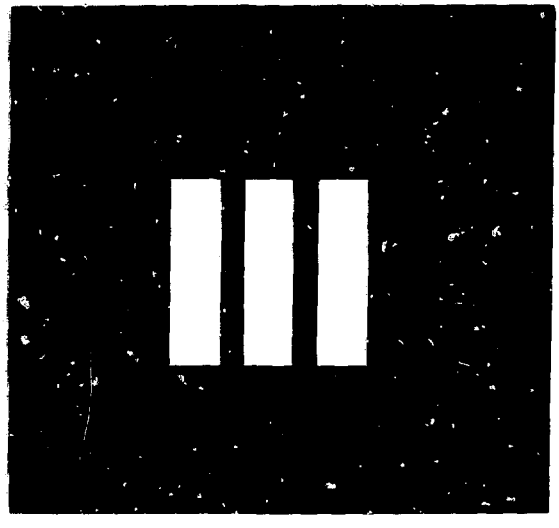
Atomic Energy of Canada Limited
L'Énergie Atomique du Canada, Limitée

# GUIDE to the Canadian Nuclear Fuel Waste Management Program

SECOND EDITION





# GUIDE to the Canadian Nuclear Fuel Waste Management Program

SECOND EDITION

compiled by
E. L. J. Rosinger, R. B. Lyon,
P. Gillespie, and J. Tamm

**Abstract**

This document describes the administrative structure and major research and development components of the Canadian Nuclear Fuel Waste Management Program. It outlines the participating organizations, summarizes the program statistics, and describes the international cooperation and external review aspects of the Program. It is the second edition of the Guide, which was first issued under the same title in December 1981.

**Atomic Energy of Canada Limited**
**L'Énergie Atomique du Canada, Limitée**
**Whiteshell Nuclear Research Establishment**
**Pinawa, Manitoba R0E 1L0**

1983 February
AECL-7790

Canadian Nuclear Fuel Waste Management Program

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LIST OF ABBREVIATIONS

| | |
|---|---|
| AECB | Atomic Energy Control Board (Canada) |
| AECL | Atomic Energy of Canada Limited |
| CANMET | Canada Centre for Metals and Energy Technology (EMR) |
| CEC | Commission of the European Communities |
| CRNL | Chalk River Nuclear Laboratories (AECL) |
| CRPPH | Committee on Radiation Protection and Public Health (OECD/NEA) |
| EMR | Energy, Mines and Resources Canada |
| EPB | Earth Physics Branch (EMR) |
| EURATOM | European Atomic Energy Community (CEC) |
| FEARO | Federal Environmental and Assessment Review Office |
| GSC | Geological Survey of Canada (EMR) |
| HTF | Hydrostatic Test Facility |
| IAEA | International Atomic Energy Agency |
| ITF | Immobilized Fuel Test Facility |
| IRC | Interagency Review Committee |
| NHRI | National Hydrology Research Institute (Environment Canada) |
| OECD/NEA | Organization for Economic Cooperation and Development/Nuclear Energy Agency |
| ONWI | Office of Nuclear Waste Isolation (U.S.A.) |
| R&D | Research and Development |
| RWMC | Radioactive Waste Management Committee (OECD/NEA) |
| TAC | Technical Advisory Committee |
| UKAEA | United Kingdom Atomic Energy Authority |
| UKDOE | United Kingdom Department of Environment |
| URL | Underground Research Laboratory |
| WIPP | Waste Immobilization Process Experiment |
| WNRE | Whiteshell Nuclear Research Establishment (AECL) |

# 1. INTRODUCTION

The objective of the Canadian Nuclear Fuel Waste Management Program is to ensure that there will be no significant effects on man and the environment from nuclear fuel wastes at any time. Under an agreement between the governments of Canada and the province of Ontario announced in 1978, the provincially owned utility, Ontario Hydro, has the responsibility for developing technologies for the interim storage and transportation of irradiated fuel, while Atomic Energy of Canada Limited (AECL), a federal crown corporation, is responsible for coordinating and managing the research and development (R&D) program for the immobilization and disposal of fuel wastes. Technologies are being developed for the immobilization of both irradiated fuel and fuel-recycle wastes, so that options are maintained for the disposal of either form.

The immobilization and disposal research program is directed from AECL's Whiteshell Nuclear Research Establishment (WNRE) in Manitoba. Additional expertise is obtained through the participation of Ontario Hydro, Energy, Mines and Resources Canada (EMR), and Environment Canada. Scientists at Canadian universities hold research contracts in various scientific and engineering fields, and private consultants are extensively involved.

Many documents are available that describe various aspects of the program. Four annual progress reports[1-4] have been issued, which reference many of the more detailed reports that describe specific aspects of the program. Two information meetings, one dealing with specific topics and one with progress in the whole program, are held each year.[5-11] Overviews and status reports of the program have been presented at international conferences.[12-14] Technical plans for all components of the program are outlined in a series of program documents.[15-25] Ten-year program plans are summarized in the Condensed Program Plan.[26] All reports and publications produced within the program are indexed in waste management bibliographies.[27,28] Participants in the program are listed in the "Who's Who of the Nuclear Fuel Waste Management Program."[29]

The purpose of this Guide to the Canadian Nuclear Fuel Waste Management Program is to assemble descriptions of the general technical and administrative aspects of the program from a variety of detailed documents. The Guide describes the management and coordination of the program and the research being done, outlines the participating organizations, and summarizes the program statistics and the international cooperation and external review aspects of the program. The technical project leaders and main contacts for the participating organizations are also given.

*Lac du Bonnet Batholith – site of the Underground Research Laboratory*

The scope of the Guide is limited to the areas of R&D for which AECL has responsibility, that is, the immobilization and disposal of nuclear fuel wastes.

# 2. MANAGEMENT AND COORDINATION

## 2.1 Management

*Mr. R. G. Hart, Executive Vice-President, AECL Research Company*, has responsibility for all research and development programs.

*Dr. R. E. Green, Vice-President and General Manager of WNRE*, has responsibility for all programs at WNRE, including the waste management program.

*Dr. T. E. Rummery, Director of the Waste Management Division, WNRE*, is in charge of waste management R&D.

## 2.2 Working Parties

Four working parties plan and coordinate the technical aspects of AECL's nuclear fuel waste management program:

*The Fuel Waste Immobilization working party*, chaired by Dr. F. P. Sargent, WNRE, coordinates the development of technology and equipment for the immobilization and containment of irradiated fuel and separated wastes from reprocessing.

*The Storage and Disposal working party*, chaired by Dr. K. W. Dormuth, WNRE, coordinates the development of geoscience techniques for nuclear fuel waste disposal.

*The Environmental Research working party*, chaired by Dr. S. L. Iverson, WNRE, coordinates the development of techniques for predicting radionuclide migration through the biosphere.

*The Environmental Assessment working party*, chaired by R. B. Lyon, WNRE, coordinates the development of techniques for the assessment of the impacts of storage, transportation, immobilization, and disposal facilities on people and the environment.

The four working parties report the results of their projects and future plans to the AECL R&D Program Committee through the Environmental Protection and Radioactive Waste Management Steering Committee, chaired by Dr. T. E. Rummery. Funding is allocated during the planning process to the four working parties. The funds are then deployed through the AECL line-management structure of divisions and branches.

## 2.3 Coordination

### 2.3.1 Canada/Ontario Nuclear Fuel Waste Management Policy Committee

This committee makes recommendations to the federal and Ontario governments on policy issues arising from the nuclear fuel waste management program. Members are Dr. A. E. Collin, Associate Deputy Minister of EMR; G. Thompson, Deputy Minister of the Ontario Ministry of Energy; Dr. R. E. Green, observer for WNRE.

### 2.3.2 Canada/Ontario Nuclear Fuel Waste Management Coordinating Committee

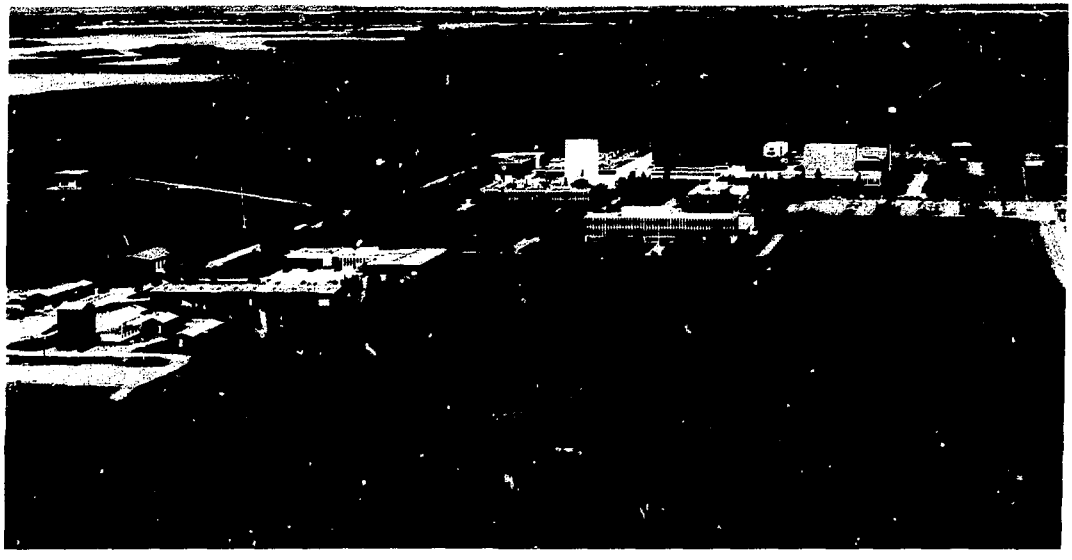
This committee coordinates activities that involve field research in Ontario. Dr. R. E. Green is chairman. Members are J. Howieson, EMR; H. N. Isaac, Ontario Hydro; G. Dominy, Ontario Ministry of Energy; E. R. Frech, WNRE, secretary.

### 2.3.3 Waste Management Program Interagency Administration Review Committee

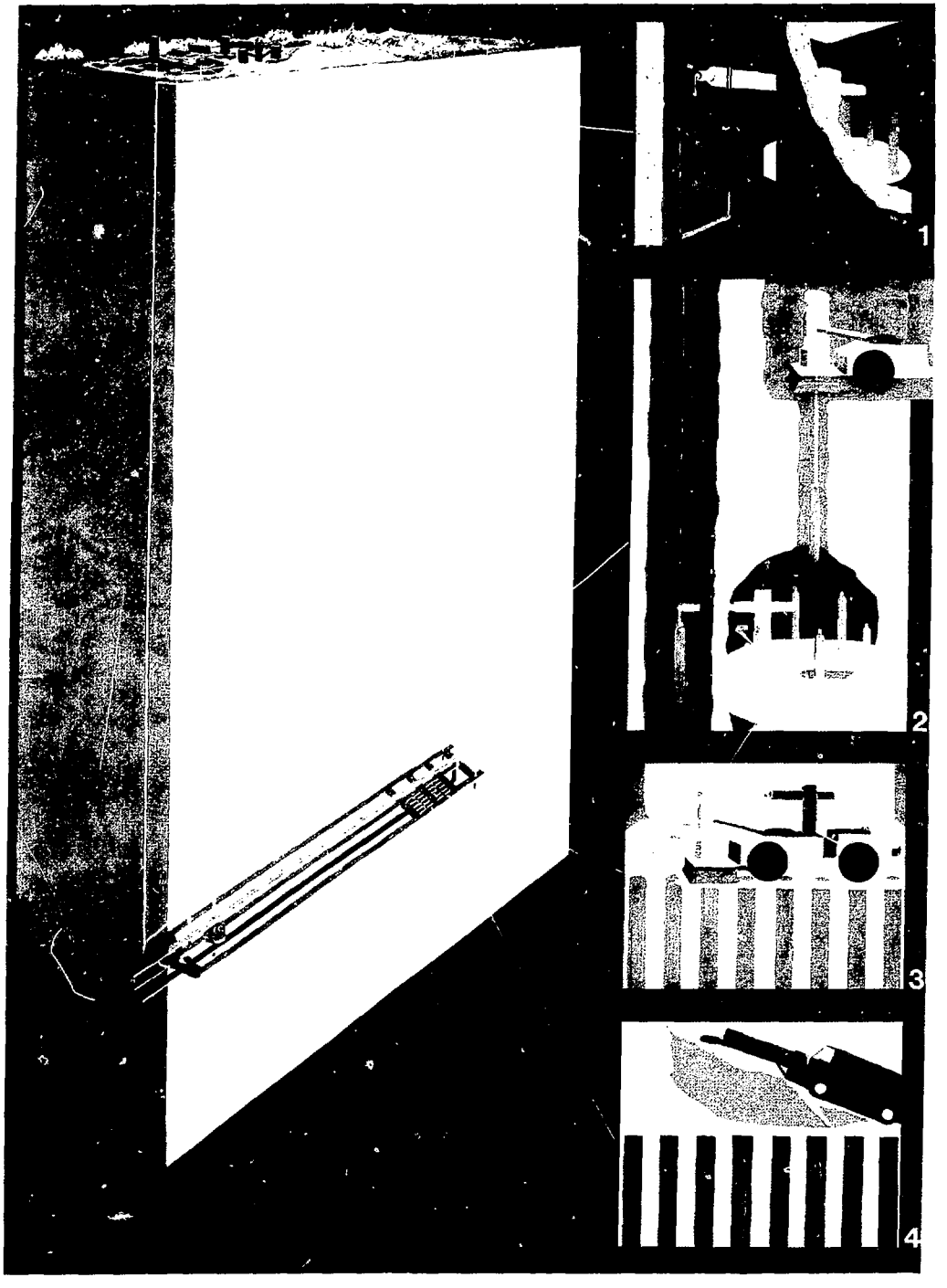
This committee addresses administrative issues among Environment Canada, EMR, and WNRE. Dr. T. E. Rummery is chairman. Members are D. H. Lennox, Environment Canada; Dr. J. S. Scott, EMR.

### 2.3.4 Program Integration Working Party

This working party identifies the specific objectives of the nuclear fuel waste management program and the required information flow between the components of the program. It ensures that the objectives are reflected in the R&D Program Plan. R. B. Lyon is chairman. Members are J. L. Crosthwaite, WNRE, secretary; Dr. K. Nuttall, WNRE; Dr. E. L. J. Rosinger, WNRE; Dr. D. B. McConnell, WNRE; Dr. K. W. Dormuth, WNRE; Dr. J. S. Scott, EMR; Dr. R. C. Oberth, Ontario Hydro; Dr. D. H. Charlesworth, Chalk River Nuclear Laboratories (CRNL); Dr. J. A. Gilliland, Environment Canada.



*The Canadian Nuclear Fuel Waste Management Program is directed from Whiteshell Nuclear Research Establishment, Pinawa, Manitoba.*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# 3. RESEARCH AND DEVELOPMENT

The Canadian concept for nuclear fuel waste management is disposal of the immobilized waste deep in plutonic rock in the Canadian Shield. The current generic R&D phase of the program involves assessment of the basic safety and environmental aspects of a system of multiple barriers designed to prevent radionuclides in the immobilized waste from re-entering the biosphere in amounts that would present unacceptable risks to man and the environment.

The AECL R&D program has three major components:

1. Research on immobilization of fuel wastes, which include both irradiated fuel and recycle wastes
2. Geoscience research
3. Environmental and safety assessment

## 3.1 Immobilization Studies

For the direct disposal of unreprocessed, irradiated fuel in a deep geologic vault, studies are concentrating on cylindrical containers employing a high integrity, corrosion-resistant metallic shell to isolate the fuel during its high-toxicity phase, about 500 years. Additional studies are considering container materials such as ceramics that may offer substantially longer isolation.

Engineering development includes design, fabrication, testing, and assessment of these containers. Specifications include the ability to withstand external hydrostatic loading of the shell to 9.8 MPa (a pressure equivalent to that in a 1000-m deep vault flooded with groundwater), container temperatures to 150°C, suitability for remote fabrication, inspection, and handling, and reasonable cost.

The discovery of highly saline groundwaters within some of the plutonic rocks of the Canadian Shield suggests that candidate materials for container construction should have high resistance to corrosion. An assessment of the physical metallurgy, weldability, and corrosion performance of a wide range of metals and alloys led to the selection of dilute titanium alloys, nickel-base alloys, and copper for detailed study.[30] Type 316L austenitic stainless steel and titanium have been used to construct test containers for preliminary engineering studies.

