Energy, Mines and Resources Canada
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Canada Centre for Mineral and Energy Technology
Centre canadien de la technologie des minéraux et de l'énergie

RESEARCH PLAN

PLAN DE RECHERCHE

REACTIVE ACID TAILINGS STABILIZATION PROGRAM (R.A.T.S.)

PROGRAMME DE RÉSIDUS ACIDES EN TRANSFORMATION ET STABILISATION (R.A.T.S.)

SP88-3

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THE REACTIVE ACID TAILINGS STABILIZATION (RATS) PROGRAM

Foreword:

The Canadian mining industry produces in excess of 500 million tonnes/annum of waste rock and tailings, the largest portion of which arises from sulphide ore operations. These sulphide-bearing wastes present a significant environmental problem in that, upon weathering, they produce sulphuric acid which in turn solubilizes residual heavy metals. This leachate has been termed acid mine drainage (AMD). Currently, treatment systems are required to ensure that effluents from tailings piles and waste rock sites do not adversely affect the surrounding environment.

The mining industry has long been concerned with the management of acid-generating sulphide wastes, particularly upon close-out of a mining operation. Efforts in the past decade have emphasized the use of vegetative covers for reactive tailings sites. While this approach improves aesthetics and surface stability, the sites have continued to generate AMD. Hence, it has been necessary to continue to operate treatment facilities long after the cessation of mining activities. In some cases, mine sites have been abandoned and the responsibility for care and maintenance has reverted to the province. Continued active treatment at these sites is not desirable since this presents an ongoing financial burden for an indefinite period of time.

Between 1984 and 1987, studies were conducted to determine the extent of the AMD problem in Canada. In total, some 14,000 hectares of AMD generating waste rock and tailings were identified. The rehabilitation of these sites could cost in excess of $1.5 billion over the next 15 years alone. However, research is required to understand the problem more fully and to identify cost-effective solutions. Since the problem is compounded by site specificity and mineralogy, one solution may not be applicable for all sites, and predictive modelling techniques are thus also required. New cost-effective close-out technology will allow the mine operator to rehabilitate waste rock and tailings impoundments, and to "walk away" from these sites with the knowledge that the environment will be protected in the long term.

In response to the collective need to develop appropriate technologies for AMD prevention and control, the Reactive Acid Tailings Stabilization (RATS) program was initiated. A Steering Committee* and a Technical Working Group ** (TWG) were established to represent industry, and federal and provincial interests.

* Membership of Steering Committee - Table 1
** Membership of Technical Working Group - Table 2

The Steering Committee asked the TWG to prepare a research plan to meet the RATS objective. Those objectives were defined as follows:

- **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;**

- **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.**

Research Plan:

In order to meet these objectives, the RATS-TWG has developed a comprehensive plan of some 40 projects grouped under 5 major topic headings. These topics are:

1. Prediction: This group of 10 projects is aimed at improving techniques to determine whether a particular waste rock or tailings will in fact present an AMD problem. A number of techniques have been used but not all are reliable.

   The second aspect of this work is to develop a mathematical model to simulate the behaviour of AMD generation, and to use the model to aid in the evaluation of remedial systems. Model development will draw heavily on other models such as those developed under the National Uranium Tailings Program.

2. Prevention and Control: This is the major task of RATS. The collective view is that the key to AMD prevention is the development of an effective and durable barrier to oxygen. Without oxygen, the sulphides will not generate acid. Research is required to develop, assess and optimize barrier systems such as water cover and synthetic membranes. Laboratory tests and field trials are required to fully evaluate a number of options under a variety of conditions.

3. Treatment: Currently, AMD is neutralized with lime before discharge to the open environment. Such systems are expensive but more critically require ongoing monitoring and maintenance.

With improved methods of prevention and control, the need for treatment will be substantially reduced, however, it is generally accepted that these methods will be less than perfect. Disposal areas will require some effluent treatment before final discharge. The research target is to develop passive treatment systems. One such system is the use of wetlands to ameliorate residual acidity, and precipitate and stabilize heavy metals. Research is required to better understand the natural systems in terms of capacity, sensitivity to upset, long term stability and costs.

4. Monitoring: In addition to tasks of prevention and treatment, there is a need to develop consistent and reliable monitoring techniques. One of the main items is to establish closure criteria, that is, what levels of acidity, heavy metals, etc., will be accepted by the regulatory agencies. Further to this, there must be agreement on methods of sampling and standards for analysis. Rapid indirect monitoring techniques could reduce such costs and new technologies in this area must be assessed.

5. Technology Transfer: The development of new technology is important. Good technology must also be used. The systematic documentation of the technology and communication with the users are essential. This task includes reviewing existing technology and developing easy access to available information. Coordination of efforts with all interested parties is a central part of this task.

Program Costs and Schedule

It is estimated that the research required to achieve the program objectives can be undertaken in five years at a cost of $12,500,000. The breakdown by project topic is shown in Table 3. More detailed costs by sub-topic are provided in the summary sheet on page 1 and in the individual projects in the body of the report. The project ranking and total costs are given at the beginning of each section. An index for the individual projects can also be found.

The work will likely be performed approximately 50% by the participants and 50% by contractor . Specific details on funding mechanisms are currently being finalized.

This RATS research program summary has been published to inform participants, contributors, researchers, consulting groups, the general public and other interested parties of the scope of the program. Interested parties should contact Michel P. Filion, Co-ordinator - Environmental Technology, CANMET, 555 Booth Street, Ottawa, Ontario K1A 0G1 (613) 996-7936, or any member of the RATS Steering Committee or Technical Working Group.

TABLE 1

REACTIVE ACID TAILINGS STABILIZATION PROGRAM

STEERING COMMITTEE

Dr. F. Frantisak	Committee Chairman, Noranda Inc.
Mr. E.G. Joe	Secretary, Energy, Mines & Resources Canada
Mr. W.A. Bardswich	Manitoba Energy & Mines
Mr. V.E. Dawson	B.C. Ministry of Energy, Mines & Petroleum Resources
Mr. R. Duquette	Ministère de l'Environnement du Québec
Mr. W.C. Ferguson	INCO Ltd.
Mr. W. Fraser	Hudson Bay Mining & Smelting Co. Ltd.
Mr. W. Gibson	Ontario Ministry of the Environment
Mr. G.J. Greer	N.B. Department of Natural Resources & Energy
Mr. L.L. Sirois	Energy, Mines & Resources Canada
Mr. J.E. Udd	Energy, Mines & Resources Canada
Mr. D. Kelly	Environment Canada
Mr. J. LeBuis	Ministère de l'Énergie et des Ressources du Québec
Mr. D.R. McKay	COMINCO Ltd.
Mr. F.G. Pickard	Falconbridge Limited
Mr. J.A. McIntosh	Ontario Ministry of Northern Development & Mines

TABLE 2

REACTIVE ACID TAILINGS STABILIZATION PROGRAM

TECHNICAL WORKING GROUP

Mr. W.C. Ferguson	Committee Chairman, INCO Ltd.
Mr. K. Wheeland	Deputy Chairman, Noranda Research Centre
Mr. E.G. Joe	Secretary, Energy, Mines & Resources Canada
Mr. W. Scheding	Curragh Resources Corp.
Dr. N. Davé	Energy, Mines & Resources Canada
Mr. R.E. Michelutti	Falconbridge Limited
Mr. D. Cook	Manitoba Energy & Mines
Mr. W. Fraser	Hudson Bay Mining & Smelting Co.Ltd.
Mr. K. Ferguson	Environment Canada
Mr. J. Errington	B.C. Ministry of Energy, Mines & Petroleum Resources
Mr. R.T. Gardiner	COMINCO Ltd.
Mr. R. Patterson	Equity Silver Mines Limited
Mr. R.S. Siwik	Noranda Research Centre
Mr. M.C. Campbell	Energy, Mines & Resources Canada
Mr. J.S. Scott	Environment Canada
Mr. S. McEwan	N.B. Department of Natural Resources & Energy
Mr. B. Bell	INCO Ltd.
Mr. J.A. Hawley	Ontario Ministry of the Environment
Mr. R. Tervo	Energy, Mines & Resources Canada
Mr. J-M. Robert	Ministère de l'Énergie et des Ressources du Québec

TABLE 3

SUMMARY OF RATS PROJECTS

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

LE PROGRAMME DE RÉSIDUS ACIDES EN TRANSFORMATION ET STABILISATION (RATS)

Avant-propos

L'industrie minière canadienne produit chaque année plus de 500 millions de tonnes de stériles et de résidus dont la grande partie provient de l'exploitation des minerais sulfurés. Ces déchets, qui contiennent des sulfurés, soulève un problème environnemental important du fait qu'ils produisent, lorsqu'ils sont altérés, de l'acide sulfurique qui, à son tour, solubilise des métaux lourds résiduels. Cette lixiviation est appelée drainage minier acide (DMA). Pour s'assurer que les effluents provenant des parcs à résidus et de stériles ne polluent pas l'environnement, des systèmes de traitement doivent être mis en place.

L'industrie se préoccupe depuis longtemps de la gestion des résidus sulfurés acidogènes, en particulier lors de la fermeture d'une exploitation minière. La principale mesure prise à cet effet au cours de la dernière décennie consistait à implanter un couvert végétal sur les parcs à résidus réactifs. Bien que cette mesure ait amélioré l'aspect des sites et leur stabilité en surface, elle n'a pas pour autant éliminé le DMA. C'est pourquoi il a fallu poursuivre l'exploitation des installations de traitement longtemps après la cessation des activités d'exploitation minière. Dans certains cas, les sites miniers ont été abandonnées obligeant la province à prendre en charge leur entretien. Cependant, il est souhaitable de ne pas prolonger le traitement actif, car cela impose un fardeau financier pour une période de temps indéfini.

De 1984 à 1987, des études ont été réalisées pour déterminer l'étendue du problème du DMA au Canada. Quelque 14 000 hectares au total de stériles et de résidus à l'origine des DMA ont été localisés. La remise en état de ces zones coûterait plus de 1,5 milliard de dollars au cours des 15 prochaines années seulement. Toutefois, il faudra effectuer des travaux de recherche pour mieux cerner ce problème et pour trouver des solutions rentables. Comme les caractéristiques et la minéralogie de chaque emplacement diffèrent, it n'y a pas de solution unique et il faudra en outre mettre au point des techniques de prévision par modélisation. Une nouvelle technologie rentable de fermeture permettra aux exploitants miniers de remettre en état des bassins de stériles et de résidus et de les "abandonner" avec l'assurance, qu'à long terme, ils ne pollueront pas l'environnement.

Pour répondre au besoin collectif de mise au point de technologies appropriées pour la prévention et l'élimination du DMA, on a entrepris la réalisation du programme de Résidus acides en transformation et stabilisation (RATS). Un comité directeur* et un groupe de travail technique** (GTT) ont été mis sur pied pour représenter les intérêts de l'industrie et des gouvernements fédéral et provinciaux.

Le comité directeur a demandé au GTT de préparer un plan de recherche qui permette d'atteindre les objectifs visés par le RATS. Ces objectifs sont les suivants:

- **Mettre sur pied une base de données scientifiques, techniques et économiques complète permettant à l'industrie minière et aux organismes gouvernementaux de prévoir avec assurance les besoins à long terme en matière de gestion des résidus acides réactif et des stériles;**

- **Mettre au point des techniques qui permettront d'exploiter et d'abandonner les parcs à résidus acidogènes et de stériles de façon prévisible, peu coûteuse, opportune et acceptable pour l'environnement.**

Plan de recherche

Pour atteindre ces objectifs, le GTT du RATS a élaboré un plan global de quelque 40 projets regroupés sous les cinq sujets principaux suivants:

1. Prévision: Les dix projets de ce groupe visent à améliorer les techniques utilisées pour déterminer si une zone d'accumulation de stériles ou de résidus particulière causera en réalité un DMA. Un certain nombre de techniques on été utilisées à cette fin mais elles ne sont pas toutes fiables.

