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

03-Mar-2009

English - Or. English

NUCLEAR ENERGY AGENCY
RADIOACTIVE WASTE MANAGEMENT COMMITTEE

RWMC REVERSIBILITY AND RETRIEVABILITY PROJECT: PHASE-2 REPORT

At its March 2007 meeting, the RWMC agreed to start an initiative on Reversibility and Retrievability (R&R), with a particular focus on policy and regulatory issues. The R&R initiative is being carried out in several phases. The first phase, in 2007-2008, was the compliation of a bilbliography of references on the topic, and the second was a data gathering phase through use of a questionnaire. The questionnaire was issued to NEA member countries, in May 2008. A working group was convened and a meeting was held in Toronto, Canada in October 2008 at which the responses were analyzed. This report summarizes the discussions at that meeting and its outcomes, and it provides a progress report on the second phase. Plans for subsequent phases of the project are outlined.

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JT03260478

FOREWORD

In 2001 the NEA Radioactive Waste Management Committee (RWMC) issued a brochure[1] entitled "Reversibility and Retrievability in Geologic Disposal of Radioactive Waste". This brochure provided a framing of the issues as seen in 2001. Since its publication, international work on reversibility and retrievability has focused mainly on technological issues.

Reversibility and retrievability (R&R) appears, more and more, to be a significant issue in an increasing number of countries, and recent reflections on decision making as well as progress in the various national programmes over the last few years suggested that it would be appropriate to revise the 2001 document. At its March 2007 meeting the RWMC agreed to start an initiative on Reversibility and Retrievability (R&R), with a particular focus on policy and regulatory issues.

The RWMC R&R initiative is being carried out in several phases. The first phase, in 2007-2008, was the compilation of a bibliography of references on the topic, and the second was a data gathering phase through use of a questionnaire to elicit information on the current status of disposal programmes in member countries with respect to the role(s) of reversibility and retrievability in those programmes. The questionnaire was issued to NEA member countries in May 2008. A working group was convened and a meeting was held in Toronto, Canada in October 2008 at which the responses were analyzed. This report summarizes the discussions at that meeting and its outcomes. It also provides a review of progress in the second phase, and plans for subsequent phases of the project. This report to the RWMC was prepared by the Project Co-ordinator with the concourse of all participants in the project.

1. Reversibility and Retrievability in Geologic Disposal of Radioactive Waste - Reflections at the International Level, NEA-3140, Paris 2001.

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EXECUTIVE SUMMARY

The responses to the R&R questionnaire distributed to NEA member countries in May 2008 were found to be very helpful in illustrating areas of general agreement, areas where there are significant differences, and areas where further discussion and investigation could be useful among countries. There was general agreement that the past work in this area, in particular NEA-3140, still provides a current basis for discussion; however, there are few, if any, aspects of reversibility and retrievability that might be considered to be routine.

One of the key general responses noted was that reversibility and retrievability are two separate concepts. The term retrievability is fairly commonly used, and follows the definition in NEA-3140. It is generally used to describe retrieval of waste packages, generally containing HLW or other long-lived wastes from deep geological disposal facilities, usually only for pre-closure stages, but the scope is sometimes extended either to other waste categories (for example, wastes that may be disposed of in near-surface facilities) or to other time periods (e.g. for a limited period post-closure).

The term reversibility is less widely used as a term, except for France and Switzerland. The concept of reversibility of decision-making is referred to in many countries, often using different terminology (e.g. adaptability, flexibility). The difference in terminology may be driven by the fact that reversibility implies only going backwards, whereas other terms allow not only for reversal but also for a revision or re-adjustment of earlier decisions and may permit changes in direction as well. On the other hand, it may be the possibility of reversal of decisions that is of specific interest to the general public and politicians in some countries. Reversibility can also be considered as good engineering practice (step-wise, modular design; avoiding making irrevocable steps sooner than necessary during the process). *The concept and terminology for reversibility or adaptability may merit further investigation.*

There was general agreement that as the retrievability and reversibility project matures, it may be better to deal with the two terms separately and avoid combining them. Thus, based on the responses to the questionnaire, the following definitions could be used during the project to better distinguish the concepts:

- Reversibility: refers to the ability to potentially reverse decisions or processes;
- Recoverability: refers to the ability to potentially recover emplaced material;
- Retrievability: refers to the ability to potentially retrieve entire waste packages;
- Retrieval: refers to the actual action of retrieving waste packages.

The retrievability concept was generally incorporated in a number of countries in response to legal requirements which may have been dictated at times by social (political, public) pressures. In countries where programme development has not yet reached a point where there is significant public discussion, there is interest expressed within the technical community to discuss reversibility and retrievability. This interest may be triggered by observing what has happened elsewhere (i.e. in anticipation of future societal pressures).

In some countries, social pressures for reversibility were more directed towards avoiding irreversible steps rather than of specifically requiring ease of reversibility. In addition to access to resources and the ability to confirm repository performance, it appears that the strongest motivations for such social

pressures may include unfamiliarity with (or lack of confidence in the maturity of) the technology and discomfort with the concept of purely passive safety without any means of control, as well as a desire to avoid making decisions today that might preclude different actions in the future. It is also possible that part of the motivation for reversibility may be simply to recognize the perceived need for ongoing monitoring and control even after closure.

Step-wise decision-making (see NEA-4429)[2], including some aspects of reversibility as defined in NEA-3140, is an area that could benefit from continuing study. This includes the relationship between reversibility and licensing. It was noted that many programmes do not yet have processes for stepwise decision-making worked out in detail, nor an outlined methodology and principles for stepwise decision making and related public consultation, even in cases where a stepwise approach is national policy. It was felt that this is not necessarily a negative observation - designing a detailed process too far in advance of when it will be used is probably not appropriate. The general principles should, however, be clear from the beginning.

Communication on disposal issues is confirmed to be difficult because of the great disparity between geological time scales and human or social time scales and because of the uncertainty that must be communicated when describing potential impacts that may only occur in the far future. There is a tendency among many non-technical stakeholders to look for absolute yes/no answers and to have difficulty understanding statements about consequences that involve low likelihoods of occurrence. *This is a topic that will no doubt undergo development in most countries.*

It was noted that monitoring as a design tool for performance confirmation, to provide feedback during the construction and operation phases, is quite different from monitoring to detect post-factum gross environmental consequences of failure. Designers tend to focus on the former and non-technical interlocutors on the latter. This difference may give rise to misunderstandings, miscommunications, and unrealistic expectations. *It is expected that the subject areas of monitoring and performance confirmation will continue to develop as repository programmes are implemented. This is an area where R & D is likely to be needed.* This is also an area that the FSC has identified a need for stakeholder dialogue and involvement.

The Andra R&R "scale" was discussed during the meeting. It was felt that such a scale should focus on retrievability during repository development, or alternatively on the relative increase in passivity (vs. the need for active management), since the end-point of a passivity scale is a desirable state that all programs want to achieve. A simple proposal with relatively few attributes to be considered would be preferred over a complex one. A small task group was formed that will investigate this further[3] and make a more detailed proposal to the R&R working group at its next meeting (in June 2009).

Other planned future activities include: a review of NEA-3140 in light of the questionnaire responses with a view to deciding whether it needs updating and if so, how best to go about it, and a study of some relatively advanced programmes where reversibility and retrievability no longer appear to be major issues (USA, Sweden and Finland) in order to complete the understanding of the drivers for R & R issues. *It may be that retrievability and reversibility play a more important role during the early stages of development of a programme than they do once a programme moves into implementation.* There may be a parallel here with the role of natural analogues, as observed at a recent topical session of the FSC.

With respect to the scope of the project, there was general agreement that work should focus on wastes that are not suitable for near-surface disposal (notably HLW and spent fuel), although there may be some aspects where practices with respect to other wastes may also cast some useful light. It was also

2. Stepwise Approach to Decision Making for Long-term Radioactive Waste Management – Experience, Issues and Guiding Principles, NEA-4429, Paris 2004.
3. The Task Group held its first meeting in early February 2009.

agreed that it would be helpful to discuss the application of retrievability separately for post- and pre-closure situations. It is important to be aware that the ease of retrievability may decrease significantly at or near closure, and that this may have an important impact on discussions of retrievability and related design provisions.

PHASE-2 REPORT

Historical Background

Since the publication of the NEA brochure (NEA-3140) in 2001, international work on reversibility and retrievability has focused mainly on technological issues. There has been relatively little international work related to policy or regulatory aspects of R&R. Though policy issues related to reversibility and retrievability are currently prominent in a number of countries, regulatory guidelines on requirements for reversibility and retrievability do not yet exist in many countries.

An advisory group on reversibility and retrievability met in connection with the RWMC Bureau meeting in Washington DC in November 2007. Under guidance from the Bureau, the advisory group was tasked to develop the project on reversibility and retrievability. The work would include the development of a questionnaire to focus input from the Member countries on policy and regulatory issues. The questionnaire (see Annex 1) was distributed to Member countries on 20 May 2008, with a request that responses be provided by 15 August. Member countries were also invited to nominate members for a reversibility and retrievability working group. Thirteen responses were received during this time period.

The first meeting of the reversibility and retrievability working group took place in Toronto, Canada on October 8-10, 2008. During the meeting, the responses from thirteen member countries were discussed and proposals for further work were considered. The meeting was very successful. A way forward plan was approved. As part of the plan, the present draft report and analysis of responses was prepared in advance of RWMC-42, for distribution to RWMC members in February 2009. Detailed accounts of the discussions during the sessions at the Toronto meeting are given in Annex 2, and a compilation of the responses to the questionnaire (responses from two countries have been added since the Toronto meeting) can be found in Annex 3.

Responses to the Questionnaire

The questionnaire responses were very helpful in illustrating both areas of general agreement and areas where there are significant differences among countries. The discussion on the historical development of the concept within different programmes touched on many aspects that also arose during later discussions.

Areas of General Agreement

It was agreed that the subjects of reversibility and retrievability are deserving of continuing study, particularly as regards policy and regulatory aspects. Adaptive stepwise decision making processes and the interaction between retrievability and licensing were felt to be two aspects of particular interest.

There was also agreement that the past work in this area, in particular NEA-3140, still provides a current basis for discussion. Most of the issues that were open questions at that time are still open and there are few, if any, aspects where the situation is not still changing in at least some countries.

It was unanimously agreed that both long-term and short-term safety must not be compromised by the incorporation of design provisions for retrievability or decision making processes for reversibility.

It was noted that all programmes are working towards the goal of a final management condition for wastes without any intent to retrieve, in keeping with the definition of disposal in the Joint Convention. However, the lack of intent to retrieve does not preclude the inclusion of features that might facilitate retrieval in the future, should intentions change. In current programmes, waste is practically never completely irrecoverable, albeit possibly at great effort and expense. So in a sense the retrievability question is one of degree rather than of the presence or absence of a possibility to recover the waste. It was recognized that any repository programme will be developed over several decades, and that changes should be expected during such a protracted process. The existence of a long-term plan today cannot pre-empt the possibility that future generations may decide to follow a different path or take different decisions. This is one fundamental argument behind incorporating provisions for retrievability, as well as for maintaining information and memory about the repository and its contents.

Retrievability of waste packages is important to many stakeholders. In addition to access to resources and the ability to confirm repository performance, it appears that the reasons for this may include unfamiliarity with (or lack of confidence in the maturity of) the technology, a greater degree of trust in observations as compared with predictions or analysis, and discomfort with the concept of purely passive safety without any means of control or maintenance, as well as a desire to avoid making decisions today that might preclude different actions in the future. A number of these drivers are likely to decrease as the level of familiarity and trust in a programme increases over time, and an extended period of control may increase willingness to accept passive/intrinsic safety as familiarity grows.

It was also noted, however, that in some geological settings there are practical limitations to ease of retrievability of intact, handleable packages, and that as time goes on retrieval may only become feasible in the more limited sense of re-mining of wastes that would need considerable processing before they could be conditioned or repackaged, whether for further use or for alternative management methods. In the UK, the CoRWM study suggested the use of the term recoverability for the more limited sense of re-mining wastes after closure, but this distinction was not adopted in the Government's response.

Thus, retrieval itself may be somewhat more problematic that retrievability. It may be worthwhile to investigate some of the technical issues related to pre-closure retrieval in more depth. However, with respect to recovery of wastes post-closure, the spectrum of possibilities is very wide and it was felt that putting too much emphasis on demonstration of retrieval techniques for such speculative situations could be inappropriate.

Areas of Significant Differences

With respect to reversibility, there was some feeling expressed that the term is limiting, since it implies that the only option to moving forward is to reverse directions and backtrack, whereas one of the characteristics of an adaptive step-wise approach might be that the programme might change directions without actually reversing. For this reason, terms such as adaptability and flexibility are used in some programmes. These terms recognize the possibility that a design can be modified to reflect changing needs and intentions. On the other hand, the term reversibility may imply a greater degree of robustness/resilience, in that a reversible process is *a fortiori* also flexible and adjustable.