Several container concepts are under study. The simplest, called the "stressed-shell" design, has a shell of sufficient thickness to withstand the hydrostatic pressure in a flooded vault; conceptual designs have been produced for titanium, nickel-base alloys, and Type 316L stainless steel. A full-scale prototype, capable of isolating 72 fuel bundles, was fabricated from Type 316L stainless steel, and tested under increasing hydrostatic loading to collapse-failure. Data obtained from strain gauges attached to the container's surface were in close agreement with those predicted by a pre-test stress-strain analysis.[31]

Another container concept, called the "supported-shell" design, includes some form of internal support, permitting the use of thinner-walled containers. The support is provided by either a cast metal matrix or packed particulate material surrounding the fuel bundles, or some form of structural support.

Candidate materials for the metal matrix include lead, zinc, and an aluminum/silicon alloy. For testing purposes, various amounts of void will be introduced into the metal matrix to simulate potential casting imperfections. In the packed-particulate concept, material is poured into the container and vibratory compacted. The principal advantages of this concept are processing at room temperature, lower weight, reduced handling stresses, and lower cost.

*The Canadian concept for nuclear fuel waste disposal involves emplacement of the waste in granitic rock formations in the Canadian Shield.*
*1. Immobilized waste from CANDU nuclear reactors would be sealed in corrosion-resistant containers and transferred down a shaft to underground rooms.*
*2. At the bottom of the shaft the containers would be loaded into a shielded cask on a truck for transport to an emplacement room.*
*3. One option is to lower waste containers into holes in the floor of an emplacement room. A buffer material, probably clay, would be packed around the containers.*
*4. Backfill materials would then be packed into the rooms and shafts.*

After a series of compaction tests, the particulate selected for further evaluation was 1-mm diameter glass beads.

In the structurally supported design, the fuel bundles are sealed inside a rigid inner "basket" of thick-walled carbon steel tubes, which is then inserted into the prefabricated corrosion-resistant shell. Particulate material, used to fill the voids between and around the tubes, is vibratory compacted.

When all container prototypes have been tested, the performance of the various design concepts will be compared. Eventually, one will be selected as the reference design for more detailed study.

The dissolution and leaching of irradiated fuel are being investigated in detail. Dissolution rates in typical groundwaters have been studied over a wide range of water-chemistry conditions. Experiments under conditions that are probable for a disposal vault, i.e., reducing hydrothermal conditions, have begun. Studies of dissolution and leaching of irradiated fuel are being supported by the investigation of the electrochemical oxidation of $UO_2$ as a function of redox potential and pH.[32]

Waste immobilization studies are leading to the development of products and processes for immobilizing, in a durable solid matrix, the radioactive wastes that would arise from recycling irradiated uranium and thorium fuels. A variety of techniques will be required to immobilize the various gaseous, liquid, and solid wastes.

Processes and equipment are being developed for calcination, vitrification, and other high-temperature methods for immobilization of non-volatile radionuclides. Methods are also being developed for separating and immobilizing volatile radionuclides from off-gas streams.

High-level liquid wastes have not yet been generated in large quantities in Canada. Small quantities from the molybdenum-99 production facility at CRNL and from the thorium fuel reprocessing experiment at WNRE have been immobilized in borosilicate glass using an in-can melter.

In addition to borosilicates, glass compositions under investigation include aluminosilicates and calcium aluminosilicates (nepheline syenites). Leaching and dissolution processes, including both thermodynamic and kinetic aspects, have been studied under anticipated vault conditions.[33,34]

The leach resistance of a glass is closely related to its composition and structure.[35] For some borosilicate compositions, an increase in leachant pH, due to dissolution of the glass, can produce a dramatic increase in leaching rate.[36] Conversely, the dissolution rate of many aluminosilicate glasses decreases with time until an apparent constant value is reached, possibly due to saturation of some species in solution. When granite groundwaters or highly saline groundwaters are used as leachants, some aluminosilicate glasses gain weight due to the formation of hydration layers or the precipitation of ions from the leachant. In general, under anticipated disposal conditions, where the water flow rate is expected to be low, the saturation concentration of a radionuclide in the available water may be more important than the leach rate in determining the release of radionuclides to the geosphere.

The world-famous field test at CRNL, involving 25 lime-nepheline syenite glass hemispheres buried in sandy soil beneath the water table, was begun 21 years ago and still provides useful data for testing leaching models. The plume distributions of leached strontium-90 and cesium-137 in the surrounding soil were compared with computer predictions using an ion-exchange model.[37] For strontium-90 the predictions and measurements were in good agreement, but

for cesium-137 the model did not predict the migration accurately. Recent work on the particulate transport of cesium in groundwater[38] suggests that bacterial action may play a role in cesium transport. The effects of geochemical processes on the release and migration of radionuclides from the glass hemispheres have been evaluated,[39] and it appears that slow geochemical interactions ultimately control the rate of migration.

The main advantages of durable glasses as high-level waste forms are their ease of fabrication, ability to accommodate large variations in waste composition, and their low rate of dissolution at moderate temperatures (under 150°C). However, they are metastable, i.e., they cannot reach true equilibrium in natural waters and are therefore susceptible to alteration, particularly at elevated temperatures. Crystalline products are more resistant to alteration at higher temperatures (200 300°C), and may reach equilibrium under suitable groundwater conditions.

The crystalline minerals perovskite ($CaTiO_3$), a component of a synthetic rock known as SYNROC,[40] and sphene ($CaTiSiO_5$) are of particular interest, since geochemical evidence indicates that they can take a wide range of foreign ions into their lattices.[41] Studies of the thermodynamic stability and dissolution kinetics[42,43] of perovskite suggest that it is less stable than sphene under the disposal conditions anticipated in the Canadian Shield. Sphene is stable at high pH and at the high calcium concentrations found in typical silica-containing groundwaters. A program has been initiated to develop sphene-based glass-ceramics, comprising sphene crystallites within a residual sodium aluminosilicate glass matrix.[44] This glass-ceramic represents a promising compromise between a glass, with its greater ability to incorporate waste elements, and a purely crystalline matrix, with its greater resistance to radiation damage.

Two options are being considered for the treatment of medium-level wastes. The first, direct immobilization in a solid, requires minimal pretreatment (neutralization and evaporation only), and permits the use of several alternative waste forms. On the basis of preliminary results, glass appears to be the best

*Preparing non-radioactive glass samples*

waste form, followed by plastic, bitumen, and cement.[45] The second option involves decontamination of the medium-level waste solution with ion-exchange materials, followed by immobilization of the latter in ceramics or glass.

Many of the low-level wastes that would arise from a fuel reprocessing operation are similar to those generated during the operation of CANDU reactors. Low-level wastes are being catalogued to determine if gaps in technology exist, and if new methods of treatment need to be developed.

In a fuel reprocessing plant, gaseous mixtures containing radionuclides such as tritium, carbon-14, krypton-85, and iodine-129 are released to the off-gas waste stream. Tritium can be immobilized as an insoluble metal tritide.[46,47] Solid hydrated lime and barium hydroxide are being studied as sorbents for carbon-14.[48] For krypton-85, selective sorption on zeolitic molecular sieves such as silver- and hydrogen-mordenites is being investigated.[49,50] Two methods of removing iodine are under investigation, one using a corona discharge technique[51] and the other a photochemical abatement process.[52] Both methods remove organic iodides or elemental iodine through precipitation of iodine oxides.

Disposal vault sealing research is concerned with the buffer material to be placed around each waste container, the backfill material to fill the rest of the excavated space, and the plugs and grouts to seal the man-made openings to the surface. The objective is to provide materials and technology for each of

these barriers and to assess the effectiveness of each. Bentonite and illite clays are among several materials being examined.

Research includes investigation of additives to potential buffer materials to retard the movement of specific radionuclides, and investigation of biological effects in buffer materials. Mass transport in the buffer and backfill is being modeled. A preliminary evaluation of backfill materials has begun. Studies of water-uptake and permeability characteristics of potential backfill materials, as a function of temperature and composition, are in progress. The applicability of cements and clays for grouting is being investigated. Plugging materials for boreholes and shafts are expected to be similar to those used for the buffer.

### 3.2 Geoscience Research

Geoscience research entails the development of methods for characterizing and quantifying those features of the geosphere that are important in the design and construction of a disposal vault and in the long-term isolation of the waste from man and the environment.

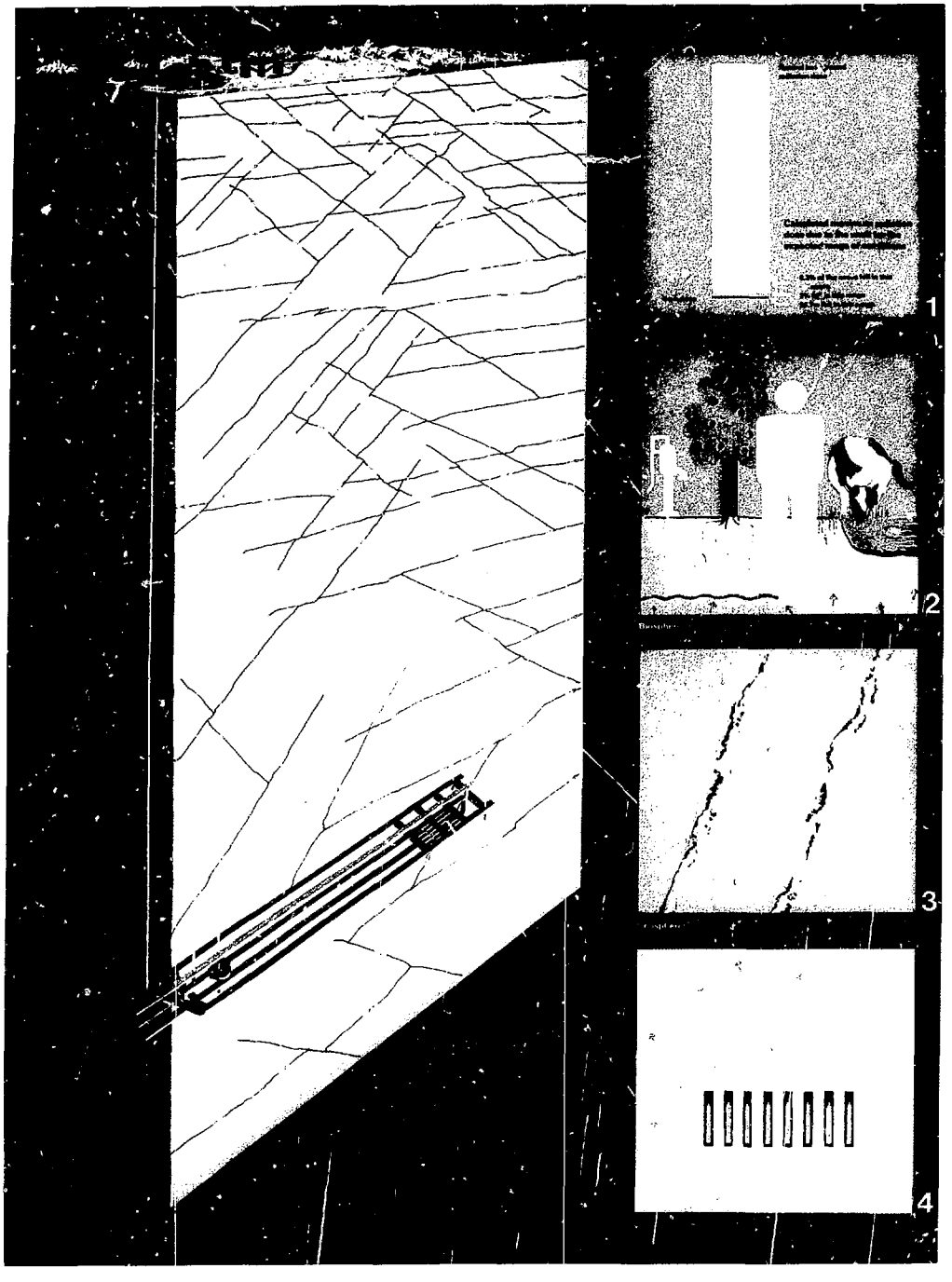
As a result of a recommendation by the Geological Survey of Canada (GSC) in the early 1970s Canada is directing the main thrust of its geoscience research toward plutonic igneous rocks within the Canadian Shield.[53] A geological map, identifying 1365 plutonic bodies in Ontario that are potentially suitable as disposal sites, has been prepared.[54] Some effort is also being devoted to an examination of alternative geologic formations. As part of the assessment of salt formations in Canada, the GSC has carried out a literature study of areas in Saskatchewan,[55] the Maritimes, and Ontario. The suitability of shale as a potential host rock is also being examined. In addition, Canada is participating in cooperative studies of disposal in the seabed.

Field research is underway on rock bodies at five research areas: (1) gneissic rock at CRNL in Ontario, (2) gabbroic rock at East Bull Lake near Massey, Ontario, (3) granite at Forsberg Lake near Atikokan, Ontario, (4) gabbro at Overflow Bay near Kenora, Ontario, and (5) granite at WNRE and near Lac du Bonnet, Manitoba. Field studies are being performed to quantify the major features of the geologic formations, to develop and evaluate equipment and methods for characterizing the formations, and to obtain an understanding of the hydrogeology and geochemistry. Important aspects of the field research are the correlation of results from various test methods and the identification of subsurface characteristics from measurements at the surface and in boreholes.

Laboratory studies include investigation of the extent to which waste/rock interactions can retard radionuclide migration. The importance of alteration minerals in the sorption process has been demonstrated using autoradiographic techniques on fracture-fill sections of core from the Forsberg Lake research area.[56] Preliminary observations suggest the following descending order for the degree of sorption: sphene, epidote and chlorite, hornblende and biotite, mica, altered plagioclase feldspar, plagioclase feldspar, potassium feldspar, and quartz. Results to date suggest that it may be possible to predict radionuclide sorption if the chemical and mineral compositions of the rock are known.

An Underground Research Laboratory (URL) is to be constructed in the Lac du Bonnet area near WNRE. It will be the first research facility constructed below the water table in previously undisturbed plutonic rock. After extensive site characterization, laboratory rooms will be constructed at a depth of 240 m. They will be used for experiments intended to validate predictive models for the performance of a full-scale disposal facility, but no radioactive waste will be used or stored there. A detailed design of the URL was completed in 1982, with construction scheduled to begin in 1983 and operation after 1985.

*Preparing for tests of blasting techniques*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### 3.3 Environmental and Safety Assessment

Environmental and safety assessment involves the estimation of the effects of storage, transportation, immobilization, and disposal of nuclear fuel waste on man and the environment. The assessment will form the basis on which endorsement of the disposal concept will be sought from the regulatory authorities, the technical community, and the public.

The assessment is divided into two parts, pre- and post-closure.[57-59] Pre-closure assessment considers the time until the vault has been backfilled and sealed, and the surface facilities removed. It encompasses radiological (pathways) analysis, biophysical/resources analysis, socioeconomic analysis, and occupational safety analysis. The post-closure assessment considers the potential long-term effects of the disposal facility on future generations. In the post-closure assessment, the migration of radionuclides from a disposal vault through the geosphere and biosphere, and the effects on man and the environment, are analyzed.

Environmental and safety assessment draws together information from all parts of the program and is based on a systems approach. Laboratory and field research provide data and empirical models, while detailed computer programs help interpret the measured data. The systems assessment is performed with the computer program SYVAC,[60] which links a set of submodels, representing the various components of the system, i.e., the vault, the geosphere, and the biosphere. The submodels are executed in sequence leading to an estimate of the consequence for a given scenario. The consequence is presently defined as the maximum annual radiation dose to an individual in the most exposed group during the first million years after disposal.

Uncertainty in the data and variations in space and time are allowed for by defining the parameter values in the submodels as distributions rather than "best estimate" or "conservative" single values. A value for each parameter is sampled from its distribution to form a set. This set of values defines a "scenario." SYVAC then estimates the transport of radionuclides from the vault to the biosphere for this scenario, and determines a "consequence" (dose to man). Repeated sampling produces different scenarios, for which individual consequences are determined. The consequences are plotted versus the frequency of their occurrence in the form of a histogram.

The assessment philosophy is to perform the analyses with the information currently available and to prepare updated assessments as the research and development progress. During the generic research phase, each updated assessment document will be distributed to the regulatory and review agencies and to scientists and other interested parties for review and comment. During the later stages of the generic research program, a formal assessment document will be presented at public hearings and finally will form the basis for evaluation of the concept.

