Deliverable D10.14: UMAN -

Pluralistic analysis of site and geosphere uncertainty

Work Package 10 - Uncertainty Management multi-Actor Network (UMAN)

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What is UMAN project about?

Decisions associated with Radioactive Waste Management (RWM) programmes are made in the presence of irreducible and reducible uncertainties. Responsibilities and role of each stakeholder, the nature of the RW disposal programme and the stage of its implementation influence the preferences of each category of actors in approaching uncertainty management. EURAD WP UMAN carries out a strategic study about the management of these uncertainties. This study is based on extended exchanges of the experience accumulated in the national RWM programmes by a broad range of stakeholders representing WMOs, TSOs, REs and Civil Society, as well as on a review of knowledge generated by past and on-going R&D projects, and findings of international organisations (such as IAEA, NEA, etc.).

UMAN discusses the classification schemes and approaches applied to the uncertainties management and identifies possible actions to be considered in the treatment of uncertainties. The relevance for safety of the uncertainties associated with site and geosphere, human aspects, spent fuel, waste inventory, spent fuel and near-field, as perceived by each type of the above mentioned stakeholders, and approaches used by these stakeholders to manage these uncertainties are explored via questionnaires, workshops and seminars, with the aim to reach either a common understanding on how uncertainties relate to risk and safety and how to deal with them along the RWM programme implementation, or, when agreement is not achieved, a mutual understanding of each individual view. As result of these activities, UMAN identifies uncertainties assessed as highly significant for safety and associated R&D issues that should be further investigated.

This Work Package (WP) of EURAD includes the following tasks:

- Task 1 - Coordination, interactions with Knowledge Management (KM) WP & integration
- Task 2 - Strategies, approaches, and tools
- Task 3 - Characterization and significance of uncertainties for different categories of actors
- Task 4 - Uncertainty management options and preferences of different actors across the various programme phases
- Task 5 - Interactions between all categories of actors including Civil Society

Interactions between the different tasks and types of actors including civil society are central to this WP. These interactions take place notably through workshops (Task 4) and seminars (Task 5) where the significance of identified uncertainties (Task 3) as well as possible strategies and options to manage them (Tasks 2 and 4) are discussed.

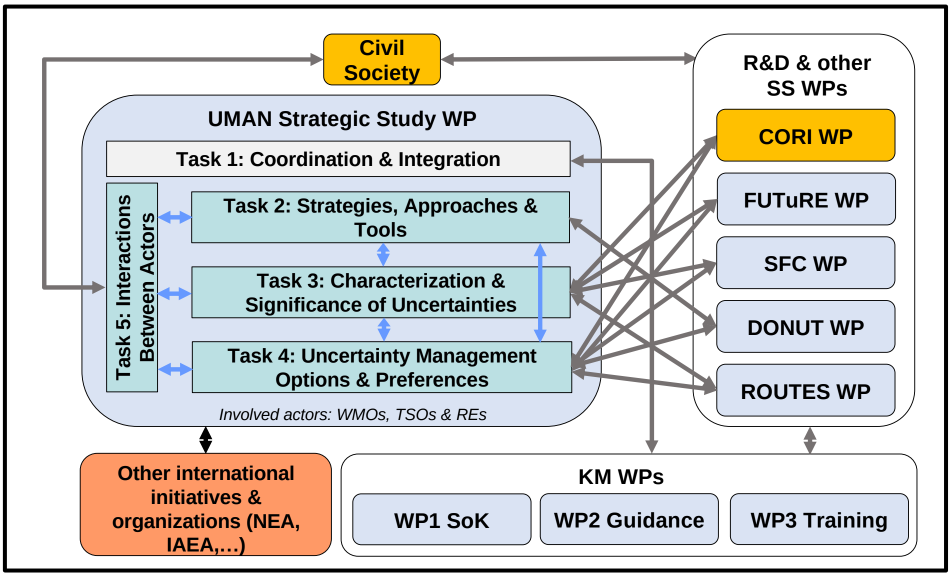

Figure 1 – UMAN WP structure and interactions

Executive Summary

This report provides information about the work carried out in UMAN Task n°5 - *Interactions between all categories of actors, including Civil Society* in the frame of Subtask 5. 1 – *Preparation, support and reporting of pluralistic analyses*. Initially, it was planned to organize discussions of Seminar 2 on Topic 2 (uncertainty pictures at different steps of geological disposal programme) and Seminar 3 on Topic 3 (uncertainty management options for addressing uncertainties throughout a disposal programme). As it is a continuous process, Task 5 adapted the initial planned to take into account the results of seminar 1. During seminar 1, it was underlined that the discussions related to uncertainty picture could not be dissociated from the discussions on uncertainty management options. In addition, after having a global discussion on uncertainty picture and management options in seminar 1, Task 5 methodological team discussed the way to avoid duplicating the work already done. Instead of addressing Uncertainty Picture in seminar 2 and Management Option in seminar 3 in a generic way, it was decided to focus seminar 2 on Site and Geosphere domain and seminar 3 on human related uncertainties. Therefore, Seminars 2 and 3 will discuss uncertainty picture and uncertainty management options for the two selected domains.

Various inputs were used for this report, but the central instrument was a seminar held on 4, 5 and 11 October 2021 («*UMAN seminar 2. Management of uncertainties related to site and geosphere characteristics*»). The report provides a description and interpretation of this seminar.

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Acronyms

Andra	Agence nationale pour la gestion des déchets radioactifs
BC	Boundary Conditions
CS	Civil Society
DGR	Deep Geological Repository
DM	Decision Making
EURAD	European Joint Programme on Radioactive Waste Management
FEP	Features, Events, Processes
GD	Geological Disposal
GRS	Gesellschaft für Anlagen und Reaktorsicherheit (in Germany)
ICS	Interaction with civil society
IRSN	Institut de Radioprotection et de Sûreté Nucléaire
NGO	Non-governmental organisation(s)
NTW	Nuclear Transparency Watch
R&D	Research and development
RE	Research Entity
RWM	Radioactive Waste Management
SA	Safety Assessment
SC	Safety Case
TSO	Technical Safety Organisation
UMAN	Uncertainty Management multi-Actor Network
WMO	Waste Management Organisation
WG	Working Group in UMAN Seminar 2
WP	Work Package

1. Introduction

This report provides information about the work carried out in UMAN Task n°5 - Interactions between all categories of actors, including Civil Society. According to UMAN's WP description, the objectives of Task 5 are:

1. To develop a common understanding or understanding of the different viewpoints among the different categories of actors on:
    1.1. uncertainty management and how it relates to risk & safety,
    1.2. whether and why a safety case is robust vis-à-vis uncertainties.
2. To share knowledge/know-how and discuss common methodological/strategical challenging issues on uncertainty management among a broader group of actors.

More specifically, the report is addressing Subtask 5. 1 – *Preparation, support and reporting of pluralistic analyses*, Topic 2: *Pluralistic analysis of uncertainty pictures* and Topic 3: *Uncertainty management options*, focusing the analysis on site and geosphere uncertainties. The work in Subtask 5.1 consisted in several meetings aiming at preparation and organisation of the Seminar 2, held on 4, 5 and 11. October 2021. For several reasons, described in the following section and stressed in the feedback received from the previous UMAN Seminar 1 (see Röhlig K-J. (2021): UMAN - Understanding of uncertainty management by the various stakeholders. Final version as of 09.07.2023 of deliverable D10.13 of the HORIZON 2020 project EURAD. EC Grant agreement no: 847593) and other various activities in UMAN, during the preparation meetings it was decided to deal with the Topic 2 and Topic 3 together during the Seminar 2, addressing one type of uncertainties, i.e. that associated with site and geosphere.

2. Conception and preparation of the seminar

In the UMAN Subtask 5.1, the Topic 1 focussed on the «Meaning for different actors of uncertainty management and of its relationships with risk, safety and the safety case». It has been mainly addressed through the Seminar 1, which outcome is summarized in the Deliverable **D10.13 - UMAN - Understanding of uncertainty management by the various stakeholders**. One feedback from this seminar and other workshops organised by UMAN was the need to look for and develop more realistic concepts instead to discuss the very abstract concepts associated with risk, safety and safety case using concrete examples. Also, focussing only on Topic 2 initially defined as «*Uncertainty pictures at different steps of a geological disposal programme*» required to rely on milestones that were not finalized. To the contrary, important work was achieved on the management of site and geosphere related uncertainties (MS22, 27 and 76 from subtask 3.3, MS89 from subtask 4.2, subtask 4.3 Workshop 1 & MS108) and it offered a panel of concrete examples around which discussion can be held, including the evolution of uncertainties through a disposal program (Topic 2) but also their management options (Topic 3) and ways to favour a pluralistic assessment of uncertainties and their management along the disposal programme (Topic 4). During the Task 5 preparation meeting held on April 22, 2021, it was thus concluded that it would be more relevant to address in a same discussion both the characterisation (Topic 2) and management of uncertainties (Topic 3), as well as to dig a specific domain on concrete examples and scenarios. This approach was thus chosen for the discussions in the Seminar 2, held on 4, 5 and 11 October 2021 («UMAN seminar 2. Management of uncertainties related to site and geosphere characteristics»).

The same approach is foreseen for the UMAN Subtask 5.1 Seminar 3, i.e., sharing **views of different actors on uncertainty management options** throughout the different phases of DGR implementation as well as **on governance and interactions** between stakeholders, which will rely on examples of uncertainties related to human aspects.

Similar to Seminar 1, a participation of around 40-50 people was envisioned, gathering various kinds of actors, i.e., those participating in UMAN (half UMAN partners of Task 5, half coming from Task 3 and 4), namely WMOs, REs, TSOs as well as CS representatives including some members of the CS larger group, but also people invited from and outside of EURAD consortium, notably some representatives of the regulatory authorities. An equilibrium between the different types of actors was researched. Due to the COVID-19 pandemics, the seminar had to be held online and was split into three half days to favour efficiency of the participants.