   Le second volet de ces travaux vise à mettre au point un modèle mathématique simulant les processus à l'origine du DMA et d'utiliser ce modèle pour faciliter l'évaluation des systèmes permettant d'y remédier. La mise au point du modèle se fondera en grande partie sur d'autres modèles, tels que ceux élaborés dans le cadre du Programme national de recherche sur les résidus d'uranium.

* Membres du comité directeur - tableau 1
** Membres du groupe de travail technique - tableau 2

2. Prévention et élimination: Il s'agit de la principale fonction du programme RATS. Du point de vue général, it ressort que pour prévenir le DMA, it faut d'abord mettre au point une barrière durable et efficace à l'oxygène. Sans oxygène, les sulfures ne produisent pas d'acide. Des travaux de recherche devront être réalisés pour mettre au point, évaluer et optimiser des systèmes de barrière telles que la mise en place d'une couverture aqueuse et de membranes synthétiques. Il faudra effectuer des essais en laboratoire et sur le terrain pour évaluer intégralement un certain nombre de possibilités dans diverses conditions.

3. Traitement: Actuellement, les effluents de DMA sont neutralisés avec de la chaux avant d'être déversés dans l'environnement. Les systèmes utilisés pour ce faire sont coûteux et nécessitent, ce qui est encore plus crucial, une surveillance et un entretien permanents.

   Ces méthodes améliorées de prévention et d'élimination permettront de réduire considérablement les besoins en traitement; cependant, il est généralement accepté que ces méthodes ne sont pas parfaites. Dans les bassins de sedimentation, it faudra effectuer un traitement des effluents avant déversement final. Les travaux de recherche auront pour objectif de mettre au point des systèmes de traitement passif. L'un de ces systèmes consiste à utiliser des marécages pour diminuer l'acidité résiduelle et pour précipiter et stabiliser les métaux lourds. D'autres recherches devront être effectuées pour mieux comprendre les systèmes naturels en ce qui a trait à leur capacité, leur sensibilité aux changements, leur stabilité à long terme et leur coût d'utilisation.

4. Surveillance: En plus d'accomplir ces fonctions de prévention et de traitement, il faudra mettre au point des techniques de surveillance fiables et cohérentes. L'un des principaux éléments de la surveillance est d'établir des critères de fermeture, c'est-à-dire déterminer les niveaux d'acidité, les métaux lourds, etc. qui seront acceptés par les organismes de réglementation. Il faudra par la suite se mettre d'accord sur les méthodes d'échantillonnage et les normes d'analyse. L'application de techniques de surveillance indirecte rapide pourrait réduire ces coûts de sorte que les nouvelles technologies dans ce domaine doivent être évaluées.

5. Transfert de la technologie: Il est important de mettre au point une nouvelle technology qui soit aussi efficace. Il est essentiel de documenter systématiquement cette technology et de communiquer avec les utilisateurs. Cette fonction comprend l'analyse de la technologie existante et la mise au point d'une méthode d'accès facile aux information existantes. La coordination des travaux entrepris par toutes les parties intéressées constitue un élément central de cette fonction.

Coût du programme et calendrier

Selon les estimation, les travaux de recherche nécessaires pour atteindre les objectifs du programme peuvent être réalisés en cinq ans et au coût de 12 500 000 $. La répartition par sujet est présentée au tableau 3. Des données plus détaillées sur les coûts par sous-sujet sont contenues dans le relevé récapitulatif de la première page et dans la description des projets individuels dans le corps du rapport. La priorité et les coûts totaux des projets sont indiqués au début de chaque section. On y trouve aussi un index des projets.

Les travaux seront vraisemblablement accomplis à parts égales par les participants et l'entrepreneur. On est à mettre au point les derniers détails des mécanismes de financement.

Le présent résumé sur le programme de recherche RATS a été publié pour informer les participants, les collaborateurs, les chercheurs, les groupes d'experts-conseils, le grand public et les autres parties qui s'intéressent aux répercussions du programme. Les parties intéressées devraient communiquer avec Michel P. Filion, coordonnateur à la Technologie de l'environnement, CANMET, 555 rue Booth, Ottawa (Ontario) K1A 0G1 (613) 996-7936 ou tout membre du comité directeur ou du groupe de travail technique du programme RATS.

TABLEAU 1

PROGRAMME DE RÉSIDUS ACIDES EN TRANSFORMATION ET STABILISATION

COMITÉ DIRECTEUR

F. Frantisak	Président du comité, Noranda Inc.
E.G. Joe	Secrétaire, Énergie, Mines et Ressources Canada
W.A. Bardswich	Énergie et Mines Manitoba
V.E. Dawson	Ministry of Energy, Mines & Petroleum Resources de la Colombie-Britannique
R. Duquette	Ministère de l'Environnement du Québec
W.C. Ferguson	INCO Lteé
W. Fraser	La Compagnie Minière et Métallurgique de la Baie d'Hudson Lteé
W. Gibson	Ministère de l'Environnement de l'Ontario
G.J. Greer	Ministère des Ressources naturelles et de l'Énergie du Nouveau-Brunswick
L.L. Sirois	Énergie, Mines et Ressources Canada
J.E. Udd	Énergie, Mines et Ressources Canada
D. Kelly	Environnement Canada
J. LeBuis	Ministère de l'Énergie et des Ressources du Québec
D.R. McKay	COMINCO Ltée
F.G. Pickard	Falconbridge Limitée
J.A. McIntosh	Ministère du Développement du Nord et des Mines de l'Ontario

TABLEAU 2

PROGRAMME DE RÉSIDUS ACIDES EN TRANSFORMATION ET STABILISATION

GROUPE DE TRAVAIL TECHNIQUE

W.C. Ferguson	Président du comité, INCO Ltée
K. Wheeland	Président adjoint, Centre de recherches Noranda
E.G. Joe	Secrétaire, Énergie, Mines et Ressources Canada
W. Scheding	Curragh Resources Corp.
N. Davé	Énergie, Mines et Ressources Canada
R.E. Michelutti	Falconbridge Limitée
D. Cook	Énergie et Mines Manitoba
W. Fraser	La Compagnie Minière et Métallurgique de la Baie d'Hudson Ltée
K. Ferguson	Environnement Canada
J. Errington	Ministry of Energy, Mines and Petroleum Resources de la Colombie-Britannique
R.T. Gardiner	COMINCO Ltée
R. Patterson	Mines d'Argent Equity Limitée
R.S. Siwik	Centre de recherches Noranda
M.C. Campbell	Énergie, Mines et Ressources Canada
J.S. Scott	Environnement Canada
S. McEwan	Ministère des Ressources naturelles et de l'énergie du Nouveau-Brunswick
B. Bell	INCO Ltée
J.A. Hawley	Ministère de l'Environnement de l'Ontario
R. Tervo	Énergie, Mines et Ressources Canada
J.-M. Robert	Ministère de l'Énergie et des Ressources du Québec

TABLEAU 3

RÉSUMÉ DES PROJETS RATS

- Prévision	3 765 000 $
- Prévention et élimination	5 705 000 $
- Traitement	1 285 000 $
- Surveillance	385 000 $
- Transfert de la technologie	225 000 $
Fonds de prévoyance	1 135 000 $
Coûts totaux du programme	**12 500 000 $**

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TABLE DES MATIÈRES

SUMMARY OF RATS PROJECTS

TOPIC/ SUBTOPIC	TOTAL $K	1988/89	1989/90	1990/91	1991/92	1992/93
1. PREDICTION TECHNIQUES						
1.1 Chemical Prediction	1835	335	320	730	350	100
1.2 Modelling	1930	140	465	690	485	150
TOTAL PREDICTION TECHNIQUES	**3765**	**475**	**785**	**1420**	**835**	**250**
2. PREVENTION BARRIERS & CONTROL						
2.1 Wet Barriers/Tailings	2500	510	640	500	400	450
2.2 Dry Barriers/Tailings	1485	240	270	470	280	225
2.3 Waste Rock	1720	15	175	440	680	410
TOTAL PREVENTION/CONTROL	**5705**	**765**	**1085**	**1410**	**1360**	**1085**
3. TREATMENT						
3.1 Downstream Passive	435	50	135	190	60	0
3.2 On site Treatment	850	125	225	350	150	0
TOTAL TREATMENT	**1285**	**175**	**360**	**540**	**210**	**0**
4. MONITORING						
TOTAL MONITORING	**380**	**155**	**125**	**85**	**0**	**20**
5. TECHNOLOGY TRANSFER						
TOTAL TECHNOLOGY TRANSFER	**225**	**125**	**25**	**25**	**25**	**25**
TOTAL	11365	1695	2380	3480	2430	1380
CONTINGENCY	1135	105	120	20	370	320
GRAND TOTAL FOR PROGRAM	**12500**	**1800**	**2500**	**3500**	**2800**	**1700**

Page

1. PREDICTION TECHNIQUES

PROJECT	RANKING	TOTAL ($K)	
1.1 CHEMICAL PREDICTION			
1.11 AMD from Waste Rock - Literature Review	I	50	3
1.12 Compile AMD Prediction: Tailings and Rocks	I	50	5
1.13 Evaluate Prediction Techniques - Rocks	I	200	7
1.14 Field Evaluation Rock Hydrogeochemistry	II	650	9
1.15 Field Evaluation AMD Production - Open Pits	III	300	11
1.16 Evaluation of Predictive Techniques - Tailings and Waste Rock	I	200	13
1.17 Hydrogeochemical Investigation of Waite-Amulet Reactive Tailings	I	235	15
1.18 Hydrogeochemical Characterization of the Faro Tailings and Sub-Site	I	150	17
SUBTOTAL CHEMICAL PREDICTION		**1835**	
1.2 MODELLING			
1.21 Model Development Tailings/ Verification of Tailings Models	I	1380	18
1.22 Reactive Waste Rock and Open Pit Modelling	I	550	20
SUBTOTAL MODELLING		**1930**	
TOTAL PREDICTION TECHNIQUES		**3765**	

RATS PROJECT SUMMARY

Date: Feb. 3, 1988
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TOPIC PREDICTION SUB-TOPIC CHEMICAL PREDICTION

PROJECT NO 1.11 BUDGET $ 50 k (1988) $ 50 k (Total)

TITLE: AMD FROM WASTE ROCK-LITERATURE REVIEW

OBJECTIVES: To develop a state-of-the art understanding of the process of acid generation from waste rock.

MAJOR STEPS (INCL. GO/NO GO DECISION)	YEAR	$k
1. Evaluate recent CANMET literature reviews of bioleaching for applicability to AMD from waste rock.	88-89	-
2. Conduct additonal literature reviews to fill identified information gaps	88-89	50

BACKGROUND:
The process of acid generation from tailings is reasonably well understood compared to the process in waste rock. Important differences between the two processes include oxygen and water transport and geochemical reactions rates. These differences will be reflected in prediction techniques, both chemical techniques and models, and in prevention/control strategies. This study will establish the state of understanding of acid generation from waste rock for future RATS projects.

OUTPUT:
State of the art understanding of AMD generation from waste rock.

PRIORITY: [I] II III Rationale: A thorough understanding of AMD from waste rock is required to develop solutions to the problem.

RATS PROJECT SUMMARY

Date: Feb. 3, 1988
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TOPIC PREDICTION SUB-TOPIC CHEMICAL PREDICTION

PROJECT NO. 1.11 BUDGET: $ 50 k (1988) $ 50 k (Total)

TITLE: AMD FROM WASTE ROCK-LITERATURE REVIEW

ADDITIONAL DETAILS:

1. Decision to conduct this literature review depends on whether CANMET review of bioleaching is adequate to cover AMD from waste rock.
2. Review of the CANMET publications could be conducted by the chemical prediction subcommittee.
3. Relevant literature from coal mine sector should also be included (ie. USBM studies).
4. Computer databases and direct contact with leading researchers should be used.
5. A list of questions provided by the subcommittee for the literature reviewers would be useful to focus the search.
6. Key references are: Cathles, L.M. (1982) "Acid Mine Drainage" Earth and Minerals Sciences, Penn, State Univ., Vol. 51, No. 4, p.37-41.