Areas for Further Discussion and Investigation

The discussion concluded that *retrievability and reversibility are separate concepts and should each be investigated on its own merits*. Retrievability, as defined in NEA-3140, is a concept that appears in many programmes, whereas the terminology of reversibility is less commonly used, and appears to show greater variability between countries and programmes.

It is suggested that the following definitions could be used during this project:

- Reversibility: refers to the ability to potentially reverse decisions or processes.

- Recoverability: refers to the ability to potentially recover emplaced material.
- Retrievability: refers to the ability to potentially retrieve entire waste packages.
- Retrieval: refers to the actual action of retrieving waste packages.

Depending on the host geology and the design concept, incorporating retrievability provisions may have safety implications that could be important for design, but as a general rule it was felt that retrievability provisions can be incorporated into most designs with only limited impact on safety. It was noted, however, that *in the case of spent fuel the concept of retrievability may be in conflict with the safeguards goal of "practicably irrecoverable" condition for the waste. This topic appears to be evolving and is worthy of further investigation.*

Many, but not all, programmes associate the concept of reversibility more closely with decision making processes than with technical design provisions. In general, it was felt that the subject of decision-making processes is one that will continue to develop and grow in importance as programmes approach the initial stages of implementation, and that building bridges through communication will be a key enabler for the success of many programmes. It was agreed that further development of the FSC's *investigation into stepwise decision making, and in particular further studies of how stepwise decision making relates to reversibility and to retrievability, could be fruitful*.

The working group agreed that a review of NEA-3140, with a view to deciding whether it needs updating in light of the responses to the questionnaire and other recent developments, would be a necessary next step. Such a review could provide insight into current issues as well as into how a future publication might be developed.

It was noted that some programmes, notably the Swedish and Finnish programmes, which are in a relatively advanced state of development, appear to be less "stressed" on issues of reversibility and retrievability than other programmes that are still in the approval of concept phase. It is possible that this is related to the degree of familiarity with the topic, and to the fact that decision making processes are better developed in programmes that have reached a more advanced stage. *It was agreed that this subject was deserving of further investigation by the working group*.

With respect to the scope of future discussions, it was agreed that the focus should be on wastes that are not suitable for near-surface disposal. This includes high-level wastes and spent fuel (where that is considered to be waste), as well as some long-lived low- and intermediate-level wastes that are not good candidates for near-surface disposal.

In general, decision-making processes related to reversibility have not yet been developed in most countries. It was noted that in a stepwise decision-making process not all steps, let alone decisions, can be recognized/pre-determined in advance. In fact there are often more steps than envisaged initially. Therefore it is probably not appropriate to try to specify stepwise decision making processes too exactly, particularly during the early stages of programme development.

It was noted that monitoring is likely to be an aspect of continuing interest to stakeholders as well as to developers and regulators. Monitoring as a design tool for performance confirmation, to provide feedback during the construction and operation phases, is quite different from monitoring to detect gross environmental consequences of failure, but communication on this topic without raising false expectations is likely to be problematic. There are also likely to be quite significant differences between monitoring before closure and post-closure, both for technical reasons and because the use to which the monitoring results would be put will change. Monitoring post-closure has links to preservation of information, markers and institutional control issues as well. The role of monitoring appears to be an area where further work, including research and development on monitoring techniques, is likely to be needed.

The regulatory expectations of monitoring should also be clarified. The concept of monitoring after emplacement of wastes is closely linked to the concept of control as an important aspect of safety. In fact, as long as safety authorities continue to exist, it seems unlikely that controls and monitoring would be entirely relinquished. Descriptions of disposal that focus on passive safety and lack of a need for control or monitoring in fact run counter to this concept, and it is possible that part of the motivation for reversibility may be simply to recognize the perceived need for ongoing monitoring and control even after closure.

However, it was also recognized that there may be lessons to be learned from past experience with near-surface disposal, and that this experience should not be excluded in such cases.

It was noted that, because of its potential as a resource as well as safeguards and security issues, spent fuel may deserve special consideration and need to be treated somewhat differently than other high-level wastes.

It was felt that retrievability aspects post-closure, as well as pre-closure, were deserving of attention, as were some of the questions that arise when considering the act of retrieval (as distinct from the design of retrievability provisions). Retrieval takes place only after wastes have been emplaced, whereas retrievability is primarily a design consideration that can and should be addressed as early as possible during the process of design and development. If all of these aspects are discussed, it will be important to make clear the distinctions between them in order to avoid confusion.

Additional points

A number of additional points were raised as useful contributions or starting points for future discussions. Rather than run the risk of losing them, some of the more interesting ones are captured below, in no particular order:

- The link between the optimization process and stepwise decision making deserves further investigation. Is optimization only a technical matter? If retrievability or reversibility is part of a repository concept, what role do they play in the design optimization process?
- Is there a significant difference between programmes in which reversibility is an important component and programmes where it is not?
- Financial aspects of retrieval remain to be investigated. Is the purpose of retrievability provisions to support and/or demonstrate the feasibility of retrieval of waste packages in case a future society decided it wanted to retrieve, or must retrieval operations be planned, costed and funded now even in the absence of definite plans to actually retrieve? For how long?
- If retrievability is a key aspect of a programme, should there be a demonstration of actual retrieval? Do the regulatory requirements applicable to retrieval need to be elaborated in advance?
- How should we go about treating extreme scenarios? How well-prepared do we need to be for such scenarios? For example, should facilities be built in view of potential retrieval even if retrieval is not actually yet planned? Even if facilities are not built, should contingency funds be set aside?
- With respect to funding both for retrieval and for extreme scenarios, a parallel with decommissioning was noted. Decommissioning funding as required in most countries must include funding for foreseen activities and costs, but it is not required to set aside specific funding for unlikely contingencies.
- There may be new insights to be gained if a parallel reflection is made between the issues and requirements that retrievability raises and those issues and requirements already experienced for decommissioning.

- Ethical aspects: ethical arguments that have been discussed in the broader context of disposal also have a bearing on questions of retrievability and reversibility. For example:
  - Should all generations to come have identical rights? Is this possible? Or should reducing real dangers to the close generations be considered to be more important than reducing potential risks to generations in the very distant future? Whatever the answers, how do they affect decisions on reversibility and retrievability?
  - We may recognize basically equal rights for all generations, but also recognize that our ability to deliver is not equal on all time scales. Do reversibility or retrievability provisions enter into this? Are they primarily only applicable to a relatively few generations to come, i.e. beyond a few immediately succeeding generations, do retrievability and reversibility have any significance?
- At this stage, we have said very little on R&D for retrievability and reversibility (as a decision-making concept). This is a topic for future development, and at some point perhaps a platform for exchange should be created.
- Reversibility may add to the quality of the decisions, of the design, and ultimately safety, i.e. it is a good engineering and management practice. Reversibility (in the NEA sense) is intrinsic to most regulatory frameworks. The mere fact of being subject to decisions made by a separate organization may mean that one must be adaptable and, if needed, able to reverse previous steps.
- If retrievability is envisaged, there may be advantages if a period and boundary conditions are specified. This is certainly helpful for making a plan.
- In one particular case, a change of design to include retrievability improved safety through the addition of a new barrier (Spain)
- Providing for retrievability through design optimization may not necessarily increase costs (UK)
- Social viability has cost advantages. Implementing retrievability may help social viability of programmes (reduces risks to programme development)

Reversibility Scale

During the working group meeting in Toronto, Andra presented a concept for an international scale on "Reversibility". The scale is currently in an early stage of development, and several examples were illustrated for how it might be organized and applied.

The following is a summary of the highlights from the technical discussion on the scale:

- A scale could either include predisposal waste management, or be focused only on disposal. There was some sense of greater interest in a focus on disposal.
- A scale could be presented in a number of alternative ways: as a life-cycle chart for a repository (e.g. for illustrating program plans); as a retrievability scale; or as a passivity / passive safety scale.
- The passivity approach has the value that the end-point of the scale is a desirable state that all programs want to achieve, whereas there is not uniform interest among all programmes in communication about retrievability.
- As a life-cycle chart, a scale could be used for showing the difference between alternative planning options, or for how a program has evolved over time, or possibly for demonstrating the influence of different geologies on a DGR facility.

- A scale approach should be associated with the decision making process and should be also easy to explain and to understand by different stakeholders. Therefore a simpler scale approach, with fewer attributes, was felt to be preferred over more complex scales.
- This is an area where there may be interest from the IGSC and the FSC.

Way forward

The next meeting of the working group is planned for 2-4 June 2009 in Paris, France. In preparation for this meeting, a number of actions will be undertaken, including:

- A review of NEA-3140 with a view to deciding whether it needs updating, and if so how to proceed
- Further development of the reversibility scale approach by a small task group
- Potentially, a review of the Swedish and Finnish programmes, which have now reached a relatively advanced state but in which reversibility and retrievability do not appear to have the same importance as they do in a number of other less advanced programmes (Canada, France, UK, …). Which are lessons to be learned?

It is expected that in addition to following up on the above actions, the working group meeting will also consider issues such as terminology/definitions, stepwise decision making processes, the role of monitoring, safeguards, the interaction between retrievability and the operational period, and initial planning for the proposed conference on reversibility and retrievability in 2010.

It is expected that the work on this project will involve a number of other groups and audiences. The working group has not developed the aspects of most interest to the Integration Group for the Safety Case (IGSC) at this point, but it is anticipated that as the scale concept develops and as additional technical issues are raised, there will be more interaction with the IGSC. Additionally, it is anticipated that the Forum on Stakeholder Confidence (FSC) will probably be asked to participate more fully, particularly in areas such as stepwise decision making and social aspects of reversibility and retrievability. This draft report will be distributed to the IGSC, INTESC, and FSC for comment.

Other groups, such as the Swedish National Council for Nuclear Waste (KASAM), who have been working on societal and ethical issues, could also contribute usefully, and consideration will be given to including them in plans for the 2010 conference. The International Experiences for Safety Cases (INTESC) questionnaire responses need to be integrated into the work of the reversibility and retrievability working group.

Annex 1

THE RWMC REVERSIBILITY AND RETRIEVABILITY PROJECT QUESTIONNAIRE AND GUIDELINES

At the Topical Session on Reversibility & Retrievability at RWMC-41 in March2008, it was agreed that the guidelines/questionnaire that were presented at that session would be revised in response to comments at the session and distributed to all Member countries. The revisions have been completed, and the revised guidelines/questionnaire are provided in this document. Each Member organization (or country) is requested to provide its **response to the Secretariat by 15 August**, in order that the project working group can analyze the responses and begin drafting its report on the role of R&R in Member countries' disposal programmes.

Member organizations are also invited to nominate representatives to join the working group for this project. **Nominations should be sent to the Secretariat, Claudio.Pescatore@oecd.org and John.Stein@oecd.org by 15 August at the latest.** Nominations before 15 August are appreciated.

The first meeting of the working group will be held in Toronto, Canada on October 8-10 2008.

Guidelines

Purpose of the questionnaire

The purpose of the RWMC questionnaire is to obtain information about the concepts of reversibility and retrievability as they apply in various national programmes for the long-term management and disposal of radioactive wastes. The results will be used as input to a comparative study on reversibility and retrievability in NEA member countries, whose goal is to further develop and update the findings of the 2001 NEA report "Reversibility and Retrievability in Geologic Disposal of Radioactive Waste - Reflections at the International Level" (NEA-3140, ISBN 92-64-18471-6).

Scope of information

We are looking for information on how these terms or closely related terms are used in your country, how they are applied within national programmes for radioactive waste management, and how the current situation developed historically. We are also looking to better understand how the concepts are applied in policy making, regulation, implementation and public communication, and what factors led to their adoption and/or influenced their application.

If the concepts of reversibility and/or retrievability play an important role in decision making (e.g. in a stepwise decision making process), we would like to elucidate the relationship between the concepts and the decision making process.

Focus

The focus of the study is on geologic disposal, specifically for high-level radioactive waste, long-lived intermediate-level radioactive waste and spent nuclear fuel if it is disposed of as waste.

The study will also take into consideration any (optional) related information that member countries choose to provide on how reversibility and/or retrievability may affect programmes for disposal of other types of radioactive waste.

Terminology

For the purpose of this study, we use the following key terms:

- *Reversibility*, meaning the ability to reverse decisions or processes;
- *Retrievability*, meaning the ability to retrieve entire waste packages;
- *Recoverability*, meaning the ability to recover emplaced materials.

Guidance for responding

As guidance for the expected responses, we have posed a few broad questions. Each broad question is further illustrated by one or more questions at a more detailed level. However, in order to avoid biasing or limiting the results by the specific questions asked, it is not intended that the questions be prescriptive or that the answers respond only to the questions given. If some of the questions do not seem applicable to your country's programme, please do not constrain your responses to fit the questions. If there is information relevant to reversibility and/or retrievability in your country's programme that is not addressed by these guidelines, we hope that you will feel free to supply it even if it is not directly related to one of the questions we have posed.

If possible, we would like to know how the concepts of reversibility and/or retrievability impact your country's national programme for radioactive waste management. If the terms are used and applied differently in different organizations or different constituencies (including stakeholder groups, if information is available), we would like to have information about the differences and how they arose. The objective is to obtain as complete an understanding as possible about the range of approaches/views that exist.

