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**NUCLEAR ENERGY AGENCY
RADIOACTIVE WASTE MANAGEMENT COMMITTEE**

Expert Group on Preservation of Records, Knowledge and Memory across Generations

Articles about strategic aspects of the preservation of Records, Knowledge & Memory (RK&M) across Generations

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FOREWORD

Since taking up its work in 2010, the RK&M project team has written a number of articles about strategic aspects of the preservation of records, knowledge and memory across generations. These strategic articles, which represent a consensus amongst the project members, are brief, concise and consistent with one another in terms of terminology and structure. They are continuously updated to reflect the progress of the RK&M project. Until the publication of the present document (March 2014), the following topics have been addressed:

- Archives
- Bibliography
- Key Factors for Loss of Records, Knowledge and Memory
- Connection to Safety
- Guiding Principles
- International Mechanisms
- Markers
- Monitoring and RKM Preservation
- Regulation
- Terminology

The strategic articles are collected in this document and represent one of the products of the Project at the end of its Phase-I. This document, like many others by the project, is also available on the project website www.oecd-nea.org/rwm/rkm/.

ARCHIVES

The mission of established, existing archives is to preserve collections of records for future generations. They are therefore a key institutional component of the RK&M preservation process. Depending on their respective aims and scope, different types of archives may play a different role in preserving and granting access to relevant records.

Summary of work

Archives and their Role

In the context of the RK&M project, the term archive refers to a “collection of records that have been selected for permanent preservation due to their continuing administrative, informational, legal and historical value as evidence of the work of the creating organisation or programme.”¹ In the understanding of the project, an archive is an institution that is (or at least has been) maintained over time, as opposed to information repositories such as, e.g., time capsules.

As distinct from libraries, which are usually created with the intention of providing public access to collections of published materials, archives are defined through their long-term preservation mission² with no limit of time.

Regulations

As records are produced by an organisation (e.g. implementer, regulator), they are usually stored in the organisation’s own records management system. In many countries, legislation requires that records from specific institutions be ultimately transferred to the national archive for preservation³⁴. National archives, with their typically long experience in the continuous management and preservation of such records, for which they have established policies and standards, are a key component in the preservation process of RK&M over time.

In any country, archives exist at several geopolitical levels: national, regional, municipal. The International Council of Archives (ICA) coordinates policies and standards developments at the international level.

¹RK&M Glossary, online available at <http://www.oecd-nea.org/rwm/docs/2011/rwm2011-14-rev4.pdf>.

²Ibid.

³Ibid.

⁴RK&M 2012 Workshop Proceedings, p. 85, online available at <http://www.oecd-nea.org/rwm/reports/2013/rwm-r2013-3.pdf#page=86/>.

Project learning

The mission of established, existing archives is to preserve collections of records “forever”. Indeed, some archives, such as the Vatican Archive⁵, have existed for more than 1 000 years. There are, however, only few examples of well-kept archives beyond 500 years. Though archives typically describe their task as “long-term” preservation, they are, as institutions, strongly dependent on society continuity. In the understanding of the project they can therefore be considered reliable means for RK&M preservation in the medium-term.

Archives differ on the status of the organisation who maintains them (e.g., government, non-profit, for-profit, etc.), their geographic scope (e.g., international, national, municipal, on-site) and their thematic focus (e.g. generic, specialised).

International bodies, such as UNESCO, have initiated large-scale, collaborative projects (such as Memory of the World Programme or⁶, World Digital Library) related to documentary heritage. These initiatives aim primarily at federating existing cultural heritage projects and at making content easily accessible – (digital) preservation being “only” a means to facilitating access.

Other examples of collaborative projects, specifically in the nuclear field, include INIS, the International Nuclear Information System developed and operated by the International Atomic Energy Agency (IAEA)⁷ and the NEA Data Bank⁸. Neither is an archive in the proper sense, but both aim at collecting and making vast quantities of data and information in the nuclear field widely available.

The main criteria to evaluate the different types of archives include (1) their potential longevity as institutions and (2) their ability to select, organise and make accessible the relevant material in a meaningful way. On the first criterion, national archives are the ones that are likely to last longest. Non-governmental initiatives are more likely to be interrupted and abandoned, for lack of funding or when the organisation ceases to exist or loses interest in the archive⁹.