*Buried radioactive materials could reach the environment if they were dissolved in flowing groundwater that eventually reached the surface through cracks in the rock. Post-closure assessment studies are predicting the degree to which this could occur.*

*1. An overall computer program assembles the data for a range of possible situations and predicts what might happen under expected geological and environmental conditions. In 43 percent of the cases no radioactive material reached the surface for more than a million years and even extreme cases indicated an additional exposure of no more than 1/10 of existing natural background radiation.*

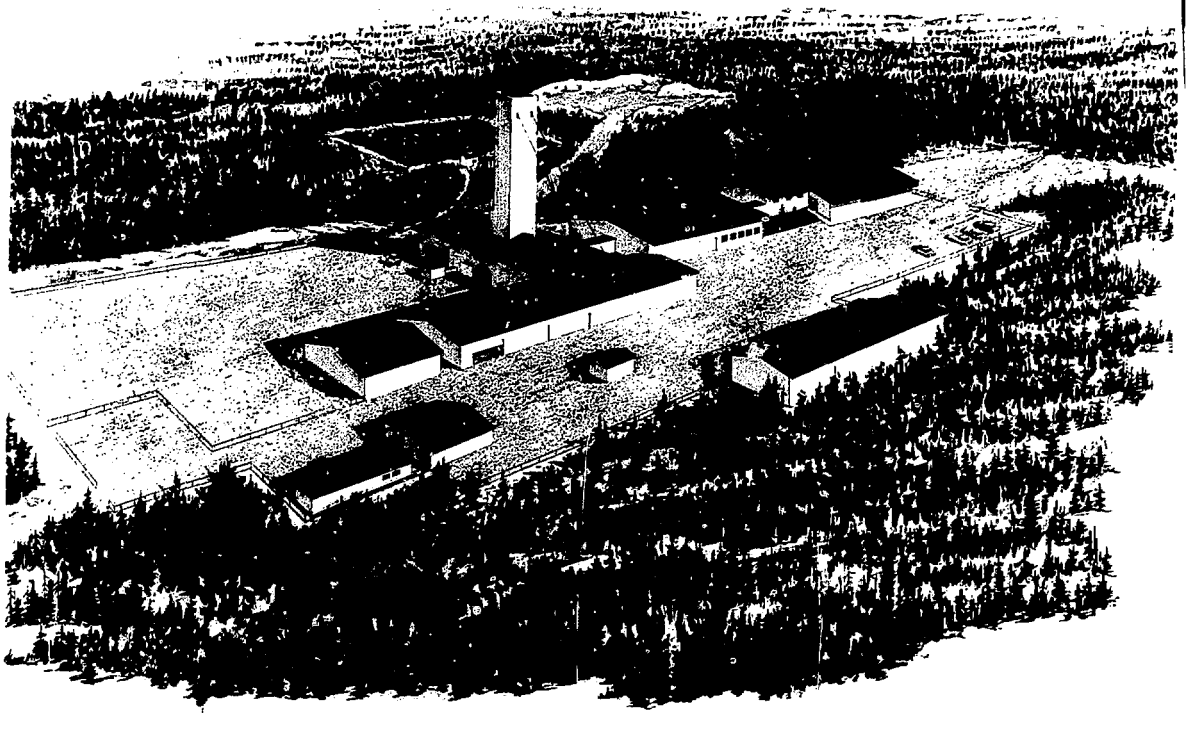
*Three computer models are used in the overall model.*

*2. The biosphere computer model analyzes the possible movement of dissolved radioactive material through near surface water and through the food chains leading to man.*

*3. The geosphere computer model analyzes the possible transport of radioactive material through crack networks in the rock to the surface.*

*4. The vault computer model analyzes the performance of the engineered barriers of the disposal vault.*

The Underground Research Laboratory, to be built near WNRE in the Lac du Bonnet Batholith, will be the first in situ test facility built below the water table in previously undisturbed plutonic rock. The shaft will be excavated to a depth of 255 m, with experimental rooms developed at the 240 m level. Experiments will be conducted in the URL to assess surface to subsurface predictive capability, to assess the effect of excavation on a rock mass, to study and model the hydrogeological and geochemical environment, and to validate models on a scale and in an environment similar to that proposed for a full-scale disposal facility. Techniques will be developed and assessed for sealing shafts and drifts and for monitoring rock-mass conditions. No nuclear wastes will be used or emplaced in the URL.



The Storage and Disposal working party is responsible for the URL project. The project is managed by a committee with two subcommittees:

***Project Management Committee***

G. R. Simmons *WNRE (Chairman)*
J. A. R. Hillier *WNRE (Secretary)*
Dr. K. W. Dormuth *WNRE*
C. C. Davison *WNRE*
Dr. P. J. Kurfurst *GSC*
Dr. R. C. Oberth *Ontario Hydro*
Dr. S. A. Mann *United States Department of Energy*
D. A. Peters *WNRE*
D. W. Jung *WNRE*
O. T. Vik *WNRE*
R. W. Pollock *WNRE*

***Site Evaluation Subcommittee***

C. C. Davison *WNRE (Co-Chairman)*
Dr. P. J. Kurfurst *GSC (Co-Chairman)*
A. J. Rogowski *WNRE (Secretary & URL Site Manager)*
Dr. N. M. Soonawala *WNRE*
G. R. Simmons *WNRE*
R. Nicks *United States Office of Nuclear Waste Isolation (ONWI)*

***Underground Experiment Subcommittee***

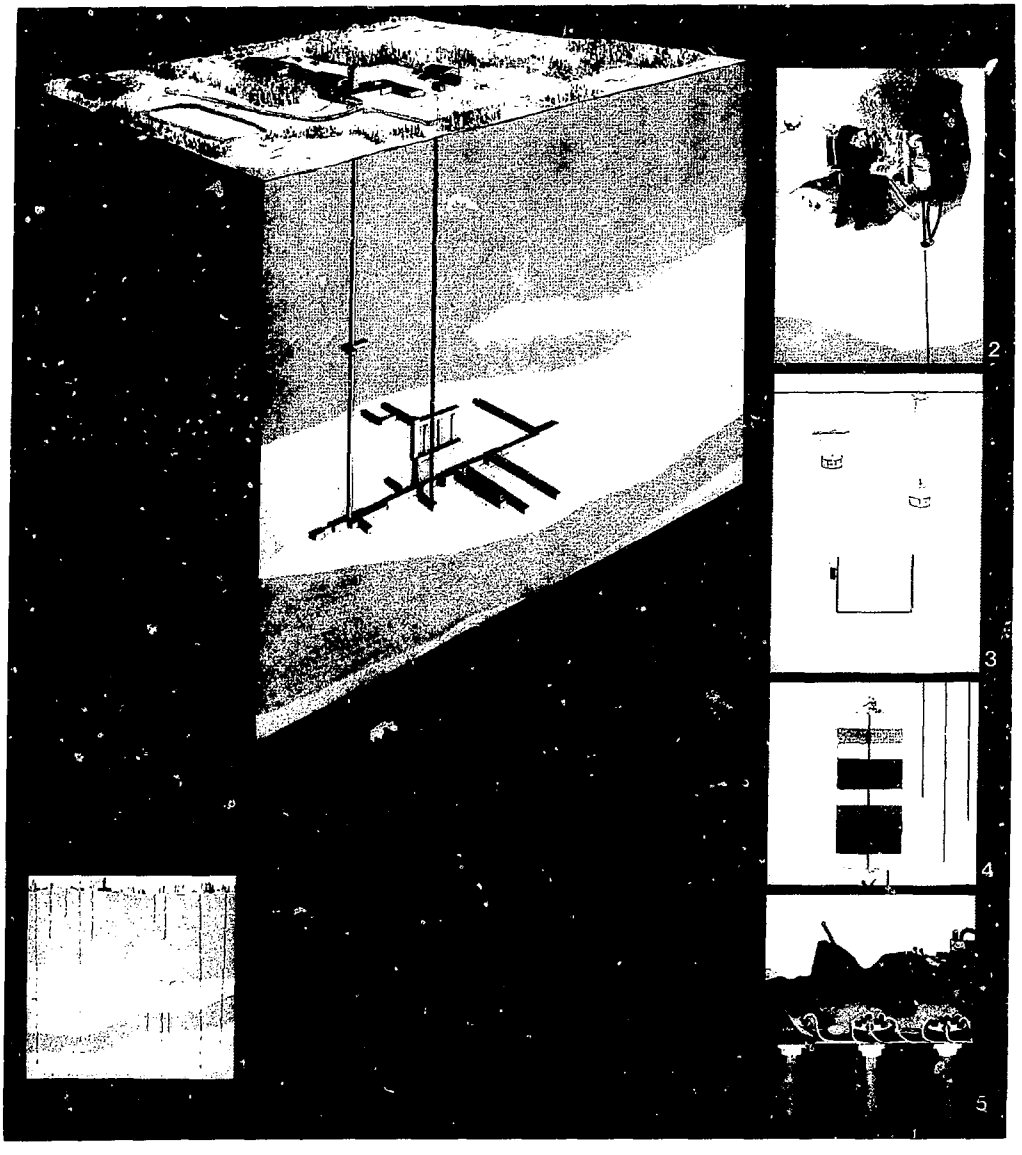
G. R. Simmons *WNRE (Chairman)*
P. P. Baumgartner *WNRE*
Dr. R. Pearson *WNRE*
D. A. Peters *WNRE*
C. C. Davison *WNRE*
Dr. F. P. Sargent *WNRE*
R. S. Lopez *WNRE*
W. F. Heinrich *WNRE*
Dr. N. M. Soonawala *WNRE*
Dr. R. A. Robinson *ONWI*
W. Ubbes *ONWI*

The Site Evaluation Subcommittee directs site evaluation and schedules activities on the surface and in boreholes. The site evaluation activities receive a continuing peer review through the involvement of EMR and Environment Canada. The Underground Experiment Subcommittee provides direction for the URL design and the experimental program. A program document outlining the proposed underground experiments[24] has been reviewed by experts in the geotechnical community.

During 1981 and 1982, geologic, geophysical, and hydrogeologic techniques were applied in boreholes to study the rock mass and to correlate findings with surface data. A network of hydrogeologic and geochemical monitoring boreholes was drilled in 1982 and will be used for monitoring the undisturbed groundwater flow conditions. Models of the groundwater flow systems are being developed to predict the effect of URL construction and operation. The actual construction effects will be monitored and compared with the predictions.

Construction activities began in late 1982 with access road development and site leveling. Surface facilities will be constructed in 1983 and shaft sinking will begin in early 1984. During underground excavation, various blasting techniques will be used and the resulting zone of blast damage will be characterized. Detailed geological and geophysical surveys of the rock surrounding the shafts and drifts will provide further data for comparison with

*Artist's conception of the surface facilities for the Underground Research Laboratory.*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earlier predictions of subsurface geology. Hydrogeological and geochemical monitoring instrumentation will be installed underground as the excavation advances. The response of the rock mass and groundwater systems to various thermal and mechanical perturbations will be measured and modeled.

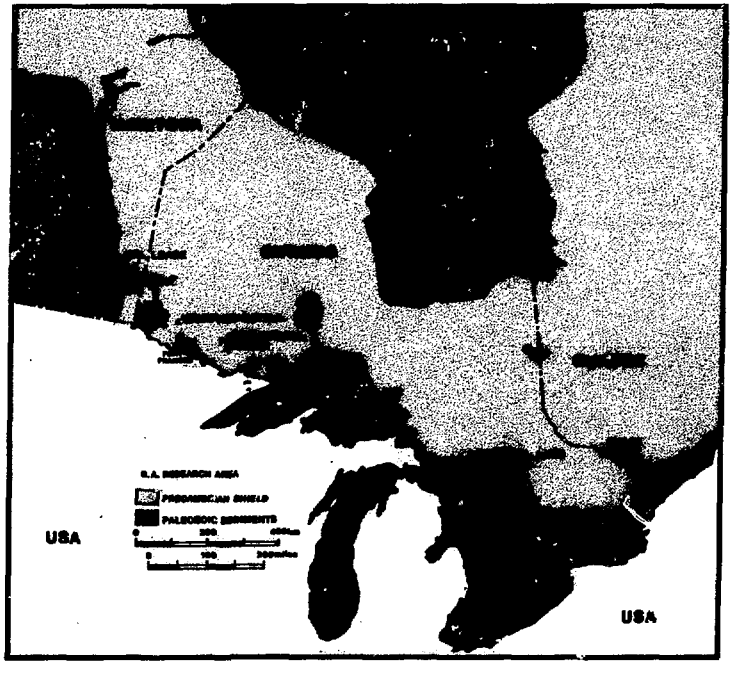
The URL surface and underground experiments will be completed by the time AECL's lease expires in the year 2000. The laboratory excavation will be sealed in a manner acceptable to the Manitoba authorities, the surface buildings will be removed, and the land will revert to the province.

### 4.2 [illegible] Research Areas

AECL and its contractors are conducting research at five field areas, each of which encompasses plutonic rock and some surrounding country rock. Tools and techniques were tested by drilling several boreholes at White Lake, near Ottawa, but in recent years that area has been used sparingly and is no longer considered an active research area. Hydrogeological investigations at the research areas are carried out by AECL, Environment Canada, and various contractors, coordinated by Dr. R. Pearson of WNRE. Geological and geophysical activities and rock properties studies are carried out principally by EMR and are coordinated for AECL by Dr. N. M. Soonawala of WNRE.

**Lac du Bonnet Batholith**

The WNRE geotechnical activities site and the URL lease (see Section 4.1) lie on the Lac du Bonnet Batholith, which is a large granite pluton in southeastern Manitoba. Ten boreholes have been drilled at the WNRE site, the longest to 923 m. On the URL lease, 20 boreholes deeper than 300 m have been drilled, the longest to 1100 m. An additional 11 bedrock boreholes are 150 m long, and 37 are 10 to 60 m long. Fifty-five shallow overburden boreholes have also been drilled. Instrumentation is being installed in all these boreholes as part of a hydrogeological and geochemical monitoring network.




*Left: A rock formation near Lac du Bonnet, Manitoba has been selected as the site for an Underground Research Laboratory (URL).*
*1. Instruments in deep boreholes will measure changes in the groundwater system during and after excavation of the URL.*
*2. Boreholes will be drilled into the surrounding rock from inside the URL to install experimental testing equipment.*
*3. Three test shafts will be used to measure the effectiveness of grouting and fracture sealing techniques.*
*4. Water containing tracers will be forced through shaft seals. The seals will then be taken apart to determine the water flow paths.*
*5. Electric heaters will be installed in some boreholes and sealed off to simulate what will happen when a real vault is closed up.*

*Right: Location of field research areas*

**Overflow Bay**
The Overflow Bay research area is located southeast of Kenora on a gabbroic pluton. It is anticipated that studies will be less intensive here than at other research areas.

**Atikokan**
The Atikokan research area is on the Eye-Dashwa Pluton northwest of Atikokan. This granitic pluton has been surveyed by various geophysical and geological methods and a small area of about 200 m by 200 m has been mapped in great detail. Five boreholes have been cored, the longest to 1183 m, and hydrogeological testing is proceeding in these boreholes.

**East Bull Lake**
The East Bull Lake research area is situated on a gabbroic pluton east of Elliot Lake and north of Massey, Ontario. Extensive geological and geophysical mapping of the area has been completed and hydrological work is in progress. Drilling of three boreholes, ranging in length from 400 to 700 m, is planned for 1983.

**Chalk River**
The Chalk River research area is located in the Ottawa Valley at CRNL. The rock underlying the site has been metamorphosed and fractured. Because features amenable to geophysical studies are plentiful, the site has been used extensively by EMR staff to test tools and concepts. Since it is becoming so well characterized, both on the surface and to depth, Environment Canada staff have also concentrated their programs at that site. Over 20 boreholes of various diameters and depths have been drilled to date, using both core-recovery and air-drilling methods. These boreholes have been hydrogeologically tested and six have been used for interborehole tracer experimentation.

**Immobilized Fuel Test Facility**
The Immobilized Fuel Test Facility (IFTF) is a recent extension to the existing hot-cell facilities at WNRE. It consists of a canister loading area, a canister storage area, five lead-shielded cells, a mock-up and maintenance area, three laboratories, change-room facilities, and offices. Responsibility for IFTF operation lies with D. W. Jung, head of the Technical Services Branch at WNRE. The facility provides for a wide range of experiments in support of the waste management program.

**High-Activity Experiments**
Corrosion, chemical interaction, and dissolution and leaching experiments will be conducted in the presence of high-radiation fields. Each experiment will involve groundwater, rock samples (in some tests), and materials proposed as engineered barriers in a nuclear fuel waste vault (metals, ceramics, clays).

These tests will be performed in pressure vessels, contained within shielded concrete canisters (2 m in diameter by 1.7 m high). In some cases, the radiation field will be provided by a complete irradiated fuel bundle, encapsulated in a stainless-steel container. For some dissolution and leaching studies the radiation field will be provided by segments of irradiated fuel in contact with the groundwater and materials to be tested.

High-activity experiments will be assembled and instrumented in the existing hot cells and transferred via a shielded corridor to the IFTF hot cell, where they will be installed in the shielded concrete canisters. These canisters will then be decontaminated and placed in a canister storage area, where the conditions inside each one can be continuously monitored and controlled.