We are also interested in obtaining information about key reference documents for these concepts used in your country, regardless of whether they are available in English or only in your national language.

We thank you for your participation in this project.

QUESTIONNAIRE

1. Definitions and Scope of Application

Describe whether reversibility and/or retrievability are considered in your country's programme, and if so how they are defined and applied.

- If applicable, how is the terminology for reversibility and/or retrievability defined in your country? Do you use the same definitions as given in the 2001 NEA report on Reversibility and Retrievability[4]? Is retrievability considered to be a special case of reversibility or vice-versa, or are they considered to be independent concepts?
- Are there other concepts or terms relevant to the topics of reversibility and retrievability, or to related topics, used in your country's programme, e.g., the concepts of "adaptability", "accessibility" and/or "recoverability"? If so, what are they and how are they defined?
- What are the stages of repository development envisaged in your country's programme? At which of these stages are formal regulatory, governmental (local or national) or parliamentary decisions required?
- Is reversibility foreseen for all stages of repository development, only during certain stages, only for a limited period of time, or not at all? For instance do you have "reversibility" in order simply to allow accessibility, control and maintenance of repository features?
- Is retrievability of packages and/or recoverability of materials envisaged post-closure, pre-closure, only during certain stages of repository development, only for a limited period of time, or not at all? If only during certain stages, please explain which.
- If applicable, is the same terminology used for all stages of repository development, or does the terminology or its application vary depending on the stage?
- For which sites, if any, do reversibility and/or retrievability apply, i.e. are they considered generic or site-specific?
- For which categories of waste, if any, do reversibility and/or retrievability apply?

2. Historical Development

Describe the history of the development of your country's current policy with particular attention to aspects related to reversibility and/or retrievability and discuss the factors that influenced this history.

- What discussions, if any, were held on the technical, safety, ethical and social aspects of reversibility and/or retrievability both within your programme and with a broad range of stakeholders, interested individuals and organizations?
- If applicable, what role did these discussions play in the development of the programme?
- If applicable, which were the conflicting points of view and how were they resolved during the process?

4. http://www.nea.fr/html/rwm/reports/2001/nea3140.pdf. "Reversibility denotes the possibility of reversing one or a series of steps in repository planning at any stage of the programme. Retrievability denotes the possibility of reversing the action of waste emplacement"

- If reversibility and/or retrievability were considered during the development of your national programme, what were the main drivers or motivations for considering these elements?
- If reversibility and/or retrievability were considered during the development of your national programme, what reasons are now expressed for their incorporation or non-incorporation in the programme?
- Are reversibility and/or retrievability considered to be safety-related issues, economic or social issues, or a combination of issues?

3. Current Policy

3.1 General

Describe the extent of and the means by which reversibility and/or retrievability are incorporated in your national programme for radioactive waste management.

- If applicable, what is the administrative basis for this incorporation (e.g. imposed by legislation, or by the implementer in response to public concerns)?
- Even if reversibility and/or retrievability are not requirements, is it expected that their presence or absence could contribute to regulatory and political decision making? For example, might they contribute to choices among disposal options? Have you used them as such?
- If applicable, how do reversibility and/or retrievability impact upon or contribute to social acceptance?
- If at all, how do reversibility and/or retrievability requirements differ for different categories of waste?
- Do reversibility requirements, if any, vary between stages of repository development or with time? If so, please describe how.
- Do retrievability requirements, if any, vary between stages of repository development or with time? If so, please describe how.
- Have responsibilities been allocated for decision making about reversibility and/or retrievability aspects of your country's programme? If so, please describe them.

3.2 Communications with stakeholders and part of stakeholders in decision making

Describe how communications with stakeholders and their involvement in decision making are considered in your programme with respect to reversibility and/or retrievability.

- Are there communications approaches in place or planned to inform stakeholders about reversibility and/or retrievability aspects of your country's programme? If so, please describe them.
- Do stakeholders take part in decision making related to the incorporation of reversibility and/or retrievability in your programme? If so, how?
- If applicable, have responsibilities been allocated for decision making about whether to reverse steps or, if envisaged, to retrieve packages or recover materials? If so, please describe them.
- If applicable, are there communications measures in place or planned to communicate information to stakeholders about decision making related to the reversal of decisions or, if envisaged, the retrieval of packages or recovery of materials? If so, please describe them.

- If applicable, is it anticipated that stakeholders could take part in decision making related to the actual reversal of decisions, or if envisaged, the retrieval of packages or recovery of materials? If so, how would this take place and what communications measures would be used to facilitate the participation?

3.3 Stepwise decision-making

Describe the extent to which reversibility and/or retrievability are considered to be part of a stepwise decision making process in your national programme.

- Does your country's programme incorporate a staged or stepwise decision making process?
- If so, do elements of reversibility and/or retrievability contribute to the decision making process? If they do, please describe how.
- Is it anticipated that increases in the difficulty of retrieval or recovery during repository development (from one step to the following) could affect the decision making process? If so, please describe how.
- If applicable, which features are considered to characterize such increases in the difficulty of retrieval or recovery (for instance: accessibility to the disposed waste, availability of technology for retrieval, package integrity, cost or dose associated with retrieval, etc.)?
- Does keeping the repository at a given (reversibility) stage become increasingly difficult with time? How does this affect the decision making process? Which features are considered to characterize such evolution (for instance: cost or dose, etc?)

4. Practical Implementation Issues

4.1 Regulatory

Describe what regulatory provisions and processes, if any, are in place or planned to deal with reversibility and/or retrievability.

- If decision making on reversal of steps in repository development is envisaged, are there regulatory requirements applicable to this decision making?
- If retrieval of packages or recovery of materials is envisaged as a possibility, are there regulatory requirements in place that are applicable to the process of retrieval or recovery?
- If retrieval of packages or recovery of materials is envisaged as a possibility, are there regulatory provisions in place for the management of recovered or retrieved wastes?

4.2 Monitoring, demonstration, performance measures

Describe what monitoring, demonstration and performance measures, if any, are in place to support reversibility and/or retrievability in your national programme.

- What role, if any, does monitoring play in reversibility and/or retrievability at each stage, and for how long at each stage?
- What research, development and demonstration, if any, is being done or is being planned on reversibility and/or retrievability from the point of view of demonstrating the capability to retrieve packages or recover materials or to reverse decisions before proceeding?

- During staged repository development, is it anticipated that progress in reversibility and/or retrievability demonstration at each stage would support the decision making process to go to the next stage?
- What research, development and demonstration, if any, is being done or is being planned on reversibility and/or retrievability from the point of view of repository performance demonstration as an aid to decision making during later stages?
- During repository development, is it anticipated that progress in repository performance confirmation at each stage would support the decision making process to go to the next stage?

4.3 Procedural and operational issues; technical and other limitations

Describe the important operational issues (both procedural and technical) related to reversibility and/or retrievability.

Decision making process: criteria for reversal/retrieval, decision makers

- To what extent has the decision making process for reversibility and/or retrievability been defined for various stages of repository development?
- If reversibility of decision making is part of your country's programme, what criteria have been established for determining when a decision would be reversed, and who would make that decision? Does this vary depending on the stage of repository development?
- If retrieval of packages or recovery of materials is envisaged as a possibility in your country's programme, what criteria have been established for determining when packages would be retrieved or materials recovered, and who would make that decision? Does this vary depending on the stage of repository development?
- If applicable, what are the main factors expected to influence decisions on reversal of steps and/or on retrieval of packages or recovery of materials (e.g. new technology, access to resources, safety issues, cost)?

Financial aspects

- Have the costs resulting from incorporating reversibility and/or retrievability into the programme been estimated or provided for, and if so how?
- Have the costs of actually reversing decisions, retrieving packages or recovering materials been estimated or provided for, and if so how?
- If retrieval of packages or recovery of materials are envisaged as possibilities, are there provisions in place (procedures, ancillary facilities, etc.) for the management of the retrieved packages or recovered materials and how have the resulting costs been estimated or provided for?

Technical aspects

- How do reversibility and/or retrievability contribute to repository system design and what is their relationship to safety? Please describe.
- What technical (engineering, geological, safety or safeguards) limitations on the ability to implement reversibility and/or retrievability, if any, have been identified in your programme?

- To what extent do specific repository design features and/or host geology features limit the ability to implement reversibility and/or retrievability, as they affect the development of your programme?

Annex 2

THE RWMC REVERSIBILITY AND RETRIEVABILITY PROJECT DETAILED DISCUSSION OF RESPONSES TO THE QUESTIONNAIRE

A total of thirteen countries replied to the questionnaire in advance of the first project working group meeting in October 2009. Two more countries have responded since the meeting. This Annex and the table in Annex 3 include information based on all fifteen responses.

Question 1: Definitions and Scope of Application

Describe whether reversibility and/or retrievability are considered in your country's programme, and if so how they are defined and applied.

Retrievability is considered in some way, at least at a conceptual level, although not necessarily as a formal requirement, in the majority of programmes. For a number, however, this is anticipatory only, i.e. it is expected that retrievability will have a future role, even if to date it may not have been a significant issue. On the other hand, there are some programmes in which retrievability of waste has played an important role historically, and in some it has been a policy driver.

Reversibility is considerably less common as a term. If it is taken to mean the ability to undo or revisit previous decisions, it may also be contained in concepts such as adaptability, flexibility, and phased approach. During discussion at the Working Group meeting, it was suggested that the most important aspect of reversibility focuses not so much on the possibility of reversal as on the avoidance of irreversibility. To a considerable extent, reversibility relates to an attitude or culture rather than to specific measures for reversal.

In the discussion on other terminology and particularly the differences between a 'staged approach' and a 'step-wise approach', a staged approach was viewed as instituting a check point (to ensure satisfactory completion) before moving to another phase, whereas a step-wise approach allowed for backward or forward steps or for a stop or pause in the process.

From the submissions and discussions at the Working Group meeting, it was clear that terms have not been fully harmonised. Since certain terminology has been used in national policy and legislation, complete harmonisation would prove difficult. The group recognised that better understanding and agreement on terminology could not be resolved at this time, would require additional development and would need to recognise limitations on complete harmonisation.

- *If applicable, how is the terminology for reversibility and/or retrievability defined in your country? Do you use the same definitions as given in the 2001 NEA report on Reversibility and Retrievability? Is retrievability considered to be a special case of reversibility or vice-versa, or are they considered to be independent concepts?*

The term 'reversibility' is not officially used in most of the countries surveyed (Austria, Canada, Czech Republic, Korea, Finland, Germany, Hungary, Japan, Spain, UK, USA). 'Retrievability' is more commonly used in most programmes (but not in France) to refer to the ability to retrieve.

Reversibility is currently the only term used officially in France where it is stipulated as a legal requirement. In Belgium, reversibility applies to reversal of stages prior to sealing and closure. Both concepts (reversibility and retrievability) are present in the Swiss programme.

Reversibility as defined in the NEA-3140 document, relating to reversibility of decisions, is present in some programmes even if the term reversibility is not used. Other terms used include: adaptability; flexibility; phased geological disposal; and performance confirmation.

Retrievability was considered by most to be simply the "ability to retrieve", and is often limited to pre-closure phases.

- *Are there other concepts or terms relevant to the topics of reversibility and retrievability, or to related topics, used in your country's programme, e.g., the concepts of "adaptability", "accessibility" and/or "recoverability"? If so, what are they and how are they defined?*

The term 'reversibility' is less used across programmes than retrievability, and terms other than 'reversibility' have been used in several programmes. "Adaptability" is used in the Canadian programme as the "capacity to adapt to changing knowledge and conditions over time". "Phased or stepwise disposal process" in Belgium reflects a "phased activity spread over a long period of time, with clearly defined steps and a number of decisions marking the transition to the next phase. "Phased geological disposal" in the UK programme is identified as "sequential phases of development that lead eventually to the sealing and closure".

- *What are the stages of repository development envisaged in your country's programme? At which of these stages are formal regulatory, governmental (local or national) or parliamentary decisions required?*

A consolidated view of stages of development proves difficult at this stage. The responses varied, some responses reporting the stages of development as technical phases (e.g. waste emplacement) and other responses referred to licensing decision phases (e.g. licence for operation). Broadly speaking, technical stages include conceptual development, site preparation/siting, repository construction, operation and emplacement, closure and decommissioning of surface facilities, and post-closure. Decision steps may apply to any or all of these, and sometimes to intermediate stages as well.

- *Is reversibility foreseen for all stages of repository development, only during certain stages, only for a limited period of time, or not at all? For instance do you have "reversibility" in order simply to allow accessibility, control and maintenance of repository features?*
- *Is retrievability of packages and/or recoverability of materials envisaged post-closure, pre-closure, only during certain stages of repository development, only for a limited period of time, or not at all? If only during certain stages, please explain which.*

The phases over which retrievability and reversibility applied were generally limited to the pre-closure phase, but a few countries refer explicitly to the capability for removing wastes post-closure.

