For Official Use **NEA/RWM/PEER(99)2**

OECD OCDE PARIS

Organisation de Coopération et de Développement Economiques
Organisation for Economic Co-operation and Development

OLIS : 20-Oct-1999
Dist. : 22-Oct-1999

English text only

NUCLEAR ENERGY AGENCY
RADIOACTIVE WASTE MANAGEMENT COMMITTEE

NEA/RWM/PEER(99)2
For Official Use

International Peer Reviews

OECD/NEA International Peer Review of the Main Report of JNC's H12 Project to Establish the Technical Basis for HLW Disposal in Japan

Report of the OECD Nuclear Energy Agency International Review Group

English text only

83184

Document complet disponible sur OLIS dans son format d'origine
Complete document available on OLIS in its original format

Executive Summary

In compliance with a request by the Atomic Energy Agency of Japan (AEC), the Japan Nuclear Cycle Development Institute (JNC) approached the Nuclear Energy Agency (NEA) of the Organisation for Economic Co-operation and Development to carry out an independent, international peer review of the Project Overview Report of the H12 study. The latter is described as the "Draft Second Progress Report on Research and Development for the Geological Disposal of HLW in Japan".

The main objectives of the H12 study are:

- to outline the technical basis for assessing the reliability of geological disposal in Japan;
- to provide input into the siting and regulatory procedures following the initial R&D phase.

The acceptance of the H12 study by the Japanese government would allow the programme to move from the present R&D phase to a new phase where siting and regulatory procedures would be formulated, and a new implementing agency would commence work.

The NEA accepted to undertake the review according to an agreed upon terms of reference, and assembled an international review group (the "IRG") of experts. The review took place between mid-May and mid-October 1999. An important part of the review was a week long workshop in Japan where the IRG could interact, in depth, with the JNC staff and could visit the technical facilities of JNC. The review workshop was open to other interested parties, and it was attended by observers from other Japanese institutions.

The NEA review is at an executive level and is complemented by other, more specialised reviews of modelling tools and data to be carried out by other groups. The NEA review is meant to help JNC assess their overall achievements and to provide suggestions that would be useful to prepare an updated report to be submitted to the AEC.

The general conclusion of the review is that the technical basis for geological disposal in Japan has been outlined and convincingly assessed in a generic way, giving a sufficient level of confidence, at the present stage, that the tools have been developed to proceed to an adequate site characterisation and assessment in the next phase. The present H12 reports and analysis need to be updated, however, in ways that have been discussed with JNC, and are documented in this report. The main findings of the review are as follows:

Geology The description of the geology of Japan in H12 is competently done and adequately comprehensive for the purposes of the report. It must be recognised, however, that, at this stage, actual purpose-specific data and field observations are relatively limited and that the greatest part of the geological information is derived from a review of the literature. Significantly more detailed investigations will be necessary to proceed to successive stages within the siting process.

The structural geology of Japan is determined by the position of the Japanese islands on plate collision zones, which leads to tectonic activity that is relatively intense and generally higher than in other parts of the world where the geological disposal of radioactive waste is considered. The potential impact of this tectonic activity on long term safety is a recognised concern of the AEC Guidelines and of the H12 study. The IRG is of the view that, while it is reasonable and believable to identify areas where the probability of faulting will be low, it is not acceptable, at the present stage, to ignore faulting scenarios in the safety assessment of the repository. It is thus recommended that a faulting scenario be added to the safety assessment in order to explore and illustrate better the robustness of the proposed disposal concept.

Repository technology and engineered barriers The H12 study places emphasis on the design and performance of the engineered barrier system and less reliance on the barrier functions of the geosphere. This is acceptable, considering that in the early, conceptual phases of repository design a relatively high uncertainty exists in the performance of the geosphere. It is noted that the work of JNC is of a particularly high level in the area of design and performance of the engineered barrier system. The latter is competently designed with ample margins for later optimisation and can likely accommodate a variety of faulting scenarios.

Safety Assessment The safety assessment is at the core of the H12 study. The general methodology applied is comparable to similar studies published in other countries and in general agreement with the guidelines of international organisations. Bearing in mind the generic nature of the data base and the relatively preliminary stage of the Japanese geological disposal programme, the work performed is impressive and very encouraging for the future steps. The IRG recommends a closer look at some specific aspects, in particular to clarify the degree of completeness of the scenario analysis, and a more cautious approach in the selection of data and assumptions. Special complexities affect the H12 study because of its wide scope of diverse geological and surface environments, as a consequence there are high demands on traceability and transparency. Improvements, to this effect, are needed throughout the Project Overview Report.

On the presentation of the H12 study and lessons learnt A sufficient technical basis has been established to provide the input into future siting and regulatory procedures, but this input has not been used adequately in formulating a logical and well structured proposal in respect of the future steps necessary for advancing to site selection and to the definition of an adequate regulatory infrastructure. In particular, it is important that the nature of the H12 study and its main findings be made totally unambiguous, and that the lessons learnt from the conduct of the study be summarised better for the decision makers and their technical advisors. The discussions between the IRG and JNC have identified useful avenues for summarising this information, and the final H12 report should be able to fulfil the two most important objectives of the study. Namely, to provide useful input into both the siting process and the accompanying regulatory procedures.

TABLE OF CONTENTS

1. INTRODUCTION

Background to the review

Research and development into geological disposal of high level radioactive waste has been ongoing in Japan for the past twenty years. At present, a key role is played by the Japan Nuclear Cycle Development Institute (JNC). This organisation, which has been in existence since October 1998, is the successor of the Power Reactor and Nuclear Fuel Development Corporation (PNC). The charter of JNC is to carry out R&D activities to establish nuclear fuel cycle technologies relevant to fast breeder reactor development, spent fuel reprocessing, plutonium fuel fabrication, and disposal of high-level radioactive waste (HLW) ensuing from the reprocessing of spent nuclear fuel.

In 1992, PNC published a report entitled 'Research and Development on Geological Disposal of High-Level Radioactive Waste, First Progress Report', generally referred to as the H3 report [PNC, 1992]. This report has been the object of numerous reviews.

In 1997 the Atomic Energy Commission (AEC) of Japan issued their 'Guidelines on R&D Relating to Geological Disposal of High-Level Radioactive Waste in Japan' (the "Guidelines" hereafter) [AEC, 1997]. According to the Guidelines, a second progress report would need to be produced. This report is expected to further demonstrate

> *"the technical feasibility and reliability of the geological disposal concept and to provide key input for site selection and development of regulations."*

Accordingly, JNC prepared a Draft Second Progress Report on Research and Development for the Geological Disposal of HLW in Japan, generally referred to as the H12 report. In its present form, the H12 report consists of four documents: a Project Overview Report and three supporting reports on the geological environment of Japan, on repository design and engineering technology, and on the safety assessment, respectively.

The Guidelines also stipulate that:

> *"The second progress report will be reviewed by international experts and the reviewed version will be submitted to the Japanese Government for evaluation".*

In compliance with the AEC indications, JNC approached the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (OECD/NEA) to carry out an independent, international peer review of the H12 Project Overview Report. This review would complement other, more specialised reviews of tools and data to be made by external groups.

The NEA accepted to undertake the review according to agreed upon terms of reference, and assembled an international review group (the "IRG", or the "Group", hereafter). This report documents the review.

The Terms of Reference

The Terms of Reference (ToR) of the review [JNC, 1999a] state that:

> *"The NEA review should focus on assessing the adequacy of the H12 study, taking into account the relatively early stage of development of the Japanese geological disposal programme and, in particular, the generic nature of the geological database, which inherently constrains the possible depth of treatment. Thus, the NEA review should be conducted at an executive level, focused on fundamentals and principles, and on verifying that the concepts, methodology and system understanding represent the current state of the art. JNC will complement the NEA executive review with another more specific review of models and databases."*

> *"The review material is the final draft of the H12 main report. Supporting documentation would be made available as needed by the reviewers."*

The Project Overview Report [JNC, 1999b] was thus the main source of information for the present review. The supporting reports [JNC, 1999c; 1999d; 1999e] were also distributed to the members of the IRG, and were consulted but not reviewed in depth.

