Nova Scotia

Open File Report ME 1994-6

THE ACTIVITIES, CONCLUSIONS AND RECOMMENDATIONS OF THE INTERDEPARTMENTAL URANIUM COMMITTEE CONCERNING THE URANIUM EXPLORATION AND MINING INDUSTRIES

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July 1994

Final Report of the
Interdepartmental Uranium Committee - 1994

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FINAL REPORT OF THE INTERDEPARTMENTAL URANIUM COMMITTEE

A report entitled "The Activities, Conclusions and Recommendations of the Interdepartmental Uranium Committee concerning the Uranium Exploration and Mining Industries, July 1994" is hereby submitted to Government through your office. This report documents the investigations carried out by the Committee since its formation in 1985 and we believe it satisfies the mandate defined in our Terms of Reference.

The Interdepartmental Uranium Committee was formed pursuant to a recommendation of the Uranium Inquiry - Nova Scotia, Judge R. J. McCleave, Commissioner to carry out certain tasks and review issues associated with the uranium exploration and mining industries that were raised during the Inquiry. The Committee was established under the authority of the Minister of Mines and Energy and includes representatives of the Departments of Natural Resources (formerly Mines and Energy), Environment and Health. All members of the Committee concur with the conclusions and recommendations presented herein, and on their behalf I submit the report. We respectfully request you forward this report to the Honourable Minister of Natural Resources for his consideration.

George A. O'Reilly
Chair, Interdepartmental
Uranium Committee

FORWARD

This report documents the activities, conclusions and recommendations of the Interdepartmental Uranium Committee since it's formation in 1985. The Committee was given a variety of tasks, all of which were related to the uranium exploration and mining industries and the current moratorium on these activities that is due to expire in January 1995. The issues reviewed and the tasks carried out were defined in 1985 in the final report of the Uranium Inquiry - Nova Scotia, Judge R. J. McCleave, Commissioner. The report is written in non-technical language for the interested layperson but readers may need some background knowledge of the issues in order to fully understand certain aspects. Unfortunately, due to the complexity of some aspects, this is unavoidable.

The report is laid out as follows. A section outlining the history of the uranium issue in Nova Scotia (Section 1) is intended to provide readers with a background of information about how the issue(s) developed. Section 2 describes activities of the Committee between 1985-89 in dealing with one of our main tasks, which was providing Government with a means of releasing a large segment of the Province that was closed to all exploration during the Uranium Inquiry. Section 3 separately discusses the issue of exploration for uranium from the more contentious mining of uranium issue. Sections 4-7 describe advances made in the uranium mining/milling industry since 1985 in the issues of mining, radiation dosimetry, health risk assessment and jurisdiction respectively. A general discussion of the issues and how the Committee feels they relate to the future of the moratorium are presented in Section 8.

There have been several changes in the Committee membership over the years, but all have contributed significantly in their fields of expertise. The report was written by the chairperson of the Committee in concert with the various members. While all of the members concur with the conclusions and recommendations presented herein, the chairperson accepts responsibility for the report.

The Committee believes it has discharged its duty as laid down in the Terms of Reference and considers this document to be our final report to Government.

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS PRESENTED IN THIS REPORT

INTRODUCTION

Conclusions and recommendations are found at the end of several of the sections of this report. They are also listed here for quick reference of the reader. The Section in which each conclusion or recommendation is found is indicated. Readers are urged to read the appropriate sections in the report in order to understand the full context of each entry.

CONCLUSIONS OF THE INTERDEPARTMENTAL URANIUM COMMITTEE

Section 3 - The Issue of Exploration for Uranium

Conclusion 3-1 The Committee concludes that the results of environmental surveys show that advanced uranium exploration does not significantly impact on the surrounding surface waters. Radiation surveys indicate that the levels of radiation in the areas surrounding uranium exploration sites are not raised above background levels. The radiation levels within actual uranium-rich zones are elevated above background but the radiation exposures encountered by exploration workers are well below accepted radiation dose limits.

Conclusion 3-2 The Committee concludes that there is no scientific evidence to show that exploration for uranium, if done according to the regulations of the Mineral Resources Act, 1991, either adversely affects the environment nor the health of workers associated with this task.

Section 4 - Recent Advances in Uranium Mining Technology

Conclusion 4-1 The Committee feels that any uranium tailings management system involving the use of tailings dams can never be put into a true walk-away condition. The industry can design systems using dams that, in all probability, will contain the tailings for the long period of time necessary, but there always remains the potential for failure of the dams.

Conclusion 4-2 The pervious surround technology, in the last decade, has emerged as the accepted and preferred option of the uranium mining industry for management of mine and mill tailings for the future. It is the Committee's opinion that this technology, by far, represents the best option available to allow for long term abandonment of mine/mill tailings.

Conclusion 4-3 The Committee feels that the emergence of remote mining and non-entry mining techniques will enhance the uranium industries ability to adhere to the ALARA principle and minimize the radiation exposure encountered by mine workers.

Section 5 - Radiation Dose Limits

Conclusion 5-1 The Committee feels that the radiation dose limits about to be formalized in Nova Scotia's Health Act Regulations are more stringent than those currently followed by the AECB for uranium mining. This discrepancy will have to be addressed should a uranium mining development be proposed in the Province.

Conclusion 5-2 The Committee recognizes that adherence to the ALARA principle is an important factor contributing to the observed trend toward decrease of radiation dose levels received by uranium mine/mill workers in Canada. The formalization of ALARA as a regulation under the Atomic Energy Control Regulations will further insure this trend continues in the future.

Section 6 - Epidemiological Studies and Health Risk Estimates

Conclusion 6-1 The Committee concludes there is a risk associated with being a uranium miner. This risk is the result of uranium mine workers being subjected to levels of radon and radon progeny that are higher than those encountered in other industries and by the general public. The Committee feels that the magnitude of this risk can be minimized to acceptable levels if proper measures are taken. The Committee also concludes that the uranium mining industry has acted responsibly in defining the risk and openly relating it to the mine workers and the general public.

Conclusion 6-2 There is a direct association between risk and radiation dose. The risk to uranium miners will decrease as technological advancements continue to enter the industry. Any drop in radiation exposure will directly result in a further drop in risk.

Conclusion 6-3 A sound program of occupational health training involving co-operation between management and mine workers will further minimize the risk associated with uranium mining. Not only will such training introduce sound practices for dealing with radioactive substances, it will also educate the miners about the relative risks of mining radioactive ores versus the mining of non-radioactive ores. Since conventional mine accidents (i.e. those that occur in all mines and are not particular to uranium mines) account for up to 60% of the total risk facing uranium miners, the Committee feels there can never be too much occupational safety training.

Conclusion 6-4 Uranium miners who smoke incur a total risk that is more than a simple addition of the risk due to cigarette smoke and the risk associated with the mining of radioactive ores.

Conclusion 6-5 The existing epidemiological database for uranium miners may have a gender bias due to the fact that, historically, uranium mining populations are almost exclusively male. The resultant risk estimates are therefore applicable to males and may not be directly applicable to females. The trend toward gender equality in the workplace that exists in modern society will have to address this shortcoming.

Conclusion 6-6 The Committee concludes that the risk to the general public as a result of uranium mining is very low and may be considered to be insignificant. Windblown re-distribution of tailings and surface and groundwater radionuclide contamination are the only means by which radioactivity may escape the actual confines of a mine site. If proper mining procedures are followed the potential for such escapes affecting the levels of radiation received by the general public is extremely remote.

Section 7 - The Issue of Jurisdiction

Conclusion 7-1 The Committee concludes that the concept of a well structured Joint Management approach between the Federal and Provincial Governments is the most favourable method of regulating and managing the uranium mining/milling industry in Canada. A structured joint management scheme: (1) minimizes the chance of failures due to confusion over jurisdiction and responsibility; (2) provides excellent opportunity for public input; (3) satisfies the need to have separate reviews of site-specific proposals.

RECOMMENDATIONS OF THE INTERDEPARTMENTAL URANIUM COMMITTEE

Section 2 - Release of Closed Grounds Process

Recommendation 2-1 The Committee recommends that, to properly handle all types of naturally occurring hazards, a Committee or Panel be created that ensures proper notification is made and appropriate action is taken. This Committee should have representation from: Natural Resources, Health, Environment, Municipal Affairs, Transportation and Communication, and Land Use Secretariat. To ensure accountability, the Committee should report and make recommendation to Government through an agency not responsible to any particular Department, for example Policy and Planning.

Section 3 - The Issue of Exploration for Uranium

Recommendation 3-1 The Interdepartmental Uranium Committee finds there is no scientific or technical basis to warrant a moratorium on uranium exploration and therefore recommends the present moratorium on exploration for uranium be lifted.

Section 4 - Recent Advances in Uranium Mining Technology

Recommendation 4-1 The Interdepartmental Uranium Committee recommends that any future uranium mine development in Nova Scotia include use of pervious surround technology for tailings management.

Section 5 - Radiation Dose Limits

Recommendation 5-1 The Committee considers that the radiation dose limits currently in place in Nova Scotia are more stringent than those adopted by the AECB for uranium mining. The Committee therefore recommends that if ever a uranium mining development proceeds in Nova Scotia, the proponent conform to the Provincial radiation dose limits and the ALARA principle.

Section 6 - Epidemiological Studies and Health Risk Estimates

Recommendation 6-1 The Interdepartmental Uranium Committee recommends that, if and when there is any uranium mine development in Nova Scotia, there be a regulatory requirement for all mine/mill workers to take occupational health training prior to working in the mine. This training should include a presentation in which the risks associated with uranium mining are clearly stated and compared to the risks associated with non-uranium mining, other occupations and with the general public. There should be a clear statement of the synergistic relationship between cigarette smoking and uranium mining. Implementation of a non-smoking policy should also be considered as this would further serve to reduce risk to a minimum.

Section 7 - The Issue of Jurisdiction

Recommendation 7-1 The Committee recommends that if a uranium mining facility is ever proposed in Nova Scotia, the Provincial Government adopt a joint management scheme fashioned after that currently in place between the Governments of Canada and Saskatchewan.

Recommendation 7-2 Before any uranium development proceeds in Nova Scotia, the Provincial Government should first negotiate and formalize a Memorandum of Agreement between all of the Federal and Provincial Departments and Agencies involved. This will eliminate any chance for confusion over jurisdiction and responsibility.

Recommendation 7-3 If ever a uranium mining facility is contemplated in Nova Scotia, the Provincial Government should ensure that the various Departments tasked with regulatory and monitoring responsibilities are provided with the necessary equipment and staff training and accreditation to carry out these duties.

Section 8 - General Discussion, Conclusions and Recommendations on the Future of the Moratorium

Recommendation 8-1 The Committee recommends the moratorium on uranium exploration and mining in Nova Scotia be lifted.

Recommendation 8-2 The Committee recommends that the Government of Nova Scotia not re-activate the Uranium Inquiry for a global examination of the issues associated with the uranium mining/milling industry. Instead, if and when a proponent proposes to undertake advanced exploration of a uranium deposit, the Province should negotiate and implement a joint federal/provincial management scheme to review the proposal. The environmental review process, that is required under the joint management scheme, would serve as a uranium inquiry for that specific proposal.

CONCLUSIONS AND RECOMMENDATIONS OF THE URANIUM INQUIRY - NOVA SCOTIA

INTRODUCTION

The following is a summary of conclusions and recommendations of the Uranium Inquiry - Nova Scotia, Judge Robert J. McCleave, Commissioner. Although the Inquiry was completed in 1985, several of its conclusions and recommendations served as a basis from which the work of the Interdepartmental Uranium Committee proceeded. The lists below (indicated in bold) are direct quotations from the Inquiry Report. The pages of the report on which each quotation is found is given as an aid to readers.

CONCLUSIONS

As a result of a trip to a past-producing uranium mine in Bancroft, Ontario, Judge McCleave made the following conclusions given on pages 25-26 of the Inquiry Report:

The Commission concluded:

(1) That a small uranium mine could operate in a community without degrading the environment around it;

(2) That the vagaries of the uranium market were such that sudden economic disaster could hit hundreds of families;

(3) That Bancroft provided a model which Nova Scotians could reach easily (less than two hours drive from Ottawa) before making their own decision as to whether there should be uranium mining in this Province.

The following general conclusions relating to the uranium mining/milling industry are found on pages 29-31 of the Uranium Inquiry Final Report:

GENERAL CONCLUSIONS

(1) Methods exist by which uranium can be mined safely. It would have to be determined whether such uranium mining could take place at the one site in Nova Scotia which may prove to be viable and, more particularly, whether the tailings disposal which would be set up near any uranium mine would provide safe storage over an indefinite period of time.

(2) The uranium market for Nova Scotia would be an uncertain one, because the ore resources are not as rich as those now being developed in Ontario and Saskatchewan. There are also anti-uranium mining elements in the population who are concerned about its possible use in nuclear weapons. And, while this is an age productive of great feats such as mankind's ventures into space, the fact is that no one has yet designed a system to deal with the dismantling of nuclear generating stations of electricity and the safe storage of its radioactively impregnated materials.

(3) At first blush it would appear that control over uranium resources of Nova Scotia would pass entirely to the Federal government should the day arrive that uranium is to be developed. There are however methods by which a large measure of control could still be exerted by the Provincial government, and the Inquiry considers that it is in the public interest that there remain such control.

(4) **Uranium is an awesome source of energy yet, paradoxically, a wasteful user of its energy. Of the uranium taken from the ground, 1% is used in a nuclear reactor, 14% is part of the waste of that nuclear reactor, and 85% goes into the tailings disposal from the mining-milling. In addition, the chemicals such as barium used in its extraction pose problems to the environment.**

(5) **There is no level at which the radiation produced by uranium will have no effect. If proper measures such as ventilation, personal cleanliness and adherence to time limits for exposure, the risk can be made acceptable. To find otherwise would be to adopt a line of reasoning which would close down the nuclear medicine facilities which have helped Nova Scotians to live, and, if risky livelihoods were to be eliminated, close down our fisheries.**

(6) **Because of the divided nature of the jurisdiction between the Federal and Provincial governments, the public could be faced with several levels of public hearings should the question of resumption of prospecting for, and mining of, uranium arise in the future. It would be better that one set of hearings be held, with specific proposals such as site and method for tailings containment on the agenda.**

Section 41 of the Environment Protection Act of Nova Scotia gives the Minister of Environment the power to enter into agreements with Canada "to carry out the purposes of this Act."

The statement made by the Minister of Development to the Legislature on April 3, 1981 sets out the goals which the Inquiry considers to be appropriate for uranium mining.

(7) **While the Inquiry received more than 200 presentations it was odd that nobody really raised the issue of what to do with uranium finds made in such small amounts that would not lend to any attempt at uranium mining. The Inquiry will deal with such a possibility as an environmental issue quite divorced from the mining issue.**

The following are the recommendations of the Uranium Inquiry - Nova Scotia found on pages 32-38 of the Inquiry Final Report:

JURISDICTION

(1) **The Province should assert as much control as it can over its uranium resources. This can be accomplished by declaring its own provincial environmental standards for unacceptable levels. The Commission's preference is for the levels established by the Government of British Columbia, which have been accepted generally by both mining interests and environmentalists. Such levels can then be incorporated in the exploration of mining licenses, and these can still be effective should Federal jurisdiction enter the scene.**

(2) **The Provincial Public Service has the expertise and the will in its personnel of the Departments of Mines and Energy, Environment and Public Health - indeed the Commission has been impressed by the quality of public servants it met during the Inquiry and their ability to stand unjustified criticism - to deal with the mining, environmental and health issues raised by uranium. It is recommended that a committee be formed from these Departments to establish the levels, or recommend them to Government, that are set forth in Recommendation (1), and in the long run to carry out the other recommendations of the Inquiry by developing or sharing information now available.**

RADIATION IN MINING

(3) The Mineral Resources Act and the practices relating to reporting should be amended to require that when radiation is found during exploration or mining operations involving non-uraniferous minerals which is above the levels established by Recommendation (1), that such be reported as quickly as possible.

PROSPECTING

(4) The Inquiry considered that the laws of the Province are now sufficient to protect landowners against wrongful or excessive acts by those prospecting or exploring on their lands. Consideration should however be given to require that such parties who do not usually operate in Nova Scotia post performance bonds or make available some contact in the Province for the settlement of claims, such arrangement to be suitable to the Department of Mines and Energy. The Department should also consider placing restrictions or bans upon the use of chain saws in exploration unless there is specific written consent by the land owner.

(5) Legal remedies are available now for breaches of guidelines for uranium exploration, but the Commission considers that such should be given the force of regulations, so that breaches can be dealt with in the Courts. The public will be more comfortable if it considers that alleged breaches will be dealt with in the dispassionate atmosphere of the Provincial Court rather than in some Ministerial office. The Minister will probably be more comfortable too.

BAN ON URANIUM EXPLORATION

(6) The ban on exploration for all minerals in lands set out by license for uranium exploration is too sweeping and should be lifted. The minerals rights of Companies holding such licenses can be protected by giving them first rights to finds of uranium within the licensed areas whether they have discovered such or not, upon such terms and conditions as seem just to the Governor-in-Council. The areas licensed and now under ban but not found to contain uranium should be treated under the terms and conditions established by the Department of Mines and Energy. However, the time lapse - between the date of the ban and the adoption of this recommendation plus one month to advise affected parties - should not count against the time requirements of the Mineral Resources Act. When uranium is found in sufficient quantities to justify the exclusion of any area from development now, the time lapse should continue until permission is given.

TIME FOR RECONSIDERATION

(7) During 1990, the Government should determine from its interdepartmental committee established pursuant to Recommendation (2), and announce publicly, whether the five year ban should be continued. In the meantime, its Committee should keep itself up to date on a variety of matters (most of them set forth in the Digest) such as:

1. advances in the mining process for uranium - see the views of the Federal and Provincial Departments of the Environment, in the views of the various mining briefs and the options suggested by Ralph Torrie:

2. monitoring of the uranium tailings at Bancroft, Ontario, by the Federal Departments of Energy, Mines and Resources and the Environment, and the information available on small uranium mines in France (note the suggestion of Peter Warrian of the United

Steelworkers of America);

3. study the health factors from the Bancroft area and other Canadian areas as they relate to the fears held regarding uranium-induced cancers;

4. study the issue raised by Dr. Michael Brylinsky, Elizabeth May and others as to the uptake of radioactivity into the food chain, "biological magnification", and satisfy itself that corrective measures can be put in place.

PU8LIC ANXIETY AS TO USE

(8) The Inquiry considers that much public anxiety would be alleviated should peaceful purposes be found for Nova Scotian uranium. Unrest cannot be entirely eliminated because the uranium industry has been noted for its secretiveness and has thus laid itself open to misrepresentation and mistrust. It should be noted that Crown corporations in Canada can involve themselves in an international cartel with immunity of prosecution according to the Supreme Court of Canada.

The Inquiry considers that the factors, which should be considered by a Nova Scotian government of the future, in making a determination as to whether further uranium exploration and uranium mining should take place, should include:

1. the right miner - the mining should be done properly, by a company of impeccable and proven standing and financial resources (Kidd Creek would qualify because of its professionalism and resources and high standards of operation);

2. market - the Inquiry's personal preference would be uranium mined in Nova Scotia for use in Nova Scotia. This would mean use for electric power generation. Indeed such a step may be solution for heavy water industry of Cape Breton. This would involve a change of Government policy, and the Inquiry considers that such should only be considered when the safe dismantling of a nuclear reactor is shown to be possible. if tidal power or the offshore resources or large new coal mines are able to generate electricity, and if the technology for long-term tailings containment is proven, then our uranium resources would have to be developed for world markets. Secure markets should then be found.

PUBLIC HEARINGS

(9) The Inquiry considers that there should be a high level of Federal-Provincial cooperation in any future dealing with this resource. Instead of a series of hearings, for example, by the Environmental Council in Nova Scotia and the Atomic Energy Control Board there should one set of hearings, specific as to site and other factors. Citizens' groups should be asked to submit names of expert witnesses who would be heard in addition to the experts from the various government departments and agencies.

GENERAL CONCLUSIONS

(10) The Inquiry accepts the argument that it would be improper to permit exploration for uranium but withhold the right to mine what has been found, at least until a re-determination is made during 1990. It is however satisfied that exploration can be carried out safely within the provisions suggested by the Medical Society of Nova Scotia, and it may be in the public interest

to have a better knowledge of the extent of the uranium resources which could be mined. In short the matter of exploration should be reviewed even if the ban on mining is to continue for another period of time, but that 1990 consideration should report the technical and technological changes that would make it more likely that uranium mining could be carried out with its long-term tailings disposal properly secured. Apart from the tailings issue, the Inquiry clearly finds that the mining of uranium can be carried out if proper precautions are taken for the health of the miners and that techniques also exist at the milling stage.

PUBLIC RELEASE

(11) The Inquiry recommends that its report including the digest be made public as quickly as possible, and that copies be made available without charge to the presenters. Envelopes for such distribution will be made available to Government before the Inquiry is closed and its staff released.

FORMATION OF THE INTERDEPARTMENTAL URANIUM COMMITTEE

The Interdepartmental Uranium Committee was formed in 1985 as a result of one of the recommendations of the Uranium Inquiry - Nova Scotia. Announcement of formation, makeup and tasks of the Committee was made to the Legislative Assembly by the Honourable Joel Matheson, Minister of Mines and Energy. The complete text of the Ministerial statement follows:

STATEMENT BY THE HONOURABLE JOEL R. MATHESON
MINISTER OF MINES AND ENERGY
TO THE NOVA SCOTIA LEGISLATIVE ASSEMBLY
MARCH 1985

Mr. Speaker:

I would like to make a statement to the House of Assembly on the report and recommendations of the Nova Scotia Uranium Inquiry Report and provide the House with the Government's response to those recommendations.

Mr. Speaker, the inquiry came about following the declaration of a province-wide moratorium on uranium exploration.

Judge Robert J. McCleave, Q.C., was appointed in February of 1982 to head an inquiry into public attitudes and risks associated with all phases of the uranium mining cycle.

During the course of the Inquiry, Mr. Speaker, 44 public meetings were held and more than 200 briefs were submitted by private citizens, interest groups, government agencies and the mining industry.

Judge McCleave has now completed his work and his final report was submitted to the Executive Council on January 30, 1985.

At this time, I would like to publicly thank Judge McCleave for the time and energy he spend in developing such a detailed report on a subject that is important to many Nova Scotians, both private citizens and the industry as well.

The Inquiry Report represents the Commissioner's assessment of public concerns addressed to the Commission.

Mr. Speaker: Judge McCleave arrived at six principal conclusions. The Government's response is given after each conclusion.

1. The Inquiry recommended that a provincial moratorium on uranium exploration be continued for at least an additional five year period.

   Mr. Speaker: The ban on uranium exploration and, therefore, mining, will be extended for an initial period until at least January 1990.

2. The Inquiry further recommended that an interdepartmental committee should be constituted to (a) establish the threshold value for uranium mineralization above which all exploration activity must be terminated, and conditions governing its application and, (b) monitor and report on new management and technical developments in uranium mining and milling operations over the five year period, including the methods used to contain uranium tailings.

Mr. Speaker: An interdepartmental committee consisting of Mines and Energy, Environment, and Health will be established. The committee will:

(a) Establish a regulatory requirement for a uranium threshold value above which all exploration/mining activity will be halted on lands so specified. This value will be determined through evaluation of existing information from provincial files and comparison with similar limits established in other jurisdictions.

(b) Establish, through regulation, procedures for:
- (I) Notification to Mines and Energy when the threshold value has been reached;
- (II) Uranium mineralization sampling and reporting;
- (III) Delineating the boundaries of properties where all exploration/mining activity is to be prohibited;
- (IV) Monitoring properties identified as having uranium above the threshold value.

(c) Monitor developments in management procedures and technologies to address outstanding environmental issues associated with all phases of the uranium mining cycle.

3. The third major conclusion, Mr. Speaker, is that the existing ban on exploration for all minerals in specified lands set out by License for Uranium Exploration should be lifted for those properties exhibiting uranium mineralization below a specified threshold value.

Mr. Speaker: When the necessary regulatory procedures are in place, as established by the Interdepartmental Committee, properties held under the existing moratorium and exhibiting uranium mineralization within the established limit will be released for all other exploration activity. It is Government's intention to proceed quickly to establish proper threshold values.

4. The Inquiry further stated that the Province should exert as much control as possible over the entire uranium mining cycle.

Mr. Speaker: The Government is in agreement that it will be necessary to ensure that the uranium mining industry will meet all relevant provincial mining, environmental and health legislative requirements before any consideration is given to altering or removing the moratorium.

The committee will examine existing mechanisms and approaches adopted in Saskatchewan and Ontario with a view to evaluating their effectiveness in ensuring compliance with provincial legislation.

5. The inquiry determined that safe procedures for the long term abandonment of mine/mill tailings are a major issue in uranium mining.

Mr. Speaker: Uranium mining and milling has never been carried out in this Province, consequently, this issue does not presently apply in Nova Scotia. As indicated in the response to Conclusion 2, the Government will, however, continue to monitor research and technological developments related to the safe abandonment of uranium mine/mill tailings.

6. Finally, Mr. Speaker, the Inquiry recommended that at the close of the five year period, the Government should decide whether there should be a thorough review of the issues and another opportunity provided for public input, or a further extension of the moratorium.

   Mr. Speaker: The Government agrees that prior to making any change in the conditions of the moratorium, there will be an opportunity for further continuing public review and assessment.

Those, Mr. Speaker, are the six major conclusions in the Inquiry Report and the Government's response to each.

It is also noted that in the Judge's report he stated a personal preference that should there ever be uranium mining in the Province, such uranium should be used for peaceful purposes such as power generation.

Mr. Speaker, I wish to make it clear to this House and the people of Nova Scotia that this Government has no intention of using uranium for provincial power generation.

Thank you Mr. Speaker.

INTERDEPARTMENTAL URANIUM COMMITTEE
TERMS OF REFERENCE

INTRODUCTION

An Interdepartmental Uranium Committee was established on March 19, 1985 on recommendation of the Uranium Inquiry - Nova Scotia final report of Robert J. McCleave, Q.C. The Ministers of Natural Resources, Environment and Health have appointed the following personnel to the Committee:

George A. O'Reilly (Chairperson)
Project Geologist
Mineral Resources Division
Nova Scotia Department of Natural Resources

Daniel A. Khan (Secretary)
Mining Engineer
Mining Engineering Division
Nova Scotia Department of Natural Resources

Daniel E. Hiltz
Manager
Industrial Pollution Control
Resource Management and Pollution Control Division
Nova Scotia Department of the Environment

David R. Briggins
Hydrogeologist
Water Resources Branch
Resource Management and Pollution Control Division
Nova Scotia Department of the Environment

Dr. Jeff Scott
Medical Officer of Health
Nova Scotia Department of Health

Mr. Patrick J. Wall
Radiation Officer
Environmental Health Division
Nova Scotia Department of the Environment

DUTIES

The Interdepartmental Uranium Committee was established by Cabinet to address the following tasks:

1. Recommend the establishment through regulation of a level of uranium in the Province above which all exploration and mining activity must be halted.

2. Recommend a regulatory framework for:

- Notification to Department of Natural Resources by exploration license holders when the established threshold level has been reached.

- A monitoring system of exploration for minerals other than uranium to insure the threshold level for exploration has not been exceeded.

- Delineation of the boundaries of areas where all exploration/mining activity is to be prohibited for the five year term of the moratorium.

- Monitoring of properties recognized as exceeding the threshold level.

3. During the five year term of the moratorium, the Committee will monitor developments in technologies and management procedures to address outstanding environmental and health issues related to all phases of the uranium mining cycle. Special attention will be given to studies related to the safe abandonment of mine and mill tailings.

4. Examine existing regulatory frameworks and approaches utilized in jurisdictions where uranium is mined at present, in order to evaluate their effectiveness.

APPROACH

To achieve the above listed duties, the Committee will meet on a regular basis and:

- Examine existing data on the distribution of uranium in the various geological environments of Nova Scotia. The main source of this data will be all assessment reports of exploration which were submitted to the Department of Natural Resources as part of the special uranium license regulations.

- The Committee will examine the criteria used by other jurisdictions to establish uranium threshold values in exploration for and mining of minerals other than uranium.

- The Committee will examine the environmental and health impacts of various threshold levels and their implications for the mining industry in Nova Scotia.

- Once existing data are evaluated, the Committee may recommend designation of areas which are to remain closed to all exploration and mining activity for the five year term of the moratorium.

- During the period of the five year moratorium, the Committee will communicate with jurisdictions in which uranium mining is permitted. This will allow the Committee to examine existing regulatory frameworks in order to evaluate their effectiveness if applied to Nova Scotia.

- The Committee may request input from sources it deems appropriate.

REPORTING PROCEDURES

The Interdepartmental Uranium Committee will report to the Nova Scotia Government through the Nova Scotia Department of Natural Resources. Official requests and reporting will be made in writing to the Minister of Natural Resources through the Executive Director, Mines and Minerals Branch.

BUDGET

Each Department represented on the Committee will allow staff time and in Province travel expenses for Committee members.

The Department of Natural Resources will be considered the agency responsible for additional expenses incurred by the Committee. All requests for these additional expenses will be prior approved by Natural Resources.

SECTION 1

HISTORY OF THE URANIUM ISSUE IN NOVA SCOTIA

1.1 INTRODUCTION

This section provides a background of the uranium issue in Nova Scotia. This includes a description of where uranium has been discovered and the process or jurisdictional framework under which uranium exploration was carried out. Exploration activity in the late 1970's resulted in discovery of numerous occurrences of uranium and spurred a realization that mineable-sized deposits of uranium may exist in the Province. This led to public outcry, particularly in regions where exploration was most intense. In response to the public concern the Government placed a moratorium on uranium exploration in 1981 and implemented a process of inquiry and review that is still in effect today. The information herein is but a brief summary and readers are referred to the submission of the Nova Scotia Department of Mines and Energy (now part of Natural Resources) to the Uranium Inquiry (NSDME, 1982) for more detailed information on the evolution of this issue.

