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NUCLEAR ENERGY AGENCY
RADIOACTIVE WASTE MANAGEMENT COMMITTEE

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Integration Group for the Safety Case (IGSC)

TOPICAL SESSION PROCEEDINGS OF THE 5TH IGSC MEETING ON:

OBSERVATIONS REGARDING THE SAFETY CASE IN RECENT SAFETY ASSESSMENT STUDIES

Held on 5th October 2003 in Paris, France

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FOREWORD

The IGSC (Integration Group for the Safety Case) is an international expert group that was launched three years ago. The IGSC takes initiatives in the area of confidence-building in repository technical safety cases (SC) and their underlying methodological and scientific bases for the purpose of decision-making in repository development. In particular, the IGSC focuses on the strategic and methodological issues of preparing a safety case, the integration of the science that is the basis for a safety case and on the development of that scientific basis.

In recent years, it has become increasingly evident that repository development will involve a number of stages punctuated by interdependent decisions on whether and how to move to the next stage. These decisions require a clear and traceable presentation of technical arguments that will help in giving confidence in the feasibility and safety of the proposed concept. The depth of understanding and technical information available to support decisions will vary from step to step. A safety case is a key item to support the decision to move to the next stage in repository development. Progress is noted, in the past decade, in the performance and safety assessment areas, particularly in the methodologies for repository system analysis.

In the three past years, definite progress has been observed mainly in technical aspects of planning and performing long-term safety evaluations of repository systems. This progress is also evident in the quality of the technical work displayed in safety evaluations over time. From 2001, a number of major safety studies have been attempted and subjected to international peer review (e.g. ONDRAF/NIRAS, SAFIR 2, Andra Dossier 2001 Argile, Nagra Opalinus Clay [OPA]). An important role of international co-operative projects (by the International Atomic Energy Agency [IAEA], the European Commission [EC], and the NEA) is in promoting improvement in work done in established programmes, and helping newer programmes to make rapid advances.

An important contribution of the IAEA in this respect is its pending document: “IAEA Safety Standards Series, Geological Disposal of Radioactive Waste, Draft Safety Requirements (DS-154)” which is now to be published jointly with the NEA. This document defines the safety case and discusses its content, thereby culminating several years of IAEA work on this topic. The IGSC draft safety case brochure “The Nature and Purpose of the Post-closure Safety Case in Geological Disposal” similarly serves to clarify the outcomes of a series of initiatives that the NEA has sponsored and conducted in the past decade. Especially given that the IAEA Safety Requirements document is to be jointly published with the NEA, it was important that this IGSC brochure on the safety case be in harmony with the safety case discussion in the Safety Requirements document. To that end, the IGSC provided comments on the IAEA proposed document, and has ensured the content of its own document recognises and emphasises its role and importance.

The Topical Session reported here reflected the fact that the IGSC document “The Nature and Purpose of the Post-closure Safety Case in Geological Disposal” was under finalisation. Therefore, the Topical Session sought to confirm some of that document’s content, by having a presentation from the IAEA on the status of the Safety Requirements document, and to hear from within the IGSC the status of safety case related developments in member programmes through a series of presentations on the

"lessons learnt from recent national initiatives including international peer reviews." This topical session was organised in the framework of the 5th meeting of the IGSC, held in Paris, France, on 15 October 2003.

36 participants represented national waste management organisations and regulatory authorities from 16 NEA member countries, the IAEA, and the European Commission (EC).

The items covered in the presentations, in addition to short discussions on the IAEA Safety Requirements document and the IGSC safety case brochure discussed above, concerned analyses with respect to the recent results from safety assessments and international peer reviews for the deep disposal of radioactive waste. The main issues of interest to the session were:

- The impact of the peer review in terms of confirming the need to focus on some scientific issues, documentation, and assessment methodology.
- The emerging issues from the recent safety cases in terms of improving the integration of scientific information in a safety case.
- The emerging issues in the context of making an "overall safety case" as defined in the forthcoming brochure on a safety case.
- The compatibility of statements in the IGSC safety case brochure and the Draft Safety Requirements.

The presentations showed the progress and maturity gained by the relevant national organisations in developing the long-term safety case to support stepwise decision-making. They also confirm the interest in the objective of a safety case brochure that aims to describe the issues connected to a safety case and the approaches available for providing its key elements.

The presentations summarised the lessons learnt within some focused studies as they have evolved over the last three years so as to now allow a comprehensive view of what constitutes a safety case. The discussions of the various presentations suggested that this is a rapidly maturing area in national programmes, and that the IGSC safety case brochure properly and correctly captures the maturity of the approaches now being pursued regarding the preparation of competent and comprehensive cases for system safety. Finally, there is an appropriate agreement between the IGSC's draft brochure and the IAEA Draft Safety Requirements document where the safety case is concerned.

ACKNOWLEDGEMENT

The NEA expresses its gratitude to:

- Abe Van Luik (US-DOE-YM, Chair of the IGSC) who chaired the Topical Session;
- Alan Hooper (United Kingdom Nirex Limited) who co-chaired the Topical Session as a rapporteur;
- The speakers for their collaboration, for their interesting and stimulating presentations;
- The IGSC participants for their constructive contribution.

Alan Hooper and Sylvie Voinis (NEA Secretariat) have prepared the proceedings. Abe Van Luik has reviewed the document.

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PART A

SYNTHESIS

1. INTRODUCTION

It is accepted universally that assessments of the safety of proposed geological repositories are a key input to the decision-making process regarding the development of these facilities. Accordingly, implementing and regulatory organisations in many of the OECD/NEA countries are involved in the investigation and resolution of issues associated with repository safety and NEA has been concerned with this issue for several years.

Most current repository development programmes envisage that repository development will occur in an incremental fashion, with decisions being taken by national authorities at several steps in the development process. It may be envisaged that safety assessments will become progressively more refined at successive stages of the development process, with an expectation of increasing levels of confidence that the assessed levels of safety can be realised in practice.

Different countries are at different stages and therefore opinions can be expected to vary on where the key issues remain.

In accordance with current terminology, the safety case for a proposed facility should present the results of the safety assessment together with an illustration of the level of confidence in the results. The safety case should also discuss how levels of uncertainty would be reduced in succeeding development phases.

The IAEA and the NEA propose to publish jointly a Safety Requirements document for the long-term safety of geological disposal facilities. This document, which has been reviewed by the NEA (principally through the RWMC and the IGSC) presents a consensus definition and description of a safety case and in general terms explains its role in showing compliance with standards and requirements. The IAEA has conducted activities over the past few years helping it develop its views on the need for and characteristics of the safety case. These views are now incorporated in this proposed joint IAEA/NEA publication.

Within the NEA, over the past few years, insights regarding the need for and characteristics of a safety case were similarly obtained from several activities. Under guidance from the RWMC, the IGSC (Integration Group for the Safety Case) was formed with a mandate to define and develop the safety case. In addition, the RWMC and its working groups, as well as the IAEA, have conducted international peer reviews of national safety studies e.g. US-DOE Yucca Mountain TPSA, ONDRAF/NIRAS SAFIR 2, Andra Dossier 2001 Argile). At the same time, assessments were done by national programmes, often informed by regulatory and other inputs (e.g. SKB, Nagra). The objective of the IGSC is to integrate information coming from these activities that relate to the safety case, recognising the key role that a comprehensive and competent safety case plays in the process of repository development. Initiatives currently launched by the IGSC along with the development of a

"Safety Case Brochure", such as the EBS[1] and AMIGO[2] projects, demonstrate the group's interest in integrating scientific understanding in a safety case.

Within the NEA, the IGSC has, as an essential role, to develop common views on such key aspects of the safety case. Therefore, since the inauguration of the IGSC in 2000, four meetings were organised with topical sessions to explore various of these key aspects. This is a report on the fifth such topical session, held as part of the 5th plenary meeting of the IGSC. This session took place in Paris, France, on 15 October 2003. The session was attended by 36 participants, representing waste management organisations and regulatory authorities from 16 NEA member countries, the IAEA and the European Commission.

The purpose of this topical session was to provide support to the finalising of the IGSC safety case brochure by getting a description of the safety case content of the IAEA Draft Safety Requirements document and by getting an overview of progress that could be observed from national organisations on developing their cases for system safety and/or developing the required methodologies. The objective was that the IGSC safety case brochure should be supportive of the IAEA/NEA document, and be reflective of the experience of the IGSC member programmes and organisations.

The topical session was mainly aimed at exchanging information on:

- The safety case related content of the proposed IAEA/NEA document (currently titled: "IAEA Safety Standards Series, Geological Disposal of Radioactive Waste, Draft Safety Requirements (DS-154)").
- National programmes where safety assessments have recently been completed, e.g. ONDRAF/NIRAS, Nagra and Andra.
- Feedback from international peer reviews, e.g. the Andra Dossier 2001 Argile, the Belgian SAFIR 2 report, the SR 97 report and the US-DOE Yucca Mountain TSPA.
- The evolution of some national assessment methods and approaches e.g. SKB and Nagra.
- The content of the draft IGSC safety case brochure entitled: "The Nature and Purpose of the Post-closure Safety Case in Geological Disposal".

The Chairman of the topical session was Abe Van Luik (US-DOE-YM, USA). The rapporteur was Alan Hooper (United Kingdom Nirex Limited, UK). The NEA Secretariat coordinator was Sylvie Voinis.

This document presents the various presentations and exchanges that took place during the topical session. Part A of this document summarises the material presented and provides the main outcomes. The overheads presented are compiled without elaboration by the NEA Secretariat as Part B of the document, and Part C gives a list of participants. It is hoped that the document as a whole provides a synthesis of current issues in safety case development including key issues being identified in recently undertaken international peer reviews.

1. EBS: OECD/NEA International Project on the integration of the Engineered Barrier Systems in a safety case.
2. AMIGO: OECD/NEA International Project on Approaches and Methods for Integrating Geological Information in the Safety Case.

2. BACKGROUND

The concept of a "safety case" has been progressively clarified in a series of initiatives undertaken by the NEA in the past decade, which culminated with the publication of the NEA document on building confidence in a long-term safety case [NEA 1999] and the latest IPAG (Integrated Performance Assessment Group) exercise [NEA 2001].

At the same time, several IAEA initiatives also addressed the need for a more comprehensive approach to making a case for system safety. It is fitting that the endeavours of these two international agencies are proposed to be brought together in a joint statement on repository Safety Requirements which defines and describes the safety case at a high level, and discusses its role.

Generally, the safety case is considered as one of the key requirements in a national repository development programme. To fulfil its role, it needs to be structured, technically argued, and supported, with a clear link to the step-wise decision-making process such that the level of confidence must reflect commitments to be made at each relevant step.

Over the years, insights were obtained from the IPAG initiatives that started in 1994 and consisted of three phases ending in 2000, with the aim to provide an international platform to examine the overall status of safety cases and their supporting Integrated Performance Assessment (IPA) studies and to confirm the ideas by practical examples.

The recent international peer reviews are also considered as a relevant activity when applied both to methodologies and major R&D studies in order to provide a basis for the decision to take the next step in the reviewed programme. Peer reviewers want to see more of a safety case than a safety or performance assessment. In the past three years, definite progress has been observed mainly in technical aspects of planning and performing long-term safety evaluations of repository systems. This progress is also evident in the quality of the technical work displayed in safety evaluations over time. Since 2001, several, major safety-related reports have been developed in national programmes and subjected to international review (US-DOE Yucca Mountain TSPA, ONDRAF/NIRAS SAFIR 2, Andra Dossier 2001 Argile, Nagra OPA). An important role of international co-operative projects sponsored by the IAEA, NEA, and/or EC is to help both in promoting improvement in work done in established programmes, and in transferring information to newer programmes to enable them to make rapid advances.

Consistent with the different initiatives carried out by the NEA since 1990, one of the activities under the NEA-IGSC platform concerns the publication of a brochure on the safety case. This brochure is under finalisation and in view of confirming some its aspects, a topical session that focused on the "lessons learnt from recent national initiatives including international peer reviews" was organised in the framework of the 5th meeting of the IGSC. This session was held in Paris in France on 15 October 2003. As already noted, in order to place this topical session into the current context of the work of the IGSC, two presentations were made in addition to the "lessons learnt" presentations. One discussed the status and safety-case content of the IAEA Draft Safety Requirements document, the other the status and content of the draft IGSC safety case brochure.

3. SUMMARY OF PRESENTATIONS

US-DOE

The session started with Abe Van Luik (IGSC Chair, US-DOE-YM, USA) who presented the feedback of the international peer review of the US-DOE Yucca Mountain TSPA (Total System Performance Assessment) supporting the successful designation of the site by the Congress and the President of the U.S. In particular, he listed key implications of the IRT (International Review team) recommendations on the forthcoming US-DOE documentation of its case for safety to be submitted to the regulator, the U.S. Nuclear Regulatory Commission, mainly:

- The documentation submitted to the licensing authority should address technical aspects and compliance with regulatory criteria.
- That documentation should reflect sound science and good engineering practice; it should present detailed and rigorous modelling.
- In addition, it should present both quantitative and qualitative arguments, make a statement on why there can be confidence in the face of uncertainty, acknowledge remaining issues and provide the strategy to resolve them.
- Demonstrating understanding is as important as demonstrating compliance.
- There is a need to provide a clear explanation of the case made to the regulator for more general audiences to complement the large amount of technical documents that will be produced. The US-DOE response to these recommendations for the License Application, which is under preparation, is that the recommendations will be implemented to the maximum extent possible.

In subsequent discussion, with respect to the License Application, it was acknowledged that detailed guidance from the U.S. regulator was very useful, and guidance of this type would be generally useful. At the current time, the words “safety case” are not mentioned in U.S. regulations, but if one reads both the regulation and guidance documents it becomes evident that all aspects of a safety case need to be provided in the License Application and its accompanying documents.

ONDRAF/NIRAS

Peter de Preter (ONDRAF/NIRAS, Belgium) presented the lessons learnt from the international peer review on SAFIR 2 of 2002 and the implications of the IRT’s considerations for future work. He mentioned that the IRT, in accordance with its mandate, focused on the long-term safety (methodology and application), on the scientific basis of the safety assessments and on the management of uncertainties. During the peer review it was agreed that the mandate could be extended to the discussion of policy issues. The IRT noted that SAFIR 2 could be considered as a first integration exercise in attempting to combine the knowledge accumulated to date into an integrated safety case

format. In the future, the two aims of recording the status of R&D and putting the R&D into a safety assessment/safety case would be addressed in separate documents. The results presented in SAFIR 2 confirmed that the main barrier was the Boom Clay, but the IRT considered that more credit could be taken for the Engineered Barrier System (EBS). Novel and innovative methods were established and the IRT encouraged ONDRAF/NIRAS to develop them e.g. safety functions, safety indicators. There is a need to better argue the geosphere stability and the engineered system capability. Peter de Preter mentioned that one of the difficulties during the preparation of the SAFIR 2 case was the lack of national guidance. The main lessons learnt from the peer review were:

- Most recommendations were more or less expected, known weakness have been confirmed.
- The international peer review provided the incentive for improved argumentation for the relevance of the system studied and justification of decisions.
- Policy and regulations are necessary to have a clear framework and therefore the regulatory framework will be one of the priorities of the regulators.
- There was a gap between the completion of the reviewed report (with results up till end 2000) and the timing of the review (2002) therefore the review process was exposed to new achievements and developments not reported in SAFIR 2.

Peter de Preter then presented the main implications of the review on the future programme in view of making a safety case:

- The future programme will focus on technical feasibility (construction and operation). One of the major problems concerned the level of the design, and the deliberations leading to choices being made. In response, ONDRAF/NIRAS has launched an integrated design group (with engineers, scientists and assessors), which will go through a complete design review with the aim of achieving more quality assurance and traceability of decisions and their bases.
- The integration of the understanding of processes with recognition of the importance of a good interface between the different actors (engineers, scientists, assessors) which is viewed as a management issue at ONDRAF/NIRAS. Additionally, a good balance between realism and robustness is recommended: even if all understanding is not integrated in the modelling, it could be used as support for the argument for safety.
- The uncertainty management, the strategic environmental assessment, and the involvement of stakeholders will be further developed in the future programme.
- Some scenario analyses will be updated in the light of the experience of SAFIR 2.
- The need for prioritising the work (uncertainty management to be reinforced) in respect of the stepwise decision-making process was recognised.

In conclusion, Peter de Preter acknowledged that although such peer reviews require the implementer to mobilise resources, they are a very helpful exercise.

ANDRA

Arnaud Grévoz (Andra, France) presented the Andra Dossier 2001 Argile, which is an evaluation of knowledge and an interim report in anticipation of the Dossier 2005, and served as a test of methods to be applied to this dossier. The "Dossier" consists of three main parts: a high-level synthesis, a more detailed one, and a series of reports. The Dossier 2001 Argile was not a safety case but some items of the safety case were already addressed. The Dossier 2001 Argile was submitted to an international peer review in 2002/2003. The main recommendations from the IRT were:

- A clarification of the documentation is needed, mainly on information flow in the network of various levels of documents.

- In view of communication to a wider audience, the synthesis could be improved e.g. using more illustrations.

- The "Dossier" did not always reflect the level of knowledge acquired.

- New methodologies were presented and need to be further developed**.** In particular, the AQS (Analyse Qualitative de Sûreté) corresponds to a failure mode analysis, but time-dependent phenomena were not taken into account. The IRT suggested less emphasis on the results of failure analysis, and more on the basis for analyses to allow the results to be placed into a coherent context.

In view of the forthcoming "Andra Dossier 2005", and with respect to the international peer review experience, Arnaud Grévoz described the main part of Andra's future work. The APSS (Analyse Phénoménologique des Situations de Stockage) will be updated. The safety analysis is being revised in more convincing and transparent ways to provide a clear exposition of the bases for arguments made in setting up the analyses and defining the models used for the analyses. The FEPs (Features, Events and Processes) date base will be utilised as a check list. In its future report, Andra intends to clarify terms such as pessimistic and conservative with a view to providing a more understandable document for wider readership. Some items where more development was needed were underlined, i.e. corrosion. Andra's research programme for 2002-2005 was judged adequate in this respect. For waste package source terms, Andra will integrate more the international experiences in particular on spent fuel. The gas issue that was not developed in the Dossier 2001 is one of the priorities that will be studied for the Dossier 2005.

The safety strategy is a key part of the safety report; in particular safety margins and reserves could be used as arguments for building confidence in the robustness of a repository.

One additional key point of the Dossier concerns the need to clarify the transposition of understanding to modelling. In conclusion, Arnaud Grévoz acknowledged the helpfulness of the international peer review to structure the new version of the Dossier 2005. He emphasised the international studies as a good input to build a high-level of argumentation and to inform the research programme.

SKB

Allan Hedin (SKB, Sweden) presented the current situation of the SKB programme. SR 97 was developed a few years ago and feedback of the international peer review was presented in a previous IGSC topical session.

The primary function of the KBS-3 disposal concept is isolation, and the second function retention. Regarding the site investigation, two sites will be studied from 2002 to 2008. An application for the encapsulation plant will be submitted in 2006, supported, as regards long term safety of the deep repository in which the canisters are to be emplaced, by a safety assessment "SR Can". The SR Can report is planned by end 2005 and an interim report on methodology by summer 2004. The report will contain references to applicable regulations issued by SKI and SSI regarding long-term safety of deep repositories. The principal compliance criterion states that the annual risk for individuals should be less than 10^{-6}.