As the AEC Guidelines specify the purpose of the H12 report and identify its main issues, they were also used as a further base for the IRG review.

The OECD/NEA International Review Group

The IRG was comprised of six members: four with experience in national waste management programmes; one independent international consultant; and one technical representative of the OECD/NEA. Prof. Helmut Röthemeyer (Germany) acted as the Chairman of the Group. The names and qualifications of the Group members are provided in the Appendix.

All members of the IRG familiarised themselves with the entire study. Furthermore, working as a team, they divided among themselves the detailed evaluation of the Project Overview Report and other documents, such that each member could focus his attention on the subjects closest to his professional expertise. Some limited recourse was made to colleagues in the respective reviewers' organisations, or their subcontractors, when specialised technical insights were considered necessary.

Principles and conduct of the review

The principles of the review were discussed early on, at the first meeting of the IRG, and were refined in later discussions. The following understanding was reached:

1. The present review represents the international review recommended in the 1997 Guidelines. The Guidelines stress the aspect of confidence building. Accordingly, this review focuses on the technical and confidence building aspects of HLW disposal in Japan, paying only limited attention to the policy issues.
2. The review will be kept at an executive level with most attention being paid to the Project Overview Report. This is the best course in accordance with the ToR.

3. The information provided in the H12 documentation is generic in nature. No site has been proposed for the location of the repository and the potential host rocks are defined only as crystalline rock, such as a granitic intrusive body, and sedimentary rocks, such as Tertiary mudrocks and sandstones. In accordance with the ToR, this lack of specific data is to be borne in mind when evaluating the conclusions of the technical analyses.

4. Specific attention is to be given to whether the two main objectives of the H12 study are achieved. They are:

   - to outline the technical basis for assessing the reliability of geological disposal in Japan;

   - to provide input into the siting and regulatory procedures following the initial R&D phase.

5. The technical documentation addresses three main subjects which are closely linked in the assessment of the feasibility of safe disposal of HLW in Japan. It is considered important to make sure that different parts of the assessment make use of logically consistent assumptions, and that priorities are adequately identified.

The review documents were received in mid-May 1999. Thereafter the review proceeded as follows:

- A meeting of the review team took place in Paris in early June. At this meeting, JNC representatives made two presentations about the "General Background and Specific Features of JNC's Second Progress Report". In addition to providing a description of the approach used in the H12 study, these presentations also described, to the IRG, the general policy framework in Japan within which the H12 study was prepared. Thus, it was clarified that the H12 study is to deal with the geologic disposal of only HLW; that, at the present stage, the disposal concept is not to rely on post-closure institutional controls, including monitoring; and that waste retrievability is not to be factored in the study. These aspects may have to be considered at later stages, at which time the JNC disposal concept may require appropriate modifications.

- Preliminary comments and questions were provided by the IRG during the months of July and August. JNC offered written responses to all comments and questions. These preliminary comments, questions, and responses were collated in order to facilitate the discussion at the subsequent meeting between the IRG and the JNC staff. After a JNC request, it was accepted that they may be made available to parties external to the review[1].

- A week long workshop with JNC staff, attended as well by observers from other Japanese organisations, took place in Japan the 4th week of August. The workshop allowed in-depth discussions of all topics identified in the preliminary set of comments and questions. New areas were also identified and discussed. The IRG also visited the JNC R&D facilities at Tokai. During the workshop, JNC indicated that they agreed with most of the IRG general and specific comments, and that they would amend the H12 documentation accordingly. At the end of the workshop Dr. Röthemeyer presented, orally, the preliminary conclusions of the review. The following week, two members of the IRG visited the Tono mine.

  A most important observation made at the workshop, and to be borne in mind when considering this review, was that the H12 study and, in particular, the Project Overview Report, were still evolving:

---

1 This is document NEA/RWM/PEER(99)3. It is to be understood that the latter contains the unstructured, first impressions by the individual members of the IRG and first JNC replies. Some of these views and replies were revised during, and after, the IRG and the JNC staff meeting in Japan. The present document NEA/RWM/PEER(99)2 is the only one giving the final, official views and judgement of the IRG as a whole.

data were still being gathered; JNC was producing additional documentation in Japanese; and the contents of the Project Overview Report was being determined, in part, by ongoing consultations within the Japanese Co-ordination Conference on R&D in HLW Disposal.

- Preparation of the review report went through several iterations within the IRG, until finalization and submission to JNC on 20th October 1999.

About this report

This report documents the peer review of the May 1999 draft of the Project Overview Report of the H12 study on behalf of JNC, in order to help this organisation to assess their own achievements and to produce an updated report in order to fulfil their obligation towards the AEC of Japan. This report has thus been written mainly for the JNC staff and management, *i.e.*, for an audience who is fully familiar with the H12 study. The report has been kept, however, at an executive level, as much of the detailed comments and discussions have been collected elsewhere, *i.e.*, in document NEA/RWM/PEER(99)3 and in the minutes of the workshop that took place in Japan. The text of this report is thus sufficiently general to be accessible to informed readers not necessarily familiar with all the details of the H12 study and its documentation.

The review is structured in six parts, for which titles and bearings on specific chapters in the H12 Project Overview Report are as follows:

1. Introduction

2. The Geology of Japan and the Safety Concept
   broadly covering Ch. III of the Project Overview Report

3. Repository Design and Engineering Technology
   broadly covering Ch. IV of the Project Overview Report

4. Safety Assessment
   broadly covering Ch V. of the Project Overview Report

5. Presentation of the H12 Study and Lessons Learnt
   broadly covering Chapters I,II,VI and VII of the Project Overview Report

6. Overall Judgement

The present report has been prepared with the concourse, and final approval, of all members of the IRG. The report has not been checked by JNC, and the IRG takes full responsibility for any factual inaccuracy.

2. THE GEOLOGY OF JAPAN AND THE SAFETY CONCEPT

General aspects

The structural geology of Japan is determined by the position of the Japanese islands on plate collision zones, which leads to a tectonic activity that is relatively intense and generally higher than in other parts of the world where the geological disposal of radioactive waste is considered. The potential impact of this tectonic activity on long term safety is a recognised concern of the Guidelines and of the H12 study. As no part of Japan can be considered as being tectonically stable, in the sense generally accepted in other countries, the development of a safe geological repository represents a particular challenge to the Japanese programme. To some extent, this challenge is faced also by other countries, *e.g.*, Italy, Taiwan and Switzerland.

Overall, the description of the geology of Japan in H12 is competently done and adequately comprehensive for the purposes of the report. It must be recognised, however, that, at this stage, actual purpose-specific data and field observations are relatively limited and that the greatest part of the geological information is derived from a review of the literature.

The main issues considered in the H12 report are volcanic activity, fault displacement and resulting seismic activity, uplift and subsidence, erosion and sedimentation. Consideration is given also to climatic change and sea level variations. These, however, are believed to be somewhat less important in respect of the long term performance of a geological repository, despite their potential impacts on the biosphere.

Some of these points were addressed repeatedly in written comments and were discussed extensively during the workshop in Tokyo. The most important aspects of those discussions are briefly summarised below.

Volcanism

The analysis of existing data on volcanism in Japan is adequate and the conclusion that areas exist in the country, where the risk that a repository might be disrupted by volcanic activity is negligible, appears to be well founded.

Uplift and subsidence

The data, presented in the H12 study, on vertical tectonic movements in Japan indicate that there is a prevalence of uplift, meaning that most of the territory is subject to tectonic stress with a significant upward component. There are, however, also zones undergoing subsidence. The reported rates of uplift are generally high and occasionally much higher than known rates of epeirogenic/orogenic movements in other tectonically active regions. Considering the obvious impact of uplift/subsidence on the estimated rates of future erosion and, therefore, on the potential thickness of overburden that might be removed from above a geological repository, the IRG stressed the importance of a reliable database on these geological processes.