- *If applicable, is the same terminology used for all stages of repository development, or does the terminology or its application vary depending on the stage?*
- *For which sites, if any, do reversibility and/or retrievability apply, i.e. are they considered generic or site-specific?*

The responses on scope of reversibility and retrievability relative to sites advised that it was applied generically and was not site-specific.

- *For which categories of waste, if any, do reversibility and/or retrievability apply?*

The types of wastes considered generally applied to higher active wastes (e.g. HLW/SF) and long-lived wastes to be disposed of in deep geological repositories. Wastes in near surface disposal facilities are not normally considered. However, there is experience with the application of retrievability to a near-surface LILW disposal facility in Spain, where measures to facilitate retrievability were implemented.

Question 2: Historical Development

Describe the history of the development of your country's current policy with particular attention to aspects related to reversibility and/or retrievability and discuss the factors that influenced this history.

In the questionnaire's national answers, a wide range of different histories is evident, ranging from countries where reversibility and retrievability considerations have played little role so far to countries where it has been a major driver. Reversibility and retrievability considerations have played a major role in several countries (notably Canada, France, Germany, Switzerland, and the United Kingdom), and in those cases it has generally been socially motivated, e.g. public reaction to initial proposals for geologic repository concepts has led to the incorporation of reversibility, retrievability or related features (adaptability, phased approach) into the programme. In Finland retrievability appears to have played a larger role in the past than at present; in Germany it has played an important past role and it is expected that it will play an important role in the future. In Spain the retrievability concept emerged in the 80´s in association with the development of the El Cabril near surface disposal facility for LILW.

A reason behind this requirement may be that the people want controls and flexibility, which might indicate that it does not trust today in passive solutions. R or R probably reassures the public that controllability, accessibility, and repairability for the whole facility are not overlooked during development and implementation. Reversibility is about showing a sound approach to engineering and to decision making.

The hypothesis of a lack of confidence of the politicians in the work of the technicians on a sensitive subject was also raised.

A number of other programmes, including many where proposals have not yet reached the stage of widespread public debate, view reversibility and/or retrievability in an anticipatory sense (these have not been significant issues in the development of the programme to date, but it is anticipated that they may become important issues during future decision making). Depending on the programme, it may be anticipated that reversibility may be more important than retrievability or vice versa.

- *Are reversibility and/or retrievability considered to be safety-related issues, economic or social issues, or a combination of issues?*

The relationship between R&R and safety appears in the questionnaire's answers in two main ways: One is as a motivation, i.e. concern about the possibility that safety-related problems may develop necessitating retrieval of the wastes. The second is the observation that retrievability provisions, particularly if they were not incorporated from the beginning, could negatively impact safety as well as cost. This is quite often expressed in requirements that any such provisions must not have a negative impact on safety.

In principle, some degree of retrievability of waste packages can be provided during the operational phase without affecting the long term safety. Two national programmes (France and Switzerland) have

successfully integrated retrievability in their designs, as shown in peer reviews. The Finns have also done so. The three concepts are quite different.

In the Czech Republic, the optimization of the repository is a priority, and retrievability does not correspond to this optimization.

Some countries need to close disposal rooms as soon as possible, to limit perturbations in the host rock, which is not the case in some other programs. This may be a function of the host rock or the type of waste.

There is a consensus that provisions in the design to enhance retrievability or reversibility would have only limited impact on long term safety. However, these provisions may imply a need to study additional transient situations, sometimes with complex processes and interactions, which increases the need for research and simulations.

Along with long term safety, operational safety is also to be considered. It was suggested to add security as well.

The question of safety of retrieval also arose. In some countries this safety has been studied, particularly in the early stages of the repository management.

Passive safety provides robustness against uncertainties in societal evolution. Some have emphasized that control is difficult over long periods of time. Stability of society over thousands of years is difficult or impossible to assess. In this sense the debate between retrievability & reversibility vs. passive safety refers to a debate between the confidence in the stability of institutions vs. the confidence in geology.

It was also mentioned that long term time scales are difficult to discuss with the public. We need more maturity to understand passive safety, and a progressive approach would help.

In some responses to the questionnaire, R&R would constitute an economic burden, in other countries it is considered that adding provisions for R & R will not.

A potential economic benefit of retrieving waste was discussed. In particular is the preservation of retrievability of spent fuel wanted for economic value? It seems that the motivations for retrievability include economic reasons only rarely. For example, in Canada it has been estimated that it would be more economic to mine new uranium than to retrieve waste from a backfilled repository.

In most cases, the economic issue is not so much for the benefit of value of waste, but the value of the program.

The Spanish experience indicates that provisions to enhance retrievability in the El Cabril repository have increased the cost, but included the incorporation of an additional safety barrier.

R&R may also add economic benefits. For instance some expenses are delayed, making it possible to benefit from growth of funds; to leave options open offers potential opportunities for future optimization of the repository including its costs.

Nevertheless it is hard to predict what the economics will be in the long term, for instance when considering a cost-benefit analysis for the future.

In the Questionnaire's answers, no one says R and R is unethical. Some cite ethical principles as reasons for incorporating retrievability or reversibility.

Providing reversibility allows for opportunities of choices for the future generations, typically generation 3 or 4 from now.

The decrease of opportunities with time was also mentioned. Therefore a tool to describe this evolution of reversibility in time would be suitable.

Also the question of funding future opportunities arose: Do we have to provide the funds today for something that may not happen?

The vocabulary used in different countries to qualify the emplacement of waste in underground geological formations may be an indicator of various R&R relating histories. In Canada, NWMO does not use the term "disposal". In France the term "stockage" is used, and disposal is more a term used by opponents (enfouissement). The Swiss use long term monitored disposal instead of final disposal. But in Belgium, the term disposal is used to underline that there is no intention to retrieve the waste.

There is no desire to build a repository whereby waste is specifically made irretrievable. In fact if that was the goal, this goal would not be achievable. Waste is always recoverable through mining techniques. The question becomes then the degree of retrieval easiness we may want to provide for as function of time and repository phases.

Question 3.1: Current Policy - General

Describe the extent of and the means by which reversibility and/or retrievability are incorporated in your national programme for radioactive waste management.

There is a wide variation in the responses. Reversibility or retrievability is a formal or primary component of the national programme in a few cases (e.g. France, Switzerland, US); although not formally required, it has had an important impact in some others (e.g. Canada, UK). There seems to be no clear consensus on the role of R&R.

There was some difference of view as to whether incorporating reversibility and retrievability considerations early or late in the process would make a substantive difference to the design of the repository. There was some feeling that incorporation of these considerations would lead to a more 'robust' or upgraded design, for instance stronger containers. However the contrary view was also expressed. There was some feeling that any changes necessitated in the design of a repository to address these considerations would be made anyway through the normal course of engineering.

It was suggested that designing a repository to maximize safety may not, on its own, lead to the inclusion of reversibility and retrievability.

The suggestion was made that all programs already incorporate, to a degree, reversibility in normal flow of engineering work even if it is not a formal part of the repository program. We all make decisions in steps and need to demonstrate to ourselves and regulators the appropriateness of our action at multiple points along the way, any of which may require re-thinking and going back to a previous step.

The suggestion was made that coming at the question from the opposite perspective, if one had to turn a non-reversible design into a reversible design, many changes would be required.

The point was raised that incorporating reversibility and retrievability brings with it some specific implementation related requirements, especially with respect to monitoring. What is to be monitored, how is the monitoring to be conducted and for how long? For instance does the incorporation of R&R require the construction of a pilot facility, with sacrificial canisters, as has been identified in the Swiss

program? If so, such a facility would need to be incorporated into the design of the repository facility early on.

The question of whether reversibility and retrievability demand different design/plans requirements with respect to long term institutional control, records and markers was also raised. There was some feeling that irrespective of whether a program is incorporating R&R, records and markers at least would be important for safety and to minimize risk of inadvertent intrusion.

There was some exploration of the question whether reversibility and retrievability ought to be incorporated in programs irrespective of whether it is required in law or regulation. Included in this discussion was the observation that reversibility and retrievability have come on to the agenda in many countries because of public demand and political concerns rather than to satisfy technical and/or regulatory issues or needs. In some programs, such as the French program, reversibility and retrievability are requirements from stakeholders and the design of the repository must be able to demonstrate that it is appropriately addressed.

There was some discussion that R&R would and should not be addressed unless they are entrenched in legislation or regulation as their inclusion may compromise the safety and integrity of the system. Conversely, there was some feeling that voluntary incorporation of these considerations early on would create greater flexibility and make it easier to respond to changes in regulations and/or legislation which may occur in the future.

The observation was made that even if one had not included reversibility and retrievability in the initial concept, it may become a requirement during the site selection process. It may be demanded in the future (through public or stakeholder demands or via legislated requirements).

Question 3.2: Current Policy - Communications with stakeholders and part of stakeholders in decision making

Describe the extent of and the means by which reversibility and/or retrievability are incorporated in your national programme for radioactive waste management.

In most countries, this is covered by existing stakeholder consultation requirements, or it is expected that communications programmes will be put in place as the disposal programme proceeds to siting. In Canada and the UK, the reverse has occurred; consultations with stakeholders have taken place in advance of the siting process.

The suggestion was made that the origin of the requirement for including reversibility and retrievability in a national program should influence the approach to stakeholder communication. For instance, if the incorporation of these considerations is driven by social reasons, then it would be inappropriate to focus on discussion of the technical reasons in stakeholder communication.

It was suggested that reversibility and retrievability need to be defined not by engineers alone, but in negotiation with the social side.

There was some feeling that reversibility and retrievability are not requirements which should be raised and discussed with the public. There was some contrary feeling that if these subjects are not raised early with stakeholders, stakeholders will raise them later in the process, for instance during siting. The comment was made that in some countries it is not a choice, if the waste organization does not go out to discuss R&R proactively with stakeholders the stakeholders will approach the waste organization insisting on a discussion of these issues.

A cautionary comment was made that our communication about reversibility and retrievability with respect to spent fuel not be confused with low level waste and vitrified high level waste, for which reversibility and retrievability would have very different issues and implications.

A caution was expressed that communication with stakeholders on R&R need to avoid being disingenuous and creating false hope through an over –accommodation of what the public has said and expects. For instance, it might be considered disingenuous to say that partitioning and transmutation holds substantial promise for the future, given there is no scientific reason to believe this is the case. This gave rise to a broader discussion suggesting the concern that in the eyes of the public and society at large it is impossible to prove today that 100 years from now transmutation will never be possible. This is because we cannot predict what science can do one century from now. "As engineers, we cannot prove that one day it would not be possible to do this."

Similarly, it was suggested, that it is impossible to prove the repository will always be the best way to manage the waste, thus giving rise to the need for flexibility and adaptability.

There was some discussion concerning why there might be a social requirement for reversibility and retrievability in some countries. The discussion included the observation that although the engineers in the waste programs have high confidence in the safety of the repository, some stakeholders may not have developed this level of confidence or trust. Rather than waiting until there is full trust in the repository concept before beginning to emplace waste, in a step wise process, trust and confidence can be built one step at a time as the waste organization and stakeholders move together through the process. The question of whether the process needs to be reversed needs to be addressed at each step in the process. And with each step there would be a changing degree of retrievability and reversibility until the repository is closed. It is possible that once the program is at the point of emplacing waste, trust will have been built in the repository system, through the process of implementation, and the need for retrievability will diminish.

It was suggested that retrievability might be considered a type of 'control switch' which is negotiated with stakeholders as a license to proceed with a program.

Given the large amount of resources required to investigate a site, it was suggested that the waste organization needs to make sure the site is investigated effectively to determine its suitability.

The comment was made that even once the reversibility and retrievability concepts are designed, confirmation is still required that the particular design is in fact what people want – that is it meets the societal need. It was also suggested that the concept would likely have to evolve over time as part of an iterative process in which adjustments are made in response to public comment to ensure designs continue to be socially acceptable.

In addition to involving stakeholders, the importance of involving regulators in the technical development work was also underlined.

There was general agreement that there is value in having "the rules" (regulatory requirements) clear from the very beginning so these can be taken into account at the repository design stage.

Question 3.3: Current Policy - Stepwise decision-making

Describe the extent to which reversibility and/or retrievability are considered to be part of a stepwise decision making process in your national programme.

Most countries have some degree of stepwise processes for implementation of a deep geological repository for spent nuclear fuel or high-level radioactive waste. Generally, the stepwise implementation process is linked to the regulatory review and approval process within the country.

Reversibility and retrievability are being discussed in several national radioactive waste management programmes, both at the conceptual level and at a more practical implementation level. However, a detailed description of the decision-making process has not been prepared for national programmes since the process will invariably depend on future outcomes and future learning which cannot be well known at earlier stages of repository implementation.

The stepwise implementation process includes reversibility. The process of reversibility is implied during the scientific development of a deep geological repository. Therefore, reversibility and the special case of retrievability of spent fuel or high-level radioactive waste are inherent features of most deep geological repository concepts being developed by national organizations.

While reversibility and retrievability remain "on the table" throughout most or all stages of repository implementation, it is clear that the process of retrievability becomes increasingly more difficult with time as the repository system moves towards an increasing state of passive safety. Also, some options may not be available as time progresses.