1.2 EXPLORATION AND DISCOVERY OF URANIUM IN NOVA SCOTIA

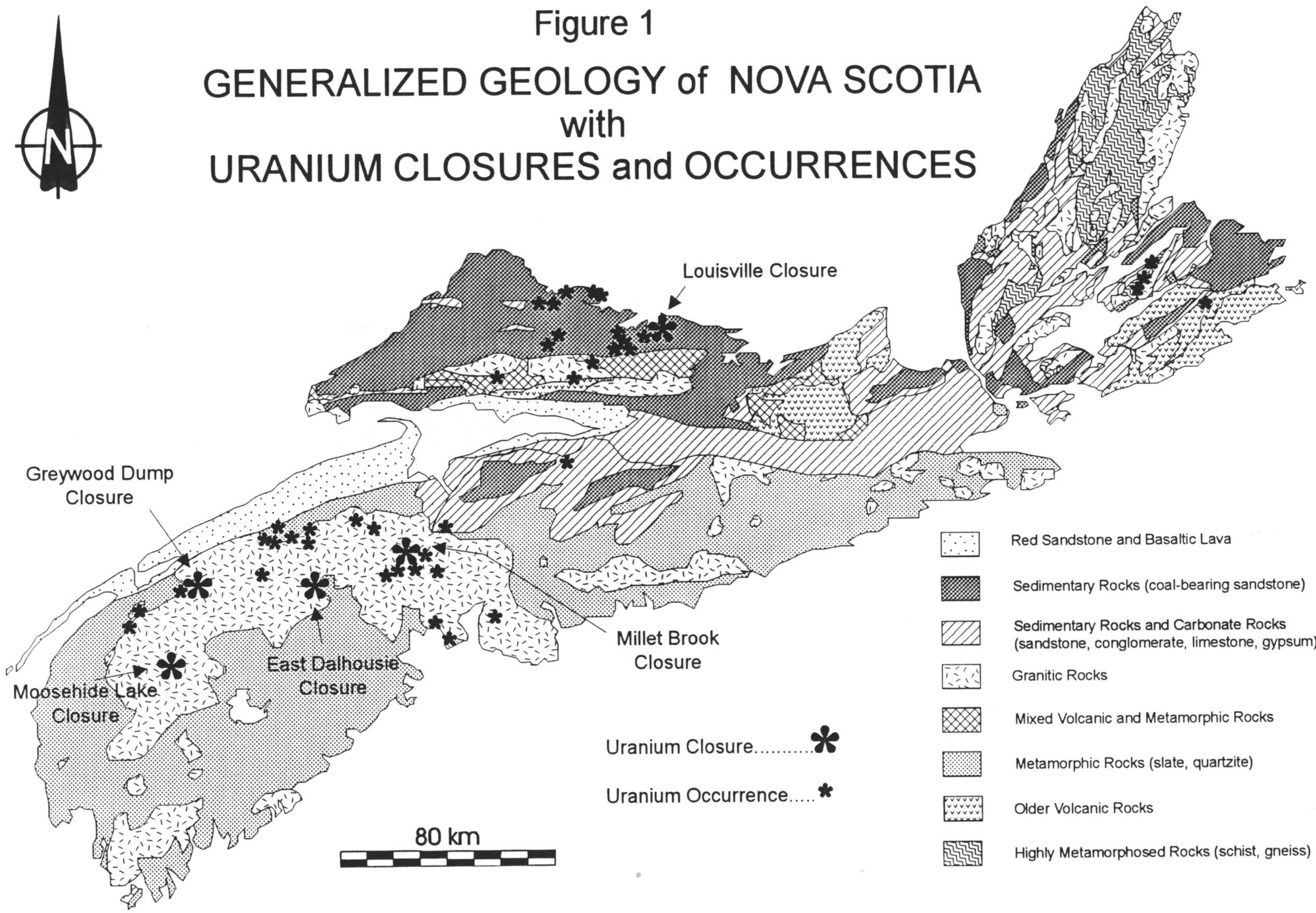
Occurrences of uranium-bearing minerals have been known in Nova Scotia since the early part of this century (Fig. 1). All of the occurrences discovered in the early years are minor in size and none are the result of what would be considered to be extensive exploration programs. Discovery was usually the result of prospectors and exploration geologists recognizing the presence of radioactive minerals in outcrop exposures.

The Province underwent a period of intense exploration for uranium from 1976 up until the calling of a moratorium on uranium exploration in 1981. This period of elevated exploration activity for uranium coincided with a similar boom in exploration for deposits of tin and related elements. In the mineral exploration industry there exists a common knowledge that, on a world-wide basis, there is an association between deposits of tin and some types of deposits of uranium. Geological terrains that are found to host deposits of tin are often found to host deposits of uranium. This statement holds true in Nova Scotia. It should be clarified that, although the deposits of tin and uranium occur in the same areas, they do not very often occur in the same deposit. Uranium deposits can often have elevated levels of tin and other metals while some deposits of tin and base metals can have a mildly elevated level of uranium. Economically mineable amounts of both tin and uranium in the same deposit are rare.

The period of modern era mineral exploration cited above resulted in discovery of numerous occurrences of uranium throughout several of the geological terrains that exist in the Province (Fig. 1). The exploration also resulted in discovery of many other types of mineral occurrences including tin, tungsten, copper, lead, zinc, gold, silver, antimony, beryllium, bismuth, cadmium and indium. Only one of the uranium deposits discovered during this era is large enough to be considered as a possible candidate for mining. The Millet Brook Uranium Deposit (Fig. 1) was discovered in the granitic rocks near Vaughans, Hants County in 1978 by a Canadian subsidiary of a French exploration company, Aquitaine Company of Canada Limited. Aquitaine was taken over by Kidd Creek Mines Limited in 1981 who were subsequently taken over by Falconbridge Limited in 1986. The Millet Brook Deposit actually consists of three separate uranium-bearing zones, the accumulative grade and tonnage of which were thought may form an economic-sized uranium deposit. The Millet Brook area contains numerous other occurrences of uranium. Many of these are known to be sub-economic but many others had yet to be evaluated in detail before the moratorium was called.

Figure 1

GENERALIZED GEOLOGY of NOVA SCOTIA with URANIUM CLOSURES and OCCURRENCES



1.3 TYPES OF URANIUM OCCURRENCES

Promising indicators of the presence of uranium deposits were reported in a federal government survey of the metal content of well waters in northern Nova Scotia (Dyck et al., 1976). This attracted uranium exploration to the large sedimentary basins that underlie that area (Fig. 1). The exploration discovered several examples of a type of uranium occurrence known as roll-front deposits. The sedimentary rocks of northern Nova Scotia are similar to those found in the Colorado Plateau area of the western United States. The Colorado Plateau is the main uranium producing area for the United States with most of these deposits being of the roll-front variety.

All of the roll-front occurrences discovered in Nova Scotia are of low grade and tonnage (i.e. small content of uranium in a low tonnage of rock) and are non-economic. The roll-front occurrence with the most extensive uranium mineralization occurs at Louisville, Pictou County (Fig. 1) where thin discontinuous bands of uranium mineralization in the order of less than 200 parts per million (ppm) were intersected in 9 of 20 diamond-drill holes drilled by Lacana Mining Corporation.

During exploration for roll-front deposits, Gulf Minerals Canada Limited encountered radioactive boulders of volcanic rock in a breakwater near Port Howe, Cumberland County. The boulders were found to be from the Folly Lake quarry area, thus Gulf Minerals embarked on an extensive exploration program throughout the volcanic terrains of the Cobequid Highlands. Early exploration resulted in discovery of more highly radioactive boulders. This resulted in further exploration effort, including thousands of feet of diamond-drilling, but only a few minor occurrences of uranium were discovered.

By far the most promising occurrences of uranium were found within a large granitic massif, the South Mountain Batholith, that underlies much of the central part of south-central mainland Nova Scotia (Fig. 1). Esso Minerals Canada and Aquitaine Company of Canada Limited concentrated much of their efforts in the central and western portion of the South Mountain Batholith. Shell Canada Resources Limited explored along the southern margin of the Annapolis Valley and Saarberg Interplan explored the region between Windsor and Saint Margarets Bay. The occurrences found within the South Mountain Batholith are of a variety known as vein-type uranium deposits. Prior to these discoveries this type of deposit was not known within the Canadian Appalachians. Geological research established that this type of uranium deposit is common within the granitic terrains of France and eastern Europe where several deposits are currently being mined. The Millet Brook Deposit was being extensively explored by diamond-drilling at the time of calling of the uranium moratorium in 1981. At cessation of exploration, Kidd Creek Mines Limited had defined a possible reserve of 1,180,495 pounds of uranium oxide (U_3O_8) in the three zones that comprise the deposit.

1.4 GOVERNMENT REGULATION AND ACTION ON URANIUM ISSUES

1.4.1 Special Uranium Exploration Licences

The Nova Scotia Government has jurisdiction over the mineral resources of the Province. Mineral exploration activity is regulated through the Mineral Resources Act and administered and monitored by the Department of Natural Resources (formerly Mines and Energy). In May 1975 the Mineral Resources Act was revised to withdraw coal, salt, potash and uranium from application for an exploration license. In the case of uranium (the other three commodities will not be discussed), the Government felt it was necessary to monitor the progress of exploration through special Order-in Council agreements. These

"Special Licences for Uranium Exploration" allowed Government to know where and by whom exploration for uranium was being carried out. It also stated (Section 24, (2)) that "Lands withdrawn from application for a licence may be worked, licenced or leased under an agreement or arrangement with the Crown in such a manner and upon such terms and conditions as may be provided by order of the Governor in Council". Placing uranium exploration under special licence category allowed the Government to add separate and additional constraints over and above those normally placed on exploration for other commodities. These "extra" constraints are placed on the Special Licence holder as the "terms and conditions" cited above.

1.4.2 Formulating the Terms and Conditions for Uranium Exploration

In 1975 the only terms and conditions placed on a Special Uranium Licence was the submission of a work proposal. In 1979 the Government began to formulate special guidelines for uranium exploration. This was in response to the realization that a significant discovery of uranium had been made at Millet Brook, Hants County and that the licence holder, Aquitaine Company of Canada, wished to enter a more advanced stage of exploration involving ground disturbance and detailed diamond-drilling. By 1981 the guidelines had gone through two drafts and considerable review and were then formalized as "Terms and Conditions Governing Special Uranium Exploration Licences in Nova Scotia". This move allowed the Government to closely constrain and monitor uranium exploration activity by formally tying adherence to the Terms and Conditions to the actual granting of the licence. In a sense, the Terms and Conditions were more restrictive than regulations, since the determination of adherence to the prescribed procedures was a direct Cabinet decision.

1.4.3 Calling of a Moratorium on Uranium Exploration in Nova Scotia

A moratorium on the issuing of new Special Uranium Exploration Licences and the renewal of existing licences was approved by Cabinet and announced by the Minister of Mines and Energy on Sept 22, 1981. Uranium exploration on all existing licences essentially ceased at that time. By May of 1982, all Special Uranium Licences that existed at the time of the calling of the moratorium had expired. Since that date there has been no further exploration for uranium in the Province.

With the calling of the moratorium the Government announced its intention to establish a public inquiry to look into all aspects of the uranium exploration and mining industries. The Government would not make a decision on the status of the moratorium until final report of the Inquiry.

In 1982, the Minister of Mines and Energy withdrew 507,360 acres from exploration for all minerals for the duration of the moratorium. These grounds were closed in the names of several of the mining companies that were actively exploring for uranium at the calling of the moratorium. These closed grounds included sites of known uranium mineralization as well as large tracts of land on which the companies wished to retain uranium exploration rights when the moratorium was over. The main purpose of the closures was to protect the rights of the licence holders during the period of the moratorium.

1.4.4 The Uranium Inquiry - Nova Scotia

Early in 1982 the Government announced the appointment of Judge Robert J. McCleave, Q. C. as Commissioner under the Public Inquiries Act, to look into the impact of uranium exploration and mining in the Province. On February 9, 1982, the Uranium Inquiry - Nova Scotia was established by Order in

Council No. 82-200 of the Nova Scotia Government.

Judge McCleave intended the Uranium Inquiry to take place in three stages. A first stage was to identify the issues by way of public meetings held throughout the Province. At these meetings all interested citizens, groups of citizens, organizations, companies and Government Departments and agencies were allowed to present their views in a semi-formal, non-confrontational surrounding. All presentations were asked to be provided in written form for inclusion in Inquiry files. Upon conclusion of 44 public meetings, which took about six months, the submissions were digested and the issues defined by Judge McCleave. This ended stage one. Initially, the Inquiry was to then proceed to stages two and three. Stage two was to bring the Inquiry into a more formal setting and involve a confrontation between opposing views. The participants were to testify under oath and there would be an opportunity for cross-examination. Stage three was to consist of final arguments to issues questioned in the first two phases after which Judge McCleave would document his conclusions and recommendations.

The Inquiry did not proceed to stages two and three due to one main factor. The industries chief proponent in the Inquiry, Kidd Creek Mines Limited, withdrew from any further discussions at the end of Stage 1. Kidd Creek had made a corporate decision to withdraw based on a depressed market price for uranium and a poor outlook for its future rise. Equally important in this decision, was the questionable economic viability of mining a low grade uranium deposit such as is the Millet Brook deposit. In the mid-1980's several much higher grade uranium deposits with immense reserves of ore were about to enter a mining stage in Saskatchewan thus providing insurmountable competition in an already depressed market. After this development in the Inquiry, Judge McCleave elected to forego the second and third stages and concluded that these confrontation stages would be impractical and a waste of public monies without input from Kidd Creek. The Inquiry recognized that, in practical terms, any complete analysis of whether or not uranium should be explored for or mined requires analysis of some specific-site example. Without a site-specific analysis the Inquiry could only deal with the issues in general terms. To conclude the Inquiry, Judge McCleave documented a digest of Stage 1, defined what he considered to be the main issues and made several general conclusions and recommendations. He submitted his "Report of the Commission of Inquiry on Uranium" to Government on January 30, 1985. A summary of the McCleave Inquiry recommendations and conclusions is provided earlier in this report.

1.4.5 The Interdepartmental Uranium Committee

The Minister of Mines and Energy announced Government action on the McCleave Inquiry report and recommendations to the Legislature on March 19, 1985. As a result of the recommendations, the Government extended the moratorium until January, 1990 and appointed a six person Interdepartmental Uranium Committee made up of representatives from the Departments of Mines and Energy, Health and Fitness, and Environment. Appointed to the Committee were:

1.4.5.1 Department of Mines and Energy (now Natural Resources)

George O'Reilly (Chairperson), Project Geologist, Mineral Deposits Section, Mineral Resources Division.

Patrick Hannon (Secretary), Manager of Mining Engineering, Mining Engineering Division.

> Mr. Hannon was replaced by Michael Grice, Mining Engineer in 1987 who was subsequently replaced by Daniel Khan, Mining Engineer in 1993.

1.4.5.2 Department of the Environment

William Coulter, Environmental Engineer, Environmental Assessment Division.

Mr. Coulter was replaced by Daniel Hiltz, Manager Industrial Pollution Control, Resources Management and Pollution Control Division in 1990.

Dr. Chang Lin, Chief of Water Resources Planning.

Dr. Lin was replaced by Creighton Brisco, Manager, Water Resources Services in 1990 who was subsequently replaced by David Briggins, Hydrogeologist, Water Resources Branch in 1994.

1.4.5.3 Department of Health

Dr. Pierre Lavigne, Provincial Epidemiologist.

Dr. Lavigne was replaced by Dr. Christiane Poulin, Field Epidemiologist in 1988 who was in turn replaced by Ted Dalgleish, Senior Radiation Health Officer in 1990. Mr. Dalgleish was replaced by Patrick Wall, Radiation Officer, Environmental Health Division in 1994. The Environmental Health Division has since been transferred to the Department of the Environment where it now resides.

Dr. John Prentice, Director, Fundy Health Unit.

Dr. Prentice was replaced by Dr. Donald Langille, Director, Cobequid Health Unit in 1988. Dr. Langille was replaced by Dr. Jeff Scott, Medical Officer of Health, Public Health Services Division in 1994.

Readers are referred to the Terms of Reference provided earlier in this report but in short, the Committee was given short and long term mandates. The immediate task of the Committee was to delineate areas of known uranium mineralization and recommend changes to the existing regulatory framework and exploration monitoring procedures to allow release of the portion of the closed grounds on which there is no uranium mineralization identified. The long term mandate of the Committee was to monitor technological developments in the uranium mining industry, especially those dealing with long term abandonment of uranium mine tailings. In addition, the Committee is to review regulatory frameworks in jurisdictions that allow uranium mining.

The Committee accomplished their short term mandate and submitted recommendations to the Minister of Mines and Energy in January 1986 (Appendix 2). Government action to accommodate the recommendations consisted of formulation of regulations as well as alterations to existing exploration monitoring procedures. These changes were formalized in December 1989 as Report and Recommendation to Executive Council (Appendix 2) that: (1) released the portion of the closed grounds that was found not to contain uranium mineralization as defined by the Committee; (2) amended the Mineral Resources Act Regulations to add regulations respecting mineral exploration in general and chance encounters of uranium during non-uranium mineral exploration in particular; and (3) extended the uranium moratorium until January 1995 to allow the Interdepartmental Uranium Committee additional time to carry out its long term mandate.

SECTION 2

RELEASE OF CLOSED GROUNDS PROCESS

2.1 INTRODUCTION

This section describes the activities of the Interdepartmental Uranium Committee leading up to submission of a series of recommendations to Government on January 20, 1986 (Appendix 2). These activities comprised the first stage of the two stage mandate of the Committee. The first stage, or immediate first priority of the Committee was to establish a framework to allow Government to release for non-uranium exploration, that portion of the 507,360 acres closed to all exploration during the moratorium. The second, or long term stage of the Committees mandate, is described in subsequent sections. The Committees 1986 recommendations suggested changes to the regulations under the Mineral Resources Act as well as alterations to the mineral exploration monitoring procedures of the Department of Mines and Energy (now Natural Resources). The recommendations also established a concentration threshold of uranium above which exploration and/or mining of commodities other than uranium must cease. Government action on the recommendations led to release of much of the closed grounds in 1989 (see Section 1.4).

2.2 RADIATION EXPOSURE VERSUS A URANIUM CONCENTRATION THRESHOLD

The Interdepartmental Uranium Committee commenced formal meetings in May of 1985. Once the Committee began detailed deliberations, it became immediately apparent that one particular component of the assigned tasks was going to be a problem and needed clarification. The Ministerial statement to the Legislature that created the Committee (provided earlier in this report) stated that the Committee will: "establish a regulatory requirement for a uranium threshold value above which...". A uranium threshold value is a measure of uranium concentration and affixing environmental and health impacts to a concentration threshold raises several problems. Firstly, there are no uranium concentration levels that can be linked to health risk assessments. The abundant volumes of medical studies that deal with aspects of health risk assessment for radioactive substances always deal in terms of *radiation* thresholds not *concentration* thresholds. Thus a concentration threshold for uranium cannot be scientifically defended.

Secondly, a uranium concentration threshold does not take into account the environmental and health impacts due to important uranium progeny such as radon and radium. Radiation dosimetry (measurement of radiation levels) accounts for radiation from all sources, not just uranium. Situations have been documented in which the workings of non-uranium mines have been found to contain high levels of radon, sometimes far in excess of levels permitted in uranium mines (e.g. the fluorspar mines of Cape St. Lawrence, Newfoundland).

Thirdly, radiation levels are more easily and cheaply monitored than a uranium concentration level. A uranium concentration level is subject to the problem of sample size selection and therefore situations such as high-grading and diluting would have to be considered. These problems do not come to play in radiation dosimetry as a work site would simply be monitored for its ambient radiation levels regardless of the source element(s) of the radioactivity.

The Committee related these concerns to the Minister of Mines and Energy and indicated that a change in the philosophical approach to our duties would be required. A combined radiation/concentration threshold approach was proposed by the Committee and was accepted by the Minister. In this combined approach, environment and worker safety concerns would be accommodated by using a radiation threshold. A concentration threshold would be based solely on economic criteria and would serve only to alert that a particular exploration/mining project is dealing with rock of uranium content approaching sub-ore grade. The Committee therefore, refers to the concentration threshold as an "economic concentration threshold for uranium." A concentration threshold of 100 parts per million uranium was eventually recommended to the Government. The criteria used to establish this particular level is outlined in Section 2.3.

2.2.1 Radiation Exposure Thresholds

Once approval of a combined radiation/concentration threshold approach was received, the Committee continued its review and quickly determined that radiation exposure thresholds already exist in Nova Scotia. Jurisdiction for ionizing radiation exposure falls under the Occupational Health and Safety Act for persons in the workplace and under the Health Act for the general public. Radiation exposure limits have existed for some time under these Acts and conform to the International Commission on Radiological Protection (ICRP) accepted levels. In short then, all work sites in the Province, including mines and exploration sites, must adhere to these existing radiation thresholds regardless of the concentrations of uranium or other radioelements in the surroundings. A review of the radiation thresholds is discussed in a later section.

2.2.2 The Concept of an Economic Concentration Threshold for Uranium

There is some concern on the part of the Committee that there may be mis-interpretation of the concept of an economic concentration threshold. The Committee wishes to emphasize that the concentration threshold is not a measure of health risk or environmental impact. This threshold was determined solely on economic grounds to: (1) provide the Government with a cut-off criteria by which they may determine areas of specific uranium mineralization that will remain closed for the term of the moratorium; (2) provide an estimate of uranium concentration below which a deposit would be non-economic to mine even under the most optimistic of circumstances (e.g. high price of uranium per pound, utilization of low-cost mining methods); (3) assure the public that any particular non-uranium mine is not mining an ore which has an elevated uranium content and that uranium is simply being disposed of in the waste tailings.

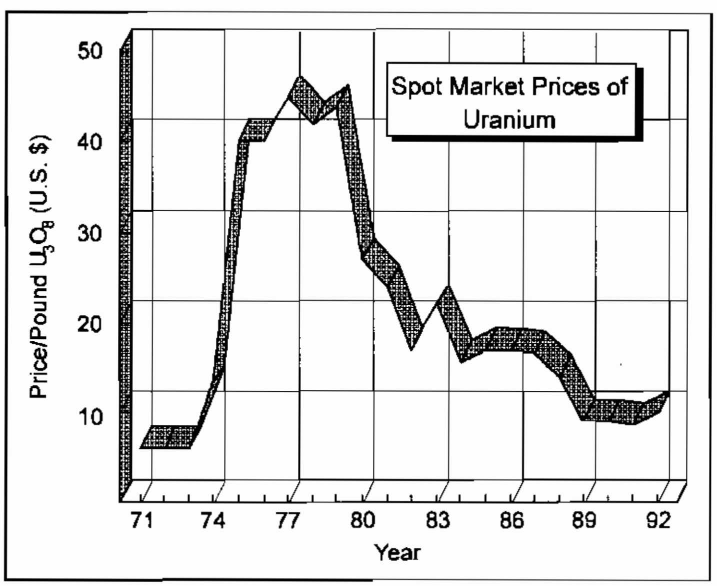


Figure 2. Prices of uranium from 1971 to 1992. Note the high prices during the period of uranium exploration in Nova Scotia between 1976-1981. Data from Canadian Minerals Yearbook.

2.3 ESTABLISHING AN ECONOMIC CONCENTRATION THRESHOLD FOR URANIUM

The Committee worked with the Mining Engineering Division of the Department of Mines and Energy to arrive at an economic concentration threshold for uranium. The main intention of this joint effort was to determine as low a concentration of uranium as is likely to ever be considered to mine for profit. A hypothetical mining situation was modelled utilizing open pit mining techniques, as these are generally accepted as the lowest cost mining methods (Appendix 3). The model is totally hypothetical and is not representative of any uranium deposit in particular, but some of the information used was taken from a feasibility study done by Kidd Creek Mines in the early 1980's on the Millet Brook uranium deposit. Standard mining industry costs and assumptions for a medium-sized open pit operation were also used. The resultant hypothetical mine model was examined for economic viability using different values of uranium ore varying from $10/pound to a high of $50/pound. From this exercise it was determined that, at a uranium value of $50/pound, the lowest grade of uranium that would be considered for mining is in the order of 400 parts per million (ppm). At the current price for uranium (the price has remained between $8-$15/pound for the last decade; Fig. 2) a minimum economic cut-off grade of uranium ore is well above the 0.15-0.25% (1500-2500 ppm) grade of the Millet Brook deposit. The Committee decided to use the high uranium price scenario ($50/pound) which indicates a 400 ppm economic cut-off. Subsequently, the Committee decided to further reduce this value by a factor of 4 in order to accommodate unforseen variations in several of the assumptions required in the mine model. The resultant value of 100 ppm was proposed by the Committee as the economic concentration threshold for uranium.

2.4 REVIEW OF EXISTING REGULATIONS AND MONITORING PROCEDURES

The Committee undertook a through review of: (1) the regulations governing mineral exploration and mining in Nova Scotia; (2) the mineral exploration monitoring procedures and policies of the Department of Mines and Energy; and (3) the role the Department of Labour and the Department of the Environment play in regulating the mineral exploration and mining industries. This review resulted in the Committee making suggested improvements by way of recommendations to the Minister of Mines and Energy in January 1986. The complete list of recommendations is provided Appendix 2 but the more significant points covered are:

(1) A recognition by the Committee that, even though radiation exposure threshold levels exist in the Province, little data exists on the ambient radiation levels in any of the active mines and quarries. This situation was considered unacceptable and a recommendation was made that the work environments of these sites be surveyed.

(2) Establishment of 100 ppm as the economic concentration threshold for uranium. This will provide the Department of Mines and Energy with a uranium cut-off value in order to determine which areas have actual uranium mineralization.

(3) Recommended changes and additions to the mineral exploration monitoring procedures and policies of the Department of Mines and Energy. In short, these additions consist of incorporating the exploration practices outlined in the "Terms and Conditions for Uranium Exploration" as practices governing exploration for all mineral exploration in the Province. The Committee is of the opinion that if all mineral exploration takes place utilizing the regulatory framework and monitoring procedures outlined in the Terms and Conditions, than irregardless of the level of uranium in the rocks being explored, environmental and worker health concerns will be met.

2.5 IMPLEMENTATION OF 1986 COMMITTEE RECOMMENDATIONS

2.5.1 Determining Areas of Uranium Mineralization

The Department of Mines and Energy coordinated action on the Interdepartmental Uranium Committee 1986 recommendations between 1986 and 1989. First order of business was to determine the areas of uranium mineralization which exceed the 100 ppm economic concentration threshold for uranium. The intention of the concentration threshold is to allow definition of areas in which the average grade of uranium exceeds 100 ppm for a significant tonnage of rock. It is not intended that the threshold be applied to every uranium occurrence in the Province. The Committee recognized the need to provide a size limitation to application of the threshold hence a qualifier was indicated in Recommendation #4 (Appendix 2) to say that 100 ppm or higher must not be representative of the average of the mineralized zone(s) that will ultimately be mined.

Department of Mines and Energy staff reviewed all uranium exploration assessment reports and applied the criteria as outlined by the Committee. Originally, it was found that four areas met the criteria: the Millet Brook deposit, Hants County; the Greywood municipal dump, Annapolis County; Louisville, Pictou County; and East Dalhousie, Annapolis County (Fig. 1). These areas were put forward as sites to be closed for the duration of the moratorium. A fifth site, at Moosehide Lake in Digby County, was placed under closure in 1990. A summary of the five designated sites of uranium mineralization is provided below.

2.5.1.1 *Summary of Uranium Closures*

The Millet Brook Closure The Millet Brook uranium deposit occurs in the granitic rocks northwest of Vaughans, Hants County (Figure 1). This deposit is the only one known in the Province that is of significant size, hence it is the largest of the closures (5,760 acres). There was a considerable amount of diamond-drilling and trenching at the site before calling of the moratorium and therefore, calculated grade and tonnage figures for uranium exist. Although the mineralized zones from which the tonnage reserves for the deposit were calculated vary from 0.15-0.25% U_3O_8, almost all drillholes in the area intersected uranium mineralization above the 100 ppm economic concentration threshold. The deposit actually consists of three separate zones occurring in close proximity to each other. In addition to the three zones, there are numerous other uranium occurrences throughout this area, many of which contain uranium mineralization above 100 ppm. Several of these had yet to be evaluated when the moratorium was called, so in the interest of protecting the investment of the mining company involved, the entire area was closed.

The Greywood Dump Closure Shell Canada Resources Limited explored for uranium in and adjacent to the Greywood Municipal Garbage Dump, 10 km south along Highway 8 from Annapolis Royal. The uranium mineralization occurs at two sites. The initial discovery was uranium-bearing boulders and glacial till at the northwest end of the municipal dump. Diamond-drilling and trenching showed the uranium mineralization does not exist in bedrock underlying the glacial till even though parts of the till are quite radioactive. Further exploration discovered uranium in veins within granite and slate a few hundred meters in the woods on the other side of Highway 8 from the dump. In total, there were 39 diamond-drill holes and 200 backhoe pits in the area. Uranium mineralization above 100 ppm occurred in 9 of the backhoe pits (channel samples in bedrock) and 8 drillholes. The mineralization is sporadic (i.e. discontinuous) therefore non-economic, but individual intersections of several hundred to thousands of ppm occur over a wide enough area to justify the closure.

The Louisville Closure The Louisville closure is located 3 km southwest of River John, Pictou County. The uranium mineralization occurs as thin, discontinuous strata-bound horizons in Pictou Group sedimentary rocks. Lacana Mining Corporation carried out a 20 hole diamond-drilling program in 1977 and 1978 and encountered uranium mineralization above 100 ppm in 9 of the holes. The uranium intersections are quite low (100-200 ppm), but potentially there may be a significant tonnage of rock containing these levels.

The East Dalhousie Closure The East Dalhousie uranium occurrence is found in granitic rocks within and adjacent to a gravel pit along the Cheeryfield Road near the east end of Annapolis County. The occurrence was discovered by Esso Minerals Limited in the late 1970's and 52 diamond-drillholes were put down. Twenty-seven of the drillholes intersected uranium mineralization above the 100 ppm economic uranium concentration threshold. The uranium mineralization was deemed to be of too low a grade and tonnage to be considered for mining so the claims were dropped by Esso Minerals in 1979. At the time of calling of the moratorium the occurrence was not held under exploration licence so it was not closed during the moratorium. The Department of Mines and Energy review of uranium exploration data showed that there is sufficient continuity of mineralization to warrant a closure and the area was added to the areas closed to all mineral exploration.