Regarding the ability to select, organise and make accessible the specific records related to radioactive waste management (RWM), it has been noted that national archives, who by definition have a very broad focus, might not be in the best position to operate a good selection (“appraisal”) in terms of significance of the records or to ensure their readability and understandability in the long-term. Local archives may be considered more accessible, because of their proximity to the repository site.

In an archive, records are traditionally maintained in their original form and structure. The latter – “principle of provenance” – helps understanding the context of their creation within an organisation, but requires more efforts to get the necessary overview when processes have been performed and documented

⁵Paztor S.B., Hora S.C. (1994), “Lessons from the Vatican archives for repository recordkeeping”, *Radwaste Magazine*, 1994, 1: 3, pp. 39-47.

⁶RK&M 2012 Workshop Proceedings, p. 87.

⁷Ibid., p. 88.

⁸Ibid., p. 91.

⁹OECD NEA (2014), “Loss of information, records, knowledge and memory in the area of conventional waste disposal”, NEA/RWM/R(2014)3, online available at <http://www.oecd-nea.org/rwm/docs/2014/rwm-r2014-3.pdf>.

independently by various stakeholders. This means that archival collection policies and appraisal practices regarding RWM need to be looked at closely and that a close collaboration should be established between the archives and the many institutional stakeholders that play a role in the generation, management and ultimate delivery of the records, such as policy making bodies, regulators and implementing organisations.¹⁰

With most government records being generated today in digital form, archival material now collected is seldom kept in paper form anymore. Though national and international (ISO) standards for policies regarding the long-term preservation – including migration – of digital archival material have been established¹¹, the actual longevity of such material, in connection with the timeframes addressed in geological disposal, can be questioned. Current international initiatives also rely on digital media. However, their main objective is not primarily preservation, but access to information.

Avenues for further inquiry

- An initiative could be created to specifically allow archivists to interact in the RWM context. Aims and questions to be addressed by this initiative are listed below:
 - Member archivists would help identify current issues and possibilities for standardisation.
 - Requirements regarding the structure of records collections, metadata and contextual information, media, language, retention periods, access and confidentiality could be developed in concert with the institutional stakeholders (in particular the regulator) for RK&M preservation and compared to current archival policies and practices, as defined by international (e.g. ISO) and national standards.
 - Interaction with RepMet will be sought.
- As one of the key elements of RK&M strategies is redundancy, it would be useful to keep sets of records in several archives at multiple levels, e.g. in local (municipal), regional and national and international archives. Is this feasible?
- National archives already cooperate at international level. How can sharing waste repositories' RK&M be fostered? Which are potential difficulties that could arise?
- To what extent could other mechanisms such as the World Digital Library and others be used by national organisations as one further means to disseminate information?
- In the context of the Set of Essential Records initiative, implementers and regulators and policy makers could be invited to define jointly what they would consider a reference set of essential records for archiving.

¹⁰RK&M 2011 Workshop Proceedings, p. 62, online available at <http://www.oecd-nea.org/rwm/docs/2012/rwm-rkm2012-1-final.pdf>

¹¹Ibid., p. 27.

- Studies of questions related to the types of RK&M that are most likely to be useful in the long-term may become important input for the development of regulatory requirements for long-term preservation of RK&M
- Similarly, it should be investigated whether several stakeholders (such as the implementer and the regulator) could compile a joint set of records that would synthesise the context and procedures, as complementary practice to the regulator, implementer and others sending their separate files to their national archives.
- Finally, the experience of Andra at the low-level waste repository "Centre de la Manche" and other organisations in organizing records at different levels of detail should be tapped.
- The possibility to establish a dedicated archive, either at the national or – given the relatively small number of projects – at the international level, with dedicated funding, should be kept in focus. The project of a Nuclear Archive drafted by the Nuclear Decommissioning Authority (NDA, United Kingdom) should be tracked.

