ABSTRACT

The Concept of disposing of high-level nuclear waste in granitic rocks in the Canadian Shield, developed by Atomic Energy of Canada Limited (AECL), is anticipated to undergo a national public review within two years. The disposal Concept, its documentation, and its process of evaluation, including the role of the public, government and the scientific/engineering community, are summarized. A Technical Advisory Committee (TAC) has provided external peer review of the Program since 1979 and its findings are published in annual reports which are publicly available.

1. INTRODUCTION

The overall objective of the Canadian Nuclear Fuel Waste Management Program (CNFWMP) is "to ensure that there will be no significant adverse effect on man or the environment from nuclear waste at any time."\(^1\) Nuclear fuel waste is defined as either irradiated fuel or high-level radioactive material separated from the used fuel through reprocessing, although there are presently no plans to pursue this latter possibility. In the following sections, we give a general overview of the disposal Concept being presented by Atomic Energy of Canada Limited (AECL).

2. THE CANADIAN WASTE DISPOSAL CONCEPT

2.1 The Multi-Barrier System

Similar to efforts in several other nations, the Canadian Program of research on deep geological disposal of nuclear waste is based on the concept of isolating wastes with a series of barriers situated in a deep (500 m—1000 m) underground vault, built in a stable, terrestrial geologic formation such as the granitic rocks of the Canadian Shield.

The bundles of used fuel would be encased in containers with an anticipated life of at least five hundred years which corresponds to the period of high fission-product activity. The containers would be designed to withstand hydrostatic and lithostatic pressures and be resistant to corrosion under the temperature, groundwater exposure and radiation fields that could potentially exist at depth. The containers would be emplaced in the vault and surrounded with compacted buffer material such as a mixture of sand and bentonite clay. This candidate material swells upon contact with water, thus acting as a highly impermeable seal against leaching and corrosive agents. It also has a high capacity to absorb chemical species, including most of the significant radionuclides. The vault and the shaft would then be backfilled, probably with a mixture of crushed rock, sand, and bentonite to close any opening to the surface.

The geologic medium in which the underground vault is built acts as yet another barrier to the migration of radionuclides should they escape the vault. Retardation occurs as a result of a number of natural processes taking place at depth, including chemical absorption of radionuclides onto rock surfaces, ion exchange, diffusion into the body of the rock, and the long path lengths to the surface due to the relatively small size and frequency of fractures in the chosen rock. The effectiveness of this natural barrier depends on careful selection of a site which exhibits favourable geochemical, geological and hydrogeological conditions.

Finally, although the biosphere is not generally regarded as a "barrier" in the same sense as those described above, the surface environment, with its large volume of soil and water, has a great capacity to disperse and dilute whatever material which, no matter how unlikely, may reach the surface.

2.2 Three Phases of the Program

The Canadian Program, unlike disposal research programs of many other countries, is divided into phases. The first, Concept Assessment, involves research which
aims to determine whether and to what extent waste disposal in deep, stable, terrestrial geologic formations can be achieved with the stated objective of ensuring human safety and environmental protection. This "generic research and development" phase was formally initiated in 1981 and the results of the ensuing years of research are now being assembled by AECL as the substantive work by which the Concept can be evaluated and judged as to its acceptability. This evaluation process is discussed in the succeeding section.

The second phase, that of Site Selection, involving the actual process of screening, evaluating and finally selecting a suitable site, can only begin if the Concept is deemed acceptable. However, there are two other possibilities. The Concept may be found to be conditionally acceptable, in which case AECL will have to conduct further research or otherwise modify present work to satisfactorily address the deemed inadequacies. Should the Concept be judged unacceptable, then it would be the responsibility of the Federal and Ontario Governments to consider alternatives.

The final phase, assuming success in both of the previous phases, would be the construction and operation of the disposal vault. It may be that a demonstration facility would first be built to provide the engineering and operational experience for the full-scale facility. In either case, this third phase is not envisioned to start until sometime in the next century.

The Canadian Program is unusual among other international programs in its clear distinction between the phases — work in one phase cannot begin until successful completion of the previous phase. This sequential approach has both its advantages as well as its disadvantages. These are manifested in the characteristics of the research program as well as in its evaluation.

The scientific and technical research work as originally envisioned and initiated was "generic" in nature, without reference necessarily to any particular location or site. The biospheric conditions and associated data values were obtained from various sources including different locales in the Canadian Shield, field and laboratory experiments and from the literature. This composite of environmental and biologic information is representative of the Shield conditions in general but does not necessarily portray any particular location.