The preparation of the seminars notably consisted in elaboration of case studies. Following the answers to UMAN second questionnaire and the discussions held on activities associated with abovementioned subtasks on site and geosphere related uncertainties, two topics of interest immediately stand out: uncertainties in fault locations, detection and reactivation, and in climate evolution with a focus on glaciations and permafrost. Another topic, not grasped either in the UMAN 2nd questionnaire or in UMAN subtasks, required to be explored: site's natural resource (e.g., mineral, water, geothermal). For each of these three topics, several scenarios were developed and discussed, describing the (time and space) context of occurrence of an uncertainty. For each topic, the uncertainties of most concerns to be fed into the discussions of the seminar was chosen by the UMAN Subtask 5.1 members.

3. UMAN seminar 2

After few words of «welcome», presentation of the agenda of the seminar (see Appendix A), of the rules of the remote meeting and recall of the terms of references for participation to UMAN seminars (see Appendix B), the seminar unfolded in three parts: (i) presentations with an introductory session, (ii) plenary session with five presentations of views of the representatives of WMOs, REs, TSOs and CS on 3 topics, and (ii) discussions in four working groups and restitution of these discussions for general conclusions.

3.1 Key lectures on management of uncertainties related to site and geosphere

This session aimed at presenting the possible evolution and safety significance of uncertainties related to three site & geosphere related topics as well as possible options to represent these uncertainties in a safety assessment and, where needed, to reduce, avoid or mitigate them. The provided information was significant and based notably on the outcome of other UMAN tasks.

3.1.1 Introductory session

As an introduction to the seminar, it was recalled the three chosen topics that were:

- Topic 1: Fault detection & reactivation
- Topic 2: Climate evolution (with a focus on future glaciations & their effects)
- Topic 3: Site's natural resources

For each topic, presentations were prepared by respectively a representative of a RE, a WMO and a TSO but reviewed by representatives of other actors so that all views were accounted for. The presentations explored on how to deal with uncertainties on the following sub-topics:

- Description and potential safety significance of uncertainties
- Possible evolution of uncertainties
- Uncertainty management options

Various types of uncertainties may have to be managed in a disposal programme and a safety case. Two different uncertainty classifications, developed in UMAN, provided the framework for the discussion in the seminar. The first uncertainty classification, based on the 1st UMAN questionnaire, contains:

1. Programme uncertainties, i.e., uncertainties associated with the national radioactive waste management programme and other prevailing circumstances
2. Uncertainties associated with the initial characteristics of the waste, site and engineered components
3. Uncertainties in the evolution of the disposal system and its environment
4. Uncertainties associated with the data, tools and methods used in the safety case
5. Uncertainties associated with the completeness of FEPs (Features, Events & Processes) considered in the safety case

The second uncertainty classification is based on availability and use of knowledge:

- Knowledge is available:
  - Known knowns (what is known and used)
  - Unknown or ignored knowns (what is known but we are not aware or do not consider)
- Lack of knowledge
  - Known unknowns (what we know we do not know)
  - Unknown unknowns (what we do not know we do not know)

These two classifications were crossed in a Table with examples of uncertainties. Then, examples were shown for the 3 topics chosen for this seminar (see figures below).

	Known Unknowns
2. Uncertainties associated with initial characteristics	*Uncertainties on fault locations*
3. Uncertainties in the evolution of the disposal system & its environment	*Uncertainties on fault reactivation*
4. Uncertainties associated with data, tools & methods	*Uncertainties in fault detection methods*

Figure 2 – Examples of uncertainties following the 2 abovementioned possible classifications (vertically based on the 1st UMAN questionnaire and horizontally based on availability & use of knowledge); Topic 1- Fault detection & reactivation

	Known Unknowns
3. Uncertainties in the evolution of the disposal system & its environment	*Uncertainties about future glaciations, associated effects and their modelling*
4. Uncertainties associated with data, tools & methods	

Figure 3 – Examples of uncertainties following the 2 abovementioned possible classifications (vertically based on the 1st UMAN questionnaire and horizontally based on availability & use of knowledge); Topic 2- Climate evolution (with a focus on future glaciation)

	Known Unknowns		Unknown Unknowns
1. Programme uncertainties	*Possible emergence of new natural resources & technologies*		
2. Uncertainties associated with initial characteristics	*Uncertainties on the presence of natural resources*		*Uncertainties on the presence of unknown natural resources*
3. Uncertainties in the evolution of the disposal system & its environment	*Uncertainties about the exploitation of natural resources*		*Uncertainties about the exploitation of unknown natural resources*

Figure 4 – Examples of uncertainties following the 2 abovementioned possible classifications (vertically based on the 1st UMAN questionnaire and horizontally based on availability & use of knowledge); Topic 3- Site's natural resources.

The principles of uncertainty management strategy were also recalled to the participant, through a figure illustrating the main options available to represent and characterize these uncertainties in a safety assessment, as well as to reduce, avoid or mitigate it where needed: R&D, data acquisition, siting criteria, design and construction options, definition of limits, controls and conditions and interactions with the different stakeholders. It was also underlined that uncertainty management is an iterative process repeated at each step of implementation of the disposal programme and should be adapted to this step of development and to the following decision that is supposed to be taken.

3.1.2 Topic 1: fault detection & reactivation

The presentation on «fault detection & reactivation» was done by Dirk Becker, GRS (Germany, acting as a RE here). After basic definitions, it was underlined that uncertainty in fault detection is highest during site selection and characterisation phase due to the detection limits of the no-invasive methods, preferentially used to avoid damaging the host rock.

Applying site selection criteria could help to avoid presence of local faults, therefore minimizing the risk of future fault formation. Structural mapping of the site and verification of assumptions during excavation leave minimal uncertainty on potential of undetected faults.

Uncertainties remain however on fault reactivation due to the possible evolution of the geosphere. Anyway, the initial characteristics of the faults, notably their hydraulic conductivity, and the evolution of these characteristics over time are uncertain. Potential consequences of the presence and reactivation of existing faults are an increased radionuclide transport and intrusion of oxidizing waters into the repository near-field. The extension or reactivation of existing faults through seismic activity could cause displacement of groundwater and, if the emplacement chamber is reached, may lead to mechanical failure of the engineered barriers such as the canister. The probability of faulting and reactivation, as well as its potential safety significance, depend on host rock characteristics as well as on the disposal concept.

Uncertainty related to faults can partially be addressed explicitly through

- systematic uncertainty analysis in safety assessments
- probabilistic investigations
- specific scenarios: undetected fault, fault reactivation
- possible evolution of uncertainties

Uncertainty related to the presence of faults can partially be reduced through site selection and characterisation (e.g. assuring a sufficiently large volume of «undisturbed» rock). Remaining uncertainties can be mitigated by choosing an appropriate repository design, which could also be adapted if one discovers during construction that previous assumptions are not confirmed by field observations and/or faults are encountered.

Regarding fault reactivation, uncertainty on their likelihood might only marginally be reduced by statistical analysis on relevant data from observations in the past and extrapolate to the future by modelling. However, quantitative characterisation of uncertainty related to long-term evolution is difficult and one often has to rely on expert judgement. Mitigation strategies (for instance, selecting a clay host rock for its self-sealing property, or adapt the multi-barrier system so that the overall disposal system remains robust despite presence of an unexpected fault, etc.) can be followed.

Uncertainty related to the properties of potentially reactivated faults and how they evolve over time can be tackled by experiments and data from site characterisation. Remaining uncertainties can be managed through development of specific scenarios bringing into play undetected fault and/or fault reactivation and evaluation of consequences.

3.1.3 Topic 2: climate evolution (focus on future glaciations & their effects)

The presentation on «climate evolution» was done by Jean-Noël Dumont, Andra (WMO, France). In the near term, climate changes could include the effects of anthropogenic global warming (higher precipitation rates during certain periods and areas, or dry climate, etc.), with implications, among others, on the erosion rate. In the long term a «normal» alternation of glacial and interglacial periods (as in the Quaternary) could be expected, notably a glaciation of the northern zones of the Earth could occur in ~60,000 years from present, and again in ~125,000 years from present. However, due to the current levels of greenhouse gases in the atmosphere the beginning of the next glaciation may be delayed. Also, changes are expected with uncertainties associated with:

- extent and thickness of the ice sheet, which may impact all the uncertainties listed below, as well as the ground stresses and thus the geo-mechanical stability of the repository system and geosphere
- depth of the permafrost layer or temperatures at repository depth, in meteorological (precipitation rate, evapotranspiration rate, wind speed and directions) and hydrogeological characteristics (infiltration rate, water table level, geochemistry). This may affect groundwater flow field and thus, radionuclide release rates
- sea level because of the formation of ice (glaciation) and the dilatation of water (during interglacial periods). This may displace the shoreline and thus hydraulic boundary conditions notably for a repository situated in a coastal area
- landscape due to uncertainties on depth and location of glacial erosion and on the magnitude of relaxation of the geological layers after the glacial periods (isostatic adjustment). This may also impact the boundary conditions, and change the erosion rates and consequently, the location of the outlets. Uncertainties on changes in the erosion rates could become important especially for the safety of the near-surface disposal or any disposal located in areas potentially nearby future glaciers
- habits and diets of the population and more largely in the biosphere (surface hydrology, flora, fauna), taken into account for dose calculation.

Regarding the possible evolution of uncertainties, we are entering an era of increased uncertainty due to climatic conditions changing that also depends on human activities and political decisions. At the same time, we are developing more and more sophisticated models. These two folds of the uncertainty will probably last for several phases of the repositories' lifecycle.

The effects of glaciations relate only to post-closure, but the uncertainties on glaciations modelling may increase or decrease along the repository phases. Glaciations are emphasized in the presentation of this scenario. But at the seminar, possible extreme events in a shorter period were also raised and discussed, which may occur to varying degrees due to climate changes (floods, high temperatures and fires, etc.) which also give rise to uncertainties.