The uplift data are useful in identifying areas where future erosion may remove significant thickness of overburden. In the site selection phase of the programme, the uplift data should be considered for ranking candidate sites and for defining some features of repository design, for example minimum depth. Consequently, the quantitative knowledge of these processes might be an important repository siting factor.

Faulting

The database on active faults in Japan is based essentially on surface observations (aerial photography and field surveying) and seismic historical data. Both approaches are likely to produce significant underestimates of the actual number of active faults. Consequently the IRG has reservations about discounting the potential impact of faulting on a suitably sited repository in the next 100,000 years. The distribution of faulting probability in Japan seems to be an aspect of the programme requiring additional work.

Accordingly, the IRG expressed reservations about the way faulting has been handled within the H12 report, namely that the expectation of faulting in specific areas will be largely predictable in the next 100,000 years. The information on active faults presented in H12 is certainly useful to define areas characterised by higher or lower probability of faulting, but cannot be used to identify areas where faulting can be excluded.

The assumption is made in the H12 report that future fault activity, during the next 100,000 years, will be restricted to the identified active faults and, consequently, that any repository at least 10 km distant from a known active fault is not exposed to the risk of disruption. The IRG does not consider this critical assumption to be scientifically defensible. In addition, the way faulting is treated in the various parts of the H12 report is not fully consistent. Some of the assumptions used in the chapter on safety assessment seem to contradict the hypothesis described above.

It is, therefore, recommended that faulting, either displacement along existing faults or generation of new ones, is considered as a stochastic process and handled accordingly. JNC is now addressing this issue and that a faulting scenario is being evaluated.

The general evolution of the geological environment

Regarding the likely future evolution of the geological environment in more general terms, and on the basis of available and presented information, it is believed that reasonable estimates can be produced, at least in the more stable parts of Japan. However, the level of uncertainty of such estimates increases in proportion to their distance in the future.

H12 uses the assumption that the evolution of the geological environment can be estimated reliably up to 100,000 years, on the basis of what is known about the geological events in the past several hundred thousand years, and much less reliably afterwards. However, the assumption that after 100,000 years some geological processes or events, previously considered negligible, will become more likely, is arbitrary. It would be more logical and scientifically defensible to estimate the future evolution of the geological conditions as the result of gradual and progressive changes. No scientific ground exists to assume that the behaviour of the geosphere will change pattern past one hundred thousand years.

Consideration of alternative geological formations

The H12 report develops the geological disposal concept for two generic host rocks: granitic intrusions and sedimentary formations. Little use has been made of the extensive international literature on the potential merits and problems associated with the various types of host rock. In particular, the different response of the various rock types to tectonic displacements would appear to be very relevant in the structural conditions of the Japanese islands. For example, many clay-rich formations around the world are known to exhibit a relatively plastic behaviour and to be able to accommodate some faulting displacement with little or no increase in hydraulic conductivity. The clay content does not need to be especially elevated. It would be beneficial if this aspect were taken into account in present or future descriptions of potential host rocks and/or potentially favourable formations in the overburden of a repository in Japan.

Comments about geology and repository siting

Throughout the H12 report, statements are repeated to the effect that minimum distances from potentially negative geological features will be used as criteria for siting the geological repository. Thus 10 km is quoted as the minimum distance from major active faults and 50 km as the distance from volcanic structures.

In consideration of the relatively preliminary stage of the geological disposal programme and of the fact that actual site selection is not in the remit of the H12 report, attention is called on the potential drawbacks of giving the impression that quantitative siting criteria can be defined at this preliminary stage. While it is true that screening factors, including the estimated distance from particular geological features, will be used in the selection of potentially favourable areas, it is also true that the numerical values to be used in any siting criteria will depend on site specific features and will need to be supported by detailed and realistic safety assessments.

At the present time it would be preferable to discuss the spatial relationships between a repository and the potentially negative geological features as siting factors, which might be transformed in siting criteria when specific information on the candidate site will be available.

Additional siting factors which seem to deserve consideration in the eventual ranking of potentially favourable areas are: subsidence, occurrence of formations with relatively high clay content, and siting on minor and remote islands.

- With respect to subsidence, it may be worthwhile to consider that the latter might be a favourable feature for a candidate repository site, as it would lead to increased isolation with time.
- As described above, formations relatively rich in clay, if available at depth or in the overburden, are believed to present additional favourable features in respect of long term safety in a tectonically active area.
- The focus of the H12 report is on geological disposal in a still undefined site located on one of the main islands of Japan. It is believed that the minor islands, many of which are remote from population centres, should also receive serious consideration. If some of the small islands were found to present acceptable geological features, mainly with respect to tectonic stability and hydraulic conditions of the potential host rock, then the beneficial aspects related to the distance from humans and the great dilution potential of the marine environment should be carefully evaluated with site specific safety assessments.

Recommendations

Based on the preceding remarks and on the discussions at the meeting in Tokyo, the IRG offers the following recommendations.

- With respect to faulting, it would be more defensible to acknowledge that in a tectonically active region, such as Japan, fault displacement, either as activity of existing discontinuities or along newly generated fractures, is possible everywhere. The database on known active faults and on hypocenters of earthquakes could then be used to rank the territory in relation to the probability of future fault activity. As a result of this approach, and for the purpose of safety evaluation, faulting should be considered to be stochastic in nature and faulting scenarios should be considered in safety assessment (this has been already accepted by JNC during the Tokyo meeting). It should be also pointed out that any quantitative estimate of faulting probability is always and unavoidably characterised by significant uncertainty, therefore the robustness of the isolation barriers, both engineered and natural ones, with regard to faulting should continue to receive careful consideration and should be used as a decision-making factor in both repository design and site selection.

- With respect to the selection of suitable host rocks there are obvious relationships with the preceding recommendation on faulting. Since it is difficult, if not impossible, to justify a quantitative value for the probability of faulting, the response of different rocks to faulting should be considered as an important site selection factor. It is a known fact that clay-rich formations may exhibit plastic behaviour and preserve low bulk permeability even when intersected by faults. Clay-rich formations have the additional advantage of a generally higher retention capacity, being therefore more effective geochemical barriers. On the basis of these considerations it is recommended that, if available either at depth or in the overburden, clay-rich sedimentary formations be seriously assessed in Japan.

- With respect to repository siting, it is recommended that, in due time, consideration be given to potentially favourable features that, so far, have not received the necessary attention, namely: the progressively enhanced isolation potentially provided by subsidence and the remoteness of some small islands.

- Finally it is recommended that no quantitative siting criteria, e.g. regarding distance to potentially active geologic features, be defined at the present stage of the programme, and to postpone any definition of numerical criteria until such a time when site-specific data and safety assessments will be available.

3. REPOSITORY DESIGN AND ENGINEERING TECHNOLOGY

General aspects

The safety of a deep geological repository depends on both a suitable geological environment and properly designed and selected man made barriers. While the choice of geology may be strongly limited by the conditions in the country, the engineered barrier system offers opportunities for optimisation and adaptation to the local environment. The performance of the engineered barriers can be tested. These tests allow long-term predictions, if the stability of the hydrogeochemical environment can be reasonably assured.

The engineered barrier system and the repository design are of fundamental importance to the development of the safety case for the repository, especially in the early, conceptual phases of repository design because, at that time, a relatively high uncertainty exists in the geosphere model. Accordingly, the H12 study places emphasis on the engineered barrier system and less reliance on the barrier functions of the geosphere. In the H12 report, this is reflected in the choice of materials for overpack and buffer and backfill, and in the design and construction of the repository.

The JNC studies of overpack and buffer/backfill materials appear to be of high international standard and, in some cases, at the leading edge.

Overpack

The choice of overpack material and the design of the overpack are clearly described. Three different materials are considered: titanium, carbon steel and copper. The choice of carbon steel is based on an evaluation of the material against a set of design requirements. These requirements as well as those on service life of the overpack are shown to be met with sufficient confidence.