Some national programmes prefer the concept of adaptability instead of reversibility. Adaptability can be considered to be a more flexible concept than reversibility since a future decision may involve a change or modification in the programme's direction rather than a reversing of a prevision decision or step.

Finally, reversibility and retrievability do have an impact on the design of a deep geological repository in national programmes. This impact occurs during conceptual design, but more importantly at the site-specific design of a deep geological repository which depends to a great extent on the host rock geology and characteristics.

Question 4.1: Practical Implementation Issues - Regulatory

Describe what regulatory provisions and processes, if any, are in place or planned to deal with reversibility and/or retrievability.

There exist in different countries several types of instruments bearing on the question: legal (non-regulatory) requirements, (nuclear) regulations, regulatory policies and guidance, requirements from other legal bodies, and requirements resulting from environmental impact assessments. As a result, a question formulated so as to receive a simple "yes/no" response is not well-suited to capturing the subtleties of the situation.

Retrievability is currently not considered a regulatory issue in most countries. In those countries where retrievability or reversibility is a legislated requirement, there may be regulations in place to enforce that requirement. Otherwise, most regulators appear to consider the presence or absence of retrievability provisions to be simply an optional feature of the design. Regardless of whether a repository concept incorporates retrievability provisions or not, it must meet the same safety requirements.

However, the Spanish member of the Working Group commented that when retrievability was required for low level waste disposal in Spain, the regulator also developed requirements applicable specifically to retrievability provisions.

With the principal exception of France, reversibility is not explicitly defined or considered in most regulatory programmes. However, conceptually all regulatory programs allow for reversibility of

decisions at each of one or more decision-making stages, and reversibility is generally considered to be inherent in regulatory processes.

- *If decision making on reversal of steps in repository development is envisaged, are there regulatory requirements applicable to this decision making?*

The answer to this question appears to be "no" in all cases.

- *If retrieval of packages or recovery of materials is envisaged as a possibility, are there regulatory requirements in place that are applicable to the process of retrieval or recovery?*

In almost all cases, it was considered that if retrieval were to take place, existing waste management requirements would apply, and/or there would be time to develop appropriate provisions, and therefore explicit requirements have not been developed in advance.

- *If retrieval of packages or recovery of materials is envisaged as a possibility, are there regulatory provisions in place for the management of recovered or retrieved wastes?*

Any recovered or retrieved wastes would be managed in facilities which would have to meet the normal pre-existing requirements for waste management facilities. Regulatory requirements specifically intended for management of retrieved or recovered wastes do not appear to exist, except in the Spanish case where provisions for management of the potential recovered wastes are available at the same site.

Question 4.2: Practical Implementation Issues - Monitoring, demonstration, performance measures

Describe what monitoring, demonstration and performance measures, if any, are in place to support reversibility and/or retrievability in your national programme.

Many countries indicated that there were or would be monitoring and demonstration aspects in their programmes, but these were not necessarily specifically related to reversibility and retrievability, although some of them might contribute to decision making on reversal or retrieval.

It is expected that monitoring will play a role in programmes in which reversibility or retrievability is a feature, but at present that role is not generally very well defined. Likewise, the links between monitoring and staged repository development remain to be developed.

The French response pointed out that the assessment of safety does not rest on monitoring results, i.e. monitoring is confirmatory only, and not the primary basis for decision making. The discussion during the Working Group meeting confirmed that this was generally agreed.

It was also noted in the Canadian response that the results of monitoring during repository development would likely be considered a precondition to any future decision on retrieval, even if it was not the primary criterion for such decisions. That is, monitoring may contribute to decision-making but it is generally considered that monitoring would not be the sole input to assessment or decision making.

The difference between monitoring in the sense of surveillance with feedback to design, construction and operation, vs. in the sense of observation of global parameters (such as concentrations of radionuclides in ground water) needs to be taken into account. Another type of monitoring is "baseline" monitoring, for example for safeguards purposes, and it is considered likely that this would also be undertaken at the beginning of repository development.

Monitoring is likely to apply at all stages of repository development. Before closure, there will be surveillance programmes to confirm the performance of systems and components as an aid to design optimization. However, current monitoring and measurement techniques are not very robust on

timescales relevant to geological disposal. Therefore it is considered that this type of measurement and monitoring will not be feasible in the extended post-closure phase.

The term "performance confirmation" is not meaningful to most stakeholders, and explanations of the role of monitoring and surveillance during repository development might be difficult. It appears that the type of monitoring likely to be requested by stakeholders may therefore be different from the type of monitoring most useful to implementers during repository development. The former may be considered to be a support to the decision-making process rather than as a direct contributor to safety.

Both before and after closure, environmental monitoring to check for releases from a repository is likely to be required for reassurance purposes, but measurements of global quantities such as releases will not be likely to give useful information on system performance to designers and operators. It was noted that management of expectations with respect to monitoring is important, because the environmental impacts of a deep geologic repository, even in the event of failures, will be so small that it may not be feasible to detect them on socially relevant time scales.

Research and development on a number of specific topics related to retrievability provisions has been taking place in some national and international programmes. The discussion on monitoring suggested that further research and development of monitoring and measuring techniques could be useful.

Question 4.3: Practical Implementation Issues - Procedural and operational issues; technical and other limitations

Describe the important operational issues (both procedural and technical) related to reversibility and/or retrievability.

This aspect was discussed in less detail than the policy-related questions. These more practical issues may often be program-specific. In most programs, practical issues have not yet arisen, in which case discussion of them at this stage in the program may not be very illuminating.

Decision making process: criteria for reversal/retrieval, decision makers

- *To what extent has the decision making process for reversibility and/or retrievability been defined for various stages of repository development?*

Generally speaking, procedures for decision making do not yet exist, and it would probably be premature to try to develop such procedures in many programmes. It was noted that attempting to establish detailed procedures too far in advance could in fact detract from the flexibility and adaptability of a decision making process.

Financial aspects

- *Have the costs resulting from incorporating reversibility and/or retrievability into the programme been estimated or provided for, and if so how?*

Cost estimates for retrieval do not generally exist. There would appear to be some agreement with the position that costs of ensuring that retrievability is possible, if retrievability is a requirement, should be borne by present generations, but that the costs of the actual retrieval would be the responsibility of the future generation actually performing the retrieval (unless, perhaps, the retrieval were required for safety reasons).

Technical aspects

- *How do reversibility and/or retrievability contribute to repository system design and what is their relationship to safety? Please describe.*

A number of technical issues related to R&R provisions were raised. These tend to be design- and site-specific in nature. For the most part they are not considered to be show-stoppers or impediments.

Annex 3

Table of Responses to Questionnaire/Guidelines

	1. Definitions and Scope of Application	2. Historical Development	3.1 Current Policy - General	3.2 Communications with Stakeholders	3.3 Stepwise Decision-Making
Austria	N/A	The issue of final disposal of radioactive waste is still unresolved. Questions regarding reversibility and retrievability have not played a major role. Austria is very interested in common shared repositories for radioactive waste.	The concepts of reversibility and retrievability would influence our decision making because of the following reasons: • Appropriate new techniques could be developed in the future. • Technical problems of disposal could lead to unexpected hazards or risk. • The public acceptance for the disposal of radioactive waste is likely to be higher if retrievability of the waste is kept.	N/A	N/A
Belgium	Terms: "phased or stepwise disposal process" "flexibility" - the possibility of reversing decisions already taken "retrievability" – the possibility of removing the	The issue of retrievability will be dealt with specifically in the context of the first Safety and Feasibility Case (2009).	Retrievability is not considered to be a firm requirement. Retrievability must not adversely affect long-term safety. Care is taken not to make decisions that would rule out the possibility of a	A Waste Plan in which political and societal requirements will be taken into account via a process of a broad societal discussion and involvement is being set up.	In addition to formal licensing stages, the repository will be operated in 3 consecutive disposal campaigns: historic waste; operational and dismantling waste; and HLW. The role of retrievability has not yet been determined.

	waste previously placed in the disposal facility "reversibility" is applied to reversal of stages prior to sealing and closure.		hypothetical retrieval.		
Canada	"Retrievability" - the ability to remove waste from where it has been placed "adaptability" - the capacity to adapt to changing knowledge and conditions over time Stages of development include Preparing , Technology Demonstration and Long-Term Containment. Retrievability of packages of used nuclear fuel applies both during the preclosure phase and during the postclosure phase.	The collaborative development of the management approach, Adaptive Phased Management, and in particular the need for retrievability of used fuel throughout all phases of implementation, was responsive to the needs expressed by citizens and specialists in radioactive waste management during the NWMO's study process. Retrievability of used nuclear fuel is a fundamental feature of Adaptive Phased Management, the approach selected in June 2007 by the Government of Canada for long-term management of Canada's used nuclear fuel. During the NWMO's three-year study process from 2002 to 2005, Canadians indicated that retrievability was an important feature that they wanted in the approach for long-term management of Canada's used nuclear fuel.	Retrievability of used fuel during all phases of implementing Adaptive Phased Management is an important feature of the used fuel management approach in Canada.	It is expected that the NWMO would communicate with interested individuals and organizations all key decisions associated with implementing Adaptive Phased Management including a key decision associated with retrievability of used fuel. The NWMO is committed to providing meaningful opportunities for interested individuals and organizations in Canada to participate with implementing Adaptive Phased Management including key decisions such as the retrieval of used fuel.	Adaptive Phased Management has stepwise decision making and retrievability of used fuel would be considered during implementation of Adaptive Phased Management. Retrieval of used fuel would become increasingly more demanding and costly during the later stages of implementing Adaptive Phased Management and thus it is expected to affect the decision-making process. However, there has been no point identified in the implementation process when retrieval of used fuel would not be possible. Keeping the deep geological repository accessible for monitoring and retrievability for an extended period of time (e.g., several hundred years after used fuel container placement operations are completed) is not expected to become more demanding with time.
Czech Rep.	The terms reversibility and	Discussions on retrievability	The reversibility concept is	The main forum for opinion	A stepwise decision making

	retrievability are not defined or used. Reversibility is a natural consequence of stepwise decision making, but retrievability is not part of the programme.	and reversibility were held among representatives of the involved stakeholders during the Czech concept development. These discussions led to the decision not to include the reversibility and retrievability explicitly in the proposed concept. The main reasons for non-incorporation of retrievability into a DGR development concept were the safety and economical aspects of the retrievability concept. Reversibility is implicitly incorporated in the concept as natural feature of the stepwise decision making process. Retrievability is considered mainly politically-driven.	implicitly included into the stepwise DGR development approach, during which at each decision making stage several options for follow up stages will be discussed. Involvement of stakeholders into the decision making process, in which they could influence the proposed solution (in the extreme also reverse the solution) makes the process transparent and acceptable to the broad public.	and policy discussion is during the particular stages of the environmental impact assessment when public hearings are part of the process. If the issue of retrievability is raised, stakeholders will take part also in that decision making process.	process is an essential part of the Czech concept. If the question of retrievability is raised for inclusion into the concept, it will affect and will make more difficult the following decision making process. This issue is still open.
Finland	The only term used is “to open” the repository, i.e. retrievability. The final disposal has been designed in such a way that it is technically feasible to retrieve the final disposal canisters from the repository to the surface in all phases of the project (including post-closure).	Retrievability entered the policy discussion at the time of the EIA in 1997-1999. Politicians, in particular, wished to have the possibility of doing things better in the future if new technology became available. Possible conflicts are seen between retrievability requirements, safeguards considerations and long-term safety aspects; retrievability must not compromise the long-term safety of disposal	Spent fuel disposal shall be planned so that no monitoring of the disposal site is required for ensuring long-term safety and so that retrievability of the waste canisters is maintained to provide for any development of technology that would make it a preferred option. Retrievability applies only for spent fuel and HLW. Retrievability requirements do not vary between stages of repository development or	Rretrievability has not played an important role during public communication.	Key milestones and phases are: the site characterisation and selection phase; the site-specific research and design phase; the application for the construction licence; construction and non-radioactive pilot testing; the application for the operating licence; and disposal operation.

		in any way. Retrievability is not considered a safety issue.	with time.		
France	Reversibility - the possibility of progressive, flexible management of the disposal process, leaving future generations free to make their own decisions in the matter. The staged approach is as follows: “Post package emplacement” stage; “Post cell-sealing” stage; “Post module-closing” stage; “Post repository zone-closing” stage; and “Post-closure” stage. For the time being, reversibility and retrievability are focused on the pre-closure phase, which does not exclude the recoverability of waste after closure. The 2006 Act states that reversibility duration may not be less than 100 years. By law, the wastes considered for deep reversible geological repository are those that cannot be disposed in above-ground or near surface repository for safety or radioprotection reasons.	The 1991 French Radioactive Waste Act requested the feasibility study of a deep geologic repository to include consideration of a reversible approach. During the siting phase of the URL (1992-1998) reversibility appeared to be a significant issue for public acceptance and decision makers. Here are listed reasons found by Andra to express the motivations for reversibility: prudent approach allowing progressive decision-making, precautionary principle, and attitude of modesty. These are obviously social issues. Note that politicians recently expressed that a reason for reversibility is the possible need for retrieving failing disposed wastes. This is a safety-related issue.	The reversibility of deep geological disposal is required by law for a period which cannot be less than 100 years. The historical development shows that this demand relates to social acceptance. Regarding variation between stages of repository development or with time, the answer to these questions will come from the work that Andra will have to carry out from now to 2014 in order to prepare proposals for the future law. Reversibility is not addressed in the law after final closure for the time being.	Andra will have a dialogue from now to 2014 with various stakeholders to prepare socially acceptable options with respect to technical limits. In particular, the decision-making process will be an important issue. A reversibility - retrievability scale would provide a suitable framework to support dialogue with stakeholders. Stakeholders will take a strong part in establishing proposals for reversibility requirements. It is expected that this will address the motivations for reversibility, and the decision-making process.	Stepwise decision making process is incorporated in French programme, technically and legally. The license for creating the disposal facility cannot be delivered unless the reversibility requirements defined by law are fulfilled. It is anticipated that the following features will be considered when assessing the difficulty of retrieval or recovery: • Time of access to the disposed waste according to the available technology. • Availability of technology for retrieval of the package, considering its state: package integrity, mechanical environment (is it free of movement or not) • Estimated dose associated with retrieval.