There are several possible options to represent uncertainties in a safety assessment:

- list of FEPs (Features, Events and Processes), which are addressed if glaciations and climate changes cannot be ruled out for the assessment period
- Conservative assumptions or bounding cases
- Depending on the regulator's expectations, specific scenarios related to climatic cycles and greenhouse effects
- Stylized approaches (agreed arbitrary assumptions), usually followed to treat uncertainties related to biospheres

Site selection criteria (e.g., depth) are ways to reduce or avoid some uncertainties. Mitigation is possible with specific design requirements or «design-basis glacier scenarios», using conservative or bounding assumptions on induced conditions. Of course, safety margins can also be included in the design to address uncertainties.

3.1.4 Topic 3: Site's natural resources

The presentation on «site's natural resources» was done by Muriel Rocher, IRSN (TSO, France). Two types of uncertainties are associated with «natural resources»:

- Uncertainties about the presence of «natural resources» in the vicinity of the disposal facility and about their characteristics (depth and extent, concentration, purity, etc.)
- Uncertainties related to the possible emergence of new natural resources in the future.

The potential presence of natural resources may have impacts after the repository commissioning. The consequence is a potential deprivation of access to the resource due to the presence of the radioactive waste disposal, thus rather societal. But the natural resource may be coveted and reached anyway (e.g., through deviated borehole) and in that case, the conflict of use may affect safety (radiological dose to users, increased risks during operation, impact on long-term safety). Therefore, the occurrence of such situation should be reduced as much as possible.

Natural resources may be sought and/or found after loss of memory of the repository. The probability of such situation can be reduced but will always remain and has to be considered as a situation of inadvertent human intrusion (IHI):

- The intruders and/or users of the resource may be (radiologically, chemically) impacted
- Hydraulic shortcut of the host formation due to borehole(s): all safety functions are questioned, may affect long-term safety of the disposal system

The (operational and post closure) safety significance of the impact is initially potentially high but can be drastically lessen by site selection (exclusion of sites with potential natural resources), site characterisation (verification -by mapping, boreholes, and geophysical investigations- of the absence of such natural resources) and then consequences can be mitigated by design optimisation. The risk is also decreased during operational phase and potentially after closure by defining an exclusion zone around the disposal facilities and then by maintaining memory of the facility as long as possible, also relying on the support of civil society, which can potentially be very large and effective. Anyway, some uncertainties remain on the identified natural resources of interest at present day, due to great depth, limits of geophysics etc. In addition, the potential interest for today unknown resources (or without interest, or technically/ economically inaccessible) will always remain (ex: schist gas, some geothermic uses, lithium, and various rare earth elements that were not researched few decades ago, etc.).

Two French examples were given to illustrate the need to define precisely in the regulation, from the beginning of the site selection process, what kind of «natural resources» should be avoided: a potential geothermal resource near the site for deep geological disposal, and a water resource in a potential site for disposal of low-level, long-lived radioactive waste at intermediate depth.

As written above, the management of uncertainties associated with natural resource is twofold:

- Uncertainties can be avoided or reduced by site selection as well as by defining precisely «natural resources» in the regulation in the very beginning of development of the disposal programme, and by maintaining memory of repository,
- The consequences can be mitigated notably by design choices, definition of waste acceptance criteria and waste emplacement strategy.

The (unavoidable) remaining uncertainties should be represented in the safety assessment by Human intrusion evaluation, through stylised scenarios, updated with evolution of knowledge. Also, consequences of the use of a hypothetical natural resource should be evaluated through numerical modelling still at the site selection stage.

3.1.5 EURAD CS larger group perspectives on management of uncertainties related to site and geosphere

3.1.5.1. Relevant uncertainties in the view of CS larger group

The members of the Civil Society (CS) larger group, through several meetings, selected uncertainties of relevance for CS in connection with the topic of site and geosphere.

Gabriele Mraz, NTW (Austria), presented these uncertainties, formulated as questions and addressed as input to the working groups activity planned on the second day of this seminar. These uncertainties were particularized for each of the three hypothetical scenarios proposed to be discussed by the working groups.

Scenario 1 - Unexpected faults affecting the performance of the host rock

Uncertainties on transparency and participation:

- Will Civil Society be informed about the detected fault? Who will be informed by whom? And at which point in time?
- Are there procedures foreseen to manage this situation? Is CS included in these procedures? If yes, how?

Uncertainties on alternatives:

- Is there any other fully elaborated option available in case that the GD has to be abandoned if the problem cannot be managed?

Uncertainties on costs and financing:

- Is there enough budget available to manage the situation? And/or to retrieve the RW to a new storage/disposal?

Uncertainties on quality assurance/monitoring:

- Why has this fault been detected only so late? What quality assurance activities were foreseen? Have they been re-evaluated regularly? Who controlled quality assurance (incl. updates of geological studies)?
- Will the monitoring plans be adjusted?

Scenario 2 - Climatic evolution affecting the reliability of erosion models related to glaciation

Uncertainties on transparency and participation:

- Will the results of the changes in models ‘accuracy be discussed with CS? Have structures been established for such a discussion?
- Who will decide upon the further options and the next steps in climate modelling, but also in proceeding with the DGR based on results of such models?

Uncertainties on safety and risk assessment:

- Have exclusion criteria been defined before the results of the modelling became known?

Uncertainties on alternatives:

- Are there also other sites being researched in parallel for their suitability?

Scenario 3 - New natural resources near the disposal facility

Uncertainties on transparency and participation:

- Has any structure been foreseen to enable societal discussion on this issue?
- Who will decide if the increased risk of radioactive contamination will outweigh the needed mineral resource?

Uncertainties on ethical principles:

- Will the type of new resource (e.g., digging for fossil shale gas versus a rare earth mineral for green economy) result in different justifications for disturbing the DGR?
- How does a general benefit, which might be replaced by other general benefits, justify a concrete risk with irreversible consequences that cannot be mitigated?

Uncertainties on alternatives:

- Is there any other option for a final repository available/can another option be made available?

Uncertainties on reversibility and retrievability:

- Is it possible to retrieve the radioactive waste?

Uncertainties on quality assurance.

- Will quality assurance/monitoring measures be updated if the RW stays in the DGR during drilling? How can CS take part in the quality assurance regime?

3.1.5.2. Intergenerational perspective

Gilles Heriard-Dubreuil, Mutadis (France), as UMAN Task 5.2 leader, presented the key CS priorities regarding their contribution to UMAN. The purpose is not to establish a ranking of uncertainties but priorities in the CS expert work in the next stages of UMAN. The role of CS participants is not to replace the other categories of actors- researchers, but to check if CS views are duly considered in the next stages of this project.

The effective participation of CS should be seen in an **intergenerational perspective**. Implementation of a DGR is far from being a classical industrial delivery; it is an experimental process of development involving unavoidable uncertainties that will be dealt with along with time, incorporating at each stage new social, political, economic, and technical information. Thus, ensuring a rolling stewardship of CS along the long-term implementation of the DGR, is a key asset in the perspective of dealing with uncertainties. Grounding on the Aarhus Convention, creating the effective, practical capacity of each successive generations to access the necessary information and to participate in decision-making is a key priority. An effective participation of CS along successive generations requires to maintain, on the long term, a good governance (including regulators’ independence) and high standards of safety, security, and risk assessments.

3.1.5.3. Key priorities in CS contribution to UMAN

The limited resources in UMAN in terms of CS participation and ICS (interaction with civil society) require focussing on issues of special importance in order to make sure that due attention will be given to safety at all stages of DGR implementation:

- Developing a «Preliminary Framework on Rolling Stewardship» as a way to address uncertainties on transparency and participation, with complementary issue such as:
  - the perspective of increasing complexity of uncertainties with time
  - uncertainties on knowledge and information management for hundreds of thousands of years
- Promoting the contribution of CS members into the UMAN picture
- Setting ethical principles on how to identify and deal with uncertainties.

3.2 Working group discussions on site and geosphere uncertainties

Discussions in working groups were based on concrete cases linked to Site and Geosphere uncertainties presented in introduction. The scenarios illustrated the issues related to the three selected topics: site's natural resources, fault detection and reactivation, climate evolution (with the examples of future glaciations).

3.2.1 The scenarios

The three scenarios were presented by Julien Dewoghelaere, Mutadis (France), as UMAN task 5 leader.

3.2.1.1 Scenario 1: Unexpected faults affecting the performance of the host rock

After operation has started (30 years after operational phase begins), some radioactive waste is disposed of in galleries designed to receive it. One fault located at 200 m from the geological disposal (GD) facility is discovered.

This fault is not linked to an active system so there is no earthquake risk, but the hydrogeology is locally different from the conditions considered in the safety assessment: water is moving in the host rock four time faster than modelled. The presence of this fault may increase the groundwater flow on the side of the disposal system close to the fault leading to faster radionuclide transport to the outlets at surface. Water may also fill up the disposal cells more rapidly than expected leading to a faster deterioration of the waste packages.

Therefore, the performance of the host rock regarding its safety function «limitation of the water flow» is lower than expected in that part of the disposal system.

3.2.1.2 Scenario 2: Climatic evolution affecting the reliability of erosion models related to glaciation

In 2030, the site of GD has been selected but neither construction nor operation have started. Climate change due to greenhouse emissions impacts ocean currents stronger than initially thought questioning the reliability of the models used to investigate the time of occurrence, extent, and consequences of future glaciations.

As a consequence, although it is not expected that an ice sheet will ever reach the disposal site, the prediction of the erosional processes associated with future glaciations (effects of rivers, wind, etc.) in the area surrounding the site (how important the erosion will be) is more uncertain after 50 000 years. After this time limit, the possibility of having a deeper incision of rivers and a higher soil erosion rate over the entire area becomes greater. Unexpected natural outlets (radionuclide release pathways at surface) may appear more rapidly than initially predicted by simulations.

Consequently, more radionuclides then initially expected may reach the surface.

3.2.1.3 Scenario 3: New natural resources near the disposal facility

In 2150, a new mineral resource including rare earth elements enabling notably the construction of much more performing solar panels, batteries and electronic devices is sought after throughout the world. In addition, these resources are owned by a very small number of countries, creating geopolitical tensions. The exploitation of these mineral resources becomes a strategic activity for the country from an economic, ecological, and geopolitical point of view.

