norway	$ 38,500	$ —	BC ($19.3k), Norway ($19.3k)	
3.11.1(d)	Treatment of Acidic Seeps	$ 80,000	$ 20,000	INCO ($20k), Env Can ($20k), CRM ($20k), Project submitted for approval	
3.13.1(a)	Treatment of Small Seeps	$ 90,000	$ 30,000	Noranda ($60k)	$ 250,000
3.21.1(b)	Removal of Metals IX	$ 75,000	$ 75,000	($175k)	
3.21.2(a)	Removal of Metals - Chem	$ 100,000	$ 10,000	Noranda ($100k)	
3.31	Use of Lime Sludges for Capping	$ 20,000	$ 13,000	INCO ($7k)	
4.5.2	Field Sampling QA/QC	$ 9,500	$ —	Noranda ($9.5k)	
4.6.2	Geophysical Monitoring	$ 118,000	$ —	INCO ($40k), Ontario ($39k), CANMET ($39k)	
4.7.3(b)	Aquatic Invertebrate Monitoring (1990/92)	$ 83,000	$ —	BC ($42k), CANMET ($22k), Env Can ($4k), Noranda ($15k)	
4.7.5	Ion Speciation	$ 35,000	$ —	Noranda ($23.6k), BC ($6k), CANMET ($5.5k)	
4.7.6	Paleolimnology Techniques	$ 16,500	$ —	Noranda ($16.5k)	
4.8.1	Monitoring Solbec Pit	$ 130,000	$ —	CRM ($100k), CANMET ($30k)	
5.3.1	Laurentian Data Base	$ 35,000	$ —	Ontario ($35k)	
5.4.1	ARD Manual - version française	$ 23,700	$ —	CRM ($23.7k)	
5.6.1	International Conference	$ 72,000	$ —	To credit contributors who paid deficit	
	Totals	$1,813,700	$ 298,000		

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Table 5

MEND REPORTS AVAILABLE / RAPPORTS DISPONIBLE SUR NEDEM PREDICTION/PRÉVISION

1.11.1 Critical Literature review of Acid Drainage from Waste Rock, April 1991. 25$

1. 16. 1a Investigation of Prediction Techniques for Acid Mine Drainage, November 1989. $25

1. 16. 1b Acid Rock Drainage Prediction Manual, March 1991. $40

1. 16. 1c New Methods for Determination of Key Mineral Species in Acid Generation Prediction by Acid-Base Accounting, April 1991. $25

1. 17. 1a Hydrogeochemical Investigation of Reactive Tailings at the Waite Amulet Tailings Site, Noranda, Quebec - 1985 Program, July 1986. $25

Hydrogeochemical Investigation of Reactive Tailings at the Waite Amulet Tailings Site, Noranda, Quebec, Phase 2 -1986 Program, July 1987. $25

Hydrogeochemical Investigation of Reactive Tailings at the Waite Amulet Tailings Site, Noranda, Quebec, Phase 3 -1987 Program, Volume I Report, May 1988. $25

1. 17. 1b Hydrogeochemical Investigation of Reactive Tailings at the Waite Amulet Tailings Site, Noranda, Quebec, Phase 3 -1987 Program, Volume H - Appendices, March 1988. $25

1. 17. 1c Hydrogeochemical Investigation of Reactive Tailings at the Waite Amulet Tailings Site, Noranda, Quebec, Phase 3 -1987 Program, Supplementary Report, March 1989. $25

1. 17. 1d Hydrogeochemical Investigation of Reactive Tailings at the Waite Amulet Tailings Site, Noranda, Quebec, "Generation and Evolution of Acidic Pore Waters at the Waite Amulet Tailings - Final Report", April 1990. $60

1.21.1a Critical Review of the Reactive Acid Tailings Assessment Program (RATAP.BMT2), April 1990. $30

1.21.1b Workshop on Modelling of Reactive Tailings sponsored by the MEND Prediction Committee, Final Report, August 1990. $40

PREVENTION AND CONTROL PRÉVENTION ET CONTROLE

2.11. 1a Subaqueous Disposal of Reactive Mine Wastes: An overview, June 1989. $25

2.11.1a A Preliminary Assessment of Subaqueous Tailings Disposal in Benson Lake, British Columbia, March 1990. $25

A Preliminary Assessment of Subaqueous Tailings Disposal in Anderson Lake, Manitoba, March 1990. $25

A preliminary Assessment of Subaqueous Tailings Disposal in Mandy Lake, Manitoba, March 1990. $25

Geochemical Assessment of Subaqueous Tailings Disposal in Buttle Lake, British Columbia, March 1990. $25

2. 11. 1 b Geochemical Assessment of Subaqueous Tailings Disposal in Anderson Lake, Snow Lake Area, Manitoba. $25

Geochemical Assessment of Subaqueous Tailings Disposal in Mandy Lake, Flin Flon Area, Manitoba. $25

2.23.1 Draft Acid Rock Drainage Technical Guide, November 1989. $55

2.24.1 Manual of Methods Used in the Revegetation of Reactive Sulphide Tailings Basins, November 1989. $20

TREATMENT/TRAITEMENT

3.12. 1a Assessment of Existing Natural Wetlands Affected by low pH, Metal Contaminated Seepages (Acid Mine Drainage), May 1990. $25

MONITORING/SURVEILLANCE

4.1.1 Field Sampling Manual for Reactive Sulphide Tailings, November 1989. $15

4.3.1 RTS-1, RTS-2, RTS-3 and RTS-4: Sulphide Ore Mill Tailings Reference Materials, April 1990. $25

TECHNOLOGY TRANSFER/TRANSFERT DE LA TECHNOLOGIE

5.5.1 Reactive Acid Tailings Stabilization (RATS) Research Plan, July 1988. $15

5.6.1 Proceedings - Second International Conference on the Abatement of Acidic Drainage, Montreal, September 16, 17 and 18, 1991. (4 Volumes) $150

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1.17.1c Hydrogeochemical Investigation of Reactive Tailings at the Waite Amulet Tailings Site, Noranda, Quebec, Phase 3 -1987 Program, Volume I Report, May 1988. $25

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Hydrogeochemical Investigation of Reactive Tailings at the Waite Amulet Tailings Site, Noranda, Quebec, Phase 3 -1987 Program, Supplementary Report, March 1989. $25

1.17.1d Hydrogeochemical Investigation of Reactive Tailings at the Waite Amulet Tailings Site, Noranda, Quebec, "Generation and Evolution of Acidic Pore Waters at the Waite Amulet Tailings - Final Report", April 1990. $60

1.21.1a Critical Review of the Reactive Acid Tailings Assessment Program (RATAP.BMT2), April 1990. $30

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