   Harries, J.R. and A.I.M. Ritchie (1985) "Pore Gase Composition in Waste Rock Dumps Undergoing Pyritic Oxidation" Soil Science, Vol. 140, No. 2, p.143-152.
7. SRK has conducted a literature review for the American Mining Congress.
8. Project includes literature search for field procedures in waste rock (link to project 4.5).

RATS PROJECT SUMMARY

Date: Feb. 3, 1988
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TOPIC PREDICTION SUB-TOPIC CHEMICAL PREDICTION

PROJECT NO 1.12 BUDGET $ 50 k (1988) $ 50 k (Total)

TITLE: COMPILE AMD PREDICTION: TAILINGS AND ROCKS

OBJECTIVES: To compile existing AMD prediction information for waste rock dumps, open pits and tailings in Canada.

MAJOR STEPS (INCL. GO/NO GO DECISION)	YEAR	$k
1. Evaluate results of B.C. AMD Task Force compilation of AMD prediction and information for waste rock, open pits and tailings in B.C. (Go/No Go)	88-89	-
2. Conduct a survey of AMD prediction information for waste rock, open pits and tailings across Canada	88-89	50

BACKGROUND:

The prediction of AMD for waste rock dumps and open pits is more difficult than for tailings due to the heterogeneity of rock dumps and pits. Comparison of pre-mine predictions to post-mining water quality for a large number of sites will be required to verify chemical prediction techniques for all waste types. This study will compile all available prediction and water quality information as a first attempt to verify prediction tests. Candidate sites for other projects (1.13 & 1.14) will also be identified.

OUTPUT:

State of pre-mine prediction for waste rock, open pits and tailings in Canada.

PRIORITY: (I) II III Rationale: Defining state of art is first step in developing accurate predictions.

RATS PROJECT SUMMARY

Date: Feb.3, 1988
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TOPIC PREDICTION SUB-TOPIC CHEMICAL PREDICTION

PROJECT NO. 1.12 BUDGET: $ 50 k (1988) $ 50 k (Total)

TITLE: COMPILE AMD PREDICTION-ROCK

ADDITIONAL DETAILS:

1. Project is contingent on success of B.C. AMD Task Force questionnaire in compiling useful information on pre-mine prediction data. The assessment of the B.C. experience could be conducted by the chemical prediction subcommittee.
2. Support from provincial agencies and national and regional mining associations is required for survey.
3. B.C. AMD Task Force questionnaire could be used as a guide in preparing survey documents.
4. B.C. Research have extensive files on pre-mine prediction but, authorization from companies and sample location information are required to access this information.
5. Results of this survey will be used to select study sites for projects 1.13 and 1.14
6. Environmental impact reports for new mines are important sources of information.
7. Key reference is the B.C. AMD Task force State of Art Review Questonnaire attached to the minutes of the 7th RATS-TWG meeting.
8. For tailings facilities particularly interested in sulphide /carbonate ratio and paste pH for samples of fresh tailings and surface of exposed tailings.

RATS PROJECT SUMMARY

Date: Feb. 3, 1988
Page 1 of 2

TOPIC PREDICTION SUB-TOPIC CHEMICAL PREDICTION

PROJECT NO 1.13 BUDGET $ - k (1988) $ 200 k (Total)

TITLE: EVALUATE PREDICTION TECHNIQUES-ROCKS

OBJECTIVES: To conduct a laboratory investigation of selected AMD prediction techniques for waste rock sites and compare test results to field water quality.

MAJOR STEPS (INCL. GO/NO GO DECISION)		YEAR	$k
1.	Conduct a laboratory investigation of selected AMD prediction techniques for up to 10 waste rock sites in Canada, and comparison of test results to field water quality or field scale tests.	89-90	75
		90-91	75
2.	Compile results and prepare report	91-92	50

BACKGROUND:

The survey of AMD prediction information (Project 1.12) for waste rock dumps and open pits will likely find only a few mines with comprehensive prediction information. This study will expand the data base for selected sites and will verify prediction techniques for rocks.

OUTPUT:

Report describing laboratory results and guide for sampling and testing procedures and confidence levels.

PRIORITY: [I] II III Rationale: Identification of effective AMD prediction tests are necessary for future mine projects.

RATS PROJECT SUMMARY

Date: Feb. 3, 1988
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TOPIC PREDICTION SUB-TOPIC CHEMICAL PREDICTION

PROJECT NO. 1.13 BUDGET: $ - k (1988) $ 200 k (Total)

TITLE: EVALUATE PREDICTION TECHNIQUES-ROCKS

ADDITIONAL DETAILS:

1. Study follows project 1.16 that selects testing procedures, and project 1.12 that identifies candidate sites.
2. Related non-RATS work includes verification studies by USBM and U. of West Virginia in coal fiels of Appalachia.
3. Selected sites should include those with a potential to produce AMD, but, also high carbonate content; sites containing a range of acid producing and consuming rock types; sites with a potential to produce acid, but, with low sulphur; and sites with acid production and consumption in near balance.
4. Topic is a key goal of B.C. AMD Task Force. Research should be coordinated with that group.
5. Key reference is: Ferguson, K.D. and P.M. Erickson "Will it generate AMD? - An Overview of Methods to Predict Acid Mine Drainage" Preceedings of Acid Mine Drainage Seminar/Workshop. Halifax, Nova Scota, March 23-26, 1987, p. 215-244.

RATS PROJECT SUMMARY

Date: Feb. 3, 1988
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TOPIC PREDICTION SUB-TOPIC CHEMICAL PREDICTION

PROJECT NO 1.14 BUDGET $ - k (1988) $ 650 k (Total)

TITLE: FIELD EVALUATION ROCK HYDROGEOCHEMISTRY

OBJECTIVES: To improve understanding of acid production in waste rock dumps.

MAJOR STEPS (INCL. GO/NO GO DECISION)		YEAR	$k
1.	Conduct a field study investigating mechanisms of acid production at two waste rock dumps in Canada (Go/No Go)	89-90	400
2.	Continue field study of waste rock dumps	90-91	200
3.	Compile results of field study into report	91-92	50

BACKGROUND:

The hydrogeochemistry of waste rock dumps is complex and not completely understood. This study will fill some of the information gaps by studying two dumps in detail. In particular, the complex interaction of rock mineralogy, bacteria growth, oxygen transfer, and water infiltration will be examined in several zones of the dumps. No similar study of this detail has been conducted at a waste dump in Canada.

OUTPUT:

Report describing field study procedures, results and conclusions, and a manual of field techniques for waste dump field studies.

PRIORITY: I [II] III Rationale: Information gaps must be filled and effective field techniques developed to support prediction and control.

RATS PROJECT SUMMARY

Date: Feb. 3, 1988
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TOPIC PREDICTION SUB-TOPIC CHEMICAL PREDICTION

PROJECT NO. 1.14 BUDGET: $ - k (1988) $ 650 k (Total)

TITLE: FIELD EVALUATION ROCK HYDROGEOCHEMISTRY

ADDITIONAL DETAILS:

1. Study should be initiated after completion of project 1.11 and 1.12 that identify information gaps and candidate sites respectively.
2. Should consider dumps with significant data and instrumentation to save resources (e.g., Equity and Westmin).
3. Field procedures and results from Australia (Rum Jungle) and Scandinavia (Sweden and Norway) waste dumps, and RATS tailings study (project 1.17) and USBM coal mine research may be of value.
4. Key references include:

Harries, J.R. and A.I.M. Ritchie (1981). "The Use of Temperature Profiles to Estimate the Pyritic Oxidation Rate in a Waste Rock Dump from an Opencut Mine" Water, Air, and Soil Pollution, Vol. 15, p. 405-423.

Erickson, P.M. and K.J. Ladwig (1986) "Field Observations of Potential Acid Sources Within Surface Mine Backfills" W. Va. AMD Task Force Symposium

5. Field procedures to be identified in project 1.11 and monitoring topic projects.

RATS PROJECT SUMMARY

Date: Feb. 8,1988
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TOPIC PREDICTION SUB-TOPIC CHEMICAL PREDICTION

PROJECT NO 1.15 BUDGET $ - k (1988) $ 300 k (Total)

TITLE: FIELD EVALUATION AMD PREDICTION - OPEN PITS

OBJECTIVES: To develop an understanding of acid production from open pits.

MAJOR STEPS (INCL. GO/NO GO DECISION)		YEAR	$k
1.	Conduct a field study investigating mechanisms of acid production at three open pits in Canada (GO/NO GO DECISION)	1990/91	150
2.	Continue field study of open pits	1991/92	100
3.	Compile results of field study into report	1992/93	50

BACKGROUND:
The state of knowledge of acid production from open pits is probably the poorest of all mining sources. Control techniques are also poorly developed. This study will fill some information gaps. If combined with studies in project 1.14, will develop empirical relationships for acid production in open pits and waste rock dumps. The study will identify the relative contribution of AMD from pit walls, berms, slide material etc. in open pits. Results will be used to calibrate/verify models.

OUTPUT:
Report describing field study procedures, conclusions, and manual of field techniques for future studies of open pits.

PRIORITY: I II [III] Rationale: Information gaps must be filled and empirical models are important tools for prediction

RATS PROJECT SUMMARY

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TOPIC PREDICTION SUB-TOPIC CHEMICAL PREDICTION

PROJECT NO. 1.15 BUDGET: $ - k (1988) $ 300 k (Total)

TITLE: FIELD EVALUATION AMD PREDICTION - OPEN PITS

ADDITIONAL DETAILS:

1. Study should be initiated after project 1.11 and 1.12 that identify information gaps and candidate sites respectively.
2. If possible, the same sites for project 1.14 should be used allowing comparison of acid production rates and mechanisms for open pits and waste dumps.
3. Non-RATS work includes studies conducted at the Mt. Washington mine in B.C. by provincial Ministry of Environment and Environment Canada and at several open pits including Brunswick No. 6 by Noranda.
4. Some data exists for B.C. open pits (Equity, Westmin and Noranda Bell).
5. Sites selected should include both abandoned and operating mines.
6. Sampling of pit walls in both fractured and unfractured zones is suggested to determine the depth of oxidation.
7. Possible link to project 2.12A Underwater Disposal in Flooded Open Pits.
8. Must be careful in site selection to differentiate between AMD from other sources i.e., tailings ponds and waste rock.

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TOPIC PREDICTION SUB-TOPIC CHEMICAL PREDICTION

PROJECT NO 1.16 BUDGET $ 70 k (1988) $ 200 k (Total)

TITLE: EVALUATION OF PREDICTIVE TECHNIQUES - TAILINGS AND WASTE ROCK

OBJECTIVES: To identify and evaluate techniques for predicting the potential for tailings and waste rock to produce contaminated runoff and seepage

MAJOR STEPS (INCL. GO/NO GO DECISION)	YEAR	$k
1. Evaluate range of prediction techniques for up to 12 tailings and waste rock samples (GO/NO GO DECISION)	1988/89	70
2. Test selected methods on wide range of tailings across Canada	1989/90	100
3. Develop test protocols and confidence limits for prediction	1990/91	30

BACKGROUND:
AMD prediction tests have been used in Canada for over a decade, but, no comprehensive program to evaluate their effectiveness has been conducted. Researchers have recently developed new approaches for prediction that may enhance existing well used techniqes. This study will both evaluate all current techniques and verify the most promising tests for tailings and waste rock to produce contaminated run off and seepage.

OUTPUT:
A manual describing recommended AMD testing procedures, advantages, disadvantages, and confidence limits for tailings prediction.