Although this approach proved to be satisfactory for characterizing the surface environment, it proved less successful when applied to the underground geologic conditions. The very wide range of values and heterogeneous conditions encountered in this domain made the concept of a "generic geosphere" questionable, at least in the Canadian Shield situation. Recognition of this fact during the mid-80s led to a much more focused effort in and around the Whiteshell Research Area (WRA) located near the Manitoba-Ontario border close to the Whiteshell Nuclear Research Establishment (WNRE) site. Most data gathering, fieldwork, laboratory experiments and modelling work are specific to this location, although considerable geologic exploratory research work has been carried out in two other research areas, one near Atikokan and the other at East Bull Lake, both in Ontario. The present AECL work, therefore, is based on a hybrid of both generic (mostly environmental conditions) and site-specific (mostly geologic conditions) information.

To a lesser degree, the problems encountered in the geologic case are also applicable to the assessment of socio-economic impacts which belong in the pre-closure studies. Although a generic approach was adopted, the effects of transportation and other activities associated with siting are difficult to assess without reference to a specific site.

Despite these difficulties there is an important advantage conferred by this approach. The clear distinction of the phases also defines what type of work is to be done during each phase and gives guidance on where emphasis is to be placed. During this first phase, for instance, the goal is to assess the Concept of waste disposal in deep, stable, terrestrial geologic formation - to see if, and how, this can be accomplished to meet the regulatory requirements of human safety and environmental protection. As such, the research work is necessarily concerned with technical issues such as the effectiveness of system components (e.g. containers, the vault, the geologic barriers) for long periods of time, the possible failures that may occur at each barrier, the consequences of such failures, etc. In brief, the central and critical question which this phase of the work is to answer is: "Will it be technically possible to dispose of high-level nuclear waste safely?" Other considerations associated with disposal such as ethical, social, economic, and political issues, valid as they are, must be treated as secondary considerations at this stage. If it cannot be established that safe disposal is at least technically possible, then clearly all other considerations are irrelevant.

The establishment of technical feasibility, although necessary for the ultimate act of waste disposal, is not sufficient. A satisfactory resolution of non-technical issues such as the ones mentioned above are just as necessary for an eventual successful outcome. It is during the second phase when the process focuses on selecting a specific site, that issues such as equitable treatment, social and economical impacts on a certain region, matters of impact mitigation, compensation, etc. will come to the fore, and properly so. The experiences in other disposal programs show the critical importance of non-technical issues to successful siting. The experiences of the Low Level Waste Siting Task Force,2 the Ontario Waste Management Corporation and even the present controversy over selection of landfill sites in Southern Ontario all provide valuable lessons and insights on the immense difficulty of siting. Intense and vociferous opposition, characterized by the acronyms NIMBY (Not In My Back Yard) and LULU (Locally Unwanted Land Use) have accompanied recent attempts at siting any type of disposal facility.

It is in this sense that the CNFWMP enjoys an advantage over all other disposal situations - the phased approach
clearly separates assessment of the Concept (i.e., judgment of technical possibility and feasibility) from the actual process of site selection where experience has shown that non-technical considerations overwhelm technical issues. This phased approach has allowed the Program to concentrate on doing the necessary technical work without being mired in counter-productive controversies and delays as faced by other disposal programs.

3. EVALUATION OF THE DISPOSAL CONCEPT

3.1 Development of an Evaluation Process

Because of the increasing recognition during the eighties that implementation of technological projects, large or small, involves the need to better address the concerns of a democratic society in terms of giving due emphasis to socio-economic and political issues in addition to the technical ones, it was felt that an independent body with such a mandate would be the most appropriate agent to lead the Concept evaluation. Consequently, in a referral letter, the Federal Minister of Energy, Mines and Resources requested that the Federal Minister of the Environment set up an Environmental Assessment (EA) Panel to lead the review under the auspices of the Federal Environmental Assessment Review Office (FEARO). Under this new scheme, AECB will play a consultative role to the EA Panel although its regulatory requirements with respect to nuclear waste disposal as promulgated in R-71, R-104 and R-72 must still be met. In addition to these regulations, however, the CNFWM must also satisfy the requirements of the EA Panel operating under the Environmental Assessment Review Process (EARP). One of the requirements under EARP is that the proponent, AECL in this case, must submit an Environmental Impact Statement (EIS) detailing and explaining its disposal Concept and giving due emphasis to non-technical issues. Another essential requirement is that public hearings must be held as part of the process of evaluating the AECL Concept. The entire process is diagrammatically shown in Fig. 1 with dates of past events as well as expected dates of future milestones. The end point of this process is a decision by the governments based on the findings of the EA Panel as to whether the disposal Concept is acceptable, conditionally acceptable, or not acceptable.