Germany	Retrievability - possibility to retrieve waste packages disposed of in deep geologic formations. Reversibility is not defined as part of the waste management concept.	Retrievability was part of the conceptual and safety related issues regarding the disposal of radioactive wastes raised in 2000. In 2005 a workshop was held organized by the Federal Office for Radiation Protection (BfS). Conflicting points still exist and discussion will continue. The following arguments were raised: • Waste may not be stored in a geologic repository until evidence of long term safety is given. • Retrievability may not compromise disposal safety. • For common disposal concepts retrievability can be realized without particular measures. • Flexibility of disposal concept will be improved. The main drivers for discussing retrievability are NGO´s and the experiences by closing the Asse mine.	Reversibility is not considered for geologic disposal in Germany. It is intended to implement safety requirements on waste containers which contribute to retrievability. The concept of retrievability itself is not an element to be licensed.	A discussion with a wide range of stakeholders on this issue will be held from October 30 to November 1 in Berlin.	A stepwise decision-making process has not yet been incorporated within the relevant German administrative legislation. A proposal for a stepwise site selection procedure was drafted by the federal ministry for the environment, nature conservation and reactor safety.
Hungary	Retrievability - the planned ability of retrieval of waste from the disposal facility which is planned to be final but not closed and not	No such discussions were held with a broader range of stakeholders. Arguments learnt at international fora were taken into account	Retrievability might have helped to gain social acceptance during the Bataapáti LILW repository project.	Some experience has been collected in the communication on a new LILW repository (which is expected to be put into	Stepwise decision making process exits in the sense that it has to be started with the Parliament's approval in principle that is required by

	sealed (not back-filled) yet. No explicit reference to reversibility in the regulation.	when the regulator and policy maker decided to incorporate the issue into the regulation and the national programme in order to facilitate the future communication with the public.	Retrievability is required only under the operation period and not required after the closure of the repository.	operation this year in Bataapati). We believe that R&R has not been a key issue regarding the communication with the stakeholders.	the Atomic Act (see previous bullets). In the case of the Bataapati repository prior to the Parliament's decision a local referendum was held, too.
Japan	Retrievability - considered the same as given in the 2001 NEA report. Reversibility - not defined.. Although retrievability is not legislated, official reports point out necessity of pre-closure retrievability from a perspective of safety regulation. At present, retrievability of high-level radioactive waste (vitrified waste) and TRU waste for deep geological disposal is explicitly referred to in the official reports.	To date, discussion on retrievability has been carried out only from a perspective of safety regulation, as found in the official reports. From a perspective of safety regulation, maintaining waste retrievability at pre-closure stage is thought necessary to cope appropriately with contingencies which could have a harmful influence on human environment. The discussions were made focusing on the period of maintaining retrievability until repository closure from a perspective of safety regulation. There were no significant conflicts.	Although regulatory requirements are now considered to be less influential to make a disposal choice, it may contribute to political decision making, considering that stepwise process could go backward. Though such matters on social acceptance have not been fully discussed yet, reversibility may contribute to improvement of social acceptance.	The siting process stipulated by the law requires respecting views of mayors of municipalities and prefectures where candidate sites locate. However, qualification factors specified by the law do not include reversibility and retrievability. They are not topics in communications with stakeholders at this moment.	A repository is regulated in a stepwise manner from license application/permission, through subsequent detailed regulation, to programme termination. According to an official report for safety regulation, it is stated: "safety regulation has no rational reason to require maintaining retrievability after confirming post-closure long term safety because it is inconsistent with disposal concept, and because development and long-term maintaining of retrieval method create cost and technical problems".
Korea	Retrievability – as defined in the 2001 NEA Report. Reversibility is foreseen for all stages of repository development after establishing the national programme. At this moment we consider that reversibility	Discussions between researchers affected the applicable technology in developing the repository, and the design of the repository. We think the retrievability and/or reversibility can be	There is no administrative basis for the incorporation of the reversibility and/or retrievability in Korea. They can improve the social acceptance because they will enhance the reliability of the safety in the disposal	We don't have any program for stakeholders to take part in decision making related to the incorporation of reversibility and/or retrievability yet. Stakeholders-that is the government, utilities,	We expect a stepwise decision making process in the national programme. It is expected that reversibility and/or retrievability is one of main elements to contribute to the decision making process.

	can be possible during the emplacement of the disposal canister in the deposition hole only before backfilling of the disposal tunnel according to the current design.	possible in all stages. But it might be difficult to ensure the retrievability after the backfilling of the tunnels. The main drivers are the safety of the repository and the long term management of the HLW waste in the case that some innovative techniques appear. R&R are considered a combination of the safety issues and the social issues. The safety is the impact factor in designing of the repository and the social issues are the important factors in public acceptance.	system. That is, we can retrieve the wastes in the case of failure of the disposal system. We think that the requirements for the reversibility have to vary between stages or with time. Whether the backfilling of the disposal tunnels is carried out or not is the main reason. Also, with time, the degradation of the repository makes the requirements vary. Finally, the reversibility itself is possible as soon as the money for the reversibility remains.	regulatory body, implementers and publics-could take part in the workshops or hearings on decision making of the reversal or retrieval.	For example, it will contribute to determine the disposal option in our country. As the progressive steps in the repository development are taken, the technical complexity and cost of retrieval will tend to increase because of the backfilling of disposal tunnel and access tunnel and the placing of seals. Retrieval after repository closure, although technically possible, will require additional resources to re-establish surface and underground facilities and access to the waste. To keep the repository at a given stage, the aspects of maintaining security and safety, including radiological protection and nuclear safeguards should be considered. Because of these aspects, the difficulties will increase with time.
Spain	Retrievability is used in the English versions of some Spanish public reports. The term mainly used is “recoverability” Both terms are used with the same meaning, being considered as the potentiality of recover or retrieve the wastes packages. The definitions as given in 2001 NEA Report	The retrievability issue emerged in the late 80´s with the development of the EL Cabril LILW near surface disposal facility. With regard to the HLW, a disposal programme carried out by ENRESA since 1985, including, between other activities a Site selection plan, stopped in 1996, owing	Retrievability is neither an official option nor a regulatory requirement for the final disposal of HLW in Spain and thus, it is not considered in the strategy adopted by ENRESA for HLW and SF final disposal. Nevertheless, the potential implications of an eventual implementation of	Public and stakeholders involvement in decision making is increasing in recent years in Spain and thus, it undoubtedly will be present in the HLW final repository programme. Nevertheless, nothing can be said at this moment regarding this particular retrievability issue relating to	From the practical point of view, the Spanish repository development comprises three stages: 1) Feasibility, 2) Demonstration and 3) Execution. The third stage would be performed in four phases: 1st) Design and building (including site characterization, 2nd) Operation, 3er) Closure and

	are not formally used. Additional note regarding terminology: there are English terms that have not direct translation into the Spanish dictionary or are not normally used and are not ease to be explained (e.g retrievability)	the difficulties encountered in making any further progress. At the end of 1997, the Spanish Senate created an Inquiry Committee to provide recommendations to the government for the further policy development. National and international experts as well as stakeholder (at national, regional and local level) were consulted. The report issued in 1988 recommends, among other aspects, the continuation of the R&D effort to demonstrate the repository long safety and the feasibility of waste retrieval in the Spanish concepts. The past 5th General Radioactive Waste Plan (approved by the Government in 1999) and the currently in force 6th General Plan, (approved in 2006) consider, as a strategic line of action, the consolidation of the generic designs developed for each of the studied host rock and the contemplation of alternatives considering the criterion of recovery of the waste for a defined period of time	retrievability in the HLW final repository have been studied in ENRESA following the governmental recommendation in the past 5th General Plan for Radioactive Waste (July 1999), which is also mentioned in the 6th Plan (July 2006).	the stakeholders involvement, accounting for the current stage of the Spanish programme.	4th) Post-closure. According to the current regulations governing the licensing of nuclear facilities, the licensing of a HLW final disposal facility should be submitted to the following authorizations: prior or site authorization, construction authorization operating permit, authorizations for modifications (to the design or to the operating conditions), and closure declaration.
Sweden	Reversibility is the characteristic of a process or	These questions were discussed in seminars and	From regulations: (SKIFS 2002:1) “Measures can be		Since retrievability is not required by the regulatory

	activity that may be reversed if necessary for safety or other reasons. In principle, it includes reversibility of disposal, i.e. retrievability, but it usually refers to earlier steps in waste management e.g. conditionjng of waste. Retrievability only applies to retrieval of waste packages from a repository.	meetings with interested stakeholders and organizations, often with the arrangement of the Governments Council for Nuclear Waste. Up to the late 1980´s the technical waste management discussion was mainly concentrated on the operational reliability of the system. During the 1980's the emphasis gradually shifted over to the handling of uncertainty. Since we are not in the position to foresee all future consequences, our responsibility is characterized by a dilemma of uncertainty, we act with at least a degree of uncertainty. For this reason, the systems that we put in place must be designed with this unavoidable uncertainty in mind. We must have the capacity to repair and inspect The conclusions drawn could be expressed as follows: A repository should be constructed so that it makes controls and corrective measures unnecessary, while at the same time not making controls and corrective measures impossible. In other words, our generation should not	adopted during construction and operation for the possible monitoring of a repository's integrity and its barrier performance after closure. Such measures can also be adopted to maintain safeguards. Measures can also be adopted during construction and operation with the primary aim of facilitating the retrieval of deposited nuclear materials and nuclear waste from the repository, during the operating period or after closure. Furthermore, measures can be adopted to make intrusion into the repository difficult or to caution against intrusion. The safety report for the facility, in accordance with 9 § should show that these measures either have a minor or negligible impact on repository safety, or that the measures result in an improvement of safety, compared with the situation that would arise if the measures were not adopted "		body, it may only be required by decisions taken by the municipalities and the government Phases and decision points: Licensing, construction, commissioning (including application for trial operation), operation (including application for routine operation) , closure The basis for decision will increase and get more complex. Thus, retrievability should be required early in the process. Later on it may not be meaningful.

		put the entire responsibility for maintenance of repositories on coming generations; however, neither should we deny coming generations the possibility of taking control. A two edged objective was formulated: safety in operation combined with reparability, with controls not necessary, but not impossible, disposal under safe circumstances but also scope to make changes.	No specific requirements However, SKI's view is that it ought to be less relevant to discuss rev & retr for other waste than SF. Since retrievability is not required by the regulatory body, it may only be required by decisions taken by the municipalities and the government. One scenario could be that the Swedish municipalities (where site investigation has been performed) in their statements to the application for the final repository require that SF can be retrieved if something fails during deposition.		
Switzerland	Retrievability - "the possibility to remove waste from an open, partly or completely closed facility with more or less large technical or financial investment" Retrieval - "the desired removal of radioactive waste from a facility with the aim of further disposal, processing or re-use." The disposal concept developed by EKRA involves "facilitated waste retrieval" as part of "reversibility", a key element of sustainable	The option of indefinite monitored retrievable storage was discussed with a minor fraction of opponents as early as the eighties (concept of "Nuclear Guardianship"). In 1994, the possibility of monitoring and retrievability was included in the general license application for a LLW repository at Wellenberg, Canton Nidwalden. After the cantonal veto, the analysis of the reasons for the negative outcome of the vote showed that the public was afraid of taking decisions that were	Retrievability is prescribed by the Swiss legislation. Waste retrieval should be possible "without great effort" until repository closure, which will be preceded by an extended monitoring period. It appears clearly that the public expects that the issues of monitoring and retrievability should be considered in any waste disposal concept. Retrievability requirements are the same for all categories of waste. The government will decide	Retrievability is part of the current Nagra communication concept. As no repositories exist as yet, no concrete steps have been taken to involve stakeholders in decision making in this respect. Communication measures are expected to follow the legislation established for other nuclear facilities, i.e. the relevant authorities shall regularly inform the public of the state of nuclear installations and of the situation relating to nuclear	A staged decision making process is included in the Swiss programme. Retrievability must be demonstrated prior to the operating licence application. After waste emplacement, tunnels and caverns are successively backfilled for safety reasons, which has an impact on waste accessibility. Conditions created by the presence of waste itself (temperature, radioactivity) will also be taken into account in the

	development. The disposal of radioactive wastes is envisaged in a facility where, after emplacement, a period of monitoring is foreseen before closure, during which emplaced waste can be retrieved without great effort. A representative fraction of the waste is placed in a pilot facility to test predictive models and to facilitate the early detection of any undesirable behaviour of the system, if this should occur. This concept applies to all categories of waste.	felt to be irreversible. As reasons for implementing the concept of retrievability, EKRA lists a series of ethical considerations: • A waste management concept should leave open to every generation the possibility of either shaping it or rejecting as an expression of the right of self-determination as part of democratic decision-making. Each generation should, in principle, have the possibility to make use of new knowledge regarding disposal and disposal requirements. • In the sense that we feel entitled today to make a decision which may involve irreversible consequences or considerable burdens for future generations, we are contravening the principle of fair treatment. The EKRA report also points out that “A higher level of social acceptance is to be expected for [a geological disposal concept where the repository will remain open for a period of 100 years] than for a geological repository which is sealed immediately after the operating period” and adds	on the closure of the facility, thus ending the period during which the waste should be retrievable.	articles and radioactive waste. They shall also inform the public of any particular occurrences.	retrieval concept. According to the legislation, retrievability should only be ensured up until closure and final sealing of the repository.