PRIORITY: [I] II III Rationale: Effective prediction techniques must be developed if new mines are to avoid generating AMD

RATS PROJECT SUMMARY

Date: Feb. 8, 1988
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TOPIC PREDICTION SUB-TOPIC CHEMICAL PREDICTION

PROJECT NO. 1.16 BUDGET: $ 70 k (1988) $ 200 k (Total)

TITLE: EVALUATION OF PREDICTIVE TECHNIQUES - TAILINGS AND WASTE ROCK

ADDITIONAL DETAILS:

1. Contract issued to Coastech Research of B.C. by CANMET for step 1 of project.
2. Lysimeter study being conducted by CANMET in parallel to Coastech work.
3. Related non-RATS studies include EPA contract to F. Caruccio (U. of S. Carolina), and Ontario MOE (Hawley) and EP-Pacific Region (Ferguson) ongoing studies.
4. Support of all RATS and some non-RATS companies required to complete step 2 cross Canada testing of selected AMD prediction techniques.
5. Samples tested must span a wide range of mineralogies and potential to generate AMD.
6. Step 2 of project could be coordinated by subcommittee

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TOPIC PREDICTION SUB-TOPIC FIELD TRIAL HYDROGEOCHEMICAL

PROJECT NO 1.17 BUDGET $ 90 k (1988) $ 235* k (Total)

TITLE: HYDROGEOCHEMICAL INVESTIGATION OF WAITE AMULET REACTIVE TAILINGS

OBJECTIVES: Develop a better understanding of hydrogeochemical processes and changes which occur in an acid-generating tailings area.

MAJOR STEPS (INCL. GO/NO GO DECISION)	YEAR	$k
1986/87 completed *	1986/87	*
1. 1988 Field season Piezometer sampling Flow monitoring, seepage overland flow Sampling seegage and overland flow Monitor water table fluctation with rainfall events Infiltration and permeability tests Gaseous O_2 profiles along the bench	1988/89	90
2. 1989 As above	1989/90	70
3. 1990 As above	1990/91	75

* Based on Noranda Research outline proposal to RATS TWP 6-7 Oct. 1987
$235k required for 1988/90 program

BACKGROUND:
This is a five year project (1985/89) to develop a hydrogeochemical baseline field study which will improve long-term tailings management practices. The results of this baseline field study project will provide data to develop predictive models and assess engineered covers for control technology.

OUTPUT:
Report to review the hydrogeochemical conditions, for reactive tailings with recommendations for long-term tailings management practices.

PRIORITY: [I] II III Rationale: Baseline essential to further studie
* plus $405k spent 1985/87, equalling $640k total.

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TOPIC PREDICTION SUB-TOPIC FIELD TRIAL HYDROEOCHEMICAL

PROJECT NO. 1.17 BUDGET: $ 90 k (1988) $ 235 *k (Total)

TITLE: HYDROGEOCHEMICAL INVESTIGATION OF WAITE AMULET REACTIVE TAILINGS

ADDITIONAL DETAILS:

1. Siwik R. Hydrogeochemical investigation of reactive tailings at the Waite Amulet tailings site, Noranda Quebec 1985 program. Noranda Research Centre July 1986.

2. Siwik R., Prairie R., Payant S., Hydrogeochemical investigation of reactive tailings at Waite Amulet tailings site, Noranda, Quebec Phase 2 - 1986 program Noranda Research Centre, July 1987.

* plus $405k spent 1985/87, equalling $640k total.

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TOPIC PREDICTION SUB-TOPIC CHEMICAL PREDICTION
(See also Report 60602)

PROJECT NO 1.18 BUDGET $ 75 k (1988) $ 150 k (Total)

TITLE: HYDROGEOCHEMICAL CHARACTERIZATION OF THE FARO TAILINGS AND SUB-SITE

OBJECTIVES: To determine the hydrogeochemical characteristics of the tailings deposit and sub-site at the Faro tailings impoundment

MAJOR STEPS (INCL. GO/NO GO DECISION)	YEAR	$k
1. Preliminary characterization of tailings and sub-site (already completed by Curragh and EPS)	1986/87	-
2. Phase I detailed hydrogeochemical characterization of Faro tailings deposits and sub-site (GO/NO GO DECISION)	1988	75
3. Phase II detailed hydrogeochemical characterization of Faro tailings deposit and sub-site	1989	75

BACKGROUND: Acid generation has been developing in the Original and Second tailings impoundments at Faro since placement was stopped in 1982. Preliminary acid generation evaluations have been done in 1986 and 1987 by Curragh and EPS respectively. A detailed characterization study allows natural acid generation and transportation to be determined. This forms the base conditions for the evaluation of effects of alternative covers (sub-topics 2,12, 2.13 & 2.21) and modelling of their effects over the long term (sub-topic 1.23). This study examines a tailings facility in the early stages of acid generation and therefore, is different from project 1.17 which involves a well established acid generating tailings

OUTPUT: Tailings acid generation characterization and tailings and sub-site AMD transportation and geochemical retardation characterization for use as base case data for assessment of effects of alternative covers and modelling of both acid generation and acidic product migration.

PRIORITY: [I] II III Rationale: Allows effects of alternative covers to be modelled.

RATS PROJECT SUMMARY

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TOPIC PREDICTIVE MODELLING SUB-TOPIC MODEL DEVELOPMENT TAILS

PROJECT NO 1.21 BUDGET $ 90 k (1988) $ 1380 k (Total)

TITLE: MODEL DEVELOPMENT TAILS/VERIFICATION OF TAILINGS MODELS

OBJECTIVES: To develop a mathematical model to predict acid generation in sulphide tailings and to evaluate the effectiveness of various control technologies

MAJOR STEPS (INCL. GO/NO GO DECISION)	YEAR	$k
1. Phase 1		
1.1: Develop Objectives and specifications	1988/89	90
- Prepare draft document		
- Hold meetings/workshops industry/Govt.		
- Finalize document		
1.2: Review and Select Models	1989/90	70
- Identify Models		
- Identify Deficiencies		
GO/NO GO DECISION		
2. Phase 2 Model Development	1989/90	295
- Develop/Modify component modules	1990/91	100
- Calibrate model and identify important parameters	1990/91	240
3. Phase 3 Measurements and model validation	1990/91 1991/92	335 100
4. Phase 4 Technology Transfer	1992/93	50

BACKGROUND:

Currently there is no unified model for reactive tailings. Models such as RATAP, CANECT etc., to be evaluated. A singular model having modules for varous sources and transportation terms to be developed to effectively predict various tailings management options.

OUTPUT:

Predictive model capable of evaluating the effectiveness of various tailings disposal options.

PRIORITY: [I] II III Rationale: Model development is an essential and integral part of RATS program.

RATS PROJECT SUMMARY

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TOPIC PREDICTIVE MODELLING SUB-TOPIC MODEL DEVELOPMENT TAILS

PROJECT NO. 1.21 BUDGET: $ 90 k (1988) $ 1380 k (Total)

TITLE: MODEL DEVELOPMENT TAILS/VERIFICATION OF TAILINGS MODELS

ADDITIONAL DETAILS:

1. Model to be calibrated at two sites, possibly at Waite Amulet and Faro tailings.
2. Model validations at three additional sites.
3. CANMET has a contract ($50k - 1988) with SENES titled, "Adaptation of RATAP Model For Base Metal Tailings"
4. Included above are funds for Faro's tailings model development and evaluations

   Development 1989 - 100 k

   Evaluation 1990 140 k

RATS PROJECT SUMMARY

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TOPIC PREDICTIVE MODELLING SUB-TOPIC MODEL DEVELOPMENT, WASTE ROCK/ OPEN PIT

PROJECT NO 1.22 BUDGET $ - k (1988) $ 550 k (Total)

TITLE: REACTIVE WASTE ROCK AND OPEN PIT MODELLING

OBJECTIVES: To develop a mathematical model to predict acid generation and associated metal loadings in reactive waste rock and open pit and evaluation of various control technologies.

MAJOR STEPS (INCL. GO/NO GO DECISION)	YEAR	$k
1. Phase 1		
1.1 Develop objectives and specification - Refer to phase 1 Project 1.21	1988	-
1.2 Review and select model	1989	
- Identify models		20
- Identify deficiencies		30
GO/NO GO DECISION		
2. Phase 2 Model Development		
- Develop/modify component modules	1990	100
- Calibrate model and identify important parameters Refer to 1.14 and 1.15	1991	100
3. Phase 3 Measurements and validation	1991/92	250
4. Phase 4 Technology Transfer	1993	50

BACKGROUND:

Currently there is no model for waste rock and open pits. Because of the extreme heterogenity of waste rock piles this project will be re-evaluated during phase 1 of project 1.2 1 for a Go/No Go decision.

OUTPUT:
Model capable of predicting the effectiveness of various waste rock and open pit management options.

PRIORITY: [I] II III Rationale: Model development is an essential and integral part of RATS program

RATS PROJECT SUMMARY

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TOPIC PREDICTIVE MODELLING SUB-TOPIC MODEL DEVELOPMENT, WASTE ROCK/ OPEN PIT

PROJECT NO. 1.22 BUDGET: $ - k (1988) $ 550 k (Total)

TITLE: REACTIVE WASTE ROCK AND OPEN PIT MODELLING

ADDITIONAL DETAILS:

1. At the end of Phase 1 task 1.21, it should be evaluated whether the Reactive Tailings Model could be transported for waste rock/open pit.

2. A Go/No Go decision should also be made early (end of Phase 1, task 1.21) whether waste rock/open pit scenario should be modelled, for in practice there is extreme heterogeneity in terms of contents, particle size and distribution etc.

2. PREVENTION AND CONTROL

PROJECT	RANKING	TOTAL ($K)	Page
2.1 WET BARRIERS/TAILINGS			
2.11 Existing Underwater Disposal Sites	I	460	23
2.12 Underwater Disposal in Flooded Open Pits	I	700	25
2.13 Flooding of Existing Tailings Areas	I	650	27
2.14 Establish Vegetative Wetlands over Tailings	I	550	29
SUBTOTAL WET BARRIERS/TAILINGS		**2500**	
2.2 DRY BARRIERS/TAILINGS			
2.21 Engineered Dry Covers Tailings (and Waste Rock)	I	800	31
2.22 Assessment of Hardpan	III	600	33
2.23 Documentation of Disposal Methods for Tailings and Waste Rock	III	50	35
2.24 Vegetation Manual	I	35	37
SUBTOTAL DRY BARRIERS/TAILINGS		**1485**	
2.3 WASTE ROCK			
2.31 Field Evaluation of Dry Covers on Waste Rock	I	600	39
2.32 Laboratory Insitu Blending/ Segregation of Waste Rock	I	300	41
2.33 Cellular Dump Construction	I	670	43
2.34 Alkaline Trenches	II	150	45
SUBTOTAL WASTE ROCK		**1720**	
TOTAL PREVENTION/CONTROL		**5705**	

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TOPIC PREVENTION AND CONTROL SUB-TOPIC WET BARRIERS

PROJECT NO 2.11 BUDGET $ 160 k (1988) $ 460 k (Total)

TITLE: EXISTING UNDERWATER DISPOSAL SITES

OBJECTIVES: Establish feasibility of underwater disposal of reactive tailings

- Evaluate representative existing sites
- Establish general criteria for disposal
- Propose demonstration projects

MAJOR STEPS (INCL. GO/NO GO DECISION)	YEAR	$k
1. Review potential sites, define evaluation parameters, conduct preliminary assessment of ~ 10-12 sites	1988	160
2. Conduct more detailed examination of 3-4 sites	1989	250
3. Evaluate and report results. Propose disposal criteria and evaluation projects. Includes consideration of in-lake, in-pit, in-pond and under-water wetlands systems	1989	50

BACKGROUND:

Water cover should minimize the transport of oxygen, hence limit acid generation. Systematic evaluation of existing sites (Buttle Lake in B.C., Mandy Lake in Manitoba, etc.,) will provide a basis of a) assessing benefits b) developing design criteria.