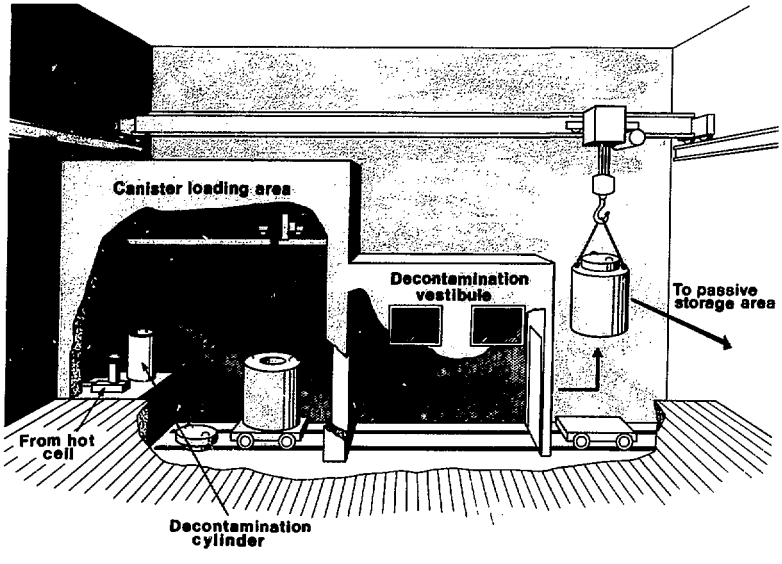
**Medium-Activity Experiments**
Medium-activity experiments involving beta and gamma radiation will be assembled remotely and performed in the serviced bench area (shielded "warm" cells). One of the most important features of these shielded cells is that leaching studies can be carried out without introducing contamination.

Leaching experiments, involving irradiated fuel and radioactive waste glasses, are being designed to give the option of continuous sampling. The radiation source will be placed inside the individual pressure vessels, in direct contact with an aqueous solution. The warm cells will also be used for chemical operations such as solvent extraction, chromatography, colorimetry, and titrimetry, in support of waste management studies and other WNRE programs.

**Low-Activity Experiments**
The mock-up area, in addition to being used for developing the assembly techniques for the high-activity experimental modules, will accommodate large pieces of equipment or large-scale experiments using radioactive tracers. Examples are an integrated off-gas clean-up system (Modular Off-Gas Process System, MOPS) to study removal and recovery of radioactive gases on an engineering scale, and radionuclide experiments that involve large blocks of granite with natural fractures to study radionuclide migration and interaction with rock.

The alpha-activity laboratory will be used for studies involving actinides. Solvent extraction equipment and flowsheets for the processing of simulated irradiated fuel will be studied. Use will be made of a method called "co-processing," in which the fissile elements (plutonium and uranium-233) are not completely separated from the fertile elements (thorium and uranium-238).

In the low-activity laboratory, essentially inactive samples of rock and clay will be prepared for the high- and medium-activity experiments, and leaching solutions will be extracted and analyzed. Also, hydrothermal leaching experiments with low-activity or inactive samples of glass or ceramic will be

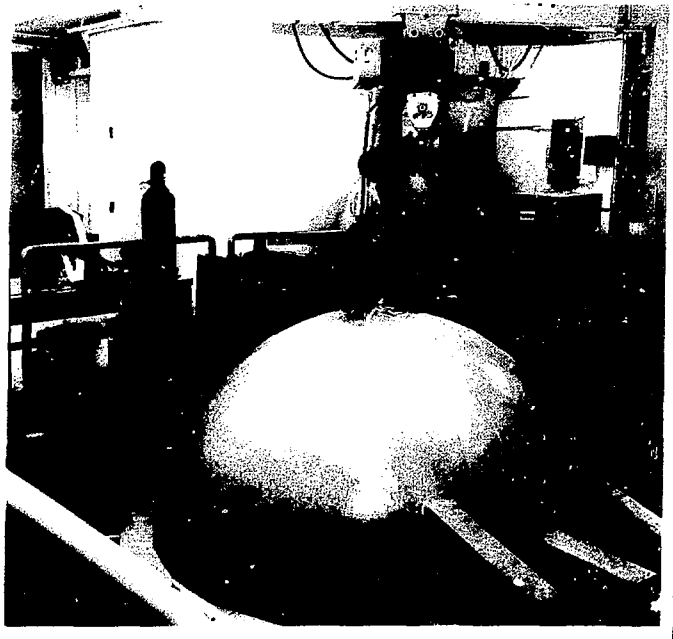



*Immobilized Fuel Test Facility — diagram of the canister-loading area*

performed. The laboratory also houses facilities to study electrochemical corrosion in the presence of a gamma-radiation field.

The Hydrostatic Test Facility (HTF) at WNRE is designed to subject fuel waste containers to hydrostatic pressures and temperatures as high as those expected in a 1000 m deep disposal vault. Thus the HTF can subject containers to pressures up to 10.5 MPa and temperatures up to 200°C. Temperature changes and container deformation can be monitored from the start of an experiment to the end of the two to three month test period. It is expected that data from these tests can be extrapolated to predict the changes that would occur over much longer time spans.

The HTF consists of a large carbon-steel pressure vessel, control systems, and instrumentation. It is installed in a pit in the floor of a building to facilitate the loading of containers through the top of the vessel. The testing compartment, which is 1.5 m in diameter and 3 m high, can accommodate a full-scale container having a mass of up to 3500 kg. After the container is in place, the compartment will be flooded with chemically treated water, and the pressure increased and controlled by a small volume of high-pressure nitrogen gas above the water. The temperature will be raised by heating the water. Strain and temperature will be measured by sensors on the container and recorded by instruments outside the vessel. After the test period, the container will be removed from the pressure vessel and examined extensively.



*Hydrostatic test facility*

# 5. PARTICIPATING ORGANIZATIONS

The Canadian Nuclear Fuel Waste Management Program brings together a wide range of scientific and engineering expertise from all parts of Canada. AECL performs and coordinates R&D on the immobilization and disposal of nuclear fuel waste, and contracts work out to EMR, Environment Canada, universities, and private contractors. Ontario Hydro provides technical assistance to AECL in the immobilization and disposal program.

The participating organizations and their contributions are described in this section. Only project leaders and main contacts for work connected with the waste management program are named. A complete list of participants is given in the "Who's Who of the Nuclear Fuel Waste Management Program."[29]

## AECL WNRL Waste Management Division

**Dr. T. E. Rummery** *Director*

**Dr. E. L. J. Rosinger** *Scientific Assistant to the Director*

**P. D. R. Lisle** *Technical Assistant to the Director*

**J. H. Wright** *Administrative Assistant*

***Fuel Waste Technology Branch***

**Dr. K. Nuttall** *Head*

***Geochemistry and Applied Chemistry Branch***

Dr. F. P. Sargent *Head*

***Applied Geoscience Branch***

Dr. K. W. Dormuth *Head*

***Environmental and Safety Assessment Branch***

R. B. Lyon *Head*

***Waste Management Public Affairs Section***

E. R. Frech *Head*

***Program Coordination and Data Management Section***

Dr. E. L. J. Rosinger *Head*

### 5.1.1 Fuel Waste Technology Branch

Dr. K. Nuttall *Head*

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***Vault Chemistry Section*** L. H. Johnson *Section Head*

L. H. Johnson *Fuel dissolution and leaching*

Dr. R. B. Heimann *Active waste/buffer/groundwater interaction experiments*

R. M. Johnston *Stability of buffer and backfill*

Dr. D. W. Oscarson *Sorption of radionuclides on buffer material*

S. Stroes-Gascoyne *Fuel dissolution and leaching*

***Fuel Isolation Section*** Dr. K. Nuttall *Section Head (acting)*

Dr. K. Nuttall *Materials selection and evaluation*

J. L. Crosthwaite *Radioactive-experiments coordination and remote handling and fabrication*

L. J. Hosaluk *Container development and testing*

Dr. B. M. Ikeda *Effect of radiation on corrosion*

Dr. P. M. Mathew *Materials engineering (primarily metal casting)*

Dr. P. McKay *Corrosion of container materials*

M. Onofrei *Evaluation of ceramic materials and coating technology*

K. J. Truss *Container development and testing*

***Disposal Vault Sealing Section*** R. S. Lopez *Section Head*

R. S. Lopez *Geotechnical and vault engineering*

Dr. S. C. H. Cheung *Mass transport modeling and experimental studies*

D. A. Dixon *Studies of buffer and backfill materials*

P. H. Seymour *Studies of vault grouting and shaft sealing*

**Vault Chemistry**

The Vault Chemistry Section is responsible for the characterization of irradiated fuel as a waste form, the study of waste form/container/buffer/groundwater interactions under simulated vault conditions, evaluation of clay buffer and backfill alteration reactions, and studies of radionuclide sorption on geologic materials used in the disposal vault.

**Fuel Isolation/Container Development**

The development of high-integrity containers with a life of about 500 years is being undertaken[17] in order that irradiated fuel (or recycle waste) may be isolated for the duration of the high-toxicity phase. The major development work at present is directed toward thin-walled, supported, metallic-shell designs. The support could be provided by a cast-in-place metal matrix, a packed particulate, or rigid bracing. A major component of the work is the evaluation of the corrosion performance of container materials and of the technology to fabricate and inspect containers. Consideration is also being given to ceramic materials that may offer the prospect of very much longer containment.

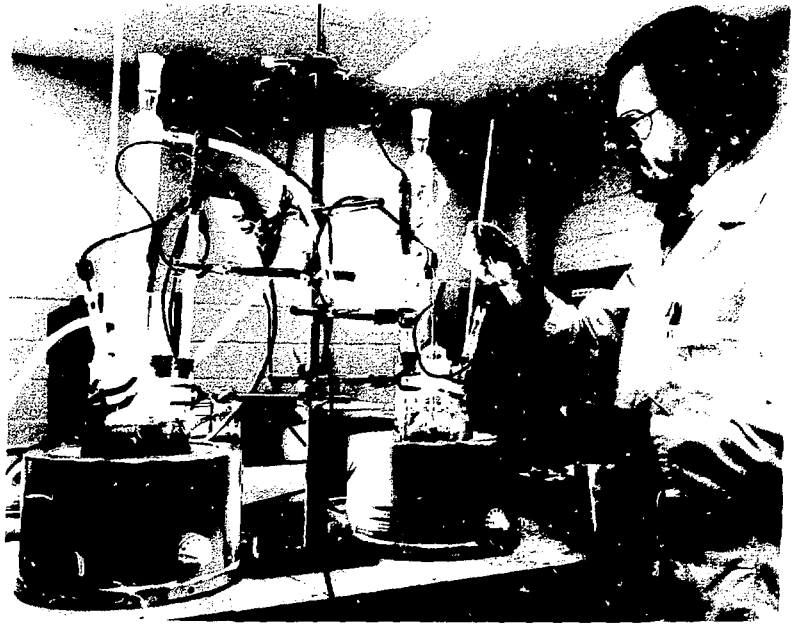
**Vault Sealing**

The Vault Sealing Section is responsible for studies and designs of engineered barriers and vault seals. These include: buffer (clay barriers in immediate contact with the waste containers), backfill (in rooms, drifts, and shafts), grout (in rock fractures), shaft seals, and borehole plugs. The studies include development of predictive models, evaluation of material properties, engineering design, and evaluation of the technical and economic feasibility of engineered barriers.

## FUEL WASTE TECHNOLOGY BRANCH CONTRACTS

| Contractor | Project Officer | Objective |
|---|---|---|
| Bristol Aerospace Ltd. | K. J. Truss | Design, develop, and manufacture structurally supported prototype container |
| Carleton University<br>*Dr. A. P. S. Selvadurai* | R. S. Lopez | Theoretical modeling of container/buffer/rock interactions |
| McGill University<br>*Dr. R. N. Yong* | R. S. Lopez | Evaluate candidate backfill materials and develop composition and emplacement specifications |
| McGill University<br>*Dr. R. N. Yong* | R. S. Lopez | Creep behavior of buffer materials |
| University of Saskatchewan<br>*Dr. J. Postlethwaite* | Dr. P. McKay | Corrosion of titanium-base and nickel-base alloys |
| University of Waterloo<br>*Dr. C. J. Mayfield*<br>*Dr. J. Barker* | L. H. Johnson | Biogeochemistry of buffer and backfill materials |
| University of Western Ontario*<br>*Dr. R. M. Quigley* | R. S. Lopez | Chemical and mineralogical characterization of selected buffer and backfill materials |
| W. L. Wardrop and Associates | J. A. Remington** | Design engineering, contract administration, and non-resident services for the Immobilized Fuel Test Facility |
| W. L. Wardrop and Associates, Canadian Mine Services Ltd., and Hardy Associates | R. S. Lopez | Buffer and backfill engineering (acquisition, transportation, preparation, handling, and emplacement) |
| Welding Institute of Canada | Dr. K. Nuttall | Evaluation of techniques for arc-welding thick copper |

*Joint contract Ontario Hydro—AECL, WNRE
**Design and Project Engineering Branch



*Electro-chemical corrosion tests*

### 5.1.2 Geochemistry and Applied Chemistry Branch

Dr. F. P. Sargent *Head*

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***Geochemistry Section*** Dr. F. P. Sargent *Section Head (acting)*

Dr. J. J. Cramer *Geochemistry, radionuclide migration and geological analogues, large-scale laboratory and field migration*

Dr. V. N. Fleer *Saline water effects on mineral stabilities and the release and migration of radionuclides*

Dr. M. Gascoyne *Geochemistry, radionuclide migration and geological analogues, large-scale laboratory and field migration*

Dr. T. W. Melnyk *Sorption kinetics, diffusion, geochemical modeling of the rock mass*

Dr. E. R. Vance *Radiation damage and radiation-chemical effects*

Dr. T. T. Vandergraaf *Static sorption, sorption on fracture-fill minerals, sorption in natural fractures*

F. B. Walton *Sorption kinetics, diffusion, and geochemical modeling*

***Waste Immobilization Section*** Dr. A. G. Wikjord *Section Head*

N. Fenton *Engineering processes for waste solidification*

Dr. K. B. Harvey *Glass products and melting processes*

Dr. P. J. Hayward *Ceramic and glass-ceramic products for reprocessing wastes*

C. B. Saunders *Engineering processes for waste treatment*

Dr. T. S. Sridhar *Calcination, vitrification, and off-gas treatment processes*

Dr. J. C. Tait *Chemical interactions at glass surfaces and viscosities of glass melts*

The Geochemistry Section is primarily concerned with predicting the degree of chemical retardation of radionuclide migration provided by the geosphere. The Waste Immobilization Section deals with the immobilization in durable waste forms of the solid, liquid, and gaseous wastes that would arise from fuel reprocessing.

**Static Sorption**

Sorption of radionuclides on drill cores from the WNRE, CRNL, Atikokan, and White Lake research areas has been studied by simple static experiments. Recently these experiments have been extended to fracture-fill materials from Atikokan. Sorption techniques combining petrology and radiography are proving to be very powerful methods for determining which minerals preferentially sorb radionuclides.

**Sorption Kinetics**

Experimental and theoretical work is in progress to understand the kinetics of chemical processes leading to sorption of radionuclides by geological media. A detailed examination of the kinetics of these processes leads to a better understanding of the underlying mechanisms, and therefore to a greater degree of certainty in the extrapolation from comparatively short observation times to very long geological time scales.

**Sorption in Natural Fractures**

To simulate migration of radionuclides in fractures, a laboratory apparatus has been designed for the injection of radionuclide solutions into a natural fracture in drill core. The equipment allows experiments to be done at a confining pressure similar to the lithostatic pressure, i.e., under conditions relevant to those in the field.

**Geological Analogues**
The geological records are being examined for examples of migration of radionuclides and rare-earth elements. These analogues should provide an understanding of radionuclide migration over geological time scales.

**Radiation Effects**
The effects of radiation damage and radiation-chemical effects on radionuclide release and migration are being studied

**Saline Water Interactions**
The effects of saline waters on mineral stabilities will be studied and the effects on radionuclide release and migration assessed.

**Large-Scale Migration**
Since it is not possible to measure the rates of migration of all radionuclides in the field, it is important to establish a relationship between field and laboratory observations. A massive block of rock with a natural fracture will be quarried and set up in a laboratory. Radionuclide migration through the fracture will be studied under simulated field conditions for several nuclides. After the methodology is established, field experiments will be performed.

**Modeling**
The chemical interactions of radionuclides with geological media can be analyzed by use of chemical models that are based either on fundamental data or on empirical relationships established by laboratory experiments. Various simple models are being examined and the validity of the underlying assumptions assessed. Under certain circumstances, an important mechanism for retardation of radionuclide migration is the diffusion of radionuclides from a fracture into small pores in the bulk rock formation. Various models for pore-structure interactions are being developed and compared to experimental observations.