Glossary Definition of Archives

Collection of records that have been selected for permanent preservation due to their continuing administrative, informational, legal and historical value as evidence of the work of the creating organisation or programme. The term archives also refers to the building or part of a building in which archives are preserved and made available for consultation, as well as to the agency or programme responsible for selecting, acquiring, preserving and making available archives. Commentary National archives acquire, preserve and make available for research national records, in particular those created by national agencies. They usually establish policies and procedures for managing these records and assist national agencies in carrying out their records management responsibilities. Archives differ from libraries in the sense that libraries are usually created with the intention of providing public access to collections of published materials.

BIBLIOGRAPHY

The RK&M project has created a bibliography relevant to RK&M preservation for radioactive waste disposal. A significant portion of the existing references deals with one of two main topic areas: retention of RK&M for short-term, primarily operational purposes; and long-term retention of RK&M aimed at informing future generations about the existence of and hazards posed by a geologic repository. The analysis also revealed or confirmed the existence of a number of more specialised topic areas for which the existing literature provides relatively few references. The bibliography is available on the RK&M wiki web site; there is also a browser that allows users to select subsets of the bibliography.

Summary of work

The RK&M project has collected documentation relevant to RK&M preservation for radioactive waste disposal, including papers, reports, articles, books and other materials that bear on the subject matter. A first step in organising the documentation was to compile a bibliography of these project-related resources. Since the subject area is evolving, the list in the bibliography is continually updated. While the dominant language in the documents included in the bibliography is English, a number of relevant documents in French, German and Swedish have also been identified, and documents in these and other languages will continue to be added to the list.

In a first step towards identifying the most important documents in the bibliography, a core subset of documents was selected consisting mainly of reports (primary sources). Abstracts in a uniform style and format were written for all of these core documents. For purposes of analysis, the contents of each of the core documents was categorised against a range of characteristics relevant to the subject. This was done using a set of closed form (yes/no answers) questions about each document. The questions are grouped in a number of areas, which may be succinctly summarised as questions related to the when, why, what, who, where and how characteristics of RK&M covered in each document. A complete list of the questions is available on the wiki. In addition to simplifying the analysis process, the closed form of the questions facilitates the selection of documents that deal with specific aspects of RK&M, as follows: a short key phrase is associated with each question, and these key phrases can be used in a browser on the wiki to select documents from the bibliography dealing with combinations of the characteristics specified by the chosen key phrases.

The list of core references, the list of questions, the browser and the individual abstracts and other data on the references are all available under the heading Bibliography in the wiki.

Project learning

An analysis of correlations among the answers to the questions revealed two separate clusters of questions corresponding to two groups of documents. One group relates to the retention of RK&M for short-term and very-short-term purposes, including information from waste producers, with one of the main goals being responding to unforeseen events. The second group relates to the long-term retention of

RK&M, including physical markers, aimed at informing a broad audience including the future general public, with one of the goals being to deter inadvertent intrusion. The majority of documents in the bibliography deal with one or the other of the two groups, but relatively few documents attempt to cover both areas of interest.

Using the yes/no responses to the questions, the core documents were also analysed to look for trends and gaps. This analysis identified a number of areas that have received relatively less attention in the literature. Some of these have been the subject of discussions or further study during the project, including:

- the role of monitoring in both creation and preservation of RK&M;
- security and safeguards as motivations for preserving RK&M;
- actions that might be taken in the long-term to preserve RK&M and/or to mitigate loss of RK&M; and
- the role RK&M preservation might play in ensuring the existence of future expert knowledge needed to help preserve and interpret factual data and metadata in the longer term.

Some other gap areas have not yet been dealt with within the RK&M project, including:

- costs and funding for activities that may be required for ongoing preservation of RK&M; and
- the role of NGOs in RK&M.

Topics in both groups may be studied further in a subsequent phase of the project.

Avenues for further inquiry

- As further documents are developed during the time frame of the RK&M project, either within the project itself or in parallel with it, these documents may be added to the bibliography.
- The indexing of documents for the RK&M wiki search engine will be extended to documents both within and outside the current core group of key documents in the bibliography.
- The entire bibliography will be reviewed in order to identify existing documents that are important enough to be included in the core group.
- Abstracts in the standard format and style will be prepared for newly-identified core documents and added to the bibliography.