OUTPUT:

An evaluation report with a) an assessment of effectiveness, b) proposed disposal criteria, c) recommendations for demonstration projects.

PRIORITY: [I] II III Rationale: Required for guiding a) technique development and b) interim disposal practise.

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TOPIC PREVENTION AND CONTROL SUB-TOPIC WET BARRIERS

PROJECT NO. 2.11 BUDGET: $ 160 k (1988) $ 460 k (Total)

TITLE: EXISTING UNDERWATER DISPOSAL SITES

ADDITIONAL DETAILS:

1. Literature review of sites in other countries should be conducted.

2. This project should precede the other "Wet Barrier" studies.

RATS PROJECT SUMMARY

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TOPIC PREVENTION AND CONTROL SUB-TOPIC WET BARRIERS

PROJECT NO 2.12 BUDGET $ 100 k (1988) $ 700 k (Total)

TITLE: UNDERWATER DISPOSAL IN FLOODED OPEN PITS

OBJECTIVES: Evaluate disposal in open pits, related to

- properties of waste material
- hydrological and other characteristics of pit
- benefits of inert covers, dense water zones, etc., over waste

MAJOR STEPS (INCL. GO/NO GO DECISION) (costs are for each study - 3 may be required)		YEAR	$k
1.	Conduct laboratory and bench evaluation of characteristics and leachability of material	1988	50
1.(a)	Review existing open pits *		50
2.	Establish characteristics of pit (configuration, hydrogeology....). Install piezometers, etc...	1988/89	100
3.	Deposit waste material (with solid or modified liquid cover). *	1989	50
4.	Monitor changes in water chemistry in pit and adjacent	1989/92	300
4.(a)	Need to evaluate further - ongoing studies.		100
5.	Issue evaluation report with design criteria. Include data from previous studies , BMS No. 6, Equity etc.	1992	50

* covers examined could include (solid) organic or alkaline material or meromixic layer.

BACKGROUND:

The deposition of reactive materials in a flooded open pit may opportunistically eliminate acid generation and transport, particulary if further steps are taken to minimize oxygen transfer (solid inert covering material, meromixic layers....)

OUTPUT:

A comparison of laboratory and full-scale results for alternative disposal design and recommendations for designing effective in-pit disposal systems.

PRIORITY: [I] II III Rationale: Should parallel Project 2.11 & 2.13

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TOPIC PREVENTION & CONTROL SUB-TOPIC WET BARRIERS

PROJECT NO. 2.12 BUDGET: $ 100 k (1988) $ 700 k (Total)

TITLE: UNDERWATER DISPOSAL IN FLOODED OPEN PITS

ADDITIONAL DETAILS:

1. Conduct literature search to determine what other countries have done e.g. Sweden and Norway.
2. Should have high priority to capitalize on work to be performed in Quebec during 1988.
3. Heath Steele also will be dumping waste rock into an open pit, as well as ongoing work by Equity Silver.

These experiments should be properly designed from the outset; i.e. this ongoing work needs to be coordinated or guided right now.

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TOPIC PREVENTION AND CONTROL SUB-TOPIC WET BARRIERS

PROJECT NO 2.13 BUDGET $ 50 k (1988) $ 650 k (Total)

TITLE: FLOODING OF EXISTING TAILINGS AREAS

OBJECTIVES: Evaluate disposal in flooded tailings deposition areas.

MAJOR STEPS (INCL. GO/NO GO DECISION)	YEAR	$k
1. Characterize material(s) geochemically and via column leach test, etc.	1988/89	75
2. Establish and monitor several field plots with varying depths of water.	1989/92	200
3. Flood a large existing tailings area, (with baffles, etc. to minimize transport of oxygen and/or particulates) and monitor changes in water and tailings chemistry. *	1989/92	300
4. Issue an evaluation/design recommnedations report.	1992	75

* presumption that structural costs incurred by owner

BACKGROUND:

Storing of deposited tailings underwater in a tailings structure may be attractive, if the relatively shallow water depth is sufficient to control oxidation, taking into account the risk of solar and wind mixing, changes in water depths seasonally etc.

OUTPUT:
An evaluation of lysimeter, small-scale and full-scale tests, providing design guidelines and basis for estimating degree of reaction control.

PRIORITY: [I] II III Rationale: Should parallel Project 2.11 & 2.12

RATS PROJECT SUMMARY

Date: Feb. 4, 1988
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TOPIC PREVENTION AND CONTROL SUB-TOPIC WET BARRIERS

PROJECT NO. 2.13 BUDGET: $ 50 k (1988) $ 650 k (Total)

TITLE: FLOODED TAILINGS AREAS

ADDITIONAL DETAILS:

1. Literature search for work in other countries to be done first.
2. Curragh Resources will be attempting these tests, and should be supported.
3. Flooding of old oxidized tailings versus fresh unoxidized tailings needs evaluation.
4. Method of operation needs to be determined i.e. are tailings discharged into low lying wet areas during life of operation and kept constantly wet, or are tailings discharged as normal practice and flooded upon abandonment.

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TOPIC PREVENTION AND CONTROL SUB-TOPIC WET BARRIERS

PROJECT NO 2.14 BUDGET $ 150 k (1988) $ 550 k (Total)

TITLE: ESTABLISH VEGETATIVE WETLANDS OVER TAILINGS.

OBJECTIVES: Establish feasibility of establishing wetlands over tailings to control oxygen/water transfer, enhance control of acid generation

MAJOR STEPS (INCL. GO/NO GO DECISION)	YEAR	$k
1. Review on-going projects and literature; recommend what further project(s) and/or extension or support of ongoing projects should be undertaken.	1988/89	50
2. Concurrently, provide interim support to one or more ongoing projects (e.g. Curragh, Inco, Falconbridge)	1988/89	100
3. Based on (1) proceed with justified field studies (No/Go)		400

BACKGROUND:

Some work has been undertaken by Inco, Falconbridge and others.

OUTPUT:

PRIORITY: [I] II III Rationale:

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TOPIC PREVENTION AND CONTROL SUB-TOPIC WET BARRIERS

PROJECT NO. 2.14 BUDGET: $ 150 k (1988) $ 550 k (Total)

TITLE: ESTABLISH WETLANDS ON TAILINGS.

ADDITIONAL DETAILS:

1. Work done at Kamkotia should be closely followed. (Wetlands are proposed to be built over 2/3 of the tailings area).
2. Work is ongoing along these lines by other groups i.e. Falconbridge, Inco.
3. If funding is limited, this project could be given lower priority presuming Kamkotia will be proceeding - proper monitoring design must however be installed at Kamkotia.

RATS PROJECT SUMMARY

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TOPIC PREVENTION AND CONTROL SUB-TOPIC DRY BARRIERS' TAILINGS

PROJECT NO 2.21 BUDGET $ 155 k (1988) $ 800 k (Total)

TITLE: ENGINEERED DRY COVERS TAILINGS (AND WASTE ROCK - See also 2.31)

OBJECTIVES: To develop methodlogies for testing, designing, placement and evaluation of various engineered dry covers for tailings and waste rock for control of acid generation and contaminant discharge

MAJOR STEPS (INCL. GO/NO GO DECISION)	YEAR	$k
1. Phase 1 Laboratory testing, Design and Modelling	1988	
1.1 Laboratory studies - Development - Fabrication - Methods testing - Materials testing		130
1.2 Modelling	1989	100
1.3 Preliminary Engineering Design	1988/ 1989	25
GO/NO GO DECISION		
2. Phase 2 Field Trials (incl. $210k for Faro trials)	1990/92	520
3. Phase 3 Technology Transfer		25

BACKGROUND:
Various dry covers such as clay, soils, till, polymer/synthetic membranes and cementitious materials are to be evaluated for their effectiveness in control of oxygen penetration and water percolation rates. Design and placement of a suitable cover on tailings and waste rock to control oxidation and containment migration.

OUTPUT:
Laboratory methodologies for testing and design of engineered covers, their placement and modelling their effectiveness both for reactive tailings and waste rock.

PRIORITY: [I] II III Rationale: Evaluation of various covers for oxidation and contamination to migration is essential for many existing sites. See also 2.3

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TOPIC PREVENTION AND CONTROL SUB-TOPIC DRY BARRIERS, TAILINGS

PROJECT NO. 2.21 BUDGET: $ 155 k (1988) $ 800 k (Total)

TITLE: ENGINEERED DRY COVERS TAILINGS (AND WASTE ROCK - See also 2.31)

ADDITIONAL DETAILS:

1. This project will provide laboratory testing and design procedures to both projects 2.21 "Dry Engineered Covers" for tailings and 2.31 for "Waste Rock Field Trials"
2. Likely areas for field evaluation
   - Waite Amulet
   - Faro
   - Kam Kotia
   - Inco
3. Kam Kotia site may be using a cementitious dry cover on exposed tailings and a system of dykes and wetlands on water saturated tailings areas.

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TOPIC PREVENTION AND CONTROL SUB-TOPIC DRY BARRIERS, TAILINGS

PROJECT NO 2.22 BUDGET $ 50 k (1988) $ 600* k (Total)

TITLE: ASSESSMENT OF HARDPAN

OBJECTIVES: To assess use of hardpan as a protective cover to oxidation.

Methods to characterize and stabilize hardpan.

MAJOR STEPS (INCL. GO/NO GO DECISION)	YEAR	$k
1. Complete mineralogical studies on selected core samples, from 4 Manitoba sites (not incl. MDA funding)	1988	150 *
2. Investigate chemical or other treatments to stablize hardpan	1988	100 *
3. Lysimeter work on pilot scale	1988/89	50 *
4. Control and monitor pore water	1988/90)	150
GO/NO GO DECISION	)	
	)	
5. Monitor Effluents	)	
6. Field treatment on site	1990/91	200
	1991/92	150
	1992/93	100

BACKGROUND:

Hardpan exists at 2 feet below surface insulphide tailings at four Manitoba sites. Sheridon site has the most adverse effect on the environment - hardpan associated with proximity to water table.

OUTPUT:
Methods development to stablized hardpan as a protective cover to prevent oxidation

PRIORITY: I II [III] Rationale: Naturally existing barrier

* Plus additional $300 MDA in 1988/89

RATS PROJECT SUMMARY

Date: Feb. 5, 1988
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TOPIC PREVENTION AND CONTROL SUB-TOPIC DRY BARRIERS, TAILINGS

PROJECT NO. 2.22 BUDGET: $ 50 k (1988) $ 600 k (Total)

TITLE: ASSESSMENT OF HARDPAN

ADDITIONAL DETAILS:

1. Samples are now in testing laboratory.
2. Core samples selected to characterize four different hardpans.
3. Water table at one site to be stabilized to determine its relationship to hardpan formation, its growth and permanence to be evaluated on a yearly basis
4. Department of Environment, Manitoba will monitor corrective measures. Contractor will monitor hardpan formation, sampling of hardpan over the period of 1989/91

RATS PROJECT SUMMARY

Date: Feb. 8, 1988
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TOPIC PREVENTION AND CONTROL SUB-TOPIC DRY BARRIERS TAILINGS

PROJECT NO 2.23 BUDGET $ - k (1988) $ 50 k (Total)

TITLE: DOCUMENTATION OF DISPOSAL METHODS FOR TAILINGS AND WASTE ROCK

OBJECTIVES: To document and evaluate existing tailings and waste rock disposal in terms of their effectiveness in controlling AMD and permitting walkaway closure

MAJOR STEPS (INCL. GO/NO GO DECISION)	YEAR	$k
1. Review of existing methods (via project 5.1)	1988	-
GO/NO GO DECISION		
2. Document and evaluate disposal methods	1990	50

BACKGROUND:
Disposal manuals for uranium tailings (NUTP), base metal and coal spoils (for American Mining Congress) prepared by SRK will soon be available. Documentation of other terminologies tried during field trials should be done at a later date.