When developing the report, an audit of the NEA FEPs database will be used as a check list. One or more initial states of the system will be selected as the basis for the analysis, corresponding to a "reference state" and "deviating" states. Preliminary analyses are made in order to gain insight into the system evolution and to inform the subsequent choice of scenarios; a number of alternative scenarios will be identified. If evolution for a certain scenario implies canister ruptures, then a calculation of consequences will be performed.

With respect to the handling of uncertainty, Allan Hedin noted that various approaches exist that may prove suitable for providing rigorous uncertainty analyses. During the discussion, it was acknowledged that one key step is to get feedback from the regulator on the selection of methodology for handling uncertainty before going forward.

Regarding the initial state of the system, it was noted that the point in time for the initial state will depend on the component you are looking at.

During the discussion the relevance was noted of having one report per aim, viz SR Can, to support the application for the encapsulation plant, and SR Site, to support a siting decision in 2008. The coupling between the biosphere and the other components was also noted as an issue in the discussion.

Nagra

Jürg Schneider (Nagra, Switzerland) described the project on the Opalinus Clay (Project Entsorgungsnachweis, demonstration of disposal feasibility for SF/HLW/ILW in the Opalinus Clay of the Zürcher Weinland) for which the main objective is to demonstrate disposal feasibility and to provide input to the decision how to proceed. The report structure was described, the focus of the presentation being the report that aimed to provide a comprehensive assessment of long-term safety. The current situation was described in the presentation as follows:

- The key need is to provide arguments for having proposed a good system for which there is sufficient understanding to allow a credible safety evaluation.

- Alternative options exist, on which attention is maintained by a task-force. However, Nagra is confident in its results on Project Entsorgungsnachweis, given the knowledge base that currently exists, and has put forward a proposal, for consideration by the Swiss Government, to focus future work on the Opalinus Clay (OPA) of the Zürcher Weinland.

- Making the safety case requires a proper integration of science, engineering and safety assessment.

- Three key issues were identified in making a safety case: completeness, sufficient safety, and robustness to diminish the importance of uncertainties.

- A safety case needs to be adequate to support a decision to proceed to the next stage in the programme, with multiple arguments including the existence of reserve FEP's.

- The interacting functions of the relevant teams were viewed as a key component of the process of preparing a safety case: management; science; safety assessment; bias audit.

During the discussion, the role of the bias team was recognised as being helpful to ensure completeness, as well as using the NEA FEP database as a check list. When speaking about sufficient safety, it should not imply predictive capability but rather that there is enough confidence in the current level of understanding to reliably bound the consequences, and that there is a continuing program for expanding and refining that understanding.

IAEA

Vincent Nys (AVN, Belgium) then presented the IAEA international projects ISAM/ASAM. ASAM (application of methodology developed under ISAM) began in 2002 as a follow-up of ISAM (project to develop methodology for near-surface disposals e.g. scenarios). One of the objectives of the working group of the ISAM project was to provide definitions, to look at the integration of the safety assessment and at the review procedure. The NEA international FEP's database was used and adapted to the near-surface context.

The so-called "design scenario" might be defined as the expected scenario according to functions. Building confidence in each stage is related to the confidence in the system, the scenarios process, and the assessment context.

With regards to the on-going ASAM project, participants acknowledged that the safety case contains both a safety assessment and a confidence statement. Additionally, traceability and transparency are of importance. The management framework, e.g. clear regulatory framework and clear regulatory process (review procedure), is a key element for the success of a safety case. The use of what-if scenarios could be helpful for testing the robustness of the design. It was also noted that at each stage of a safety case, the implementers should always give alternatives and should argue the choice of the reference (reversibility of the process). IGSC members noted that the safety case of near-surface disposal facilities has much in common with the safety case for deep disposal facilities. Discussion suggested that the definition and achievement of "optimization" are open issues in the post-closure safety context. Optimisation has a generally accepted meaning in the context of achieving safety in the operational phase

Phil Metcalf (IAEA, Austria) gave an overview of the background, content, sources of information and schedule for the document that is proposed to be published jointly with the NEA currently known as the "IAEA Safety Standards Series, Geological Disposal of Radioactive Waste, Draft Safety Requirements (DS-154)". Discussion focused on the status of such a document, in respect of which the primacy of national laws and regulations was acknowledged by the speaker, as well as in the document, and on the safety case definition and description in the document.

IGSC

Abe Van Luik (IGSC Chairman, US-DOE-YM) gave a quick overview of the status of the IGSC safety case brochure titled: "The Nature and Purpose of the Post-closure Safety Case in Geological Disposal". The need for IGSC member review, and the schedule for the review process, was explained. The objective was to have a document to present to the March 2004 RWMC meeting for its approval.

In discussion it was noted that this document was in good agreement with the safety case content of the Safety Requirements document described by the preceding presenter. It accurately paraphrases the IAEA document's definition and expands on the idea of a safety case without contradiction of that document.

4. OUTCOMES

Alan Hooper (UK Nirex Ltd, UK) presented the main outcomes of this session. He noted that three presentations showed a direct response to international peer reviews, two of them presented examples of developments in order to support key decisions, and three presentations dealt with "Frameworks" for safety cases, including the two that discussed the content and status of forthcoming international organization documents with safety case content.

Peer reviews had clearly provided valuable guidance on required developments, evidenced by responses in reviewed programmes. The international frameworks/databases are used as benchmarks and not as prescriptions. Peer reviews of all types are helpful to inform programmes, and there was clear evidence of the value of national regulatory and advisory committee reviews.

With respect to documenting a safety case, it might be concluded that there is a need to identify a clear and single objective (see for example the SR-Can/SR-Site discussion in the viewgraphs in part B provided by the Swedish programme). Additionally, whereas the safety case is fixed at a given time, different forms of its presentation could exist, and the safety concept should be made accessible - probably through a short "high level" document (avoiding technical details). One key issue concerns how to deal with new information (that becomes available after development of a particular safety case).

On the regulatory framework, regulators are providing guidance on expectations in some countries and others are encouraged to engage in similar work. The IAEA is also providing guidance on safety requirements, including the content of a safety case in a proposed joint publication with the NEA. Working in fora such as ASAM helps regulators to develop a structured approach to safety case review.

Making a safety case successfully is a management issue and the importance of using the key resource of personnel in the best way had been demonstrated very clearly. Examples were given such as the integrated design team (ONDRAF/NIRAS) and the Bias Audit Group (Nagra), which provide internal yet somewhat independent review and oversight that can aid the achievement of clarity and traceability in the making and documenting of decisions and results.

With respect to the technical aspects, there is a need to show how the expected system evolution contributes to safety. It is now well recognised that robust or conservative modelling may send a misleading message because these approaches may mask component contributions and uncertainties. Formal approaches are essential for showing how uncertainty is taken into account. Capabilities exist to handle coupled processes but the challenge is to select the approach that is most suitable for the system studied and the stage that the programme has reached. Reversibility/retrievability are not a safety requirement, but must be explained and accommodated in the safety case to provide an assurance of having adopted a cautious approach, that does not compromise long-term safety.

At the end it was concluded that:

- The development of a long-term safety case for geological disposal of high-level, long-lived wastes is now a mature area of applied science and technology – the community is no longer finding its way as is evident in the presentations made at this topical session.

- There is confidence that information needs can be identified and that methods have been developed to deal with the various types of uncertainty; the safety assessments foreseen in national programmes over the next five years will test whether the methods are sound and acceptable.

- The challenges are now more to do with how best to make the case to relevant stakeholders.

- Information exchange and peer review in international fora play a key role.

- The IAEA Draft Safety Requirements document and the draft IGSC safety case brochure are in harmony where the safety case is concerned.

- The draft IGSC safety case brochure properly reflects the experience presented by member organisations in this topical session; review by the IGSC members should be completed, and after that the document should be submitted to the RWMC for approval.

PART B

COMPILATION
OF
ORAL PRESENTATIONS

U.S. Department of Energy
Office of Civilian Radioactive Waste Management

YUCCA MOUNTAIN PROJECT

International Review Team (IRT) Safety Case Recommendations for the Yucca Mountain Total System Performance Assessment (TSPA) Supporting the Site Recommendation

Prepared for the NEA's Integration Group for the Safety Case (IGSC), **Topical Session on the Safety Case**, October 15, 2003, Paris, France

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Purpose of Presentation

- **To disclose the IRT's recommendations on the safety case (pages 3 through 8)**
- **To summarize the IRT's recommendations (page 9)**
- **To show what impact the IRT's recommendations have on the DOE's work for the License Application (LA) (pages 10 through 12)**
- **To show that Nuclear Regulatory Commission (NRC) expectations of the DOE's LA, as defined in their Yucca Mountain Review Plan, are in line with IRT suggestions for the content of a safety case (pages 13 through 16)**
- **To suggest that the DOE is preparing the equivalent of a safety case, as suggested by the IRT, but in documents that fit the national situation and regulatory context (page 17)**

IAEA/NEA International Review Team (IRT) Safety Case Recommendations

- **Mention of the safety case was made in several places in the IRT document: "An International Peer Review of the Yucca Mountain Project TSPA-SR: Total System Performance Assessment for the Site Recommendation (TSPA-SR)." OECD 2002.**
  - **Summary Section 2.2:** . . . a broader safety case should have been developed to support the site recommendation decision.
  - **Summary Section 3.1**: A Safety Case should be developed as a higher level document, and include the articulation of a strategy to achieve safety as distinct from the strategy for demonstrating compliance, with an emphasis on obtaining and communicating understanding and facilitating dialogue with the relevant stakeholders. A Safety Case is the integration of relevant arguments in support of the long-term safety of the repository. In particular, a statement of confidence should be included, to elucidate the means that were adopted to achieve sufficient confidence, and to acknowledge the remaining issues, together with a suggested strategy for resolving those issues. This should build upon the current Repository Safety Strategy document.

IRT Safety Case Recommendations (Cont'd)

- **"An International Peer Review of the Yucca Mountain Project TSPA-SR: Total System Performance Assessment for the Site Recommendation (TSPA-SR)." OECD 2002.**
  - **Summary Section 3.2:** In a future safety case it would be helpful to include a section in the main body of the report describing the evolution of the disposal concept. In addition to indicating how design changes have responded to safety concerns, this would provide continuity and would enhance confidence by demonstrating that the project is maturing and developing in a logical and systematic manner.
  - **Summary Section 3.4:** Nevertheless the TSPA-SR report has some shortcomings in terms of overall clarity and comprehensibility. This may be due to it being written for a number of different types of readers and is an area where improvement could be made. To address this problem in future, it would be appropriate to produce documents for different sets of stakeholders including a summary document where the whole YM concept, context and safety case is presented in a form suitable for a more general audience.

IRT Safety Case Recommendations (Cont'd)

- **"An International Peer Review of the Yucca Mountain Project TSPA-SR: Total System Performance Assessment for the Site Recommendation (TSPA-SR)." OECD 2002.**
  - **Section 2.2:** Alternative rationales for site suitability evaluation could also have been based around the development of a "safety case" . . . . Performance assessment is only one component of the safety case, other components being development of a strategy to achieve safety as distinct from the strategy for demonstrating compliance, with an emphasis on obtaining and communicating an understanding of the integrated system ant its performance and favouring dialogue with the relevant stakeholders. . . . . the existence of multiple barriers in the repository design and natural system is also a part of a safety case. . . . a safety case should include a statement of confidence . . . that acknowledges the existence of any unresolved issues and provides guidance for work to resolve these issues in future development stages . . . . it would have been preferable to have incorporated the TSPA within a safety case in support of the site recommendation decision . . . .

IRT Safety Case Recommendations (Cont'd)

- **"An International Peer Review of the Yucca Mountain Project TSPA-SR: Total System Performance Assessment for the Site Recommendation (TSPA-SR)." OECD 2002.**
  - **Section 2.3:** A sixth step is also mentioned in the TSPA-SR report, namely the development of a repository safety strategy and the principal factors. This step is discussed within a separate Repository Safety Strategy (RSS) document . . . which is potentially the most important safety case report but whose status is somewhat unclear. This represents a move towards implementing the NEA Confidence Document . . . as discussed in Section 2.2 above.
  - **Section 2.4:***The IRT recommends that, at an appropriate point, the USDOE should produce a document of a few tens of pages where the whole YM concept, context, and safety case is presented in a form amenable to a more general audience. This should emphasise the expected performance of the repository up to and beyond the compliance period. A relevant example is the summary of the Canadian Environmental Impact Statement (AECL, 1994).*

IRT Safety Case Recommendations (Cont'd)

- **"An International Peer Review of the Yucca Mountain Project TSPA-SR: Total System Performance Assessment for the Site Recommendation (TSPA-SR)." OECD 2002.**
  - **Section 3.1:** *The IRT recognises the need for a performance assessment to be well focused on a given design. However, the IRT recommends that a discussion of design improvements and their role in the safety strategy should be included in future safety case documentation. This would provide continuity and would enhance confidence by demonstrating that the project is maturing and developing in a logical and systematic manner.*
  - **Section 4.5:** . . . *the IRT recommends that if the Yucca Mountain project proceeds to the licensing stage, a safety case should be developed along the lines discussed in the NEA Confidence Document . . . . key messages from the NEA Confidence Document should be addressed in a safety case report for Yucca Mountain aimed at both the strategy to achieve safety and to demonstrate compliance. In particular, a statement of confidence should be produced, ... information contained in the RSS should be updated and extended, and used as a basis for developing the proposed safety case document for the next phase of the programme*.

IRT Safety Case Recommendations (Cont'd)

- **"An International Peer Review of the Yucca Mountain Project TSPA-SR: Total System Performance Assessment for the Site Recommendation (TSPA-SR)." OECD 2002.**
  - **Section 4.6:** *The IRT recommends that a safety case produced in support of licensing should incorporate an improved demonstration of system understanding to counterbalance the present emphasis on uncertainty.*
  - **Section 5.1.2:** . . . a broader safety case should have been developed to support the site recommendation decision.
  - **Section 5.3.2:** A safety case report should be developed along the lines discussed in the NEA confidence document.

Implications of IRT Safety Case Recommendations

- **Separate safety cases can be written, and should be written, to address the capabilities and interests of different audiences**
- **A submittal that is part of a licensing process, written for experts, should address system understanding as well as compliance**
- **A safety case, at any level of technical sophistication, should contain descriptions and evidence of:**
  - "science and good engineering practice"
  - "detailed and rigorous modelling of the disposal system"
  - "semi-quantitative and qualitative arguments"
  - *"a statement of confidence. . . an elucidation of the means that were adopted to reach sufficient confidence"*
  - *"acknowledgement of the remaining issues, and the suggested strategy for resolving the remaining issues"*

Impacts of Key IRT Safety Case Recommendations

- In Section 2.4
  - **"*The IRT recommends that, at an appropriate point, the USDOE should produce a document of a few tens of pages where the whole YM concept, context, and safety case is presented in a form amenable to a more general audience. . . .*"**
- Products prepared and in progress:
  - A brochure was prepared by the Secretary of Energy's office to inform the public about the Yucca Mountain site approval decision, it discussed the safety functions of the proposed system. It is available on the Internet at: **http://www.ocrwm.doe.gov/ymp/sr/faq.pdf**
  - The Environmental Impact Statement prepared to accompany the siting decision has a Summary with several pages explaining the site, transportation, the engineered system, and short and long-term safety implications: **http://www.ocrwm.doe.gov/documents/feis_a/rgd_summ/rgsum_bm.pdf**
  - A "Yucca Mountain Story" document is in preparation for the broader scientific/educated lay reader audiences (being written at a "Scientific American" level)

Impacts of Key IRT Safety Case Recommendations (Cont'd)

- In Section 4.5 of the IRT report on TSPA-SR:
  - ***"The IRT recommends that key messages from the NEA Confidence Document should be addressed in a safety case report for Yucca Mountain aimed at both the strategy to achieve safety and to demonstrate compliance. In particular, a statement of confidence should be produced, which is an elucidation of the means that were adopted to reach sufficient confidence in the current analyses, an acknowledgement of the remaining issues, and the suggested strategy for resolving the remaining issues in support of the next decision."***
- TSPA-LA documents now in preparation:
  - Explicitly recognize the advice given by the IRT
  - Explicitly address confidence (in validation section)
  - Recognize that TSPA is part of a larger safety argument or case which addresses remaining issues and data needs for their resolution

DOE's 2002 TSPA-LA Methods and Approach Document

- In Section 1.1 explicit mention is made of the NEA/IAEA review as an external review that will be taken into account as TSPA-LA continues to be developed.
- In Section 7, on TSPA model 'validation,' the words 'confidence' and 'confidence-building activities' appear in association with several of the techniques specified under the general heading of 'validation'
- The NEA/IAEA review is cited, with the suggestion that a model that includes some of the enhancements suggested by that review for this next phase of TSPA, should increase confidence in the TSPA-LA model

The Safety Case for the License Application

- **The License Application is a product being written by implementing organization specialists for regulatory organization specialists**
- **The regulator, the US Nuclear Regulatory Commission, has written detailed guidance, stipulating its review criteria (Yucca Mountain Review Plan, NUREG 1804, Rev. 2, 2003)**
- **The words "safety case" only occur in reference to a DOE usage of the words, but document headings and content make it clear that what is expected is the near equivalent of a safety case**

Postclosure Safety Demonstration to Include Plans for Ongoing Science Work

- **The NRC's Yucca Mountain Review Plan requires a comprehensive statement demonstrating postclosure safety in its Section 2.2** Repository Safety After Permanent Closure
- **It requires the identification of remaining safety questions and how they will be addressed in its Section 2.3** Research and Development Program to Resolve Safety Questions
- **Its Section 2.4** Performance Confirmation Program **requires the plan for monitoring key aspects of the system over time to assure data and assumptions remain valid**

Other Safety Case Aspects Expected in the TSPA-LA: Basis, Context, Uncertainty

- The TSPA-LA is to be evaluated as described in Section 2.2.1 of NRC's Yucca Mountain Review Plan, e.g.:
  - "the technical support for models and parameters . . . based on detailed process models, laboratory and field experiments, and natural analogs"
  - "the barriers important to waste isolation" in terms of their "importance," and their "capability" and its "technical basis"
  - "identification and classification, screening, and construction of scenarios from the features, events, and processes considered"
  - "parameter ranges and distributions, . . . representation of spatial and temporal scales, and whether the performance assessment model appropriately implements the abstracted model" including "the relevant data, the corresponding uncertainty, and effects on the performance of the repository"

Confidence Is A Requirement for the License Application Safety Analysis

- **The NRC's Yucca Mountain Review Plan mentions "confidence" several times in its section 2.2.1.4: "**Demonstration of Compliance with the Postclosure Public Health and Environmental Standards"
- **Confidence is mentioned under a statement of a criterion entitled:** "The Total System Performance Assessment Code Provides a Credible Representation of Repository Performance."
- **The requirement is for there to be** "confidence that the code is modeling the physical processes in the repository system in the manner that was intended."