References

The bibliography page on the wiki is a starting point for viewing and searching the bibliography. This page includes links to individual pages describing each document in the bibliography, as well as links to the full question set and to a search engine and a browser that can be used to select documents according to desired combinations of characteristics. The September 2012 Workshop Proceedings contain more detail on the question set and the analysis process used in the project.

KEY FACTORS OF LOSS OF RECORDS, KNOWLEDGE AND MEMORY

Analysis of recorded experience in primarily the field of hazardous waste management has been used to develop understanding of the key factors for the loss of records and memory relating to waste disposal. There are many examples to be found in all industrialised nations, with a range of consequences for nearby populations and the environment. The key factors for loss of records and memory appear to be related to allocation of resources, related both to human behaviour and to levels of economic support. Secondary factors of importance are related to deliberate (unlawful) acts, and to transient societal discontinuities.

Summary of work

Waste is a material that inherently has 'no value', so the prevailing philosophy has been that its disposal must be without cost, or at the lowest possible cost. Industrialisation led to a massive increase in the scale and toxicity of the waste problem. Traditional approaches to the handling of wastes were simply to dump them in an uncontrolled fashion, on the basis that the environment has a capacity to absorb, degrade and disperse the wastes. History has shown that the challenges presented by technological wastes are only addressed properly when strong regulation and appropriate sanctions are in place. Recently, the environmental movement has played a significant role in focusing attention on proper waste management and records. Two studies were commissioned directly by the project during Phase I, with additional relevant information being collected from other sources such as the 'Tsunami Marker Stones' in eastern Japan¹². The first commissioned study was a presentation of seven different examples of loss of records and memory, collected from the members of the project group¹³. The examples addressed hazardous industrial waste, radioactive waste, information in municipal archives and non-existent information on buried dead animals after the outbreak of anthrax. In the larger of the two commissioned studies¹⁴, examples of loss of records and memory were analysed in a study based on 21 examples of conventional (non-nuclear) waste disposal in Switzerland, Germany and USA. These examples were all drawn from industrial and military processes, but were operated by a range of landowners, including national government, local authorities, private companies and individuals. Each of the examples had a history in which the original information and data was forgotten or details had been lost, resulting in accidents or uncontrolled environmental contamination and costly cleanup. There were also examples where the original information were preserved in accordance with the laws and regulations at the time, but it turned that it was not sufficient.

¹²Van Luik, A., Patterson, R., Shafer D., and T. Klein (2012), "Tsunami stones. Memory saves lives. Intergenerational warning effectiveness", 2012 WS Proceedings, p. 77ff, available at <http://www.oecd-nea.org/rwm/reports/2013/rwm-r2013-3.pdf#page=78>.

¹³Tunbrant S. (2011), "Examples of loss of RK&M", Examples based on inputs from Buser M, Charton P, Nagy Z, Pescatore C, and Van Luik A. in October 2011 WS Proceedings, available at <http://www.oecd-nea.org/rwm/docs/2012/rwm-rkm2012-1-final.pdf#page=41>.

¹⁴OECD NEA (2014), "Loss of information, records, knowledge and memory in the area of conventional waste disposal", NEA/RWM/R(2014)3.

Project learning

It is important to note in the first place, from the historical perspective, that record keeping and its subsequent loss refers to the situation where it was envisaged/planned/prescribed to store the records in the first place and that these were then subsequently “lost”. The concept of “loss of records” and by extension “loss of memory” is not applicable for information, data & knowledge that was never stored in the first place but that we now would need in order to take some remedial action for example.

Both studies were based on identifying the key factors that are considered important with respect to the loss of information/data, see Table 1. Buser’s 15 three main conclusions were:

- It is rare to lose all information about the waste disposal site itself, but that the details of its contents tend to be lost first.
- It is also clear that many records were made with insufficient data to inform us now so that the proper remediation actions can be executed
- Once lost, records are very difficult to re-construct them.

A number of sub-factors were identified under each of the headings in Table 1. Four of these were identified as relevant contributory factors in every one of the example cases studied. These were:

- absence of records/poor archives,
- insufficient updating of records,
- insufficient budgets to fulfill the duties,
- personnel changes.