The geological disposal facility is filled and about to be closed. However, it is planned to expand a gallery to accommodate additional waste, not originally planned. A feasibility study is conducted. When drilling a borehole for this study, an ore deposit of this rare mineral resource is revealed, at a depth of one kilometre at the outskirt of the disposal system.

It generates a problematic decision-making context. On one side, the exploitation of this resource would help to solve energy issues and would generate social and economic benefits for present and future generations. On the other side, the extraction of these mineral resources near the GD facility may endanger safety: the co-activity could lead to additional damages to the host rock (e.g., through fault reactivation) and hence to new potential radionuclide pathways, and so on. If the extension is not built, there will be also a need for an alternative solution for the additional waste.

3.2.2 Discussions in working groups

The participants were divided into four working groups (see Appendix C), each gathering various kinds of actors and from different countries (regulators, WMOs, REs, TSOs and CS) including an animator and a rapporteur.

For each of these three scenarios, the two following questions were asked to participants:

Question 1: Views on uncertainty management options

- Does this type of uncertainty need to be represented and assessed in a safety assessment? If yes, how?
- What are the best options to avoid, reduce or mitigate (where needed) uncertainties related to faults throughout the different phases of GD implementation?

Question 2: Governance and interactions between stakeholders

- What kind of governance would you foresee to manage this situation?
- Do you think that a regular dialogue with civil society would contribute to managing this type of uncertainty? If yes, how would you interact with civil society?

3.3 Restitution of working group discussions

The rapporteurs of the working groups presented a synthesis of the results of the discussions held during the working group sessions.

3.3.1 Scenario 1: Unexpected faults affecting the performance of the host rock

3.3.1.1 Working group 2

General comments on scenario 1

The WG 2 takes the hypothesis that the scenario does occur after 30 years. The discussion takes place in 30 years. The WG then prefigures a stage of governance where different categories of actors are gathered to discuss the consequences of the discovery of this fault.

Question 1: Views on uncertainty management options

Representation and assessment in a safety assessment

- The scenario is mostly valid for granite; of course, it could be possible for clay, but clay has self-healing capacities.
- There were some mistakes in the initial SC. Some participants stated that it would not happen in their country: This kind of scenario would not happen if things had been done properly. But it is true that perhaps not enough has been studied on how human excavation activities can reactivate faults.
- We need to rethink the safety assessment thoroughly. The safety assessment must be completely revisited.
- From the point of view of civil society, the precautionary principle has not been applied, which would have involved taking into account the worst-case scenario.

Best options to avoid, reduce or mitigate (where needed) uncertainties

- There are technical solutions to imagine, such as putting up new barriers.
- There are multiple possible solutions: it may be necessary to rebuild the repository elsewhere. It depends on the size of the fault.
- There are a lot of safety margins today. We are not sure that an event of this type would involve complete reconsideration.
- It is also for this type of event that recoverability is foreseen.
- If there is no money, we cannot do anything, and everything has to be stopped.

Question 2: Governance and interactions between stakeholders

Governance

- On the side of civil society, this situation would be the source of real anger, and real fear for residents.
- CS participants state they have experience of managing environmental issues which always includes dimensions of uncertainty. In this situation, the NGOs would collect and disseminate information as much as they can. Such an occurrence would result in significant costs and would require public funds to be able to manage the situation.
- From a lawyer’s point of view, these types of situations are very difficult to regulate. You can only regulate when there is some predictability.

- For some participants, it is a question of management. The generations who built the facility should be able to handle this problem. Whereas for other participants, it is not only a problem of management as soon as trust might be broken. The maintenance of social trust is a precondition for the governance system to operate. Otherwise, the tasks cannot be distributed. Regulators, experts, operators, even elected representatives would not have legitimacy to do their work. There is a real risk here of losing the conditions of trust.
- Intergenerational continuity is here presented as not so obvious, regarding transmission of knowledge, skills, etc. It is possible to imagine for the future, that those who are today under 30, will be in a position to examine the problem and put decisions on hold. They will be able to discuss with the experts, with the jurists and with the society to move forward. Of course, new situations and new information may arise, but this should not be an obstacle to implementing a good solution now. There is a confidence that future generations can find solutions and maybe even improve what we do today. But we also have a responsibility to implement a good or even the best solution today. It necessitates a real culture of uncertainty, building a common understanding, an ability to manage uncertainty.
- It is important that this generation can take into account things that might happen but that cannot be predicted. The safety case should be considered as a work that includes all the players, stakeholders, and civil society, in the future, too. In the IAEA standards, the safety case includes stakeholders and civil society. In any case, the generations to come will be autonomous, they will make their own decisions. All decisions can be reviewed as we ourselves have made decisions. All of this can be reviewed when the time comes. Afterwards it will be a new world with different people. It is up to them to say what is appropriate for their lives for their children, to look at the past and criticize, if necessary. When you look at the past from the future, there is always something that can be improved. Building the safety case with the inclusion of civil society is really something that needs to be done. This is for example what is happening in Germany today. And if there are any changes in the future, the society will be involved.

Interactions with Civil Society:

- Such a situation should be discussed with the regulator. One should even imagine that times should be regularly scheduled in which the whole issue of safety would be discussed again with the regulator but also with civil society and with the locals. This is how it is currently happening in Asse (Germany), when new elements are discovered, as recently, there are discussions with all the stakeholders. Certainly, in some countries the problem is not at all approached in that way. It is more in the logic: «Dump the waste and forget». A situation like this requires openness and transparency, a little bit like what we do here when we discuss this scenario in this group. We can imagine that we would need the conditions for a very broad consultation involving all the concerned actors, with a broad sharing of information. These things must be well established in advance.
- Of course, there should be a regular dialogue with the regulator and with civil society. We cannot just stick to ad hoc consultations. When it comes to transparency and honesty, we have to show that we are doing our best. The issue of transparency and governance starts today. It is not when the problem will arise that we will be able to define a way of working and making decisions with the public. It will be too late. It is essential to start today. This approach has a lot of impact on the public.
- As a lawyer, I hope that we can put in place an appropriate framework so that the actors can be responsible. And also put in place insurance systems that can finance corrective actions, if necessary. I also hope that the means of the Internet and electronic communication will facilitate public access.
- Protocols for waste governance should be put in place and it should be done today.
- The question of Rolling Stewardship is a question for today. Not just a nice idea for the future. The future is built on the ground of the present. The foundations must be laid now for this future governance. We cannot just make optimistic assumptions about what the future will be.
- Research needs to be done in order to look at the possibilities for this long-term governance.
- It is important to specify what kind of steps and procedures before starting the implementation. In Germany, for example, there is now a step-by-step procedure which allows new information to be included throughout the process.

3.3.1.2 Working group 3

General comments on scenario 1

Faults are well understood and are linked to the geodynamic environment, host rock; therefore they are not unknown unknown!

Likelihood of this scenario:
- Likelihood depends on the genesis and nature of the host rock (crystalline, clay, salt).
- This scenario is seen by several participants as highly unlikely:
  - The probability of such situation in the CZ programme is very low as one of the site selection criteria is the presence and size of the «homogeneous block»
  - Site characterization should have picked up such situation.
  - If no movement, why would it be detected later?
- However, this situation is similar to what happened at Yucca Mountain where water flow rates greater than expected were observed.

Safety significance
- Possible consequences dependent on the genesis and characteristics of the host rock
- German context:
  - Depends on whether the fault is located inside or outside the «containment providing rock zone» (German regulation)
    - If inside: there is a problem with primary safety function of host rock (but very low probability in this case as high requirements on characterization in this zone)
    - If outside: there is a problem with robustness of the system (as migration may increase in a «secondary barrier»).

Question 1: Views on uncertainty management options

Representation and assessment in a safety assessment
There was a general agreement that such scenarios should be addressed in the SA.

When & How (which is dependent on the «When»)?
Should the scenario actually occur:
- This would probably lead to updates/revisions of the SA to investigate possible consequences on safety (functions).
- CS views:
  - Would depend on how much additional radioactivity could reach the biosphere.
  - Would require (independent) experts' opinion on timeframes and potential risks.
  - Modelling should indicate/guide decisions on how to address the issue.

Should it be addressed in the SA during earlier phases (although seen as unlikely by several participants)?
- The answer is «Yes» according to several participants.
- This could be done through specific scenarios, e.g.:
  - where the permeability would be locally higher.
  - that would illustrate the consequences of such faults and at what distance this could create a problem (& assess how likely such a situation would be).
- There should be enough confidence through modelling that safety would not be compromised.
  - The modelling could predict what distance would prevent having safety issues.
  - Mathematical models could be developed to quantify the probability/consequences of such faults.
- CS views:
  - It should be addressed in the SA so that it would not be a surprise if such situation would occur.
  - It would not necessarily lead to abandonment but should be carefully investigated.

Best options to avoid, reduce or mitigate (where needed) uncertainties
This situation should be anticipated to make it very unlikely (in particular following the construction of the repository) and to make sure it would not lead to the abandonment of the facility.

However, be ready for the unexpected (e.g., Yucca Mountain)
- In the case of site characterization during construction, one must be prepared to manage «surprises».

- It might be difficult to communicate on this to CS if it is claimed that «it can be excluded»; it is better to have a management option even for things which are considered as highly unlikely.

Therefore, a combination of avoidance/reduction & mitigation measures is needed (i.e., defense-in-depth principle).

- First reduce the likelihood: Safety-significant uncertainties regarding faults should be avoided or reduced as much as reasonably possible through site selection and characterization.
- Then foresee measures to mitigate/attenuate possible consequences of remaining uncertainties.

Examples of measures to avoid and/or significantly reduce uncertainties:

- Site selection:
    - If faults can be an issue, this has to be taken into account in site selection.
    - Site selection criteria e.g., presence/size of an «homogeneous block» (CZ programme).
- Site characterization both before construction & during operation:
    - Seismic campaigns.
    - Geological mapping.
    - Monitoring of micro seismicity and geodynamic movements (if the fault is active).

Mitigation measures:

Mitigation measures can be implemented before & after the occurrence of such a scenario.