The corrosion behaviour has been determined using both synthetic chloride dominated and carbonate/bicarbonate water, which simulate the typical deep groundwaters in Japan. For both types of water, reducing conditions are expected. The extent of the corrosion is estimated conservatively and, therefore, reasons may eventually become evident to relax from the present level of conservatism when site specific data become available.

The final choice of wall thickness should also take into account factors like the feasibility for reliable fabrication of the overpack and the non-destructive verification of the quality of the material used and the welds in the final product.

It is noted that shear movements in the rock across a waste package has not been considered as design basis load. Nor have any transient or permanent non-uniform loads been considered. With present design and wall thickness, there is no reason to believe that foreseeable non-uniform loads would be a threat to the integrity of the overpack. However, even if shear movements in the rock are not considered as design basis loads, the confidence in the design would increase if the limits for the strength of the overpack were determined.

Buffer and backfill

In the H12 study, a quartz-bentonite mixture is proposed for buffer material instead of the pure bentonite evaluated in H3. This material is shown to meet the design requirements.

The technical feasibility of manufacturing and installing methods for buffer has also been confirmed in laboratory tests. It should, however, be borne in mind that the installation in a moist environment in the repository may be less straightforward than expected from the laboratory tests.

Repository design

The description of the design and construction of the repository is done at a level that is quite sufficient for the purpose of the report. The descriptions are currently at a generic level and may have to be reassessed when the programme has moved into a more site-specific phase.

To some extent the actual repository layout will have to be determined once the site has been selected and as the investigations proceed. This process may also have an impact on the final requirements on the number and location of shafts for access and ventilation. It will also affect the needs for the division between radiologically controlled areas and other areas.

Concluding remarks

It is regrettable that much of the technical studies are not published in international journals and are, therefore, inaccessible to a wider, non-Japanese speaking audience. Some of the results certainly merit publication, and JNC is encouraged to give to its studies and results a wider circulation in the future. Having the reports and papers published in international journals will lead to a continuous peer review process and also contribute actively to the process of confidence building. The work that has been and will be performed in the excellent laboratory facilities ENTRY and QUALITY at Tokai Mura will be of great value not only to the Japanese programme but also to waste management programmes elsewhere in the world.

Compared to other high-level waste disposal programmes, the present repository design appears, in fact, to be more advanced than the usual level of development when entering the site selection phase. One reason for this is that, in the Japanese programme, full advantage has been taken of the experience in other countries and also of international co-operation. International co-operation is also an essential part in establishing confidence in the concepts and methods used for the design, the construction and, later on, the operation of deep geological repositories.

4. SAFETY ASSESSMENT

General aspects

The safety assessment (SA) is at the core of the H12 study and has been performed on the basis of generic information about the geological and environmental conditions of large parts of Japan. Bearing in mind the generic nature of the data base and the relatively preliminary stage of the Japanese geological disposal programme, the work performed is impressive and very encouraging for the future steps. In particular, the results of the safety assessment show that the proposed system is expected to meet the relevant dose constraints, and that, in general, ample margins are available to accommodate variations in the final data.

Notwithstanding the objective merits of the JNC safety assessment, the IRG has noted areas where improvements can be achieved both at the present stage and in the future:

- The general methodology applied is comparable to similar studies published in other countries and in general agreement with the guidelines of international organisations. The IRG recommends a closer look at some specific aspects, in particular in relation to the completeness of the scenarios considered, and a more cautious approach in the selection of data and assumptions. (see sections on scenarios and data)
- Special complexities affect the H12 study because of its wide scope of diverse geological and surface environments. As a consequence there are high demands on traceability and transparency. Improvements are needed in the amount of information provided, in the presentation of the material, and in assessing the lessons to be drawn from the assessment (see section on documentation).
- In contrast with design-specific information available for the near field, geological data are generic. Thus, the results obtained have to be interpreted with caution.

These areas will be identified and commented upon below. Additional comments are also provided in order to foster a more explicit application of the safety assessment in the decision making process for repository development.

The documentation of the safety assessment

As it presently stands, the documentation of the safety assessment in both Chapter V of the Overview Report and in the Supporting Report 3 [JNC, 1999e] needs to be completed with additional information and explanations. The problem is especially important in the case of the Project Overview Report. The IRG had to receive special presentations in order to understand some of the essential points of the assessment. The situation is more satisfactory in the supporting document, but the comments referring to additional explanations and improvements on methodological and conceptual aspects apply there too.

While it is recognised that the organisation and structure of a safety assessment are a demanding task, this is even more so in the case of the H12 study because many different disposal systems are assessed at the same time. A practical approach to favour readability is to introduce at the beginning of the chapter a section describing the context of the assessment. This should present the different alternative disposal systems, the criteria and the general methodology along with the structure of the chapter. The latter should be explained more comprehensively than in the present draft.

It is recommended, in particular, that the documentation in Chapter V be revised in order to assure an orderly and gradual presentation of its contents. All relevant information on the same topic should be put together, and the consistency between the section headings and the relative text should be checked. As an example, at present, the description of the "Reference Case" is found scattered throughout Chapter V. Most of the relevant information is found in the section on "Conceptual models", whereas, in this section, very little information is provided on the conceptual models themselves. Cross references should be used widely in order to facilitate reading of the report.

The IRG has remarked that the conclusions of both Chapter V of the Project Overview Report and of the Supporting Report 3 [JNC 1999e] do not contain enough discussion of the lessons to be drawn regarding future work. Further analysis of the results obtained from the assessment should be carried out in order to identify, *e.g.*, basic assumptions of the assessment that have to be confirmed in order to be applicable to real sites; the importance of relevant site characteristics, as groundwater flow or uplift rate, in order to provide grounds for the future development of site selection criteria. This does not mean that it is recommended that quantitative values be set at this stage, but rather that there be a discussion at a qualitative level on the relevance of site related issues to the safety of the repository system.

Scenarios

Scenario analysis is a cornerstone in any safety assessment, and it poses special difficulties at the level of both its performance and documentation. The challenge is even greater in the H12 study because of the multiple contexts covered (different designs, geological settings, surface environments, exposure groups) and the specific nature of the Japanese geology. Accordingly, the earlier recommendations as to the structure and organisation of the documentation are especially relevant here.

In general, it appears that much emphasis was placed on the description of calculation cases and in providing the supporting information. This information, however, is so prolific that the overall picture is somewhat obscured. More discussion should be provided, rather, of the rationale for the decisions taken, as well as a discussion of the completeness of the scenarios that have been identified.

Additional desirable clarifications and/or review regarding some conceptual and methodological aspects are as follows:

- The concept of scenarios related to the future evolution of a disposal system should be distinguished from other related concepts. The potential reviewer will have difficulties in understanding the management of scenarios that concern alternative systems: these are not "alternative scenarios" but rather "scenarios of alternative systems". The loose use of terms can lead to even more confusion. For instance, the term "alternative scenario" is sometimes used to mean "sensitivity case" and "uncertainty analysis" (alternative models, data, ..). Overall, this raises difficulties when trying to understand the methodology and its application.

- More attention should be given to the steps of the analysis dealing with the development of groundwater scenarios, *i.e.*, how and why the different FEP's are combined to form scenarios. This is a critical step (as is the identification of FEP's) in achieving a sufficient degree of completeness. With regard to this crucial aspect little information is given in the reports on the basis and on the criteria that were followed, whereas detailed and satisfactory information is provided regarding the FEP lists. It appears that the process is performed in two cycles: in the first, single variations are done on the reference case. Even at this level, all linked consequences of a single assumption have to be considered simultaneously. For example, a higher groundwater flow means a faster transport in the geosphere, and at the same time a different boundary condition for near field release calculation. In a second phase, called Total System Performance Analysis. some multiple variations are considered simultaneously, but the justification for the variations considered or not considered is not explicit. Regarding, for example, the choice of a given geosphere-biosphere Interface, for an inland site, it is only said that it is regarded as a suitable base line [JNC 1999e; section 7.1]

- In the H12 study, the term "total system" is used differently from its use in other international studies. Its role in the methodological approach should be explained as part of the introduction to the methodology. The treatment given in the Project Overview Report (a subsection in the presentation of results) is not fully consistent with the one in the Supporting Report . What is referred to here as first cycle seems only an interim step aimed at supporting the choices made in the second (Total System) cycle, the results of which provide the performance measure of the system. This understanding may or may not be the correct one, but the important thing to note is that the text needs to be unambiguous in this respect.