The Moosehide Lake Closure The Moosehide Lake closure is found in a very remote area of Digby County, immediately north of the Tobeatic Game Sanctuary. The area was prospected by Kidd Creek Mines Limited in 1980-81 who found numerous, highly radioactive boulders of granite. The mineralization does not outcrop nor has any drilling or trenching been done so, strictly speaking, the occurrence does not meet the Interdepartmental Uranium Committee criteria for closure. However, the abundance and areal extent of the boulders and their angularity strongly suggest their source is in the immediate area. The exploration geologists of Kidd Creek have every confidence that a uranium deposit exists at the site that rivals the Millet Brook deposit in size. Based on these factors the area was closed in 1990.

2.5.2 Radiation Surveys of Mines and Exploration Sites in Nova Scotia

The Department of Mines and Energy carried out radiation surveys of the work environments of active mines and quarries, and at selected exploration sites in the Province during 1986 and 1987. This was in response to a recommendation of the Committee who made note of the lack of such data in the Province. The surveys concentrated mostly on determining the levels of radon, as the Committee considered that in non-uranium mining and exploration, the levels of gamma radiation are insignificant and any health concern would lie with the presence of radon and radon progeny. The monitoring of gamma radiation exposure need only be considered in work environments where relatively high levels of this radiation are present, for example in uranium mines and sites of advanced uranium exploration.

2.5.2.1 Radon Surveys

The radon surveys were carried out using two methods. A passive method utilizing "track etch cups" involved leaving a track etch detector for a period of at least a month at each site. This method is considered to be the more accurate of the two methods employed and measured radon levels to within 8 becquerels/cubic meter (Bq/m^3, Appendix 1). In Canada remedial action is recommended for levels above 800 Bq/m^3 (approximately 0.1 working levels) in residences. The allowable level of exposure to radon progeny for occupational health workers is 4 working level months/year (see Appendix 1 for explanation of common radiation exposure units).

A second, active method, used an electronic apparatus called a working level monitor which records the level of radon progeny in a unit called milli-working levels (1/1000th of a working level). The working level unit is commonly used in the uranium mining industry as a measure of the exposure rate that results from the presence of radon progeny in the air (Appendix 1). A level above 100 milli-working levels (0.1 working level) was considered unacceptable in a residence. The monitor used in these surveys is very sensitive and able to detect radon at background levels. Survey periods were a minimum of 3 hours and a maximum of 1 day. A summary of the survey results is given below.

Active mines surveyed included: (1) the four Cape Breton Development Corporation coal mines (Lingan, Prince, Donkin, Phelan); (2) the Pugwash salt mine, Cumberland County; (3) the East Kemptville tin mine, Yarmouth County; (4) Evans coal mine, Inverness County; and (5) Beaverdam gold mine, Halifax County. Three sites of uranium exploration that involved ground disturbance were also surveyed, the Millet Brook uranium deposit and the East Dalhousie and Greywood dump uranium occurrences. Also surveyed were facilities at which diamond-drill core from uranium exploration projects is stored. These are located at the Millet Brook site and at the Department of Natural Resources core storage libraries in Stellarton and Debert.

Several locations were surveyed at each mine site. The locations were selected to provide a representation of the actual work areas in which the mine workers carry out their days duties. In addition, some sites where radon is most likely to accumulate (e.g. low-lying areas such as mine shaft sumps and ventilation portals) were also surveyed. Even though mine workers do not spend a significant amount of time in these potential radon traps, they were surveyed to provide an assurance because if radon is high in the mine it should be most anomalous in these sites. If these sites have low radon then it is likely low everywhere else.

The results of the radon surveys of all active mines showed that levels present were well below established occupational health exposure levels. The levels encountered are even well below the existing guideline of 800 Bq/m^3 and 0.1 working levels that are permitted in homes. The radon levels at open air mine sites such as the open pit at the East Kemptville tin mine were particularly low and essentially at background levels. These levels can be considered background and typical of outdoor air at any location. The radon levels in the Pugwash salt mine, the Cape Breton Development Corporation coal mines and the Beaverdam gold mine, Halifax County were also very low and only marginally higher than those at East Kemptville. The Committee concluded that the low levels in the East Kemptville mine are due to it being an open pit mine and subject to atmospheric circulation. The low levels at the DEVCO, Pugwash and Beaverdam mines are due to their efficient ventilation systems.

The highest radon levels obtained were from the Evans coal mine, Inverness County (20-28 milli-working level and 240-520 Bq/m^3). These higher readings were obtained from poorly ventilated areas in the mine where radon levels would be expected to be higher (e.g. the mine sump). The better ventilated areas where the mine workers spend most of their time would therefore be expected to have lower levels. One of the ventilated sites was surveyed and a level of 228 Bq/m^3 was obtained.

The survey of past uranium exploration sites (Millet Brook, East Dalhousie and Greywood Dump) showed that the radon levels in the areas of defined uranium mineralization are between 0.1-0.5 milli-working levels as measured with the working level monitor and 120-160 Bq/m^3 with the track etch cups. These are considered to be low and not of concern.

Three measurements using track etch cups placed in the core storage facility at the Millet Brook site returned values of 1040, 1360 and 1720 Bq/m^3. A measurement at this same location using the working level monitor indicated radon progeny radiation around 3 milli-working levels (0.003 working levels). The anomalous radon levels indicated by the track etch method contrast sharply with the low measurements obtained with the working level monitor. A logical explanation for this discrepancy is that the track etch cups, which were left in the facility for periods greater than a month, record the radon accumulation over long periods of time with little or no disturbance of the air. By contrast, the working level monitor measurements record the radon level during a period of greater disturbance to the air. The simple matter of the surveyor visiting the facility, opening and closing the door and moving about was apparently enough to disperse the radon accumulation.

Surveys of the Department of Natural Resources core library facilities showed that the three buildings in Stellarton and the one in Debert all have background levels of radon.

2.5.2.2 Gamma-Ray Spectrometer Surveys

As stated earlier the Committee considered it unnecessary to survey the mines and exploration sites in the Province for levels of gamma radiation. Gamma radiation dosimetry results from a year long survey of exploration workers from the Millet Brook site showed that, even though these individuals were working within and around areas of uranium-bearing rock, they were receiving gamma-ray doses well below existing thresholds (see Section 3.3.2). It follows then, that gamma-ray dose levels for exploration and mining sites involving rock of much lower uranium content should also be lower. In spite of this conclusion, the Committee requested that the Department of Mines and Energy carry out gamma-ray spectrometer surveys at two sites, the East Dalhousie and Greywood Dump uranium closures. Those particular areas are easily accessible to the public so it was thought that maps showing where the areas of highest radioactivity exist should be available on file. In addition to these detailed surveys, there were spot surveys done at numerous non-uranium exploration sites from a variety of geological terrains. This is in line with additions to exploration monitoring procedures recommended by the Committee in 1986 (Appendix 2).

The equipment used in the gamma-ray spectrometric surveys does not measure radiation in units applicable to radiation dose exposure. In these surveys the radiation was recorded simply as counts per minute (cpm), which only serves to show areas of highest radioactivity relative to areas of lower radioactivity. The maps produced from these surveys are useful for showing where future non-mining related activity may want to take extra precautions. For example, a home built on one of these sites could conceivably have a radon problem in their living spaces or have a high uranium or radon content in their well water. Furthermore, material extracted from either of these sites for home building, fill or road construction, could also give rise to problems if proper precautions are not taken. Non-mining related developments involving ground disturbance need be aware of such naturally occurring situations. Judge McCleave made somewhat of a similar observation in his Inquiry Report.

The survey of the gravel pit at the East Dalhousie closure showed that the highest radioactivity (800 to 2500 cpm over a background of 400 cpm) occurs in the northern and eastern portion of the pit and coincides with the area of defined uranium mineralization. Uranium-bearing minerals were visible in the glacial till in the area of highest radioactivity. At the Greywood municipal garbage dump closure, elevated radioactivity (1500 to 5000 cpm over a background of 400 cpm) occurs in a small area near the base of the earthen ramp leading up to the incinerator. Shell Canada Resources Limited determined that the uranium occurs only in the glacial till and does not extend into the underlying bedrock. Portions of the glacial till were found to be quite uranium-rich so for public relations purposes, once exploration was completed, Shell Canada covered the site with non-uranium bearing gravel from another pit. This reduced the level of radioactivity considerably, but elevated radioactivity remains.

In all cases, the spot surveys of non-uranium exploration sites found only background levels of radioactivity.

2.5.3 Revision of the Mineral Resources Act Regulations and Exploration Monitoring Policy

The Mineral Resources Act of Nova Scotia was completely revised and passed through the Legislature in 1990. The Act and revised regulations to the Act were proclaimed in 1991. Essentially all of the regulatory revisions and additions that were recommended by the Committee in 1986 (Appendix 2) have been adopted in the revised regulations. Since many of the additions recommended by the Committee were taken from the Terms and Conditions for Uranium Exploration, most of the extra constraints that were originally placed only on uranium exploration are now in place for all exploration activity.

The Department of Natural Resources monitors all mineral exploration activity in the Province. Exploration programs involving ground disturbance are strictly monitored from an early conceptual stage by requirement for an excavation permit and diamond-drill notice, during the period of ground disturbance by on-site visits and, after exploration ceases, with a final approval of site reclamation. The Committee suggested additions to the monitoring policy to accommodate chance encounters of uranium during non-uranium exploration. The Department of Natural Resources has included these additions with one exception. Instead of a Department official monitoring all exploration sites with a scintillometer, only those projects in which uranium is known or likely to occur are surveyed.

2.6 RECOMMENDATIONS

The Committee makes the following recommendation as a result of review of existing data on uranium occurrences throughout the Province.

RECOMMENDATION 2-1

The Committee is of the opinion that there needs to be better communication among the various Government Departments and Municipal units for dissemination of information on naturally occurring hazards including uranium and radon. Judge McCleave (page 31) also noted the lack of a system to deal with "uranium finds made in such small amounts that would not lend to any attempt at uranium mining." A system of proper notification is required so the appropriate agencies can assess the situations and take suitable action. Furthermore, the Committee feels there needs to be a degree of accountability by way of an Interdepartmental assessment of whether or not appropriate action has been taken.

Recommendation 2-1. The Committee recommends that, to properly handle all types of naturally occurring hazards, a Committee or Panel be created that ensures proper notification is made and appropriate action is taken. This Committee should have representation from: Natural Resources, Health, Environment, Municipal Affairs, Transportation and Communication, and Land Use Secretariat. To ensure accountability, the Committee should report and make recommendation to Government through an agency not responsible to any particular Department, for example Policy and Planning.

SECTION 3

THE ISSUE OF EXPLORATION FOR URANIUM

3.1 INTRODUCTION

The uranium moratorium currently in effect in the Province applies to both exploration and mining. This section deals with issues related to the exploration of uranium. Judge McCleave recommended the moratorium on uranium exploration be extended even though he clearly agreed with a Department of the Environment acceptance that "the environmental effects associated with uranium exploration were not considered to the important when appropriate measures to control pollution are followed" (McCleave, 1985, page 16). His recommendation to continue the moratorium on uranium exploration is based solely on the grounds that it would be improper to permit exploration for uranium but withhold the right to mine it. This section commences with a brief description of the format of a typical exploration project followed by an outline of some environmental studies carried out during the period of uranium exploration at Millet Brook between 1980-1982.

3.2 THE MINERAL EXPLORATION PROCESS

Exploration programs for most commodities, including uranium, tend to follow a similar format. The physical and chemical characteristics of certain elements may result in exploration techniques being employed that are particular to that element, but for the most part, the general format of an exploration program remains the same. A typical exploration program consists of three main stages: preliminary or regional, initial, and advanced. The exploration process then advances to a mine development stage if the exploration efforts define a mineable-sized mineral deposit. The transition from exploration to mine development is gradational.

3.2.1 Preliminary Exploration Stage

A preliminary or regional stage of exploration consists of a cursory examination of a large area and may include application of a certain geological model(s) of mineral deposit formation. There is often a geological feature or characteristic of an area that serves as a drawing card to attract exploration companies. Regional scale exploration first involves a review of pre-existing geological reports and maps after which one or all of airborne geophysical surveys, regional-scale geochemical sampling programs and reconnaissance prospecting may be initiated. This stage of exploration involves no ground disturbance other than prospectors or geologists taking rock or soil samples. By law, all exploration workers must gain permission of the landowner to enter private lands for the purpose of exploration.

3.2.2 Initial Exploration Stage

The preliminary exploration efforts may define potential targets or anomalies on which to carry out an initial or follow-up evaluation. The techniques employed at this stage are similar to those at the preliminary stage except that they are now applied in more detail and in a smaller area. All areas in which there are indications that there may be a mineral deposit present are prospected or surveyed in great detail. For example, all logging roads, streams and lake shores may be traversed and prospected. A flagged grid may be surveyed through the bush after which the grid lines are systematically mapped and prospected. A grid allows for accurate plotting of all sample locations and bedrock exposures. Such accuracy becomes important if follow-up work is warranted on the property. Again, as with the regional surveys, permission to trespass onto private lands must be gained.

3.2.3 Advanced Exploration Stage

The transition from initial exploration into that of a more advanced nature is gradational but is best marked by the initiation of programs involving significant ground disturbance. An exploration program enters an advanced stage in order to outline the nature and sub-surface extent of an area of mineralized rock. Detailed trenching and diamond-drilling are used to evaluate if the deposit has economic potential. All aspects of ground disturbance must first gain Government approval. The site is monitored during the period of ground disturbance and during the post-exploration reclamation work if further exploration is not warranted. Before ground disturbance is permitted the exploration company and landowners involved must come to an agreement on compensation for property damages.

3.2.4 Mine Development Stage

If exploration results continue to be promising, the site may be excavated and underground exploration such as a small test pit or exploration shaft may be constructed. This will enable a bulk sample (approximately 100 tonnes) to be removed for metallurgical testing to determine if the metal(s) of interest can be extracted profitably from the ore by milling. The combined data from all of the exploration efforts is factored with market condition studies, the overhead costs of mine/mill construction, operation costs and site reclamation costs to arrive at a decision of whether or not to proceed with development. The mine development stage has requirement for extensive environmental impact studies which include an evaluation of the total proposed mine/mill design as well as mine closeout and reclamation proposals. All mine developments in the Province have reclamation bonds posted, the size of which is commensurate with the size and extent of the particular mining operation.

In Canada, uranium mining falls under federal government jurisdiction and is governed by the Atomic Energy Control Board (AECB, see Section 7). Control over exploration for uranium falls under Provincial jurisdiction until such time that detailed and systematic diamond-drilling and surface or underground excavation work is planned to define a uranium orebody. At this point AECB enters and an Excavation Licence is required. If a bulk sample of 10 kg of uranium and/or thorium in rock exceeding 0.05% (500 ppm) concentration is anticipated, then the licensee must also obtain a Removal Licence from the AECB. From this point on AECB oversees and approves all aspects of the project regardless of whether it terminates at the exploration stage or continues into the mine development stage.

3.3 ENVIRONMENTAL MONITORING OF EXPLORATION AT MILLET BROOK

Several environmental and worker health studies were carried out during uranium exploration activities by Kidd Creek Mines Limited at the Millet Brook uranium deposit between 1980 and 1982. During that time, the exploration work consisted of ground disturbance activities such as detailed diamond-drilling and trenching of several zones mineralized with uranium. The concentration of uranium in the zones reached levels in the thousands of parts per million so this site serves as an excellent example of a uranium exploration project at the ground disturbance stage. The environmental and worker health monitoring studies that were carried out therefore provide a good means of evaluating the impact of such activities on the environment and on the health of uranium exploration workers.

3.3.1 Exploration Workers Radiation Exposure Surveys

Exploration geologists, field assistants and senior project geologists involved with exploration at the Millet Brook site wore TLD gamma-ray monitors during all on-site work from late October 1980 until October of 1982. As is required practice, the badges were sent to Health and Welfare Canada for determination of radiation dose and for reporting of results. The highest skin dose reported was 10.95 millisieverts (mSv) and total body was 4.65 mSv. These doses were well below the levels requiring intervention for occupational radiation workers which in 1982 were 300 mSv skin and 50 mSv total body. They are also below maximum levels allowed for the general public which in 1982 were 30 mSv skin and 5 mSv total body. For comparative purposes, the average exposure received by the geologists at this site was less than what would be received by a member of a commercial airline crew for the same period of time.

During the survey period, these individuals carried out duties such as prospecting, supervision of diamond-drill rigs, logging of drill core, geological mapping and sampling of trenches. All of these activities are normal practice in all mineral exploration projects but differ here only in that the rocks and trenches being explored often contain high levels of uranium. The perception may be that working in these conditions may pose an unacceptable risk of radiation exposure but the data from this particular radiation survey shows otherwise.

3.3.2 Radon Monitoring Program

The levels of radon and radon progeny that are encountered by uranium exploration workers was indicated to Judge McCleave as being a potential health risk. Radon and radon progeny are formed by natural radioactive decay of uranium and exposure to high levels of these elements for a prolonged period of time increases risk of developing lung cancer. Aquitaine Company of Canada carried out a program of radon progeny monitoring (referred to as radon daughters in 1982) at the Millet Brook site between May and October 1981 (Wade, 1981, Appendix 5). The Aquitaine study consisted of monitoring levels of radon progeny at several work areas during the period of exploration and thus allow an evaluation of the levels of these elements encountered by uranium exploration workers. The monitoring was done with an EDA WLM-300, which is the same working level monitor used in the Interdepartmental Uranium Committee survey of active non-uranium mines in the Province (Section 2.5.2.1).

The Aquitaine study surveyed several work sites including a trench dug in uranium mineralized rock, core storage buildings and their core sampling shack. The companies office in downtown Windsor, Nova Scotia was also surveyed in order to provide a background level with which to compare the results from the exploration site. The results of the surveys showed that factors such as ventilation, weather conditions and amount of human activity drastically affect the radon levels but in all cases the levels encountered were well below accepted radiation thresholds. Outdoor sites, even those in known uranium-rich rock, had a radon progeny concentration well below existing radiation thresholds. The survey included an experiment where a trench in uranium-rich granite was first surveyed with the trench completely enclosed with a tarp and then surveyed again with the trench open to the atmosphere. The result showed that with the tarp (i.e. no ventilation), the level of radon was elevated in the trench but still below the existing threshold. The survey with the trench open to the atmosphere recorded only background radon levels just above the detection limit of the equipment. The drill core sampling shed, where geologists sample diamond-drill core taken from uranium-bearing zones, had a radon level comparable to that in the companies office in downtown Windsor. One important finding from the study was that the installation of vents in the core storage building greatly reduced the buildup of radon. From this a recommendation was made to be sure that all work site buildings have adequate ventilation.

3.3.3 Millet Brook Environmental Monitoring Programs 1980-82

A program of comprehensive environmental monitoring of the Millet Brook site and surrounding area was carried out by SENES Consultants Limited of Toronto for Kidd Creek Mines Limited between 1980 and 1982 (SENES, 1982 and 1983). This time period coincided with the period of ground disturbance at the site. The surveys consisted of surface water quality, ambient radon and gamma radiation exposure, air quality and meteorology. The water quality parameters and sample site locations were determined in consultation with Kidd Creek Mines Limited and the Nova Scotia Department of the Environment.

The water quality measurements for all parameters were near analytical detection limits and were below federal maximum acceptable concentrations in drinking water by at least a factor of ten. Most importantly, the radiological quality of the surface waters (concentration of uranium, thorium and radium) was found not to vary over the three years of the surveys and were generally typical of background levels that are present away from the uranium deposits. The uranium levels in the waters ranged from less than 0.5 micrograms/liter (1 microgram/liter=1 part per billion) to 1.3 micrograms/liter. These levels are in the upper range of background levels but are typical of levels found in areas known to contain uranium deposits (SENES, 1982, page 3-3). At that time the federal drinking water limit for uranium was 20 micrograms/liter but has since been raised to 100 micrograms/liter.

Radon monitoring surveys carried out by SENES indicated that slightly elevated radon concentrations occur immediately over the known uranium mineralized zones. All other sample sites recorded background levels. The slight elevation of radon over the mineralized zones was not restricted to the areas of actual ground disturbance (i.e the trenches). A likely source for this radon elevation may be decay of the naturally high uranium content in the soils over those areas. The surveys also showed some seasonal variation in radon levels with lower levels recorded in the winter monitoring period. This is consistent with low radon emission under freezing and wet conditions due to less porosity in the soils.

The level of gamma radiation exposure was measured at many of the radon sampling locations. Background levels were recorded at all sites except those directly over trenched mineralized zones. As with the radon survey there was some seasonal variability in the data with lower exposure rates occurring during the winter monitoring period.

In summary, the environmental monitoring program of SENES Consultants showed there is no evidence of contamination of surrounding surface waters and air quality concomitant with the exploration activities being carried out at the Millet Brook site.

3.4 CONCLUSIONS

The Interdepartmental Uranium Committee has reviewed information on the impact that uranium exploration at an advanced ground disturbance stage has on the environment and on the health of exploration workers. The Committee, in conjunction with the Department of Natural Resources, has carried out radiation surveys at sites of past uranium exploration, non-uranium exploration and active mines in the Province.

The Committee has reviewed the regulations that currently govern exploration for all commodities under the revised Mineral Resources Act of 1991 and compared these to exploration procedures and policies that were previously in place for uranium exploration as Terms and Conditions for Uranium Exploration. This comparison has shown that most of the procedures and policies that were previously followed for uranium exploration are now in place as regulations under the Mineral Resources Act - 1991 for all exploration.

Conclusion 3-1

The Committee concludes that the results of environmental surveys show that advanced uranium exploration does not significantly impact on the surrounding surface waters. Radiation surveys indicate that the levels of radiation in the areas surrounding uranium exploration sites are not raised above background levels. The radiation levels within actual uranium-rich zones are elevated above background but the radiation exposures encountered by exploration workers are well below accepted radiation dose limits.

Conclusion 3-2.

The Committee concludes that there is no scientific evidence to show that exploration for uranium, if done according to the regulations of the Mineral Resources Act, 1991, either adversely affects the environment nor the health of workers associated with this task.

3.5 RECOMMENDATIONS

Based on the above conclusions the Committee wishes to put forward the following recommendation on the exploration of uranium in Nova Scotia.

Recommendation 3-1.

The Interdepartmental Uranium Committee finds there is no scientific or technical basis to warrant a moratorium on uranium exploration and therefore recommends the present moratorium on exploration for uranium be lifted.

SECTION 4

RECENT ADVANCES IN URANIUM MINING TECHNOLOGY

4.1 INTRODUCTION

The Terms of Reference of the Committee state that we are to monitor recent developments in technologies and management procedures in the uranium mining industry, in particular, those relating to the long term abandonment of mine and mill tailings. Tailings are essentially what remains after the ore has been crushed and the mineral(s) of interest have been extracted. Typically, tailings are sand-sized particles which, during the period of mining and milling, are maintained as a slurry by mixing with water. Judge McCleave made particular note of the aspect of tailings disposal on page 37-38 of his Uranium Inquiry report by saying the Interdepartmental Uranium Committee should:

> "report the technical and technological changes that would make it more likely that uranium mining could be carried out with its long-term tailings disposal properly secured. Apart from the tailings issue, the Inquiry clearly finds that the mining of uranium can be carried out if proper precautions are taken for the health of the miners and that the techniques also exist at the milling stage."

A large proportion of the presentations to the Inquiry cited the long term disposal of uranium mine/mill tailings as a major area of concern. This section provides an overview of the tailings containment issue. First, there is a brief description of how tailings were dealt with up until the time of the Uranium Inquiry and then there is a report on advances made on this topic since that time. A wealth of information on uranium-related topics exists in the public realm. Readers may easily obtain more detailed information on uranium tailings management systems from the Atomic Energy Control Board. Bates et al. (1980) also provides an excellent and clearly written summary of many of the uranium mining/milling issues, including tailings management commonly employed up until 1980.

4.2 TAILINGS DISPOSAL - PAST, PRESENT AND FUTURE

4.2.1 Past

The uranium mining industry historically has used tailings disposal systems similar to those used in non-uranium mining operations. The type of system employed varies from deposit to deposit and region to region. Factors such as the topography of the surrounding landscape, the prevailing weather conditions, hydrogeological regime in the area and the type and size of the orebody being mined all have to be considered. It is normal practice to use low-lying depressions in which to construct a tailings compound. Tailings from the mine/mill complex are then discharged into this compound.

Uranium mining poses a unique problem over the mining of non-uranium bearing commodities. Uranium is radioactive but decays to stable (non-radioactive) lead through a series of steps. Each step produces a different radioactive element or progeny (referred to as daughter element in previous years) which, in turn, decays to the next element in the series until the process ends by decay to a non-radioactive element which, in the case of uranium, is an isotope of lead. As a result, most of the radioactivity from a uranium ore is not actually coming from the uranium but instead emanates from the many radioactive elements that are derived during the decay of uranium to stable lead. When uranium ore is crushed and processed in the mill, the uranium is removed but the other radioactive elements are not. These progeny elements remain in the tailings rendering them radioactive for the period of time required for them to decay to stable lead. With uranium ores this process takes many thousands of years.

In most cases, design of a tailings compound requires construction of earthen structures called tailings dams. In uranium mines, tailings dams are specially engineered and constructed to provide the necessary strength for holding back the mass of tailings, and for controlling interaction of the water and materials within the compound with the surrounding environment (Bates et al., 1980). At the conceptual or planning stage of all modern era uranium mines (post 1970), the AECB required special attention be paid to acheiving what is commonly known as a "walk-away condition" after the mine closes. To acheive a true walk-away state, the tailings compound would have to be put in a condition such that it will not require further maintenance or monitoring. The tailings compound would have to be constructed to withstand the natural forces of nature for the many centuries required for the radioactivity in the tailings to decay to much lower levels. The uranium mining industry has long been attacked for proposing that a tailings management system employing the use of dams, can withstand the forces of nature for such a long period of time. Although tailings dams are constructed of durable natural materials such as clay, sand, gravel and rock, the very fact they are raised mounds holding back large volumes of materials that would otherwise spread out over a large area means that there will always be a potential for failure.

A second feature of pre-1984 tailings management systems is their attempts at minimizing the flow of water through the tailings after mine close-out. Efforts to do this begin at the site selection stage for the tailings compound where only sites away from major water courses are considered in order to minimize the problem of erosion. In addition, sites with impervious or watertight bottoms are most favourable. On close-out of the mine the tailings are covered with a layer of soil to impede downward migration of surface water and the surface of the compound is shaped and contoured to channel away precipitation and surface run-off. Several other measures are employed to impede or slow down the potential migration of contaminants from the tailings, but since these were accepted as being reasonable by Judge McCleave they are not discussed further. The Committee considers that most of the measures at minimizing the flow of water through the tailings are well founded but some act against the forces of nature, especially considering the long periods of time required. For example, the concept of finding a site for the tailings that is completely impervious to the migration of water outward from the tailings pile is questionable at best. Furthermore, any man-made barrier between the tailings and the underlying bedrock is likely to deteriorate at some time in the future. The Committee instead favours an approach that works with the forces of nature rather than against. Such a system does exist and is described in the following sections.

4.2.2 Present and Future

Up until the early 1980's most uranium mining operations used tailings dams in their tailings compounds. In 1981 the Saskatchewan Department of the Environment rejected a proposed extension of the mining operation at the Rabbit Lake Uranium Mine to include mining of some new uranium zones. The rejection was based on a need for a greater degree of environmental protection than was provided in the proposal. The mine operator, Gulf Minerals Canada Limited (eventually to become Cameco Corporation), considered using several other potential tailings disposal systems and arrived at a new and innovative system of tailings management that involved depositing the tailings in the mined-out open pit from the Rabbit Lake mine. This would eliminate the need for tailings dams. A revised proposal was presented and accepted by the Saskatchewan Government in 1982 provided the project include a multi-year program of environmental monitoring and inspection. This innovative tailings management system became known as the Pervious Surround Method of Tailings Management and, in a sense, the Rabbit Lake example has become it's test case. The Rabbit Lake example has been in operation since 1984 and, by far, represents the most significant advance in the uranium mining and milling industry in recent years. The following section breifly describes the technology and a more detailed description is provided in Appendix 4.

4.2.3 The Pervious Surround Method of Tailings Management

Instead of attempting to seal out or alienate the tailings from nature, the pervious surround method takes advantage of certain natural tendencies of groundwater behaviour. Tailings are deposited in an excavated pit that is either specifically constructed for receiving tailings or is an exhausted open pit mine that is modified or prepared for the pervious surround process. Placing the tailings in a pit, below the natural land surface and also below the water table eliminates the need to use tailings dams and removes them from the most prominent erosional forces in nature, surface run-off, rain and wind.

Prior to commissioning, the excavation must first be prepared for use. The first step is to drive a horizontal tunnel outward from the bottom of the pit (the sump). This tunnel intersects a vertical shaft constructed near the edge of the pit. The tunnel is then filled with crushed rock and the base and walls of the pit are also covered with a layer of crushed rock and sand (Appendix 4). This mixture of crushed rock and sand provide a pervious layer for transporting water around the tailings, thus the term "pervious surround". Instead of attempting to seal the tailings from nature, the pervious surround takes advantage of groundwaters tendency to follow the path of least resistence. Contaminated water emanating from the tailings and any groundwater migrating toward the pit from the surrounding bedrock will follow the pervious layer to the sump where they are pumped through the tunnel, up the shaft and into the mill for treatment before release to the environment.

Throughout the life of the mine, tailings are deposited in the pervious surround pit. As the depth of tailings increases, their great weight causes self-compaction and results in further amounts of contaminated water being expelled from the tailings mass. This contaminated water continues to migrate along the pervious layer to be collected in the sump and pumped to the mill for treatment. With time and continued compaction, the tailings become more dense and emit less and less contaminated water.