		that for the term "final disposal" may be disturbing, in the sense that "'Final' relates solely to the giving up of responsibility by those previously responsible under law and not to the transition of the waste to a permanently safe state."			
UK	Reversibility - a form of retrievability in which the waste could be removed by reversing the original emplacement process. Retrievability - the building into a repository concept of a methodology that would allow access to the waste even after vaults had been backfilled. Recoverability - a "third category" of retrievability in which waste is recovered from a repository by mining or similar intrusive methods. "phased geological disposal" - the identification of sequential phases of development that lead eventually to the sealing and closure of the filled geological disposal facility. No decisions on reversibility, retrievability and recoverability have been made at this stage.	Following the failure of the repository siting programme in 1997, discussions with stakeholders, and the findings of a parliamentary committee and of a citizens' panel, showed that retrievability was an important issue for acceptance of geological disposal. This led to the proposal of the phased disposal approach. The principal conflicting points of view can be summarized as follows: • whether or not enhancing retrievability by design and construction measures will increase environmental, security and safety risks; and • whether or not enhancing retrievability provides additional reassurance that justifies the additional detriments such as increased radiation exposures of workers or	Government acknowledges that there is a divergence of views on the issue of waste retrievability, but on balance considers that CoRWM's conclusion was correct, i.e. that "leaving a facility open, for centuries after waste has been emplaced, increases the risks disproportionately to any gains". Closure at the earliest opportunity once facility operations cease provides greater safety, greater security from terrorist attack, and minimizes the burdens of cost, effort and worker radiation dose transferred to future generations. CoRWM noted that it is likely to be at least a century from publication of their recommendations in July 2006 until final closure of an entire facility is possible. Hence Government's view is that the decision about whether or not to keep a geological disposal facility	NDA-RWMD has recently published a consultation document on its proposals for public and stakeholder engagement (PSE), which would be expected to cover, inter alia, the topic of retrievability. Stakeholders have not taken part in the actual decision-making process but, as noted in responses to previous questions, have strongly influenced the process. It is envisaged in NDA-RWMD's proposals for PSE that major decisions would not be made without prior consultation and engagement, and that an important aspect of the overall process is the reporting back of information to stakeholder groups and more general dissemination, for example by means of the NDA website.	The UK has specifically chosen not to refer to "stepwise decision making" in stating its policy. Rather it has said that: "Implementation will be undertaken on a staged basis, with clear decision points allowing progress to be reviewed and costs, affordability, and value for money, safety and environmental and sustainability impacts to be assessed before decisions are taken on how to move to the next stage." It is almost inevitable that there will be evolutionary processes that make retrievability more difficult with time. The main processes that have been considered in the UK programme are instability of underground openings (which can be overcome by refurbishment), deterioration of in-vault waste package

	In the UK this description refers to all ILW (short- and long-lived), vitrified HLW, long-lived LLW unsuitable for near-surface disposal, and radioactive materials such as spent fuel or separated plutonium or uranium that may be declared as wastes in the future.	increased costs. The main driver for consideration of retrievability has been stakeholder desire for an ability to respond to future technological advance or new information about risks and opportunities. Safety, economics and social issues are of course all relevant to consideration of retrievability. All will need to be considered in evaluating and deciding the way forward. The main driver for consideration of this issue has been societal. No benefits are perceived in respect of safety and economics, rather there is the potential for detriments in these respects.	(or vaults within it) open once facility waste operations cease can be made at a later date in discussion with the independent regulators and local communities.		handling equipment, e.g. the rails on which overhead cranes run (which again can be overcome by refurbishment) and corrosion of metallic waste packages (which can be limited by control of the vault environment).
USA	"Retrieval" - the act of permanently removing radioactive waste from the underground location at which the waste had been previously emplaced for disposal. The term "reversibility" is not explicitly used or defined in the United States HLW program. "Performance confirmation" - the program of tests, experiments, and analyses that is conducted to evaluate the adequacy of the information used to	Retrieval of waste was considered and specified in legislation in 1982. Consideration is based on economic and safety reasons. At the time this legislation was considered, stakeholders were involved through their elected members of Congress. As part of its rulemaking process, NRC proposed its geologic disposal regulations for public comment. Stakeholders commented on the practicality aspects of	The Nuclear Waste Policy Act of 1982 [NWPA], as amended, specifies that retrieval of spent nuclear fuel be maintained for any reason pertaining to public health and safety, or the environment, or to permit recovery of the economically valuable contents of spent fuel. This legislation also provides that DOE specify the appropriate period of retrievability, subject to NRC approval, as part of the construction authorization	The NRC has a communication plan in place for its repository oversight program which outlines approaches for communication with stakeholders. As development of the repository proceeds, any decisions about retrievability will be made through the licensing process or legislative processes with the benefit of stakeholder involvement. EPA has similar communications materials	The U.S. program incorporates a staged or stepwise decision making process. Maintaining a capability to retrieve waste, prior to closure of the facility, provides the necessary flexibility for decision making for either safety or economic reasons. NRC regulations provide for making decisions at four key steps, namely construction authorization, license to

	demonstrate compliance with the performance objectives for the repository. The performance confirmation program is conducted up to the time of the decision to permanently close the repository. Retrievability is considered during the operational or pre-closure period of repository development during which the performance confirmation program is conducted. There are no plans to provide for retrievability after permanent closure of the repository. The same terminology applies for all stages of repository development.	retrievability requirements. NRC received no comments with respect to the social and ethical issues As a result of public comment on its generic regulation, the NRC provided more flexibility in the application of the retrievability requirement (e.g., definition of retrieval does not imply ready or easy access to emplaced wastes at all times prior to permanent closure – DOE may elect to backfill parts of the repository with the intent that the wastes emplaced there will never again be disturbed; this is acceptable so long as the waste retrieval option is preserved). There is no record of significantly conflicting views on the subject of retrievability during the legislative process and since that time. The main driver was legislative direction that retrieval of spent nuclear fuel is to be maintained during an appropriate period of operation of the facility, for any reason pertaining to public health and safety, or the environment, or for the purpose of permitting the recovery of the economically valuable contents of such	process. The ability to retrieve waste and conduct a performance confirmation program up until the time of the decision to permanently close the repository might contribute to social acceptance, however, no information is available on the extent to which reversibility and retrievability has increased social acceptance. At the WIPP, the fact that DOE has successfully removed waste containers after emplacement, and that EPA has exercised its oversight authority to ensure that it does so, has likely increased public confidence.	describing its requirements for the WIPP, including provisions related to retrievability.	receive and emplace waste, a decision to permanently close the repository, and a decision to terminate the license. There are no explicit regulatory requirements addressing the potential increase in difficulty of retrieval at these stages, however, it could be expected that increasing information obtained during repository development would be used to inform retrieval plans.

		spent fuel. A regulatory decision by the NRC to retrieve waste would be for protection of public health and safety and the environment. Any decision to retrieve waste based on economic reasons would be the result of a change in national policy.			

	4.1 Regulatory Issues	4.2 Monitoring, Demonstration, Performance Measures	4.3a Decision Making Process	4.3b Financial Aspects	4.3c Technical Aspects
Austria	N/A	N/A	N/A	N/A	N/A
Belgium	No specific regulatory requirements.	Not yet determined.	Decision making processes for retrieval not yet determined.	No separate cost estimation for the retrieval of LILW-LL or HLW has so far been made. It should be noted that a cost estimation of a waste retrieval case has been made for the LILW-SL surface repository.	The ease with which a hypothetical retrieval could be achieved was taken credit for in the selection of the current reference disposal concept for HLW.
Canada	Currently, there are no explicit Canadian regulatory requirements pertaining to reversal of steps in repository development or retrieval of used fuel.	Adaptive Phased Management includes monitoring of used fuel throughout all phases of implementation. Monitoring of the deep geological repository will provide necessary information regarding the performance and safety of the facility and will likely be a precondition regarding any decision to retrieve used fuel from the repository.	The decision-making process for retrievability has not been defined for each stage of implementing Adaptive Phased Management in Canada. It is expected that accessibility (to the used fuel container which has been placed in a deep repository), repository performance, safety, new technological developments, cost, unforeseen events and the next steps (e.g., transportation, reprocessing, high-level waste management, etc.) associated with long-term management of used fuel would be the main factors expected to influence a decision on retrieval.	Detailed cost estimates to retrieve used fuel from a deep geological repository have not been prepared in Canada. However, preliminary estimates would suggest that it is reasonable to expect that the costs to retrieve used fuel from a deep geological repository would be of the same order of magnitude as the costs to place used fuel in a deep geological repository. It is expected that the decision to place used fuel in a deep geological repository would not be made if there is a strong likelihood that the used fuel would be retrieved from the repository. Consequently, it is expected that allocating funds for a	No technical limitations have been identified for retrieving used nuclear fuel during implementation of Adaptive Phased Management in Canada. The ability to monitor and retrieve used fuel containers from a deep geological repository at a particular site with particular host geology features will be incorporated into the final design, development and demonstration of the deep geological repository system. A key aspect in the design would be the ease of retrieval prior to backfilling, sealing and closure of the repository. However, the repository system with features associated with monitoring

				very low probability event such as retrieval would not be fair or appropriate.	and retrievability must be designed to be safe from an operational perspective and it must be designed to be passively safe over the long term.
Czech Rep.	There are not any explicitly defined requirements on reversibility in the Czech regulations.	The stepwise process with detailed evaluation of received results of each DGR development stage with proposal of justified follow up options is an essential part of the Czech concept. We consider that this approach is the only way which will make the decision making process and the DGR development progress effective.	N/A	N/A	N/A
Finland	There are no specific regulatory requirements related to retrievability or retrieval.	A range of characterization and monitoring activities are and will be performed to support development and operation of disposal facility. Baseline monitoring is and will be carried out from the surface and underground. During construction, operation, and possibly part of the post-closure period, monitoring would continue. Plans for monitoring, data recording and safeguards measures are needed in all stages of the project.	There are no specific decision making processes in place related to retrievability or retrieval.	During the Decision in Principle discussion the position was approved by the majority that the responsibility for costs of retrieval should be with those who want to retrieve the canisters. During construction licensing, the proponent shall provide specified, sufficiently detailed reports on and plans for the re-opening of the repository and factors affecting it, as well as the opening technology and the safety of opening. An up-to-date estimate of the costs of opening shall also be	The KBS3-concept itself is considered to be retrievable enough and this is advantageous for acceptance. Moreover no extra technical features are needed for retrievability purposes.