Conclusion: The DOE is Providing the Equivalent of a Safety Case

- **NEA/IAEA IRT recommendations on the safety case are being implemented**
  - **The NRC's statement on what will be looked for in the review of the postclosure Safety Analysis Report, which will contain the TSPA-LA, show it to be expecting the equivalent of a safety case**
  - **The 2002 Final Environmental Impact Statement for a Yucca Mountain repository contains analyses that go beyond the times and distances required for a compliance demonstration, to provide additional understanding**
  - **A plain language brochure explaining the Yucca Mountain site approval decision in 2002 contained elements of a safety case for the general public**

Impact of the NEA Peer Review of SAFIR 2 on the future programme

5th IGSC meeting – October 15-17 2003

P. De Preter & Ph. Lalieux - NIRAS/ONDRAF

NIRAS

Context and terms of Reference of NEA review

- On request of Belgian Government
  - Review report submitted to responsible minister (August 2003)
  - No official reaction yet
- Review focus on
  - Long-term safety assessment methodology, the well-fondness of its results and the quality of its scientific and technical bases
  - The remaining key uncertainties and the RD&D programme that is proposed to deal with them in the next phase of the programme

NIRAS

General observations (1/9)

- SAFIR 2 is first integration exercise
  - Attempt to combine knowledge accumulated to date into integrated safety case format
- Hybrid report
  - Status report R&D period 1990 – 2000
  - Put into framework of a safety assessment
  - Future: two aims not to be fulfilled by single report
- Some analyses (scenario analyses) outdated

NIRAS

General observations (2/9)

- Fundamental role of Boom Clay acknowledged
  - Main barrier in disposal system
- More credit could be taken for EBS performance
  - Full effectiveness of multibarrier concept should be analysed and argued
  - In order to enhance robustness claims
- Uncertainty management to be developed further (how to define programme priorities ?)

NIRAS

General observations (3/9)

- Transferability of information from experiments to models
  - adaptation of models to different and changing *in situ* conditions to be improved
  - Balance to be struck between predictive capability (realism and mechanistic understanding) and capability to support safety through robust models and arguments

NIRAS

General observations (4/9)

- A good basis exists for the future programme
  - Studies made are relevant
  - Excellent platform exists to continue the disposal programme
  - Information very extensive + covers all relevant areas
  - Work in line with other national programmes
  - Some novel and innovative methods and tools (safety functions, complementary safety indicators)

NIRAS

General observations (5/9)

- Boom Clay at Mol and associated repository concept
  - Good focus of R&D programme
  - Geological situation in Belgium
  - Choices (Boom Clay at Mol/Dessel) are justified
  - Adequate properties for safety and construction
  - But: better argue "geological stability" and "engineering ability"

NIRAS

General observations (6/9)

- Ypresian Clays
  - Advantages (e.g. no exploited aquifer underneath) and disadvantages (e.g. lower mechanical strength, heterogeneity, more saline interstitial water)
  - Transferability between host formations or between sites within the same host formation of methods and information is important issue

NIRAS

General observations (7/9)

- SAFIR 2 report suitable basis for dialogue with regulators and policy makers
- SAFIR 2 highlights the need for further support and clarification at the policy level:
  - To move ahead beyond the methodological R&D phase
  - To start consultations on siting (+ dialogue with other stakeholders)
  - What considerations to be given to monitoring and retrievability ?

NIRAS

General observations (8/9)

- SAFIR 2 highlights need for a regulatory framework on issues such as
  - Criteria for judging safety and compliance
  - Radiological and non-radiological protection of the relevant water resources
  - Time frames for assessing regulatory compliance
  - Human intrusion
- Merit of SAFIR 2: extensive review of international guidance when national guidance was missing

NIRAS

General observations (9/9)

- Clear awareness of future R&D needs, BUT: need to develop strategy for setting priorities and structured approach for managing uncertainties
- Programme sufficiently advanced to address siting issue
  - Important experimental capability and database of information (Competent experimental team and URF HADES)
  - Important capability in area of safety assessment
  - At the forefront internationally in considering stakeholder involvement (Low level waste programme + SAFIR 2 companion booklet "Towards a sustainable management of radioactive waste")

NIRAS

Lessons learnt NIRAS/ONDRAF (1/3)

- Most of remarks and recommendations were some how expected
- The weaknesses and uncertainties have been confirmed
- An auto critical attitude is beneficial (and not only with respect to peers, but to all stakeholders)
- Peer Review has forced the team to better justify and argue
  - Arguments for the relevance of the studied system
  - Justifications of past decisions on e.g. design and material selection

NIRAS

Lessons learnt NIRAS/ONDRAF (2/3)

- More unexpected
  - Importance of recommendations on policy and regulations
    - Clarification of political choices on radioactive waste disposal
    - Definition of a general strategy for the protection of aquifers
    - Adaptation of regulations to the case of disposal
  - Programme sufficiently advanced to tackle the issue of siting
- Challenging experience for the team

NIRAS

Lessons learnt NIRAS/ONDRAF (3/3)

- A difficulty resides in the time gap between the period covered by the report and the moment of the review
  - New achievements and evolutions in the programme
  - Positive: shows the reactivity of the programme
  - Negative: complicates the discussions during the review

NIRAS

Impact on the future programme (1/5)

- Next reporting milestone: Safety and Feasibility Case 1 (2013)
- Focus on technical (construction and operation) feasibility for high level waste (vitrified waste and spent fuel), with a.o. large *in situ* experiments
  - Thermal impact
  - Sealing and plugs
  - Waste handling
  - Not yet optimisation
- Focus on compatibility waste - clay for intermediate level waste (bituminous waste)

NIRAS

15 5th IGSC - October 15 - 17 2003

Impact on the future programme (2/5)

- Focus on integration
  - within the study of component performance (e.g. radionuclide migration, geochemistry, radiochemistry, natural analogues …)
  - within the study of the system: integrating the interactions between scientific understanding - design and technology – evaluations
    - By restructuring the programme and the disposal team
- Focus on arguments and uncertainty management
- Focus on Knowledge Management and traceability

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16 5th IGSC - October 15 - 17 2003

Impact on the future programme (3/5)

- Interaction with Safety Authorities
  - Started officially for disposal of high level long-lived waste beginning of 2003
  - Emphasis on
    - Policy and Regulatory issues (e.g. decisional process, siting process, protection of water resources, monitoring, retrievability, foundations of a safety case)
    - Strategic issues of the disposal programme (e.g. transferability of information to another host formation and sites)

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Impact on the future programme (4/5)

- Confirmation of the disposal option
  - Elaboration of a Strategic Environmental assessment
  - Milestone 2008
  - Assessment of alternatives (technical, host formation, design, planning)
  - Stakeholder involvement
  - Practical implementation of the EU directive ? - to be discussed with safety and environmental authorities

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Impact on the future programme (5/5)

- Interaction with the stakeholders
  - From the local to the national level (bottom - up and top - down approach)
  - Already clear demands from the local partnerships for low-level short-lived waste for a dialogue on high-level waste management and disposal
  - Preparatory work 2003 - 2004
  - Siting issue to be tackled
  - Strong interactions with the SEA work

NIRAS

Conclusion

- An intensive exercise, mobilising the small team during a considerable period of time
- Critical and constructive review
- Appreciated input on the technical AND strategic level
- Useful elements for
  - prioritising and structuring the next phase of the programme
  - clarifying the decisional process
- ONDRAF/NIRAS thanks the Review Team and NEA

NIRAS

Observations of the NEA Peer Review on Dossier 2001 & Future steps

Arnaud GREVOZ
Andra

IGSC Meeting - Technical Session
October 16th, 2003

Outline

- Dossier 2001 and Andra's program.
- Lessons drawn from the NEA Peer review in terms of :
  - presentation of the dossier,
  - safety strategy,
  - methods,
  - key issues.
- Andra's program regarding those items for 2002-2005.

Andra's dossier 2001

- Andra is required to produce an evaluation of the feasibility of an underground repository for intermediate and high level - long lived wastes in view of a parliamentary debate in 2006.
- Studies focus on :
  - Clay, using data from the Bure URL,
  - Granite, generic studies.
- Dossier 2001 is a milestone in the development of the French programm, focusing on clay.

Andra's dossier 2001 (2)

- Its main objectives were :
  - Formalising and testing the safety assesment methods in the view of the dossier 2005,
  - Evaluating if scientific and technical knowledge for safety assessment is available and identifying gaps and uncertainties,
  - to inform the research programme for 2002-2005,
  - to allow a further revision of the design of the concepts.
- Dossier 2001 drew no definitive conclusion about the feasibility of the repository.

Presentation of the dossier

- Dossier 2001 consisted of :
  - a synthesis file (“part A”),
  - a more detailed file, meant for an audience interested in a deeper understanding of the lines of arguments (“part B”),
  - Reference files (on waste forms, materials, geology, biosphere),
  - Technical notes.

The IRT findings

- A clear presentation of how the various components of the Dossier fit together is needed.
- Not all information is documented, or easy to find.
- The clarity of the documentation is variable :
  - partly because only preliminary information available,
  - partly because on “learning curve” for such a documentation exercise.
- Dossier does not always reflect the work performed (e.g. hydrogeological modelling).

Synthesis Documents

- Parts A and B not successful in terms of meeting needs of different audiences.
- More comprehensive overview of entire Dossier needed.
- More extensive referencing needed to the underlying documents.
- More illustrations needed to support and clarify the written text.

Individual Documents

- Make more complete and able to stand alone.
- Provide more exhaustive referencing to the underlying sources of information.

Overall recommendation

- Dossier 2005 documents should be written to fit a pre-designed structure, tailored to the needs of different audiences.

Andra's intentions for the structure of dossier 2005

- The peer review was very useful to revise the intended structure for dossier 2005 :
  - different volumes meant for different kinds of audiences :
    - a volume for the « general public »,
    - specialized volumes meant to address different points of view, each able to stand alone,
    - Might imply having some degree of duplication from a document to another.

Andra's intentions for the structure of dossier 2005 (2)

- Structure of the rest of the documentation :
  - structure of the reference files revised so they can reflect more accurately the work performed by Andra and its partners,
  - reflections on the referencing structure,
  - reflections on the iconography,
- Reflections on the possibility of "internal reviews" while writing the dossier.

Safety Assessment Methodology

- All steps of the (preliminary) safety assessments were reviewed and compared to “good international practice”.
- Topics addressed more specifically :
  - APSS : analysis and modelling of system evolution.
  - Qualitative Safety Assessment (AQS) :
    - identification of potential failures,
    - derivation of scenarios.

Consistency and Adequacy of Applied Methodologies

- All key methodological elements for a safety assessment are present.
- Some newly developed elements (APSS, AQS) potentially useful but need further development (alternative evolutions, integration of temporal evolution in the AQS).
- Consistency between method descriptions and applications not always transparent regarding e.g. choice of parameters.
- Application of methods : consistency between elements generally adequate, but propagation of uncertainties needs improvement e.g. fixation of time frames.
- Methods allow identification of key sensitive components of repository at present stage ; need development to a more formalised approach for future assessments .

Andra's work on the revision of methodologies

- APSS will be revised to take into account phenomenology of alternative evolutions.
- The safety analysis is being revised so it can :
  - be more convincing in presenting the arguments of the safety analysis ,
  - be more transparent regarding subjective elements,
  - be more explicit as regards the management of uncertainties,
  - take into account time frames in a more explicit way.
- The failure modes derived from qualitative safety analysis will be compared to international FEP's databases.

Internal Consistency Between Knowledge Base and Hypotheses

- Cautious approach has been adopted.
- Basic knowledge already supports greater confidence than presented.
- Phenomenological descriptions : clearly traceable to existing knowledge.
- Selected values of parameters : consistent - often in sense of sound identification of pessimistic value, but the procedure for selection not easy to trace.

Andra's lines of progress in terms of safety strategy, as identified after the NEA review

- Improve the consistency between the level of knowledge and the hypotheses of the safety assessment.
- More explicit management of uncertainties, at the heart of the safety assessment :
  - how they informed the proposed design of the repository,
  - how they informed the choice of parameters and models for the safety assessment,
  - how they inform sensitivity analysis,
  - how they relate to the building of alternative evolution scenarios.

Lifetime of Metallic Materials

- Focus
  - Secondary containers for vitrified waste packages,
  - Containers for spent fuel.
- Recommendations
  - More complete analysis of expected hydrogen partial pressures in the repository environment, in relation to possibility of embrittlement of the carbon steel overpack ;
  - Strengthen hypotheses and supporting evidence for iron/clay interactions, in relation to evolution of overpack-clay system.

Waste Package Source Terms

- Wide range of waste types (greater than in most other programmes), creating challenge for integrating information nationally and from abroad
- B wastes
  - comprehensive, sophisticated treatment,
  - new approaches, work at the forefront internationally.
- C (Vitrified) Waste
  - key uncertainties clearly identified and represented,
  - reasonable conclusions, prospects for improvement identified.
- Spent Fuel
  - depth of understanding that exists in international work and CEA studies not reflected in document (unbalanced and too brief),
  - values for safety assessment appear conservative.

Waste Package Source Terms (2)

- Recommendation :
  - More balanced and comprehensive treatment of scientific understanding of spent fuel dissolution, with a clear presentation of the relative importance of specific uncertainties.
  - Make maximum use of verified data from international studies.

Non-treatment of Gas in Safety Analysis

- Only important omission from the Dossier.
- Recommendation :
  - To inform design choices and possible need for further waste characterisation, and take account of limited transport in tight formation, boundary conditions for far-field gas transport to be evaluated as soon as possible.

The Callovo-Oxfordian and its Surroundings

1. Sound overall geological characterisation, in forefront in assessing long-term stability :
   - Efficiency of retention processes to be supported further.
2. Multiple arguments supporting :
   - Overall favourable properties/ability to fulfil the confinement roles given to the argillites in the Dossier 2001 safety approach,
   - Basic hypotheses for the conceptualisation (especially diffusion-control),
   - Presence of safety reserves or margins.

The Callovo-Oxfordian and its Surroundings (2)

3. Transition from hydrogeological phenomenological modelling towards safety model well justified but poorly documented

4. “a priori” URL reprensentativeness tested by “equivalent geological area”

5. Scientific programme 2002-2005 systematically informed by the Dossier 2001 (e.g. testing of hydrogeological model, quantifying retention)

Andra’s program for 2002 - 2005 regarding these topics (1)

- Focus on interactions between Iron/Argilites so as to model the nature and extension of the disturbed zone.
- Extensive work on the choice of better source terms for spent fuel, taking into account dissolution mechanisms. Andra will integrate the results from the international SFS program.
- Analysis (not performed at the stage of dossier 2001) of gas emissions from the various waste packages. Evaluation of the quantities accumulated and their possible mechanical interactions with materials / host formation.

Andra's program for 2002 - 2005 regarding these topics (2)

- Regarding the host formation and its surroundings
  - Andra participates in the AMIGO group,
  - the definition of the « transposition zone » including geochemical and geomechanical caracteristics,
  - the better characterization of the chemistry of the host formation waters,
  - the better characterization of transportation mechanism (sorption…).

Reversibility

- Andra's analysis is systematic. It considers technical and scientific aspects ; it does not address the interface between reversibility and operational and long-term safety.
- Recommendations :
  - The principles underlying reversibility should be gathered in one document along with definitions of concepts and policy indications, and ensuing "reversibility" options catalogued and analysed.
  - It would be good to promote a wide discussion of principles and management solutions to enable integration of the views of Andra and those of relevant stakeholders in anticipation of the national debate.

Andra's lines of progress for 2002-2005

- Developments in the design of reversible concepts.
- Reflections on the implication of reversibility regarding safety.
- A specific part of dossier 2005 will be dedicated to engineering and reversibility, so as to enable a debate on these options.

Conclusions

- Dossier 2001 was not a safety case, and not evaluated as such.
- However, some items mentioned in the safety case brochure were analysed in depth
- The Peer review was crucial in terms of helping Andra to establish the structure Dossier 2005
- It was very helpful in optimizing Andra's program for the 2002-2005 period
- It helped a lot in comparing Andra's work to international standards.

The safety assessment SR-Can

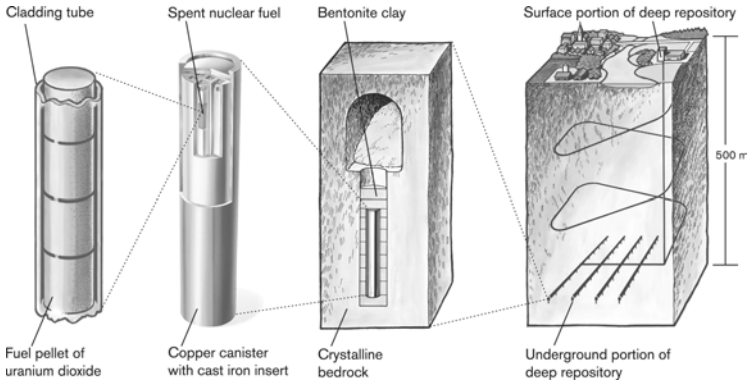
Allan Hedin, SKB

Outline

- Context
- Purposes, time plans etc
- Methodology

SR-Can planning IGSC topical session 15 October 2003

The KBS 3 repository

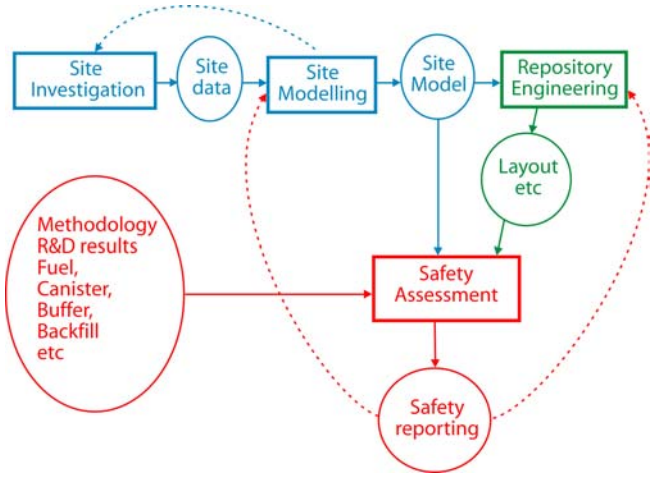


- Primary safety function: isolation
- Secondary safety function: retention

Context: Safety assessments during current program stage

- SKB is pursuing site investigations for SNF deep repository at Östhammar and Oskarshamn (2 sub-areas)
- Initial site investigations 2002 - 2005
  - Preliminary site evaluations to i) assess suitability and ii) give feedback
- If OK: Complete site investigations 2005 – 2008
- Aim: Application to build deep repository at one site to be handed in 2008, supported by safety assessment SR-Site
- Application to build encapsulation plant to be handed in 2006, supported by safety assessment SR-Can

Context: Site, engineering & safety



Context: Site description

- Site analysis group provides site description based on site investigation data. The site description consists of
  - A model of the geosphere and the biosphere at present
  - Site understanding, essentially a demonstration of how historic evolution has lead to the present situation
  - Hydrological simulation model to be used also in safety assessment to study future evolution

Purpose of the SR-Can project

- The purpose of the SR-Can project … to produce a safety report for the deep repository that will form part of the application to build an encapsulation plant
- The report shall be finished by the end of 2005.