Although they occurred more rarely, two other reasons are considered to be particularly significant namely:

- unlawful activities and
- societal discontinuities.

The first involves the deliberate loss or destruction of records, usually motivated by financial gain. The second relates to major societal upheavals, such as war and the shift of national boundaries. It is clearly difficult, if not impossible, to prevent these two factors occurring simply by creating management systems.

¹⁵ OECD NEA (2014), “Loss of information, records, knowledge and memory in the area of conventional waste disposal”, NEA/RWM/R(2014)3.

Table 1 - Key factors and reasons for loss of records, knowledge and memory

Key factor	Reason for loss of records, knowledge and memory	Reference
Resources – personnel and financial	Financial support missing or withdrawn. Staff leaves, retire or die – memory goes with them.	Buser 2013. Tunbrant 2011.
Skills – knowledge and understanding	Ignorance and/or incompetence. Staffs are poorly trained or have low level qualifications. Motivation – many staff do not see the importance of RK&M. Inherited knowledge not regularly proved.	Buser 2013. Van Luik et al. 2012.
Assumptions – human error, arrogance, etc.	Altered awareness, inadequate records. Underestimation of effective risks.	Tunbrant 2011.
Institutional issues	Poor legislation and/or weak regulation. Procedure-driven organisations ignore relevant events. Unlawful activities (e.g. falsification of documents, illegal disposal).	Buser 2013.
Key events – political and environmental	Crisis such as war - change of national borders. Poor structural continuity in society. Commercial sale of site/private operation. Loss /destruction of archives. Environmental changes/environmental catastrophes.	Buser 2013. Tunbrant 2011.

Additional preliminary conclusions have been identified as follows:

- The lack of human action is the most important factor – principally in terms of regulatory enforcement, followed by economic factors (lack of funds). Technological failure plays a third role.
- Loss of memory is rare over timescales of up to 100 years, and only appears in the case of major historical disruptions. Partial loss of records is much more common.
- Inherited knowledge of something dangerous does not last forever. Information and warnings must be regularly proved valid to be believed and understood.
- Records are often made with insufficient data to inform remediation actions.
- There is a need for a culture and awareness of the importance of preservation of records and memory.
- Redundancy is important: geographic redundancy of archives, redundancy of responsibility, redundancy through conserving and managing of knowledge and memory in various disciplines.

It is recognised that there are significant links between the key factors for loss of RK&M and

- The use of site markers
- Regulatory catalogue
- Any others

It was suggested and agreed that we now possess enough information regarding the key factors for loss of information or the reasons why it was never stored in the first place. In order to ensure that records are properly collected, managed and shared in this day and age one should focus now on the following:

- Management should be aware of the importance of this task and provide sufficient resources (financial and human)
 - Management should acknowledge that, apart from the above, time is required to acquire the necessary work-ethos to compete the job to the required standard (including aspects of record keeping).
 - Senior personnel needs to be trained and coached in transferring skills to junior personnel
- Information sharing is an important value that all staff should cultivate

The strength of regulating and regulating bodies and their tools for enforcement is crucial as it assures that appropriate records, knowledge and memory are created, retained and made available to future users.

Avenues for further inquiry

The study conducted in Phase I lists potential key factors for loss of RK&M in the field of hazardous waste management in the short term. These key factors should be investigated with regard to the medium and long term.

- Which key factors could be avoided? Which methods could be used?
- Can remediating measures be envisaged for loss of RK&M?
- Develop more the issue of “knowledge reconstruction”, e.g. explore the concept of “mothballing”,
- Examples of reconstruction of extinct languages, interpretation of symbols

CONNECTION TO SAFETY

One of the frequently asked questions about the commitment to preserving RK&M is: “Is RK&M preservation needed for safety purposes once the repository is closed?” “Safety” is not uniquely defined, not even in regulatory texts. There is a technical view of what safety is and also a broader view. The RK&M project offers its view on the question based on these two perspectives.