				submitted.	
France	Reversibility is imposed by the French law. The output of the research programme to be carried out from now to 2014 will support the definition of reversibility requirements. These requirements will be the object of a new law to be voted prior to the completion of the licensing procedure.	The main reasons mentioned in Andra's dossier 2005 for conducting observation and surveillance monitoring are to assist in reversible repository management and to contribute to the mastering of operational and long-term safety. Repository surveillance is aimed at detecting changes that might affect operational safety or long-term functions. Under no circumstances is it intended to base the assessment of a repository's safety on its monitoring. Nor can the existence of a monitoring programme during repository operation be used to compensate for a lack of any data concerning the safety assessments that would precede any disposal authorisation. Tests are planned in the next years to demonstrate the retrievability. This includes in particular full scale waste handling tests.	The reversibility is imposed by law. The stepwise approach of the disposal process contributes to reversibility as envisaged in France. The decision making process to go from one stage to the next will be part of the reversibility requirements. The retrievability of the waste packages in the next stage will probably constitute a facilitating factor of the decision process.	The cost estimate for the repository includes design features enhancing the reversibility as presented in the Dossier 2005. This cost estimate is based on a centennial operating period. This cost estimate is used as a basis to determine financial provisions for long term waste management. The cost of waste retrieval has not been estimated at the present stage.	The repository architecture presented in the Dossier 2005 incorporates a number of design factors enhancing reversibility without jeopardizing safety. They include the modularity of the repository, the durability of the structures, and various features facilitating waste package retrieval. Reversibility was one of the criteria used in the multi-criteria analysis carried out to select design options, along with safety relating criteria, cost and demonstration capability. No compromises with regard to safety are allowed while taking into account reversibility. Technical and scientific limits were identified and discussed in Dossier 2005. These limits relate in particular to the long term behaviour of materials and underground structures. This analysis led Andra to conclude to the technical possibility of a 200-300 years reversibility period. Some reviewers stated that such a duration is not consistent with state of the art and still needs to be demonstrated. A duration of hundred years

					seems today reasonably reachable towards the state of the art. In the French programme, the host rock is argillite, which creeps over time. This limits the possible duration of reversibility.
Germany	Up to now there have not been regulations for incorporation of retrievability in Germany. It is intended to implement safety requirements with respect to retrievability and other safety related aspects within the framework of the current update of the legal regulation: "Safety Requirements on Heat-generating Radioactive Waste" (GSR). Reversibility is not considered.	There are monitoring programs envisaged for the operational phase devoted to ensure compliance with the long term safety assessment. In principle they could also be used as a basis for a decision on retrievability.	Not applicable	As R&R have not been part of the German radioactive waste programme so far, no detailed cost estimations are available. Concerning retrievability rough estimations were made by considering the required increased host rock volume.	Results of R&D work show significant differences in limitations depending on the way of retrievability incorporation (e.g. open storage without backfill/sealing vs. open storage with backfill). Especially for salt rock there are serious difficulties expected for retrieving waste during the first 100 years because of the temperature effect on the salt rheology.
Hungary	In lack of discussions, decisions and/or common Hungarian standpoints on these practical issues we cannot answer these specific questions.	In lack of discussions, decisions and/or common Hungarian standpoints on these practical issues we cannot answer these specific questions.	In lack of discussions, decisions and/or common Hungarian standpoints on these practical issues we cannot answer these specific questions.	In lack of discussions, decisions and/or common Hungarian standpoints on these practical issues we cannot answer these specific questions.	In lack of discussions, decisions and/or common Hungarian standpoints on these practical issues we cannot answer these specific questions.
Japan	Any regulatory provisions and processes are not specified to deal with reversibility and/or retrievability at the present	At present, monitoring, demonstration and performance measures are not linked to reversibility and/or retrievability. However	Decision making processes and criteria are not defined at present and will be discussed in the future.	Costs resulting from reversibility and/or retrievability haven't been estimated or provided yet.	An official report for safety regulation states: "For implementing retrieval safely and effectively, it is important to study repository design

	time. Safety standards will be established at an appropriate time, considering retrievability until repository closure.	monitoring is expected to be capable of affording data necessary for safety assessment and confirmation of operational safety, during the period of maintaining reversibility until repository closure. In addition, it seems irrational to require maintaining retrievability as safety regulation after post-closure long term safety is confirmed by carrying out safety analysis for repository closure with using data obtained from monitoring.			incorporating retrievability and retrieving measures. Details such as scope and period of sustaining retrievability; design and implementation method of retrieval; and others should be studied, considering domestic/overseas technological findings in the future. It is important for the responsible organization to be considerate to prevent adverse effect on the safety performance of repository."
Korea	In Korea, we don't have any regulatory provisions or processes on reversal of steps in repository development yet. So there is no regulatory requirement related to this decision making.	There are two monitoring stages in the stages of the repository development. The first one is when the disposal tunnel is not backfilled during the operation and the second one is after the backfill of the disposal tunnel. In our concept of research phase, the materials can be retrieved by reverse process in the first monitoring stage, but in the second monitoring stage, we don't consider the retrievability yet.	Nothing is decided on this matter because we are now at the beginning stage of retrievability and/or reversibility. We think that the main factor to influence decision on reversal and/or retrieval is the appearance of an innovative technology, which could enhance the safety of the repository and remarkably reduce the volume of the wastes.	Cost of reversibility and/or retrievability and/or recoverability have not been estimated yet.	Technical limitations in implementing the reversibility and/or retrievability are - The potential negative effects because of conventional safety and radiological exposure of workers engaged in extended storage operations - The increased opportunity for unauthorized access to the repository - Increased financial costs because the repository should open for longer.
Spain	Specific regulatory provisions were developed to facilitate the retrievability of waste packages in the ILLW near surface disposal.	At the current state of the Spanish repository programme there is no specification on the possible monitoring requirements and	It has not been defined.	Provisions taken for the retrievability incorporation in the design of the LILW disposal facility had an impact in the construction	In the case of the ILLW disposal, the original proposed design was modified, to another which could make easier the

	There are not specific regulation and neither regulatory provisions on retrievability regarding the HLW disposal.	not related with the support of retrievability. It is recognized that at later stages monitoring will have to be implemented, and that if retrievability is considered, monitoring will be necessary		costs, which were estimate at that time (1978-1992) In the case of the HLW disposal, several alternatives to the main reference concept have been studied in order to facilitate retrievability of waste packages, but only during the operational phase of the repository. Nothing has been studied in order to incorporate retrievability in the post-closure phase. These alternatives include a combination of measures like using a different liner, providing clean areas without canisters in the disposal galleries or using shorter disposal galleries. The extra costs ranges from 2% to 11% in the case of granite and from 3% to 16% for clay.	recoverability of the waste packages, based on the use of hardly tested cubic concrete containers, for the emplacement of the immobilized waste drums inside the disposal cells, piled up without any bonding between them. The design modification added, in this case, an additional engineering barrier In the case of the HLW disposal, the analyses made in order to assess the consequences on safety are very preliminary. In general, no very relevant implications are expected. Perhaps the postponing of the sealing of disposal galleries is the modification with highest unacceptable consequences for safety.
Sweden		The basic principle in the Swedish waste management programme is that the final repository for SF must be designed in such a way that it does not need to be monitored. The KBS-3 concept in itself allows for retrievability if future generations wish to retrieve the SF. Through the various stages of the disposal of the spent fuel, normal monitoring for	The basis for decision will increase and get more complex. Thus, retrievability should be required early in the process. Later on it may not be meaningful. The decision making process relates to the approval by the authorities for trial and routine operation. A small number of canisters will be deposited during trial operation of the final repository. The activity will be	Costs have been provided for up to closure. Resources are funded according to legislation (financing act).	It will be technically possible but it will become more and more difficult as time goes. More resources and labour will be needed after backfilling of deposition holes and tunnels.

		the operation and safe handling of the waste will be provided. Monitoring of the engineered barriers is part of quality assurance process (in the "production line"). Monitoring of the near field (groundwater conditions,,,) is part of characterisation programme. In the Canister retrieval test at Äspö HRL SKB has shown that it is possible in practice to free a canister from saturated bentonite and retrieve it. However, the process was very time consuming. Important to show that safety is maintained by being able to retrieve the package if something goes wrong. It is most probable that the society can easier accept a repository if retrievability can be demonstrated.	evaluated regularly. If the evaluation has a positive outcome, deposition will continue during routine operation. SKB's request to be allowed to commence trial operation (entails that nuclear material is brought into the repository) contains updated assessments of long-term safety and updated safety analysis reports.		
Switzerland	The new (draft) HSK guideline specifies that waste retrieval should be described in a retrievability concept. This concept should take into account the specific conditions (temperature, radioactivity) caused by the presence of radioactive	Monitoring and waste retrieval are closely linked. Waste should be retrievable up until repository closure, which will be preceded by an extended monitoring period. Monitoring of the pilot facility after the waste has been emplaced and the	The new (draft) HSK guideline briefly outlines safety-related reasons that would make waste retrieval necessary: • during the operational phase: the consequences of an accident have an impact on the long-term	The EKRA report states that "facilitated retrievability of the waste is part of the requirement for reversibility and necessitates both technical and financial means. If retrieval is effected for safety reasons, then the case is one of liability which	The nuclear energy legislation indicates that the ability to retrieve the waste should not affect the safety barriers. Furthermore, the new (draft) HSK guideline specifies that waste retrieval should be described in a retrievability

	waste.	emplacement tunnels are backfilled and sealed will support the decision-making process leading to closure of the repository. This facility will provides ample possibilities for a broad instrumentation of all components of the disposal system which will allow for a comprehensive long-term monitoring of the hydraulic, chemical and mechanical conditions of the waste, the engineered barriers and the surrounding host rock. The monitoring concept will be developed for the general license application and refined at later stages of repository development.	safety of a repository where waste has already been emplaced • during the monitoring phase: failure of (a component of) the engineered barrier system • after completing waste emplacement: the long-term safety cannot be demonstrated. It further specifies that the expected radiation exposure for staff and populations outside of the operation area at the time of retrieval should be evaluated.	has to be regulated by law. If retrieval is implemented for other reasons, then no reserves require to be put aside by the generations who are benefiting from the use of nuclear energy." In the current programme, provisions have been made for ensuring that the waste is retrievable (e.g. costs of RD&D prior to the operating license application, costs of operation of the pilot facility, etc.). The costs of the actual retrieval of the waste, if it became necessary, have not been part of the cost estimates so far.	concept. This concept should take into account the specific conditions (temperature, radioactivity) caused by the presence of the waste itself.
UK	There are no regulatory requirements specific to the reversal of steps in repository development. In their recently published consultation on draft guidance, the environmental regulators state that their guidance does not require the waste to be capable of retrieval after the act of disposal (i.e. emplacement of the waste). If provisions for retrieval are included, they should not damage the environmental safety case, for example due to potential degradation of waste	It is envisaged that monitoring will be carried out at each stage of repository development to ensure that the condition of repository components, the waste packages and the repository environment have remained consistent with requirements for safety, security and environmental protection. We do not see a link between reversibility and/ or retrievability and "repository performance confirmation". CoRWM concluded in its recommendations to Government that for some	In the UK retrievability is viewed as a possible means of affording flexibility of future actions rather than to meet some pre-defined decision or need to retrieve waste subject to a full case being made at some future point. Formalised reversibility of decision-making is not part of the UK programme.	The costs resulting from incorporating retrievability into a reference ILW repository have been estimated previously by the NDA's predecessor organization, Nirex, using a parameterized cost model where the component costs for example of maintaining a controlled vault environment or of maintaining underground openings are well established. This assessment will need to be updated in light of the new policy.	Retrievability is not seen as having a relationship to safety except in the sense that it will have to be shown that retrievability does not introduce an unacceptable detriment to safety. No absolute limitation has been identified provided that society will be willing and able to continually refurbish or replace disposal vaults and tunnels and other underground openings and retain the skilled workforce necessary to undertake this work.

	packages during any extended period for which the facility is kept open.	people the period of monitoring associated with keeping the waste relatively accessible represents an important check, but cannot provide reassurance about repository performance in the long term, which is usually the period of greatest concern.			To date it has been found that design features and host geology features are unlikely to be limiting but will demand different technological approaches to affording the option of retrievability.
USA	A decision to abandon the repository or a portion of the repository for safety reasons, and retrieve some or all of the waste could occur if the site, design, or a portion of either the site or design were found to be unsuitable (i.e., not protective of public health and safety). Such a decision would be made through NRC's licensing process.	The performance confirmation program, which may include monitoring, would be used to inform a safety decision to retrieve waste prior to permanent closure. Any decision to retrieve waste after permanent closure, however, would be a far more complicated decision that is neither anticipated nor prescribed in legislation or NRC regulations. DOE needs to design (and build) the repository in such a way that the retrieval option is not rendered impractical or impossible. The retrieval operation would be an unusual event and may be difficult and expensive.	The retrieval decision based on safety, whether proposed by the DOE or mandated by the NRC, is determined through NRC's licensing process. This process would not vary between stages. Any decision to retrieve waste based on economic reasons would need to be the result of a change in national policy. At the WIPP, the decision to remove specific waste packages has been made on two occasions. These decisions have been based on the determination that the packages did not comply with regulatory requirements. In general, the same decision-making process would be applied at all stages.	Precise costs associated with reversibility and retrieval have not been estimated. As a general matter, repository costs are paid through the Nuclear Waste Fund. If retrieval is ever conducted the costs would be expected to come from the waste fund if the decision is safety-related. However, if a retrieval decision were made for economic reasons, its costs would be paid out of general revenues.	DOE needs to develop retrieval plans that are feasible and reasonable. DOE needs to design (and build) the repository in such a way that the retrieval option is not rendered impractical or impossible. Even after permanent closure the entire system can be re-opened and taken apart, albeit at great cost and considerable difficulty. Clearly, there is a balance to be struck between demanding long-term retrievability and the need to provide for nuclear safety and security. Repositories must be sealed in such a way as to make re-entry a costly and difficult enterprise to discourage unauthorized re-entry and retrieval operations.