- The classification of the scenarios could give rise to controversy as the category of "perturbation scenarios" is presented as distinct from "natural evolution scenarios", whereas the FEP's giving rise to the former are, or at least may be, part of the normal evolution of the system: climatic change, limited number of early canister failures, some trivial human actions, and even, for a large part of Japanese territory, uplift-denudation.

- Besides the conceptual aspects mentioned above, it can be asked whether all relevant combinations of FEPs are considered. For example, uplift is only combined with the reference case of crystalline host rock. On the other hand, in the case of a repository in sedimentary rock, the change to oxidising conditions in the near field (as well as exhumation) would happen earlier for the same rate of uplift.

- The eventual exhumation of the wastes due to the combined effect of uplift and denudation is a specific feature of the H12 study. The acceptability of this can only be assessed within the framework of regulation, which, in the case of Japan, needs to be formulated. The use of a hypothetical uranium mineralisation at the surface is certainly useful. as a natural analogue, with the intent to interpret the meaning of the situation, but significant differences are lost this way as, for example, the local specific radioactivity would be different in the two cases.

Regarding other scenarios, or scenario generating FEPs, additional consideration could be given to the assumptions on the degradation of the tunnel supports and on the characteristics of wells[2]. Also, the potential relevance of repository seal failure should be analysed. Regarding the latter, it must be observed that quality assurance cannot be relied upon one hundred percent.

Some comments have been made already, in Chapter 3. on the analysis of a faulting scenario. In this respect, it should be stressed that the main strategy for site selection should be the avoidance of areas where the risk of faulting is high, and that emphasis should be given to studies aiming to show confidence that the probability of a fault directly affecting the repository is sufficiently low. In this case the faulting scenario could be treated as an illustration of a low probability event.

The scrutiny of the application of screening criteria to FEPs cannot be addressed within the scope of a review at an executive level. Nevertheless this is an area of great importance, and it is recommended that the report deal more widely with the uncertainties in this area, as they are important to define future lines of work.

---

[2] See also the biosphere section below in this document

Modelling

- **Near field**: The analysis of the FEP's for the near field is very comprehensive and detailed, in line with the state of the art.

  More discussion would be advisable on the EBS-rock mutual influences, due to thermomechanical and geochemical (as an alkaline plume) effects, and on specific aspects as the assumptions on the degradation of tunnel supports, or alternative lay outs (disposal drifts parallel to groundwater flow, drifts intersecting faults, etc.).

  The radionuclides selected for numerical calculations are consistent with the type of wastes assumed (high level vitrified wastes) but the presentation of the screening method is somewhat obscure and needs to be improved. A screening approach based on potential dose might be more straightforward.

  Regarding the assessment of the performance of the near field it is recommended that the uncertainties remaining about certain processes, as gas flow and transport through EBS, long term stability of bentonite, or near field-host rock influences, be discussed in the light of future R&D programmes.

- **Far field**: A simplified geometrical arrangement of the repository and of the significant features of the natural barriers is used for the modelling of groundwater flow and mass transport through the host rock. This simplified approach is reasonable at the present stage where no specific data are available from potential sites. The methods and database will have to be upgraded as site specific information becomes available.

  The same basic model developed for fractured crystalline rock is applied to sedimentary rock, with adjustments to take into account the differences in bulk permeability and small scale properties as porosity and sorption. This is a very rough approximation; more in depth analysis for each type of rock will be necessary in the future. The potential relevance of transport mechanisms through the porous matrix should be discussed in the study, especially in the case of relatively permeable rocks, as sandstone.

  The models and assumptions for transport through the rock merit a more extended description in the Project Overview Report. At present, only the recourse to the Supporting Report provides meaningful information.

  Bearing in mind the constraints mentioned above the implemented approach is state-of-the-art and appropriate.

- **Biosphere**: The methods for biosphere modelling follow the work developed in the BIOMASS project; they are then well placed within international trends, and appear to be quite comprehensive in terms of FEP's and exposure groups. Climate change has not been accounted for in the treatment of the reference biosphere. However, this is not necessarily a limitation at this stage as Japan is not going to undergo glaciation.

  The IRG recommends that the treatment of the biosphere be more integrated within the overall assessment. In particular, more detailed analysis and discussion of the different biosphere contexts in the framework of general scenarios are warranted. Also in this case it is recommended to give more information in the Project Overview Report. The IRG had the benefit of additional explanations on the assumptions about dilution capacity of the biosphere, and geosphere-biosphere interface (well characteristics) that should be documented in the report.

The selection of a river as the geosphere-biosphere interface for the total system analysis rather than the more conservative case of a well is questionable. Shallow wells can be expected to be a likely situation and it would be appropriate to take these as the basis for the illustration of long-term safety. Alternatively, a more solid case must be made for the river as the geosphere-biosphere interface for the total system analysis.

It is noted that, if a very large amount of dilution is used, e.g., for the river or a deep industrial well as the geosphere-biosphere interface, then the safety assessment must employ the critical group concept. It is very unusual to use such a large dilution factors - as they are used in the H12 study - to derive a dose estimate that is then compared to individual exposure criteria. It is suggested that JNC give consideration to the use of a critical group concept for analysis. Such a group would have a location, lifestyle and diet that would cause its risk from the repository to be greater than or equal to that of any actual group. Estimated exposure of members of the group would more appropriately be compared with individual risk criteria.

- **Validation.** The IRG disagrees with the repeated use of the term "validation" in relation to the outputs of long term modelling of the performance of particular barriers and/or of repository impacts. This use of this term can be misleading. It is currently agreed at the international level that "model testing" and "confidence building" are less demanding and more defensible expressions and that, as far as the substance of the argument is concerned, the best that can be achieved with long term modelling and performance/safety assessments is 'reasonable assurance' of the safety of the repository. (see also [NEA 1999])

Data

The data used in the study are well documented. Some more specific numerical values on relevant parameters should be brought to the Project Overview Report, as for example, those related to the geosphere-biosphere interface (as river flow).

In general, the selection of data is supported by an analysis of available information, much of it generated within the Japanese programme. Overall the work performed is extremely valuable.

The nature of the present review does not allow an evaluation of the justification of each parameter value used in the calculations. A general comparison with values found in other recently published Safety Assessments shows that, in some cases, the data in H12 are more favourable to a desirable performance. Examples are the solubility limits of some elements (Zr, Th, Ra) and parameters related to retention in the geosphere, *e.g.*, diffusion penetration depth in the rock matrix. Values more in line with international references might be used in the main calculations, and more favourable ones for best calculations, while awaiting additional confirmation and general acceptance.

As ^{79}Se is a relevant radionuclide in the H12 study, at least some scope calculations with the half life recently proposed in the literature should be appropriate.

Finally, it is important to emphasise that the consideration of the chemotoxic inventory or other types of radioactive wastes would give rise to additional demands on the repository system not covered in the present study. A relevant example would be the inclusion of wastes containing high soluble, long lived, low sorption radionuclides as ^{129}I or ^{36}Cl.

Concluding remarks

The results of the generic safety assessment indicate that the proposed disposal system is expected to meet the relevant dose constraints, and that, in general, ample margins are available to accommodate variations in the final data. As a consequence, the critical part of the assessment is confirmation that appropriate sites can be found, where the probability of isolation failure scenarios can be estimated to be adequately low.