**Process and Equipment Development**
Process development work is concentrated on calcination, vitrification, and other high-temperature processes to solidify liquids in glass or ceramic matrices. Two types of calciners (fluid-bed and roto-spray) and two types of glass melters (in-can and Joule-heated) are being developed. Radioactive borosilicate glass is being made in a small in-can melter as part of a thorium fuel recycle experiment in the WNRE hot cells.

*Roto-spray calciner*

A Joule-heated ceramic melter and a roto-spray calciner are the principal components of the Waste Immobilization Process Experiment (WIPE)—a non-radioactive facility designed to immobilize simulated high-level wastes at a rate of up to ten kilograms of borosilicate glass per hour. This production rate is about one-tenth that of a full-scale process. The modular design of WIPE will allow comparison of flowsheet alternatives (e.g., calcine-fed versus slurry-fed operation of the melter) and will allow future addition or substitution of process units.

Systems for separating volatile radionuclides are under development at WNRE, CRNL, Ontario Hydro, and the University of New Brunswick. The molybdenum-99 production facility at CRNL is being used to test systems for the separation of radioactive iodines from air.

***Waste Product Development***

Glasses and ceramics are being developed for immobilizing liquid wastes from uranium and thorium fuel reprocessing. Glass compositions under investigation include borosilicates, aluminosilicates, and calcium aluminosilicates (nepheline syenite). Waste forms containing crystalline phases can be tailored for durability in a granitic groundwater environment. Products for immobilizing gaseous radionuclides such as tritium, carbon-14, krypton-85, and iodine-129 are being developed.

The general relationships between the composition of waste products and their hydrothermal, mechanical, and radiation stability are being studied to gain an understanding of their performance over long periods of time. System tests and chemical models are being developed to predict product behavior under simulated vault conditions.

**GEOCHEMISTRY AND APPLIED CHEMISTRY BRANCH CONTRACTS**

| Contractor | Project Officer | Objective |
|---|---|---|
| Hanford Technology | N. Fenton | Consulting services for the detailed design of a Joule melter |
| McGill University<br>*Dr. D. Simkin* | Dr. J. C. Tait | Determination of the distribution of waste ions in glass-ceramics by luminescence spectroscopy |
| McMaster University<br>*Dr. D. A. Thompson* | E. R. Vance | Study heavy-ion damage in glass and crystalline waste forms, and predict the long-term effects of radiation damage |
| McMaster University<br>*Dr. G. R. Piercy*<br>*Dr. G. R. Purdy* | Dr. P. J. Hayward | Electromicroscopic study of sphene glass-ceramic nucleation |
| University of Alberta<br>*Dr. C. M. Scarfe* | Dr. P. J. Hayward | Preparation and characterization of material suitable for the immobilization of iodine-129 |
| University of British Columbia<br>*Dr. H. J. Greenwood*<br>*Prof. T. H. Brown* | Dr. F. P. Sargent and<br>Dr. V. N. Fleer | Theoretical and experimental evaluation of rock/water interactions |
| University of New Brunswick<br>*Dr. D. M. Ruthven* | Dr. T. S. Sridhar | Engineering tests of inorganic sorbents (molecular sieves) for the recovery of krypton and other gaseous radionuclides |
| University of Toronto<br>*Dr. C. R. Phillips* | Dr. T. W. Melnyk | Modeling of solid/solution interfaces to predict sorption of radionuclides |
| University of Western Ontario<br>*Dr. G. M. Bancroft*<br>*Dr. N. S. McIntyre* | Dr. P. J. Hayward | Surface and microanalytical studies of the leaching of ceramics |
| University of Western Ontario<br>*Dr. H. W. Nesbitt*<br>*Dr. W. S. Fyfe* | Dr. F. P. Sargent | Investigation of apatites and their influence on actinide and iodine mobilities in a natural environment |

### 5.1.3 Applied Geoscience Branch

Dr. K. W. Dormuth *Head*
Dr. S. H. Whitaker *Senior Research Advisor*

***Engineering and Geomechanics Project***

G. R. Simmons *Project Leader*
P. Baumgartner *Mining engineering*
Dr. T. Chan *Rock mechanics analysis*
R. B. Cooper *Geotechnical instrumentation*
A. Rogowski *URL site supervision*

***Research Area Hydrogeology Project***

Dr. R. Pearson *Project Leader*
W. R. Ridgway *Hydrogeology*
P. A. Flavelle* *Radionuclide transport*
K. Novokowski* *Radionuclide transport*
J. Smedley* *Hydrogeology*

***WNRE Hydrogeology Project***

C. C. Davison *Project Leader*
E. T. Kozak *Hydrogeology*
G. M. Reeves *Coordination of drilling and logging*

***Geotechnical Studies Project***

Dr. N. M. Soonawala *Project Leader*
A. L. Holloway *Precambrian geology, geophysical logging*
Dr. A. Brown** *Field geology*
Dr. P. A. Brown** *Fracture analysis*
P. J. Chernis** *Rock properties*
B. A. Chomyn** *Magnetic rock properties*
J. J. B. Dugal** *Drilling*
J. R. Goddard** *Data base*
J. G. Hayles** *Geophysics*
C. F. Huang** *Downhole seismic investigations*
R. D. Jackson** *Mechanical rock properties*
Dr. D. C. Kamineni** *Field geology and geochemistry*
J. S. O. Lau** *TV and acoustic logging*
G. F. D. McCrank** *Regional geology*
Dr. D. Stone** *Field geology, structural geology*
D. K. Tomsons** *Geophysics*

***Computation and Analysis Project***

Dr. K. W. Dormuth *Acting Project Leader*
Dr. V. Gu[illegible]anasen *Hydrogeological modeling*

*attached to National Hydrology Research Institute (NHRI)
**attached to EMR

This branch is responsible for providing the tools and techniques for assessing and quantifying the processes occurring within, and the properties of, geological formations. The work[21-24,54,61-68] spans the spectrum of such geoscience disciplines as geology, geophysics, rock properties, rock mechanics, mine design, hydrogeology, and hydrogeochemistry. In certain areas, particularly hydrogeology, much of the work is done by AECL staff at WNRE. In other areas, most of the effort comes from AECL staff attached to EMR and Environment Canada, EMR and Environment Canada staff, Ontario Hydro, Canadian universities, geotechnical and engineering consultants, and private contractors.

The Applied Geoscience Branch has responsibility for management of the geoscience work, including the contributions from the above groups. The branch is responsible for the Underground Research Laboratory (Section 4.1) and the Field Research Areas (Section 4.2). The work of the branch has been divided into the following five projects:

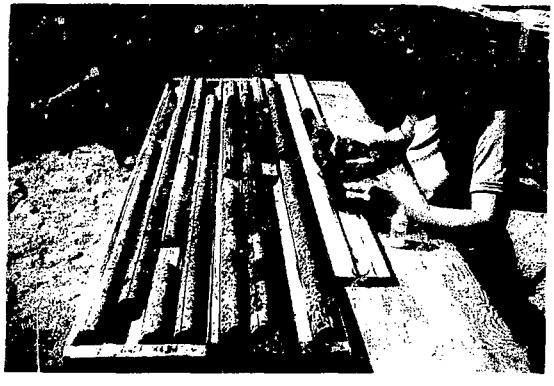
**Engineering and Geomechanics Project**
The objectives are to develop and apply techniques to analyze the thermal and mechanical behavior of plutonic rock under conditions relevant to a disposal vault, to develop designs for construction of the URL and underground experimental facilities, to develop conceptual designs for a nuclear waste vault in plutonic rock, and to assist Ontario Hydro in the development of interim storage and transportation concepts.

**Research Area Hydrogeology Project**
The objectives are to develop and apply techniques to define the physical and chemical characteristics of groundwater flow systems at research areas in Ontario.

**WNRE Hydrogeology Project**
The objectives are to develop and apply techniques to define the physical and chemical characteristics of the groundwater system at the WNRE and URL research sites, and to perform hydrogeological research in, and around, the URL.

**Geotechnical Studies Project**
The objectives are to define the physical and chemical properties of plutonic rock and to investigate alternative geological disposal media. Extensive field research in geology, geophysics, and rock geochemistry is carried out in conjunction with EMR.

**Computation and Analysis Project**
The objectives are to develop and apply computer programs for the prediction of water flow fields and mass transport through an underground disposal vault and through the fractured rock in which it is located.



*Upper left: Examining cores from boreholes at Atikokan*
*Upper right: Shallow drilling for hydrogeological investigations at Atikokan*
*Lower right: Hydrogeological testing at Underground Research Laboratory*

**APPLIED GEOSCIENCE BRANCH CONTRACTS**

| Contractor | Project Officer | Objective |
|---|---|---|
| Acres Consulting Services Ltd. | G. R. Simmons | Conceptual design study for a multi-level disposal vault |
| A-Cubed Ltd. | A. L. Holloway | Provide a ground-probing radar survey in the East Bull Lake area |
| Adina Engineering AB | P. P. Baumgartner | Provide ADINA and ADINAT computer codes for URL use |
| C.I.L. Inc., Consulting Services Group | P. P. Baumgartner | Design and evaluate blasting techniques for the URL |
| Energy, Mines and Resources | Dr. N. M. Soonawala | Geoscience research |
| Environment Canada | Dr. R. Pearson | Hydrogeological research |
| G. Hart and Sons | G. Reeves | Perform drilling at the URL to allow deep and shallow hydrogeological investigations |
| Gartner Lee Associates | Dr. R. Pearson | Hydrogeological testing services at Atikokan |
| Geologic Testing Consultants | Dr. R. Pearson | Review groundwater tracer methods |
| Golder Associates (Eastern) Ltd. | G. R. Simmons | Geotechnical consultation on URL experimental program |
| Hayter Drilling Ltd. | G. Reeves | Deep far-field groundwater investigation boreholes at the URL and WNRE sites |
| Heath and Sherwood Drilling Ltd. | J. A. Harding* | Diamond drilling for boreholes URL-6 and URL-7 |
| In-Situ Inc. | Dr. R. Pearson | Supply hydrologic analysis system for use at Atikokan |
| INTERA Environmental Consultants | Dr. V. Guvanasen | Regional vault-scale and local-scale hydrogeological modeling |
| INTERA Environmental Consultants | Dr. V. Guvanasen | Update and calibrate a two-dimensional and three-dimensional hydrogeologic computer model for the URL site |
| MacLaren Plansearch Ltd. | Dr. R. Pearson | Hydrological studies at East Bull Lake |
| Paterson, Grant and Watson Ltd. | Dr. N. M. Soonawala | Geophysical field measurements, preliminary interpretation, and data synthesis at East Bull Lake |
| Quetico Exploration and Development Co. | Dr. R. Pearson | Groundwater monitoring at Forsberg Lake |
| Roke Oil Enterprises Ltd. | G. Reeves | Geophysical logging in deep and shallow groundwater boreholes |
| TTI Geotechnical Resources | P. P. Baumgartner | Conduct hydrofracturing in situ stress measurements at the URL |
| Underwood McLellan Ltd. | Dr. R. Pearson | Hydrological studies in the Atikokan area |
| University of Alberta<br>*Dr. F. W. Schwartz*<br>University of British Columbia<br>*Dr. L. Smith* | Dr. V. Guvanasen | Develop a two-dimensional stochastic computer code for nuclide migration |
| University of Manitoba<br>*Dr. W. C. Brisbin* | Dr. N. M. Soonawala | General consultancy in the area of igneous and structural geology |
| University of Toronto<br>*Prof. J. H. Curran* | P. P. Baumgartner | Study the influence of shear velocity on the frictional resistance of rock |
| University of Toronto<br>*Dr. R. N. Edwards* | Dr. N. M. Soonawala | Magnetometric resistivity survey at Atikokan; summary and evaluation of all ground electrical survey results |
| University of Waterloo<br>*Dr. E. O. Frind*<br>*Dr. R. W. Gillham* | Dr. R. Pearson | Radionuclide migration in fractured rock—modeling and supporting laboratory studies |
| University of Waterloo<br>*Dr. P. Fritz*<br>*Dr. S. K. Frape*<br>*Dr. J. Barker* | Dr. R. Pearson | Occurrence and geochemistry of saline groundwater in the Canadian Shield; organic complexing of radionuclides and the biogeochemistry of groundwater |
| W. L. Wardrop and Associates | D. A. Peters* | Consulting engineering services for the design of the URL |
| Westbay Instruments Ltd. | D. A. Peters* | Provide engineering services, manufacturing, product evaluation, development, and testing of Westbay's multiple piezometer groundwater sampling and monitoring systems |

*Design and Project Engineering Branch

### 5.1.4 Environmental and Safety Assessment Branch

R. B. Lyon *Head*

***Systems Analysis Section***

T. Andres *Section Head*
K. J. Hoffman *Quality assurance*
Dr. J. A. K. Reid *Systems analysis*

***Mass Transport Section***

Dr. B. W. Goodwin *Section Head*
Dr. J. W. Barnard *Chemical modeling*
Dr. N. C. Garisto *Chemical modeling*
Dr. J. R. Walker *Mass transport modeling*

***Pre-Closure Assessment Coordination***

Dr. D. B. McConnell *Coordinator*
J. Tamm *Technical assistance*

***Post-Closure Assessment Section***

D. M. Wuschke *Section Head*
V. M. Guvanasen *Alternative disposal concepts*
W. F. Heinrich *Geosphere modeling*
D. LeNeveu *Vault modeling*
Dr. K. K. Mehta *Biosphere modeling*

***Computer Programming Section***

G. R. Sherman *Section Head*

The objective of the branch is to assess the impact of proposed nuclear fuel waste management facilities on man and the environment, now and in the future. This involves assimilation of data and descriptions of important phenomena and processes from the R&D programs, and development and application of computer programs.[15,69] The results of the assessment studies[57-59] help to guide the research and to define site and design criteria. They also provide the basis for judging the acceptability of the concept.

**Systems Analysis**

Procedures are being developed to assimilate field and laboratory data, to simulate the behavior of physical systems, and to analyze statistically the results of such simulations. A computer code called SYVAC[60,70] has been developed to link system submodels and to carry out simulations, taking into account uncertainties. Standards are being developed for quality assurance of data, models, and computer programs.

### Mass Transport

Mass transport codes are being developed and modified to permit a detailed study of various chemical sorption isotherms. Equilibrium thermodynamic chemical models, such as SOLMNQ, are used for predicting chemical interactions in the vault,[71] and together with other codes will be applied to the geosphere. A kinetic model is being developed to describe the dissolution of potassium feldspar. Work is continuing on the validation of chemical and mass transport models using field and laboratory data.

### Pre-Closure Assessment

Ontario Hydro carries out the pre-closure assessment studies, which involve estimation of the environmental impact due to transportation, construction, operation, and decommissioning. Dr. D. B. McConnell coordinates the pre-closure assessment and interacts with the regulatory agencies involved with concept assessment.

### Post-Closure Assessment

The post-closure phase begins after the underground vault has been backfilled, the shafts sealed, and the surface facilities removed. The post-closure assessment involves the application of computer models and data to assess the capability and reliability of the barriers and protective features. The assessment is carried out with the computer program SYVAC, which links system sub-models describing the vault, geosphere, and biosphere. The status of alternative disposal concepts is being reviewed, and SYVAC is being used to assess subseabed disposal for an international working group of the Organization for Economic Cooperation and Development/Nuclear Energy Agency (OECD/NEA).

### Computer Programming

This section designs, implements, and runs the computer programs required for assessing nuclear fuel waste disposal concepts.

**ENVIRONMENTAL AND SAFETY ASSESSMENT BRANCH CONTRACTS**

| Contractor | Project Officer | Objective |
|---|---|---|
| Beak Consultants Ltd. | D. M. Wuschke | Study of transport of carbon-14 and tritium in the environment of the Canadian Shield |
| MacLaren Plansearch Inc. | D. M. Wuschke | Review the current status of alternative disposal concepts, and evaluate their suitability for Canada |

*Computer analysis of environmental consequences of nuclear fuel waste disposal in an underground vault*

### 5.1.5 Waste Management Public Affairs Section

E. R. Frech *Head*

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D. A. Carson *Public Affairs Officer (Toronto)*
*Supervisor of Regional Programs*

R. B. Anderson *Information Officer (Thunder Bay)*

M. A. Greber *Social Research Specialist*

J. A. R. Hillier *Information Officer*

Dr. M. C. Tutiah *Writer and Producer*

The Waste Management Public Affairs Section produces and distributes information materials on waste management, including booklets, posters, display units and models, slide-tape shows, films, newsletters, news releases, radio tapes, media advertisements, and a weekly newspaper column on energy. It undertakes interactions with elected officials at the federal, provincial, and municipal levels, with various interest groups, and with the news media.