One of the most favourable features of the pervious surround method is its ability to integrate in the decommissioning or close-out process that takes place when the mine reaches the end of production. The ultimate aim of the decommissioning process is to acheive a true walk-away condition. Once mining ceases and deposition of tailings into the pit ends, the pervious surround system must be maintained (i.e. continued pumping and treatment of water) for the first years of the decomissioning process. This provides additional time for the tailings mass to continue to densify and to maximize the amount of contaminated water that is recovered and treated. The tailings mass is then capped with a layer of rock or compacted till after which the remainder of the pit is allowed to fill with water. At this point the original natural groundwater regime is allowed to re-establish. Since the now dense tailings mass is much more resistent to groundwater flow than the encompassing pervious surround layer, the groundwater tends not to enter the tailings and become contaminated. In addition, the design and placement of the cap material is such that release of contaminants to the overlying surface water are expected to be well within acceptable levels. At this point, a true walk-away condition is possible.

The original pervious surround model predicted that a period of 25 years would be required to decommission the Rabbit Lake facility. Continued inspection and monitoring studies of the Rabbit Lake pervious surround example has shown that the predicted rates of consolidation are well ahead of schedule.

This suggests the decommissioning process may therefore be substantially reduced and a walk-away condition may be possible in 15 years. The system also provides a couple of safeguards. At any time in the future the pervious surround system can be re-activated by re-installing pumps and collecting and treating any contaminated water. In addition, at any time the tailings may be recovered by draining the surface water and removing the cap material.

4.2.4 Other Technological Advances

While the pervious surround technology represents the most significant advance in uranium mine waste management in the last decade, other recent advances are also worthy of note. New or modified mining methods have been designed to reduce uranium mine workers exposure to radiation while working in very high grade uranium deposits. These advances are more site-specific in that their design and implementation are the result of a need to have a solution to certain unique situations at particular mines. These are referred to as "non-entry" mining methods in that they allow miners to mine with little or no actual contact with the uranium ore.

The Cigar Lake Uranium Deposit in northern Saskatchewan is perhaps the highest grade uranium deposit known to man with portions exceeding 15-20% uranium. Mining these concentrations by conventional methods could mean the miners may receive doses of radiation that are excessive and contrary to the ALARA principle (see description of ALARA in Radiation Issues section). Conceivably, miners could receive their maximum allowable yearly dose in a relatively short time. The industry arrived at a solution by using a method known as "jet boring". Large diameter holes are drilled into the ore zone from a region of the mine in which background or low radiation exists. High pressure water is pumped into the drillholes and, due to the soft, crumbly nature of this particular uranium ore, it easily breaks up and mixes with the water. This "slurry" of water and ore is then pumped to the mill for processing. The end result is that miners have minimal contact with high grade ore and thus receive much reduced radiation doses. This method has been proposed for use at Cigar Lake and a test mining project is currently in place and has been operating as expected. Any added expense to implement this method would be offset by the high value of ore being produced. More importantly, it allows the mine operator to adhere to the ALARA principle.

Another innovative non-entry mining approach involves a combination of remote mining and a method called "vertical panel" mining. Again, this technique has been proposed for situations of highly radioactive ore so that mining is carried out without miners actually coming in contact with the ore. First, a tunnel system in the barren rock is prepared above and below the ore zone. Following this, the ore zone is drilled from the upper tunnel in such a way that blasting results in "panels of ore" falling into the tunnels below. Remote miners (mining equipment operated by remote control) then collect and move the ore to a conveyor for transport to the mill. Miners are seldom in contact with the highly radioactive ore.

Implementation of these advanced remote mining methods, in pilot projects, has resulted in the irony that miners of highly radioactive ores are typically receiving radiation doses that are significantly less than those received by miners of lower grade ores mined by conventional methods.

4.3 CONCLUSIONS

The Interdepartmental Uranium Committee has reviewed information on advances in uranium mining technologies that have occurred since the conclusion of the Uranium Inquiry in 1985. Based on this review the Committee has made the following conclusions:

Conclusion 4-1.

The Committee feels that any uranium tailings management system involving the use of tailings dams can never be put into a true walk-away condition. The industry can design systems using dams that, in all probability, will contain the tailings for the long period of time necessary, but there always remains the potential for failure of the dams.

Conclusion 4-2.

The pervious surround technology, in the last decade, has emerged as the accepted and preferred option of the uranium mining industry for management of mine and mill tailings for the future. It is the Committee's opinion that this technology, by far, represents the best option available to allow for long term abandonment of mine/mill tailings.

Conclusion 4-3.

The Committee feels that the emergence of remote mining and non-entry mining techniques will enhance the uranium industries ability to adhere to the ALARA principle and minimize the radiation exposure encountered by mine workers.

4.4 RECOMMENDATIONS

The Committee finds that the industry acceptance of pervious surround technology represents a substantial advance in the management of uranium mine/mill tailings. Use of this technology greatly facilitates the uranium industries ability to ensure the long term abandonment of these tailings.

Recommendation 4-1

The Interdepartmental Uranium Committee recommends that any future uranium mine development in Nova Scotia include use of pervious surround technology for tailings management.

SECTION 5

RADIATION DOSE LIMITS

5.1 INTRODUCTION

This section discusses the topic of radiation exposure limits as they apply to uranium mining and to the general public. The discussion focusses on what the Committee considers to be the most significant changes relative to this issue that have occurred since the time of the Uranium Inquiry - Nova Scotia final report in 1985. Most notable changes are recommendations by the International Commission on Radiological Protection (ICRP) in 1990 for a reduction of radiation dose limits and the decision by the AECB to adopt the ALARA principle as regulation under the Atomic Energy Control Regulations.

A discussion of radiation dosage is complicated by the fact that different studies and jurisdictions often use different units of radiation measurement. There is no one system of radiation dose measurement that is universally accepted and all have advantages and shortcomings. In many cases, units of measurement can be converted from system to system in much the same way that miles can be converted into kilometers. Conversely, some systems of measurement are not directly comparable. The complexities of having to deal with a variety of units is often unavoidable but Appendix 1 provides a further definition and comparison of some of the common units in use.

5.2 ICRP RECOMMENDATIONS - 1990

The ICRP is a committee of medical doctors, physicists and other scientists which are a wing of the International Society of Radiology. Their main task is to review scientific data on radiological issues and make recommendations to regulatory and advisory agencies around the world. The ICRP has a stated philosophy of striving to "determine the level of exposure to ionizing radiation that ensures that radiation remains a minor component of the spectrum of risks to which we all are exposed". In 1990 the ICRP reviewed its previous 1977 radiation dose limits and recommended reductions. The recommendations are the result of a re-analysis of atomic bomb survivor data and other epidemiological studies, including those on uranium miners. While there is no requirement to adhere to ICRP recommended levels, many jurisdictions world-wide adopt their recommended levels, the Governments of Canada, and Nova Scotia are no exception. Many of the jurisdictions in the country are considering a change to the 1990 ICRP levels.

5.2.1 The ICRP - 1990 Recommended Limits

The ICRP - 1990 recommendations include a wide variety of radiation dose limits that are applicable to the entire nuclear industry. Those that most pertain to occupational workers[1] such as uranium miners and uranium exploration workers and those for the general public are summarized as follows:

Occupational Limit An average of 20 mSv (milliSeiverts, see Appendix 1) effective dose per year averaged over a 5 year period (i.e. 100 mSv in 5 years) with the provision that the dose not exceed 50 mSv in any one year. Once a female radiation worker declares pregnancy, a limit of 2 mSv to the

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[1] An occupational worker (referred to as "radiation worker" in Nova Scotia) is a person who might receive, during normal exercise of their occupation, radiation doses above those expected for the general public.

surface of the abdomen applies for the remainder of the pregnancy. A yearly limit of 4 Working Level Months (WLM, Appendix 1) of exposure to radon and radon progeny, which applied prior to 1990, was retained by the ICRP in their recommendations. For comparative purposes, 1 WLM is roughly equal to 5 mSv.

Public Limit The recommended limit for the general public is 1 mSv of effective dose per year which can be exceeded in a single year in special circumstances provided the average over 5 years does not exceed 1 mSv/year.

5.2.2 Radiation Dose Limits Prior to 1990

The accepted radiation dose limits which were in effect in Nova Scotia and throughout Canada at the time the ICRP recommended reductions in 1990 are as follows:

Occupational Limit Radiation workers have a maximum allowable exposure of 50 mSv/year effective dose. Exposure to radon and radon progeny is not to exceed 4 WLM/year.

Public Limit A member of the general public is not to have an annual effective dose exceeding 5 mSv/year.

5.2.3 Current Radiation Dose Limits in Nova Scotia

Prior to the ICRP recommended reductions in 1990, Nova Scotia was conforming to the dose limits summarized in Section 5.2.2. Limits for radiation workers and the public were regulated under the Health Act. Nova Scotia is in the final stages of formally adopting new limits for both occupational and public exposure under the Health Act Regulations. This process will probably be completed within 1994. Informally, the new limits have been in effect in the Province since 1991. The new Nova Scotia limits conform to the ICRP 1990 recommended limits except for one revision which, in effect, makes the Nova Scotia limits even more stringent. The ICRP recommends averaging of limits over a 5 year period while Nova Scotia does not. In this Province an individual's effective dose is not to exceed 20 mSv/year (radiation worker) and 1 mSv/year (public) with no allowance for exceeding this limit by averaging over a 5 year period. The Province retains the 4 WLM exposure limit to radon and radon progeny for radiation workers.

5.2.4 AECB Radiation Limits for Uranium Mining

The AECB, like most regulatory agencies around the world, gives great credence to ICRP recommendations. Once the ICRP 1990 recommended radiation dose limit reductions were released, the AECB reviewed the recommendations and began the process of amending the Atomic Energy Control Act Regulations to adopt the reduced limits. This adoption process has not yet been formalized. Informally, the AECB has been following to the ICRP 1990 limits since 1991 (AECB, C-122, 1991).

5.3 THE ALARA PRINCIPLE (AS LOW AS REASONABLY ACHIEVABLE)

The nuclear industry in Canada, including uranium mining has been following a principle of "As Low As Reasonably Achievable" or ALARA for a number of years. This principle refers to a policy of trying to achieve radiation levels in the workplace that are as low as can reasonably be attained considering social and economic factors. The principle is applied regardless of existing radiation dose limits such that a licencee is required to implement measures to reduce radiation levels to below radiation dose limit values if it is reasonably possible to do so.

The concept of ALARA was first introduced as an ICRP recommendation in 1977 and resulted from an acceptance by the ICRP of the linear theory model of radiation dose versus health effect. At that time the ICRP formally recognized that there is no level of radiation dose that is without a health risk and therefore every effort should be made to reduce radiation dosage to levels as low as is possible within reason. The AECB accepted the recommendation and implemented it throughout the nuclear industry as a specific condition of the operating licence of most nuclear facilities, including uranium mines. Adherence to ALARA is determined by the AECB according to a series of conditions and formulae.

The effectiveness of ALARA has periodically been questioned since it is not a regulation under the Atomic Energy Control Act. In reality, its status as a specific condition of the facilities operating licence is essentially as stringent as a regulation as it provides the AECB with power to interpret if it is being adhered to. In any event, the AECB is in the process of amending the Atomic Energy Control Regulations to include adherence to ALARA (AECB, C-129, 1994). Not only will this formalize the principle as regulation it will result in it becoming a requirement of all AECB licencees. It should be noted that in the uranium mining industry, it has been efforts to adhere to the ALARA principle that are a major contributor to the observed trend toward decreasing radiation levels that uranium miners receive. Presently in Canadian uranium mines the workers receive an average of approximately 1 WLM of exposure annually even though the maximum permissible is 4 WLM. Adherence to ALARA is a mojor reason for this difference. Furthermore, requirement to adhere to ALARA has also contributed to the need to develope non-entry and remote mining techniques such as are described in Section 4.2.4. These techniques will result in miners of very high grade uranium ore receiving radiation doses that are equivalent to or less than those received by miners of much lower grade ore.

5.4 CONCLUSIONS

The Interdepartmental Uranium Committee has made the following conclusions about advancements in the field of radiation dosimetry in the uranium mining industry since 1985:

Conclusion 5-1

The Committee feels that the radiation dose limits about to be formalized in Nova Scotia's Health Act Regulations are more stringent than those currently followed by the AECB for uranium mining. This discrepancy will have to be addressed should a uranium mining development be proposed in the Province.

Conclusion 5-2

The Committee recognizes that adherence to the ALARA principle is an important factor contributing to the observed trend toward decrease of radiation dose levels received by uranium mine/mill workers in Canada. The formalization of ALARA as a regulation under the Atomic Energy Control Regulations will further insure this trend continues in the future.

5.5 RECOMMENDATIONS

The Interdepartmental Uranium Committee makes the following recommendation on the radiation dose limit issue:

Recommendation 5-1

The Committee considers that the radiation dose limits currently in place in Nova Scotia are more stringent than those adopted by the AECB for uranium mining. The Committee therefore recommends that if ever a uranium mining development proceeds in Nova Scotia, the proponent conform to the Provincial radiation dose limits and the ALARA principle.

SECTION 6

EPIDEMIOLOGICAL STUDIES AND HEALTH RISK ESTIMATES

6.1 INTRODUCTION

Estimating the health risks associated with any occupation is often a complex endeavour and is the result of the interplay of numerous variables. Mining, especially underground mining, presents specific occupational safety risks. There is always the risk of fatal and non-fatal injuries due to rock bursts, roof collapses, heavy equipment mis-use and failure. There is also the risk associated with prolonged inhalation of rock dust, diesel exhaust and other gases. Uranium mining is no exception and has all the risks of conventional mining as well as a risk associated with the radioactivity of the ore being mined. Epidemiological studies of uranium miner populations are the best means of accessing the added risk that the radioactivity of the ore places on a miner of uranium over miners of other commodities.

The Committee has reviewed the results of the most recent epidemiological studies of uranium miners and the risk estimates derived from these studies. In addition, the Atomic Energy Control Board, at the Committees request, provided a scientist to make a presentation to the Committee on this issue. This section provides the Committees assessment and opinions of these studies and risk estimates. In its considerations, the Committee paid special attention to answering the following questions: (1) what is the risk associated with being a uranium miner; (2) is this risk at an acceptable level and in line with risks in other occupations; and (3) is the uranium mining industry directing reasonable and sufficient efforts toward minimizing the risks. From this assessment the Committee draws several conclusions and makes a recommendation.

6.2 WHAT IS THE RISK

Epidemiological studies of uranium miners began in the early 1970's and have been on-going ever since. With time, the database becomes larger and improves due to several factors. Early studies were somewhat hindered by the fact that, prior to 1970, recording of important information was less regulated and vigorous, and relied on less accurate and sensitive equipment. In addition, many of the miners in the "old era mines" were immigrants from eastern Europe where they had previous mining experience under less-regulated conditions. The quality of the data available for modern era uranium mines (post 1970) is much improved due to: (1) much more stringent regulations and health awareness; (2) better monitoring equipment; and (3) detailed data recording.

Exposure to any level of radiation has a health impact. It is often assumed there is a linear relationship between the amount of radiation received (dose) and the probability of developing radiation induced cancer. This assumption appears to be reasonable but there are other factors that are also important and are treated as such in the epidemiological studies. The age of the recipient on first exposure, the time since first exposure and last exposure are important as radiation induced cancers have a latency period of between 5 to 20 years. The exposure rate (radiation dose) and duration are obviously important, as are the type of radiation (i.e. gamma radiation versus radon and radon progeny concentration). Lifestyle and diet of the individual also have to be considered (e.g. smoker versus non-smoker).

The estimation of a health risk value is complex and is strongly dependant on the variables used and how these are interpreted and weighted in the treatment. The resultant estimate of risk can therefore vary but in 1994, the International Commission on Radiological Protection (ICRP) estimated an added lifetime risk to a uranium miner of 2.83×10^{-4} per Working Level Month (WLM) of exposure (see Appendix 1 for an explanation of a working level and a working level month). In short, this means for every WLM of exposure that a miner receives throughout his/her career, there is 0.000283 times elevation in the risk of developing fatal lung cancer. This elevated risk is over and above the risk of developing lung cancer that every member of the general public faces. According to AECB data, in Canadian uranium mines the average miner receives an exposure of approximately 1 WLM/year. If one assumes a career of 30 years duration (this is perhaps an overly conservative estimate of career length) then a miner will be exposed to 30 WLM of radon progeny radiation over that period. This extrapolates to an accumulated risk of 2.83×10^{-4} times 30 WLM exposure to result in a risk of 8.5×10^{-3}. This means the individual will have a 0.0085 times increased risk of developing lung cancer over a member of the general public.

Even though the data shows, that in Canadian uranium mines, the average annual exposure per miner is in the order of 1 WLM, the maximum allowable level according to the current regulations is 4 WLM/year. Adherence to the ALARA principle (As Low As Reasonably Achievable; see Section 5) in Canadian uranium mines has contributed to keeping the doses, in most cases, to wel below the regulated maximum. If a miner were to receive this maximum exposure, then he/she would have an elevated risk of 1×10^{-3} for that year. This may also be stated as a one in a thousand increase in risk.

In a discussion on the relative risks of conventional (non-uranium) mining and uranium mining, the ACRP (ACRP-12, 1990) found that conventional accidents in Ontario's underground uranium mines account for 60% of the total occupational detriment. This means that, if one considers the total of all of the hazards associated with underground uranium mines, then conventional accidents (i.e. accidents that occur in all types of underground mines) account for 60% of this total and hazards associated with the radioactivity accounting for 40%. From this one can see that in a uranium mine, most risk to the miners lies with non-radiogenic hazards.

Interested readers will find excellent discussions of this topic in two documents published by the Advisory Committee on Radiological Protection in 1990 and 1991 respectively (Documents ACRP-12, 1990 and ACRP-13, 1991) and one published by the International Commission on Radiological Protection in 1993 (Document ICRP-65, 1993).

6.2.1 Radon and Radon Progeny Exposure

Particular significance in the literature is placed on exposure to elevated levels of radon and radon progeny in uranium mines. It is generally accepted that it was exposure to high levels of these elements that resulted in the observed higher incidence of lung cancers in miners from old-era uranium mines. The data shows quite convincingly, that there exists a linear association of lung cancer deaths with exposure to radon and radon progeny. In simple terms, the less exposure a person has to these elements the less risk there is of developing lung cancer in the future. Radon, a gas, is heavier than air and easily inhaled and its radioactive progeny decay while in the lung. Since radon is a gas, an efficient ventilation system is the best method for removing it from a mine.

6.2.2 Cigarette Smoking

The interaction of cigarette smoking and inhalation of radon progeny is noted in most epidemiological studies of uranium miners. It is widely known that cigarette smoking in the general public gives rise to a wide variety of heart and respiratory ailments including elevated incidence of lung cancer. It has been found too, that uranium miners who smoke incur more than a simple addition of the risk associated with smoking and the risk associated with uranium mining. The data show that the resultant total risk to a uranium miner who smokes is definitely more than additive but less than multiplicative. Similar correlations have been noted in smokers working in non-uranium mines suggesting the main reason for this synergistic relationship may lie with high rock dust levels present more so than with dust being radioactive. In any event, the fact remains that uranium miners who smoke are at a much higher risk of developing lung cancer than those who don't.

6.3 INDUSTRY EFFORTS TO MINIMIZE RISK

Even though the interpretation of epidemiological studies is dependant on many variables, one fact beyond challenge is that the lower the exposure to radiation the lower the risk. The Committee therefore considers that the efforts taken by the regulators of the uranium mining industry, the AECB, and the uranium mine operators themselves, toward minimizing the exposure levels received by the miners is of great importance.

6.3.1 Trend Toward Lower Exposures

It is obvious when one reviews available data that throughout the history of uranium mining there has been a trend toward a lowering of the radiation exposure that mine workers receive. This is partly in response to a recognition that the high exposure levels that pre-1970 era miners were exposed to was resulting in high incidence of lung cancer mortalities. Another factor leading to this downward trend is an increased scientific understanding of the health effects of exposure to low levels of ionizing radiation. Furthermore, the need to reduce the exposure levels has benefitted by, and often resulted in, technological advances in mine ventilation systems and mining technologies. For the future, the introduction of remote mining technologies (see Section 4.2.4) and adoption of the ALARA principle as a regulatory requirement (see Section 5.3) will likely continue the observed trend toward lowering the radiation exposures received by uranium miners. The Committee can recognize in the uranium mining industry that every effort is made to reducing levels of radiation that its workers receive.

6.3.2 Worker Education and Joint Radiation Monitoring

Since the beginning of the post-1970 uranium mining era there has been an increasing commitment by the industry to occupational health training of uranium mine/mill workers. Particularly impressive to the Committee is that this training is carried out jointly between management and workers and this has fostered a much more trusting relationship between these two parties. In addition, this joint approach is also followed in the environmental and radiation monitoring that is required in modern mines. All data collected in these surveys is reported to both management and worker representatives. It appears that such an open system of worker education and worker involvement is the result of a firm commitment to creating as safe a workplace as is possible.

The AECB requires that all uranium mine workers take a course in radiation protection. This course provides training in the operation of radiation monitoring equipment and the best methods of minimizing radiation risk. The Province of Ontario has carried this requirement further and requires all workers to have additional training in all aspects of mine safety.

6.4 CONCLUSIONS

A review of epidemiological studies of uranium mine workers allows the Committee to draw the following conclusions:

Conclusion 6-1

The Committee concludes there is a risk associated with being a uranium miner. This risk is the result of uranium mine workers being subjected to levels of radon and radon progeny that are higher than those encountered in other industries and by the general public. The Committee feels that the magnitude of this risk can be minimized to acceptable levels if proper measures are taken. The Committee also concludes that the uranium mining industry has acted responsibly in defining the risk and openly relating it to the mine workers and the general public.

Conclusion 6-2

There is a direct association between risk and radiation dose. The risk to uranium miners will decrease as technological advancements continue to enter the industry. Any drop in radiation exposure will directly result in a further drop in risk.

Conclusion 6-3

A sound program of occupational health training involving co-operation between management and mine workers will further minimize the risk associated with uranium mining. Not only will such training introduce sound practices for dealing with radioactive substances, it will also educate the miners about the relative risks of mining radioactive ores versus the mining of non-radioactive ores. Since conventional mine accidents (i.e. those that occur in all mines and are not particular to uranium mines) account for up to 60% of the total risk facing uranium miners, the Committee feels there can never be too much occupational safety training.

Conclusion 6-4

Uranium miners who smoke incur a total risk that is more than a simple addition of the risk due to cigarette smoke and the risk associated with the mining of radioactive ores.

Conclusion 6-5

The existing epidemiological database for uranium miners may have a gender bias due to the fact that, historically, uranium mining populations are almost exclusively male. The resultant risk estimates are therefore applicable to males and may not be directly applicable to females. The trend toward gender equality in the workplace that exists in modern society will have to address this shortcoming.

Conclusion 6-6

The Committee concludes that the risk to the general public as a result of uranium mining is very low and may be considered to be insignificant. Windblown re-distribution of tailings and surface and groundwater radionuclide contamination are the only means by which radioactivity may escape the actual confines of a mine site. If proper mining procedures are followed the potential for such escapes affecting the levels of radiation received by the general public is extremely remote.

6.5 RECOMMENDATIONS

Recommendation 6-1

The Interdepartmental Uranium Committee recommends that, if and when there is any uranium mine development in Nova Scotia, there be a regulatory requirement for all mine/mill workers to take occupational health training prior to working in the mine. This training should include a presentation in which the risks associated with uranium mining are clearly stated and compared to the risks associated with non-uranium mining, other occupations and with the general public. There should be a clear statement of the synergistic relationship between cigarette smoking and uranium mining. Implementation of a non-smoking policy should also be considered as this would further serve to reduce risk to a minimum.

SECTION 7

THE ISSUE OF JURISDICTION

7.1 INTRODUCTION

Nova Scotia does not have a jurisdictional system in place to adjudicate uranium mining simply because there has never been any mining of uranium in the Province. Both the British Columbia Royal Commission of Inquiry into Uranium Mining (Bates et al., 1980) and the final report of Judge McCleave's Uranium Inquiry highlight the complexities and deficiencies of the jurisdictional system(s) that governed uranium mining in Canada prior to 1985. This section examines what changes have occurred since that time.

7.2 ROLE OF THE FEDERAL GOVERNMENT

The Government of Canada claimed jurisdiction over all aspects of the nuclear industry by way of the Atomic Energy Control Act in 1946. This was done under the British North America Act which gives the Parliament of Canada the power to declare jurisdiction over "local works and undertakings that are for the general advantage of Canada". The Atomic Energy Control Act included "uranium ores" as one of the prescribed substances it covered, therefore the mining of uranium was from that point on under federal jurisdiction. The Atomic Energy Control Board (AECB) was subsequently formed and has become the federal governments administrator and regulator of the nuclear industry.

7.2.1 The Leadership Role of the AECB

Although the federal government, through the AECB, claims jurisdiction and regulates all aspects of the nuclear industry, it was realized that the presence of a nuclear facility, which includes uranium mines, in any particular province or territory will have an impact on the environment and public health in the area it is located. The provincial and territorial regulatory agencies in which the facility is located therefore have a legitimate interest in how the facilities are operated. The AECB has openly recognized this concern for many years. As a result, they have implemented a joint regulatory process in which all provincial and federal regulatory agencies under whose mandate the facility impacts, are invited to participate in the regulatory process. In this joint management approach the AECB serves as the lead co-ordinating agency and ensures that all concerns of the partner regulatory agencies are satisfied.

The AECB regulates uranium mines by way of a staged licencing process which is designed and has evolved to maximize health and safety of workers and to minimize impact on the environment. In a mining situation the AECB does not enter the picture until a proponent intends to remove from its place of natural formation in one calender year, more than 10 kg of uranium or thorium in a rock of concentration greater than 0.05%. A <u>Removal Licence</u> is required at this point. This sort of activity is usually associated with extensive diamond-drilling and trenching to determine if a particular deposit is potentially of mineable proportions. If the proponent intends to continue evaluation of the deposit by way of underground excavation or bulk testing, an <u>Excavation Licence</u>[1] is required. Before this licence is

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[1] These processes may require an Environmental Impact Assessment and Federal Environmental Assessment and Review Process by the Federal Environmental Assessment Office (FEARO) and similar reviews by appropriate Provincial agencies depending on the particular jurisdiction in which the facility is located. The AECB Waste and Impacts Division plays a lead role during the above reviews and the public consultation hearings associated with them.

issued three requirements must be fulfilled: (1) approval of an environmental impact overview of the planned work; (2) a "safety report" satisfying regulations of the Uranium and Thorium Mining Regulations; (3) a completed public information process according to standards set out by the AECB.

A proponent must obtain a Siting or Construction Licence[1] to construct a uranium mine and mill. The requirements for this are set out in the Uranium and Thorium Mining Regulations. This stage requires a detailed environmental impact assessment and public information process. The designs are continually reviewed and require approval during construction of the facility.

An Operating Licence[1] is required to operate a mine, mill or associated waste management facility. This licence sets out conditions under which the facility is to operate. It is incumbent on the proponent to demonstrate to the AECB and any partner regulatory agencies that the facility will be operated in compliance with all regulatory requirements. AECB inspectors routinely monitor all aspects of operation of a uranium mining facility. Monitoring is also carried out by personnel from other federal and provincial agencies as defined in joint management schemes particular to the Province in which the facility is located.

When a uranium mine/mill is to be closed, a Suspension, Cessation or Decommissioning Licence is required. Requirements for decommissioning are specified in Section 15 of the Uranium and Thorium Mining Regulations. The decommissioning process is a long, closely monitored process taking in the order of 15 to 25 years before a site is de-licenced and no longer regulated by the AECB. At that point the site returns to provincial jurisdiction. It should be noted that in Canada there are several former mines currently in the close-out process but only one has actually reached decommissioned status.

7.2.2 Role of Other Federal Agencies

The AECB involves other federal government departments and agencies in assessment, regulation and monitoring of uranium mining facilities. When proposals for extensions to mining at facilities under current Operating Licence are received by the AECB they are assessed and passed on to the federal Departments of Environment Canada, Labour Canada, Fisheries and Oceans Canada, and Health Canada for assessment and compliance under their particular mandates. If a submitted proposal involves mining of a deposit that will require licencing of an entirely new facility, then the Environmental Impact Statement is also assessed by the Federal Environmental Assessment Review Office (FEARO).

7.3 ROLE OF THE PROVINCIAL GOVERNMENT

The AECB, by specific design, invites any provincial department or agency under whose mandate a uranium mining facility will impact, to participate in the regulatory process. In Nova Scotia, activities related to a uranium mining facility would fall under the mandates of a variety of Departments. The Departments affected are: the Department of the Environment, under the Environmental Assessment Act, the Water Act, the Dangerous Goods and Hazardous Wastes Management Act and the Environmental Protection Act; the Department of Natural Resources, under the Mineral Resources Act, the Energy and Mineral Resources Conservation Act, the Crown Lands Act and the Forests Act; the Department of Labour, under the Occupational Health and Safety Act and the Metalliferous Mines and Quarries Regulation Act; the Department of Health, under the Health Act; the Department of Fisheries under the Aquaculture Act; the Department of Justice, under the Protection of Property Act, and the Indian Lands Act; and the Department of Education under the Special Places Protection Act. Conceivably, the most involved Departments would be Environment, which would be heavily involved in conjunction with AECB and FEARO in the Environmental Assessment Process, Labour would be involved in mines inspection in conjunction with AECB and Labour Canada, and Natural Resources with various site plan and mining plan approvals.

The role of the Department of Environment deserves special comment because of changes that have taken place in that Department since 1985. Not only has Environment undergone substantial re-structuring, it is in the process of revising and strengthening its regulatory framework. The Nova Scotia Environmental Assessment Act and Regulations were proclaimed in 1989 in response to a general trend in todays society toward a greater protection of the environment, for increased accountability of the review process and for increased public involvement. The Act and Regulations are designed to identify the environmental impacts associated with a given development proposal at an early stage. The process provides ample opportunity for direct public input and also allows other appropriate government agencies input into decision making.