Before:

- Safety margins at the level of the host rock and/or design.
- Complementary & independent engineered system components.
- When design measures are foreseen to mitigate such uncertainties, the point could be made of why we need to disposed of the waste underground (role of geology?).

After:

- Needs to be anticipated, which calls for the development of a flexible implementation process
- Possible options should such scenario occur:
    - 1) Accept the situation because not safety significant
    - 2) improve/adapt EBS,
    - 3) Abandon disposal cell(s)
- Retrievability/recoverability needed in the latter case.
- CS view:
    - The possibility to retrieve the waste important to build confidence,
    - … as well as the provision of sufficient financial resources,

Question 2: Governance and interactions between stakeholders

Governance

- If a fault can be an issue, this has to be taken into account in site selection.
- If the site characterization is during construction, one must be ready to manage «surprises». The process for managing such situation is important and needs to be defined beforehand.
- Different stakeholders would be involved in the decision-making process associated with such a situation (regulators, minister, expert panel, civil society…). The Canadian programme has foreseen such process (« adaptive phase management ») where the situation is (re)assessed at each phase with various stakeholders (and the decision might be made to «roll back»).
- A process for managing such situation would include the following aspects:

    + An approach for assessing and selecting possible options (e.g., abandonment of disposal cells, design adaptation, acceptance of the situation as not safety significant):

    - Identification of pros vs cons of possible options,
    - How to weight pros and cons,
    - Decision making.

    + Did we plan/anticipate that such situation could occur?

    + If no, lessons learned? How can we improve the process for the future?

    + Different views on the necessity to define (in advance) criteria to decide whether the waste should be retrieved or not (should such situation occur):

- Might not be useful as there is a need to be ready for the unexpected,
- Could be done on a case-by-case basis (for example, the Asse Mine),
- Qualitative criteria could be defined (no numbers).

CS views:

- This process could be part of the « rolling stewardship » concept.
- Civil society would insist on procedures put in place to make sure independent experts can investigate the situation and the likelihood of such a situation. Right decisions can only be made by decision makers if the processes are clearly understood.
- The implementation (or not) of mitigation measures would depend on how much additional radioactivity could reach the biosphere.
- It is important to maintain monitoring to make sure that what's going on is what is supposed to be going on.

Interactions with Civil Society:

- It might be difficult to communicate on this to CS if it is claimed that «it can be excluded», it is better to have a management process even for things which are considered as highly unlikely
- Periodic safety revisions could be a good opportunity to involve Civil Society
- Views of CS:
    - To gain confidence, transparency of the process is needed (how do we plan to manage such uncertainties/situations).
    - This can be done by engaging local and « educated » populations.
    - « Educated » = population should be aware of the issues and be able to monitor them.
    - It will have to be addressed by several generations.

3.3.2 Scenario 2: Climatic evolution affecting the reliability of erosion models related to glaciation

3.3.2.1 Working group 1

General comments on scenario 2

Timing and credibility of the scenario:

- Why so late in the process? (Climate change is considered in the safety assessments)
- Why in such a short period of time in the life of the repository (before construction)?
- Another scenario could have been set, occurring after implementation; in such case, the consequences could have been much worse (waste already emplaced).
- Not very credible, kind of a «What if» scenario.

Consequences of the scenario

- Depends on the country: for certain countries, the ice sheet cannot be avoided.
- More consequences on the surface facilities of the repository.
- Unclear whether risk will be increased or decreased. An ice sheet is not good or bad. E.g., may also lead people to go away from the site.
- In such a scenario, the models are not correct: this would claim for a new assessment.
- Need to keep memory of the information on the repository, in order to address the effects if the scenario happens later. But for safety, keeping memory is not enough for the long term.
- The whole issue has to be kept in memory: there are events that shouldn't be a surprise in the public debate but are presented as a surprise for political decisions (in fact unknown or ignored knowns).

Question 1: Views on uncertainty management options

Representation and assessment in a safety assessment

- Not to be represented in the initial safety assessment, but such scenario claims for an update of the safety assessment.
- The possible changes of relevancy should be considered along the programme: periodical assessments are planned in all national programmes, until the end of license (license release), or if are not planned in all, should be.
- Regarding comprehensiveness of the assessments: it is considered a part of good practice also to audit against FEP (features, events, processes) lists that nothing learned from other assessments has been overlooked. The FEP lists/databases may be useful also to CS to probe/inspire the extent of questions to ask well in advance and develop 'issue lists' of the most important ones to require periodic updates.
- See also relevant publications about addressing the uncertainties beyond the readily quantifiable aspects, so when looking at a scenario, we need to look at its likelihood and potential consequences. The scenario itself is not sufficient.

Best options to avoid, reduce or mitigate (where needed) uncertainties

- If it reopens the choice of the waste management solution, attention should be paid to the whole cycle.
- The decision will be based on the «optimization of protection» principle (balance benefits vs harms). This assessment may lead to different conclusions:
  - In advance to construction: no constraint from the waste, looking for another site is easier.
  - After first implementation: constraints are stronger. Retrieval also creates risks.
- Mitigate: there are various possibilities to address the scenario if it becomes reality
  - The first thing would be to review the safety assessment: the new situation might not be so bad.

- Look for another site (before first emplacement of waste). In such cases, there would be the need to talk to other people.
- Retrieve waste packages (after first emplacement); for example, in Germany, in the regulation there is the option of retrieval.
- Improve the barrier performance (when necessary).
- Go deeper (may create feasibility problems).

Question 2: Governance and interactions between stakeholders

- Dialogue with civil society is necessary and essential. The role of CS is also to alert, to be a vigil of the situation and push the regulators to take into account emerging scenarios that have not been seen.
- So, there is a necessity to have a dialogue all the time. The public should be informed at periodic safety reviews, not only before site selection! If there is regular dialogue, the issue should not be a surprise.
- Necessity also to present alternative solutions (deeper, elsewhere…), in order to be able to choose, after assessing pros and cons.
- Involve CS in research.
- Capacity building on uncertainty would be beneficial.
- Need to communicate on uncertainty / risk (e.g., using Kaplan/Garrick risk triplet = scenario/likelihood/consequence), for example with a risk report every 10 years. Communication should not be only on «it is safe», if trust is looked for.
- Dialogue should also be about decision-making on the uncertainties.

3.3.2.2 Working group 3

General comments on scenario 2

- Similarities with 1st scenario but differs from the fault scenario in that uncertainties in climate processes are more qualitative.
- Impact of glaciation on erosion is a known process. 8 to 15 glaciations can be expected during the lifetime considered in the safety case.
- However, climate change is quite uncertain and modelling capabilities are likely to improve in the future (e.g., machine learning, etc.), so such scenarios could occur and should not be surprising.
- Such uncertainties are also the reasons why we would go for geological disposal (at a sufficient depth) whose purpose is to be insensitive to surficial processes.
- Climate evolution seen as a high priority topic for (and by?) CS.
- Discussions went far beyond original questions which were quite constraining.

Question 1: Views on uncertainty management options

Representation and assessment in a safety assessment

- General agreement (including for CS) that (relatively high) uncertainties in climate change need to be taken into account in the SA.
- CS view: If you can imagine the uncertainty you need to address it.

How?

- Climate change needs to be addressed in the SA using a conservative approach – such scenario should be covered by this conservatism.

- Uncertainties in future predictions may decrease with time as new knowledge becomes available, so it is important to be sufficiently conservative at the beginning of the process.
- How do we make sure we are sufficiently conservative? This could be done by forcing the models to their limits to make sure scenarios are really bounding.
- Represented in the SA e.g., by developing specific scenarios (for example, SKB scenarios).
- Erosion rates (and related uncertainties) are important for the development of such scenarios.
- Sensitivity studies should be performed in support of scenario development by considering sensitivity of rock & EBS characteristics to glaciation-related processes
- «What if » scenarios can be used with the goal to illustrate consequences of bounding extreme cases

Best options to avoid, reduce or mitigate (where needed) uncertainties

- Important for the site selection process, emphasizing the need for appropriate site selection criteria.
- In particular, safety margins on depth need to be foreseen to deal with such uncertainties.
- Example from the CZ programme: Depth of 500 m vs. impact of glaciation down to 200 m
- Possible options should such scenario occur:
    1. Accept it as it is
    2. Relocation of your disposal rooms within the site
    3. Enhance engineered barriers
    4. Select a different site

Question 2: Governance and interactions between stakeholders

Governance

- As in the «fault scenario»: it is important to have a sufficiently flexible process to modify things if needed (does not need to be fully fixed now).
- All stakeholders should be involved.
- Yet there will always be questions of roles & responsibilities
    - who decides for the overall process?
    - should not necessarily be the WMO as it is an issue of national interest and thus should have sufficient political support and includes views of CS (but country-specific, depends on the culture, etc.)
- Some important aspects of the process:
    - What options are available?
    - How do you evaluate pros and cons? How to weigh them?
    - Lessons learned are important if something went wrong in the process.
- CS view: Precautionary principle should be applied in these situations to guarantee that such issues can be addressed e.g., through reversibility of the implementation process.

Interactions with Civil Society:

- Has CS a role to play in defining scenarios (in particular, in case a «stylized approach» is used)?
- CS should be in a position to challenge the measures foreseen to manage such uncertainties and «experts» should be able and prepared to be challenged.
- However, there is for the moment a lack of legal framework for the involvement of CS in SA/scenario development (give them the rights and expertise necessary for their involvement).

CS views:

- A process should be foreseen to involve «educated» representatives of CS in the discussions.
- This implies transparency and independent expertise (as CS are not experts).
- A process is needed considering the evolutions of society to ensure that future generations have the opportunity to have their say on the process (also a question of burden sharing).

3.3.2.3 Working group 4

Question 1: Views on uncertainty management options

Such a situation should be assessed even if it impacts a long-time frame. How to quantify the risk is not easy. The method included the use of weighing factors, fixing the waste in the matrix, connected with other uncertainties. To discuss in detail, we need to discuss the basics of EBS for GD, but there is freedom for many approaches.