Purpose of the SR-Can report

- SR-Can should assess the safety of a KBS 3 repository at Forsmark and Simpevarp with canisters according to the application to build the encapsulation plant
- SR-Can should provide feedback to further canister development, to repository design development, to further site investigations, to SKB's R&D programme, and to future safety assessment projects.

Miscellaneous

- Planning report TR-03-08
- Interim report, emphasis on methodology summer of 2004
- Final report SR-Can end of 2005,
  analyses of model version 1.2 of Forsmark and Simpevarp
- Assessment period: One million years after closure

The planning report TR-03-08

- Main chapters
  - Methodology
  - Climate issues
  - Biosphere issues
  - Geosphere issues
  - Near field issues
  - FHA (Intrusion issues)
  - Integrated modelling
- Appendix: SKI's and SSI's regulations
  - Inserted in text: references to sections in main chapters where plan for handling in SR-Can is given

SR-Can, methodology

- ”Main issue”: Does the evolution of the repository over time lead to doses/risks that exceeds given criteria? (SSI: Annual risk to individuals less than 10^{-6})
- Repository evolution determined by
  - Initial state
  - A system of coupled ”internal” processes in fuel, canister, buffer, backfill, geosphere and biosphere
  - External influences
- Need to handle uncertainties for all these aspects

Methodology in nine steps

1) Qualitative system description, FEP processing
2) Initial state descriptions
3) Description of internal processes and their handling in the safety assessment
4) Description of external conditions
5) Preliminary analyses
6) Scenario selection
7) Input data selection
8) Analysis of evolution for chosen scenarios
9) Integration of results and conclusions

SR-Can FEP database

- Audit of NEA's FEP database (which includes SKB's databases)
- FEPs sorted into categories
  - Initial state
  - Internal processes
  - External conditions
- Internal processes roughly same as those in SR 97

Initial state

- One or more initial states to be selected; both "reference state" and "deviating" states
  - Site according to model version 1.2 Forsmark and Simpevarp including alternative site interpretations
  - Reference design of KBS 3 in site specific tunnel layout (Repository engineering)
  - Conceivable deviations from reference design (e.g. mishaps during construction and operation). Note that e.g. initially damaged canisters to some extent are included in reference design.
  - Open design issues (buffer- and backfill materials, excavation technique etc)
  - Management of all "initial state FEPs"

Handling of internal processes

- Updating of SR 97 Process report
- Biosphere in separate report
- Documentations for each process
  - Overview/General description
  - Influencing/Influenced variables
  - Boundary conditions
  - Model studies/Experimental studies
  - Time perspectives
  - Natural analogues/observations in nature
  - Handling in safety assessment (“neglected or quantified”)
  - Handling of uncertainties
  - References
- Yields mapping of processes on models

Preliminary analyses

- Purpose: Gain insight into system evolution and into importance of specific issues, pave the way for selection of scenarios
- Examples of issues:
  - How does buffer and backfill evolve when exposed to ”reference water”, sea water, glacial melt water, oxygenated water?
  - Canister corrosion for the above waters, for initially entrapped oxygen and for buffer impurities
  - At what isostatic load does the canister collapse?
  - Consequences of maximum conceivable earthquakes with applicable respect distances
  - What uncertain input data dominate output distributions in radionuclide transport- and dose calculations?
  - Ditto for calculations of peak canister surface temperature, etc…

Choice of scenarios

- Overall aim of the safety assessment: Determine whether SSI's risk criterion is fulfilled
  - A number of alternative evolutions (scenarios) must be analysed
  - Together, the scenarios must give a reasonable coverage of conceivable evolutions with respect to radiological consequences
  - A risk contribution is calculated for each scenario = probability for the scenario times dose consequence
  - The risk contributions are added to yield a total risk
- Each scenario may have a number of variants

Choice of scenarios

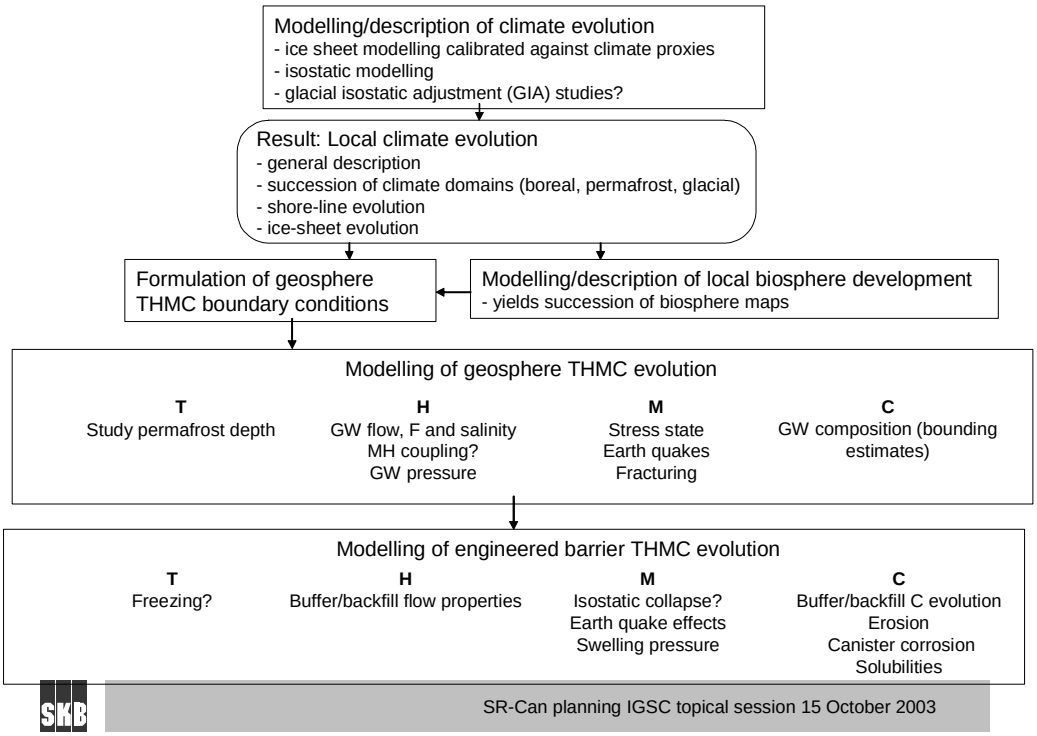
- Bases
  - Initial state report
  - Preliminary process report
  - Description of climatic evolution
  - Results of preliminary analyses
  - Descriptions of "safety functions"
  - A first analyses of repository "expected evolution"?
  - Etc
- Can be forecasted:
  - A "main scenario" with "probable" evolution of climate etc.
  - Several alternative climatic evolutions need to be included
  - A scenario where today's biosphere persists (required by SSI, zero probability?)
  - Earthquakes to be included in all scenarios (contrary to SR 97)
- A number of bounding cases will be analysed but probably not as formal scenarios (not included in risk calculation)

Analysis of chosen scenarios

- Analyse system evolution for each scenario
- If evolution implies canister ruptures (or initially damaged canisters):
  - Radionuclide transport and dose consequences for each scenario, typically for constant, pessimistic barrier properties derived from system evolution
  - Probabilistic calculations to manage data uncertainties within scenario
- Early in project: test analysis of entire glacial cycle
  - Assume repetition of last glacial cycle (Weichsel)
  - Specify sub-analyses and their interdependencies

Input data report

- Input data to radionuclide transport and other calculations
- Template for discussion of input data and data uncertainties is being developed and tested
- On what input data should we focus?
  - Sensitivity analyses on-going…



Handling of uncertainties

- Preliminary plan in Planning report; description of handling of uncertainties in the following steps:
  - Derivation of a comprehensive set of internal processes and variables
  - Compilation of Process Report
  - Derivation of a set of initial states that cover all relevant safety related features
  - Derivation of external conditions
  - Compilation of input database
  - Selection of scenarios
  - Model evolution for each scenario
  - Bounding calculation cases

SR-Can planning IGSC topical session 15 October 2003

Interim report Summer 2004

- Purpose: To consult with SKI and SSI on methodology for SR-Can
- Much of the methodology formulated in planning report
  - Dialogue has already started
- An Interim report will
  - not be a full safety report
  - not draw conclusions concerning safety for the analysed site
- Form of publication to be determined

Project *Entsorgungsnachweis*

Demonstration of disposal feasibility for SF / HLW / ILW in the Opalinus Clay of the Zürcher Weinland

Background, Objectives & Overview

NEA - IGSC Meeting
15 - 17 October 2003

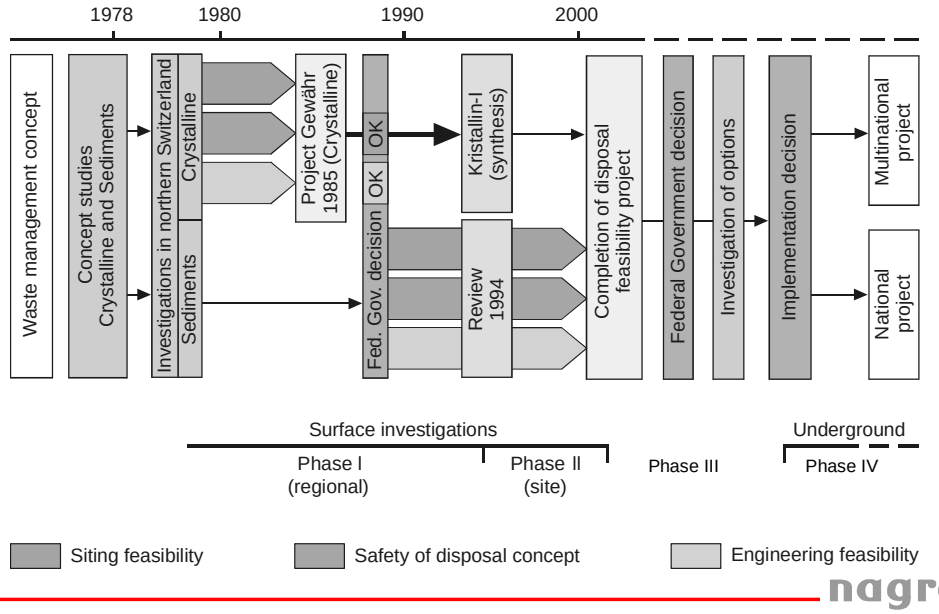
Jürg Schneider & Piet Zuidema

Aims of Project *Entsorgungsnachweis*

- **Demonstration of Disposal Feasibility ➔ Extends and complements *Projekt Gewähr 1985***
  - Re-assessment of *siting feasibility* (needs also to consider *engineering feasibility & safety*)
  - The need to consider *sedimentary formations (phased selection process of preferred investigation area* ➔ Opalinus Clay in Zürcher Weinland*)*
  - p.m.: the need for a full synthesis of all information on *crystalline basement*: synthesis completed ➔ Kristallin - I[1)]
- **Preparation of Material & Input for Deciding on Future HLW Programme (approval by federal government)**
  - Assessment of the Opalinus Clay in the Zürcher Weinland by authorities
  - p.m.: Governmental working group prepares Government decision ➔ synthesis, compilation of additional information on specific aspects

1) Authority review completed soon; additional field work done (2-D seismics in Mettauer Tal)

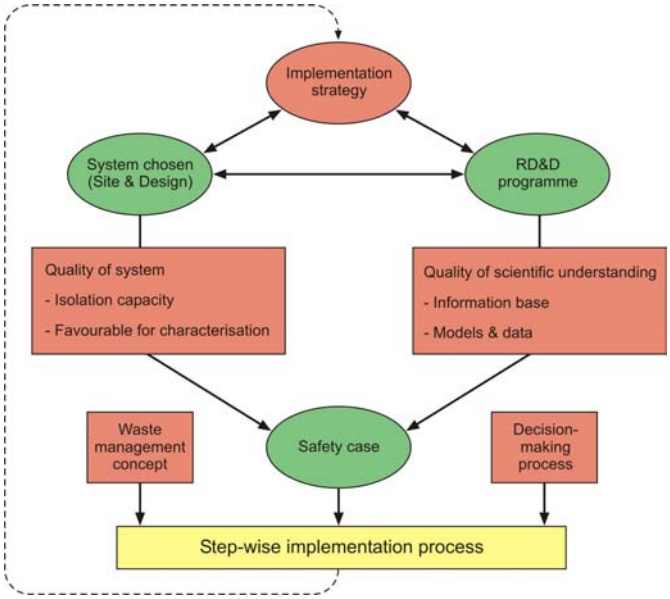
Adaptive staging in Swiss HLW programme



HLW programme: current situation (end Phase II)

- **Current milestone of HLW programme (*Entsorgungsnachweis*): 'Disposal Feasibility' based on localised investigations**
  - **Siting feasibility**: *'(Where) do adequate sites exist?'*
  - **Engineering feasibility**: *'Can repository be implemented as planned?'*
  - **Safety**: *'Is repository system safe for the site considered and the design envisaged?'*
- **Key issue: provide arguments for having chosen a good system for the 'way forward' & sufficient understanding to proceed (proposal to focus on the Opalinus Clay of the Zürcher Weinland)**
  - Sufficiently safe? ➔ level of **confidence**
  - Sufficiently **robust?** ➔ reliable in the face of uncertainty (and providing flexibility for changes)
  - No obviously better system? Role of **alternatives**?

Elements in decision-making at a given milestone



- **Implementation strategy**
  - Choice of system
  - RD+D - programme
- **Safety case: periodic assessment of strategy**
  - Quality of system
  - Quality of understanding
- **The societal element**
  - Geological disposal adequate?
  - Decision-making process (who? what? when? how?)
  - What next? flexibility left?
- **Any changes in plan?**

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Conclusions of Project *Entsorgungsnachweis*

- **The Opalinus Clay in the Zürcher Weinland and the System of Engineered Barriers …**
  - provides high level of safety
  - is technically feasible
  - can be implemented with currently available technology
- **The results have exceeded the expectations; the data acquired are reliable & the level of understanding is good**
- **Nagra considers that ....**
  - the Opalinus Clay in the potential Siting Region of the Zürcher Weinland is promising (*Siting Feasibility*)
  - the Facility can be constructed, operated and closed as planned in that host rock / region, maintaining enough flexibility (*Engineering Feasibility*)
  - and that the Safety Case is convincing (*Safety Demonstration*)
- **Nagra therefore proposes to the Swiss Federal Government to focus future work in HLW programme on Opalinus Clay in Zürcher Weinland**
- **But: Formal siting decision still many years away**
- **And: Alternative options exist on which a watching-brief is maintained**

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Swiss HLW Programme: Summary

1 The *Opalinus Clay & the potential siting area Zürcher Weinland* have been **chosen from several available sediment options** (rocks, areas) **for investigation** in a step-wise procedure lasting many years with all important decisions **cleared and supported by the Swiss regulator** (and policy maker and their advisors)

2 Due to the **excellent results** obtained in project *Entsorgungsnachweis* (investigations, synthesis), Nagra proposes to **focus future work on Opalinus Clay in the potential siting area Zürcher Weinland**.

3 **Other options are also available** (alternative siting regions in Opalinus Clay, crystalline basement, reserve option USM) on which **a watching brief is maintained**. However, Nagra feels that it is currently **not justified to perform further extensive investigations** for these options.

4 Project *Entsorgungsnachweis* is currently **under review** by the Swiss regulator (incl. international review under the auspices of NEA); a decision by the Swiss government on **how to proceed is expected in 2006**.

5 A formal **siting decision** is not expected within the next few years (General licence).

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Making of the Safety Case

- Making of the Safety Case has to ensure proper integration of science & engineering ➔ both topics discussed in combination

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The Safety Case - Definition

The safety case is the **set of arguments and analyses** used to justify the conclusion that a specific repository system will be **safe**. It includes, in particular, a presentation of evidence that all relevant **regulatory safety criteria can be met**.

It includes also a **series of documents** that describe the **system design** and **safety functions**, **illustrate the performance**, **present the evidence** that supports the arguments and analyses, and that discuss the significance of any **uncertainties or open questions** in the context of **decision making for further repository development**.

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Focus of the Safety Case

- **'Siting / Disposal Feasibility': importance to focus assessment on issues that could put safety of project into question**
  - **Completeness**: no important issue overlooked ➔ extensive phenomenological evaluation & broad spectrum of cases
  - **Sufficient safety** (vs exact level of safety) ➔ bounding & simplified assessments may be acceptable for (some of) the cases; deterministic analyses complemented by probabilistic calculations
  - **Robustness** ➔ insensitivity to residual **uncertainties** and/or reserves of safety exist
- **Importance of discussing key properties of system** *('make quality of system visible')*
  - Understanding
  - Uncertainties: importance of explorability & predictability of system
  - Diversity of phenomena contributing to safety
  - Independent evidence for the operation of key phenomena

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The Safety Case - Lines of argument

1. **Safety case is well-focused** & adequate for current stage
2. Strength of **geological disposal** as waste management option
3. **Safety and robustness** of the chosen disposal system
4. Reduced likelihood / consequences of **human intrusion**
5. Strength of the **stepwise repository implementation** process
6. **Good scientific understanding** of the system & its evolution
7. Adequacy of **methodology and models, codes and data**
8. Multiple **arguments for safety**
   - The demonstration of safety / **compliance with regulations**
   - The use of **alternative safety and performance indicators**
   - The existence of **reserve FEPs**
   - The **absence** of issues that could **compromise safety**

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Safety Case: approach chosen

- **Define meaning of a 'good system' and a 'good analysis'**
  - Disposal principles
  - Assessment principles
- **Define method for processing information (➔ integration of team) and to address 'compliance' with above goals**
  - Scientific understanding as starting point (***science***)
  - Organisation, abstraction & assessment of information with explicit consideration of uncertainty (***safety assessment***)
  - Balanced & unbiased treatment of information (***bias audit***)
  - Allow for iterations & provide feed-back (***management***)
- **Conduct analysis according to method defined**
- **Documentation: the need to divide documentation into several reports** *(keep it manageable for the reader)*
  - Transparency ➔ arguments are clear & understandable
  - Traceability & retrievability of information ➔results reproducible

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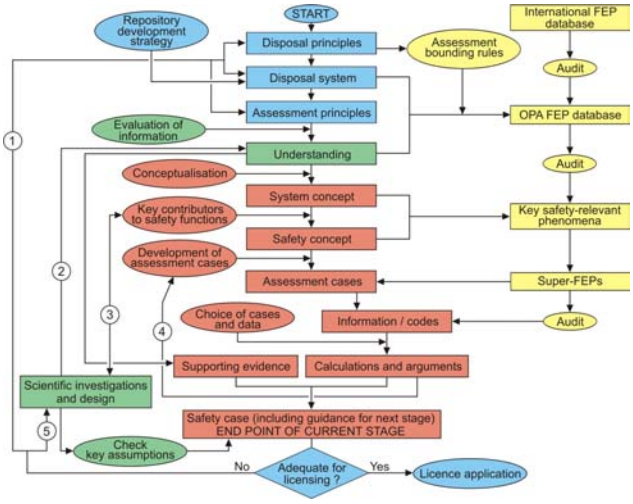
Structured & clearly defined flow of information