OUTPUT:
Prepared disposal methods manual and test effectiveness for reactive tailing and waste rock - Reference Manual.

PRIORITY: I II [III] Rationale: Evaluation after other field trials.

RATS PROJECT SUMMARY

Date: Feb. 8, 1988
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TOPIC PREVENTION AND CONTROL SUB-TOPIC DRY BARRIERS TAILINGS

PROJECT NO. 2.23 BUDGET: $ - k (1988) $ 50 k (Total)

TITLE: DOCUMENTATION OF DISPOSAL METHODS FOR TAILINGS AND WASTE ROCK

ADDITIONAL DETAILS:

1. Reference:

"Canadian Uranium Mill Waste Disposal Technology" - Steffen, Robertson and Kirsten (B.C.) Inc. CNUTP Contract Report IS.SQ. 233176 - 1730 (1987)

RATS PROJECT SUMMARY

Date: Feb. 8, 1988
Page 1 of 2

TOPIC PREVENTION AND CONTROL SUB-TOPIC DRY BARRIERS, TAILINGS

PROJECT NO 2.24 BUDGET $ 35 k (1988) $ 35 k Total

TITLE: VEGETATION MANUAL

OBJECTIVES: Prepare a state-of-the-art manual documenting demonstrated techniques for establishing vegetation on acid generating tailings, and waste rock

MAJOR STEPS (INCL. GO/NO GO DECISION)	YEAR	$k
1. Literature review and preparation of the methods manual	1988	35

BACKGROUND:
CANMET's Pit Slop Stability Manual (1977) describes vegetation techniques for slopes and reactive tailings. Since then considerable work has been done on revegetation of reactive tailings. The manual will compile the state-of-the-art techniques.

OUTPUT:
Vegetation Manual - Reference Document

PRIORITY: [I] II III Rationale: Useful methods manual

RATS PROJECT SUMMARY

Date: Feb. 8, 1988
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TOPIC PREVENTION AND CONTROL SUB-TOPIC DRY BARRIERS, TAILINGS

PROJECT NO. 2.24 BUDGET: $ 35 k (1988) $ 35 k (Total)

TITLE: VEGETATION MANUAL

ADDITIONAL DETAILS:

1. Reference:

"Reclamation by Vegetation" - Pit Slope Manual supplement 10-1,2, CANMET Report

RATS PROJECT SUMMARY

Date: Feb. 4., 1988
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TOPIC PREVENTION AND CONTROL SUB-TOPIC WASTE ROCK

PROJECT NO 2.31 BUDGET $ - k (1988) $ 600 k (Total)

TITLE: FIELD EVALUATION OF DRY COVERS ON WASTE ROCK

OBJECTIVES: To evaluate the effect of engineered natural covers on waste rock oxidation rates.

MAJOR STEPS (INCL. GO/NO GO DECISION)	YEAR	$k
1. Based upon engineering design in Project 2.21 field trials are to be established	1990	400
2. Monitoring of performance	1991	100
3. Monitoring and summary of field test results including recommendations for optimum cover material	1992	100

BACKGROUND: Natural covers should minimize the transport of oxygen and water into waste rock. Although covers of waste rock have been used to prevent and control ADM, their effectiveness is often difficult to assess.

A separate program is warranted for waste rock field trials because of potential chimney effects resulting from a variety of different topographies.

OUTPUT:

Performance evaluation report describing the effectiveness of dry barriers

PRIORITY: [I] II III Rationale: Will follow Project 2.21

RATS PROJECT SUMMARY

Date: Feb. 4, 1988
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TOPIC PREVENTION AND CONTROL SUB-TOPIC WASTE ROCK

PROJECT NO. 2.31 BUDGET: $ - k (1988) $ 600 k (Total)

TITLE: FIELD EVALUATION OF DRY COVERS ON WASTE ROCK

ADDITIONAL DETAILS:

1. The definition of engineered covers is undertaken in Project 2.21.
2. The selection of sites suitable for field scale trials will await 1990.
3. There will, however, be several sites where dry covers will be utilized prior to 1990, and could be incorporated into this program.
4. Possible sites will be : Mattabi, Heath Steel, Equity Silver, Westmin and Mt. Washington.

RATS PROJECT SUMMARY

Date: Feb. 4, 1988
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TOPIC PREVENTION AND CONTROL SUB-TOPIC WASTE ROCK

PROJECT NO 2.32 BUDGET $ 15 k (1988) $ 300 k (Total)

TITLE: LABORATORY INSITU BLENDING/SEGRATION OF WASTE ROCK

OBJECTIVES:

Evaluate disposal strategies relating to:
- blending with acid consuming waste material
- leachability of calcareous and silicate materials
- segregation of acid generating wastes
- acid production rates in relationship to particle size

MAJOR STEPS (INCL. GO/NO GO DECISION)	YEAR	$k
1. Define terms of reference for testwork along with literature search	1988	15
2. Establish laboratory tests to define variable for blending, segregation and sizing. Study properties on non-acid producting wastes for liberation of alkalinity.	1989	150
3. Monitor water chemistry	1990	50
4. Monitor water chemistry	1991	50
5. Issue evaluation report with design recommendations. GO/NO GO DECISION	1992	35
6. Field trials.		

BACKGROUND: Technically the blending of acid generating waste with alkaline wastes should be adequate to suppress acid generation processes. However, acid generation processes may contribute to the formation of secondary materials (jarosite) blinding material surfaces hence reducing the leachability of alkaline material. Test scenerios should evaluate this. Segregation of acid producing wastes may alleviate this problem however may accelerate the process unless properly sealed. Surface area exposure is directly proportional to oxidation rates of pyritic wastes. This rate should be evaluated on sized material.

OUTPUT:
An evaluation report listing results of the test and recommendations for blending, segregation, and preferential blasting to size material.

PRIORITY: [I] II III Rationale:

RATS PROJECT SUMMARY

Date: Feb. 4, 1988
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TOPIC PREVENTION AND CONTROL SUB-TOPIC WASTE ROCK

PROJECT NO. 2.32 BUDGET: $ 15 k (1988) $ 300 k (Total)

TITLE:

ADDITIONAL DETAILS:

1. This program is for a laboratory study only. Field trials have not been budgeted for at this time.
2. This program must be co-ordinated with Project 1.13: Prediction - Rocks.
3. Potential examples should be drawn from existing operations as well as mines in the planning stage of development.
4. Relevant literature from the coal mining sector should also be included.

RATS PROJECT SUMMARY

Date: Feb. 4, 1988
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TOPIC PREVENTION AND CONTROL SUB-TOPIC WASTE ROCK

PROJECT NO 2.33 BUDGET $ - k (1988) $ 670 k (Total)

TITLE: CELLULAR DUMP CONSTRUCTION

OBJECTIVES: To test and report on the practicality and effectiveness of segregated waste with separated cells in a waste dump.

MAJOR STEPS (INCL. GO/NO GO DECISION)	YEAR	$k
1. Define terms of reference along with literature search. Reference should be made to test 2.31 covers and 2.32 step 3	1990	20
2. Select four sites to establish test plots with 3-4 tests/ site (i.e. control, oxidized waste, unoxidized waste).	1991	*400
3. Monitor quantitative changes in water chemistry with time	1992	100
4. Monitor quantitative changes in water chemistry with time	1993	100
5. Report comparison of tests and effectiveness of cellular arrangement. Recommend construction costs and logistics of construction method and cost benefits	1994	50

* Labour and equipment to be supplied by companies.

BACKGROUND:

Encapsulating techniques should assist in reducing acid generation although none have been demonstrated to be a fail-safe method. The concept of multi-isolated chambers should introduce barriers to oxygen transfer. Proposed testwork offers an optimistic approach to establishing a state-of-the-art remedy for reducing the kinetics of acid generation.

OUTPUT:
The report should evaluate test results and make recommendations regarding construction costs and logistics.

PRIORITY: [I] II III Rationale: Integrate with Test 2.31

RATS PROJECT SUMMARY

Date: Feb. 4, 1988
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TOPIC PREVENTION AND CONTROL SUB-TOPIC WASTE ROCK

PROJECT NO. 2.33 BUDGET: $ - k (1988) $ 670 k (Total)

TITLE: CELLULAR DUMP CONSTRUCTION

ADDITIONAL DETAILS:

1. Should be co-ordinated with prediction work 1.12.
2. Must await design of engineered covers in program 2.21.
3. Equity Silver is currently utilizing a modified cellular dump design.
4. Should also be integrated with program 2.31.

RATS PROJECT SUMMARY

Date: Feb. 4, 1988

TOPIC PREVENTION AND CONTROL SUB-TOPIC WASTE ROCK

PROJECT NO 2.34 BUDGET $ - k (1988) $ 150 k (Total)

TITLE: ALKALINE TRENCHES

OBJECTIVES: Evaluate and report on effectiveness of alkaline supplements in reducing acid generation processes in open pits.

MAJOR STEPS (INCL. GO/NO GO DECISION)		YEAR	$k
1.	Define terms of reference and assessment of 8-10 sites	1988	10
2.	Detailed assessment of 3-4 sites	1989	15
3.	Implement testwork	1990	70
4.	Monitor chemistry changes at sites.	1991	30
5.	Evaluate data, report and make recommendations as to applicability	1992	25

BACKGROUND:
Alkaline trenches and introduction of alkaline runoff has been tested in the coal fields of eastern U.S.A. Hydrogeochemistry changes have been noted in the effluent. Testwork should be performed within abandoned pits where acid generation processes are known to exist.

OUTPUT:
An evaluation of alkaline trenches for preventing acid generation as well as slowing down established processes. Construction techniques required.

PRIORITY: I [II] III Rationale: Combine investigation with research Item 1.15.

RATS PROJECT SUMMARY

Date: Feb. 4, 1988
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TOPIC PREVENTION AND CONTROL SUB-TOPIC WASTE ROCK

PROJECT NO. 2.34 BUDGET: $ k (1988) $ 150 k (Total)

TITLE: ALKALINE TRENCHES

ADDITIONAL DETAILS:

1. This program involves open pit and not waste rock.
2. The use of alkaline trenches placed above zones of oxidation may be an effective technique for controlling acid mine drainage on some pit walls, where the zone of oxidation is shallow and exposed surface area is not too great.
3. Trenches are likely to be used on very few areas and, as a result, this program is not a high priority at this time.
4. Program should be co-ordinated with Project 1.15.
5. Equity Silver is considering their use.

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3. TREATMENT

PROJECT	RANKING	TOTAL ($K)	
3.1 DOWNSTREAM PASSIVE			
3.11 Existing Natural Wetlands Affected by low pH/Metal Contaminated Seeps	II	135	48
3.12 Constructed Wetland	III	300	49
SUBTOTAL DOWNSTREAM PASSIVE		**435**	
3.2 ON SITE TREATMENT			
3.21 Upgraded Chemical Treatment	II/III	500	50
3.22 In Situ Treatment using Chemicals/Bactericides	II	350	52
SUBTOTAL ON SITE TREATMENT		**850**	
TOTAL TREATMENT		**1285**	

RATS PROJECT SUMMARY

Date: Feb. 5, 1988
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TOPIC TREATMENT SUB-TOPIC DOWNSTREAM PASSIVE

PROJECT NO 3.11 BUDGET $ 50 k (1988) $ 135 k (Total)

TITLE: EXISTING NATURAL WETLANDS AFFECTED BY LOW pH/METAL CONTAMINATED SEEPS

OBJECTIVES: Evaluate existing seep-affected wetlands re. viability as a passive treatment system.