Climate changes are uncertain to predict, and models give diverse predictions. The point is when you go for site selection, there should be enough margin for different uncertainties, also to deal with several climate changes. During the site selection there should be enough layers to cover uncertainties, like to work on better technical barriers. Later the changes might be difficult. The site selection is based also on the history of evolutions in geological formation, ice ages, and could be taken into account in the models (history as support to the future).

Appropriate approach would be to model several scenarios for icing in different periods like 1,000, 10,000 or 100,000 years. There must be an evaluation of potential erosions with safety assessments to assess the impacts, then the conclusions could be made about the impact of the scenarios and how to approach it.

It is about model uncertainties and that they are not well representing reality. We have to rely on current knowledge which is to a certain degree uncertain (limited). There should be a protocol developed to explain uncertainties and transparently presented to the society.

By principal it should be considered in the SA although there are a lot of uncertainties to climate models. The scenarios should be taken into account, even the SA should be robust to take over the variation to check if we are still in the safety envelope. It should be considered as a reference scenario (alternative evolution scenario) as the isolation function could be endangered and should be checked. Safety envelope is very important, and it is difficult to say how far we need to go, but it is good that it should at least cover all planned actions, such as those related to increasing the safety culture. Only if the results are out of envelope, we should go in the reduction of uncertainty.

Several countries are considering the scenario in SA based on real data (e.g., glaciation due to Alps): geologists' group investigate the data and areas to reduce the uncertainty, siting process tries to avoid related uncertainties. In SA we have different scenarios related to climate changes: biosphere modelling to include hydrological evolution, scenario to assess the glaciation (as a critical one). It is difficult to answer all related challenges – there are more model uncertainties.

The issue is if we can well model such scenarios based on current data as it is not sure the climate data will be the same. There is uncertainty about what will happen in case of climate changes in the future and therefore worst-case scenarios should be taken. Also, to compare with the case when the waste would stay on the surface.

It is fundamental and critical uncertainty, the main way to avoid it, is the depth of GD. Already now the depth is large and going deeper would be a problem, also for retrievability. The further work on models should be intensified. Or even better – to fight climate changes to avoid such a scenario.

Question 2: Governance and interactions between stakeholders

The governance would need to be very transparent and include a process with protocol (written history why decisions have been made, accessible by people for different questions) to make clear how the decisions were taken, modified with new knowledge and even changed. Challenge: the more you use machine learning, the less understanding there is.

If we would be able to solve all uncertainties, it would be beautiful. Nature is well understood and predictable, with historical data, understanding of processes and natural analogues, but human behaviour is not well predictable (especially when safety culture is low). It is a very important contribution to the uncertainties.

From past experiences - the best strategy is to continuously communicate. The dialog should be installed already from beginning, the citizens should be informed about the refinement of the models and related uncertainties. The climate scenario should be assessed and evaluated if it is still in the envelope. Climate is evolving, looks like faster than first predicted, part of monitoring, deviation from the previous results should be a trigger for a dialog.

It is good to get other views. A pragmatic solution for people with different views, has to be framed in a pragmatic way. Prediction is the golden aim of modelling, but it is more about understanding what can happen. There is also the issue of framing: doing nothing or doing something else – as we need a solution for RW.

The most important is appropriate communication: we should write down a protocol, to record the decisions transparently, regular discussion to the public and regulators to make work transparent.

The governance could/should be applied during different stages on two levels - two types of discussion: between experts to exchange the expert knowledge, to have definitions for rational program and relevant roadmaps for activities, and second discussion with stakeholders (NGOs, public, representatives from society, mayors) to discuss the program and the roadmaps, but also decisions. In the first group discussion, members of CS experts should be included.

Some examples of governance are already defined: there will be a pilot part of GD, also future generations will decide about the closure – to use new data, models…, to be available for such a decision. At all times the stakeholders are involved in the decision making. The procedure foresees a longer-term interaction between government and society. Discussion on climate models – there is an ice age model for the Alps with predictive capability, transferred in the areas for discussion in site selection with different stakeholders (public, local villages, politicians, WMO, regulator…).

The fact is that this scenario also brings societal challenges – it should stay open for discussion with stakeholders during phases, there should be a long-term dialogue with civil society about the effects of climate changes.

3.3.3 Scenario 3: New natural resources near the disposal facility

3.3.3.1 Working group 1

General comments on scenario 3

- The scenario results from a combination of two uncertainties 1) on the waste inventory 2) on the natural resources.
- If the decision is to extract the natural resource, this results in a reduction of the uncertainty regarding future intrusions - but it creates a new uncertainty on the consequences of the extraction operations for the repository performance. Even the «do nothing» option might invalidate the safety case.
- There is a need to keep memory of the site characterization. Our responsibility is to provide the documentation in order to enable future generations to make their own decisions.
- Regarding natural resources: this scenario is rather new to RWM experts:
    - One of the site selection criteria is that the site should be as common as possible.
    - Here there would be intentional intrusion, whereas what is usually considered is unintentional intrusion.
    - In Germany, there is no focus on natural resources.
- The uncertainty on waste inventory is/should be taken into account at the beginning.

Question 1: Views on uncertainty management options

Representation and assessment in a safety assessment

- This kind of scenario is «out of the frame». It is not easy to put it at the beginning. Unplanned scenarios cannot be taken into account at the initial stage.
- There are two separate issues at stake:
    - harm resulting from existing facility / already emplaced waste
    - extension
- We should keep the possibility for future generations to make their own decisions. Therefore, knowledge preservation is essential regarding site characteristics and disposal concepts.
- We should have a regular look on the ground potential resources (not only mineral, water also), and this new information should be taken into account at periodic safety assessments.
- There is a need to introduce the possibility to stop.
- Needs to have some knowledge of the 'neighbourhood', too, of course with the coarser resolution the farther you go. Also useful for the safety case argumentation (description of the regional context).

Best options to avoid, reduce or mitigate (where needed) uncertainties

- If we consider the two parameters 'Capacity (extend or not)' & 'resources' (extract or not): it creates four options. But extra capacity may be taken into account at the initial stage. A new inventory should not be a surprise.
- Here, the decision that will be made (exploit new resources? extend the repository?) will be based on the justification principle. This principle considers the benefits of the decision for the society, not only regarding safety. Justification is not forever; it should be re-evaluated. The driving force is civil society.
- Avoid this scenario by freezing a zone around the repository in order to forbid any exploitation of resources? Difficult to ascertain that it will be respected.

- Look for another site? It is so difficult to get one site for a repository that the first site would be privileged in any case.
- Two opinions in the group on the budget for retrieval:
    - A budget should be made available, in order to offer a real possibility of retrieving the waste,
    - Our responsibility is only to create no undue efforts for retrieval, otherwise should we not also provide a budget for the management of waste after retrieval (never ending story)?

Question 2: Governance and interactions between stakeholders

- The dialogue with stakeholders is a long-term engagement. Must take place early in the process. Need for regular appointments.
- A potential conflict in the future between efforts to have an as much as possible reliable basis for decisions and demand for flexibility.
- Think early on change management: we should have an early dialogue on the criteria to retrieve and on the reasons for reassessment.
- The responsibility of politicians is important.
- A good work of institutional actors is important to allow fair discussions.
- Regarding local vs national decision: is the extension a rather local, the mining a rather national issue? if the benefits of the decision are only national, creates a problem.
- There should be communication on risks, but also on chances.
- Regarding trust building: if we don't know, we must tell it! Claiming that everything is under control when it is not destroys trust.

3.3.3.2 Working group 2

Question 1: Views on uncertainty management options

- This is a very important scenario. Today the only way to take it into account would be to address it as a situation of intrusion.
- In general, treating this scenario as an intrusion situation is not satisfactory since when the event occurs, operations are still in progress. There is still an operator, a regulator, knowledge is still available. Rather, it is a matter of a political decision whether or not to exploit this resource and perhaps to make special arrangements for safety or even to remove the wastes and move the facility.
- We could compare this situation to Shales Gas (SG) which has long been considered as non-viable and too expensive. And then the price of oil went up, the question arose in countries having SG with lots of questions and concerns about the consequences of fracking techniques. Many debates took place. Some countries decided on extraction and others rejected it.

Best options to avoid, reduce or mitigate (where needed) uncertainties

- Can we prevent such scenarios during the siting phase? Perhaps one could imagine introducing constraints in subsequent activity permits. Easements in property contracts, or constraints on authorizations given by public authorities for certain types of activity, for example.
- Indeed, the prospect of resources which were not imagined can be resolved by surveillance, by a legal procedure which regulates the authorization of new activities.
- We can perhaps envisage constraints on future uses of the territory, but we could be completely against the idea of pre-constraining the choices of future generations. They need to be able to do what they want to do.
- One could however imagine institutional and legal constraints (easements for example and consultation procedures prior to authorization), not to constrain decisions in advance, but to be sure that when the time

comes, the concerned actors are involved and that they all have information on the existence of the repository and its safety conditions.
- What is at stake here in the scenario is a trade-off between economic or even geopolitical issues, and safety. Even if the choice is made to exploit a resource, it can however well be accompanied by safety measures to maintain safety on the site or elsewhere (taking into account the associated costs).

Question 2: Governance and interactions between stakeholders

Governance
- Future generations will inherit the repository, but they still need to be aware of this.
- The situation is quite different if we imagine that there is institutional continuity with, for example, legal constraints that can be established and perpetuated. If, on the contrary, we are in a situation of cultural, institutional, political, and social rupture, we cannot consider solutions of continuity.
- In fact, we can see this situation as a contract between the present generations and the future generations to reduce as much as possible the burden for them. But this remains a contract with future generations. This is not, however, an optimal, complete, and definitive solution, it is not a question of overtaking the responsibility, respecting the capacity of generations to come to take the thing appropriate.
- We are already the next generation.

Interactions with Civil Society:
- This is a question of political choices regarding the exploitation of this resource. It can hardly be solved in advance.
- Over time there will be less information on geological disposal. And this is problematic in the case of the discovery of a new resource.
- This shows that the issue of governance of a facility goes beyond safety. This is an argument to justify governance even after closure, since if such a scenario arises, it will be necessary to discuss the opportunity of exploiting this resource and this question goes beyond safety even if it includes safety dimensions. This shows in particular that we cannot confine the post-closure phase to a minimum environmental monitoring. It entails the perpetuation of governance conditions.