- Understanding: **System Concept**
- What is important: **Safety Concept**
- Uncertainties & their potential effects: **Assessment Cases**
- Perform **Analyses**
- **Compilation** of analyses and arguments
- Address possibility for **Bias**
- **Conclusions**

The need for different functions to develop the safety case

	Management	Science and technology	Safety assessment	Bias audit
Management	Overall management of project	Keep work of groups focused on project goals; maintain overview of role/requirements of different groups; be responsive and accessible		
Science and technology	Keep management informed (incl. any problem areas that need resources focussed on them)	Develop and evaluate scientific basis for safety assessment	Provide safety assessment team with understanding required to develop system concept and tools for analysis; revisit key assumptions	Provide bias audit team with comprehensive view of system understanding (including limitations)
Safety assessment	(as above)	Ensure that science and technology is aware of activities and information requirements of safety assessment team	Formulate and analyse safety assessment cases; assess "independent evidence"; compile safety case	Provide bias audit team with description of cases and concepts and tools used to analyse them
Bias audit	(as above)	Ensure that the scientific basis for safety assessment is adequately documented	Ensure that appropriate use is made by safety assessment of available scientific understanding	Ensure that the scientific basis for safety assessment is complete, adequately documented and exploited in safety assessment

The importance of the team

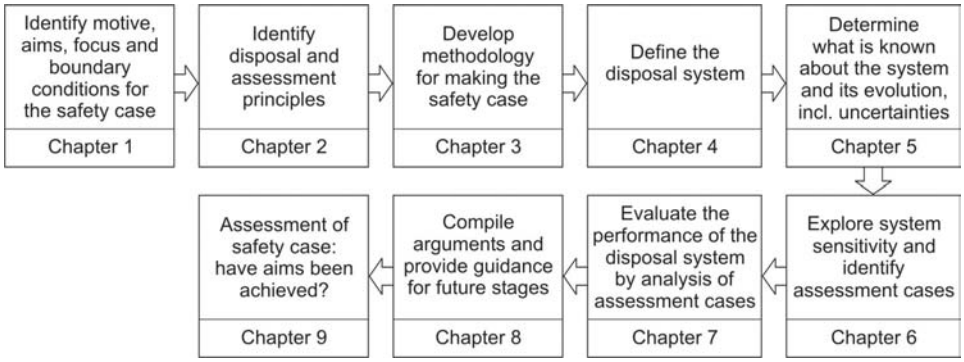
- **Management**: provide guidance, ensure interaction, iteration, feed-back
- **Science**: provide sound understanding
- **Safety assessment**: organise, analyse, compile arguments
- **Bias audit**: ensure that biases are acknowledged, avoid inadvertent biases

Documentation

- **Safety Report (*transparency*)**
  - overview: background, methodology, status of science & technology
  - results (key arguments, insight, quantitative assessment cases)
  - conclusions
- **Models, codes & data (*traceability & bias audit*)**
  - provides details for quantitative assessment cases
  - description & qualification of codes used
  - complete compilation of all data used in assessment cases
- **FEP - management (*completeness in all steps & bias audit*)**
  - complete set of information?
  - information integrated?
  - codes adequate?
- **Reference reports (*detailed justification of concepts & data*)**

The Safety Case - Flowchart for its development

The Safety Report



Safety Assessment

The means to produce a Safety Case: Safety Assessment

- **Safety Assessment is a process and includes**
  - Development of system understanding ➔ scientific analysis
  - Evaluation of safety ➔ synthesis
  - Interaction with and guidance of other disciplines (avoid unsuitable projects!)
- **Safety Assessment serves as a platform for**
  - Processing & integrating all information
  - Interaction between the different disciplines involved
  - Setting priorities and defining adequate levels of accuracy
- **Safety Assessment evaluates & documents current understanding**
  - Understanding & conceptualisation ➔ confidence in results
  - Evaluation of safety ➔ compliance
  - Feedback

1) importance of adaptive staging: iterative nature of Safety Assessment

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Conclusions

- **Safety Case is integral part of adaptive staging**
- **At each milestone the safety case needs to be focused on the decision at hand**
- **A safety case (at least in the early parts of the project) contains both qualitative and quantitative arguments**
- **Important aspects of the methodology**
  - Importance of scientific basis (*what is known? what not?*)
  - Systematic processing of information (*completeness*)
  - Assessment of *uncertainties*
  - *Bias* (acknowledged vs inadvertent bias)
  - *Feed-back* (within current phase & input for next phase)
- **Successful analysis needs integrated & dedicated team**
- **Importance of well-structured documentation**

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The Safety Case & Peer Reviews

- **Role & importance of the Safety Case**
  - Framework: adaptive staging ➔ phases & milestones (decisions)
  - Safety Case: important element for decision-making
- **Role of peer review: background, framework & impact**
  - Endpoint: government decision on how to proceed with Swiss HLW programme
  - Preparing this decision: a process with reviews, consultation, ...
  - Visibility (➔ importance) of NEA International Review expected to be very high
  - p.m.: importance of peer review in preparing the project
- **Making the Safety Case: a discussion of aims, functions and interrelation of activities**
- **Integration of science as part of making the Safety Case**
  - Broad role of safety assessment (integration of & judgement on "scientific understanding")
  - Working process adopted in making the safety case (the specific function of science, interrelation of science with other activities)
  - Importance of organisational & cultural framework (everything integrated in one unit since quite some time)

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Stepwise approach: what, when, why & how

- **Phases delineated by different milestones / decision-points**
- **No other possibility to implement such a project (of such long duration)**
  - Nobody will take full commitment at the beginning
  - Allow for learning & involvement of stakeholders
- **Elements of stepwise approach**
  - Define boundary conditions/criteria (& process) for initial definition of project & for adapting project
  - Define aim / objective of project (e.g. *finding a solution to long-term waste management*) & organisation of project (*responsibilities, milestones, ...*)
  - Adapt project according to learning & changing boundary conditions (also with the possibility to reverse)
  - Involvement of stakeholders (when, how, ...) in adapting project

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Stepwise approach: technical & societal issues

Phases delineated by different milestones / decision-points

- For each of the decisions the **information required** depends upon the **commitment involved** in the decision
  - How good is good enough? (➔ importance of concept of robustness[1)])
  - How to **choose the system** to achieve significant level of robustness (➔ confidence in feasibility of 'path chosen')
  - How to acquire the necessary information? (boundary conditions)

[1)] limited sensitivity towards residual uncertainty & changing boundary conditions

- In each of the decisions **the involvement of stakeholders** depends upon the importance of the decision at hand
  - What **information do the stakeholders** need?
  - How to ensure proper **interaction between stakeholders**?
  - How to get **'legitimation' to solve national problem**?

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The early phases of the Swiss HLW programme

- **Phase I: Feasibility of final disposal**
  - assess basic feasibility
  - develop basic concept
  - investigate siting possibilities (**regional** field programme)
  - develop expertise & infrastructure (labs, URL, team, ...)
- **Phase II: Siting feasibility**
  - consider lessons learnt from Phase I
  - optimise concept (robustness)
  - assess **siting** (& safety, engineering) feasibility
- **Phase III: Investigation of options**
  - consider lessons learnt from Phase II
  - optimise (& confirm) concept (robustness, safety, cost, ...)
  - assess alternative options (including multinational solution)
  - **decide on option** to be implemented (➔ 'Decision in Principle')

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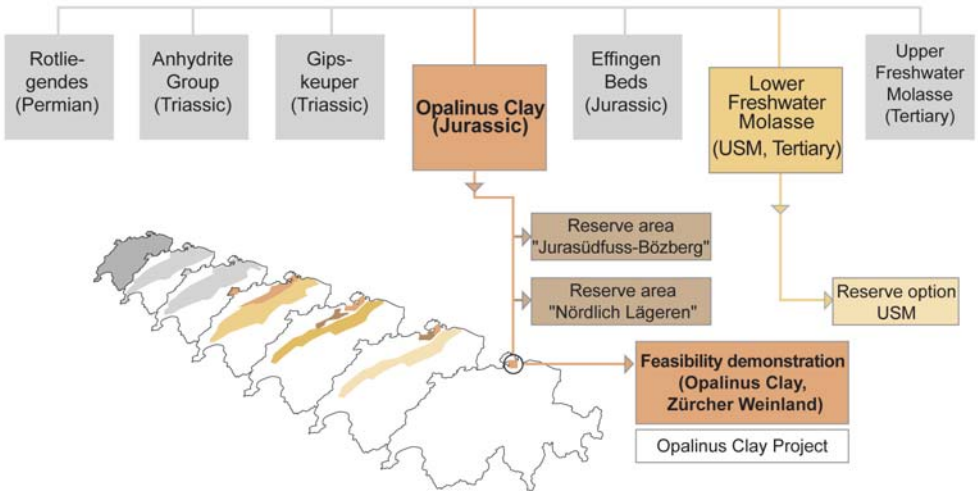
Host rock and siting area options (sediments)



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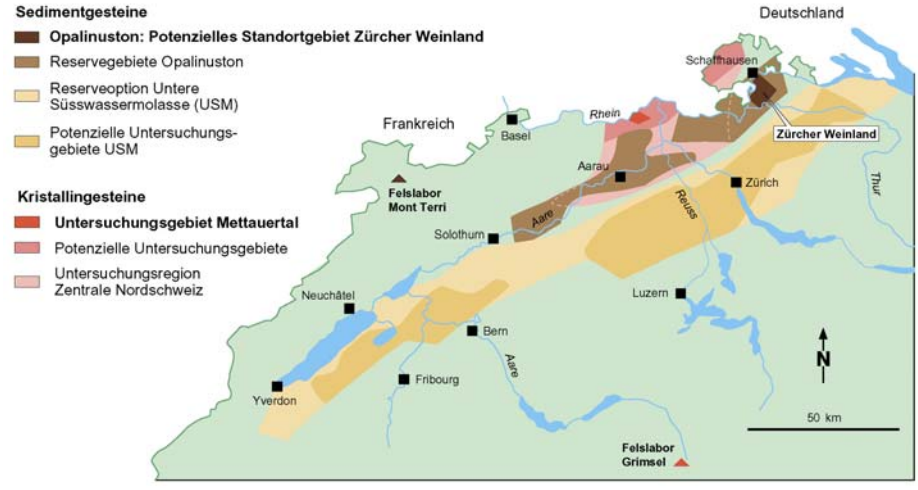
Options for HLW disposal in Switzerland



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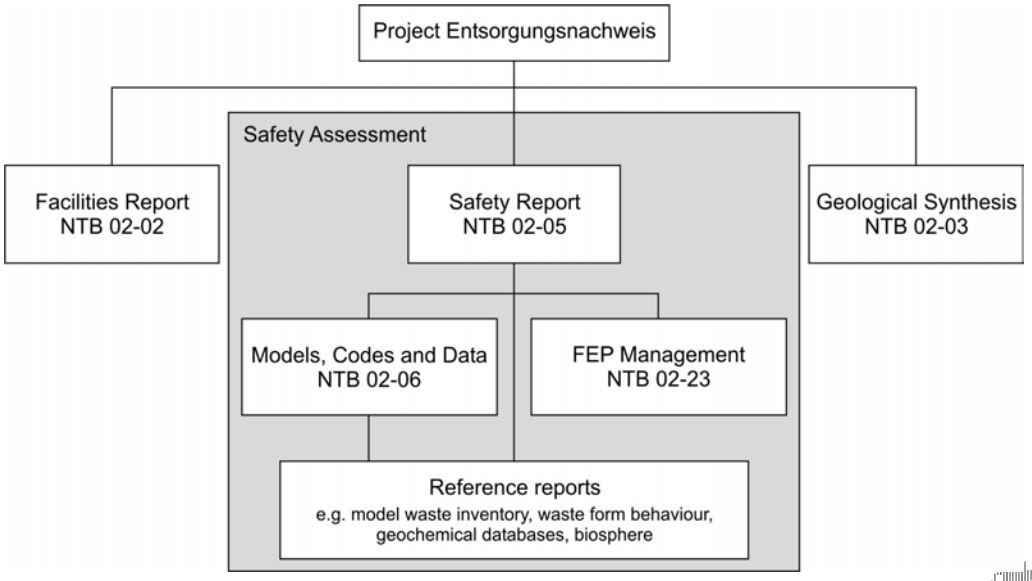
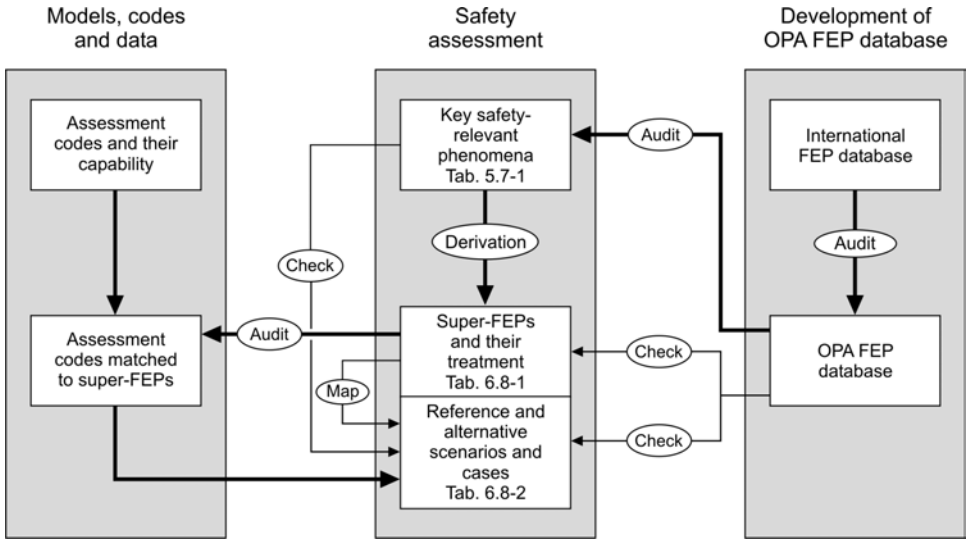
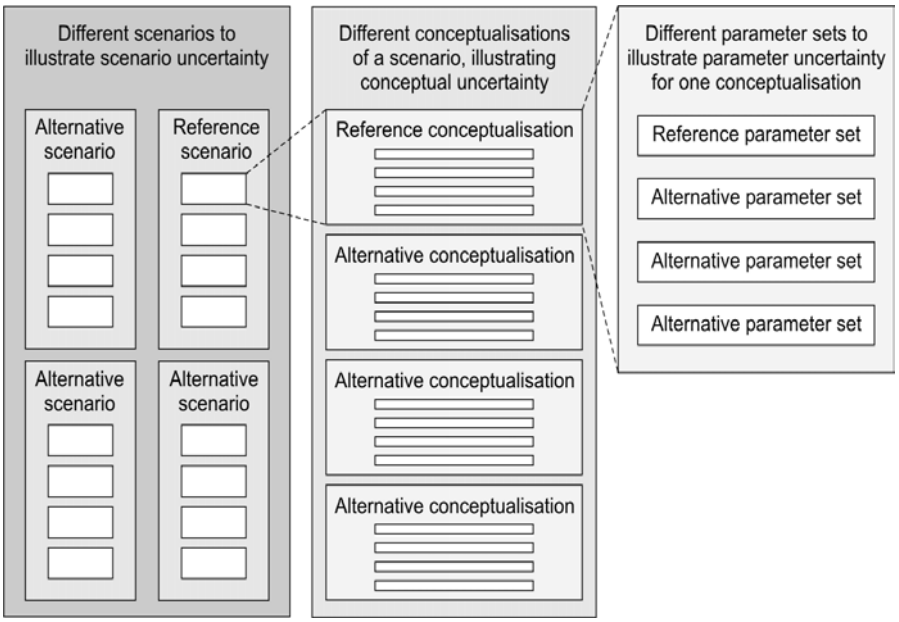
Project *Entsorgungsnachweis*: Reporting Structure (Safety)



Interrelation between reports



Structure of Assessment Cases



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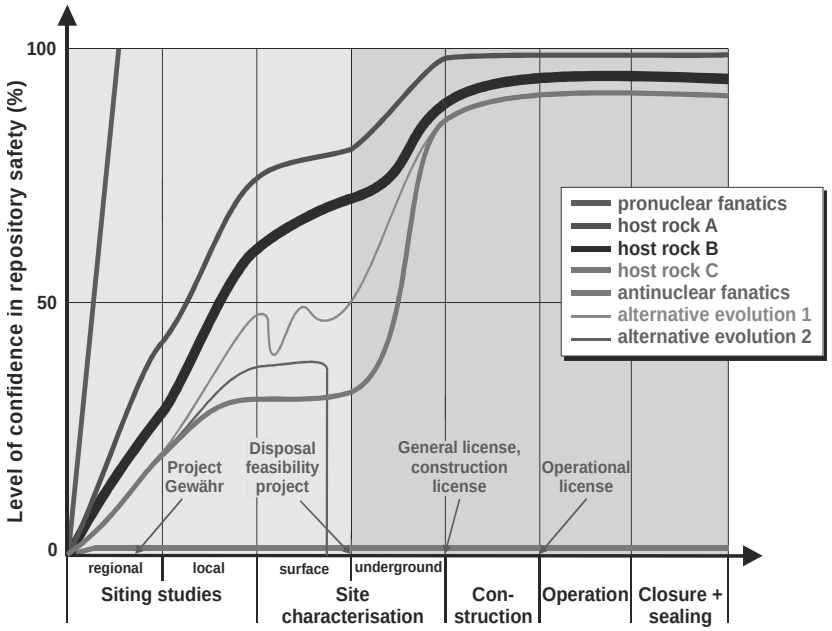
Stepwise Approach: Level of Confidence



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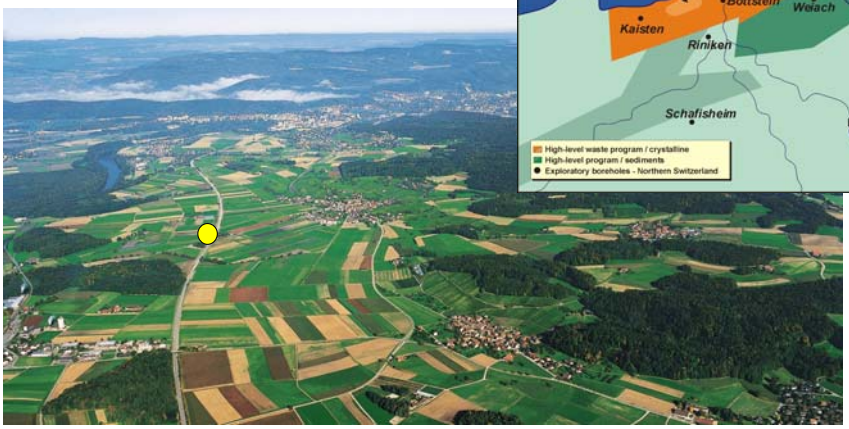
Investigation Area Zürcher Weinland

(and location of alternative options)