MAJOR STEPS (INCL. GO/NO GO DECISION)	YEAR	$k
1. Identify candidate areas, define evaluation criteria and conduct preliminary assessment of ~10 areas	1988	40
2. In parallel, review ongoing research projects re. biological polishing of effluent (Kalin, CANMET, Condor...)	1988	10
GO/NO GO DECISION		
3. Conduct detailed examination of ~3 areas	1989/90	75
4. Issue evaluation report and recommendations	1991	10

BACKGROUND:

The capacity of wetlands to cope with relatively low loadings of Fe, Mg and pH has been well documented, particularly re. USA coal areas. The practicality of treating low pH heavy metal contaminated seeps from reactive tailings areas is uncertain, and a check of existing situations should preceed any other studies.

OUTPUT:

An evaluation of : a) existing seep-affected areas and
b) the merit of any further work

PRIORITY: I (II) III Rationale: Chance of success and/or general application is small.

RATS PROJECT SUMMARY

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TOPIC TREATMENT SUB-TOPIC DOWNSTREAM PASSIVE

KGW

PROJECT NO 3.12 BUDGET $ - k (1988) $ 300 k (Total)

TITLE: CONSTRUCTED WETLAND

OBJECTIVES: Evaluate constructed wetlands for treatment of seeps

MAJOR STEPS (INCL. GO/NO GO DECISION)	YEAR	$k
1. (Would not be initiated unless outcome of 3.11 is favourable)		

BACKGROUND:

Constructed wetlands are utilized in USA to treat coal waste seeps. However, degree of contaminated and climatic conditions are significantly different for Canadian metal mines, and practicality is dubious.

OUTPUT:

PRIORITY: I II (III) Rationale: Would follow 3.11, if warranted.

RATS PROJECT SUMMARY

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TOPIC TREATMENT SUB-TOPIC ON SITE TREATMENT

PROJECT NO 3.21 BUDGET $ 75 k (1988) $ 500 k (Total)

TITLE: UPGRADED CHEMICAL TREATMENT

OBJECTIVES:
a) Document and improve state-of-the-art of lime neutralization process and sludge disposal
b) Evaluate alternative treatment processes

MAJOR STEPS (INCL. GO/NO GO DECISION)	YEAR	$k
1. Complete state-of-the-art review of AMD treatment methods	1988/89	25
2. Complete inventory and description of Canadian AMD treatment plants	1988/89	25
3. Prepare an effluent treatment procedures manual for lime neutralization plants	1988/89	25
GO/NO GO DECISION		
4. Complete laboratory and plant studies to:		
(a) improve lime sludge characteristics (densificiation, settling, stability, disposal)	1989/91	100
(b) evaluate alternative treatment methods (NaOH & sulphide precipitation, ion exchange, reverse osmosis, biotech, others) & characterize sludges produced.	1989/91	200
5. Prepare a procedure manual for effluent treatment and sludge disposal	1990/91	25

BACKGROUND:
Lime neutralization is the standard method for treating AMD in Canada. Lime costs are high, equipment scaling and sludge disposal are problems, particularly the latter. Sludge stability can present a problem in the long-term when alkalinity drops.

OUTPUT:
State-of-the-art report on treatment of AMD
Report describing AMD treatment plants in Canada (lime neut.)
Treatment plant & sludge disposal treatment manual (1989 & 1991)

PRIORITY: I [II]* [III]**
*Sludge Studies ** Effluent Treatment Studies

Rationale: Effective long-term sludge disposal methods need to be developed to prevent re-dissolution of metals from sludges

RATS PROJECT SUMMARY

Date: Feb. 8, 1988
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TOPIC TREATMENT SUB-TOPIC ON-SITE TREATMENT

PROJECT NO. 3.21 BUDGET: $ 75 k (1988) $ 500 k Total

TITLE: UPGRADED CHEMICAL TREATMENT

ADDITIONAL DETAILS:

Relevant reports and current contracts:

1. Treatment of Acid Mine Water and the Disposal of Lime Neutralization Sludges by Vachon, Siwik, Schmidt and Wheeland (Halifax AMD Seminar)
2. Description of Wastewater Plants at Seven Mining and Metallurgical Operations in Eastern Canada (Mar./85, M. Wasserlauf report to Environment (Canada).
3. Generation and Stability of Canadian Mine/Smelter Effluent Treatment Sludges (July 7/87, M. Wasserlauf report to CANMET).
4. Follow-up contract (1988) to Wasserlauf on recommended research studies to address sludge disposal problems, including alternative effluent treatment methods.
5. Environment Canada IPB reports on some AMD mechanical type treatment plants.
6. Noranda Mines has lime neutralization treatment plant operating manuals.

RATS PROJECT SUMMARY

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TOPIC TREATMENT SUB-TOPIC ON SITE TREATMENT

PROJECT NO 3.22 BUDGET $ 50 k (1988) $ 350 k (Total)

TITLE: IN SITU TREATMENT USING CHEMICALS/BACTERICIDES

OBJECTIVES: To evaluate the effectiveness of chemicals and bactericides in preventing or controlling the generation of AMD from both tailings and waste rock.

MAJOR STEPS (INCL. GO/NO GO DECISION)	YEAR	$k
1. State-of-art review of these methods	1988/89	25
2. Support of tests continuing by Noranda (lab, field)	1988/90	100
GO/NO GO DECISION		
3. Test chemicals and bactericides at two other mine sites. Prepare a procedures manual	1990/91	200

BACKGROUND:
Chemicals/bactericides are not viewed as a long-term control method but may prove effective during the operational life of a mine to prevent or control AMD until permanent mine abandonment measures are put in place. Also it may prove cheaper to apply chemicals/bactericides during the operational phase than treating AMD by current liming practices.

OUTPUT: State-of-the-art Report
Reports on testwork
Procedures manual (if the method proves out)

PRIORITY: I [II] III Rationale: Although this techniques does not offer a long-term solution, its usefullness during the operational phase of a mine should b evaluated.

RATS PROJECT SUMMARY

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TOPIC TREATMENT SUB-TOPIC ON SITE TREATMENT

PROJECT NO. 3.22 BUDGET: $ 50 k (1988) $ 350 k (Total

TITLE: IN SITU TREATMENT USING CHEMICALS/BACTERICIDES

ADDITIONAL DETAILS:

1. Studies have been carried out in the U.S. on the treatment of coal mining refuse and metal sulphides ores (lab) using bactericides. A summary of this work is presented in a paper by A.A. Sobek entitled "The Use of Surfactants to Prevent AMD in Coal Refuse and Base Metal Tailings (AMD Halifax Seminar).

2. Westmin Mines are currently doing a literature survey and plan to run field tests on the use of surfactants to prevent the generation of AMD at their copper-zinc operation on Vancouver Island.

3. Noranda have tested the suitability of 16 surfactants and have carried further testing down to 3. One of their conclusions is that the cost of treatment with bactericides is roughly equivalent to the cost of treating the AMD, that would result without bactericide treatment, by lime neutralization.

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4. MONITORING

RATS PROJECT SUMMARY

Date: Feb. 4, 1988
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TOPIC MONITORING SUB-TOPIC

PROJECT NO 4.1 BUDGET $ 20 k (1988) $ 20 k (Total)

TITLE: FIELD METHODS MANUAL: TAILINGS

OBJECTIVES: To compile a field methods manual to provide guidance in the planning, conduct and assessment of sampling and monitoring projects of tailings.

MAJOR STEPS (INCL. GO/NO GO DECISION)	YEAR	$k
1. Prepare a well indexed guidebook from available literature on field methods for use in the sampling and assessment of tailings.	1988/89	20

BACKGROUND:
In undertaking studies of tailings in Canada there is a need to ensure that sound techniques are used in sampling and monitoring of impoundment areas. The quality, reliability, reproducibility and comparability of data will depend significantly on the methodologies employed in the field. Many techniques are well established but need to be assembled for easy access and use by all participants. Feedback from users should be encouraged.

OUTPUT:
A guidebook of field methods for tailings sampling and monitoring.

PRIORITY: [I] II III Rationale: A necessary guide for all field related RATS work.

RATS PROJECT SUMMARY

Date: Feb. 4, 1988
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TOPIC MONITORING SUB-TOPIC

PROJECT NO. 4.1 BUDGET: $ 20 k (1988) $ 20 k (Total)

TITLE: FIELD METHODS MANUAL: TAILINGS

ADDITIONAL DETAILS:

1. CANMET has prepared a proposal to compile this manual and a contract is currently under negotiation.

RATS PROJECT SUMMARY

Date: Feb. 4, 1988
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TOPIC MONITORING SUB-TOPIC

PROJECT NO 4.2 BUDGET $ - k (1988) $ - k (Total)

TITLE: ANALYTICAL METHODS MANUAL

OBJECTIVES: To outline guidelines for the selection of chemical analysis methods for tailings, waste rock and related materials such as pore water, and decant water and to establish criteria for quality assurance and quality control.

MAJOR STEPS (INCL. GO/NO GO DECISION)	YEAR	$k
1. Identify the type and class of materials requiring analysis, compile a bibliography of analytical methods for analysis and prepare a list of criteria for selection of analytical method.	1988/89	
2. Detail a quality assurance and quality control methodology	1988/89	
3. Prepare a guide book with above items for tailings and waste rock analysis.	1988/89	

BACKGROUND:

The use of reliable and reproducible data will depend on the quality of chemical analysis. Common practices should be documents for RATS participants.

OUTPUT:

A manual for chemical analysis of tailings, waste rock and associated materials.

PRIORITY: [I] II III Rationale: Consistent quality of results.

RATS PROJECT SUMMARY

Date: Feb. 4, 1988
Page: 2 of 2

TOPIC MONITORING SUB-TOPIC

PROJECT NO. 4.2 BUDGET: $ - k (1988) $ - k (Total)

TITLE: ANALYTICAL METHODS MANUAL

ADDITIONAL DETAILS:

1. Dr. H.F. Steger of CANMET has advised that this project is unnecessary. Laboratories use their own familiar methods of analysis. RATS participants should, however, take steps in submitting samples to establish quality assurance (QA) and quality control (QC). Typically QA and QC will cost 10-20% of the analytical costs. Standard reference materials in Project 4.3 aid in QA and QC.

RATS PROJECT SUMMARY

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TOPIC MONITORING SUB-TOPIC

PROJECT NO 4.3 BUDGET $ 15 k (1988) $ 50 k (Total)

TITLE: STANDARD REFERENCE MATERIALS

OBJECTIVES: To establish a number of reference materials of tailings and waste rock which can be used as standards for analysis.

MAJOR STEPS (INCL. GO/NO GO DECISION)		YEAR	$k
1.	Identify and sample a representative number of tailings and waste rocks for use as standards.	1987/88	5
2.	Prepare samples for round robin analysis.	1987/88	10
3.	Undertake round robin analysis and report results.	1987/88	20
4.	Complete assessment of results and establish accepted analytical standards.	1988/89	10
5.	Incorporate standards into CCRMP system	1988/89	5

BACKGROUND:

The key to reliable and reproducible analytical results is the availability of good relevant standard reference materials. CANMET has an established Canadian Certified Reference Materials Program (CCRMP). This is an appropriate vehicle for the selection, preparation and certification of tailings and waste rock standards.

OUTPUT:

Reference materials samples and certified analysis for a series of selected samples.

PRIORITY: [I] II III Rationale: Relevant analytical standards for quality assurance.

RATS PROJECT SUMMARY

Date: Feb 4, 1988
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TOPIC MONITORING SUB-TOPIC

PROJECT NO. 4.3 BUDGET: $ 15 k (1988) $ 50 k (Total)

TITLE: STANDARD REFERENCE MATERIALS

ADDITIONAL DETAILS:

1. Samples of tailings from Noranda, Inco and Falconbridge have been selected and identified as RTS-1 to RTS-4 by Clint Smith of CANMET.
2. Samples have been prepared for analysis by participating laboratories.
3. Commercial laboratories have been contracted to perform analysis.
4. RATS members have been asked to participate in the round robin analysis.
5. Memo: C. Smith of CANMET to distribution, December 31, 1987.