3.3.3.3 Working group 4

Question 1: Views on uncertainty management options

Compatible use of the area is already part of site selection now (Swiss case) and decisions have to be taken in advance for such a possibility, before the final selection of the disposal site. In the future, a new interest in the site or a new use of resources might be already included as a possibility in the safety case. A procedure combining estimation of advantages, costs and risk should be designed, including at the end a vote for allowing people to decide (similar situation as in transport on rail for trucks). This is part of a well-established DM system.

Compared to the previous scenario here we touch the boundary conditions (BC), a new situation which we anticipated less. This situation is more related to the strategy of the DM process. We need to assess the risk of additional mines and the impact on GD. Then we could agree on the approach: reduce, mitigate or not, meaning excavate or not to excavate the extra gallery. The perception of risk could be different between the current and future generation. From the current perspective, the GD should be part of BC for the mine – like a prevailing condition.

All possible uncertainties should be listed and considered in order to have a large list of uncertainties related to technical (operation and extension) and eventual natural events (normal and extreme conditions, combinations). From the list we try to prioritise them based on safety criteria and select the scenarios for GD (normal, extension).

Options to avoid, reduce, mitigate, to perform the assessment and decide what to do. Most important is to avoid hidden uncertainties.

Approach could be to make sure of all technical input data (prediction of the waste volume for a long period), so there is no need for additional galleries. If the strategy changes, we should change the siting program, include this kind of discussion in the siting program (to avoid such areas with kind of natural resources), try to estimate the risk of human intrusion, also to include what if scenario.

This scenario brings us to the unknown unknown. What the best approach would be? It is not easy to provide the solution – precautionary principle, it might not be enough if the state would decide to explore new resources.

This is a difficult situation: SA should be done but it could be understood that it was ignored or undetected during the siting. Due diligence should be made during the siting for the unusual things in the area and that there is nothing uncommon, to be sure there is nothing.

Hard question: there is uncertain knowledge about the future resource demands, and it is difficult to predict. Siting should include investigation of available resources on site by using current knowledge for assessment. Maybe it is not totally manageable in a scientific way, and to think governmental ways to manage it (governance process, to imagine and to discuss the compatible resources) and to maximize social benefits.

SA should be done and is considered in the site selection. We don't have so many GD sites and there would also be some other areas for similar resources. Also, there are many other important topics for discussion with CS, so it could be discussed later in the future. Organised dialog with the stakeholder is not an easy task – but as soon as there is a reason, such a dialogue should be held.

Question 2: Governance and interactions between stakeholders

It is more a way to get familiar with this kind of uncertainty, to identify areas for which it is not possible to define strategy. In that sense it is possible to have discussion with society, but the governance is difficult to define and should be adapted with evolution of society and knowledge.

Dialogue to show some uncertainties still exist and could be irreducible. Precautionary principle in the sense that we know nothing about phenomenon, the most defensive approach until you reach the knowledge, apply it in scenarios and perform SA. Justification principle: if GD is already decided it becomes the BC, so the resource cannot be excavated.

Critical resources and GD are societal challenges – dialog should be established, and an open DM process should be available. An idea: if the new resource is so important, it could finance the relocation of GD.

Two types of discussions should be envisioned (as it is the case with the methodology of concrete cases used during the seminar):

- A first level of discussion between high level experts to elaborate their platform with societal experts' participation,
- A second level of discussion - to present the platform to the CS for discussion

Possible approach is to perform the synthetic analyses, then take a hypothetical scenario and discuss with stakeholders to obtain opinions.

At the end of the day, a simple method for 2 options – discussed fairly, what is good and bad, but safe (but not extremely safe, not safe - ruled out).

4. Synthesis and conclusion of the Seminar 2

4.1 Synthesis of the seminar's findings

A **first global conclusion** was given by Julien Dewoghélaëre, Mutadis (France) as UMAN Task 5 leader, based on the rapporteurs' presentations.

In general, it is considered that the potential consequences depend both on the host rock type and on the country's regulations. Such unexpected scenarios are difficult to predict, notably for the one associated with new natural resources. To deal with the unexpected (known unknowns and unknown unknowns, e.g., Yucca Mountain), it is necessary to find pragmatic solutions and allow the conditions to implement them if/when the situation occurs. Having pluralistic discussions could contribute to be prepared. It is also important to consider not only the scenarios but also the likelihood of these scenarios and their consequences happening.

Regarding **uncertainty management options**:

- There is a general agreement to include fault-related uncertainties in the Safety Assessment (SA) early phases of the programme
- Future glaciations and associated uncertainties are taken into account in many SA already, including the effects of the anthropogenic modifications of the climate. The residual uncertainty, coming from the limits of our knowledge on climate evolution, should be covered by taking margins into account (e.g., repository depth).
- Uncertainties on natural resources are not to be necessarily considered in the initial safety assessment but the possible changes of relevancy should be considered along the programme.
- Changes in the waste inventory should be transparent from the start.

More generally, the scenarios examined during the seminar included not only technical issues but also economic and political issues. The question is thus whether we need to include such non-technical issues in the SA or not.

Such uncertainties need to be re-assessed periodically and examined through FEP (Features, Events, Processes) lists and inclusion of results of other assessments, through analysis of specific scenarios (according to the local context), with stylized approach, and/or modelling. Each of these approaches will guide decision on how to address the issue (with regular update).

The uncertainties associated with faulting, erosion and mineral resources are challenges to be dealt with during sites evaluation, the site selection and site characterization. In the beginning, the programme relies on limited but increasing knowledge (faults: seismic measurement campaigns, geological mapping; climatic evolution: update of models; natural resource: update of assessment…), incorporated with periodic and regular assessment and implementation of mitigation measures (even after construction).

To avoid, reduce or mitigate the considered uncertainties, it is required to consider conservative hypothesis and safety margins in the design, to keep memory of the site characteristics, to develop a flexible implementation process. The decision will be based on the "optimization of protection" principle (balance benefits vs harms). For uncertainties associated with faults or glaciation, it should be guaranteed such issues can be addressed (precautionary principle).; For uncertainties regarding new natural resources, one can consider the benefits of the decision for the society, not only regarding safety (justification principle), but such justification should be regularly re-evaluated. But none of the considered uncertainties are manageable only by technical solutions; a governance process needs to be set up, as well as conditions to ensure the discussion.

Regarding the **governance and interactions between stakeholders to manage the situation**, one should primarily create the conditions for an adapted governance. It was mentioned the need to maintain the continuity of the institutions and to develop a «shared uncertainty culture» from the start. Also, maintain social trust is a precondition for the governance system to operate; this requires maintaining the possibility to stop (reversibility principle) and to have alternative solutions if needed. Finally, long-term safety is favoured if the system of governance is efficient during implementation but also maintained after closure (e.g., if a new natural resource is found, it will be necessary to discuss the opportunity of exploiting it).

To be able to deal with the issues when they occur, the monitoring system plays a primary role. Ensuring a budget for implementation of the solution (e.g., retrieval of the waste) was also considered as essential, as well as guaranteeing a continuous discussion. Besides, it is important to preserve information (notably information related to site characterization) and keep memory to enable future generations to make their own grounded decisions.

Finally, the flexibility of the project helps create the conditions for an efficient multi-stakeholder's governance (e.g., « adaptive phase management » in Canada where the situation is (re)assessed at each phase with various stakeholders).

Regarding the key strength of a regular dialog with Civil Society, it was underlined the role of CS to alert, to be a vigil of the situation (e.g., pushing the regulators to take into account emerging scenarios that have not been seen). Regular dialogue is needed to ensure the competence building of CS in the discussions and thus to make more relevant its vigilant role. Also, transparency is a way to ensure trust and requires telling explicitly what is not known (rather than claiming everything is under control). It is required to discuss complex issues, SA and scenario development («stylized approach») in a regular dialog. The citizens should be informed about the refinement of the models and related uncertainties; deviation from the previous results should be a trigger for a dialog. In the same way, associate CS to monitoring as well as to research could improve mutual understanding and confidence. Regular dialog is necessary from the beginning

Finally, the dialogue with stakeholders is a continuous exchange (rolling stewardship) including regulators and society in a long-term engagement that should grasp decision-making on the uncertainties, not only the uncertainties including multi-layer discussions (involving local and national stakeholders). Regular dialog embraces two levels of discussions: exchange between experts (that must include «CS experts») at «expertise knowledge» level (periodic assessments) and larger discussion with stakeholders (local and national). Inspiration can be found in existing systems (e.g., Switzerland).

4.2 Conclusions of the seminar

Frank Lemy, Bel V, Belgium, as UMAN WP leader, gave **conclusive remarks** on the seminar 2.

A stepwise, transparent & flexible decision-making « process » is needed to manage uncertainties in a way which is satisfactory to all stakeholders. However, the question of the conditions to make it sufficiently transparent and flexible remains. The Safety Assessment & Safety Case have a role to play.

The representation of uncertainties in SA scenarios & models may serve different purposes as it might be useful to investigate and communicate on:

- Their possible consequences on safety.
- The safety margins provided by the disposal system & its robustness.
- The likelihood that it could eventually go wrong.

The pros and cons of « conservative approach » vs. « Precautionary principle » were discussed but deserve to be deepened, as well as the scope of SA & Safety Case and the treatment of « programme uncertainties ».

Regarding evolution of the safety case with the programme development, the « process » involves decisions regarding the selection and use of complementary measures at different programme phases:

- to avoid/reduce safety-significant uncertainties e.g., through site selection and/or characterization to make it very unlikely (however some uncertainties cannot be « avoided »)
- to mitigate residual uncertainties and manage « surprises » that could occur e.g., during construction & through monitoring (even if very unlikely) – Be ready for the unexpected!

At each step of the programme, the « defense-in-depth » principle should be implemented (and potentially the « precautionary principle ») and the «process» should be adaptive and take benefit from the « lessons learned ».