Scientific personnel provide assistance by accepting speaking engagements, giving briefings, and being available for media interviews. The WNRE Media Relations Officer, D. Brown, also devotes part of his time to the waste management program. Assistance on social research is provided by Dr. M. Barrados of AECL Corporate Office in Ottawa.

### 5.1.6 Program Coordination and Data Management Section

Dr. E. L. J. Rosinger *Head*

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The major objective of this section is the establishment and maintenance of a comprehensive system for program data management, coordination, and planning. The system will comprise a comprehensive data base and procedures and techniques for preparation of internally consistent documentation on the Nuclear Fuel Waste Management Program, such as the R&D Program Plan, the Condensed Program Plan, and a Contracts Report.

### 5.2.1 Research Chemistry Branch

Dr. D. F. Torgerson *Head*

***Waste Form Chemistry***

Dr. D. W. Shoesmith *$UO_2$ fuel dissolution*

Dr. S. Sunder *$UO_2$ fuel dissolution*

Dr. P. Taylor *Glass chemistry, special waste forms*

***Waste/Water/Rock Interactions***

Dr. R. I. Haines *Radionuclide/mineral interactions*

Dr. C. H. D. Ho *Colloid formation and transport*

***Solute and Solution Chemistry***

Dr. R. J. Lemire *Actinide chemistry*

Dr. J. Paquette *Fission-product behavior*

Dr. P. P. S. Saluja *Thermodynamic data*

Dr. F. Garisto *Theories of ionic solutions and mineral dissolution studies*

***Abatement of Volatile Fission Products***

Dr. A. C. Vikis *Off-gas filtration*

The objective of this branch is to carry out fundamental research to provide in-depth understanding of chemical phenomena important to the waste management program. This involves developing experimental and predictive tools to assess the long-term chemical behavior of fission products, actinides, and waste forms under disposal vault conditions.

**Waste Form Chemistry**

The oxidative dissolution of uranium oxide fuel is being studied as a function of redox potential, pH, and groundwater composition using electrochemical techniques.[72-74] The surface oxidation of uranium oxide in air has also been examined.[75]

Complex glass compositions are being studied[76-79] to determine their suitability as matrix materials for the immobilization of reprocessing wastes. Since phase separation can have a substantial effect on glass leach rates, the factors that affect it during glass processing are being identified.

**Solute and Solution Chemistry**

Actinide solution chemistry is focusing on understanding uranium complexation in the presence of groundwater species such as carbonates and chlorides. Experiments are also being done to augment and assess the actinide solubility data for uranium and plutonium.[80-82]

The basic chemistry of important fission products under waste-vault conditions is being studied.[83,84] This involves assessment of the redox, hydrolysis, and complexation reactions of technetium, and solution chemistry experiments on iodine behavior.

A thermochemistry laboratory has been established to provide thermodynamic information on fission-product and actinide species at temperatures anticipated in the waste vault.

**Waste/Water/Rock Interactions**

Work on radionuclide/mineral interactions[85] is focused on the mechanisms of ion sorption onto minerals, the structure and stability of ions sorbed on mineral surfaces, and the nature of mineral surfaces in contact with groundwater. Actinide and fission-product colloid formation and transport in the waste vault, including colloid/mineral interactions, are also being investigated.

**Abatement of Volatile Fission Products**

For iodine-129, gas-phase scrubbing methods are being developed that appear to have advantages over current technology,[51,52,86] and a pilot plant is being constructed for engineering-scale demonstration. Bench-scale work is continuing on a method for krypton-85 abatement.

### 5.2.2 Environmental Research Branch

Dr. S. L. Iverson *Head*

**Ecology Research Section**

Dr. S. L. Iverson *Section Head (acting)*
Dr. M. I. Sheppard *Unsaturated soils*
Dr. S. C. Sheppard *Plant uptake*
Dr. R. Zach *Food chains*

**Meteorology Section**

Dr. P. A. Davis *Section Head*
E. E. Wuschke *Atmospheric pathways*

**Terrestrial Pathways**

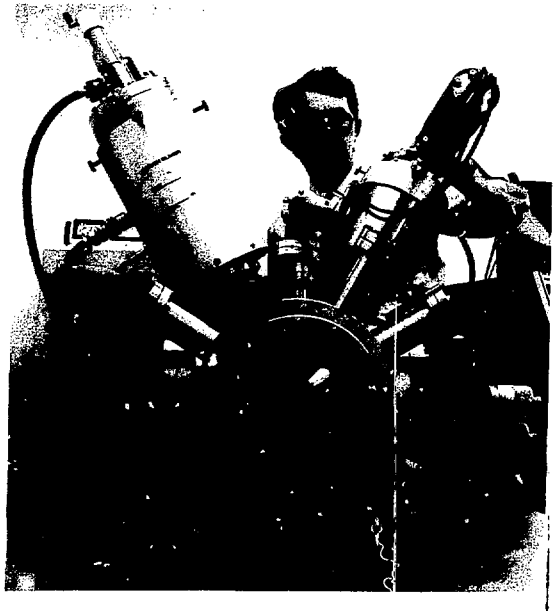
Terrestrial pathways, involving the movement of radionuclides in surface soils, uptake by plants, and transport through animal and human food chains, are being studied. Studies include the development and experimental validation of models, and the determination of appropriate data for application to possible sites on the Canadian Shield.

The computer model SCEMR[87] describes the movement of radionuclides in layers of unsaturated soil with varying hydrological properties and plant root volumes. Its validity will be tested by comparing predictions with the results obtained from an experiment to determine the movement of contaminants (uranium and chromium) in an unsaturated-soil column.

A food-chain model, NEPTUN,[88] calculates the movement of radionuclides through a number of aquatic pathways, including fish, aquatic plants, and invertebrates, to man. A new food-chain model, LIMCAL,[89,90] includes terrestrial, freshwater, and saltwater food chains to allow for the appropriate mix of man's diet. A stochastic version of LIMCAL has been developed to deal realistically with variations in parameter values.

**Atmospheric Pathways**

Long-range transport, dispersion over long time spans, and suspension of materials from the surface of the soil are being studied, since these processes may affect dose to man in the long term.



← *Study of radionuclide uptake by barley*

**ENVIRONMENTAL RESEARCH BRANCH WASTE MANAGEMENT CONTRACTS**

| Contractor | Project Officer | Objective |
|---|---|---|
| AECL Radiochemical Co. | Dr. M. I. Sheppard | Perform neutron activation analysis for uranium |
| University of Guelph<br>*Dr. W. Chesworth* | Dr. M. I. Sheppard | Field sampling and analysis to investigate the fundamental chemistry and mineralogy of podzolization |
| University of Manitoba<br>*Dr. C. M. Cho* | Dr. P. A. Davis | Verify deposition and resuspension parameters for radionuclide air dispersion model |
| University of Ottawa<br>*Dr. P. Weinberger* | Dr. M. I. Sheppard | Investigate biochemistry of uranium with respect to uptake by and effect on plants |
| University of Waterloo<br>*Dr. P. R. Slawson* | Dr. P. A. Davis | Perform field trials and validate atmospheric environmental radioactivity and dose model (AERAD) |

### 5.2.3 Radiation and Industrial Safety Branch

E. J. K. Cowdrey *Head*

E. J. K. Cowdrey *External exposure and dosimetry*

**External Exposure and Dosimetry**

Models and data have been developed to allow calculation of dose to man received by external irradiation from radionuclides in air, soil, and water. Documentation of the material is in progress.

### 5.2.4 Analytical Science Branch

R. B. Stewart *Head*

This branch, with its staff of more than fifty, provides support and performs research and development in analytical chemistry. Projects include the analysis of groundwaters for their chemical contents and character, the analysis of solutions from leaching of waste forms, the analysis of rocks and minerals, and the analysis of container materials. Waste forms studied include irradiated fuel, glasses, and ceramics, containing either real or simulated radioactive wastes. Mineral and waste-form surfaces are characterized microanalytically from the outermost atomic layers to the bulk interiors to determine various parameters, e.g., phase segregation of fission products.

← *Glass surface analysis by scanning Auger microscope.*

New analytical methods, e.g., for technetium and iodine isotopes, and remote sensors for use in boreholes to measure chemical parameters, such as dissolved oxygen, pH, and salinity, are being developed.

### 5.2.5 Materials and Mechanics Branch

W. C. Harrison *Acting Head*

Y. Liner *Thermal rock mechanics modeling and mathematics*

Dr. G. Rigby *Crack propagation in rocks; thermal rock mechanics modeling*

Dr. B. J. S. Wilkins *Crack propagation in rocks; thermal rock mechanics modeling*

**Crack Propagation in Rocks**

The objective is to develop models to describe the microcracking that would be expected, after long time periods, in rock around a nuclear waste vault, and to generate data to enable a quantitative assessment.[91-93]

**Thermal Rock Mechanics Modeling**

The objective is to develop, in cooperation with the Applied Geoscience Branch, a geomechanical modeling capability that can be used to design and assess experiments for the URL program.

### 5.2.6 Design and Project Engineering Branch

M. M. Ohta *Head*

This branch is responsible for the design and project engineering of the experimental facilities[94,95] and equipment[96] required to support the waste management program. The branch is also responsible for studies and assessments of air-cooled interim storage concepts for irradiated fuel,[97] as an AECL contribution to Ontario Hydro's studies of irradiated fuel storage.

### 5.3.1 Environmental Research Branch

Dr. R. V. Osborne *Head*

R. W. D. Killey *Groundwater transport*

Dr. D. R. Lee *Discharge zones, aquatic biology*

Dr. G. L. Moltanyer *Aquatic and groundwater modeling*

**Aquatic and Groundwater Pathways**

Discharge of groundwaters, radionuclide transport by groundwater through unconsolidated materials, transport in surface waters such as lakes and streams, and uptake by aquatic biota are being studied. Research underway includes development and experimental validation of biosphere models, and development of methods for determination of data for the Canadian Shield.

A central focus for the work in this branch is the controlled area at CRNL. Investigations of groundwater discharge zones are underway at Maskinonge Lake, where the lake level has been artificially raised and lowered to "pump" discharge zones. Changes in plant-nutrient flow, indicated by variations in plant species and changes in chemical deposits, are being studied in Perch Lake, and could provide measures of groundwater discharge rates.

The waste management areas at CRNL provide excellent "test sites" for radionuclide-transport studies. Radionuclide migration has been studied there for 20 years and hydrologic and migration experiments are now underway to provide data for validating computer programs.

### 5.3.2 Biomedical Research Branch

Dr. J. R. A. Johnson *Head*

**Internal Dosimetry**

Data are being collected and models are being developed to estimate the dose to man per unit radionuclide inhaled with air or ingested with food. The simulation system, FORSIM, is being applied in compartmental modeling of iodine-129 transfer in the biosphere.

### 5.4.1 Responsibilities and Organization

Ontario Hydro's involvement in the waste management program was initiated in 1978 with a federal/Ontario government announcement that assigned the following program responsibilities:

| Ontario Hydro | | AECL | |
|---|---|---|---|
| **Irradiated Fuel Storage** | **Irradiated Fuel Transportation** | **Nuclear Fuel Waste Immobilization** | **Nuclear Fuel Waste Disposal** |

In addition to directing and funding R&D related to irradiated fuel storage and transportation, Ontario Hydro is providing AECL with technical assistance as described in this section. Most of the work is carried out within the Design and Development Division (Ontario Hydro Building, 700 University Avenue, Toronto) and the Research Division (800 Kipling Avenue, Toronto).

Dr. R. C. Oberth, the Irradiated Fuel Management Engineer of the Design and Development Division, is responsible for all Ontario Hydro irradiated fuel management programs. Mr. R. A. McEachran, head of the Nuclear Fuel Waste Disposal Unit, manages technical assistance to AECL. He is assisted by M. Burston, Dr. N. C. Burnett, and P. Pearson. J. L. Crosthwaite of WNRE is the AECL/Ontario Hydro Liaison Officer. The technical assistance is divided into work packages, which are grouped into four broad areas with an area coordinator for each.

*Preparing to test effects of radiation on the corrosion of copper*

**Containment/Immobilization** Dr. J. Chadha *Coordinator*

A. Y. Cheung *Thin-wall container*

P. J. King *Corrosion research*

J. D. Tulk *Strain gauge development*

M. J. Tinkler *Welding technology*

Dr. M. P. Dolbey *Remote inspection*

***Civil Research*** T. J. Carmichael *Coordinator*

Dr. H. S. Radhakrishna *Buffer materials, vault backfill, moisture gauge development, shaft sealing*

Dr. H. T. Chan *Buffer materials, vault backfill, moisture gauge development, shaft sealing*

R. Koopmans *Borehole modulus measurements, stress gauge development*

Dr. R. D. Hooton *Vault grouting (cement)*

Dr. A. Jakubick *Radionuclide migration, vacuum permeability studies*

**Geotechnical** Dr. C. F. Lee *Coordinator*

Dr. C. F. Lee *Seismic risk evaluation, URL project assistance*

Dr. K. K. Tsui *URL thermomechanical response, URL hydrogeological modeling*

Dr. J. A. O'Neill *Groundwater dating*

***Environmental/Miscellaneous*** R. A. McEachran *Coordinator*

K. Johansen *Environmental assessment, biosphere parameter values, high-level waste transportation impact*

Dr. G. F. Thomas *Radionuclide inventory analysis*

R. A. McEachran *Design review*

### 5.4.2 Work Package Descriptions

**Containment and Immobilization Studies**

*Thin-Wall Container* Develop an alternative irradiated fuel disposal container.

*Corrosion Research* Copper corrosion studies to evaluate the feasibility of a long-term copper container.

*Strain Gauge Development* Develop a reliable and economical strain gauge system for hydrostatic testing of containers.

*Welding Technology* Provide welding expertise to assist in the development of remote welding systems and fuel container designs.

*Remote Inspection* Develop remote inspection systems for fuel containers.

**Civil Research Studies**

*Buffer Materials* Evaluate the performance of selected buffer materials.

*Vault Backfill* Develop methods and materials to backfill the disposal vault.

*Moisture Gauge Development* Develop a miniaturized gauge to measure changes of moisture content in compacted buffer, backfill, and soil.

*Shaft Sealing* Complete a review of shaft sealing methods and materials.

*Borehole Modulus Measurements* Test the borehole dilatometer to assess the effects of blast damage on rock.

*Stress Gauge Development* Design a new stress gauge to measure in situ stress changes in rock.

*Vault Grouting (Cement)* Develop methods and cement-based materials to grout the excavated surfaces of the disposal vault.

*Radionuclide Migration* Evaluate the radionuclide retention capabilities of selected buffer materials.

*Vacuum Permeability Studies* Design, construct, and test a rock-fracture detection and permeability assessment device.

**Geotechnical Studies**

*Seismic Risk Evaluation* Determine the seismic risk and dynamic stability of the vault.

*URL Project Assistance* Provide geomechanics support in the planning, design, and construction of the URL.

*URL Thermomechanical Response* Provide scoping calculations for the heater experiments in the URL and predict the thermomechanical response of the URL.

*URL Hydrogeological Modeling* Predict the response of the groundwater regime to the construction of the URL.

*Groundwater Dating* Improve the accuracy of groundwater dating by laser enrichment of carbon-14 and by developing the alternative technique of rare-gas analysis.

**Environmental/Miscellaneous Studies**

*Environmental Assessment* Pre-closure environmental assessment.

*Biosphere Parameter Values* Develop representative distributions of parameter values for the post-closure biosphere analysis.

*High-Level Waste Transportation Impact* Study the environmental implications of high-level waste transportation.

*Radionuclide Inventory Analysis* Temporal evolution of radionuclide inventories in a multi-compartment system.

*Design Review* Provide a design review service for AECL.

EMR has been involved in the waste management research program since 1973, first by providing geoscience advice, then reviews of relevant literature. The involvement has gradually expanded to make EMR a major contributor and contractor. Three branches of EMR, under the direction of Dr. J. S. Scott, participate in the program: Geological Survey of Canada (GSC), Earth Physics Branch (EPB), and the Canada Centre for Mineral and Energy Technology (CANMET). Most of the work is done by EMR staff and by AECL staff attached to EMR. However, a number of contracts are let to university staff in Canada and the U.S.A., as well as to a variety of private contractors.