7.3.1 The Ontario Example

Ontario has had a long history of uranium mining beginning with the Madawaska mine at Bancroft and, more significantly, with the extensive workings in the Elliot Lake district. Several submissions to the McCleave Inquiry and to the British Columbia Uranium Inquiry (Bates et al., 1980) cite the adversarial way in which the federal government and Ontario provincial agencies often interacted during the mining operations. A result of this divided jurisdiction led to submissions to the B. C. Inquiry telling of instances of questionable training of provincial mine inspectors and a lack of co-ordination and confusion between the AECB and the provincial agencies. A general conclusion of the B. C. Inquiry was that a divided, poorly defined jurisdictional system, such as existed in Ontario and Saskatchewan prior to 1980, may result in confusion over responsibility and accountability. This increases the chances of compromising the safety of mine workers.

7.3.2 The Saskatchewan - Federal Government Joint Management Example

The Committee feels the most significant advance in the issue of jurisdiction over uranium mining since 1985 is the evolution of a joint management scheme between the Federal Government and the Province of Saskatchewan. This scheme has grown out of Federal Government's expressed intention to involve all Government Departments, Federal and Provincial in the regulation of uranium mining. The Province of Saskatchewan has had a uranium mining industry for many years and generally the industry operated under the same mixed jurisdiction as was the case in Ontario. The implementation of a firm, more structured, joint management approach in Saskatchewan in the last decade is more likely due to the fact that essentially all of the new uranium mine developments in the country have occurred in that Province. The scheme is therefore not necessarily the result of a direct initiative of the Saskatchewan Government more so than an implementation of the AECB policy to more clearly define joint management. In the Saskatchewan example, the AECB assumes the role of the lead agency and co-ordinates the joint scheme among the other Federal and Provincial partner agencies. It is the intention of the AECB to have Memorandums of Agreement with each of the provincial departments and agencies involved. At present such agreements are being negotiated with the various partners but in the interim the scheme is proceeding as if formal agreements are already in place.

7.3.2.1 Public Involvement

The Federal Government - Saskatchewan scheme requires public involvement at several stages of the environmental review process. In the Committee's opinion, the most significant opportunity for public input is associated with a stage known as "Joint Federal-Provincial Panel on Uranium Mining Developments". These "Joint Panels" are formed to review any uranium mine development proposal that comes forward in Saskatchewan. The Joint Panels are formed by invoking the Public Inquiries Act of Saskatchewan and are staffed by individuals selected jointly by the federal and provincial governments. The mandate of each Joint Panel is threefold: (1) to review the environmental, health, safety and socio-economic impacts of the proposed uranium mine development; (2) to determine from its review whether or not each project is acceptable or unacceptable; and (3) provide full opportunity for public consultation and review by way of scheduled public meetings.

A Joint Federal - Provincial Panel was appointed in 1991 as part of the scheme of joint environmental assessment outlined above to conduct a combined review of three separate uranium mine proposals in northern Saskatchewan (Lee et al., 1993). These are known as: the Dominique-Janine Extension at Cluff Lake; a proposed new mine known as the McClean Lake Project; and a proposed new mine at South McMahon Lake known as the Midwest Joint Venture. The Panel consisted of 5 persons: Donald Lee (Chair), Head of the Department of Chemistry at the University of Regina; James Archibald, Associate Professor of Mining Engineering, Queens University; John Dantouze, Vice-Chief, Prince Albert Tribal Council; Richard Neal, Professor of Biology, University of Saskatchewan; and Annalee Yassi, Associate Professor and Director of Occupational and Environmental Health, University of Manitoba. The Panel was provided with the Environmental Impact Statements (EIS) for the three proposals as well as the reviews of these EIS's that were carried out by the government agencies. After the Panel reviewed the information they held a series of public hearings on the proposals over a three month period in the spring of 1993. The two governments provided $200,000 to assist public participants in the review process. The funds were intended to assist the participants in carrying out a review of the EIS's and for preparing for and participating in the public hearings. After the public hearings the Panel prepared their report and submitted it to the AECB, the Minister of Environment Canada, the Minister of Natural Resources Canada, and the Saskatchewan Minister of Environment and Resource Management (Lee et al., 1993).

The Joint Panel Report provided numerous conclusions and recommendations and the associated rationale for each. In short the Panel recommended: (1) acceptance of the Dominique-Janine Proposal with certain conditions; (2) deferral of the McLean Lake Project for 5 years to allow for more data gathering; (3) rejection of the Midwest Joint Venture Project.

The Saskatchewan Government reviewed the Joint Panel Report and announced late in 1993 that: the Dominique-Janine Extension proposal was approved pending implementation of Joint Panel recommended conditions; the McClean Lake Project was approved with added Department of Environment and Resource Management conditions; and the Midwest Joint Venture was rejected (Government of Saskatchewan, 1993). The approval of the McClean Lake Project, against the recommendation of the Joint Panel, was the result of a Department of Environment and Resource Management decision that any adverse environmental impacts resulting from that project can be successfully minimized and mitigated.

7.4 CONCLUSIONS

The Interdepartmental Uranium Committee has examined the jurisdictional issues associated with the uranium mining industry in Canada. The Committee has found that the most significant advance lies with the implementation of a more formalized joint management approach in Saskatchewan between the Federal and Provincial Governments. Such a formalized and well-defined approach not only minimizes the chances for confusion inherent with a less structured joint management system, it also provides for extensive public participation in the decision making process. In particular, the Committee finds that the appointment of a "Joint Panel" of experts from outside Government to carry out public reviews on each proposed project is a significant contribution to providing public credibility to the system. It also allows for a site-specific analysis of each proposal. It is obvious to the Committee that the Government agencies involved in the Saskatchewan joint management scheme paid serious attention to the recommendations coming from the Joint Panel assembled to review three proposed uranium developments in 1993. The Committee is convinced that the Panel operated at arms length from the Government agencies.

Conclusion 7-1

The Committee concludes that the concept of a well structured Joint Management approach between the Federal and Provincial Governments is the most favourable method of regulating and managing the uranium mining/milling industry in Canada. A structured joint management scheme: (1) minimizes the chance of failures due to confusion over jurisdiction and responsibility; (2) provides excellent opportunity for public input; (3) satisfies the need to have separate reviews of site-specific proposals.

7.5 RECOMMENDATIONS

The Interdepartmental Uranium Committee wishes to make the following recommendations on the issue of jurisdiction over uranium mining.

Recommendation 7-1

The Committee recommends that if a uranium mining facility is ever proposed in Nova Scotia, the Provincial Government adopt a joint management scheme fashioned after that currently in place between the Governments of Canada and Saskatchewan.

Recommendation 7-2

The Committee finds that the principle of the Saskatchewan scheme is sound but that it suffers by not having a formal Memorandum of Agreement in place between all of the partner agencies.

Recommendation 7-2 Before any uranium development proceeds in Nova Scotia the Provincial Government should first negotiate and formalize a Memorandum of Agreement between all of the Federal and Provincial Departments and Agencies involved. This will eliminate any chance for confusion over jurisdiction and responsibility.

Recommendation 7-3

The Committee recognizes that the various Provincial Departments of the Nova Scotia Government that would have to assume some of the responsibility of regulating and monitoring of a uranium mining facility are neither properly equipped to do so, nor are they staffed with properly trained personnel.

Recommendation 7-3 If ever a uranium mining facility is contemplated in Nova Scotia, the Provincial Government should ensure that the various Departments tasked with regulatory and monitoring responsibilities are provided with the necessary equipment and staff training and accreditation to carry out these duties.

SECTION 8

GENERAL DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS ON THE FUTURE OF THE MORATORIUM

Previous sections of this report describe the activities and findings of the Interdepartmental Uranium Committee as it carried out its two stage mandate. In particular, the document focuses on advances in the uranium mining industry since 1985. The future of the uranium moratorium in Nova Scotia remains to be discussed. This section deals with this question by discussing the reasons for the moratorium and whether or not there is a need to extend it.

8.1 THE REASONS FOR THE MORATORIUM

The uranium moratorium was first imposed in 1982 in response to a direct public outcry over what was perceived to be a rapidly developing uranium mining industry in Nova Scotia. The nuclear industry and all of its highly sensitive issues were somewhat foreign to most Nova Scotians since the Province does not have a history of uranium mining or nuclear power generation. The establishment of a Uranium Inquiry under the Public Inquiries Act was a logical step to review the issues at hand and determine fact from fiction. It was also important to know what the potential impact would be on the environment and on worker and public health if uranium mining ever occurred in the Province.

The Uranium Inquiry determined the major issues associated with the uranium mining/milling industry by way of public meetings at which the public, government agencies and the mining industry were allowed to freely present their views. The Inquiry elected not to proceed to its second stage once Kidd Creek Mines Limited opted to withdraw from further discussions. At that point, the Inquiry no longer had a site-specific example to evaluate (Millet Brook). The Inquiry, recognizing the need to have a site-specific example to examine, elected to forgo its scheduled second and third stages and simply reported on the issues in general terms.

8.1.1 Important Conclusions of the Uranium Inquiry - Nova Scotia

The Inquiry made some significant general conclusions and recommendations about the uranium mining industry. One conclusion (McCleave, 1985, page 29) is that:

> "Methods exist by which uranium can be mined safely".

Judge McCleave further qualified this conclusion by stating:

> "It would have to be determined if whether such uranium mining activity could take place at the one site in Nova Scotia which may prove to be viable".

These statements are a clear recognition on the part of the Inquiry that it is possible to mine uranium safely, but one would have to determine if it could be mined safely at a particular location (i.e. a site-specific analysis).

The Inquiry also reached an important conclusion about the long term tailings disposal issue (McCleave, 1985, page 38) when it was stated that:

> "technological changes that would make it more likely that uranium mining could be carried out with its long-term tailings disposal properly secured. Apart from the tailings issue, the Inquiry clearly finds that the mining of uranium can be carried out if proper precautions are taken for the health of the miners and that the techniques also exist at the milling stage".

This statement by Judge McCleave, shows clearly that he determined that the issue of long term abandonment of tailings to be the main aspect of the uranium mining/milling industry that required further technological advancement.

8.2 FUTURE OF THE MORATORIUM

The Interdepartmental Uranium Committee feels this report satisfies its mandate. The advances made by the industry over the last decade, that are reported in this document, coupled with the findings of the Uranium Inquiry should provide Government with sufficient information to make an informed decision on the future of the moratorium.

8.2.1 Justification for Extending the Moratorium

Although there were valid reasons for imposing a uranium moratorium in 1982, there isn't justification for its continuance based on technical and scientific facts. With the collapse in uranium prices and poor projection for its recovery in the foreseeable future, the pressing need to hold back and review the issues is no longer present. There is no doubt that there are problems and risks that are unique to the uranium mining industry. However, the Committee agrees with the findings of the Uranium Inquiry that these concerns are often overstated and that a properly regulated industry can overcome the problems and minimize risks to acceptable levels. The Committee is particularly impressed with the responsible manner in which the AECB assumes the role of regulator of the nuclear industry.

The findings presented in this report, those of the McCleave Inquiry, and those resulting from several previous public inquiries into uranium mining held in various regions of Canada have all concluded that it is possible to mine uranium with a minimum impact on the environment and risk to industry workers. At this point, extension of the moratorium can only be based on socio-political grounds and would only be responding to a general public anxiety that has always been associated with radioactivity and the nuclear industry.

8.2.2 Justification for Releasing the Moratorium

There are several factors that suggest the moratorium in Nova Scotia is redundant and should be lifted. There have been significant advances in the uranium mining industry in recent years which should further serve to reduce the public anxiety about this industry.

The development of pervious surround technology for long term abandonment of uranium mine/mill tailings represents a major advance in this most controversial area of the industry. The Committee agrees with the AECB that this technology is the industry's best option for achieving a true walk-away condition on close-out of a mine facility. Any new uranium mine development in Canada, including Nova Scotia, would have to include this tailings management technology in order to be approved through the environmental review process.

The emergence of non-entry, or remote mining techniques in the industry, the adoption of reduced radiation dose maximum limits and the official inclusion of the ALARA principle (As Low As Reasonably Achievable) within the regulatory process all indicate to the Committee the commitment to worker safety on the part of the AECB and the industry in general.

8.2.2.1 The Environmental Review Process Versus a Moratorium

The Committee agrees with Judge McCleave that one can only fully evaluate the issues if a site-specific example is available for review. A proponent would have to clearly define, by way of an Environmental Impact Statement (EIS), how a particular deposit would be mined in an acceptable manner to meet all regulatory requirements. This EIS could then be evaluated according to an environmental review process and a decision made on acceptance or rejection.

The Committee feels the most compelling rationale for release of the moratorium is found within the joint federal/provincial management schemes now used in the uranium industry. This approach provides for public input at several stages of the review process, but the Committee feels that the appointment of "Joint Panels" of experts to carry out public reviews of site-specific proposals is the most significant component. The Joint Panels are, for all intents and purposes, **separate uranium inquiries of each proposed uranium development**. This satisfies the need for: (1) public input into the system; (2) a review by experts that are outside the industry and beyond political interference; (3) a site-specific analyses of the issues. The development of an efficient environmental review process in Nova Scotia over the last decade essentially eliminates the need for a uranium moratorium. It would be a waste of public money to continue a global review of the issues associated with the uranium mining industry when, regardless of what is determined, any proposal that comes forward in the future would be required to go through a more detailed inquiry as part of the environmental review process.

8.3 RECOMMENDATIONS

The Interdepartmental Uranium Committee makes the following recommendations regarding the future of the moratorium on uranium mining and exploration in Nova Scotia.

Recommendation 8-1

The findings of the Uranium Inquiry and the information documented in this report, allow the Committee to conclude that the need for a uranium moratorium in Nova Scotia has passed.

Recommendation 8-1 The Committee recommends the moratorium on uranium exploration and mining in Nova Scotia be lifted.

Recommendation 8-2

The Committee feels that, since the environmental review process associated with joint federal/provincial management of the uranium industry in Canada requires public reviews of each proposed uranium development, this essentially eliminates the need for a global review of the issues associated with this industry.

Recommendation 8-2 The Committee recommends that the Government of Nova Scotia not re-activate the Uranium Inquiry for a global examination of the issues associated with the uranium mining/milling industry. Instead, if and when a proponent proposes to undertake advanced exploration of a uranium deposit, the Province should negotiate and implement a joint federal/provincial management scheme to review the proposal. The environmental review process, that is required under the joint management scheme, would serve as a uranium inquiry for that specific proposal.

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APPENDICES

APPENDIX 1

GLOSSARY AND EXPLANATION OF UNITS OF RADIATION MEASUREMENT

GLOSSARY

Activity - The number of spontaneous nuclear transformation which occur in a quantity of a radioactive nuclide, divided by the time interval during which those transformation occur. Activity is expressed in curies or becquerels.

Advisory Committee on Radiological Protection (ACRP) - A committee of scientists and medical or radiation protection experts appointed by the AECB to provide independent advice on any matter relating to "radiation protection".

ALARA - A principle of radiation protection according to which radiation doses are kept As Low As Reasonably Achievable, economic and social factors being taken into account.

Alpha Particle - A positively charged sub-atomic particle, composed of two protons and two neutrons, which are emitted by certain radioactive elements during radioactive decay (e.g. radon).

Atoms - The basic building blocks of all substances. Atoms cannot be broken down further by chemical means. Each has a nucleus surrounded by one or more orbital electrons. The atoms of each element have an arrangement of electrons and protons that are distinct and unique to that element.

Atomic Energy Control Act - An act passed by Parliament in 1946 in order to provide for the control and supervision of the development, application and use of atomic energy and to enable Canada to participate effectively in measures of international control of atomic energy.

Atomic Energy Control Board (AECB) - A Board consisting of 5 appointed members, 5 directorates and a secretariat which was formed under the Atomic Energy Control Act for the purposes of regulating the nuclear industry in Canada.

Atomic Energy Control Regulations - Regulations made pursuant to the Atomic Energy Control Act by the Atomic Energy Control Board.

Background Radiation - The natural ionizing radiation of man's environment, including cosmic rays from outer space, radiation from radioactive elements in the ground, and naturally occurring radioactive elements in a person's body.

Becquerel (Bq) - The new internationally accepted unit for measuring radioactivity. The becquerel is 1 disintegration per second. 1 Bq = 27 picoCuries.

Beta Particle - A high energy electron, of either positive or negative charge, emitted by an atomic nucleus or neutron during a nuclear transformation (radioactive disintegration).

Collective Dose - The sum of the individual doses received by all the persons exposed to a given source of radiation. It is also the product of the average dose to a group of exposed persons and the number of persons in the group. Collective dose is generally expressed in "person-sievert".

Curie (Ci) - A unit of measure for radioactivity. One curie is 37 billion disintegrations per second, roughly equal to the radioactivity of one gram of radium.

Decay - The process of decrease in radioactivity of an element by a series of radioactive transformations.

Detriment - The mathematical expectation of individual or collective harm incurring from exposure to radiation, taking into account the probability of each type of deleterious health effect and severity of each effect.

Diamond-Drilling - A variety of rotary drilling in which diamond bits are used as a rock cutting tool. It is a common method for exploring for mineral deposits, as it allows core samples to be recovered to test for the presence of a mineral deposit.

Dose - A dose of radiation, either an "absorbed dose" or a "dose equivalent", depending on the context.

Dose Equivalent - The "absorbed dose" multiplied by a "quality factor" or radiation weighting factor to account for different potential for injury of different types of radiation, where the "absorbed dose" is the amount of energy absorbed by the body, or in an organ or tissue of the body, due to exposure to ionizing radiation, divided by the respective mass of the body, organ or tissue; a gray of absorbed dose multiplied by the appropriate "quality factor" or radiation weighting factor yields the "dose equivalent" in units of "sieverts".

Dose Rate - Dose per unit of time.

Effective Dose Equivalent - The sum of the "dose equivalents" received by the different tissues of the human body, each multiplied by the internationally recommended values of the "tissue weighting factors" assigned to each respective tissue. The weighting factor reflects the probability that a unit dose of radiation to the tissue in question will result in a cancer in the exposed personor a serious genetic disorder in the descendants of the exposed person. The sum of the weighting factors for all tissues of the body is 1.0.

Drill Core - A cylindrical or columnar piece of solid rock or section of soil, usually 5-10cm in diameter, taken as a sample during diamond-drilling from an underground formation and brought to the surface for geologic examination and/or chemical analysis.

Element - One of the known chemical substances that cannot be divided into simpler substances by chemical means. There are ninety-two naturally occurring elements, each having its own distinctive atom.

Epidemiology - The study of the occurrence of human disease.

Gamma Rays - High-energy, highly penetrating, short-wave length electromagnetic radiation emitted by the nuclei of many radioactive atoms as a result of radioactive decay.

Geochemistry - The study of the distribution and abundance of the chemical elements in minerals, ores, rocks, soils, water and the atmosphere. It also includes the study of the circulation of the elements in nature.

Grade - The relative quantity or percentage of a particular element in a rock.

Groundwater Level - The level in the earth below which the pores spaces, fractures and fissures of the rock and subsoil, down to indefinite depth, are full of water.

Half-life - A term used to describe just how radioactive a particular element is. By definition, the half-life of a particular radioactive element is the time it takes for half of the atoms of that element to undergo radioactive decay to its immediate progeny element. An element with a long half-life such as uranium^{238} whose half-life is 4.5 billion years, has low radioactivity, while radon^{222}, with a half-life of 3.8 days, is much more radioactive. Half-lives vary from tiny fractions of seconds to billions of years.

Hydrogeology - The science that deals with subsurface waters and related geologic aspects.

Impervious - Not permitting the passage of liquids or gases.

Ionizing Radiation - Radiation which can deliver electromagnetic energy in a form capable of knocking electrons off atoms, turning them into ions.

Isotopes - Species of an element with the same number of protons in their nuclei. For example, uranium has 4 isotopes, all of which have the same number of protons but each isotope differs from the other three by having a different number of neutrons. Isotopes of any particular element tend to behave the same chemically but can have very different nuclear behaviour.

milliSievert (mSv) - 1/1000th of a sievert.

Natural Uranium - Uranium whose isotopic composition as it occurs in nature has not been altered.

picoCurie (pCi) - One trillionth of a curie. A unit that used to be used for environmental measurements of radioactivity of elements such as radon. The unit of the becquerel is now used in Canada.

Pitchblende - The uranium-bearing mineral found in ores of uranium. A heavy mineral whose color varies from dark gray or greenish-black to brown.

Progeny Elements - Elements into which a radioactive element transforms itself by radioactive decay. When an atom of a radioactive element decays, that particular atom changes the composition of its nucleus such that it becomes a different element. This new element is either (a) a new isotope of the same element (if the number of neutrons change but the number of protons stays the same) or (b) an entirely different element (if the number of protons change). Both of these progeny are derived from a parent element.

Pollution - Usually implies an unnatural circumstance (either physically, chemically or biological impure) that adversely or unreasonably impairs the existing quality of the environment.

Radiation- Ironizing radiation i.e., any atomic or subatomic particle or electromagnetic wave having sufficient energy per particle or photon to produce ions (atoms which have become charged due to the loss or gain of electrons) in the material in which it is absorbed. Ionizing radiation includes alpha and beta particles, x-rays, gamma-rays, neutrons and some other charged particles.

Radiation Equivalent - An expression of the different effects of various types of radiation on man. Different forms of radiation may have equal energy values, but when measured on the rem scale, some forms may be 10 to 20 times more harmful to life than others. When concerned with external exposure from x-rays or gamma-rays 1 rad = 1 rem.

Radiation Protection (also radiological protection) - The science and practice of assessing radiation hazards and developing, encouraging the use of, and using instruments, protective clothing, guidelines and procedures required for keeping radiation doses within the dose limits and as low as reasonably achievable.

Radioactivity - A spontaneous decay that occurs as a result of an natural instability that exists in the nuclei of certain elements such as uranium. The decay results in emission of energy from the nucleus of the atom in the form of sub-atomic particles or photons of energy. The decay will continue until an element is formed that has a stable, non-radioactive, nucleus.

Radiogenic - Caused by radiation, as in certain types of disease.

Radioisotope - A radioactive isotope of an element. Some elements have isotopes that are radioactive while others are not (e.g. potassium and carbon).

Radon (Rn) - A radioactive gaseous element formed as part of the decay series of uranium. Radon is derived by decay from radium and decays to radon progeny by emission of alpha radiation.

Radon Progeny - The four main short-lived, radioactive decay products of radon: polonium^{218}, lead^{214}, bismuth^{214}, and polonium^{214}. All of these progeny elements are metals and radioactive.

Reconnaissance - A rapid geologic survey made to gain a broad, general knowledge of the geologic features and mineral deposit potential of a region.

Roentgen (R) - A measure of radiation intensity. It is measured at some point in space and is generally measured with a geiger counter or scintillometer. When concerned with external exposure resulting from x-rays or gamma rays it can be assumed that 1 rad = 1 rem = 1R.

Sievert - The Standard International (S.I.) unit of radiation dose. One sievert is approximately equal to 100 rems.

Synergistic - The combined action of different agents producing an effect greater than the sum of the effects of the agents acting independently (e.g. combination of cigarette smoking and uranium mining).

Tailings - The waste products from a milling operation after the valuable minerals have been recovered.

Tailings Slurry - Mixture of tailings solids and water.

Thorium (Th) - A heavy, naturally occurring radioactive metallic element comprised mostly of the isotope, thorium^{232}.

Trenching - An exploration technique which excavates a long narrow cut in bedrock or soil in order to examine for underlying mineral deposits.

Uranium - The heaviest naturally occurring element. Uranium is radioactive and metallic and has 4 isotopes of which uranium^{238} (99.3%) and uranium^{235} (0.7%) comprise the major proportion.

Waste rock - Rock extracted during mining which is either barren of mineralization or of too low grade to be considered economic to mill or process.

Working level (WL) - A term describing the concentration of all of the radioactive decay products of radon. The working level is any combination of radon progeny in one litre of air that will result in the emission of 1.3 x 10^5 MeV of alpha particulate energy.

Working Level Month (WLM) - A term used to quantify the amount of exposure to radiation from radon progeny over a period of time. For example, assuming a person spends 170 hours in their workplace each month, if that workplace has 1 working level of radiation, then the individual will be exposed to 12 months times 1 working level of radiation for a total of 12 working level months (WLM) of exposure for that year. In Canada and Nova Scotia, the maximum permissible exposure limit for a radiation worker is 4 WLM/year. A person working in an environment of 0.33 working levels of radiation for one year will receive 12 x 0.33 = 4 WLM exposure for the year.

Yellowcake - The final concentrate product of a uranium mill which is usually either a uranium-bearing sodium or ammonium compound. Yellowcake is shipped from uranium mills to a uranium refineries where it is further refined into metallic uranium.

EXPLANATION OF UNITS OF RADIATION MEASUREMENT

INTRODUCTION

Readers unfamiliar with the field of radiation physics may be confused by the variety of units of radiation measurement commonly used in literature on this subject. This Appendix provides a simplified explanation of some of the common terms in use and how they relate to each other. One must understand that some of the complexities are because, in many cases, certain units are not quantitative and are not able to be directly measured. These units are determined by complex formulas derived from scientific studies of the effects of how different types of radiation affect different organs of the body (e.g. effective dose equivalent, see Glossary).

THE NATURE OF RADIOACTIVITY AND IONIZING RADIATION

All atoms are composed of sub-atomic particles called protons, neutrons and electrons. The atoms of certain elements have an unstable combination of protons and neutrons such that this instability results in the atom having a tendency to transform itself into a stable condition by ejecting some of its particles and energy. This transformation is spontaneous and is known as radioactive decay. Some radioactive elements are more unstable than others thus their atoms decay at a faster rate. The faster the rate of decay the more radioactive the element.

When a radioactive atom decays, it ejects energy from its nucleus. This energy is called ionizing radiation and there are three main types: alpha radiation, a positively charged atomic particle consisting of 2 protons and 2 neutrons; beta radiation, are essentially negatively charged electrons; gamma radiation are photons of pure electromagnetic energy similar to x-rays. Uranium miners and other radiation workers must deal with all three types of radiation because when uranium decays to stable lead through its series of radioactive progeny, all three types of radiation are emitted.

COMMONLY USED TERMS OF RADIATION MEASUREMENT

Several different terms are used to quantify the affect radiation has on living tissue. Those that are most commonly used in the scientific literature are sieverts, millisieverts, grays, rads and rems. Terms such as becquerels, becquerels/m^3, curies, picoCuries, working levels and working level months are units used to measure the amount of radiation.

Gray

When ionizing radiation is absorbed in a substance it imparts some of its energy. If the substance is living tissue, this transfer of energy can cause damage to the cells. The amount of energy transferred, divided by the mass of the material which is absorbing the energy is referred to as the **absorbed dose** and this is measured in **grays (Gy)**. 1 Gy = 1 joule per kilogram. A gray is considered a large absorbed dose so most studies refer to absorbed dose in **milligrays (mGy)** which are 1/1,000th of a gray.

RAD

Absorbed dose, until recent years, was referred to as the Radiation Absorbed Dose or **rad**. In an effort to achieve worldwide standardization of radiation units, the radiation physics field is conforming to the System International (S.I.). 1 rad = 0.01 Gy.

Sievert

Equal absorbed doses of different types of radiation have different likelihoods of producing cell damage. To account for this, the absorbed dose is multiplied by a "quality factor" to give a result known as the **dose equivalent**. Quality factors have been determined for each particular type of radiation. The dose equivalent is measured in **sieverts (Sv)**. The **millisievert (mSv)** is more applicable to radiation protection work. The millisievert is the most commonly used unit in the world for the field of radiation protection. The radiation dose limits applicable to uranium miners and other radiation workers are discussed in Section 5 in terms of the millisievert.

For comparative purposes, the following are some typical radiation exposures received by the average Canadian citizen:

- A total exposure of 2.2 mSv/year from all sources.
- 0.3-0.7 mSv/year is received from naturally occurring radioactive elements in surrounding rocks soils and construction materials.
- 0.3-0.4 mSv/year from cosmic rays originating from outer space.
- 0.4 mSv/year emanating from radioactive elements occurring naturally within your body.
- 0.1 mSv/year from medical x-rays.
- 0.04 mSv is received during each coast to coast return jet flight.

REM

Radiation Equivalent Man or **rem** is an older term used to express dose equivalent before acceptance of the sievert. To convert: 1 rem = 0.01 Sv; 100 mrem = 1 mSv; 100 rems = 1 Sv.

Becquerel (Bq) and Becquerels per Cubic Meter (Bq/m^3)

The newly accepted System International (S.I.) unit for measuring the amount of radioactivity. The **becquerel** replaces the curie as the accepted unit of measurement. One becquerel is 1 disintegration per second. 1 Bq = 27 picoCuries. **Becquerels per cubic meter (Bq/m^3)** is a term used to describe the amount of radioactivity in air. Defined as the amount of radioactivity in becquerels within one cubic meter of air. This term replaces the older picoCuries per litre (see below).

Curies (Ci), PicoCuries (pCi) and PicoCuries per Liter (pCi/l)

Prior to acceptance of the System International units, radioactivity was measured in **curies (Ci)**. one curie is 37 billion disintegrations per second which is roughly equal to the radioactivity of one gram of pure radium. A **picoCurie (pCi)** is one trillionth of a curie. 1 pCi = 2.22 disintegrations per minute.

A **picoCurie per liter (pCi/l)** is the measure of radioactivity in one liter of air.

Working Levels (WL) and the Working Level Month (WLM)

Since the effect of radon and radon progeny is of particular concern in uranium mining, the industry has devised a term by which the activity of these elements in the air in the working environments can be quantified. This is not a simple task as the radiation from any one, as well as all of the radon radioactive progeny is a concern. The **working level (WL)** was devised to account for the total of the radiation from all of the radon progeny, regardless of what the actual concentration of each particular element is in the surrounding air. The formal definition of a WL is any concentration of radon progeny in one litre of air that results in emission of 1.3×10^5 million electron volts of potential alpha energy. In some circumstances it is possible to convert radon concentration recorded as WL into radon concentration recorded as pCi/l but there are assumptions that have to be made that make this unadvisable.