It is desirable that the safety assessment chapter should be reviewed critically with the objectives of improving the logical presentation of the arguments, enhancing transparency and discussion of results. The relevance of the different parameters, understandings and assumptions should be commented upon and highlighted.

It is recommended that the conclusions of the study be based on a robust case, and that calculations based on less conservative estimates be used to allow potential gains when enough evidence and consensus are gathered on alternative approaches and data.

It is important to bear in mind the generic nature of the H12 safety assessment. In the absence of real site data, the applicability of the safety assessment is unavoidably conditioned to the confirmation of the assumptions made and to the actual selection of an "appropriate site" as the Study itself acknowledges. It is, of course, important at this stage to identify critical issues at a generic level. This should allow the definition of useful guidance for future stages of the programme. Once a candidate repository site will be identified, the safety assessment procedure will have to be revised on the basis of specific information on the natural features of the site and the adaptation of the repository to those features. In the long process going from site selection to repository licensing, several safety assessments will be required. They will be performed on the basis of progressively better databases about the disposal system.

The H12 approach to safety assessment is somewhat conventional by focusing on the estimation of radiological impacts on humans. This is fully consistent with the traditional position of ICRP and other international organizations, as well as the AEC Guidelines. However increasing attention is being paid, both within specific countries and at the international level, to a broader range of potential environmental impacts. In the future, it can be expected that increased attention will be paid to the non-radiological impacts, *e.g.* impacts due to the chemotoxicity of the waste.

5. PRESENTATION OF THE H12 STUDY AND LESSONS LEARNT

General considerations

The acceptance of the H12 study by the Japanese Government would allow the national programme to move to a new stage, leading to the formulation of siting and regulatory procedures, and the creation of a new implementing organisation. The H12 study is thus of pivotal importance for the progress of development of a HLW repository in Japan.

In order to contribute positively in the decision-making, it is important that the nature of the H12 study and its main findings be made unambiguously clear to a varied audience comprising waste disposal specialists, technical experts, as well as the interested public. The AEC Guidelines do not mention a specific audience for the H12 study and report, but indicate the need to build confidence in the concept proposed by JNC. The latter carries with it the requirement of transparency to different audiences. The Project Overview Report is very much wanting in this respect. This is especially true of the sections that are less technical and meant to be accessible to the non-specialist. An important effort needs to be made to improve those sections of the report.

Specific items

During the workshop in Japan, the IRG indicated to JNC that:

- regarding the introductory chapter of the Project Overview Report:
    1. it was not clear to the IRG who was the intended audience for this chapter, although JNC replied that it was for the technical community;
    2. basic information on long-lived waste, in general, and on geologic disposal, in particular, was not well presented, and could be confusing even to a knowledgeable reader.

Furthermore,

- regarding Chapter II:
    1. the technical aims of the H12 study, especially in relation to the H3 study, should be made clearer. For instance, the IRG had to request a special presentation to have JNC explain what is meant by "technical reliability", which is requested of the H12 study, versus the "technical feasibility", which was established in the H3 study;
    2. the basic features of the disposal concept, *i.e.*, the multiple barriers system and their safety functions should be presented clearly. This description should not be referred to later, more specialised chapters;
    3. terminology regarding basic concepts for illustrating safety, *i.e.*, does/risk constraints versus does/risk limits, should be properly applied;
    4. desirable characteristics of sites should be determined as a result of the study, rather than being mentioned in this early chapter. Furthermore, care must be exercised not to suggest, without the necessary firm basis, characteristics that might be difficult to find, all together, at one single site;

5. undue expectations should not be raised regarding future developments, *e.g.* that models and data should be "fully verified and validated";
6. analogues other than Oklo, *e.g.*, Cigar Lake, would be more fitting to show the isolation capacity of certain geological conditions. Even the natural analogues currently investigated by the Japanese programme would be more useful in supporting the effectiveness of specific isolation barriers.

- Regarding Chapter VI, where the basic lessons of the study have to be drawn as input to decisions on siting and the development of a regulatory framework in Japan, it was readily conceded, by JNC, that the present chapter is insufficient and lacks the necessary synthesis and suggestions.

- Regarding Chapter VII, it must be observed that the latter was not discussed directly during the review. It is proposed, however, that it should be re-evaluated once, in the earlier chapters, the basic aims of the H12 study are properly described, the relevant terms are appropriately defined and consistently used, and a summary of lessons learnt has been provided.

In fairness to JNC, it should be said that, during the workshop in Japan, it became clear to the review team, that the H12 study was still under completion: data were still being gathered, *e.g.*, on solubility of radionuclides, and the contents of the chapters dealing with the presentation of the study and the lessons learnt were being defined, *e.g.*, within the framework of the Co-ordination Conference for HLW disposal R&D in Japan. JNC was also in the process of drafting a document, in Japanese, meant to explain to the Japanese public many of the items identified earlier as needing clarity in their presentation.

Suggestions

It appears especially important to the IRG that a proper assessment of the lessons learnt be made in Chapter VI of the Project Overview Report with a view to provide input into siting and the development of a regulatory framework. At the workshop, it was suggested that both the revised Chapter VI and the executive summary proposed below should include a clear and concise discussion of the following points:

1. ***The basis of the judgement for the technical reliability of geological disposal.*** In particular, the reasons for the progress in confidence since the H3 study should be discussed, identifying remaining issues and items that should be clarified in future stages of the Japanese programme. It is emphasised, to this effect, that at a particular stage, having sufficient confidence does not imply that all the issues that affect repository siting, planning and development have been resolved, but rather that these issues are not judged as critical in the decision to progress to the next stage and there are good prospects to resolve them in future stages.
2. ***Methodologies for site investigations.*** They need a clear structure and the relevant procedural processes have to be assessed. Within this context the role and impact of the regulatory aspects on the evaluation of the site and the total repository system need to be clarified.
3. ***Site characteristics influencing the safety and environmental performance of a disposal facility.*** These characteristics should be described and statements should be given of how they would tend to influence the safety of the system. Besides technical factors, general and environmental factors, such as population density and protected areas, should also be considered. It is emphasised that, at the present stage in the programme, these factors do not need to be expressed in the form of quantitative siting criteria.

4. ***Factors affecting engineered barriers effectiveness.*** For example, the maximum temperature of the bentonitic clays that would not cause illitization, a guaranteed degree of purity in some of the raw materials and therefore a quality assurance programme in the acquisition of materials to be used in the repository.

5. ***Availability of engineering technologies.*** This includes an evaluation of the maturity of proposed engineering solutions and an assessment of their cost effectiveness.

6. ***Safety criteria for assessing radiological and other potential impacts.*** This includes, for instance, "dose" as an indicator of safety rather than actually received doses; the identification of credible time scales for quantitative versus qualitative analysis; means to assess impacts other than radiological ones.

7. ***Uncertainty versus confidence.*** It should be stressed that proof of performance over the long time scales involved cannot be achieved in the ordinary sense of the word. It must be borne in mind that observations and natural laws do not describe "real nature" but our knowledge of nature. The standard for decision making is thus the achievement of "reasonable assurance" of adequate safety, in view of the quality of the information that is gathered, the credibility of the persons and institutions involved, and the openness of the decision making process. A safety assessment should make clear the procedures that were gone through in order to gain technical confidence in the gathering and organization of the given information. Thus a strategy for identifying uncertainty, and avoiding or reducing it by relevant means, has to be developed in the future and documented. Examples of how uncertainty has been dealt with in some cases within the H12 would be useful. These examples could be patterned after the methodology described in [NEA 1999]. The robustness of the H12 disposal concept should be illustrated and stressed.

8. ***Special scenarios.*** A special difficulty is encountered in dealing with: i) the uncertainty arising from the possibility of human actions that may interfere with the normal functioning of the repository; ii) the lack of knowledge of human habits in the future. It is understood that scenarios involving inadvertent human intrusions are to be dealt with in a stylised fashion, in order to explore the uncertainties arising from the evolution of natural and engineered barriers versus those arising from human actions.