**EMR Geoscience Research Programs for Nuclear Fuel Waste Disposal**

Dr. J. S. Scott *Director*

**Geological Survey of Canada**

Dr. I. F. Ermanovics *Program Manager, Geological Activity*

Drilling and core logging
TV and acoustic logging of boreholes
Glacial erosion
Salt, limestone, and shale studies
Lithological mapping and geochemistry
Structural mapping
Geological analyses
Data file and modeling
Data synthesis
Reconnaissance data base
Seabed disposal

**Earth Physics Branch**

M. R. Dence *Program Manager, Geophysics Activity*

Data file
Magnetotelluric and magnetometric resistivity surveys
Surface electrical surveys (in collaboration with GSC)
Seismic lateral studies
Downhole seismic surveys (in collaboration with GSC)
Geothermal logging
Aquifer tidal monitoring
Borehole electrical surveys (in collaboration with GSC)
Standard logging (in collaboration with GSC)
Master geophysics contract
Gravity surveys
Regional seismicity

**Canada Centre for Mineral and Energy Technology**

G. E. Larocque *Program Manager, Rock Properties Activity*

Pore-structure studies (in collaboration with GSC)
Thermal rock properties (high temperature)
Mechanical rock properties
Borehole plugging and shaft sealing
Thermal rock properties (ambient temperature)
Magnetic properties (in collaboration with EPB)
Rock crack properties (in collaboration with EPB)

### 5.6 Environment Canada

The Contaminant Hydrogeology Unit of the National Hydrology Research Institute of Environment Canada has participated in the program for more than five years and is one of the major contractors. Under the supervision of J. A. Gilliland and K. G. Raven, both NHRI staff and attached AECL staff have been doing research, primarily in the areas of hydrogeology and hydrogeochemistry, at AECL's field research areas and in laboratories in Ottawa.

Environment Canada assesses and develops methodology for collection and analysis of field data to determine the hydrogeologic parameters relevant to groundwater flow and radionuclide transport from deep underground disposal zones. Field and laboratory testing techniques that will provide information concerning the origin, age, subsurface flow paths, and hydrogeochemical evolution of groundwaters in deep underground zones are being developed.

### 5.7 Contractors

#### 5.7.1 Universities

A significant portion of the R&D is contracted to Canadian universities.

**CONTRACTS ISSUED TO UNIVERSITIES**

| Contractor | [illegible] | Objective |
|---|---|---|
| Carleton University<br>Dr. A. P. S. Selvadurai | Fuel Waste Technology | Theoretical modeling of container/buffer/rock interactions |
| McGill University<br>Dr. D. Simkin | Geochemistry and Applied Chemistry | Determination of the distribution of waste ions in glass-ceramics by luminescence spectroscopy |
| McGill University<br>Dr. R. N. Yong | Fuel Waste Technology | Evaluate candidate backfill materials and develop composition and emplacement specifications |
| McGill University<br>Dr. R. N. Yong | Fuel Waste Technology | Creep behavior of buffer materials |

| Contractor (cont.) | WNRE Branch (cont.) | Objective (cont.) |
|---|---|---|
| McMaster University<br>*Dr. D. A. Thompson* | Geochemistry and Applied Chemistry | Study heavy-ion damage in glass and crystalline waste forms and predict the long-term effects of radiation damage |
| McMaster University<br>*Dr. G. R. Piercy*<br>*Dr. G. R. Purdy* | Geochemistry and Applied Chemistry | Electromicroscopic study of sphene glass-ceramic nucleation |
| University of Alberta<br>*Dr. C. M. Scarfe* | Geochemistry and Applied Chemistry | Preparation and characterization of material suitable for the immobilization of iodine-129 |
| University of Alberta<br>*Dr. F. N. Schwartz*<br>University of British Columbia<br>*Dr. L. Smith* | Applied Geoscience | Develop a two-dimensional stochastic computer code for nuclide migration |
| University of British Columbia<br>*Dr. H. J. Greenwood*<br>*Prof. T. H. Brown* | Geochemistry and Applied Chemistry | Theoretical and experimental evaluation of rock/water interactions |
| University of Guelph<br>*Dr. W. Chesworth* | Environmental Research | Field sampling and analysis to investigate the fundamental chemistry and mineralogy of podzolization |
| University of Manitoba<br>*Dr. W. C. Brisbin* | Applied Geoscience | General consultancy in the area of igneous and structural geology |
| University of Manitoba<br>*Dr. C. M. Cho* | Environmental Research | Verify deposition and resuspension parameters for radionuclide air dispersion model |
| University of New Brunswick<br>*Dr. D. M. Ruthven* | Geochemistry and Applied Chemistry | Engineering tests of inorganic sorbents (molecular sieves) for the recovery of krypton and other gaseous radionuclides |
| University of Ottawa<br>*Dr. P. Weinberger* | Environmental Research | Investigate biochemistry of uranium with respect to uptake by and effect on plants |
| University of Saskatchewan<br>*Dr. J. Postlethwaite* | Fuel Waste Technology | Corrosion of titanium-base and nickel-base alloys |
| University of Toronto<br>*Prof. J. H. Curran* | Applied Geoscience | Study the influence of shear velocity on the frictional resistance of rock |
| University of Toronto<br>*Dr. R. N. Edwards* | Applied Geoscience | Magnetometric resistivity survey at Atikokan; summary and evaluation of all ground electrical survey results |
| University of Toronto<br>*Dr. C. R. Phillips* | Geochemistry and Applied Chemistry | Modeling of solid/solution interfaces to predict sorption of radionuclides |
| University of Waterloo<br>*Dr. E. O. Frind*<br>*Dr. R. W. Gillham* | Applied Geoscience | Radionuclide migration in fractured rock; modeling and supporting laboratory studies |
| University of Waterloo<br>*Dr. P. Fritz*<br>*Dr. S. K. Frape*<br>*Dr. J. Barker* | Applied Geoscience | Occurrence and geochemistry of saline groundwater in the Canadian Shield; organic complexing of radionuclides and the biogeochemistry of groundwater |
| University of Waterloo<br>*Dr. P. R. Slawson* | Environmental Research | Perform field trials and validate atmospheric environmental radioactivity and dose model (AERAD) |
| University of Waterloo<br>*Dr. C. J. Mayfield*<br>*Dr. J. Barker* | Fuel Waste Technology | Biogeochemistry of buffer and backfill materials |
| University of Western Ontario<br>*Dr. G. N. Bancroft*<br>*Dr. N. S. McIntyre* | Geochemistry and Applied Chemistry | Surface and microanalytical studies of the leaching of ceramics |
| University of Western Ontario<br>*Dr. H. W. Nesbitt*<br>*Dr. W. S. Fyfe* | Geochemistry and Applied Chemistry | Investigation of apatites and their influence on actinide and iodine mobilities in a natural environment |
| University of Western Ontario<br>*Dr. R. M. Quigley* | Fuel Waste Technology* | Chemical and mineralogical characterization of selected buffer and backfill materials |

*jointly with Ontario Hydro

## 5.7.2 Private Contractors

**MAJOR SCIENTIFIC AND TECHNICAL CONTRACTS ISSUED TO PRIVATE CONTRACTORS**

| Contractor | WNRE Branch | Objective |
|---|---|---|
| Acres Consulting Services Ltd. | Applied Geoscience | Conceptual design study for a multi-level disposal vault |
| A-Cubed Ltd. | Applied Geoscience | Provide a ground-probing radar survey in the East Bull Lake area |
| Adina Engineering AB | Applied Geoscience | Provide ADINA and ADINAT computer codes for URL use |
| Beak Consultants Ltd. | Environmental and Safety Assessment | Study of transport of carbon-14 and tritium in the environment of the Canadian Shield |
| Bristol Aerospace Ltd. | Fuel Waste Technology | Design, develop, and manufacture structurally supported prototype container |
| C. I. L. Inc., Consulting Services Group | Applied Geoscience | Design and evaluate blasting techniques for the URL |
| G. Hart & Sons | Applied Geoscience | Perform drilling at the URL to allow deep and shallow hydrogeological investigations |
| Gartner Lee Associates | Applied Geoscience | Hydrogeological testing services at Atikokan |
| Geologic Testing Consultants | Applied Geoscience | Review groundwater tracer methods |
| Golder Associates (Eastern) Ltd. | Applied Geoscience | Geotechnical consultation on URL experimental program |
| Hanford Technology | Geochemistry and Applied Chemistry | Consulting services for the detailed design of a Joule melter |
| Hayter Drilling Ltd. | Applied Geoscience | Deep far-field groundwater investigation boreholes at the URL and WNRE sites |
| Heath and Sherwood Drilling Ltd. | Applied Geoscience | Diamond drilling for boreholes URL-6 and URL-7 |
| In-Situ Inc. | Applied Geoscience | Supply hydrologic analysis system for use at Atikokan |
| INTERA Environmental Consultants | Applied Geoscience | Regional vault-scale and local-scale hydrogeological modeling |
| INTERA Environmental Consultants | Applied Geoscience | Update and calibrate a two-dimensional and three-dimensional hydrogeologic computer model for the URL site |
| MacLaren Plansearch Inc. | Applied Geoscience | Hydrological studies at East Bull Lake |
| MacLaren Plansearch Inc. | Environmental and Safety Assessment | Review the current status of alternative disposal concepts and evaluate their suitability for Canada |
| Paterson, Grant and Watson Ltd. | Applied Geoscience | Geophysical field measurements, preliminary interpretation, and data synthesis at East Bull Lake |
| Perkin Elmer (Physical Electronics Division) | Analytical Science | Surface analytical services on secondary ion mass spectroscopy |
| Quetico Exploration and Development Co. | Applied Geoscience | Groundwater monitoring at Forsberg Lake |
| Roke Oil Enterprises Ltd. | Applied Geoscience | Geophysical logging in deep and shallow groundwater boreholes |
| TTI Geotechnical Resources | Applied Geoscience | Conduct hydrofracturing in situ stress measurements at the URL |
| Underwood McLellan Ltd | Applied Geoscience | Hydrological studies in the Atikokan area |
| W. L. Wardrop and Associates | Fuel Waste Technology | Design engineering, contract administration, and non-resident services for the Immobilized Fuel Test Facility |
| W. L. Wardrop and Associates, Canadian Mine Services Ltd., and Hardy Associates | Fuel Waste Technology | Buffer and backfill engineering (acquisition, transportation, preparing, handling, and emplacement) |
| W. L. Wardrop and Associates | Applied Geoscience | Consulting engineering services for the design of the URL |

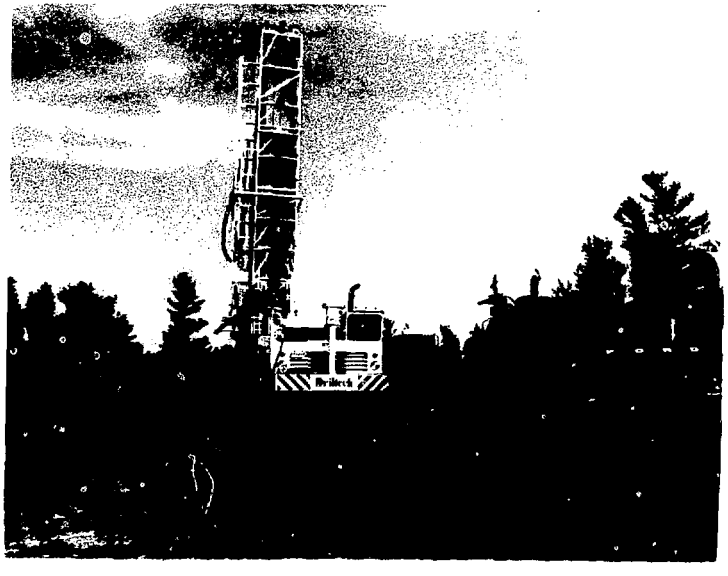
| Contractor *(cont.)* | WNRE Branch *(cont.)* | Objective *(cont.)* |
|---|---|---|
| Welding Institute of Canada | Fuel Waste Technology | Evaluation of techniques for arc-welding thick copper |
| Westbay Instruments Ltd. | Applied Geoscience | Provide engineering services, manufacturing, product evaluation, development, and testing of Westbay's multiple piezometer groundwater sampling and monitoring systems |

### 5.7.3 Government Departments

**CONTRACTS ISSUED TO GOVERNMENT DEPARTMENTS**

| Contractor | WNRE Branch | Objective |
|---|---|---|
| AECL Radiochemical Co. | Environmental Research | Perform neutron activation analysis for uranium |
| Energy, Mines and Resources | Applied Geoscience | Geoscience research (see Section 5.5) |
| Environment Canada | Applied Geoscience | Hydrogeological research (see Section 5.6) |

*Structurally-supported fuel waste container built by Bristol Aerospace Limited. The shell and the internal support structure are shown*



*Drilling at Underground Research Laboratory site by contractor*

# 6. PROGRAM STATISTICS

## 6.1 Participants

In 1982, 765 professional and technical staff were involved in the program (some part-time). The distribution is given below.

**NUMBER OF PARTICIPANTS IN PROGRAM, 1982 SEPTEMBER 30**

| Sector | Organization | Professional | Technical | Total |
|---|---|---|---|---|
| Government | AECL | 113 | 82 | 195 |
| | Environment Canada | 4 | – | 4 |
| | EMR | 45 | 14 | 59 |
| | Ontario Hydro | 50 | 5 | 55 |
| Private | | 229 | 123 | 352 |
| University | | 100 | – | 100 |
| | | | | Total 765 |

## 6.2 Funding

| Year | Funding |
|---|---|
| | (million dollars) |
| 1980/81 | 17.0 |
| 1981/82 | 23.1 |
| 1982/83 | 31.8 |
| Annual average until 1990/91 | 29.0 (1981 $) |

Funding for the nuclear fuel waste management program is provided by the federal government, which in 1981 May approved a ten-year generic research and development program with average yearly funding (operating and capital) of about 29 million (1981) dollars.

Ontario Hydro directs and funds R&D in fuel storage and transportation, and also provides technical assistance to AECL in the immobilization and disposal program. The Ontario Hydro budget for technical assistance in fiscal year 1982 was two million dollars. A budget of one million dollars is proposed for 1983.

## 6.3 Contracts

There were 65 active contracts as of 1982 September, three with government departments, 37 with the private sector, and 25 with universities. D. G. Beeskau, WNRE, is contracts coordinator.

# 7. INTERNATIONAL COOPERATION

International cooperation in nuclear fuel waste management is coordinated by Liaison and International Affairs, AECL Corporate Office, Ottawa. The office ensures that Canada is represented at international meetings and on various committees and working groups of the International Atomic Energy Agency (IAEA) and the Organization for Economic Cooperation and Development/Nuclear Energy Agency (OECD/NEA).

## 7.1 United States of America

The U.S.A. and Canada have a long history of cooperation in the nuclear field. On 1982 August 25 a renewal of an agreement between the Department of Energy of the United States of America and Atomic Energy of Canada Limited respecting cooperation in radioactive waste management was signed.

The current agreement covers nine areas of cooperation: preparation and packaging of radioactive waste, decontamination and decommissioning, surface and subsurface storage, characterization of geologic formations, disposal in geologic formations, transportation requirements, operational considerations, environmental and safety concerns, and public acceptance issues.

Three annual U.S.A./Canada cooperation and information exchange meetings have been held, the most recent on 1982 January 12-13 in Columbus, Ohio, U.S.A.

The principal coordinators of the agreement are Dr. T. E. Rummery for Canada and Dr. A. F. Perge for the U.S.A. Technical coordinators are Dr. E. L. J. Rosinger for Canada and Dr. C. R. Cooley for the U.S.A.

## 7.2 European Atomic Energy Community

An agreement for cooperation between AECL and EURATOM in the field of nuclear waste management research was signed on 1980 November 3. EURATOM is the nuclear arm of the Commission of the European Communities (CEC).

The administrators of the agreement, Dr. T. E. Rummery for AECL and Dr. S. Orlowski for EURATOM, held an inaugural meeting 1980 November 27. Protocol and procedures were established for information exchange and cooperative programs regarding environmental and safety assessment of nuclear waste disposal in hard rock, collection of experimental data for system modeling, and such other topics of research in the field of nuclear waste management as will be agreed upon in writing.

Two annual technical meetings for cooperation and information exchange have been held, the most recent on 1982 September 28-30 in Brussels, Belgium.

## 7.3 Sweden

In 1978, Sweden proposed to the OECD/NEA a cooperative experimental program related to nuclear waste management in a disused iron mine at Stripa, Sweden. The official launching of the "International Stripa Project" was announced by the OECD/NEA in the spring of 1981. An agreement was established 1981 April 22 between the contracting parties of Finland, Japan, Sweden, Switzerland, and the United States. Canada and France joined the project as associate members. Phase II of the International Stripa Project is in the planning and approval stage, and is scheduled to begin in 1983.

The bilateral agreement between AECL and the Swedish waste disposal organization, SKBF/KBS, on exchange of information in nuclear waste management was signed 1980 August 20. Senior representatives are

Dr. T. E. Rummery for AECL and Dr. L. B. Nilsson for SKBF/KBS. Two annual cooperation and information exchange meetings have been held, the most recent on 1982 October 4-8 in Sweden.