A **working level month (WLM)** is a term used to describe the exposure to radiation from radon progeny over time. Assuming a person works 170 hours each month, if that person is working in an atmosphere containing 1 WL of radon progeny radiation, then in one year he/she will receive 12 months of occupational exposure to 1 WL level of radon progeny radiation. This may be quantified as 12 months time 1 WL exposure or 12 working level months (WLM). Alternatively, a person working in 0.33 WL of occupational exposure for one year will receive 12 times 0.33 or 4 WLM of exposure. In Canadian uranium mines 4 WLM is the maximum exposure allowed in one year (see Section 5). One WLM is roughly equivalent to 5 mSv.

APPENDIX 2

CLOSED GROUNDS REPORT AND RECOMMENDATION

MEMORANDUM

TO THE EXECUTIVE COUNCIL

NUMBER:	MK1072
DEPT:	Mines and Energy
DATE:	Dec. 19/89

DOCUMENT 1 of 4

SUBJECT: Uranium Moratorium

SUBMITTED BY: Honourable Jack MacIsaac, Minister, Department of Mines and Energy
Honourable John G. Leefe, Minister, Department of the Environment
Honourable G. David Nantes, Minister, Department of Health and Fitness

PREPARED BY: Nancy Hood, Solicitor, Department of Mines and Energy

DEPUTY MINISTER: John J. Laffin, D.Eng. John J. Laffin

SUMMARY:
Approval to extend Uranium Moratorium until 1995.

In 1982 the Minister of Mines and Energy placed a moratorium on all uranium exploration within the Province of Nova Scotia.

By Order of Council 82-200, dated February 9, 1982, Judge Robert McCleave was appointed as commissioner under the Public Inquiries Act to inquire into and make recommendations to the Governor in Council respecting uranium.

Judge McCleave submitted the Report of the Commission of Inquiry on Uranium to the Governor in Council, dated January 30, 1985.

In the Report, Judge McCleave recommended, inter alia that the moratorium on uranium continue until at least 1990.

Specificially at page 34 of the Report, a copy of which is attached as Schedule 1, Judge McCleave makes the following recommendation:

> **"(7) During 1990, the Government should determine from its interdepartmental committee established pursuant to Recommendation (2), and announce publicly whether the five year ban should be continued. In the meantime the Committee should keep itself up to date on a variety of matters (most of them set forth in the Digest) such as:**
>
> **1. advances in the mining process for uranium - see the views of the Federal and Provincial Departments of the Environment, in the views of the various mining briefs and the options suggested by Ralph Torrie;**
>
> **2. monitoring of the uranium tailings at Bancroft, Ontario by the Federal Departments of Energy Mines and Resources and the Environment, and the information available on small uranium mines in France (note the suggestion of Peter Warrian of the United Steelworkers of America);**
>
> **3. study the health factors from the Bancroft area and other Canadian areas as they relate to the fears held respecting uranium induced cancers;**
>
> **4. study the issue raised by Dr. Michael Brylinsky, Elizabeth May and others as to the uptake of radioactivity into the food chain, biological magnification, and satisfy itself that corrective measures can be put in place."**

APPROVED
RCG
DEC 21/89

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It is the submission of the Undersigned that more time will be required for the Interdepartmental Committee to fully study the issues addressed in Recommendation 7, above.

The Undersigned therefore recommends the following:

1. The Uranium moratorium shall continue until at least 1995;

2. The Interdepartmental Committee established pursuant to Recommendation 2 of the Report of the Commission of Inquiry on Uranium dated January 30, 1985, shall continue its mandate and specifically, shall, continue to study the issues outlined on pages 34 and 35 of the Report which are attached; and

3. The Interdepartmental Committee shall report its findings and recommendations to the Governor in Council no later than July 31, 1994.

Respectfully submitted,

Minister of Mines and Energy

Minister of the Environment

G. David Wante

Minister of Health and Fitness

DATED: Dec 8, 1989
Halifax, Nova Scotia

for uranium exploration, but the Commission considers that such should be given the force of regulations, so that breaches can be dealt with in the Courts. The public will be more comfortable if it considers that alleged breaches will be dealt with in the dispassionate atmosphere of the Provincial Court rather than in some Ministerial office. The Minister will probably be more comfortable too.

BAN ON URANIUM EXPLORATION

(6) The ban on exploration for all minerals in lands set out by license for uranium exploration is too sweeping and should be lifted. The mineral rights of Companies holding such licenses can be protected by giving them first rights to finds of uranium within the licensed areas whether they have discovered such or not, upon such terms and conditions as seem just to the Governor-in-Council. The areas licensed and now under ban but not found to contain uranium should be treated under the terms and conditions established by the Department of Mines and Energy. However, the time lapse - between the date of the ban and the adoption of this recommendation plus one month to advise affected parties - should not count against the time requirements of the Mineral Resources Act. When uranium is found in sufficient quantities to justify the exclusion of any area from development now, the time lapse should continue until permission is given.

TIME FOR RECONSIDERATION

(7) During 1990, the Government should determine from its interdepartmental committee established pursuant to Recommendation (2), and

announce publicly, whether the five year ban should be continued. In the meantime, its Committee should keep itself up to date on a variety of matters (most of them set forth in the Digest) such as:

1. advances in the mining process for uranium - see the views of the Federal and Provincial Departments of the Environment, in the views of the various mining briefs and the options suggested by Ralph Torrie;
2. monitoring of the uranium tailings at Bancroft, Ontario, by the Federal Departments of Energy, Mines and Resources and the Environment, and the information available on small uranium mines in France (note the suggesticn of Peter Warrian of the United Steelworkers of America);
3. study the health factors from the Bancroft area and other Canadian areas as they relate to the fears held regarding uranium-induced cancers;
4. study the issue raised by Dr. Michael Brylinsky, Elizabeth May and others as to the uptake of radioactivity into the food chain, "biological magnification", and satisfy itself that corrective measures can be put in place.

PUBLIC ANXIETY AS TO USE

(8) The Inquiry considers that much public anxiety would be alleviated should peaceful purposes be found for Nova Scotian uranium. Unrest cannot be

THIS IS A CONFIDENTIAL DOCUMENT

MEMORANDUM

TO THE EXECUTIVE COUNCIL

NUMBER: MK 1073

DEPT:

DATE:

DOCUMENT 2 of 4

SUBJECT: Reopening of Certain Lands to Allow Exploration For All Minerals Except Uranium, Coal, Salt, and Potash

SUBMITTED BY: Honourable Jack MacIsaac, Minister, Department of Mines and Energy
Honourable John G. Leefe, Minister, Department of the Environment
Honourable G. David Nantes, Minister, Department of Health & Fitness

PREPARED BY: Nancy Hood, Solicitor, Department of Mines and Energy

DEPUTY MINISTER: John J. Laffin, D.Eng. John J Laffin

SUMMARY: Prior to 1982 uranium exploration was permitted under the regular Exploration License and subsequently under a Special License. In 1982 a ban was placed on exploration for all minerals upon areas then being examined for uranium and all Special Licenses were allowed to expire. With the moratorium on uranium exploration and mining, such areas remained closed to protect the rights of the license holders. It is now recommended that these areas be reopened for general exploration, except for uranium, coal, salt, and potash.

In 1982 the Minister of Mines and Energy placed a moratorium on all uranium exploration and mining. In addition to the moratorium, the Minister of Mines and Energy instituted a ban on exploration for all minerals within certain specified areas comprising roughly 507,360 acres of provincial lands. Subsequently, significant uranium was indicated upon only 0.6 per cent of this area. The licenses affected by this ban were held in abeyance in order to preserve the rights of the holders pending a public inquiry.

By Order in Council 82-200, February 9, 1982, Judge Robert McCleave was appointed a Commissioner under the Public Inquiries Act to inquire into and make recommendations to the Governor in Council respecting uranium.

After receiving written and oral submissions on this subject, Judge McCleave presented to the Governor in Council a Report of the Commission of Inquiry on Uranium, dated January 30, 1985.

The Uranium Inquiry Report made several recommendations. The first recommendation was that the provincial moratorium on uranium exploration be continued until 1990. This recommendation has been accepted and the uranium moratorium will continue until at least 1990.

The Uranium Inquiry Report also recommended the formation of an Interdepartmental Committee to establish the threshold value for uranium mineralization above which exploration for all other minerals in the vicinity must terminate. This Committee established by Government consisted of personnel from the Departments of Mines and Energy, Health and Fitness, and Environment. Guidelines as outlined in their mandate were established and approved.

The Uranium Inquiry Report further recommended that the existing ban be lifted on exploration for all minerals except uranium, within the 507,360 acres under moratorium for those properties exhibiting uranium mineralization below the threshold value established by the Interdepartmental Committee.

It is the purpose of this Memorandum to advise that the Interdepartmental Committee has determined the threshold value for uranium mineralization above which all exploration for any minerals must cease. Furthermore the Interdepartmental Committee has suggested the necessary regulatory procedures which should be adopted in this regard. Regulations have therefore been drafted by the Department to incorporate the regulatory procedures suggested by the Interdepartmental Committee.

By Report and Recommendation, dated the 8th day of December, A.D., 1989, the Undersigned request approval of regulations, which embody the findings of the Interdepartmental Committee.

.../2

By a second Report and Recommendation, dated the 8th day of December, A.D., 1989, the Undersigned request reopening certain of the lands under moratorium to exploration for all minerals other than uranium and those minerals which require a special license. There are areas which will remain closed for all exploration, however, because of uranium mineralization above the threshold values determined by the Interdepartmental Committee.

A map is attached as Schedule 1 showing the areas to be reopened and the areas which will remain closed.

Also attached as Schedule 2 is a copy of the Recommendations and Procedures for Non-Uranium Mineral Exploration and Mining in Nova Scotia.

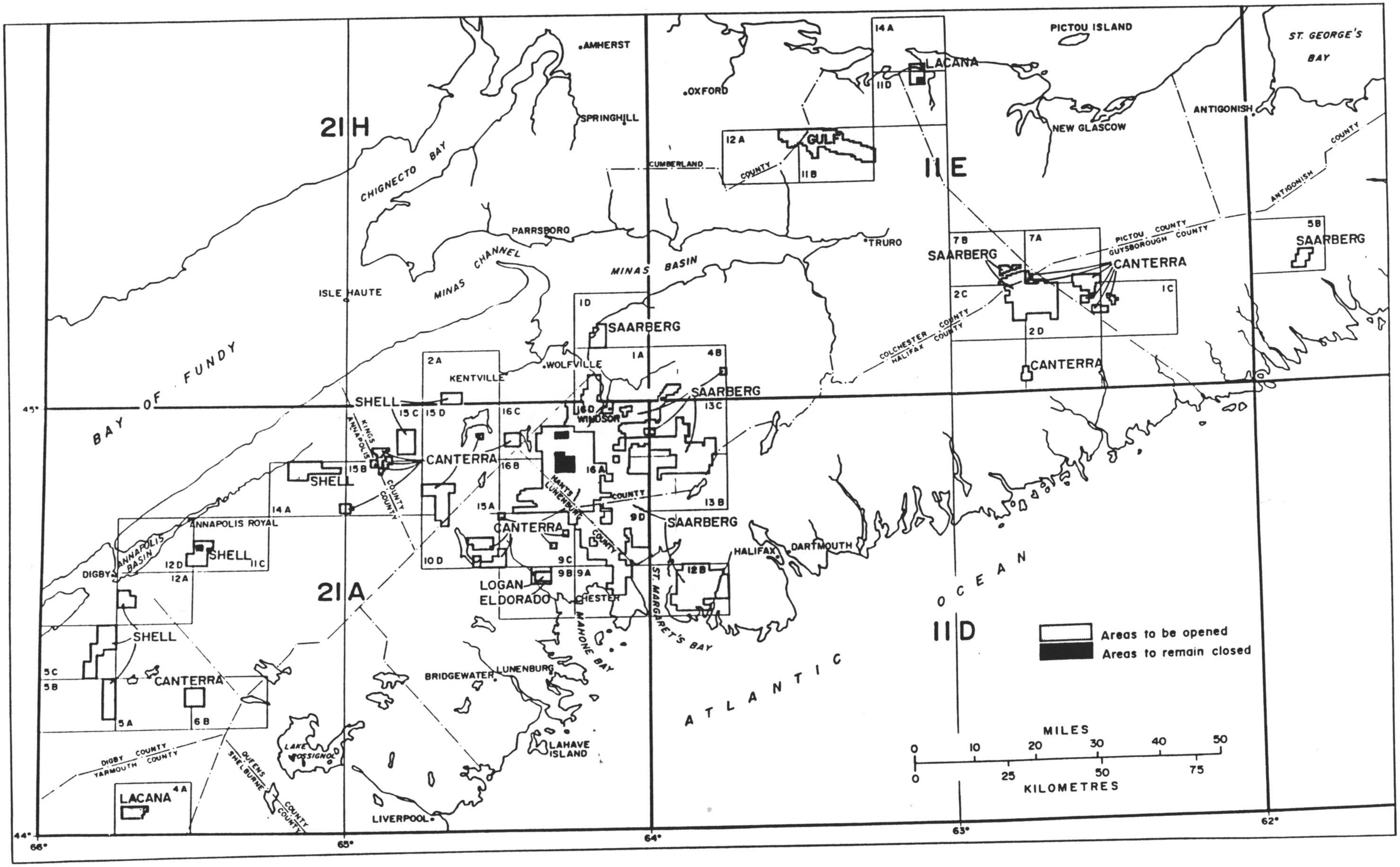
Respectfully submitted,

Minister of Mines and Energy

Minister of the Environment

Minister of Health and Fitness

DATED: Dec 8, 1989
HALIFAX, Nova Scotia



21H
11E
21A
11D
BAY OF FUNDY
CHIGNECTO BAY
MINAS CHANNEL
MINAS BASIN
ATLANTIC OCEAN
ST. GEORGE'S BAY
PICTOU ISLAND
AMHERST
SPRINGHILL
OXFORD
PARRSBORO
ISLE HAUTE
TRURO
NEW GLASGOW
ANTIGONISH
WOLFVILLE
KENTVILLE
WINDSOR
HALIFAX
DARTMOUTH
CHESTER
MAHONE BAY
ST. MARGARET'S BAY
LUNENBURG
BRIDGEWATER
LAHAVE ISLAND
LIVERPOOL
LAKE ROSSIGNOL
DIGBY
ANNAPOLIS BASIN
ANNAPOLIS ROYAL
CUMBERLAND COUNTY
COLCHESTER COUNTY
HALIFAX COUNTY
PICTOU COUNTY
GUYSBOROUGH COUNTY
ANTIGONISH COUNTY
KINGS COUNTY
ANNAPOLIS COUNTY
HANTS COUNTY
LUNENBURG COUNTY
DIGBY COUNTY
YARMOUTH COUNTY
QUEENS COUNTY
SHELBURNE COUNTY
SAARBERG
CANTERRA
LACANA
GULF
SHELL
LOGAN
ELDORADO
14A
11D
12A
11B
7B
7A
2C
2D
1C
5B
1D
1A
4B
13C
13B
16D
16C
16B
16A
15A
15B
15C
15D
2A
10D
9D
9C
9B
9A
12B
14A
12D
12A
11C
5C
5B
5A
6B
4A
Areas to be opened
Areas to remain closed
MILES
0
10
20
30
40
50
0
25
50
75
KILOMETRES
45°
44°
66°
65°
64°
63°
62°

INTERDEPARTMENTAL URANIUM COMMITTEE

INTERIM RECOMMENDATIONS AND PROCEDURES FOR NON-URANIUM MINERAL EXPLORATION AND MINING IN NOVA SCOTIA

INTRODUCTION

In its report to the Government of Nova Scotia, the Uranium Inquiry - Nova Scotia recommended the constitution of an Interdepartmental Committee which would, as part of its function, establish a threshold value for uranium mineralization above which all exploration and mining activity must cease.

In his March 1985 statement to the Legislative Assembly, the Honourable Joel R. Matheson, Q.C., Minister of Mines and Energy, noted the Government's intention to proceed quickly with the implementation of a framework to permit properties held under the existing moratorium and not exhibiting uranium mineralization, to be released for all other exploration activity. In order to accomplish this objective, the Interdepartmental Uranium Committee was instructed to:

A. Establish a regulatory requirement for a uranium threshold value above which all exploration/mining activity will be halted on lands so specified;

B. Establish procedures for:
- notification to the Department of Mines and Energy when the threshold value has been reached;
- uranium mineralization sampling and reporting;
- delineating the boundaries of properties where all exploration/mining activity is to be prohibited;
- monitoring properties identified as having uranium above the threshold value.

As an interim response to these instructions, the Interdepartmental Uranium Committee proposes the following recommendations. Amendments may be proposed as more information applicable to non-uranium exploration/mining becomes available during the Committee's work on uranium.

RECOMMENDATIONS

The Committee recognizes that little data exist on the ambient radiation levels in our active mines and quarries.

Recommendation 1. The Committee recommends the work environments of active mines and quarries in Nova Scotia be surveyed for radiation exposure levels. Such a survey should also include some present day non-uranium exploration sites involving ground disturbance and some sites of past detailed uranium exploration. These surveys will provide valuable data on the work environments of mining and exploration industries in Nova Scotia. They may also be useful in any future refinement of regulatory requirements.

The Committee recognizes the importance of protecting Nova Scotia's waters. Receiving waters in the vicinity of exploration projects and mines should be safeguarded against redionuclide contamination. The Committee therefore recommends the adoption of guidelines for radionuclides in water.

Recommendation 2. The Department of the Environment should introduce receiving water standards for alpha and beta radiation, specific radionuclides and uranium.

The Committee feels the concept of a concentration threshold for non-uranium mining must be based on economic criteria. Definition and adoption of a concentration threshold can ensure that uranium will not be exploited as either a primary or by-product commodity in Nova Scotia. Jurisdiction for such a level must fall under the Mineral Resources Act. The Mining Engineering Division of the Department of Mines and Energy at the Committee's request has modelled the various low-cost mining situations likely in Nova Scotia in order to estimate as low a grade as possible of uranium that could be economically extracted. From these models the Committee agrees the probability of economic extraction of ore of 100 ppm or less is unlikely even under the most optimistic conditions.

Recommendation 3. The Committee recommends that the Nova Scotia Department of Mines and Energy adopt as Regulation under the Mineral Resources Act a concentration threshold of 100 ppm uranium above which a non-uranium mining operation must cease. The threshold shall be applied as an average uranium content of either an orebody or the waste rock removed to exploit an orebody.

In non-uranium mineral exploration an economically defined concentration threshold will: 1. ensure a non-uranium orebody is not developed which has a uranium concentration high enough that the metal could be economically extracted; 2. allow for recognition of chance encounters of uranium mineralization during non-uranium exploration; 3. ensure a uranium ore body is not developed under the guise of another commodity.

Recommendation 4. The Regulations of the Mineral Resources Act be amended to adopt a 100 ppm uranium concentration threshold above which exploration/mining must cease. If a uranium concentration of greater than 100 ppm is encountered in a sample during investigations, by either a mining lease or an exploration license holder, or Department of Mines and Energy official, then the lease/license holder must deomonstrate to the Department of Mines and Energy that this value is not representative of the average of the mineralized zone(s) that will ultimately be mined.

Recommendation 5. Regulations of the Mineral Resources Act be amended to require all mining lease/exploration license holders to report any chance encounters of uranium mineralization or other data indicative of a potential for uranium mineralization to the Nova Scotia Department of Mines and Energy as soon as is possible.

The Committee concludes that the present exploration monitoring procedures of the Department of Mines and Energy are insufficient to properly ensure workers in this industry are receiving radiation exposures below the recommended levels of the Regulations of the Mineral Resources Act.

Recommendation 6. The Committee recommends the following additions to the exploration monitoring procedures practiced by the Department of Mines and Energy for exploration projects involving ground disturbance as defined under the Mineral Resources Act.

- During the period of ground disturbance activity an official of the Department of Mines and Energy visits all sites for the purpose of monitoring of adherence to Mineral Resources Act regulations. At this time the official will survey all workings and diamond-drill core with a scintillometer. If background levels of radiation are not exceeded, the project may continue as planned. Background levels will be defined by the official by examination of areas sufficiently removed from the exploration site to be representative of the area before disturbance.

- If elevated levels of radioactivity are encountered, the official will notify the license holder and initiate the following: 1. the site will be revisited and surveyed in detail using more sensitive radiation detection equipment; 2. the rock will be sampled and analysed by the Department of Mines and Energy to estimate the uranium concentration of the exploration target under investigation; 3. site drainage and any liquid effluents will be sampled and analyzed for radionuclide contamination.

- If during the above detailed survey the site is found to exceed the threshold limits for radiation in air or water, the license holder will be so informed and ground disturbance activity must cease. Within a reasonable period of time the site must be placed in a condition below the recommended limits. If this is achieved the project will be allowed to continue. The project must be terminated if the license holder cannot demonstrate levels can be maintained below the limits.

- With all exploration projects that involve ground disturbance, the Regulations of the Mineral Resources Act require that on completion the license holder must restore all sites to a reasonable and acceptable condition. This requirement should include radiation levels in that the disturbed sites must be returned to a level comparable to the background of the surrounding undisturbed area. A Department of Mines and Energy official will monitor the site(s) by scintillometer to ensure this is so.

The uranium monatorium has closed the 507,360 acres of land under uranium license to exploration for all minerals. The Committee is of the opinion that the Department of Mines and Energy can utilize in-house uranium data and information contained in assessment reports submitted by the various uranium exploration companies to define specific areas of uranium mineralization.

Recommendation 7. In consideration of the proposed 100 ppm uranium threshold concentration, the Nova Scotia Department of Mines and Energy should define those specific areas of uranium mineralization exceeding the threshold using geological data on file and assessment reports filed by uranium exploration companies. The remaining lands may be reopened for non-uranium exploration.

The areas designated as containing specific uranium mineralization will not be available for mineral exploration for at least the period of the five-year moratorium. The public of Nova Scotia should be made aware of the presence and significance of these closed areas.

Recommendation 8. The Department of Mines and Energy provide the appropriate Government agencies with all existing information on the specific areas of uranium mineralization which are to remain closed for the moratorium period. These agencies should review this information in order to evaluate the significance and impact of these areas relative to their mandates. The Department of Mines and Energy should notify in writing the appropriate municipal units and landowners within whose lands the specific areas of uranium mineralization are found. This notification should provide information on the location and size of the areas and a description of the extent of the uranium mineralization. They should also be provided with a list of officials within the Departments of Mines and Energy, Health and Evnironment with which they may correspond to obtain further information on these areas.

FORM 1616R-87
0234D

ATTORNEY GENERAL
approved as to form.
[signature]

TO BE USED FOR ALL REPORTS AND RECOMMENDATIONS EXCEPT APPOINTMENTS

REPORT AND RECOMMENDATION

TO EXECUTIVE COUNCIL

NUMBER:
DEPT.:
DATE:

DOCUMENT 3 of 4

SUBJECT: Reopening Certain Lands for License pursuant to the Mineral Resources Act

SUBMITTED BY: Honourable Jack MacIsaac, Minister of Mines and Energy

PREPARED BY: Nancy Hood, Solicitor, Department of Mines and Energy

DEPUTY MINISTER: John J. Laffin, D.Eng.

APPROVALS

ATTORNEY GENERAL
Approved of as to Form & Authority
[signature: Nancy Hood]

POLICY BOARD
Date Rec'd ______
Recommended ______
Forwarded w/o Recommendation ______
Rejected ______
Date of Action ______

MANAGEMENT BOARD
Date Rec'd ______
Recommended ______
Forwarded w/o Recommendation ______
Rejected ______
Date of Action ______

EXECUTIVE COUNCIL
Date Rec'd ______
Approved ______
Date ______
Rejected ______
______
Referred to ______

SUMMARY

The Governor in Council is asked to reopen specified lands for exploration for certain minerals.

BUDGETARY/FINANCIAL IMPACT of this Request - current and 3 subsequent fiscal years.

($,000's)

	19__/__	19__/__	19__/__	19__/__
Current Account				
Expenditure				
Revenue /Recovery				
Net Impact				
Capital				
Expenditure /Advance				
Recovery				
Net Impact				

($,000's)

	19__/__ Vote	19__/__ Total Departmental
Budgetary Implications (Current Year) Included in budget? Yes ___ No ___		
Authority		
Full Year Forecast (Including this request)		
Variance		

.../2

The Undersigned has the honour to refer to subsections (1) and (4) of Section 24 of Chapter 12 of the Statutes of Nova Scotia 1975, the Mineral Resources Act:

> 24 (1) The Minister may withdraw any lands in the Province from application for a license for all or certain minerals.
>
> (4) The Governor in Council may reopen for application for a license any lands withdrawn under subsection (1) for all or certain minerals.

The Undersigned has the honour to report that:

(a) by letters dated February 16, 1982, September 7, 1982 and May 29, 1986, the Minister of Mines and Energy, acting pursuant to subsection (1) of Section 24 of the said Act, withdrew approximately 507,360 acres of lands from application for all minerals until regulations respecting uranium occurrences could be promulgated;

(b) the aforementioned lands are described in Schedules "A" and "B" to this report and recommendation;

(c) draft regulations pertaining to uranium occurrences have been prepared and are set out in Schedule "A" to a report and recommendation by the undersigned dated the 8th day of December , A.D., 1989; and

(d) with the imposition of new controls and reporting procedures pursuant to the draft regulations, general exploration and mining activities may resume on the lands described in Schedule "A" to this report and recommendation but the lands described in Schedule "B" to this report and recommendation contain uranium occurrences that exceed the level permitted in the draft regulations referred to in clause (c) and should remain closed.

The Undersigned has the honour to recommend that the lands described in Schedule "A" should be reopened for general exploration activity for all minerals except uranium, coal, salt and potash upon the coming into force of the aforementioned regulations.

The Undersigned therefore has the honour to recommend that the Governor in Council make an order in the following form or to like effect:

> The Governor in Council on the report and recommendation of the Minister of Mines and Energy dated the 8th day of December , A.D., 1989, pursuant to subsection (4) of Section 24 of Chapter 12 of the Statutes of Nova Scotia 1975, the Mineral Resources Act, is pleased to:
>
> (a) reopen for application for license, in respect of all minerals except uranium, coal, salt and potash, the lands described in Schedule "A" attached to and forming part of the said report and recommendation; and

(b) direct that this Order shall be effective on, from and after the 2nd day of January, A.D., 1990, being the effective date of amendments to the Regulations respecting work on mineral rights made pursuant to Section 16 of the Mineral Resources Act and set forth in Schedule "A" attached to and forming part of a report and recommendation of the Minister of Mines and Energy dated the 8th day of December, A.D., 1989.

Respectfully submitted,

Honourable Jack A. MacIsaac
Minister of Mines and Energy

DATED: December 8, 1989.
HALIFAX, Nova Scotia

FORM 16165-87
0234D

TO BE USED FOR ALL REPORTS AND RECOMMENDATIONS EXCEPT APPOINTMENTS

ATTORNEY GENERAL
approved as to form.

Document 4 of 4

REPORT AND RECOMMENDATION

TO EXECUTIVE COUNCIL

NUMBER:
DEPT.:
DATE:

SUBJECT: Amendment of regulations made pursuant to the Mineral Resources Act

SUBMITTED BY: Honourable Jack MacIsaac, Minister of Mines and Energy

PREPARED BY: Nancy Hood, Solicitor, Department of Mines and Energy

DEPUTY MINISTER: John J. Laffin, D.Eng.

APPROVALS

ATTORNEY GENERAL
Approved of as to
Form & Authority

Nancy Hood

POLICY BOARD
Date Rec'd ______
Recommended ______
Forwarded w/o Recommendation ______
Rejected ______
Date of Action ______

MANAGEMENT BOARD
Date Rec'd ______
Recommended ______
Forwarded w/o Recommendation ______
Rejected ______
Date of Action ______

EXECUTIVE COUNCIL
Date Rec'd ______
Approved ______
Date ______
Rejected ______
Date ______
Referred to ______

SUMMARY

The Governor in Council is asked to approve amendments to Mineral Resources Act regulations to add regulations respecting mineral exploration generally and chance uranium encounters in particular.

BUDGETARY/FINANCIAL IMPACT of this Request - current and 3 subsequent fiscal years.

	19__/__	19__/__	19__/__	19__/__
		($,000's)		
Current Account Expenditure				
Revenue/Recovery				
Net Impact				
Capital Expenditure/Advance				
Recovery				
Net Impact				

($,000's)	19__/__ Vote	19__/__ Total Departmental
Budgetary Implications (Current Year) Included in budget? Yes ___ No ___		
Authority		
Full Year Forecast (Including this request)		
Variance		

The Undersigned has the honour to refer to clauses (a), (b), (c), (d), (e), (i) and (l) of subsection (1) of Section 16 of Chapter 12, S.N.S. 1975, the Mineral Resources Act:

16 (1) The Minister, with the approval of the Governor in Council, may make regulations,

(a) respecting the disposal of tailings, slimes, waste products, or any noxious or deleterious substances upon any lands or into any waters:

(b) respecting the restoration, reclamation and rehabilitation of a mine or mining lands;

(c) governing the operation of any mine or metallurgical works and may include any pit, quarry, or place where the sand, gravel, rocks and other materials are being removed;

(d) providing for the carrying out of the operations referred to in clause (c) in a safe and efficient manner;

(e) requiring, from the holder of a mineral right or the operatior of a mine, statements and plans respecting work and operations;

(i) prescribing forms and providing for their use;

(l) for the better carrying out of provisions of the Act.

The Undersigned has the honour to report that

(a) on the 1st day of June, A.D. 1975, by Order in Council 75-532, the Governor in Council made regulations respecting mineral resources;

(b) by letters dated February 16, 1982, September 7, 1982 and May 29, 1986 the Minister of Mines and Energy acting pursuant to subsection (1) of Section 24 of the said Act, withdrew approximately 507,360 acres of land from application for all minerals until regulations respecting uranium occurrences could be promulgated;

(c) by report and recommendation dated the day of , A.D. 1989, the undersigned recommends the reopening of certain of the aforementioned lands;

(d) regulations pertaining to uranium occurrences are attached hereto as Schedule "A" to this report and recommendation.