View on Northern Part of Zürcher Weinland



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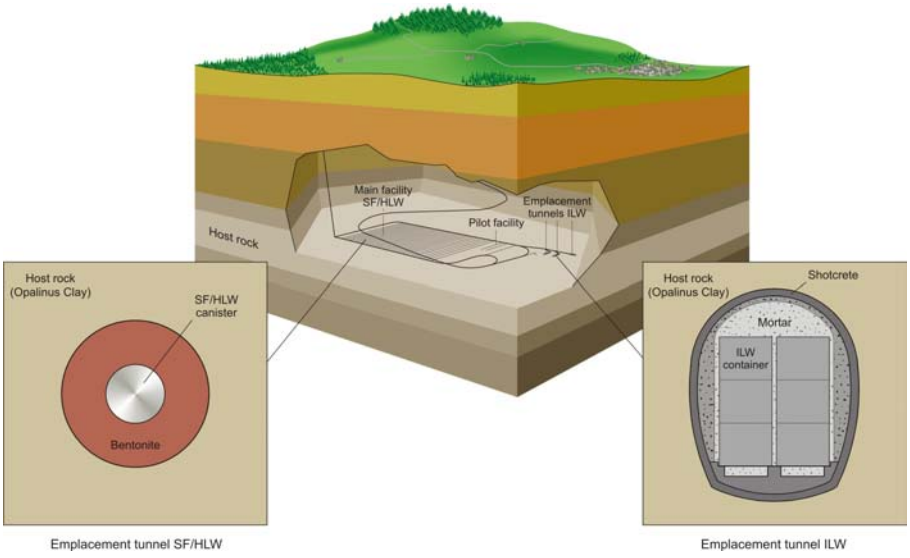
SF/HLW/ILW - Repository in Opalinus Clay



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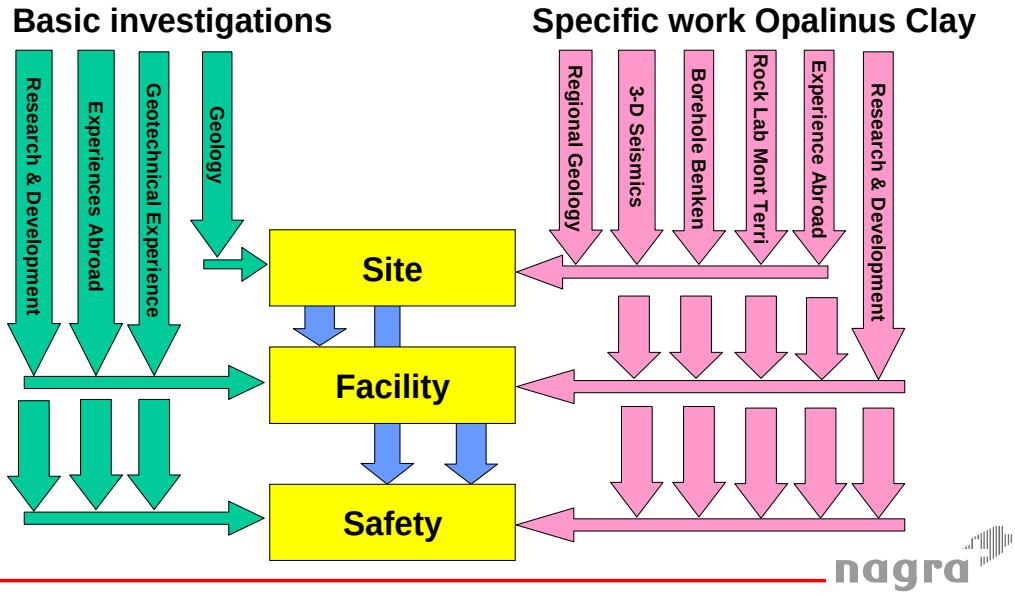
Technical Basis and Work Performed

Results of a 30 Year Programme



Project Opalinus Clay: Contribution of Different Investigations

	Benken borehole	Seismic surveys Weinland	Mt. Terri rock laboratory	other studies
Siting demonstration • Lateral extent • Tectonic structures • Thickness of clay layer • Potential underground resources				
Demonstration of technical feasibility • Stress field • Rock mechanics • Tunnel lining • Long-term evolution				
Safety demonstration • Barrier function • Flow systems • Geochemistry • Long-term scenarios				

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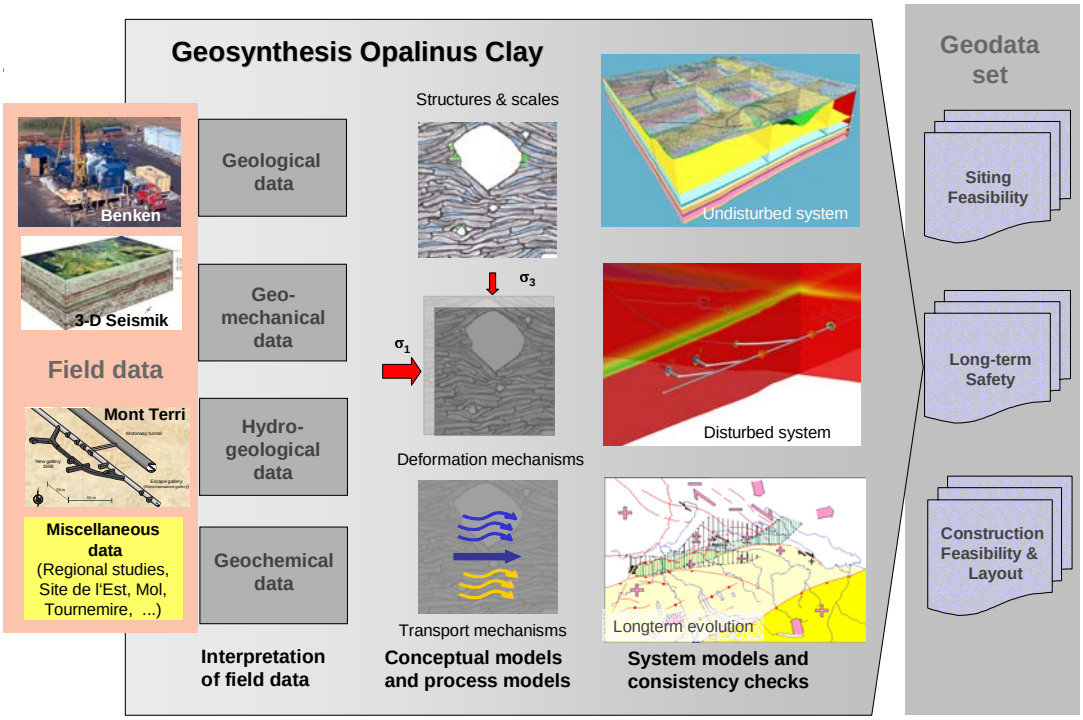
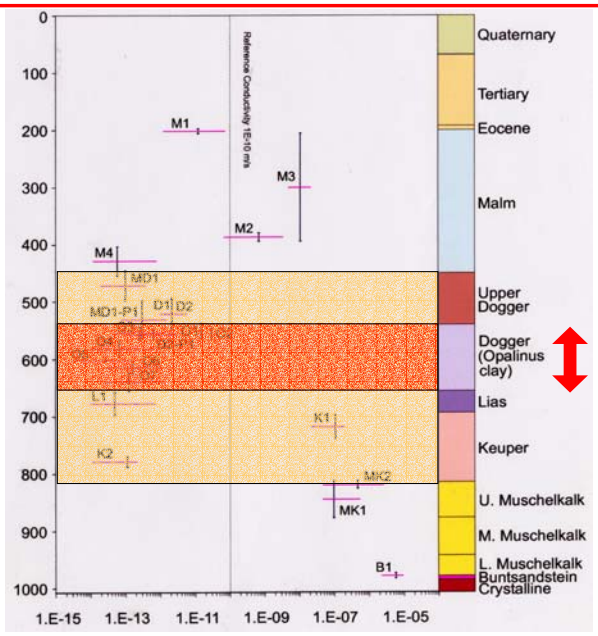


A thick layer of very low permeability clay stones



Opalinus Clay ~ 110 m thick

Confining units, incl. Opalinus Clay > 300 m thick

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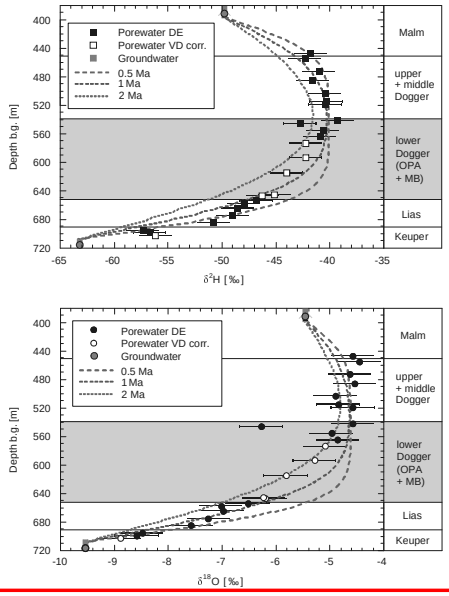
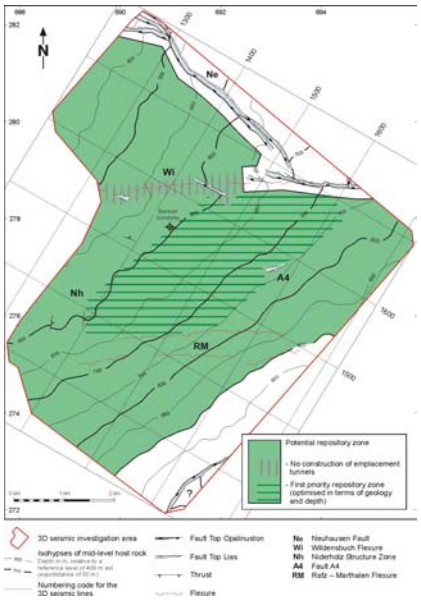
Isotope profiles: '... a diffusion - dominated system'



- Shape of isotope profiles: nature and rate of transport processes
- Data from potential siting area (Benken borehole)
- 2 naturally occurring isotopes: ^{2}H, ^{18}O
- Modelling:
  - start with uniform concentration
  - change of water composition in Malm and Keuper 1 Ma b.p.
  - best fit: diffusion only; no trace of advection
- '...in Opalinus Clay in the potential siting area, the dominating radionuclide transport process is diffusion'

Size of potential siting area



- Investigation area (including regional fracture zone als boundary) ~ 50 km^2
- undisturbed area ~ 35 km^2
- undisturbed area at preferred depth ~ 22 km^2
- within that area: area for repository for Project Entsorgungsnachweis[1)] ~ 8 km^2
- area needed for repository ~ 2 km^2

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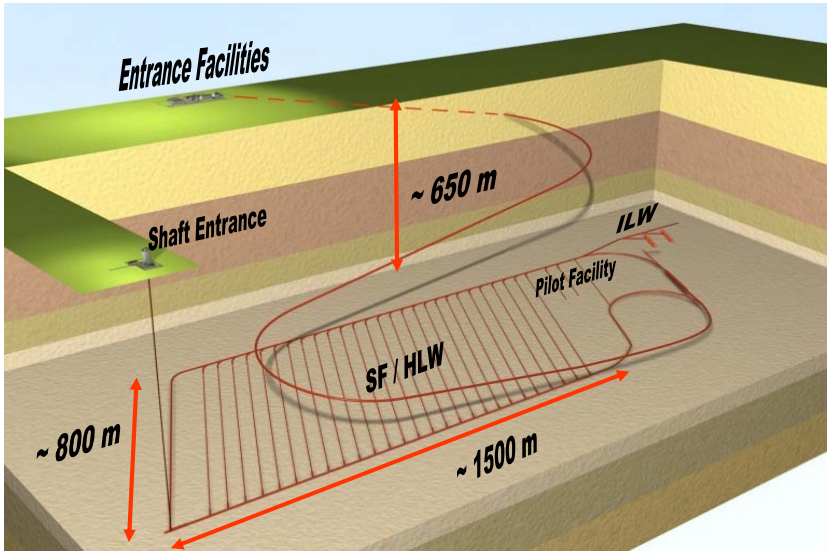
1) optimised with respect to depth and geological situation (tectonics, permocarboniferous trough?)

Geosynthesis Opalinus Clay: Key Findings

- **Simplicity** - predictable structural, hydrogeological and geochemical properties over a scale of tens of kms
- **Stability** - region tectonically stable (next few Ma); average heat flows and in situ stresses, low rate of uplift/erosion
- **Absence of resource potential**
- **Absence of water flow** - solute transport dominated by diffusion
- **Self-sealing capacity**
- **Good (reducing) + stable geochemical properties** - preservation of EBS, low solubility limits and strong sorption
- **Engineering feasibility** - Opalinus Clay: indurated moderately overconsolidated claystone
- **Sufficiently large 'block of rock'** - thickness & lateral extent

nagra

Layout for SF/HLW/ILW - Repository



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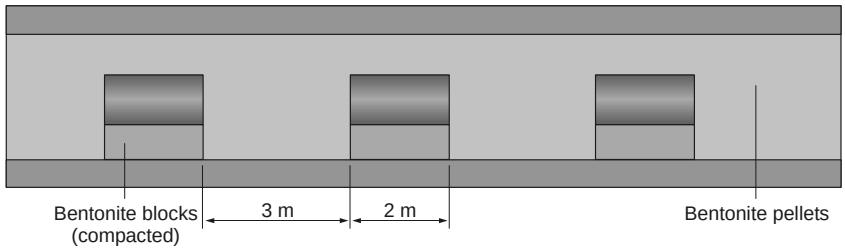
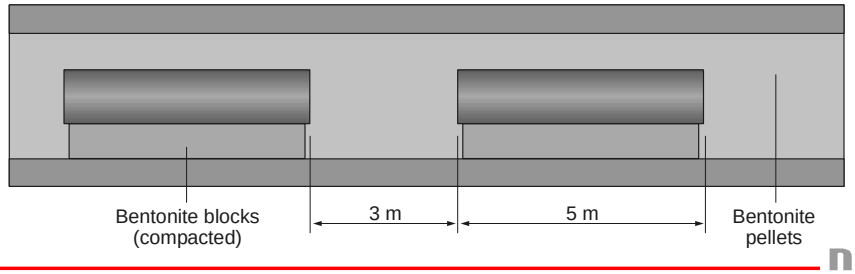
Emplacement of SF/HLW Canisters





Entrance Facility (approx. 300 m x 150 m)

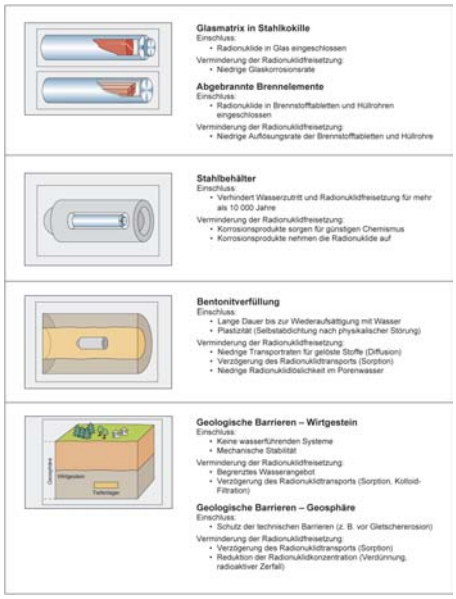
1 Administrationsgebäude
2 Betriebsgebäude
3 Lüftungsgebäude
4 Geräteschleuse
5 Konditionier- und Verpackungsanlage BE/HAA
6 Bahnzufahrt
7 Strassenzufahrt
8 Zugangstunnel, Rampe (überdeckt)

Shaft Entrance (approx. 100 m x 100 m)

1 Förderturm mit Abluftöffnungen
2 Baubüro, Mannschaftsräume, Werkstatt, Trafoanlage etc.
3 Ausbruchmaterialdepot, gedeckt
4 Geräte-/Materialhalle

nagra

Post - Closure Safety

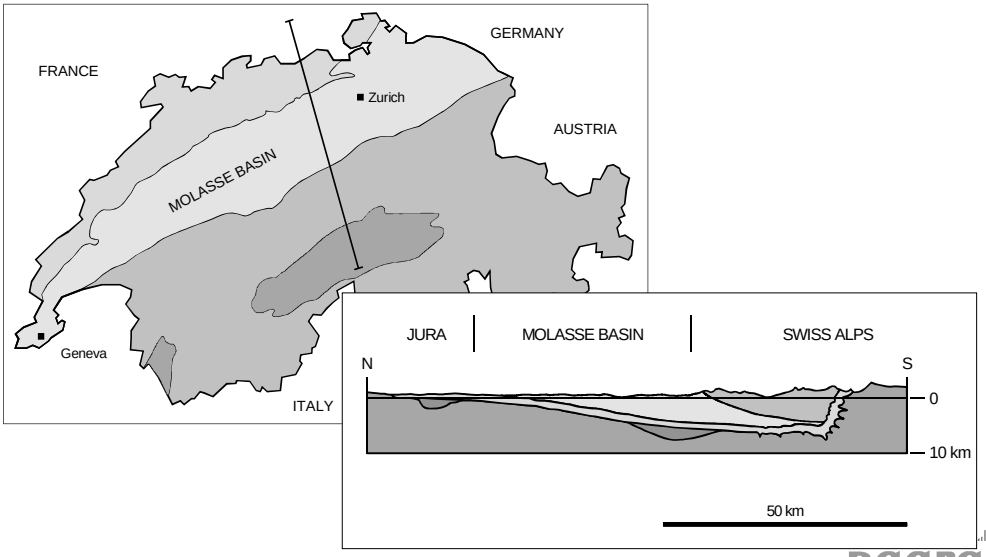


- **System with multiple safety barriers**
  - Waste matrix (glass, UO_2/MOX)
  - Container
  - Bentonite backfill
  - Opalinus Clay + other clay stones
- **Situated in stable environment**
  - large depth
  - stable geological environment
  - no resource conflicts
- **Results in:**
  - **Isolation** of radionuclides: **Decay** of nearly all nuclides
  - Release of remaining nuclides: very small (**low doses**)

nagra

Geological boundary conditions Switzerland

Importance of 'schweizerisches Mittelland'



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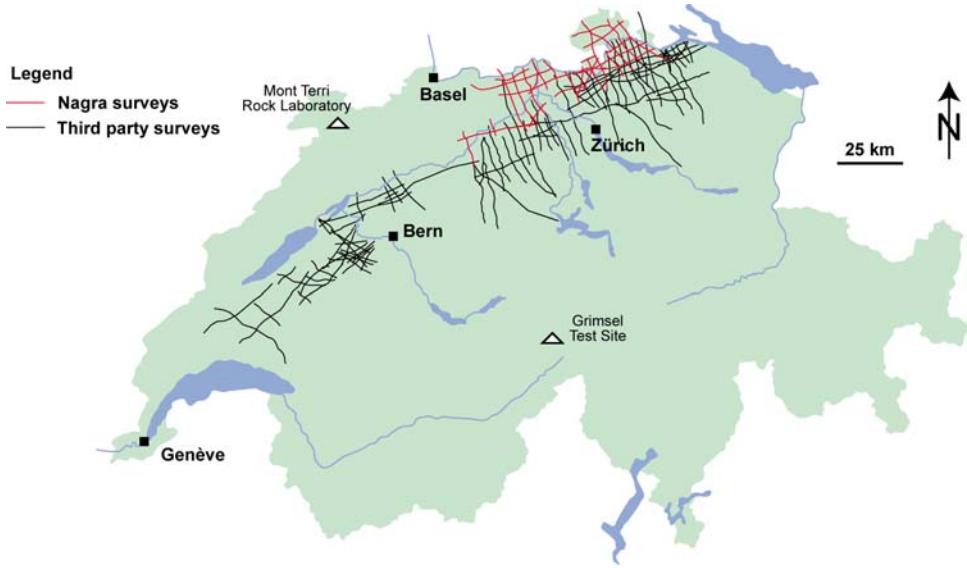
Screening of siting regions: 2D reflection seismics