RATS PROJECT SUMMARY

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TOPIC MONITORING SUB-TOPIC

PROJECT NO 4.4 BUDGET $ 100 k (1988) $ 150 k (Total)

TITLE: CLOSURE CRITERIA

OBJECTIVES: To review criteria for tailings and waste rock impoundment closure

MAJOR STEPS (INCL. GO/NO GO DECISION)	YEAR	$k
1. Prepare a draft of closure criteria to meet provincial and federal guidelines	1988/89	50
2. Hold a workshop to discuss the draft criteria and to identify serious problems with respect to measurement, analysis, best available technology and long term reliability	1988/89	50
3. Finalize RATS guidelines to establish suitable research targets	1989/90	25
4. Recommend to regulatory agencies any necessary changes to insure feasible criteria	1990/91	5
5 Issue final guidelines based on technological improvements	1992/93	20

BACKGROUND:

The overall objective of the RATS work is to achieve "walk-away" closure of tailings impoundments. This assumes that certain agreed criteria are met. There is therefore the need to establish what those criteria will be. The final decision will rest with the regulatory agencies but these should reflect the capability of operating companies to define, achieve and measure these criteria. Such guidelines are essential in defining meaningful research projects.

OUTPUT:

A set of clear and definitive guidelines for closure and/or abandonment of tailings and waste rock impoundments.

PRIORITY: [I] II III Rationale: Common targets for research are required.

RATS PROJECT SUMMARY

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TOPIC MONITORING SUB-TOPIC

PROJECT NO. 4.4 BUDGET: $ 50 k (1988) $ 150 k (Total)

TITLE: CLOSURE CRITERIA

ADDITIONAL DETAILS:

1. John Hawley of the Ontario M.O.E. has much of the data required for the first draft prepared as part of other Ontario work.
2. Regulatory agencies set the legal guidelines.
3. RATS needs guidelines as targets for R & D projects
4. NUTP did not address this issue
5. Project 2.23 will document placement methods.

RATS PROJECT SUMMARY

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TOPIC MONITORING SUB-TOPIC

PROJECT NO 4.5 BUDGET $ - k (1988) $ 100 k (Total)

TITLE: FIELD METHODS MANUAL: WASTE ROCK

OBJECTIVES: To compile a field methods manual to provide guidance in the planning, conduct and assessment of sampling and monitoring projects of waste rock.

MAJOR STEPS (INCL. GO/NO GO DECISION)	YEAR	$k
1. Assemble available methodologies, monographs and literature on field methods for waste rock.	1989/90	20
2. Prepare a well indexed guidebook for use to conduct field tests, sampling and assessment for waste rock.	1989/90	80

BACKGROUND: In undertaking studies of waste rock in Canada there is a need to ensure that sound techniques are used in sampling and monitoring. The quality, reliability, reproducibility and comparability of data will depend significantly on the methods employed in the field. Uniform and reliable techniques should be established and assembled in the compendium of some type. Feedback on problems with any methods should be encouraged since waste rock sampling is very different from tailings sampling and experience is limited.

OUTPUT:
A guidebook of field methods for waste rock sampling and monitoring

PRIORITY: [I] II III Rationale: Comparable methodologies for field test work

RATS PROJECT SUMMARY

Date: Feb. 4, 1988
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TOPIC MONITORING SUB-TOPIC

PROJECT NO. 4.5 BUDGET: $ - k (1988) $ 100 k (Total)

TITLE: FIELD METHODS MANUAL: WASTE ROCK

ADDITIONAL DETAILS:

1. BBT, Saskatoon has reported in an Appendix to the report on Gunnar tailings on unsuccessful attempts to sample waste rock. National Uranium Tailings Program Report Requisition No. 23241-4-1674, Serial No. OSQ84-00195.

2. RATS Project 1.11 on literature review will include a review of waste rock sampling experience.

RATS PROJECT SUMMARY

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TOPIC MONITORING SUB-TOPIC

PROJECT NO 4.6 BUDGET $ 20 k (1988) $ 100 k (Total)

TITLE: MONITORING TECHNOLOGY EVALUATION

OBJECTIVES: To identify and assess monitoring techniques and instruments for use during the operation and closure of tailings and waste rock management areas.

MAJOR STEPS (INCL. GO/NO GO DECISION)	YEAR	$k
1. Identify the major parameters for tailings and waste rock control	1988/89	5
2. Identify available measurement and monitoring devices and techniques currently available	1988/89	5
3. Establish a priority list for monitoring needs	1988/89	10
4. Conduct further work if warranted	1989/89	80

BACKGROUND: The procedure of core sampling, pore water, decant and seepage analysis, fish kill, etc., are time consuming, expensive and at times inadequate to determine the environmental impact of tailings and the effectiveness of remedial measures. There is a need for rapid and effective devices which can monitor the entire waste management system either indirectly or with a minimum of time and labour. Techniques such as tracers, biosensors, and thermography have been suggested but none have been well developed or tested.

OUTPUT:

Evaluation reports on methods and instruments for monitoring of tailings and waste rock control measures.

PRIORITY: I II [III] Rationale: Monitoring technologies generall poorly developed.

RATS PROJECT SUMMARY

Date: Feb. 4, 1988
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TOPIC MONITORING SUB-TOPIC

PROJECT NO. 4.6 BUDGET: $ 20 k (1988) $ 100 k (Total)

TITLE: MONITORING TECHNOLOGY EVALUATION

ADDITIONAL DETAILS:

1. Initial field trials using thermography have given mixed results.
2. Memorial University of Newfoundland in cooperation with NRC has undertaken work to develop a biosensor for effluents from BP Selco's Hope Brook Mines.
3. Expectations are not high for effective monitoring and sensing devices in the short term.

5. TECHNOLOGY TRANSFER

PROJECT	RANKING	TOTAL ($K)	Page
5. TECHNOLOGY TRANSFER			
5.1 Review of NUTP Documentation	I	50	68
5.2 General Review and Distribution of RATS and other reports	I	50	69
5.3 Information acquisition from other key services	I	50	70
5.4 Liaison	I	25	71
5.5 Program Overview Report	I	50	72
TOTAL TECHNOLOGY TRANSFER		**225**	

RATS PROJECT SUMMARY

Date: Feb. 8, 1988
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TOPIC TECHNOLOGY TRANSFER SUB-TOPIC PROGRAM PLAN

PROJECT NO 5.1 BUDGET $ 10 k (1988) $ 50 k (Total

TITLE: REVIEW OF NUTP DOCUMENTATION

OBJECTIVES: Review of NUTP Reports for significance to RATS program

MAJOR STEPS (INCL. GO/NO GO DECISION)	YEAR	$k
1. Review NUTP reports on acid generation mechanisms	1988/89	20
2. Review NUTP reports on tailings disposal modelling	1988/89	10
3. Review NUTP reports on analysis and field sampling	1988/89	10
4. Review NUTP reports on tailings disposal methods	1988/89	10

BACKGROUND:

NUTP program costs $8.6 x 10 over 5 years producing approximately 100 reports. Thirty-five of these reports were classified (R. John) as significant to the RATS Program

OUTPUT:

Abstracts of each report (35) to be included in Min. Proc.

PRIORITY: [I] II III Rationale:

RATS PROJECT SUMMARY

Date: Feb. 8, 1988
Page 1 of 1

TOPIC TECHNOLOGY TRANSFER SUB-TOPIC PROGRAM PLAN

PROJECT NO 5.2 BUDGET $ 10 k (1988) $ 50 k (Total)

TITLE: GENERAL REVIEW AND DISTRIBUTION OF RATS AND OTHER REPORTS

OBJECTIVES: Review of RATS program output reports and allied publications

MAJOR STEPS (INCL. GO/NO GO DECISION)	YEAR	$k
1. Review and abstract of RATS program and allied reports (i.e. Waite Amulet, INCO, Copper Cliff, Falconbridge Sudbury (covers), Curragh Resources, Manitoba Mines (Acres, U. of Man), Consultant Reports (Monenco), (Nolan Davis - Waste Rock) Ontario Mines (Kam Kotia), New Brunswick (Heath Steele Waste Rock), Universities (Waterloo, U.B.C., the Lakehead University, U. of Man. Laurentian U. etc.)		

BACKGROUND:

Major project reports related to the RATS Program must be reviewed and the information transferred to the mines and project managers to avoid duplication. All report data will be required for input to final RATS manuals.

OUTPUT:

Abstracts to Min.Proc for computer storage and access.
Copies to project managers.

PRIORITY: [I] II III Rationale:

RATS PROJECT SUMMARY

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TOPIC TECHNOLOGY TRANSFER SUB-TOPIC PROGRAM PLAN

PROJECT NO 5.3 BUDGET $ 5 k (1988) $ 25 k (Total)

TITLE: INFORMATION ACQUISITION FROM OTHER KEY SERVICES

OBJECTIVES: Key sources of information on Acid-generating wastes from others, such as A.E.C.L., U.S.B.M., A.M.C., overseas work I.M.M.' I.A.E.A' I.E.A., etc.

MAJOR STEPS (INCL. GO/NO GO DECISION)	YEAR	$k
1. Compile other sources of information by :		
a) Reviewing technical publications from mining, environmental and water treatment organizations such as A.I.M.E. etc.		
b) Aquire copies of signficant papers		
c) Review and abstract for Min. Proc. catering and access.		

BACKGROUND:

Other agencies and potential technical organizations have acid generating problems from waste (i.e. Norway, China, Chile, etc.) and their work on this problem should be compiled for the RATS program.

OUTPUT:

Abstracts to Min. Proc. for computer storage and access - information noted and credited to source in final RATS manuals.

PRIORITY: [I] II III Rationale:

RATS PROJECT SUMMARY

Date: Feb. 8, 1988
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TOPIC TECHNOLOGY TRANSFER SUB-TOPIC PROGRAM PLAN

PROJECT NO 5.4 BUDGET $ 5 k (1988) $ 25 k (Total)

TITLE: LIAISON

OBJECTIVES: Ensure complete communication between the project implimentors and the clients (Mining Companies, Governments, Universities and Consultants)

MAJOR STEPS (INCL. GO/NO GO DECISION)	YEAR	$k
1. Prepare and distribute periodic new information bulletins		
2. Prepare and present results of past and current work.		
3. Maintain constant mail, telephone, telex and fax information to interested parties.		

BACKGROUND:

RATS program work must be transferred to the mining companies and regulators to ensure most efficient use of project resources. This reporting mechanism can be implemented in a consistent and effective manner.

OUTPUT:

Bulletins, technical and informational presentations. Consistent and regular communication telephone calls, letters, telex and fax messages.

PRIORITY: [I] II III Rationale:

RATS PROJECT SUMMARY

Date: Feb. 8, 1988
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TOPIC TECHNOLOGY TRANSFER SUB-TOPIC PROGRAM PLAN

PROJECT NO 5.5 BUDGET $ 25 k (1988) $ 50 k (Total

TITLE: PROGRAM OVERVIEW REPORT

OBJECTIVES: To assemble and distribute widely, a documentation of:

a) the key program components, and

b) participants' support

MAJOR STEPS (INCL. GO/NO GO DECISION)	NAME	YEAR	$k
1. Finalize project summaries, tabulation and short covering report. Present to steering committee	C. Ferguson E. Joe	Feb. 1988	
2. Approve program and agree to individual elements of support by companies and agencies re sites, funds, release of information, provision of manpower and services	F. Frantisak and RATS S.C Members	Feb. 1988	
3. Edit, print and widely distribute a record of projects and support	E. Joe Volunteers*	Mar. 1988	25

BACKGROUND:

* Proposed volunteers are : K. Ferguson, J. Errington, R. Michelutti, R. Siwik, M. Campbell and N. Dave with support from G. Feasby

OUTPUT:

A brief, definitive and timely documentation of both the technical program elements and the participants' support.

PRIORITY: [I] II III Rationale: Critical