Finally, it is observed that the H12 report contains a large amount of information, and is too technical for a wide readership. Even the Project Overview Report is rather large to afford a good overview of the project. Consequently, JNC should give consideration to the preparation of a more easily readable executive summary of suitable dimensions. Such a summary could serve a very useful purpose in communicating the nature of the H12 study, the proposed approach, and the main findings to a varied audience, including the informed public. On the other hand, JNC is preparing a supplementary document in Japanese. This document may well serve the need that was just identified.

6. OVERALL JUDGEMENT

Overall, the H12 draft reports[3] of May 1999 constitute a remarkable technical achievement, particularly considering the relatively early development stage of the Japanese geological disposal programme. In relation to the first progress report of 1992, the H12 study represents a significant advancement. The improvement of the database on the engineered barrier system is particularly relevant.

The description of the geology of Japan in H12 is competently done and adequately comprehensive for the purposes of the report. It must be recognised, however, that, at this stage, actual purpose-specific data and field observations are relatively limited and that the greatest part of the geological information is derived from a review of the literature. Significantly more detailed investigations will be necessary to proceed to successive stages within the siting process.

The structural geology of Japan is determined by the position of the Japanese islands on plate collision zones, which leads to tectonic activity that is relatively intense and generally higher than in other parts of the world where the geological disposal of radioactive waste is considered. The potential impact of this tectonic activity on long term safety is a recognised concern of the AEC Guidelines and of the H12 study. The IRG is of the view that, while it is reasonable and believable to identify areas where the probability of faulting will be low, it is not acceptable, at the present stage, to ignore faulting scenarios in the safety assessment of the repository. It is thus recommended that a faulting scenario be added to the safety assessment in order to explore and illustrate better the robustness of the proposed disposal concept.

The H12 study places emphasis on the design and performance of the engineered barrier system and less reliance on the barrier functions of the geosphere. This is acceptable, considering that in the early, conceptual phases of repository design a relatively high uncertainty exists in the performance of the geosphere. It is noted that the work of JNC is of a particularly high level in the area of design and performance of the engineered barrier system. The latter is competently designed with ample margins for later optimisation and can likely accommodate a variety of faulting scenarios.

The safety assessment is at the core of the H12. The general methodology applied is comparable to similar studies published in other countries and in general agreement with the guidelines of international organisations. The IRG recommends a closer look at some specific aspects, in particular to clarify the degree of completeness of the scenario analysis, and a more cautious approach in the selection of data and assumptions. Bearing in mind the generic nature of the data base and the relatively preliminary stage of the Japanese geological disposal programme, the work performed is impressive and very encouraging for the future steps.

Special complexities affect the H12 study because of its wide scope of diverse geological and surface environments, as a consequence there are high demands on traceability and transparency. Improvements, to this effect, are needed throughout the Project Overview Report. In particular, it is important that the nature of the H12 study and its main findings be made totally unambiguous, and that the lessons learnt from the conduct of the study be summarised better for the decision makers and their technical advisors. The discussions between the IRG and JNC have identified useful avenues for summarising this information, and the final H12 report should be able to fulfil the two most important objectives of the study. Namely, to provide useful input into both the siting process and the accompanying regulatory procedures.

---

[3] This refers to both Project Overview Report and supporting documents, noticing, however, that the IRG has examined the Project Overview Report in greater detail.

With respect to confidence building, the high quality of the H12 report and the further improvements anticipated as a result of the present review, and of other ongoing more technical reviews, are both very positive factors. Additional favourable impacts could be obtained if, in the presentation of the programme achievements, use could be made of the most recent concepts presented in the technical literature in the area of confidence development and communication.

Overall, the technical basis for geological disposal in Japan has been outlined and convincingly assessed in a generic way, giving a sufficient level of confidence, at the present stage, that the tools have been developed to proceed to an adequate site characterisation and assessment in the next phase.

Concluding statement

The acceptance of the H12 study by the Japanese government would allow the programme to move from the present R&D phase to a new phase where siting and regulatory procedures would be formulated, and a new implementing agency would commence work.

The IRG is of the opinion that the scientific and technical basis is sufficiently mature to start to put in place a step-wise decision making structure and process in Japan in order to formulate relevant regulations to HLW disposal and to proceed with siting of a HLW repository. Indeed, it can be said that Japan is more advanced than other nations when they entered siting studies for a geological repository.

As repository development will progress through successive stages, the task of achieving sufficient confidence in long-term safety will not necessarily become simpler, since the decisions to be supported will tend to demand a higher commitment. Thus, efforts will need to be made continuously to ensure that confidence in the safety remains sufficient to support the decision-making process. We are optimistic for the continued success of this endeavour.

REFERENCES

AEC, 1997. Guidelines on Research and Development Relating to Geological Disposal of High-Level Radioactive Waste in Japan. Advisory Committee on Nuclear Fuel Cycle Backend Policy. Atomic Energy Commission of Japan. April 1997.

JNC, 1999a. Request by the Japan Nuclear Cycle Development Institute for an international peer review of the JNC H12 study to be organised by the OECD/NEA, letter from Mr. S. Masuda to Mr.H. Riotte, Tokyo, 11 March 1999

JNC, 1999b. H12 Project to Establish Technical Basis for HLW Disposal in Japan - Project Overview Report. JNC TN1400 99-010. Japan Nuclear Cycle Development Institute. May 1999.

JNC, 1999c. H12 Project to Establish Technical Basis for HLW Disposal in Japan - Supporting Report 1 - Geological Environment in Japan. JNC TN1400 99-011, Japan Nuclear Cycle Development Institute. May 1999.

JNC, 1999d. H12 Project to Establish Technical Basis for HLW Disposal in Japan - Supporting Report 2 - Repository Design and Engineering Technology. JNC TN1400 99-012, Japan Nuclear Cycle Development Institute. May 1999.

JNC, 1999e. H12 Project to Establish Technical Basis for HLW Disposal in Japan - Supporting Report 3 - Safety Assessment. JNC TN1400 99-013, Japan Nuclear Cycle Development Institute, May 1999.

NEA, 1999. Confidence in the long-term safety of deep geological repositories - Its development and communication, NEA/RWM/DOC(99)4, Nuclear Energy Agency of OECD. March 1999.

PNC, 1992. Research and Development on Geological Disposal of High-Level Radioactive Waste, First Progress Report. PNC TN1410 93-059. Power Reactor and Nuclear Fuel Development Corporation, September 1992.

APPENDIX

THE MEMBERS OF THE IRG

Jésus Alonso

Mr. Alonso holds a degree in energy engineering from the Politechnical University of Madrid (Spain) and a specialisation certificate from the Ecole Supérieure d'Electricité, Paris (France). He has over 27 years of experience in the nuclear field, including 14 years in power plant industry. He has devoted the last 13 years to radioactive waste management (both low- and high-level).
Mr. Alonso started his professional career in 1972 joining the French nuclear power plant constructor Framatome, with which he worked until 1976 when he joined the Spanish Architect Empresarios Agrupados as head of the Safety Analysis Section. In that position he participated in the design, construction and operational analysis of four Spanish Nuclear Power Plants (both PWR and BWR).
In 1986 he joined ENRESA, the Spanish Agency for the management of radioactive wastes, which had been created the year before. His initial commitment was the Safety Analysis, construction follow-up and licensing of the El Cabril radioactive low level waste disposal facility, and subsequently the analysis of operation and first renewal of the operation permit. From the beginning he was also involved in the safety studies of the management of radioactive high level waste. He is in charge of Safety Assessment Studies for geological disposal and has led ENRESA's participation in the European Project Spent Fuel Disposal Safety Assessment (SPA), as well as other R+D international projects in the area of disposal of radioactive wastes.
He is a member of NEA-PAAG, has participated in a number of NEA-RWMC Working Groups, and has been appointed as an expert to different IAEA advisory groups, taking part in the RADWASS Programme.