### 7.4 United Kingdom

An agreement between AECL and the United Kingdom Atomic Energy Authority (UKAEA) for the exchange of information on the peaceful uses of atomic energy has been active since 1963 October. Canada/United Kingdom conferences are hosted in turn by Canada and the United Kingdom, with the most recent being held on 1981 December 7-8 in Ontario, Canada.

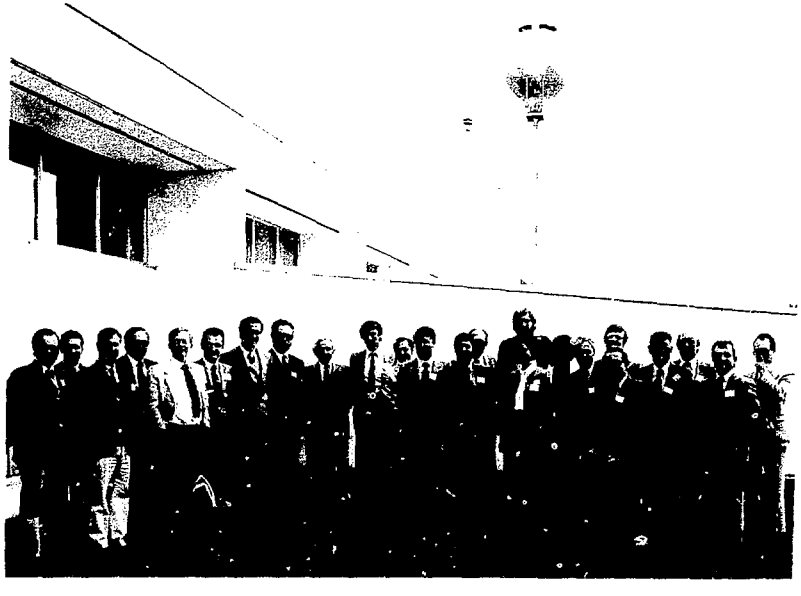
An informal agreement on collaboration on radioactive waste management exists between the UKAEA and AECL. Principal coordinators are Dr. R. H. Flowers for the UKAEA and Dr. T. E. Rummery for AECL. The parties agreed to exchange documents on waste management, arrange visits and joint meetings, and provide assistance with experiments and technical developments.

An agreement between the U.K. Department of Environment in London and AECL is in preparation. The coordinators will be Dr. F. S. Feates from UKDOE and Dr. T. E. Rummery from AECL.

### 7.5 Federal Republic of Germany

An agreement exists between Canada and the Federal Republic of Germany to exchange information and cooperate in the fields of science and technology. As part of this agreement, AECL and the Hahn-Meitner Institute, Berlin, leader of the waste management project "Entsorgung," have established an informal agreement to encourage personal contacts between scientists and engineers of both countries.

The principal contacts are Dr. K. E. Maass for the Hahn-Meitner Institute and Dr. T. E. Rummery for AECL. The main areas of interest are environmental assessment methodology, geosphere models and data requirements, and irradiated fuel characterization and immobilization.



### 7.6 International Atomic Energy Agency

The International Atomic Energy Agency, established in 1957 in Vienna, Austria, is directed by a board of governors (from 34 member states), and a general conference of the entire membership of about 110 states. Its main objectives are to "seek to accelerate and enlarge the contribution of atomic energy to peace, health, and prosperity throughout the world" and to "ensure, so far as it is able, that assistance provided by it, or at its request, or under its supervision or control is not used in such a way as to further any military purpose."

In 1958, radioactive waste management officially became an activity of the IAEA, with responsibility assigned to the Waste Management Section of the Division of Nuclear Fuel Cycle, directed by S. Fareeduddin. Currently, there is only one IAEA standing committee in waste management, called the "Technical Review Committee on Underground Disposal" (TRCUD). The Scientific Secretary for the TRCUD is K. T. Thomas and the Chairman is A. Larsson, Sweden. The Canadian representative is S. A. Mayman, WNRE.

The Technical Committee on Interim Storage and Techniques for Handling Conditioned High-Level Waste met in 1981 December. The Canadian representatives are Dr. F. P. Sargent and Dr. K. Nuttall, WNRE. This Committee will recommend, review, and advise on the development of guidelines for waste management practices.

Canada actively contributes to the coordinated research program on "Evaluation of Solidified High-Level Waste Forms." The Canadian representative is Dr. A. G. Wikjord, WNRE.

Canadian delegates attended several advisory group meetings in 1982:

Ad hoc Advisory Group to assist in preparing the program for the International Conference on Radioactive Waste Management to be held in Seattle in 1983 May
Vienna, Austria 1982 February, 1982 December
*Canadian Representative* Dr. E. L. J. Rosinger

Advisory Group on "Criteria for Underground Disposal of Solid Radioactive Waste"
Vienna, Austria 1982 June-July
*Canadian Representatives* Dr. J. R. Coady, Atomic Energy Control Board (AECB)
S. A. Mayman, WNRE

Ad hoc Technical Group Meeting on "The Analysis of the Performance Requirements of the Waste Isolation System—Generic Waste Isolation System Definition"
Columbus, Ohio, U.S.A. 1982 August
*Canadian Representative* R. B. Lyon, WNRE

### 7.7 Organization for Economic Cooperation and Development/Nuclear Energy Agency

The Nuclear Energy Agency of the OECD was established 1972 April to promote cooperation in the production and peaceful uses of nuclear energy. Twenty-three OECD countries are members of the NEA: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Federal Republic of Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, Norway, Portugal, Spain, Switzerland, Turkey, the United Kingdom, and the United States.

*Representatives of Canada and the Commission of European Communities at the annual information exchange meeting*

The OECD/NEA is administered by a General Directorate and by an international secretariat of about 80 staff members. The annual budget of the NEA is approximately seven million dollars.

**OECD/NEA ADMINISTRATIVE STRUCTURE**

**General Directorate**

Director General *H. K. Shapar*
Deputy Director General *P. Strohl*

Sector I **Safety and Regulation**
Deputy Director *K. Stadie*
A **Radiation Protection and Waste Management Division**
Head *J. P. Olivier*
B **Nuclear Safety Division**
C **Legal Affairs Section**

Sector II **Science and Development**
Deputy Director *Y. Motoda*
A **Nuclear Development Division**
B **Nuclear Science Division**

The work of the NEA is carried out under the authority of the OECD Council and under the guidance of the Steering Committee for Nuclear Energy, made up of representatives of all member countries, the CEC, and the IAEA. The Steering Committee is assisted by other committees and working groups of specialists, appointed by the member countries.

**OECD/NEA STANDING COMMITTEES ON WASTE MANAGEMENT**

**Steering Committee for Nuclear Energy**
Chairman *I. Manley, U.K.*
Canadian Representative *Dr. R. W. Morrison, EMR*

**Committee on Radiation Protection and Public Health (CRPPH)**
Chairman *J. D. Cunningham, Ireland*
Canadian Representative *P. E. Hamel, AECB*

**Radioactive Waste Management Committee (RWMC)**
Chairman *Dr. P. Dejonghe, Belgium*
Canadian Representative *Dr. J. R. Coady, AECB*

Essentially all aspects of nuclear waste management are handled by the CRPPH and the RWMC, which are administered by the Radiation Protection and Waste Management Division.

The primary purpose of the CRPPH is to contribute to a better understanding of the phenomena and problems involved in the exposure of man to radiation and of the potential health effects resulting from nuclear energy activities. The main emphasis is placed on the radiological and environmental impact of nuclear fuel cycle activities.

Specific areas of activity include: occupational exposure of workers in the nuclear industry, control of radioactive effluent discharges from nuclear installations to the environment, protection of uranium miners and consideration of environmental problems associated with uranium mining and milling, and emergency planning for nuclear facilities.

The RWMC is concerned with the handling, treatment, and disposal of radioactive wastes generated by the nuclear fuel cycle. During the past few years, questions related to radioactive waste management have had a significant impact on the attitudes towards nuclear power in many OECD countries. To assist governments in their consideration of this complex subject, the NEA has initiated studies of the various waste management options and their consequences for public health and safety.

Canada is represented on several groups of experts sponsored by the RWMC and the CRPPH.

**EXPERT GROUPS SPONSORED BY THE RWMC**

**Coordinating Group on Radioactive Waste Disposal into Geologic Formations (CGGD)**

Chairman *J. Hamstra, the Netherlands*
Canadian Representative *Dr. S. H. Whitaker, WNRE*

**Seabed Working Group (SWG)**

**Executive Committee**
Chairman *D. G. Boyer, U.S.A.*
Canadian Representative *Dr. G. Vilks, EMR*

**Systems Analysis Task Group**
Lead Correspondent *Dr. G. de Marsily, France*
Canadian Representative *D. M. Wuschke, WNRE*

**Site Selection Task Group**
Lead Correspondent *R. C. Searle, U.K.*
Canadian Representative *Dr. D. Buckley, EMR*

**Biology Task Group**
Lead Correspondent *Dr. R. J. Pentreath, U.K.*
Canadian Representative *Dr. B. Hargrave, EMR*

**Physical Oceanography Task Group**
Lead Correspondent *A. Robinson, U.S.A.*
Canadian Representative *G. Needler, EMR*

**Sediment and Rock Task Group**
Lead Correspondent *Dr. D. Rangon, France*
Canadian Representative *Dr. R. Cranston, EMR*

**Waste Form and Canister Task Group**
Lead Correspondent *Dr. N. J. Magnani, U.S.A.*
Canadian Representatives *Dr. K. Nuttall, WNRE*
*Dr. P. J. Hayward, WNRE*

**Engineering Studies Task Group**
Lead Correspondent *D. M. Talbert, U.S.A.*

Separately Financed Projects:

**International Stripa Mine Project**

Chairman *L. B. Nilsson, Sweden*
Canadian Representative *Dr. K. W. Dormuth, WNRE*

**International Sorption Information Retrieval System (ISIRS)**

Chairman *Dr. R. Brereton, U.K.*
Canadian Representative *Dr. T. T. Vandergraaf, WNRE*

EXPERT GROUPS JOINTLY SPONSORED BY THE CRPPH AND THE RWMC

**Coordinating Group on the Management of Uranium Mill Tailings**

Chairman *Dr. G. Mastino, Italy*
Canadian Representatives *P. E. Hamel, AECB*
*J. Howieson, EMR*

**Working Group on Long-Term Aspects of Uranium Mill Tailings Management**

Chairman *Dr. R. V. Osborne, Canada, CRNL*
Canadian Representative *K. Bragg, AECB*

**Working Group on Engineering of Uranium Mill Tailings Retention Facilities**

Chairman *R. Volpe, U.S.A.*
Canadian Representatives *P. Pullen, consultant*
*E. Joe, CANMET*

**Working Group on Environmental Monitoring**

Canadian Representative *Dr. P. Vasudev, AECB*

**Ad Hoc Group for the Study of Legal, Administrative and Financial Aspects of Long-Term Management of Radioactive Waste**

Chairman *P. S[illegible], France*
Canadian Representative *J. A. Schwartz, AECL*

**Multilateral Consultation and Surveillance Mechanism for Sea Dumping of Radioactive Waste — Executive Group for Research on Sea Disposal of Radioactive Waste**

Chairman *Dr. W. Templeton, U.S.A.*
Canadian Representatives *Dr. J. M. Bewers, EMR*
*Dr. B. Hargrave, EMR*
*Dr. J. N. Smith, EMR*

# 8. EXTERNAL REVIEW

## 8.1 Technical Advisory Committee

Chairman *Dr. L. W. Shemilt*
Science Secretary *G. Sheng*

***Chemical Institute of Canada***
*Dr. K. J. McCallum*
Dean of Graduate Studies and Research
University of Saskatchewan

***Engineering Institute of Canada***
*Dr. B. Ladanyi*
Dept. of Civil Engineering
Ecole Polytechnique
University of Montreal
*Dr. L. W. Shemilt*
Professor, Dept. of Chemical Engineering
McMaster University

***Canadian Geoscience Council***
*Dr. J. Tóth*
Dept. of Geology
University of Alberta
*Dr. G. B. Skippen*
Dean of Science
Carleton University

***Canadian Institute of Mining and Metallurgy***
*Dr. J. Convey*
Senior Advisor to the Canadian Government
in Mining and Metallurgy (retired)

***Biological Council of Canada***
*Dr. D. T. Canvin*
Professor and Head, Dept. of Biology
Queens University

***Canadian Federation of Biological Societies***
*Dr. G. F. Whitmore*
Head, Division of Physics
Ontario Cancer Institute
also Chairman, Dept. of Medical Biophysics
University of Toronto
*Dr. R. H. Haynes*
Professor, Dept. of Biology
York University

***Canadian Association of Physicists***
*Dr. M. H. L. Pryce*
Professor of Physics (retired)
University of British Columbia
*Dr. G. M. Volkoff*
Dean of Science (retired)
University of British Columbia

***Canadian Information Processing Society***
*Dr. T. I. Ören*
Chairman, Dept. of Computer Science
University of Ottawa

The members of the Technical Advisory Committee (TAC) are distinguished Canadian scientists nominated by their respective professional societies. The committee continuously reviews the R&D program, advises AECL on its scientific quality, and makes recommendations for improvement and additional research. The review and recommendations are published in annual reports,[98-100] available from the chairman, Dr. L. W. Shemilt.

## 8.2 The Evaluation Process

In 1981, the governments of Canada and Ontario announced the scope of the program evaluation process, the roles and responsibilities of their agencies, and the means by which the public can become involved.[101] As presently envisaged, the evaluation process will involve the following three stages:

1. regulatory and environmental review,
2. a full public hearing, and
3. a decision by governments on the acceptability of the concept based on the information and recommendations arising from the first two stages.

The federal government has decided that the Atomic Energy Control Board will be the lead agency for the regulatory and environmental review of the disposal concept. It will be assisted in the development of standards,

*Experiments at the Underground Research Laboratory site are generating international interest.*

requirements, and other regulatory functions by the federal Department of the Environment and the Ontario Ministry of the Environment. Together these three agencies comprise the Interagency Review Committee (IRC). They will adopt a consultative and iterative approach with all interested parties, including other government departments, AECL, external review groups, the universities, public interest groups, and the public in general.

It is expected that sufficient information will be available by the late 1980s to begin the formal evaluation and regulatory review. When the regulatory review is completed, there will be a full public hearing under the auspices of the federal government. Following the public hearing, the governments involved will have three options:

1. *Concept acceptance* Confirmation by the governments of Canada and Ontario would be a prerequisite to selection of any site for a waste disposal facility.
2. *Conditional concept acceptance* This would require further research work by AECL and resubmission of a final concept assessment document.
3. *Concept rejection* In this event, the governments of Canada and Ontario would have to consider alternative proposals.

### 8.3 Interagency Review Committee

As mentioned in Section 8.2, the IRC has been formed to review assessment studies and provide guidelines and criteria for determining the acceptability of proposed nuclear fuel waste disposal facilities. Dr. K. P. Wagstaff of the AECB is chairman. Members are A. W. James, Ontario Ministry of the Environment; Dr. C. Barraud, Environment Canada; Dr. P. Conlon, AECB, secretary.

### 8.4 Underground Research Laboratory Environmental Screening

Environmental screening for the URL project followed the screening guidelines of the Federal Environmental and Assessment Review Office (FEARO). An independent consulting firm, Interdisciplinary Systems Limited, performed a preliminary assessment. A draft screening document prepared by AECL incorporated this assessment, further project design information, additional field research data, and AECL policy decisions.

The draft document was offered for public review and comment. It was distributed to federal and provincial agencies and was made available at WNRE and at local government offices (Rural Municipality of Lac du Bonnet, Village of Lac du Bonnet, and Local Government District of Pinawa). The document was also distributed to parties known to be interested in the project.

The final draft incorporated the comments and suggestions received. Its review was coordinated by the Environmental Protection Service of Environment Canada in conjunction with the Manitoba Environmental Management Division. These agencies confirmed that previous comments had been adequately addressed and that no further changes were required. The screening document is being published and will be available in early 1983.

In accordance with a commitment described in the document, AECL has guaranteed access to the URL lease area and facilities so that the environmental impacts of the project can be monitored by representatives of external agencies. These individuals are provincial mine inspectors and duly authorized representatives of other provincial departments and of the federal Environmental Protection Services. Independent of AECL's monitoring activities, the Manitoba Environmental Management Division is coordinating an extensive on- and off-site monitoring of all phases of the URL project.

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** Available from Dr. L. W. Shemilt, McMaster University, Hamilton, Canada, L8S 4L7.

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