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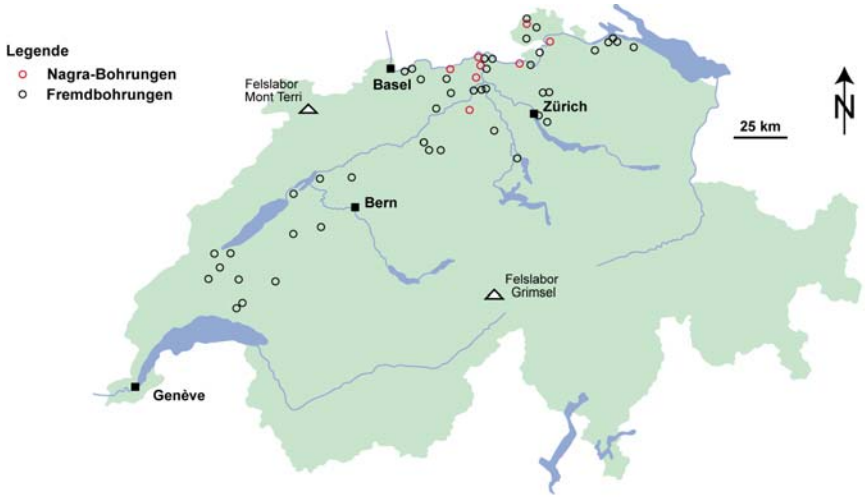
Screening of siting regions: Boreholes (Selection)



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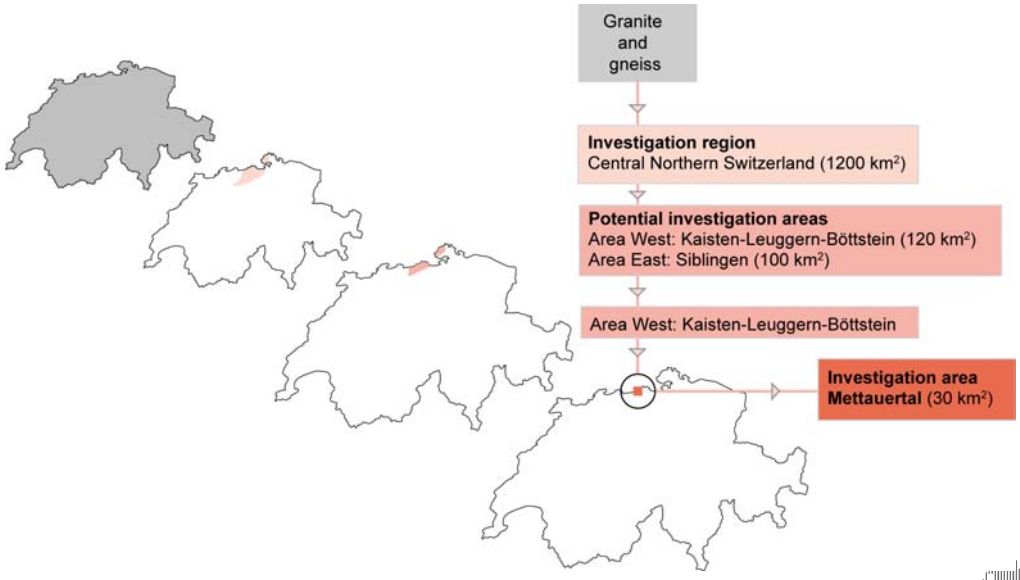
14.10.03 46 NEA_IGSC_EN_Overview_141003

Host rock and siting area options (crystalline)



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INTEGRATION GROUP FOR THE SAFETY CASE (IGSC)

15-17 Octobre 2003
Paris - France

Application of Safety Assessment Methodology for Near Surface Waste Disposal Facilities

ASAM

Regulatory Review Working Group

Safety Case

V.Nys (Belgium)

ASAM
Regulatory Review Working Group

- **ASAM Background**
- **ISAM Methodology**
- **Safety Case**
- **Conclusions**

ASAM RRWG Background

- 1st Research Coordinating Meeting, 11 to 15 November 2002, Vienna, Austria
  Group leader : C. Torres (Spain)– 18 countries – 29 participants
- Intermediate Consultant meeting, 17 to 21 March 2003, Vienna, Austria
  Group leader : B. Belfadhel (Can) – 5 countries – 7 participants
- 1st Joint Working Group Meeting, 2 to 6 June 2003, Vienna, Austria
  Group leader : C. Torres (Spain)– 10 countries – 12 participants

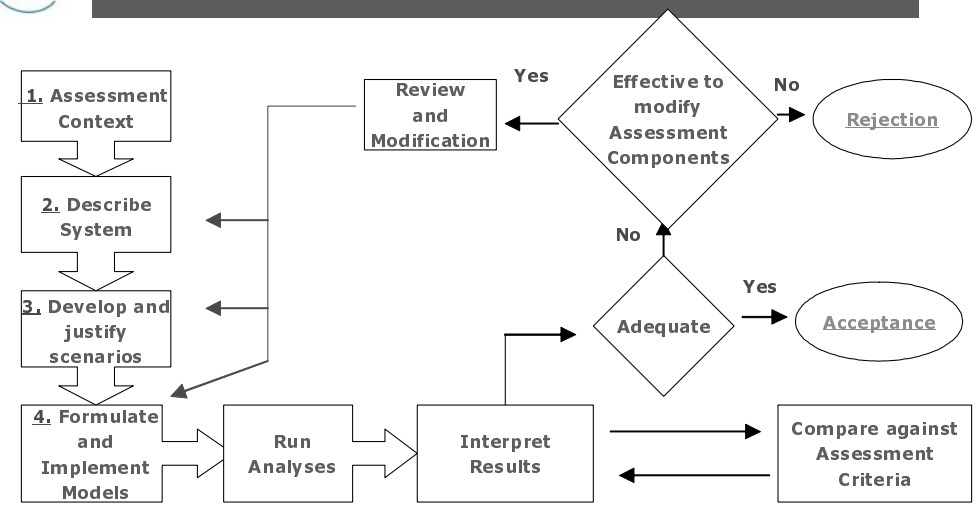
ASAM RRWG Work Plan

- Activity 1: Regulatory Review of post-closure safety assessment
  - Review of National and International Approaches for regulatory review of safety assessment for near surface disposal facilities
  - Development of guidance/procedure for regulatory review of safety assessment
  - Illustration of the review procedure
- Activity 2: Safety Case
  - Definition and identification of components of the safety case for **review**
  - Integration of safety assessment in safety case
  - Development of review procedure for the review of safety case
  - Illustration of the review procedure
- Activity 3: Confidence building
  - Review of existing documentation
  - Guidance on building confidence in different steps of safety assessment process

ISAM

Improvement of Safety Assessment Methodologies for near-Surface Disposal Facilities

ISAM Methodology



ISAM Safety Assessment Content (1/2)

Safety Assessment Context (1)

1. Assessment Context

- A description of the Safety Strategy
  - Objectives
  - Safety principles
  - Safety Functions
- A set of high-level assumptions
  - Timeframes
- A description of the regulatory framework
  - Radiological Protection criteria
  - Additional guidance
  - Waste acceptance criteria
- The purpose and the focus of the Assessment
  - Stage of the development (site, design, construction, operation, closure)
  - Assess the level of safety based on the currently available data
  - Identify the most important uncertainties
- The assessment end points

ISAM Safety Assessment Content (2/2)

Safety Assessment Context (2)

1. Assessment Context

- Stakeholders
  - Regulators
  - Decision makers
  - Other like Publics
- A brief description of the disposal system
  - Facilities
  - Types of wastes
- Planning
  - Building
  - Operational
  - Closure

ISAM System Description (1/4)

2. Describe System

- Site and Environment features
  - Geography
  - Geology and Hydrogeology
  - Natural Resources
  - Demography and Biosphere
- Waste Inventory
  - General Description (main producers, waste fluxes)
  - Waste Inventory
  - Traceability

ISAM System Description (2/4)

2. Describe System

- Facility Design and Building
  - General Design Basis
  - Individual description of each safety related building with its components
- Operation phase
  - General Description
  - Site Waste Package Acceptance
  - Handling
  - Waste disposal management
  - Monitoring and surveillance

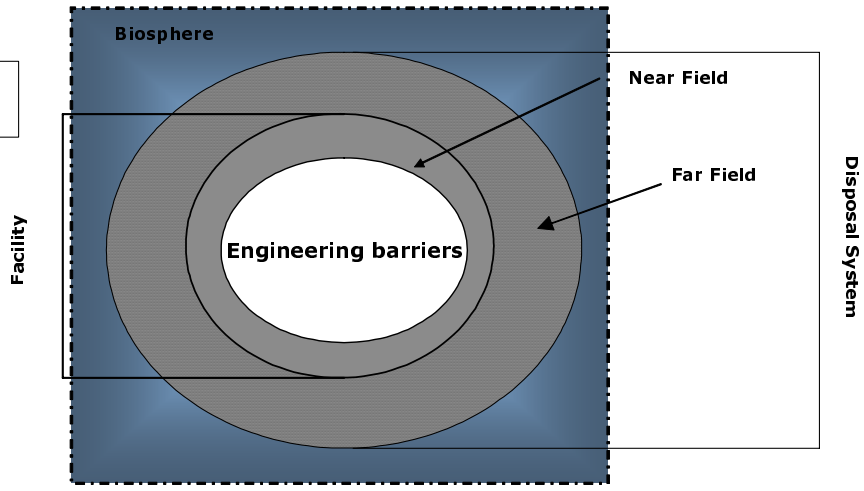
ISAM System Description (3/4)

2. Describe System

- Facility Closure
  - Closure planning
  - Description of the covers layers
- Institutional phase
  - Monitoring and surveillance
  - Active to passive transition
  - Measures during passive institutional control

ISAM System Description (4/4)

2. Describe System



ISAM Scenarios Development

- Description of the used methodology
  - Generic, Specific or Postulated Scenarios
  - Reference and Alternatives Scenarios

3. Develop and justify scenarios

- FEP's list
  - Screening of the Fep's list (external factors, disposal system, radionuclide factors)
- Design scenarios (reference and alternatives scenario including human intrusion scenario)
  - Operational Phase
  - Institutional Phase
  - Post Institutional Phase

ISAM Models implementation

- Conceptual Model Development
  - Depending of the contaminant pathways
- Identification of the safety related characteristics of each component
- Identified data depending of the safety related features of each component
- Stylization of the system or component
- Adequacy of the conceptual model with the design component

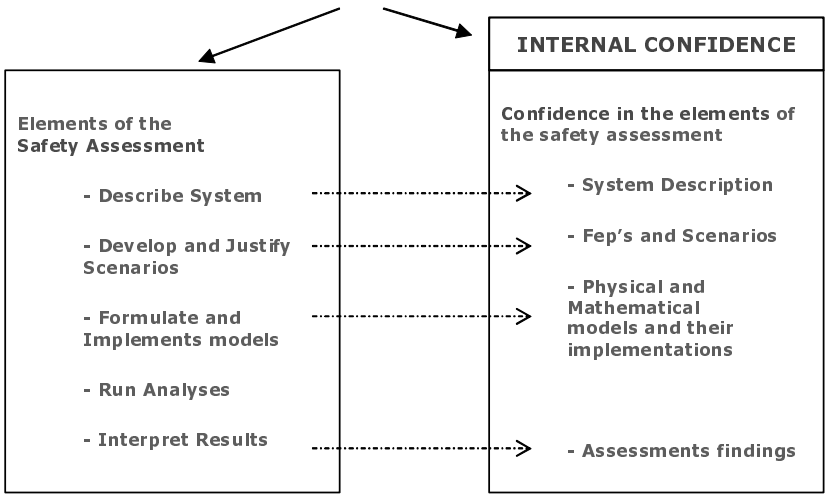
4. Formulate and Implement Models

- Adequacy of the physical phenomena and the mathematical models or their implementations
- Selection of appropriate computer tools (e.g. codes)

ASAM

Assessment of Safety Assessment Methodologies for near-Surface Disposal Facilities

ASAM RRWG
Confidence in the Safety Assessment
ISAM



ASAM RRWG
Confidence in the Safety Assessment (1/3)

Confidence in each stage of the safety assessment

- Assessment context stage
  - The implementer should demonstrate sound and complete understanding of the key components of the assessment context and how these keys elements are integrated in the safety assessment
- Description of the system
  - The implementer should gain and demonstrate confidence in the engineering and natural aspects of the system and explain how uncertainties have been considered.
- Development and justifications of the scenarios
  - The implementer should demonstrate that the set of scenarios developed is credible, comprehensive and has been developed in a systematic, transparent and traceable manner.

ASAM RRWG
Confidence in the Safety Assessment (2/3)

Confidence in each stage of the safety assessment

- Formulation and Implementation of models
  - The implementer should demonstrate that the conceptual models and associated data are consistent with the assessment context, the disposal system and with the scenarios to be investigated.
- Analysis of the results
  - The implementer should demonstrate : a thorough understanding of the underlying science and engineering science, which are governing the safety assessments results, that associated uncertainties have been adequately considered and compliance with the regulatory requirements and recommendations set out in the assessment context has been analyzed

ASAM RRWG
Confidence in the Safety Assessment (3/3)

Confidence in each stage of the safety assessment

- Review and modifications
  - The implementer should demonstrate that the review of proposed modifications is based on a transparent prioritization process and that modification of any of the assessment components is justified and conducted in a structured manner.

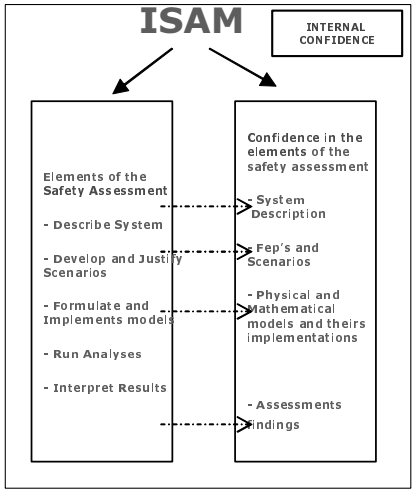
Regulatory Review Working Group
SAFETY CASE

- Does confidence in each separate module implies the confidence in the whole set ?
- Is the Internal Confidence sufficient?
- What about the "Multistep Process"?

Regulatory Review Working Group
Safety Case

- A Safety Case appears to be the solution to these questions
- Its structure could be defined as …

Regulatory Review Working Group
ASAM Safety Case Content



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- Global Statement of Confidence in the Findings
  - Approach
  - Methodology
  - Findings
- Confidence in the Management (Regulatory and Implementers) Framework
- Identification and Handling of unresolved issues
- Good engineering and robustness
- Alternative Options or Projects
- Communicating confidence to stakeholders

Regulatory Review Working Group
ASAM Safety Case Content

Inside a step, ASAM Safety Case content could be proposed as compound of :

Safety Assessment as defined by ISAM with the internal confidence (*)

+

- Statement of confidence

- Confidence in the Managerial Frameworks

- Identification and handling of unresolved issues

- Good Engineering and Robustness of the System

- Existing of alternative options or projects

- Communicating confidence to the Stakeholders

(*) ISAM Assessment Context should contain a clear description of the Safety Strategy

Regulatory Review Working Group
ASAM Safety Case Global Confidence (1/3)

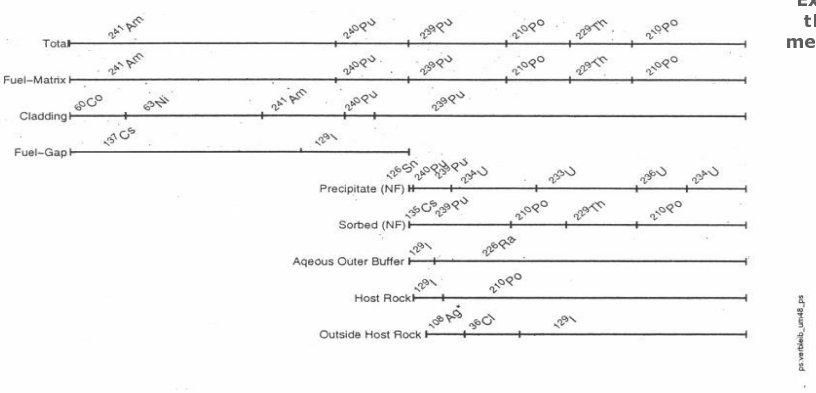
Global Confidence

- Methodology
  - A well defined and rational assessment methodology have been followed (systematic, transparent and traceable)
  - Compatibility of method with international experience
- Approach
  - Multiples lines of reasoning,
  - Safety indicators,
  - Variety of assessment techniques,
  - Complementary safety assessment
- Findings
  - All relevant data and information and their associated uncertainties have been considered
  - All key safety-related issues are identified and addressed (completeness of the study)
  - Peer review and comparison with assessment results from other similar sites
  - Checking of the coherence of the results with assumptions, codes validity range, ..

Regulatory Review Working Group ASAM Safety Case Example of Global Confidence (2/3)

Safety Indicators

Example from the 3rd IGSC meeting NAGRA



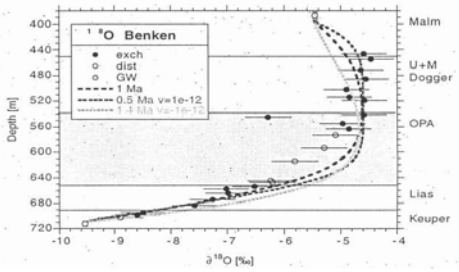
Note: Bars beneath the graph indicate the radionuclides that make the highest contribution to radiotoxicity at any particular time and in any particular part of the system

Regulatory Review Working Group ASAM Safety Case Example of Global Confidence (3/3)

Findings checking of the coherence

Example from the 3rd IGSC meeting NAGRA

Figure 9. Isotope concentration profiles across the Opalinus Clay (OPA) and adjacent rock strata, comparing measured data obtained under different conditions (labelled "exch", "dist" and "GW") and preliminary modelling results assuming diffusion only (blue lines), diffusion and upwardly directed advection (red lines) and diffusion and downwardly directed advection (green lines). The times in the legend indicate how long the model system has been allowed to evolve from an assumed initial state of uniformly high concentrations in the Dogger, OPA and Lias and the fixed present-day (lower) concentrations in the Malm and the Keuper in order to produce the three curves. v is the assumed advection velocity in ms^{-1}.