3.2 The Environmental Impact Statement

AECL is presently preparing the EIS in accordance with the EA Panel Final Guidelines, the development of which is described in section 3.3 below. The EIS will be based on the research conducted over the last 15 years as summarized in a nine volume set of documents designated as the "Primary References", each with the primary title "The Disposal of Canada's Nuclear Fuel Waste", and a subtitle as follows:

1. Public Involvement and Social Aspects;
2. Site Screening and Site Evaluation Technology;
3. Engineered Barriers Alternatives;
4. Engineering for a Disposal Facility;
5. Preclosure Assessment of a Conceptual System;
6. Postclosure Assessment of a Reference System;
7. The Vault Model for Postclosure Assessment;
8. The Geosphere Model for Postclosure Assessment;
9. The Biosphere Model, BIOTRAC, for Postclosure Assessment.

As evident from the titles, each of these nine documents addresses, in detail, a specific aspect or significant component of the Program such as the engineering, preclosure and postclosure work, the details of the vault, geosphere and biosphere models, and social aspects of disposal, etc. In addition, a summary volume of the EIS will be produced for general readership. It is expected that AECL will submit the EIS to the EA Panel sometime in 1994.

3.3 Public Participation and Participant Funding

As shown in Figure 1, the EARP provides many different opportunities during the review process for the public to receive information as well as to provide input. We describe these below.

3.3.1 Information Dissemination Through Open Houses. The Panel, after its appointment on October 4, 1989, scheduled "Open Houses" to be held in major cities in New Brunswick, Quebec, Ontario, Manitoba and Saskatchewan throughout the months of May and June of 1990. Secretariat members of the Panel were available to discuss the review process, the Panel's terms of reference, anticipated review activities and participant funding. As well, AECL and OH staff had displays and distributed literature to inform about, and explain, the disposal Concept. Attendance at the some 20 sessions, held both during the day and in the evening, was generally low.

3.3.2 Public Input Through Scoping Meetings. The Panel held some 23 "Scoping Meetings" during the months of October and November of 1990 in the same provinces as for the Open Houses. The intent of these meetings was for members of the general public and any interested parties to present to the Panel their views on what issues should be included in the Panel's guidelines for the preparation of AECL's EIS. More than 100 written and oral presentations were made to the Panel in accordance with a set of procedures announced on November 5, 1990. A wide diversity of groups including government agencies, industry, professional, scientific and engineering societies, environmental groups, labour organizations and members of the general public participated in this process. A compilation of the submissions is available from FEARO.

The most salient issues arising out of these meetings include: (1) the need to examine the disposal Concept within the context of the entire Canadian energy policy, (2) the public concern about a "walk-away" Concept; on-going post-closure monitoring being a very high priority in the eyes of the public, (3) the view that ethical and socio-economic issues are at least as important as technical issues and the difficulty of talking separately about them.
Figure 1. Evaluation of Canadian Nuclear Waste Disposal Concept

AECL - Atomic Energy of Canada Limited (Proponent)
EA - Environmental Assessment Panel (FEARO)
EC - Environment Canada (Federal Department)
EIS - Environmental Impact Statement
EMR - Energy, Mines and Resources (Federal Department)
FEARO - Federal Environment Assessment Review Office
SAT - Subsurface Advisory Team (Environment Canada)
SRC - Scientific Review Group (FEARO)
TAC - Technical Advisory Committee (AECL)

AECL - Atomic Energy Control Board (Regulatory Body)
3.3.3 Public Comments on the Draft Guidelines.

From the input provided through the Scoping Meetings, the EA Panel drafted a set of Interim Guidelines for AECL's EIS which was released for public comment. Although the level of response to the Draft Guidelines did not match that of the Scoping Meetings, comments received from some groups, including AECL, were detailed and comprehensive. Modifications were made to the Draft Guidelines as a result of the various responses and the set of Final Guidelines was issued by the EA Panel in March 1992. A complete compilation of all submissions is available from the FEARO office.