Kenneth W. Dormuth

Dr. Dormuth received a Ph.D. in Theoretical Physics from the University of Alberta in 1971, and has more than 25 years' experience in various aspects of technology related to nuclear energy and the environment.
Dr. Dormuth joined AECL in 1971 as a reactor physicist on a team developing and assessing advanced CANDU reactor designs and nuclear fuel cycles. Subsequently, he worked as a mathematical analyst, modelling the behaviour of radioactive materials in the atmosphere and groundwater, and led the development of a risk assessment methodology for radioactive waste disposal.
In 1981, Dr. Dormuth was appointed Manager of Applied Geoscience for AECL, responsible for research and development of technology for siting and designing a nuclear fuel waste disposal facility. Among his responsibilities was the development of the Canadian Underground Research Laboratory near Lac du Bonnet, Manitoba. In 1985, he became Director of AECL's Geological and Environmental Science Division, directing R&D on the siting, design, risk assessment, and biosphere effects of a nuclear fuel waste disposal facility.
Dr. Dormuth was appointed Director of AECL's Nuclear Fuel Waste Management Program in 1994. In this position, he led AECL's participation as proponent in the review of the nuclear fuel waste disposal concept under Canada's Federal Environmental Assessment and Review Process.
He assumed his current position as Director of CANDU Environmental Studies for AECL in 1998. He directs programs for continual improvement of AECL-supplied CANDU reactors in the areas of environmental emissions, waste management, and decommissioning planning. He is also responsible for environmental assessments of AECL's CANDU reactor projects.
Dr. Dormuth was the Canadian representative on the Joint Technical Committee of the NEA International Stripa Project, is currently the Canadian representative on the Waste Technology Advisory Committee of

the IAEA and was Canadian Project Director for a cooperative program of waste management research under an agreement between the United States and Canada. He has served on numerous other international committees and studies related to nuclear waste management.

Ferruccio Gera

Dr. Gera obtained his doctorate in geology from the University of Rome in 1961.In 1961-1962 he spent five months at the CEN in Mol, Belgium with an EC fellowship working on the migration of radionuclides in sandy aquifers. In 1962-1963 he spent one year at the Oak Ridge National Laboratory (ORNL), Tennessee, USA, with a post-doc fellowship to work on near surface disposal of radioactive waste.
After a brief teaching experience, in 1966, he joined the regulatory branch of the Italian nuclear organization, at the time called CNEN (National Committee for Nuclear Energy). During the following period with CNEN he spent approximately four more years as a visiting scientist at ORNL working on various aspects of safety assessment of radioactive waste disposal in salt formations. In the period between 1974 and 1976 he was head of the Waste Disposal Section at the Casaccia Center of CNEN, where he was involved with the Italian R&D programme on disposal of HLW in clay formations.
In 1976 he joined the Nuclear Energy Agency of OECD, where he remained for approximately five years working on various aspects of the Agency's programme related to geological disposal of radioactive waste.
In 1981 he joined ISMES, an Italian company of which ENEL, the national electricity generating company, is the major stock holder, with managerial functions. In the 16 years with ISMES he has managed many projects dealing with the feasibility assessment of disposal of long lived radioactive waste in Italian clay formations. In the same period, he was also involved in a variety of additional activities related to different aspects of radioactive and hazardous waste management and environmental protection.
Since leaving ISMES, in April 1997, he has been working as a consultant. Most of the consultant work has been on behalf of the International Atomic Energy Agency.

Over the years he has participated in the activities of numerous committees, groups of experts and consultancies on behalf of various organizations including the International Atomic Energy Agency, the Nuclear Energy Agency of OECD and the European Commission. Most of the groups dealt with some aspect of radioactive waste disposal.
He is the author of over 60 publications dealing with the management of radioactive and hazardous waste and other environmental issues.

Claudio Pescatore, Secretariat

Dr. Pescatore holds a Ph.D. in nuclear engineering from the University of Illinois, Urbana-Champaign (USA). He has 20 years' experience in the field of nuclear waste covering low-level waste, high-level waste and spent-fuel storage and disposal.
Dr. Pescatore joined the Brookhaven National Laboratory in 1982 and was directly involved in the study of high-level waste and spent-fuel disposal concepts in basalt, salt, and tuff formations: reliability and modelling studies of waste package materials during storage and disposal, analyses of gaseous and aqueous pathways for radionuclide migration, peer reviews of environmental impact assessments studies and site characterisation plans. At Brookhaven, he was group leader for Radioactive Waste Performance Assessment. Till 1995, he was also adjunct Professor of Marine Environmental Sciences at the University of New York, Stony Brook.
Dr. Pescatore joined the NEA/OECD in 1992 in the Division of Radioactive Waste Management and Radiation Protection, where he has been Acting-Head of the Division. He has been at the centre of several recent international initiatives such as the ASARR and GEOTRAP projects, the GEOVAL'94 symposium, the IPAG studies, etc. On behalf of the NEA he has organised numerous international peer reviews of

national studies. Namely: SKI's Project-90 (Sweden), AECL's Environmental Impact Statement of the Disposal of Canada's Nuclear Fuel Waste, the 1996 Performance Assessment of the US Waste Isolation Pilot Plant (WIPP), the SKI's SITE-94 project (Sweden), the Nirex methodology for scenario and conceptual model development (UK), and the present JNC's H-12 study (Japan).

Helmut Röthemeyer , Chairman

Dr. Röthemeyer read physics and reactor technology at the Technical University of Aachen (Germany) and the University of Bristol (United Kingdom) and concluded his studies with a diploma in physics and a doctorate degree in (nuclear) engineering. After additional qualification as research reactor operator he was appointed Head of the laboratory "Reactor Operations" of the Federal Institute for Science and Technology (PTB) in Braunschweig (Germany).
From 1973 - 1977 Dr. Röthemeyer worked in the department "Reactor Safety and Radiation Protection" of the German Federal Minister for the Interior (BMI)*. Within the supervisory functions of this department he was responsible for safety-related questions concerning the concepts, sites, construction and operation of pressurised water reactors.
Since 1977 Dr. Röthemeyer has been appointed director and professor in charge - as deputy director and since 1983 director - of the department "Long Term Storage and Final Disposal of Radioactive Waste" of the PTB, and since 1989 of the department "Nuclear Waste Management and Transport" of the newly founded Federal Office for Radiation Protection (BFS).
Dr. Röthemeyer is a member of the Radioactive Waste Management Committee (RWMC) of the OECD-NEA and of the Sub-group on Principles and Criteria for Radioactive Waste Management of the IAEA for many years. He was also a member of the former International Radioactive Waste Management Advisory Committee (INWAC) of the IAEA.
Dr. Röthemeyer is editor and co-author of the book "Final Disposal of Radioactive Waste - Guide for responsible Waste Management in Industrialised Societies", VCH 1991 (in German), and,together with Prof. Herrmann, author of the book "Long-term Safe Repositories", Springer 1998 (in German).

Lars Werme

Dr. Werme holds a Ph.D. in physics from Uppsala University, Sweden, where he has also been associate professor since 1973. He has been working for the Swedish Nuclear Fuel and Waste Management Co. (SKB) on materials science issues in nuclear waste management since 1979.
Dr. Werme joined SKB in 1979 as manager of SKB's materials science research programme; a position he still holds. The research has been focussed on the chemical stability in groundwater of high level waste glass and spent nuclear fuel and the chemical and mechanical stability of waste container/overpack materials. From 1983 to 1988 he was project manager for a joint Japanese-Swiss-Swedish ("JSS-Project") for the study of the chemical durability of a radioactive high level waste glass similar to the waste glass produced at COGEMA's "Atelier de Vitrification de La Hague". From 1992 to 1998 Dr. Werme was project manager for "Canister (container/overpack) Design" within SKB:s Encapsulation Plant Project. Since 1994 Dr. Werme is editor of the Journal of Nuclear Materials.

* These responsibilities rest now with the Federal Minister for Environment, Nature Protection and Nuclear Safety (BMU)