Regulatory Review Working Group
ASAM Safety Case Management Framework

Management Framework

- **Clear management procedures, competent personnel, etc.**
- **Clear regulatory framework and guidance**
- **Well defined regulatory process and decision points (incl. review procedures)**
- **Adequacy of the management structure of the implementers and the regulator**

Regulatory Review Working Group
ASAM Safety Case Robustness (1/2)

Good engineering and Robustness

- Multiple barriers and safety functions (e.g. containment, isolation)
- Confidence in the data and knowledge of the site
- Sensitivity studies of the whole set through the use of What-if scenarios

Regulatory Review Working Group
ASAM Safety Case Robustness (2/2)

Good engineering and Robustness

- Latent "Safety Functions" of components
- *Intrinsic robustness* is acting on hazard perturbations through siting and design provisions
- *Engineered robustness* is to conceive a system such that the system is able to resist against hazard. Over dimensioning a barrier is an example.

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ASAM Safety Case Unresolved Issues (1/2)

- Identification and handling of unresolved issues
  - Strongly dependent of the considered phase
  - Identified uncertainties that could be reduced
  - Identified irreducible uncertainties
  - Rely on a well safety-related understanding

By this item, the "Multistep Process" could be addressed.

Regulatory Review Working Group
ASAM Safety Case Unresolved Issues (2/2)

Examples :

- No specific scenarios are considered in a "siting phase"
- Chemical, Physical and Mechanical long-term concrete behavior
- Impact of the stylized modelisation

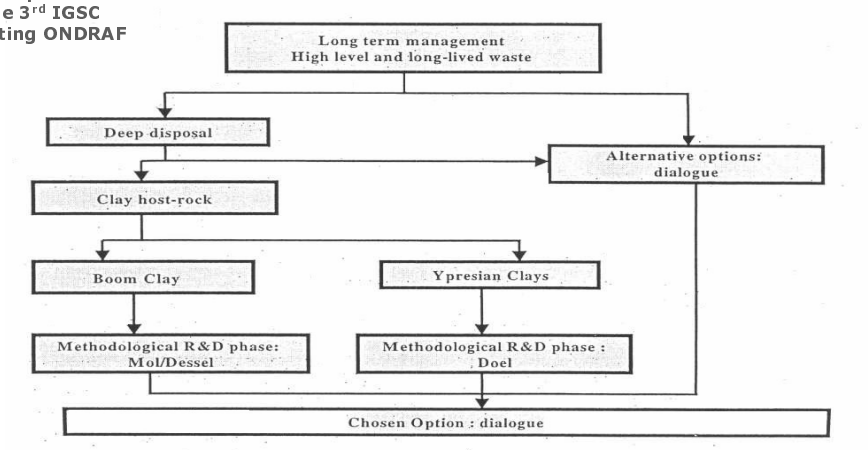
Regulatory Review Working Group
ASAM Safety Case Alternatives

- Alternative of the disposal facility (risk of non-acceptance)

Regulatory Review Working Group
ASAM Safety Case Example of Alternatives

The figure 1 hereafter shows the successive steps of the process in order to open the dialogue on the chosen option.

Example from the 3rd IGSC meeting ONDRAF



Regulatory Review Working Group
ASAM Safety Communicating Confidence

Communicating confidence to the stakeholders

- Technical aspects are necessary but not sufficient when communicating
- Identify Stakeholders – their interests and respective roles
- Define the role of the regulator with any other regulatory bodies and the implementers in the context of communication
- Different approaches for presentation of the safety case

Regulatory Review Working Group
ASAM Safety Case

CONCLUSION

Regulatory Review Working Group
Conclusions (1/2)

Inside a step, ASAM Safety Case content could be proposed as compound of :

Safety Assessment as defined by ISAM with the internal confidence (*)

+

- Statement of confidence

- Confidence in the Managerial Frameworks

- Identification and handling of unresolved issues

- Good Engineering and Robustness of the System

- Existing of alternative options or projects

- Communicating confidence to the Stakeholders

(*) ISAM Assessment Context should contain a clear description of the Safety Strategy

Regulatory Review Working Group Conclusions (2/2)

- The first step of identification of components of the Safety Case is nearly done
- The next step will be to develop a review procedure for a Safety Case and illustrate it

International Atomic Energy Agency

Highlights of IAEA Waste Safety Programme

Phil Metcalf
IGSC – NEA
Paris October 2003

International Atomic Energy Agency

Outline

- Joint Convention
- Progress Safety Standards
- Protection of the Environment
- Environmental Assessments
- New International Biospheric Modelling Project (EMRAS)

International Atomic Energy Agency

Joint Convention

- **Status**
  - **September 2003 – 32 Contracting Parties – 1 Contracting State**
- **Meetings**
  - **Coordinators and Rapporteurs 22-23 September 2003**
  - **1st Review Meeting – 3-14 November 2003**

International Atomic Energy Agency

Contracting Parties (Current status, September 2003 – 32 countries)

Argentina
Australia
Austria
Belarus
Belgium
Bulgaria
Canada
Croatia
Czech Republic
Denmark
Finland
France
Germany
Greece
Hungary
Ireland
Korea
Latvia
Luxembourg
Morocco
Netherlands
Norway
Poland
Romania
Slovakia
Slovenia
Spain
Sweden
Switzerland
Ukraine
United Kingdom
United States

International Atomic Energy Agency

Joint Convention

- **Secretariat instructed by Contracting Parties to promote the Convention**
  - **Letter to all Member States**
  - **Information Pack**
  - **Briefings at General Conference and at Regional TC meetings**
  - **Emphasise in future Training Activities and Conferences**

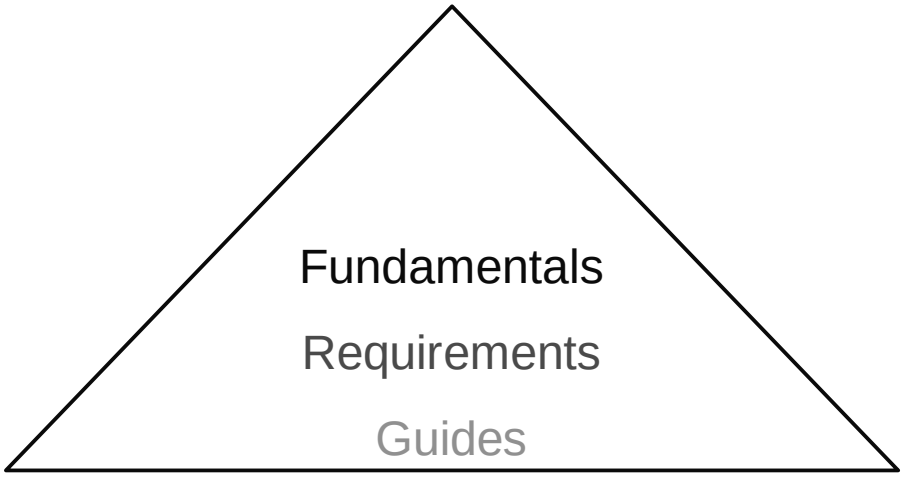
International Atomic Energy Agency

Benefits for a country from becoming a Contracting Party to the Joint Convention

- **Improvements in safety as an outcome of the review process**
- **Gain in knowledge through information exchange**
- **Improved credibility because of involvement in an international convention on safety**
- **Evidence of an open and transparent national approach**
- **Support in cases of malpractice in neighbouring States**
- **Greater influence in a regional context**
- **Possible technical assistance from other Contracting Parties**

International Atomic Energy Agency

HIERARCHY OF INTERNATIONAL STANDARDS



International Atomic Energy Agency

STANDARDS PREPARATION PROCESS

International Atomic Energy Agency

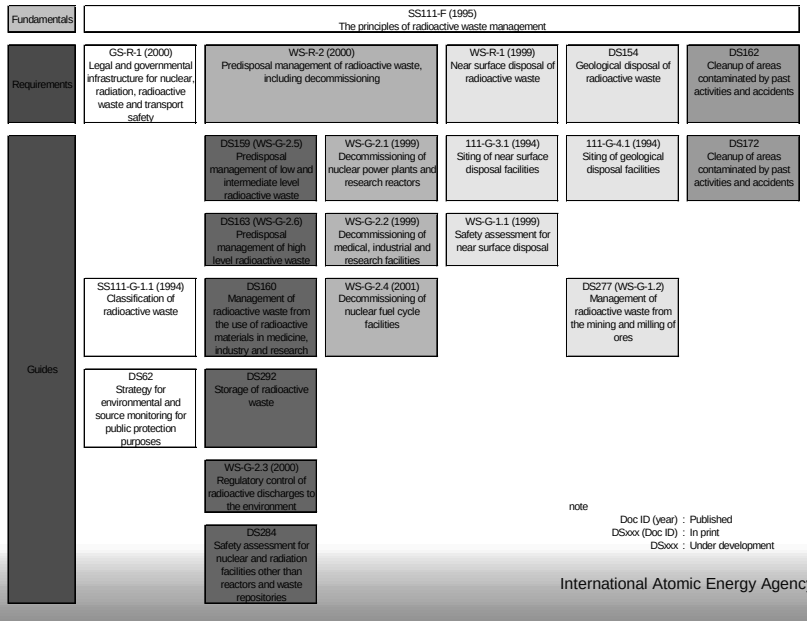
Scope of RADWASS

Safety in the management of all types of material, once declared as "waste"

Pre-disposal management – waste collection, treatment, packaging, storage
Decommissioning and associated waste management
Discharge control
Release of solid materials from control
Disposal – near surface, geological disposal
Management of U mining and milling waste
Remediation of areas affected by residual waste

International Atomic Energy Agency

Overview of the RADWASS document plan



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RADWASS features

Completion of current phase – 2004

Current emphasis:

- Safety Requirements on Geological Disposal
- Safety Guide on Specification of Radionuclide Content in Commodities requiring Regulation for Purposes of Radiation Protection
- Safety Guide on Strategy for Environmental Monitoring

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Waste safety – still a developing situation

- Borehole disposal
- Long-term storage of waste
- Release of sites and buildings after decommissioning
- Protection of the environment

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Global safety regime

- International Conventions – legally binding – (i) nuclear safety, (ii) spent fuel and waste and (iii) emergencies
- International safety standards – recommendations
- Standards increasingly seen as global reference points and as a basis for demonstrating compliance with the conventions

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Safety Standards – a new scheme

- Five safety areas
  - Safety of nuclear facilities
  - Radiation protection and safety of radiation sources
  - Safe management of radioactive waste
  - Safe transport of radioactive material
  - General safety (cross-cutting themes)

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Thematic areas

- Legal and governmental infrastructure
- Emergency preparedness and response
- Management systems
- Assessment and verification
- Site evaluation
- Radiation protection
- Radioactive waste management
- Decommissioning
- Rehabilitation of contaminated areas

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Facilities and activities

- Nuclear power plants
- Research reactors
- Fuel cycle facilities
- Radiation related facilities and activities
- Waste treatment and disposal facilities
- Transport of radioactive material

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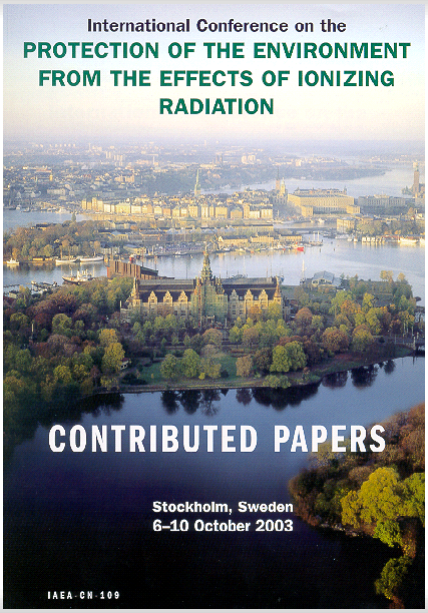

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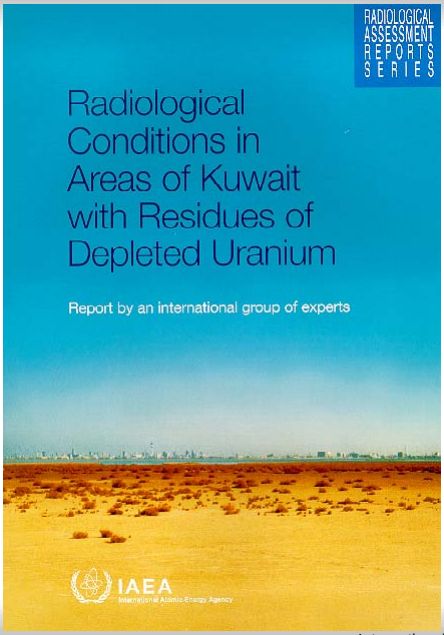
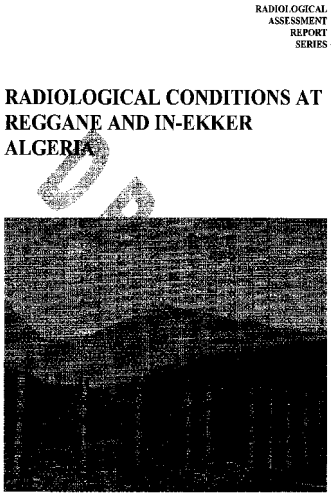
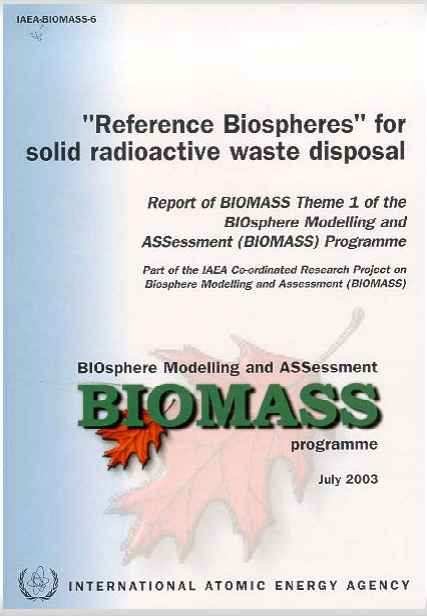


International Atomic Energy Agency



International Atomic Energy Agency



International Atomic Energy Agency

LIST OF BIOMASS DOCUMENTS

Modelling the Migration and Accumulation of Radionuclides in Forest Ecosystems (IAEA-BIOMASS –1) (August 2002).

Testing of Environmental Transfer Models Using Data from the Atmospheric Releases of Iodine-131 from the Hanford site, USA, in 1963 (IAEA-BIOMASS-2) (March 2003).

Modelling the Environmental Transport of Tritium in the Vicinity of Long Term Atmospheric and Sub-Surface Sources (IAEA-BIOMASS-3) (March 2003).

Testing of Environmental Transfer Models Using Chernobyl Fallout Data from the Iput River Catchment Area, Bryansk Region, Russian Federation (IAEA-BIOMASS-4) (April 2003).

Modelling the Transfer of Radionuclides to Fruit (IAEA-BIOMASS-5) (July 2003).

"Reference Biospheres" for Solid Radioactive Waste Disposal (IAEA-BIOMASS-6) (July 2003).

Testing of Environmental Transfer Models Using Data from the Remediation of a Radium Extraction Site (IAEA-BIOMASS-7) (to be published).

International Atomic Energy Agency

Environmental Modelling for Radiation Safety (EMRAS) – started September 2003

- **Working groups**
- **1 Revision of TRS-364, Handbook of parameter values for the prediction of radionuclide transfer in temperate environment**
- **2 Modelling of tritium and carbon-14**
- **3 Modelling the effectiveness of countermeasures used against releases of iodine-131**
- **4 Model validation of radionuclide transport in aquatic systems**
- **5 Modelling of NORM releases and remediation**
- **6 Assesment of the behaviour of radionuclides dispersed in urban environments**

International Atomic Energy Agency

IGSC Safety Case Brochure

FINAL COMMENT OPPORTUNITY

IGSC AD-HOC GROUP and CONSULTANTS

A. VAN LUIK, REPRESENTATIVE

STATUS/SCHEDULE

- **Ad-hoc Group approved at last IGSC meeting has completed a draft it recommends to the full IGSC for approval:**
  - **IGSC members should read for national policy implications, if any**
  - **Errors should be corrected**
  - **Editing suggestions are also welcome**
- **Comments should be emailed to Sylvie Voinis for routing to the ad-hoc group and consultants**
  - **Comments are due by end November**
- **Goal is submittal to RWMC at its March 2004 meeting for publication approval**

BROCHURE DESCRIPTION

- **FOREWORD:**
  - **Sets the safety case into its decision-making contexts**
  - **Gives the provenance of the document in terms of international agency (IAEA, EC, NEA) level work, and**
  - **Describes work in the RWMC and its subcommittees, such as the IPAG group, peer reviews, and other work supporting the document**

BROCHURE DESCRIPTION

- **EXECUTIVE SUMMARY:**
  - **Just under 2.5 pages summarize content of entire document, do not mimic main document structure:**
    - ***Nature and purpose of the safety case***
    - ***Elements for documenting the safety case***
    - ***General considerations when presenting the safety case***

BROCHURE DESCRIPTION

- **MAIN BODY OF BROCHURE (28 pp.):**
  - **1. Introduction (2 pp.)**
  - **2. The safety case and considerations for its presentation (7 pp.)**
  - **3. The safety strategy (7 pp.)**
  - **5. (?) The assessment basis (4 pp.)**
  - **6. Evidence, analyses and arguments and their synthesis in a safety case (5 pp.)**
  - **7. Conclusions (2 pp.)**
  - **References (1 p.)**

SAFETY CASE DEFINED

- **IAEA Safety Standard for Geological Disposal is cited:**
  - "The safety case is an integration of arguments and evidence that describe, quantify and substantiate the safety, and the level of confidence in the safety, of the geological disposal facility."
- **The Brochure's definition is a paraphrase of that definition:**
  - . . . "a formal compilation of evidence, analyses and arguments that quantify and substantiate a claim that the repository is safe." This definition is augmented with:
  - "The safety case may be seen as analogous, in some respects, to a legal case, in which multiple lines of evidence are produced, and for which the quality of each line of evidence must be evaluated to allow a judgement to be reached on the adequacy of the case to support a positive outcome of the decision at hand."

WHEN TO DO A SAFETY CASE

- **EXAMPLE OF IMPLIED COMMITMENT:**
  - **Safety cases are to be compiled to support decisions**
  - **Regulatory decisions require the most complete safety cases**
  - **Internal decisions should be supported by safety cases, but these may be less comprehensive**
- **QUESTION: Is this demarcation statement in the document at the right level, or does its current wording imply that more work is needed than is currently practiced, or planned for, in member state organizations?**

SAFETY CASE CONTENT

- **ANOTHER POTENTIAL COMMITMENT:**
- **Safety content is described, itemized**
- **IGSC members need to evaluate:**
  - **Do the content descriptions match what is done or planned for in member state organizations?**
  - **Is there an implied commitment for implementers to expand safety cases by the official publication of the brochure?**
  - **The NEA is not a national regulator, regulators are in charge of defining the safety case they need, need to approve of brochure**

POTENTIAL CHANGES

- **AD-HOC GROUP AGREES ON CONTENT, BUT:**
  - **May recommend changes in document organisation**
  - **May recommend adding graphic illustration**
  - **Welcomes IGSC recommendations in both areas**
  - **Welcomes IGSC comments of all sorts**
  - **Urges careful IGSC member organisation review: document may create or enhance national expectations, and thus lead to new commitments**

PART C

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