3.3.4 Participation Through Public Hearings.

The next opportunity for formal input and participation will be during the public hearings which are anticipated to start after AECL submits its EIS (expected in 1994) and after the EA Panel is satisfied of the EIS's compliance with the Final Guidelines. At that time the EIS will be distributed for public review to any interested party. The dates, locations and detailed procedures for the hearings will be announced by the Panel. Although it is difficult to predict how long the hearings will take, it is anticipated that completion would be within a twelve-month period. Upon completion, the Panel will submit a report of its findings and recommendations to the Federal and Ontario governments. It is then the responsibility of those governments to state the acceptability, conditional acceptability or non-acceptability of AECL's proposed Concept. Should the first outcome be realized, the second phase, site-selection, may be initiated. In the second instance, AECL may be required to do further work. In the event of the third outcome, the two governments will have to consider other alternatives.

3.3.5 Participant Funding. A critical component of the review process is the availability of funding to help the public participate more effectively over the entire process. The $750,000 participant funding, provided by AECL, is administered by a separate Funding Committee set up by FEARO which reviews and allocates funds to successful applicants in accordance with its eligibility criteria. The Committee had awarded $152,500 to 17 of 33 applicants to assist them in the preparation for, and participation in, the Scoping Meetings and for review and comment on the Draft Guidelines. The remaining amount has been allocated for Phase 2 which involves the review of the EIS and its related documents, and participation in subsequent public hearings. This amount will be distributed such that full opportunity is provided for participation in both the socio-economic and technical reviews. However, at least half of the amount will be available to participants wishing to conduct scientific reviews on the technical aspects of the Program. Information about eligibility criteria, deadlines, application forms, and the list of successful applicants from Phase 1 are available from FEARO.

4. SCIENTIFIC REVIEWING BODIES

As well as the overall Concept evaluation process led by the EA Panel as described above, the Concept is presently also being reviewed by three groups with the focus on scientific, technical and engineering aspects of the Program.

4.1 The Technical Advisory Committee (TAC)

The Technical Advisory Committee to AECL, was established in mid-1979, and has provided continuous reviews since then. The purpose of TAC is to act as an independent review body advising AECL on the extent and quality of the CNFWMP. Its responsibilities are to review the content of proposed research projects, to suggest alternatives and additions as deemed appropriate, to review the scientific methods used, to review Program results and assure that conclusions drawn are valid within the limits that are claimed, and to recommend any specific areas of work for which research should be undertaken, either by existing staff or through research contracts. Its autonomy is assured by the form of appointment to TAC of persons independently nominated by professional and scientific societies, by the requirement of reporting in the public domain and by the provision to TAC of full and free access to all aspects of the research Program. The Committee is also provided with resources that allow it to obtain additional specialist advice as it deems fit. TAC's 13 annual reports provide a publicly available documentation of its ongoing assessment of the progress and performance within the Program as well as external factors influencing it. A concise summary of TAC's recommendations over the last dozen years is presented by Shemilt and Sheng.

4.2 The Scientific Review Group (SRG)

The SRG was established by the EA Panel in mid-1990 specifically to evaluate, and to provide advice on the scientific and engineering aspects of the Concept. Similar to TAC, most of its members are Canadian scientists chosen mostly from universities although several are from industry and government. The SRG reports directly to the EA Panel and has provided input to the Scoping Meetings as well as comments on the Draft Guidelines.

4.3 The Subsurface Advisory Team (SAT) and Environmental Advisory Team (EAT)

These two teams of consultants were established in 1989-90 by Environment Canada on a contractual basis to provide it with dedicated scientific advice on AECL's disposal Concept, and to develop Environment Canada's position as an intervener during the public hearings. The SAT is responsible for issues associated with the disposal vault and the geosphere, and the EAT is to review issues associated with the biosphere as well as those involving social, economic and policy aspects of disposal. Both teams have conducted their own "scoping calculations" which are summarized in SAT's and EAT's reports. A concise description of the teams' roles, activities and major findings is given by Pascoe et al.
5. CONCLUDING SUMMARY

Using the extensive laboratory and field research carried out in the Canadian Program over the past 15 years, AECL is currently preparing a series of primary reference documents to support the Concept of deep geological disposal. An environmental impact statement is being prepared to summarize this work and will be presented for environmental assessment sometime in 1994 under federal jurisdiction and established procedures. These include public hearings as well as extensive scientific and technical review. The overall process has been initiated and an Environmental Assessment Panel established by FEARO has issued final guidelines for the EIS which must also give due emphasis to non-technical issues. Continuing scientific reviews are being made of the AECL research by TAC as presented in its annual reports.12

REFERENCES