In terms of participation of Civil Society, they should have the possibility and the means (i.e., proper «education», independent expertise, legal provisions, etc.) to be involved early in this process and monitor the situation now & in the future (several generations involved) considering that knowledge needs to be preserved during a sufficiently long period. The notion of « Rolling stewardship » concept has been introduced and discussed as it can address such involvement.

Some roles of CS in this process were defined or discussed:

- Oversight of the overseers
- Challenge experts and measures foreseen to manage uncertainties (e.g., completeness check of the FEP list & scenarios)
- Developing scenarios (e.g., stylized approaches)
- Identification & selection of possible options («Optimisation principle»)

Issues like the continuity of institutions and availability of sufficient financial provisions to deal with unexpected situations are important concerns.

Appendix A. Agenda

WP 10-UMAN

UMAN seminar 2

Management of uncertainties

related to site and geosphere characteristics

Agenda

Three half-days: 04-05-11 October 2021

ZOOM meeting: https://us02web.zoom.us/j/8384914149

This Seminar is organized by Mutadis with the support of an expert's team from task 5 of the UMAN project.

After seminar 1 providing a global picture on uncertainties and their management, seminar 2 will dig one domain of uncertainties addressed in UMAN, namely "Site and Geosphere related uncertainties". The aim is to identify and discuss the views of different types of actors on the following topics based on concrete cases:

- Preferences regarding possible uncertainty management options
- Possible evolutions of uncertainties throughout different phases of a disposal programme
- How the interactions with civil society could contribute to manage uncertainties ?

First Half Day - 04 October 2021

Introductory session

14:00 **Welcome of participants, presentation of the seminar n°2 team and rules of the remote meeting** – Julien Dewoghelaere (UMAN Task 5 leader), Mutadis, France

14:10 **UMAN pluralistic seminars: objectives and methodology** – Julien Dewoghelaere (UMAN Task 5 leader), Mutadis, France

14:20 **UMAN classification scheme, elements of an uncertainty management strategy & introduction to the 3 selected topics for seminar 2** – Frank Lemy (UMAN WP leader), Bel V, Belgium

14:40 Discussion

15:00 10 minutes break

Plenary session: management of uncertainties related to site and geosphere

This session aims at presenting the possible evolution and safety significance of uncertainties related to three site & geosphere related topics as well as possible options to represent these uncertainties in a safety assessment and, where needed, to reduce, avoid or mitigate them. The provided information will be based notably on the outcome of other UMAN tasks. The presentations will constitute the basis for the discussions that will take place during the Working Group sessions of Second Half Day.

15:10 **Topic 1 – Fault detection & reactivation -** Dirk Becker, GRS, Germany

15:30 **Topic 2 – Climate evolution (with a focus on future glaciations)** - Jean-Noël Dumont, Andra, France

15:50 **Topic 3 – Site's natural resources** - Muriel Rocher, IRSN, France

16:10 **EURAD CS larger group perspectives on uncertainties related to Site and Geosphere -** Gabriele Mraz, NTW- CS experts' team, Austria

16:20 **Key CS priorities regarding their contribution to UMAN,** Gilles Heriard-Dubreuil, (UMAN Task 5.2 leader), Mutadis, France

16:30 Questions & answers

16:45 End of the first Half Day

Second Half Day - 05 October 2021

Working Groups session

During this session, the participants will be split in 4 Working Groups with a moderator and a rapporteur coming from the UMAN team. Each working group will be composed pluralistically (representatives of different types of actors).

WG n°1:

Moderator: Klaus Roehlig, TU Clausthal, Germany (Research Entities)
Rapporteur: Jean-Noël Dumont, Andra, France (Waste Management Organisation)

WG n°2:

Moderator: Muriel Rocher, IRSN, France (Technical Support Organisation),
Rapporteur: Gilles Heriard-Dubreuil, Mutadis, France (Civil Society expert)

WG n°3:

Moderator: Dirk Becker, GRS, Germany (Research Entities),

Rapporteur: Frank Lemy, Bel V, Belgium (Technical Support Organisation)

WG n°4:

Moderator: Julien Dewoghelaere, Mutadis, France (Civil Society expert)
Rapporteur: Nadja Zeleznik, EIMV, Slovenia (Technical Support Organisation)

The discussions in the working groups will be based on concrete scenarios linked to Site and Geosphere uncertainties presented during the first half day. The scenarios will illustrate the issues related to the 3 selected topics: site's natural resources, fault detection and reactivation and climate evolution (with a focus on future glaciations).

9:00 **Welcome of participants and description of the working group sessions** – Julien Dewoghelaere (UMAN task 5 leader), Mutadis, France

9:10 **Presentation of the scenarios** – Julien Dewoghelaere (UMAN task 5 leader), Mutadis, France

9:25-12:15 **Working group sessions**

12:15 **Conclusive Remarks –** Julien Dewoghélaëre (UMAN Task 5 leader), Mutadis, France

12:20 End of Second Half Day

Third Half Day - 11 October 2021

Restitution session

14:00 **Introduction of the session**, Julien Dewoghélaëre (UMAN Task 5 leader),

Mutadis, France 14:10 **Working groups results presentations (15 minutes per group)**

The rapporteurs of the 4 working groups will present a synthesis of the results of the discussions to be held during the working groups sessions.

15:10 15 minutes Break

15:25 **First global synthesis based on the rapporteurs' presentations,** Julien Dewoghélaëre (UMAN Task 5 leader), Mutadis, France

15:40 **Synthesis Discussion** - All the participants will have the opportunity to comment and discuss the results of the discussions.

16:20 **Conclusive remarks** – Frank Lemy (UMAN WP leader), Bel V, Belgium

16:30 End of the Seminar 2

Appendix B. UMAN Seminar 2 Terms of Reference

European Joint Programme on Radioactive Waste Management

Terms of reference
UMAN Seminars

In order to ensure fruitful discussions in mutual respect, it was suggested to elaborate terms of reference that will be agreed by all the participants in the UMAN Task 5 seminars. These terms of reference establish a set of prerequisites to attend the seminar, notably based on elements of the procedure for establishing the group of CS representatives involved in EURAD that have been validated by the EURAD PMO and Bureau.

1- The participants in the UMAN seminar will have to support the EURAD vision hereunder and commit to contribute constructively to the exchanges that will take place in EURAD, respecting the goals of EURAD described hereunder:

EURAD vision:

"A step change in European collaboration towards safe radioactive waste management (RWM), including disposal, through the development of a robust and sustained science, technology and knowledge management programme that supports timely implementation of RWM activities and serves to foster mutual understanding and trust between Joint Programme participants"

EURAD goals:

- "Support Member-States in developing and implementing their national RD&D programmes for the safe long-term management of their full range of different types of radioactive waste through participation in the RWM Joint Programme;
- Develop and consolidate existing knowledge for the safe start of operation of the first geological disposal facilities for spent fuel, high-level waste, and other long-lived radioactive waste, and supporting optimization linked with the stepwise implementation of geological disposal;
- Enhance knowledge management and transfer between organisations, Member States and generations."

2- The participants in the UMAN seminar recognize that the objective of the seminar is to foster a common understanding or understanding of the different viewpoints among the different categories of actors on the management of uncertainties associated with the management of radioactive waste and how it relates to safety.

3- It is not intended to reach a consensus. Rather, the discussions during the seminar will seek to allow for a nuanced understanding of the issues at stake and a better understanding of the arguments of the various participants, without prejudice to their position with regard to a particular option.

4- The seminar will promote the clarification of the implicit elements leading each actor to establish his choices and preferences, while creating a climate of mutual listening and respect for the views of each participant. The discussion will be based on a freedom of expression of views. The plurality of categories of participants, or at least a plurality of views, experiences and professional profiles, is therefore desirable to foster an in-depth discussion that takes into account a wide range of issues.

5- The animation of the seminar will require pluralistic and transparent governance, i.e the organisation of the seminar and the facilitation of the discussions will be done by a pluralistic team gathering representatives of different categories of actors (WMO, TSO, RE and CS).

Appendix C. List of participants to the working groups (5th October)

(orange)	Research Entities
(purple)	TSO
(yellow)	Regulator
(green)	Civil Society
(blue)	WMO

WG 1

Röhlig	**Klaus**	**TU-Clausthal -KIT**
Dumont	**Jean-Noël**	**Andra**
Bernier	Frédéric	FANC
Mraz	Gabriele	NTW
Matthews	Philip	Nuleaf
Lheureux	Yves	ANCCLI
Göbel	Astrid	BGE
Ikonen	Ari	EnviroCase
Detilleux	Valery	Bel-V
Salat	Elisabeth	IRSN
Diaconu	Daniela	RATEN

WG 2

Rocher	**Muriel**	**IRSN**
Heriard-Dubreuil	**Gilles**	**Mutadis**
Surkova	Maryna	FANC
de Bulter	Malcolm	NTW
Panovics	Attila	Green Circle of Pecs
Ralls	Ian	Friends of the Earth
Kämpfer	Thomas	Nagra
Strusińska-Correia	Agnieszka	BGE
Grupa	Jacques	NRG
Grambow	Bernd	CNRS-Subatech
Tsankov	Teodosi	TUS

WG 3

Becker	**Dirk-Alexander**	**GRS**
Lemy	**Frank**	**Bel-V**
Brazier	David	Environment Agency
Heinrich-Hooge	Niels	NTW
Lindstrand	Asa	OSS
Wales	Colin	Waste Cumbria
Lahodovà	Zdena	Surao
Liebscher	Axel	BGE
Miksova	Jitka	Suro
Zuidema	Piet	Ex-Nagra
Georgieva	Rayna	TUS

WG 4

Dewoghelaere	**Julien**	**Mutadis**
Zeleznik	**Nadja**	**EIMV**
Ilett	Doug	Environment Agency
Geisler	Alexis	NTW
Grossman	Maximilan	ITAS
Swahn	Johan	MKG
Depaus	Christophe	Ondraf
Li	Xiaoshuo	Nagra
Vojtechova	Hana	Suro
Ivanov	Ivan	TUS
Slugen	Vladimir	Stuba