The Undersigned therefore has the honour to recommend that the Governor in Council make an Order in the following form or to like effect:

The Governor in Council on the report and recommendation of the Minister of Mines and Energy dated the 8th day of December, A.D., 1989, pursuant to subsection (1) of Section 16 of Chapter 12 of the Statutes of Nova Scotia 1975, the Mineral Resources Act, is pleased to approve amendments made by the Minister of Mines and Energy to Regulations under Section 16 of the Mineral Resources Act in the form attached as Schedule "A" to the report and recommendation, the amendments to be effective on, from and after the 2nd day of January, A.D., 1990.

Respectfully submitted,

Honourable Jack A. MacIsaac
Minister of Mines and Energy

DATED: December 8, 1989
HALIFAX, Nova Scotia

SCHEDULE "A"

AMENDMENTS TO REGULATIONS MADE PURSUANT TO SECTION 16 OF CHAPTER 12 OF THE STATUTES OF NOVA SCOTIA 1975, THE MINERAL RESOURCES ACT

1 The Regulations respecting work on mineral rights made by the Minister of Mines and approved by the Governor in Council pursuant to Section 16 of Chapter 12 of the Statutes of Nova Scotia 1975, the Mineral Resources Act, by Order in Council 75-532 made the 20th day of May, A.D., 1975 are amended by adding immediately following Section 13 thereof the following Sections:

14. (1) In this Section

(a) "hole" means a hole drilled for the primary purpose of obtaining geological, geochemical, or geophysical information;

(b) "intersection" means intersection as that expression is understood in the mining industry.

(2) Every holder shall

(a) prior to drilling a hole, notify the Registrar of the location, magnitude and schedule of the proposed drilling program;

(b) in respect of holes drilled within 15 metres of a watercourse as defined in the Planning Act, ensure that all effluent from the hole is discharged into a sump capable of containing the discharge;

(c) seal all intersections of salt, potash, coal or uranium;

(d) affix non-leaking caps to the surface casing of a hole until testing is completed;

(e) seal completed holes at the interface of overburden and bedrock; and

(f) remove all debris and material used in the drilling program from the site in an environmentally safe manner.

15. (1) In this Section "surface excavation" means trenching, pitting or stripping of surface material

(a) by mechanical means; or

(b) to a depth greater than one metre,

for the purpose of finding, identifying or determining the presence or extent of any mineral.

(2) No person shall conduct or engage in surface excavation except under the authority of an excavation permit issued by the Registrar.

(3) Any holder may apply to the Registrar for an excavation permit.

(4) The Registrar may issue an excavation permit in Form C and which shall specify

(a) the lands to which it applies;

(b) the term thereof;

(c) the location and approximate dimensions of any proposed excavation;

(d) the name and address of the permit holder's field representative who shall be the person directly responsible for the conduct of the excavation;

(e) such conditions as the Minister may determine.

(5) The holder of an excavation permit shall comply and shall ensure compliance with these regulations and the terms and conditions of the excavation permit.

(6) Every applicant for an excavation permit who is not the holder of a Special License issued pursuant to Section 68 of the Act shall enter into a written agreement with the owner and, if the owner is not the occupant, the occupant or tenant of the lands to be excavated, permitting the applicant to access and perform surface excavation.

(7) Every agreement referred to in subsection (6) shall describe the state in which the property is to be left upon completion of the surface excavation.

(8) Notwithstanding the agreement referred to in subsection (6), the Minister may require the permit holder to post such cash, bonds or other security as may be specified by the Minister.

(9) Notwithstanding the agreement referred to in subsection (6), except as ordered by the Minister, a permit holder shall refill each excavation within thirty days of its completion.

(10) The Registrar may cancel an excavation permit if the holder contravenes or fails to comply with a term or condition of the permit or this Section.

(11) The holder of an excavation permit shall ensure that a copy of the excavation permit and any agreement referred to in subsection (6) is kept in the custody of the field representative named in the excavation permit and is available for inspection by an officer at the excavation site.

16. Every person shall immediately

(a) notify the Registrar of encounters with uranium mineralization;

(b) if a uranium concentration greater than 100 parts per million is encountered, cease work associated with prospecting, exploration and development except

(i) work required to determine if the concentration is representative of the average of the mineralized zones, and

(ii) such other work as is allowed by an officer;

(c) cease all development or mining operations if the average uranium concentration in an ore body or in the aggregate of waste rock removed or which would be removed to develop or extract the ore body exceeds 100 parts per million;

(d) upon being directed to do so by the Minister, restore a site or any part of a site where

(i) prospecting, exploration or mining has been undertaken by that person, and

(ii) the presence of uranium exceeds 100 parts per million.

MADE at Halifax, Nova Scotia, this 8th day of December, A.D., 1989.

Honourable Jack A. MacIsaac
Minister of Mines and Energy

Department of Mines and Energy
Box 1087, Halifax, N.S., B3J 2X1

EXCAVATION PERMIT

No. ________

THIS IS TO CERTIFY THAT: ______________________________
(licensee/lessee)

BEING THE REGISTERED HOLDER OF Exploration License/Mining Lease/ Treasure Trove License No.(s) ______________________________

is hereby authorized (subject to the Guidelines on the reverse of this form) to conduct:

		Total sq. metres
☐	trenching, pitting over 1.0 metre deep	
☐	trenching, pitting or stripping by mechanized means	

☐ underground exploration

		Number of headings	Total depth/ length (metres)
☐	by shaft sinking		
☐	by driving adits, drifts, or raises		

☐ by re-opening previous workings identified as ______________________________

____

incorporating ☐ de-watering ☐ rehabilitation

☐ bulk sampling (maximum 100 tonnes)

☐ at surface of not more than ______________ tonnes

☐ underground of not more than ______________ tonnes

at the following location(s):

Ref. Map
Tract(s)
Claim(s)

in the vicinity of ______________________________

In ______________________ County; on lands owned or occupied by:

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

The work will be conducted by (provide name if not the same as the licensee) ______________

______________________ whose field representative is ______________

______________________ who may be contacted at ______________

______________________________ Telephone (   ) ______________

NOT VALID UNLESS SIGNED BELOW

Permit Issue Date ______________

Permit Expiry Date ______________

I warrant that the information provided by me herein is absolutely true and correct

____
(Registrar of Mineral and Petroleum Titles)

____
(Mineral Rights Holder/Authorized Agent)

FOR DEPARTMENTAL USE ONLY

Chief Inspector ☐
Engineering ☐
Exploration Monitoring ☐

Landowner, Occupier or Tenant Written permission ☐
Reclamation Bond – Official Receipt No. ______________
Reclamation Completed ______________

Crown Lands Act ☐
Special Places Protection Act ☐
Environmental Protection Act ☐

GUIDELINES FOR EXCAVATION PERMIT

1 An Excavation Permit is required for:

(a) all trenching or pitting to depths in excess of 1.0 metre;
(b) all trenching, pitting or stripping by mechanized means;
(c) all underground exploration, including
  (i) shaft sinking,
  (ii) driving or adits, declines, drifts, levels, crosscuts, raises or winzes, and
  (iii) the reopening, rehabilitation or dewatering of any such workings;
(d) all bulk sampling
  (i) at surface, including tailings, and
  (ii) underground on any property not in production.

2 Persons applying for an Excavation Permit are required to:

(a) complete this sheet;
(b) attach a sketch map indicating access to the work area from the nearest settlement;
(c) post a reclamation bond, if required, in an amount determined jointly by the Departments of the Environment and Mines and Energy;
(d) show proof of permission from the owner, occupant, or tenant of the land;
(e) show proof of permission to undertake the work from all necessary Departments of Government;
(f) where the project includes underground exploration or bulk sampling, submit plans of the proposed program in a form acceptable to the Department; and
(g) submit this form to the Registrar, Department of Mines and Energy at:

1701 Hollis Street	or	P. O. Box 1087
Halifax, Nova Scotia		Halifax, Nova Scotia
(902) 424-4068		B3J 2X1

3 **Persons conducting work under an Excavation Permit shall be required, within thirty (30) days of completing trenching, pitting or stripping, to refill such excavations in a manner acceptable to the Department. This restriction may be waived only if other arrangements have received the prior approval of the Minister or the Minister has accepted a written request from the landowner, occupant or tenant for the trench, pit or stripped area to the left open.**

4 Royalties must be paid if any product derived from a bulk sample is sold.

5 Where more than 100 tonnes of material for testing is to be extracted, the permission of the Minister shall be first obtained.

6 The Minister may refuse to issue an Excavation Permit where in his opinion such Excavation Permit is not being obtained for the purpose of testing.

7 The issuance of an Excavation Permit does not absolve the Permittee of his responsibilities under all other applicable Statutes, Acts and Regulations.

8 Any misrepresentation or omission in the information provided herein by the Mineral Rights Holder or his authorized agent shall entitle the Minister to forthwith revoke this Excavation Permit and to exercise any rights available to him under the Mineral Resources Act.

APPENDIX 3

INTERDEPARTMENTAL URANIUM COMMITTEE
HYPOTHETICAL URANIUM MINE, ECONOMIC ANALYSIS
1985

HYPOTHETICAL URANIUM MINE, ECONOMIC ANALYSIS [1]
1985

In October 1985, the Interdepartmental Uranium Committee and the Mining Engineering Division of the Department of Mines and Energy used standard economic modelling techniques to determine the break even grade relative to the selling price of the final product ($U_3 0_8$ contained in "yellow cake") for a hypothetical uranium deposit that might be found in Nova Scotia. The purpose of the analysis was to find the lowest cut off (break even) grade that would support a low cost open pit mine.

A computer program was used to perform the analysis. The program applied standard mine economic modelling parameters including discounted cash flows, federal and provincial income tax and mining tax provisions. The process was iterative where a fixed grade was established and the program was run several times at various prices for $U_3 0_8$ (Freight-On-Board the mine gate) until a 13% rate of return was realized for the simulated mine project. The model assumes that uranium is the only product produced at the mine.

The "mine" used for the analysis had the following characteristics:

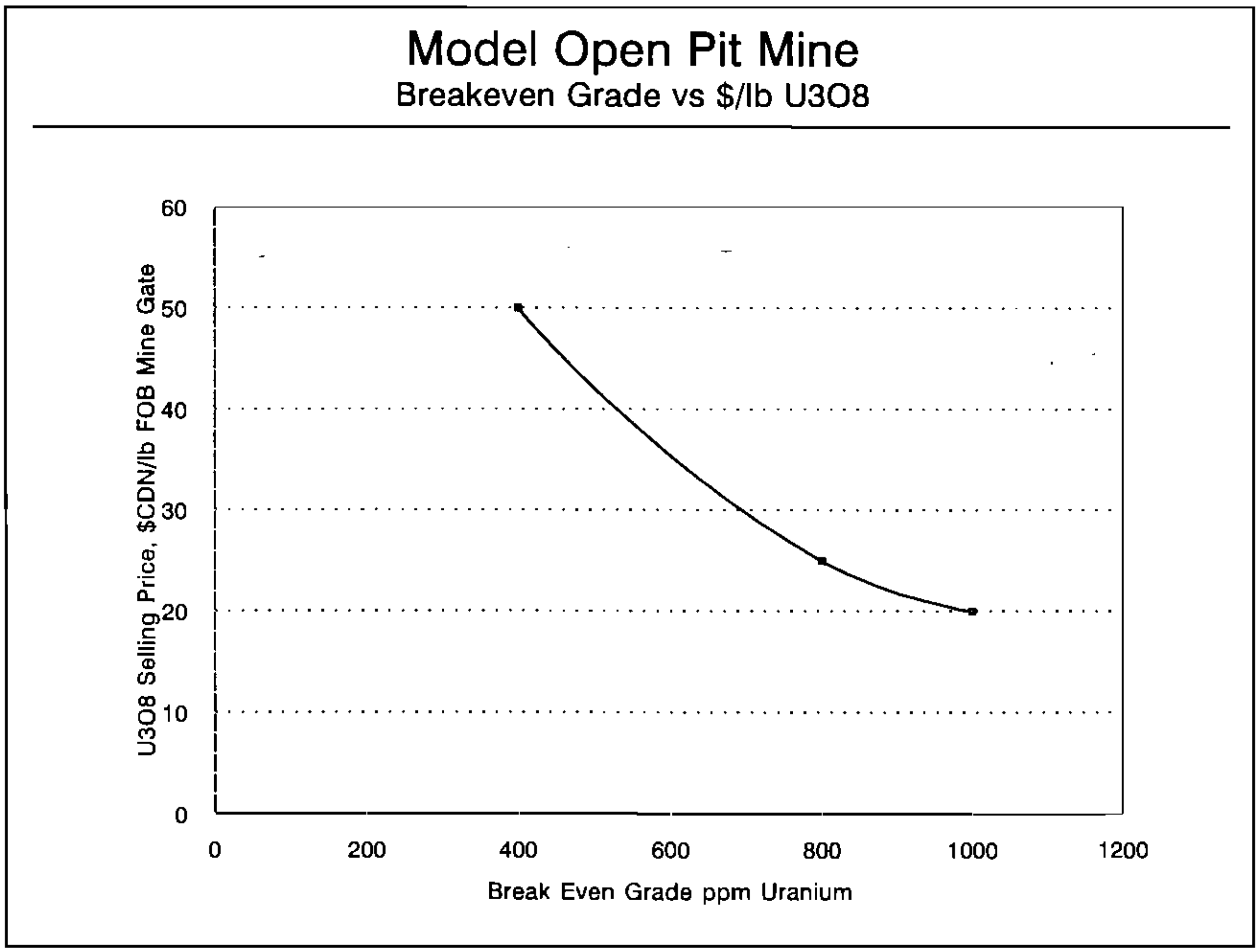
Reserves:		21,000,000 tonnes
Mine Life:		19 years including 4 years preproduction work
Grade:	400 ppm, 800 ppm, 1000 ppm	
Price:		variable
Capital Cost:		$111,306,000
Municipal Tax:		$470,000/year
Operating Cost:	Mine	$7.50/t
	Mill	$7.00/t
Mill Recovery:		90%
Cost of Capital:		11.25%
Exploration Expense		$14,844,000
Working Capital:		$ 2,921,000
Minimum Rate of Return:		13%

[1] The costs used in this model reflect a mining situation in 1985. The operating, capital and other costs in 1994 would be substantially higher. These increased costs would be reflected in a higher break even selling price for the uranium produced. In addition, the model does not include the extra costs associated with decommissioning of a uranium mine.

The following table and graph represent the results of this study.

1985

Average Grade of Uranium Deposit (ppm)	Break Even Selling Price of U_3O_8 ($CDN/lb)
400	50
800	25
1000	20



APPENDIX 4

INTERDEPARTMENTAL URANIUM COMMITTEE
SUB-COMMITTEE REPORT
ON
URANIUM TAILINGS DISPOSAL TECHNOLOGIES
AND
LONG TERM ABANDONMENT AND CLOSURE OF URANIUM MINES

INTERDEPARTMENTAL URANIUM COMMITTEE

MINING TECHNOLOGY SUB-COMMITTEE

REPORT

ON

URANIUM TAILINGS DISPOSAL TECHNOLOGIES

AND

LONG TERM ABANDONMENT AND CLOSURE OF URANIUM MINES

JULY 1994

Prepared by: D. Khan
D. Briggins
D. Hiltz

Introduction

One of the most technically difficult and costly challenges of modern mining is the reclamation and abandonment of a mine site once economically mineable ore has been exhausted. Major issues that any mine proponent must address include: tailings disposal; long term site stabilization; and re-integration of disturbed lands back to some alternative land use. Currently almost all jurisdictions in North America require that a preliminary reclamation (close-out) plan be submitted at the front end of any proposed mine development for review by regulatory agencies and the general public. There are also stringent requirements placed on mine developers to show how the environment and public will be safe-guarded during the active stages of the mine. In uranium mining these same concerns exist but at a much greater level of awareness due to the relatively long life of radionuclide contaminants that are produced in the mining sequence and public concerns associated with nuclear radiation.

Environmentally sustainable mining has been proven to be obtainable in many geographic settings in the world. One impediment to many projects now days, is the cost of long term stabilization and water treatment following closure of a mine. Judge McCleave in his "Report of the Commission of Inquiry on Uranium", understood these aspects of the mining cycle and one of his conclusions clearly stated that uranium can be mined safely if properly done. McCleave qualified this statement by saying there was a need for site specific evaluations of any particular ore deposit to determine if short and long term tailings disposal can be achieved (Conclusion 1, page 29). The McCleave report was submitted to the Government of Nova Scotia on January 30, 1985 following 44 public meetings over a period of three years.

This document has been prepared by a sub-committee of the Interdepartmental Uranium Committee whose task was to review the best practicable technology that exists today with regard to tailings disposal management and long term site abandonment at uranium mines.

Methods of Study

The main method employed by the sub-committee members was to interview colleagues in other jurisdictions as to what are the "state of the art" techniques being used by uranium mining companies throughout the world. This included extensive discussions with provincial government employee's in both the British Columbia and Saskatchewan Departments of the Environment and with federal government personnel at the Atomic Energy Control Board in Ottawa and the Federal Environmental Assessment Review Office in Hull, Quebec.

Along with these discussions, numerous documents were obtained that outlined the most recent uranium mine development proposals and the rigorous Environmental Assessment Panel reviews performed on these proposed projects. The sub-committee also obtained opinions from both provincial and federal government personnel on the trends and acceptability of future uranium mining in the country. One member of the sub-committee travelled to the offices of the AECB in Ottawa to retrieve background documents and to discuss the issues first hand with the uranium mining regulators tasked with decommissioning uranium mine sites.

Uranium Tailings Disposal

History

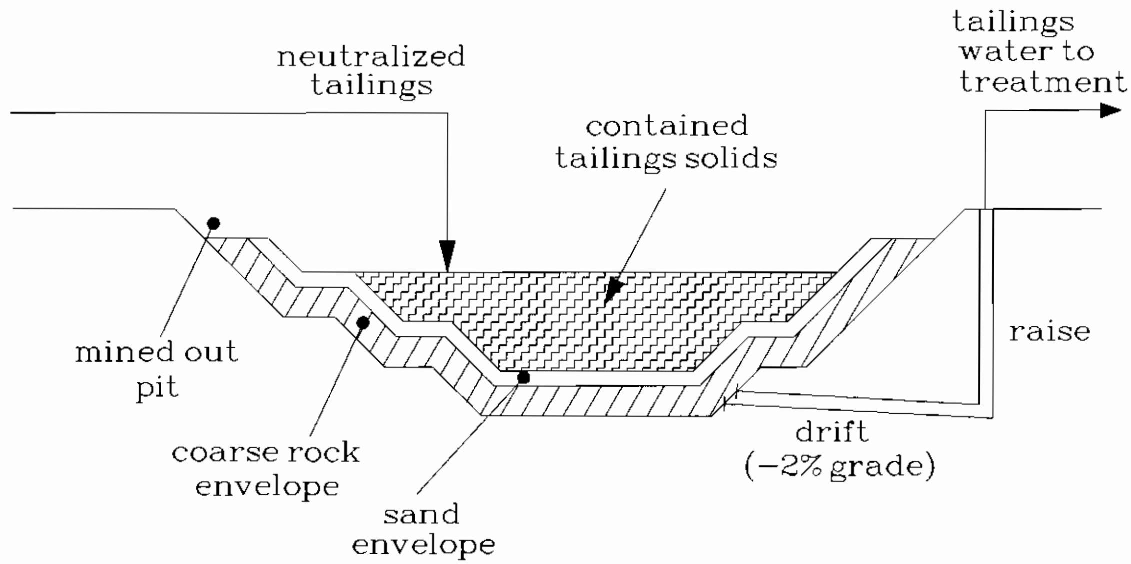
One of Judge McCleave's greatest reservations with regard to sustainable uranium mining in Nova Scotia, was the issue of tailings disposal. Early uranium mining in Canada, from the early 1940's to the early 1970's allowed sub-aqueous disposal into existing lakes with little control of the contaminant dispersal. This practice became unacceptable to regulatory agencies and uranium tailings were then disposed of using surface disposal techniques (mainly using conventional containment dams) until the early 1980's. In 1980 Gulf Minerals Limited (later to become Eldor Mines Ltd. and presently Cameco Corporation) filed an environmental impact statement with the province of Saskatchewan, requesting approval for expansion of the existing operation at Rabbit Lake. This included a request to expand the existing surface tailings management facility. The proposal was rejected by the Saskatchewan Department of the Environment in 1981 on the basis that a higher degree of protection could be achieved with alternative schemes. As a result, further studies were initiated by Gulf Minerals leading to development of pervious surround technology. Since 1984, the only tailings disposal proposals acceptable, to both the AECB and the province of Saskatchewan, for new uranium mines has included the use of in-pit pervious surround.

Problems with Conventional Tailings Disposal Techniques

Mine ore tailings are typically disposed of by depositing finely ground mill wastes into a man made containment pond. This tailings pond is constructed by using natural topographic depressions (such as a stream valley) with an engineered containment dam to decant water that is co-disposed with the tailings. The critical issues that affect the overall suitability of this type of disposal are the long term integrity of a containment dam; how the groundwater and surface water regimes are affected by the deposition of the tailings; and finally how will the tailings area be rehabilitated.

Tailings can be rehabilitated by either direct re-vegetation of the tailings material or importing a cover material which can support vegetation. An alternate plan, for some acid generating tailings, is to permanently submerge all of the tailings by maintaining a static water cover over the entire tailings pond area. Both of these options will serve their purpose for some predictable time frame with little or no maintenance, however the long term stability remains in question due to natural erosional forces. These erosional forces can affect the vegetative or other engineered covers and more critically the containment dam stability and integrity. If the containment dam is breached all control of the tailings management facility breaks down. With some mine tailings this long term containment is less critical due to the relatively low danger posed to the environment and human health by an accidental release of the tailings. Uranium tailings (again due to the long life of the radionuclide elements) need very long term management (up to 10,000 years) to ensure that any sudden release cannot occur. Above ground tailings disposal does not meet this requirement.

Finally the aspect of groundwater and surface water contamination is a difficult issue to deal with using surface disposal techniques. In general these regimes do not change drastically, however the extremely long time spans that must be dealt with in uranium mine closures add a level of uncertainty as to how hydrological patterns will be affected or what pathways will become available for contaminates to exit the tailings management facilities.



CONCEPTUAL DIAGRAM OF PREVIOUS SURROUND

TAILINGS DISPOSAL METHOD

Figure 1

Pervious Surround Tailings Disposal

The pervious surround concept recognizes that it is exceedingly difficult to construct an artificial containment system which is 100% leak-proof. It is constructed with natural geological materials that withstand natural weathering processes better than many man-made materials. The placement of mine tailings in a pit excavated in rock below the water table removes those tailings from erosional processes, such as rain, wind and freeze-thaw cycles that occur on the land surface. The placement of wastes below the natural land surface and below the water table reduces the likelihood of future dissemination of those wastes due to natural processes.

Before any mining activity starts, a natural groundwater flow system exists in the rock. When an ore body is excavated by open pit mining techniques, the water table is disturbed. Removing groundwater which has flowed into the pit causes the water table surrounding the pit to be drawn down. This event is termed a "cone of depression" and will cause the natural groundwater in the rock surrounding the pit to flow into the pit from where it can be recovered by pumping.

Once pit mining is completed, a drift (horizontal tunnel) is mined out from sumps at the bottom of the pit and connected to a vertical shaft (raise) which ascends to the surface near the edge of the pit (Figure 1). The drift is then filled with crushed rock of a prescribed size and layers of crushed rock and sand (pervious surround) are placed on the base and walls of the pit. The pervious surround is much more permeable than the rock surrounding the pit. Water from both the tailings and the rock surrounding the pit flows along the path of least resistance and will therefore flow through the pervious surround to the sumps at the base of the pit from where it is pumped via the drift and raise to the mill for treatment.

As slurry tailings (tailings with water) are pumped into the pit and their depth increases, densification by gravity causes the contaminated water to be expelled from the tailings and flow through the pervious surround to the sumps. These contaminated waters are collected and pumped to a treatment plant to remove undesirable elements. Thus, as long as the tailings mass is maintained in the dewatered condition, the system is inherently safe because all natural water flows toward the pit, into the pervious surround and is recovered. Similarly, all contaminated tailings water that flows out of the tailings to the pervious surround is likewise recovered. There is no potential for escape of any contaminants to the environment as long as the pit disposal system is maintained in a dewatered state. This is the normal condition during operation, and is also available as a fallback position should long-term concerns be identified.

In order to ensure that the pit remains in a dewatered state, a number of safeguards are in place to ensure that sufficient pumping is always occurring. There are always two fully operational electric pumps at the bottom of the shaft to pump the water to the mill. Each pump has sufficient capacity on its own to handle the dewatering of the tailings pit and therefore only one is run, with the other on standby. If there is a power outage, standby diesel generators should be available to supply the required power to ensure the system is operating correctly.

Advantages of Pervious Surround

The pit disposal system with the pervious surround is preferred because of its inherent stability, multiple barriers to flow, the multiple systems that work to minimize contaminant releases from the system and the availability of fallback systems in the event that problems do develop at some time in the future.

Conventional above-ground tailings management systems are designed to retain the tailings in a confined area within earthen dams and above the groundwater table. Gravitational effects therefore cause a high potential for downward migration of tailings porewater from tailings stored above natural water tables. The conventional systems attempt to resist this persistent potential for seepage from the tailings by providing some form of seepage barrier around and under the tailings.

Rather than work against the forces of nature (i.e. gravity), the pervious surround concept achieves equilibrium with natural forces. This principle is facilitated by the fact that the tailings are stored below the natural groundwater table, thereby eliminating seepage from gravitational effects. In addition, groundwater will flow along the path of least resistance. Therefore, all groundwater flowing towards the pit will be directed through the pervious surround and around the consolidated impermeable tailings mass. This ensures no contamination of the groundwater near the pit will occur.

In contrast to above-ground storage facilities, the pit disposal system offers a number of natural and engineered containment systems which work to minimize the risk of release of contaminants and an increase in the environmental security.

The primary barrier is the large mass of natural, relatively low permeability rock that surrounds the pit. This material, although sometimes fractured and faulted, offers a low permeability flow path, often many kilometres in thickness.

The second major barrier is the natural groundwater system which, investigations have shown, moves very slowly and requires many centuries for radioactive contaminants to move to surface water systems, should they escape from the pervious surround.

The third barrier is the pervious surround in the pit which, after decommissioning will divert groundwater flow around the tailings, allowing only a minuscule flow through the tailings. This feature allows for future dewatering and recovery of the tailings, should that become desirable for environmental or economic reasons.

The fourth barrier is the consolidated tailings mass. The natural resistance to the flow-through of water is very high and the majority of contaminated fluid will have been recovered by the time the pit is totally decommissioned, resulting in minimal release of contaminated water from the system after closure.

All of these features work together to provide increased environmental and operational security for the in-pit pervious surround tailings management system, during operations and after decommissioning and reclamation.

A number of the advantages the pervious surround system provides over above-ground tailings management facilities have been discussed above. They can be summarized as follows:

- inherent environmental safety during operations because of the diversion of all groundwater and tailings porewater through the pervious surround;

- a higher degree of long-term environmental security resulting from multiple barriers and the redundancy aspect discussed earlier;

- a system that can be analyzed and engineered according to rigorous and scientific engineering principles;

- removal of concern about overtopping or failure of the containment systems during operations (an inherent concern in the above-ground dyke systems);

- removal of concerns related to the physical stability caused by dyke failure, frost action and/or erosion, both during operations and in the long-term after decommissioning;

- disposal below the water table allows radon flux to be reduced to a point where it is no longer of concern;

- with a large depth to area ratio, the system occupies the minimum amount of land area;

- the system is easily monitored, both during operation and after decommissioning;

- operational changes needed for improved environmental protection, should they be identified, are relatively easy to make when the tailings are enclosed in a fashion that produces relatively small surface areas;

- in the low gradient, low velocity groundwater system, the potential for contaminant migration in groundwater is greatly reduced over that of a surface tailings management system. The principle mechanism of migration will be through chemical diffusion, a process which is extremely slow and has much less potential to cause environmental damage than the process of groundwater seepage;

- the system is constructed entirely of natural materials which have been, and will continue to be durable for geological time. There are also no synthetic or mechanical systems to degrade after decommissioning; and

- the pervious surround itself and the dewatering system will remain intact after decommissioning allowing the area to be dewatered and isolated from the groundwater system should this become desirable for economic or environmental reasons.

What Happens on Closure in Pervious Surround?

After placement of tailings is complete, the system will be maintained for a sufficient length of time to allow the tailings to be densified and the maximum amount of contaminated water to be recovered and treated. The tailings will then be covered with a layer of rock or compacted clean till followed by a water cover and the natural groundwater system will be allowed to recover. The densified tailings are much more resistant to water flow than the sand and gravel layers surrounding them. Natural groundwater flow will therefore bypass the tailings and flow through the pervious surround rather than flowing through the tailings and flushing contaminants from them. A simple analogy is that sugar crystals in a ball of plasticine represents radionuclide and heavy metal contaminants (sugar) in the tailings mass (the plasticine). If the ball of plasticine is placed in a layer of sand (the pervious surround) infiltrating water will flow through the sand and around the plasticine. There will be no chance for the sugar crystals to be dissolved and removed from the plasticine.

The design of the cover will ensure that any release to surface water is well within acceptable levels. Modelling indicates that this release will be very small by comparison with other tailings management facilities. Upon completion of decommissioning, there will be minimal surface disruption remaining at the site. In contrast to operations that have surface tailings storage facilities, all tailings associated with the in-pit pervious surround system are below grade. This is viewed as more socially acceptable than the option of abandoned above grade tailings storage facilities in that a closed out pit does not interfere with traditional land use.

The Rabbit Lake Experience

The depth of the tailings in the pit is presently approximately 50 meters. This represents about 30% of the total design volume of the pit. Five years from now, and at anticipated rates of deposition, the pit will have received approximately 60% of its total capacity available. Pumping of water from the shaft and raise results in a "cone of depression" diverting all flows through the pervious surround from where it is pumped to the mill for re-use or treatment prior to release to the environment. All tests indicate that the actual achieved tailings characteristics, i.e. density, permeability and contaminant concentrations in the porewater will result in a further reduction of the predicted, very low long-term contaminant transport from the tailings body.

The long-term performance of the system will be defined by monitoring of the surface and groundwater at and in the vicinity of the pit at the time of decommissioning. Considering the anticipated operational life of the Rabbit Lake in-pit tailings management facility, the actual post-decommissioning water quality results will not be available for approximately 15 years after the deposition of tailings ceases.

Extensive and frequently verified field experience obtained from the construction of the disposal system and nearly a decade of operation, has demonstrated that all pertinent design criteria were fully realized. The original modelling for the decommissioning of the tailings area predicted a 25 year time period to totally decommission the area. Subsequent field measurements of consolidation rates within the operating pit show that the time period will be substantially less.

Environmental Performance at Rabbit Lake

Ongoing technical review of all uranium mill tailings schemes is important to maintain public confidence and to facilitate continuous improvement in the degree of environmental protection. Such reviews enable early identification of concerns, such as those that resulted from an independent consultant's review of the Rabbit Lake in-pit tailings disposal system in 1988. Regulatory response has been to identify these concerns as action items in the annual operating approval and obtain a commitment from industry to respond to them. The positive results of this process are easily identifiable. The level of contaminant discharges from the Rabbit Lake scheme have reduced by tenfold over the operating life of the property, with an attendant increase in the level of environmental security. Saskatchewan Environment and Resource Management continues to press the operator for an ever higher level of engineering to reduce the level of uncertainty and upgrade predictions of future performance.

The pervious surround disposal system at Rabbit Lake has functioned better than predicted. The concerns identified in the various reviews have been addressed through licensing. Ongoing monitoring and analysis of information have led to improved analytical methodology and field operating technology.

> **These reviews have consistently concluded that the pervious surround system is the best system to meet environmental objectives prescribed by provincial and federal regulations. It is for this reason that the pervious surround system is being proposed for future projects.**

What if Pervious Surround Doesn't Perform to Expectations?

Concerns have been expressed concerning the perceived uncertainties and experimental or "pilot project" nature of the pervious surround.

It is not unusual for projects to be engineered and constructed without knowing, in specific detail, the final results. The engineering process includes investigation, concept development, design, construction, monitoring and post construction improvements where necessary. In all cases, a high degree of safety and redundancy is important. The process incorporates regular review and assessment, and using this information to continuously upgrade and improve any project.

Rigorous and detailed monitoring of the Rabbit Lake in-pit pervious surround tailings management system and surrounding area was begun before the facility was placed into operation. This monitoring continues today as a licence requirement for the Rabbit Lake site and it will continue throughout operation, decommissioning and post decommissioning. Such monitoring is not only for environmental protection but it is also part of the normal engineering process in order that minor adjustments to the facility can be made if they become necessary. Monitoring is also used to improve calibration and validation of the analytical models used in original design engineering.

Inherent to the design and construction of a pervious surround in-pit tailings management facility is a feature which would allow complete isolation of the waste material from the environment at any time in the future. The pervious surround and dewatering facilities will be decommissioned in a fashion that allows the tailings to be recovered at any time in the future. Since the construction of the facility is of natural materials that are subject only to geological modification, they will last as long as the surrounding rocks last. If the need arose at any time after decommissioning, pumps could be re-installed and the pervious surround maintained in a dewatered state with treatment of contaminated water in perpetuity (the contaminants will not become any more toxic over time therefore existing technology can successfully treat contaminated water). The rate of flows and amount of contaminates could be predicted with sufficient accuracy that the cost of such operations could be determined and, if necessary, covered by a suitable financial instrument.

Less extreme forms of future mitigation are also available depending on the nature of the concern. Improvements to surface cover, or isolation from the groundwater system can be achieved through normal construction technology such as earthworks and grouting and bentonite or similar permeability reducing agents. In essence, totally isolating the tailings from the environment. The type and cost of any future mitigation would be dependent upon the nature of the concern identified in the comprehensive long-term monitoring program. Monitoring and analysis to date indicates that such long-term concerns are very unlikely to occur.

Long Term Abandonment of Uranium Mine Sites

There are many issues to be resolved in any mine closure regarding long term abandonment, stability and ultimate reintegration of disturbed lands back into surrounding environment. As with other aspects of uranium mining, this issue takes on heightened importance due to the long life of the radionuclide substances present. One of the most contentious issues has been long term containment of uranium tailings. With the introduction of pervious surround technology this problem appears to be manageable and walk-away conditions are expected to be obtainable with proper site selection and management.

The other major source of uranium contamination at a mine site would be waste rock that contains low grade uranium concentrations (termed "special wastes" by the AECB). Left unconsolidated and uncovered on surface, these waste materials will continue to emit radiation and often produce acidic leachates which carry radium-226 and other toxic heavy metals. Acidic runoff is a common problem at many metal mine sites and mine operators must go to great lengths to control or treat acidic runoff. The contemporary management practices envisaged for low grade uranium waste rock, consist of either co-disposal of the coarse waste rock with the tailings in a pervious surround system or actually milling these waste grade materials to allow co-disposal with the normal ore tailings. These techniques are now understood to be requirements that will ultimately lead to true walk-away conditions.

Without such measures, the approval process for any new mine proposal would likely call for onerous security bonds by regulators and financial safeguards for creditors which in turn would seriously impact the economic viability of a project. With proper mine planning and scheduling and effective temporary storage of these special waste materials the site should not exhibit background radiation much greater than prior to mine development.

Current Status and Conclusions

The AECB regulates all phases of a uranium mine from advanced exploration to decommissioning. Each phase of the mining cycle receives a specific licence. A typical project may require: a licence to remove ore; followed by an Excavation Licence; a Siting, Construction and Operating Licence; and ultimately a Decommissioning Licence.

Mine closure and abandonment activities are regulated under an AECB Decommissioning Licence. When the a mine has fulfilled its obligations under a Decommissioning Licence the site is de-licensed. To date the only uranium mine site in Canada that has been de-licensed is the Kerr Addison mine in Agnew Lake, Ontario. This site only obtained de-licensing due to the fact that control of the property reverted back to the Province of Ontario via a loop-hole in their surface lease agreement with Kerr-Addison. AECB were willing to de-licence the site because ultimately the Province became responsible for any further remediation, if required in the future.

No other mine site has been de-licensed by the AECB. Because of past mining methods, waste disposal techniques, etc., the AECB is not likely to de-licence any of the existing inactive or closed mine sites because it is unlikely that walk-away conditions can be achieved. One primary condition for de-licensing is that a site not contain any *"prescribed materials"*. Prescribed materials are essentially any material that contains or is contaminated by radioactive substances above prescribed concentration limits. Although several sites, including the Madawaska mine in Bankcroft, Ontario, are generally causing little environmental impact, these sites are not likely to ever achieve a de-licensing status due to the original waste management strategies employed.

The only mine currently using in-pit pervious surround tailings disposal is Cameco Corporation's Rabbit Lake mine in Northern Saskatchewan. First placement of tailings began in August 1984 and since then all monitoring and evaluations of the tailings management facility have shown that the system has met or exceeded predicted expectations for tailings containment and potential groundwater contamination. Final closure of the Rabbit Lake site (following last placement of tailings into the pit) is now predicted to be much sooner than the original estimate of 25 years, however regulatory bodies in Saskatchewan expect monitoring to continue for at least 15 years with contaminated water treatment ending at some earlier point in the closure cycle.

In-pit pervious surround tailings management has become virtually a "de facto" standard for any new uranium mining project in Canada. Although each and every mine site is unique, it is clear that traditional surface disposal techniques are not acceptable to either industry regulators or the general public who are ultimately affected by uranium mining. Pervious surround technology requires the excavation of a pit prior to any milling of ore. The pit must meet stringent engineering criteria for groundwater management and other hydrological factors. Thus far the only economically feasible in-pit pervious surround systems have been at mines that had an existing open pit available to them. The McClean Lake project in Northern Saskatchewan is the only proposed project that would excavate a pit exclusively for tailings disposal (stockpiling both waste rock and ore until completion of the pit). The economics of this type of project require very high grades and large tonnages of uranium ore, at least an order of magnitude greater than any known uranium mineralization found in Nova Scotia.

For all intents and purposes, the Rabbit Lake in-pit tailings management system cannot be fully evaluated for another 15 to 25 years, however other mining companies are proposing (and receiving regulatory approval for) similar pervious surround tailings management facilities which are building upon the experience gained at Rabbit Lake and may produce better and quicker mine site decommissioning conditions. The use of these new techniques are expected to lead to true walk-away conditions.

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APPENDIX 5

RADON DAUGHTER MONITORING PROGRAM
AT MILLET BROOK, N. S.
E.D.A. WORKING LEVEL MONITOR - 300
PERFORMANCE AND SAMPLING RESULTS

Environment

RADON DAUGHTER MONITORING PROGRAM

MILLET BROOK, N.S.

E.D.A. WORKING LEVEL MONITOR - 300

PERFORMANCE AND SAMPLING RESULTS

by

Keith Wade

November, 1981

AQUITAINE COMPANY OF CANADA

124 Water Street
Windsor, Nova Scotia

REPORT SUMMARY

The E.D.A. WLM-300 is reliable, generates consistent data, and has proven practical in field use. Repeated sampling of several work places have shown working level concentrations well below the newly adopted International Commission on Radiation Protection standard. The sample case shows a working level concentration approximately 14 x less than the standard, (see Graph 2 and Equation 1). The drill core work area in fact has on the average a working level concentration very similar to an empty office in the Windsor building used by Aquitaine (Graph 4, October 16, 1981).

During the monitoring program the effect of increased ventilation in buildings was dramatic. Ventilation will be improved further in all work buildings and monitoring will continue.

E.D.A. WORKING LEVEL MONITOR - 300

PERFORMANCE AND SAMPLING RESULTS

The E.D.A. WLM-300 is a radon daughter[1] working level monitor which samples the air of selected environments over time at a constant air flow rate. Radon is pumped into the monitor and a disposable filter cartridge collects the airborne Rn daughter isotopes and the radioactive decay of the isotopes release measurable energies which are detected by a silicon detector. The detector is sensitive to only the alpha particle energies released by Rn daughter products of radon gas. In open air conditions the radon daughter products do not have a chance to form in significant proportions due to wind circulation, eddies and convection currents. Therefore, the WL's are considerably lower than they would be in the same area if the area was enclosed. As an example of this refer to the graph (Graph 1) of Trench 2 main zone area, one sample cycle recorded in the "open air" and the other in a sealed space over the same spot.

Passive monitoring devices have been installed in two open areas of suspected high radon concentration. The system employed is the Terradex "Track Etch" cup device. A total of 13 cups were placed to sense radon concentrations downwind of the C2 zone and A9 zone and on two residential properties 8.5 km and 17.5 km north east of the zones. The track etch detectors are sensitive to radon gas and thorium radiation energy: the alpha radiation energies are the only radiation measured. To exclude radiation due to thorium sources the track etch cups are fitted with thoron filters. Thus using both systems we are able to obtain information on working levels where employees work, as well as contribute to the environmental background radiation data.

TEST SITES AND PERFORMANCE OF WLM

During the operation period from early May, 1981 to the present the WLM-300 has functioned reliably and consistently, i.e. the data has good correlation from sample to sample. To allow extended sampling on site away from AC power sources a cable has been adapted to run the instrument from a 12V DC battery. Using the battery, sample periods of up to 25 hours have been completed. With the battery, test periods of up to 150 hours can be attempted. Locations tested were varied in the early period; later the sites were more selectively chosen, and limited to areas where employees worked indoors, such as the core storage building, the core sampling shack, and the driller's cook cabin, as well as the various offices in Windsor. Each location was sampled several times under varying weather, and employee working activity conditions. In addition a residence was tested for one 25 hour period to provide a basis for comparison with other sites. Representative sample records are presented in 3 or 4 decade semi-log graph form.

FACTORS AFFECTING WLM - 300 READINGS

Ventilation, weather, and human activity all affect the parameters measured by the WLM-300. When the work buildings were in use during sampling the ventilation was generally very good. That is, both doors and most windows were open during the work period. Days of inclement weather show on the records as slightly higher working levels since the doors would be closed.

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[1] Use of the term "radon daughter" has since been replaced by the term "radon progeny". The older expression is retained in this Appendix as it is a verbatim reproduction of the original Wade (1981) unpublished report.

Since soil-gas radon concentrations can vary by more than a factor of 100 in 24 hours due to changes in temperature, barometric pressure, wind speed and direction, moisture and other factors,1 it can reasonably be expected that these factors would influence radon concentrations in the work buildings. Accordingly monthly climatological records are being subscribed from Environment Canada, Atmospheric Environment Service.

FINDINGS RELATED TO INTERNATIONAL & NATIONAL STANDARDS

Environmental Protection Agency (USA) standards state that no worker shall be exposed to more than 4 WLM (Working Level Months) in any calendar year. A working level month is exposure to a level of radiation equivalent to a working level for 170 hours, (a working month).

The WL's of all Aquitaine Company of Canada's work areas are considerably lower than even a fraction of this level, (see sample graphs). In 1981, Canada will adopt standards of the International Commission on Radiation Protection which define allowable exposure as:

$$\frac{WLM(Rn)}{5}+\frac{Rems}{5}+\frac{WLM(Th)}{15}\leq 1 \qquad \textbf{Equation (1)}$$

To relate this to the exposure received by Aquitaine Company of Canada's employees, consider Graph 2 of the core sampling building for 3 separate dates. Take the trace for June 17, 1981 which builds from a concentration of 0.0027 WL to a plateau level of 0.005 WL for the duration of the sample period. Assuming this level is maintained throughout the work day (8 hours) and the graph shows a stable level for 5 hours, the daily WL exposure is 0.005 WL. Again assuming the WL's remain constant over a period of days and weeks (not a likely case, refer to Graph 2, July 14 and July 16 which show lower levels) the cumulative WLM (170 hours per month) would be 0.005, an inconsequential level if you consider even the new Canadian standard. Placing values in equation 1, (the highest yearly employee mrem exposure (350 mrems) is used; data from the federal Occupational Radiation Hazards Division TLD service) we have:

$$\frac{0.005\,WL}{5}+\frac{0.350\,rems}{5}+\frac{WLM(Th)}{15}=0.071+K(unknown)-WLM(Th)$$

In other words a 56x lesser level than the old EPA standard of 4 WLM and 14x less than the new ICRP standard. The WLM(Th) can not currently be calculated, however for the sum of the equation to be equal to or greater than 1, the WLM(Th) would have to be in the order of 14; highly unlikely considering the radon levels in the sample.

Graph 3 illustrates the core storage shed WL's before there was ventilation and after ventilation. Using equation 1, the June 18, 1981 WL's and the same high 350 mrem's for a year the exposure would be:

$$Exposure=\frac{0.06}{5}+\frac{0.350}{5}+\frac{WLM(Th)}{15}=0.082+15$$

The WLM(Th) would again have to be approximately 14 to push the sum near or over 1. Since no prolonged work is ever done in this building and the short periods of activity are carried out with the doors open the actual WL exposure is extremely small, very comparable to levels from the core sampling building for July 14, 1981.The new storage shed with core stored is considerably lower than the above values, in large part because the building is larger, has better ventilation, a concrete floor as opposed to dirt, and contains less "hot" core.

Two copies of the actual tape have been included as examples of the interval to interval fluctuations and how differential WL's relate to total WL's.

CONCLUSIONS

During the period May, 1981 to October, 1981 the WLM-300 has shown its worth. Reliable in operation and data generation it has given Aquitaine Company of Canada a clear idea of WL's in several work places. The instrument fits in well with the TLD, and dosimeter monitoring already underway since 1979. The instrument is physically quite practical although there is a design flaw from our viewpoint. If power modes are switched, i.e. from external DC to internal DC the memory is erased. This means for instance that if the monitor is running off the 12V battery and data printout is desired the WLM-300 and the battery, still connected, must be brought back to the office; an awkward procedure at best. Similarly, if the instrument is connected to a power grid AC source and there is a power interruption the monitor immediately switches to its internal battery pack, however the data from the period running on the external AC source is lost. Otherwise the instrument is easily transported, placed, and is relatively rugged and trouble free.

The monitor has proven a useful tool to establish worker environment in Aquitaine's exploration work phase. If further development work is carried out at the Millet Brook site the WLM-300 will become an important investment.

LITERATURE CITED

1. Gableman, John W., 1974: Economic Geology and Uranium Prospecting in Frontier Areas, Amer. Inst. of Min. Metall. and Pet. Engrs. 103rd Ann. Mtg., Dallas, Texas.

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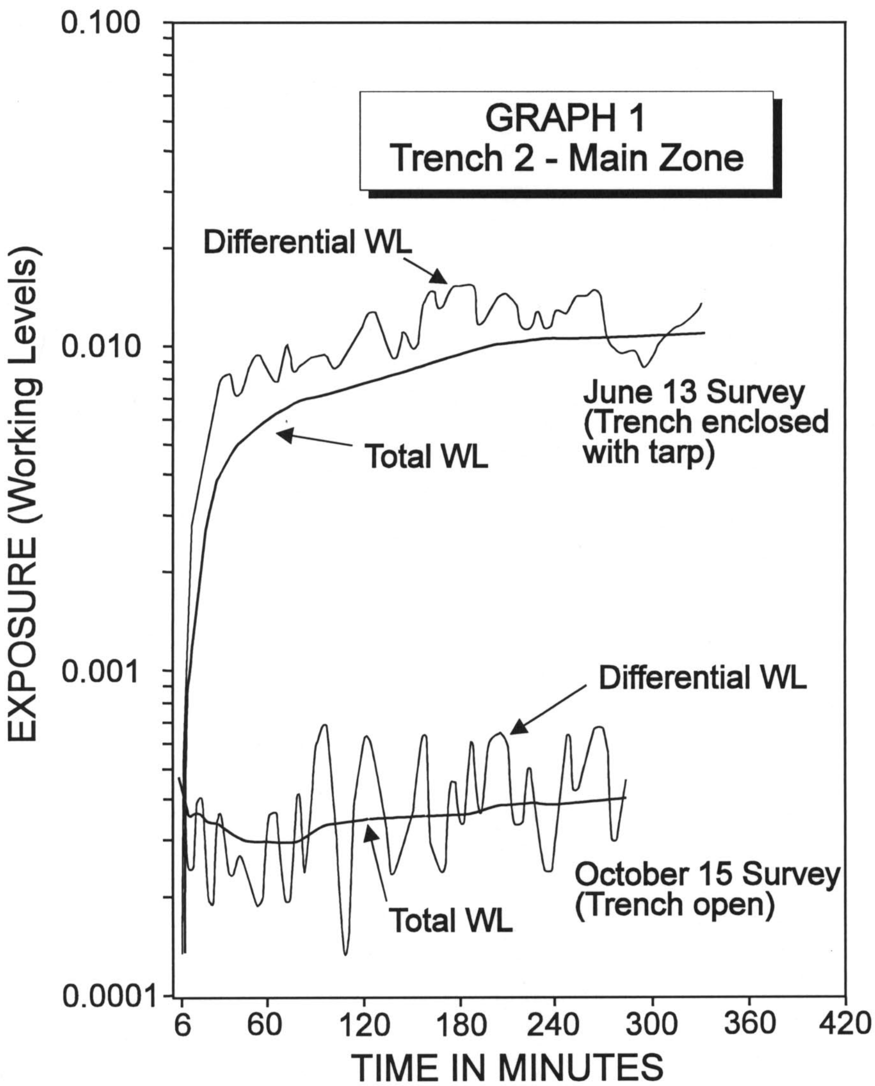
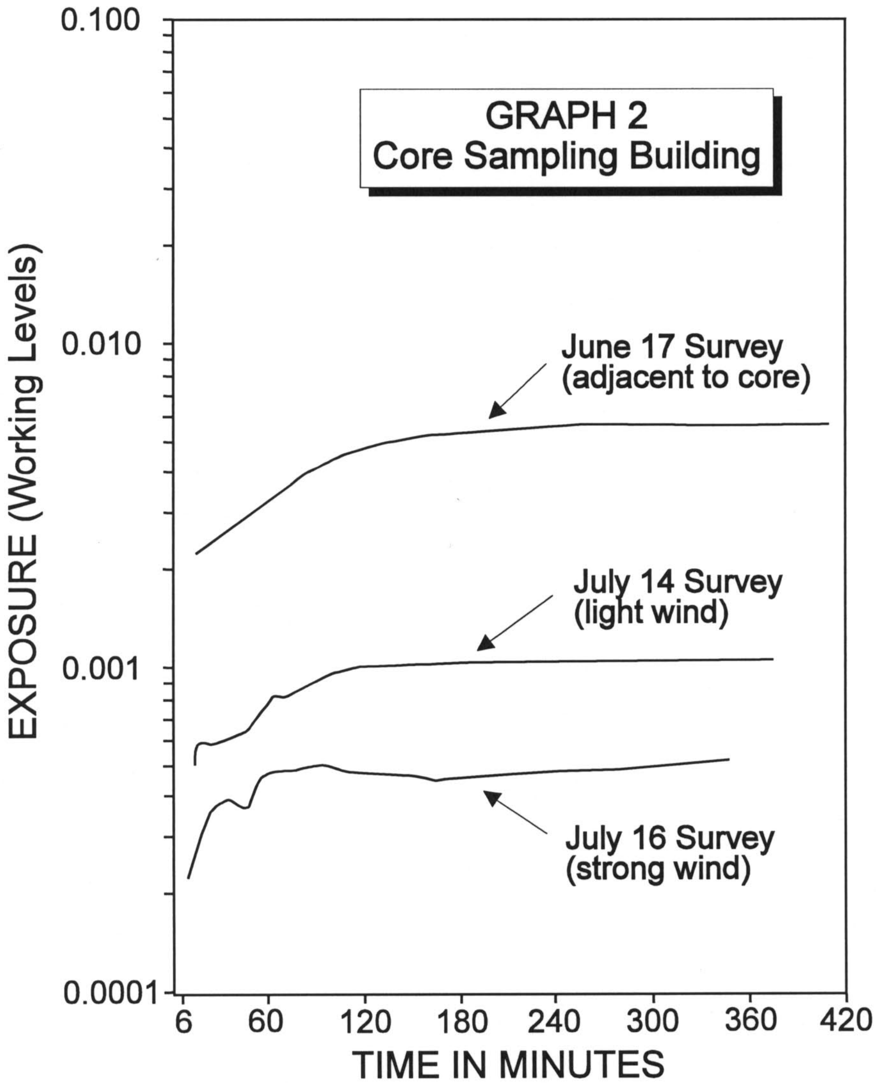
3. Gingrich, James E., Alter, H. Ward, Fisher, James C., 1980: Recent Advances in the Track Etch Radon Detection System for Uranium Exploration, presented at 8th Int. Geochemical Exploration Symposium, Hannover, Ger. 10-15 April, 1980.

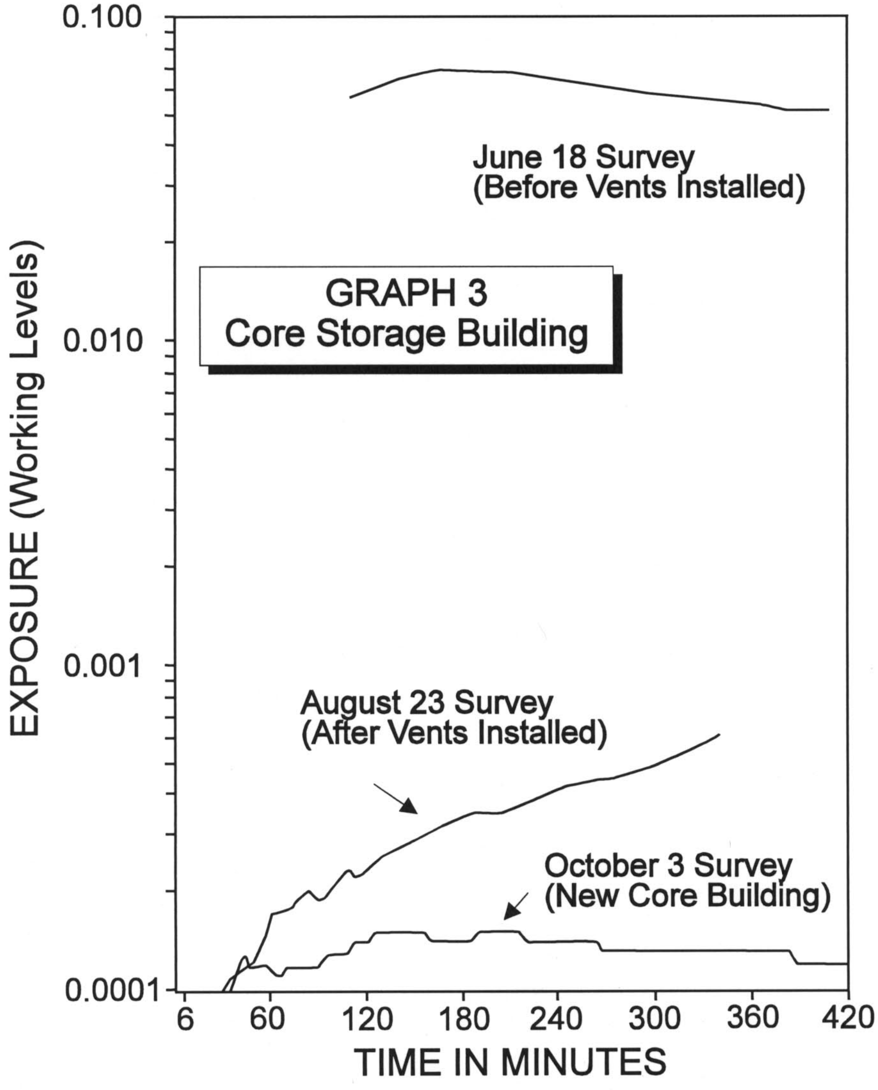
4. E.D.A. Instruments Inc., 1981. WLM-300 Working Level Monitor Operation Manual.

5. Office of Nuclear Material Safety and Safeguards U. S. Nuclear Regulatory Commission, 1980: Final Generic Environmental Impact Statement on Uranium Milling. Project M-25.

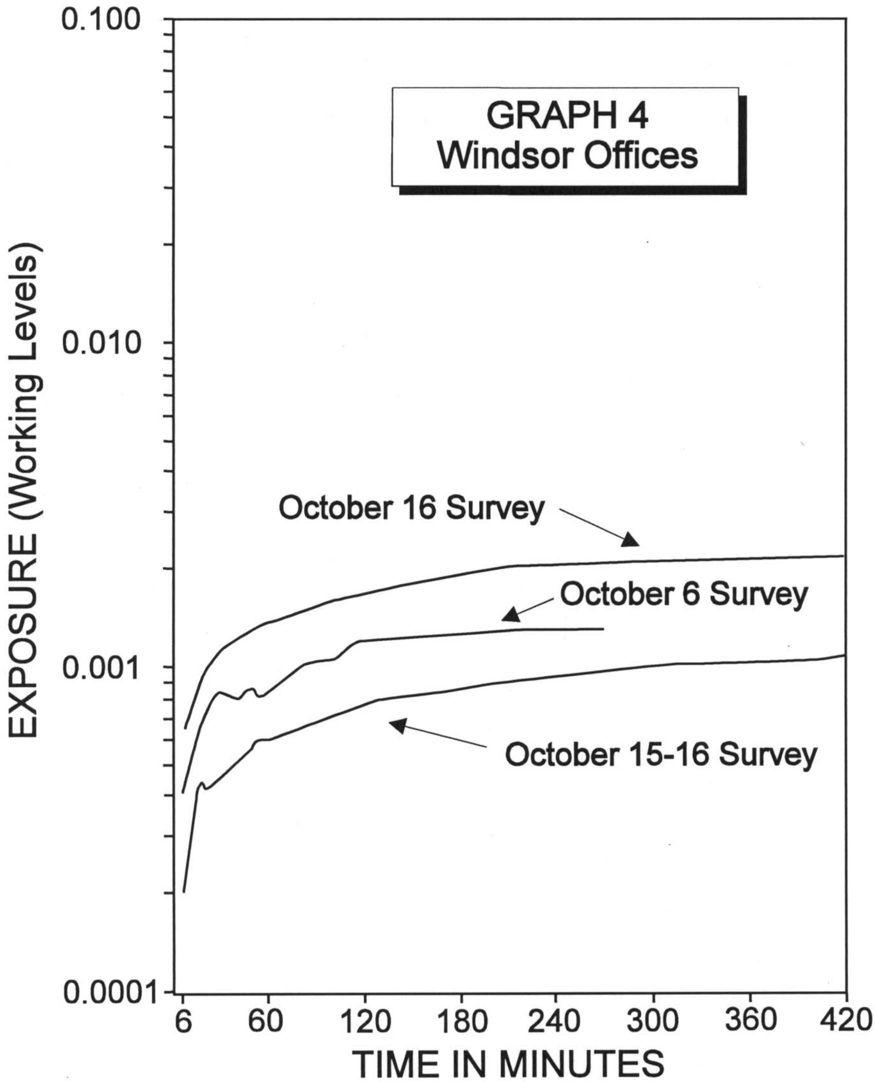


GRAPH 1
Trench 2 - Main Zone
Differential WL
Total WL
June 13 Survey
(Trench enclosed
with tarp)
Differential WL
October 15 Survey
(Trench open)
Total WL
0.100
0.010
0.001
0.0001
EXPOSURE (Working Levels)
6
60
120
180
240
300
360
420
TIME IN MINUTES


GRAPH 2
Core Sampling Building
June 17 Survey
(adjacent to core)
July 14 Survey
(light wind)
July 16 Survey
(strong wind)
EXPOSURE (Working Levels)
0.100
0.010
0.001
0.0001
6
60
120
180
240
300
360
420
TIME IN MINUTES



GRAPH 3
Core Storage Building
June 18 Survey
(Before Vents Installed)
August 23 Survey
(After Vents Installed)
October 3 Survey
(New Core Building)
EXPOSURE (Working Levels)
0.100
0.010
0.001
0.0001
TIME IN MINUTES
6
60
120
180
240
300
360
420


GRAPH 4
Windsor Offices
EXPOSURE (Working Levels)
0.100
0.010
0.001
0.0001
October 16 Survey
October 6 Survey
October 15-16 Survey
6
60
120
180
240
300
360
420
TIME IN MINUTES