Framing the issue

In order to frame the issue it is important to have a shared understanding of the following points (see [strategic article on guiding principles](#) in this document):

- The repository, once its closure is authorised, should be safe by itself. Technical safety – meaning no significant threat to people’s health and the environment – should be independent of any forms of oversight.
- At the same time, there is commitment not to abandon oversight of a geological repository of radioactive waste after its closure.
 - ICRP-122¹⁶ is clear on this point. Other international guidance exists but it is less clear.
 - Oversight is a general term for "watchful care" and refers to society "keeping an eye" on the technical system and the actual implementation of plans and decisions.
 - Oversight includes regulatory supervision, institutional control, preservation of societal records, and societal memory keeping of the presence of the facility.

Technical safety

In the technical field, safety is understood as implying no significant threat to people’s health and the environment, and this is the basis upon which a nuclear license is granted.

In any event, the ultimate safe performance of the repository does not depend on who oversees it, but on where the repository was sited and how it was constructed and operated and eventually closed. Even if there are checks and verifications, and memory is kept, the safe performance of the repository depends on the material circumstances of its implementation.

The series of “safety cases” that the developer of the repository will submit for review and subsequent authorization is about making the case that the facility as built and operated and left to evolve is safe by

¹⁶ ICRP (2013), “Radiological protection in geological disposal of long-lived solid radioactive waste”, *ICRP Publication 122*, Ann. ICRP 42(3), available online at http://ani.sagepub.com/content/suppl/2013/11/27/42.3.DC1/P122_Radiological_Protection_in_Geological_Disposal_of_Long-lived_Solid_Radioactive_Waste.pdf.

itself. Each subsequent safety case brings additional elements and data to support a stronger statement of confidence in the safety of the facility without the need for continued oversight

Each safety case also addresses the eventuality of human intrusion into the repository. The prevailing regulatory view (see ICRP-122; NEA Tokyo workshop) is that human intrusion scenarios are not required for compliance with regulatory standards, but as part of the qualitative evaluation of the system robustness.

Keeping records and using markers are among the means that have been evoked in the literature to help reduce the possibility of human intrusion (see [strategic article on regulatory aspects](#) in this document). Some regulations exclude human intrusion scenarios for a few centuries based on the implicit assumption that society and local jurisdictions will be functional over this period of time.

RK&M preservation can be seen as part of the arguments for supporting the robustness of the system vis-à-vis human actions.

The broader view on safety

Keeping RK&M of a radioactive waste repository after closure is meant to avoid inadvertent human intrusion (see above) and also to perpetuate the ability of man to take informed decisions regarding the repository and its contents. Regarding the latter, the RK&M project takes the position that (see [strategic article on guiding principles](#) in this document):

- Preserving the possibility to make informed decisions is part of sustainable radioactive waste management in that it enables future generations to make safe choices based on availability of information.
- Preserving RK&M for as long as feasible implies continued responsibility towards the succeeding generations.

Knowing that there is continued care and preservation of the ability to make informed decisions is related to safety. Namely, commitment not to forget, familiarity and some level of knowledge and oversight are important components of feeling safe, i.e., free from danger and therefore to live one's own life without additional worries. Indeed part of the judgement of safety by the regulators and licensing bodies will also rest on their familiarity with the facility and with the fact that they have or have had the possibility to exercise control on the facility.

The last point suggests that the concept of technical safety, which dominates the safety case, is only a part of a broader concept of safety. When mentioning safety, it is thus important to take into account both the technical and non-technical underpinnings for safety.

The RK&M project observes that there exist a number of demands and requirements that, explicitly or implicitly, call for RK&M preservation and go in the direction of demonstrating continued responsibility and preserving familiarity with the repository facility and ability of man to exercise choice. Namely:

- The international guidance by the ICRP-122¹⁷ recommends that we do not plan for abandoning oversight, but that we do prepare for the potential loss of it.
- Many stakeholders demand monitoring. Even if no manifestation of the repository may be detected, monitoring by itself can be seen as confidence- and capacity-building and safety-related.
- In some countries there exist legal requirements on implementing administrative provisions, such as land use restrictions, that prevent human intrusion but also help keep options open over a period of a few hundred years.

Besides, monitoring of pathways and reporting on the quality of water and air are requirements under a variety of laws and international agreements, beyond those rules and regulations that were used for licensing the facility.

After closure of the repository, RK&M preservation is not needed for the technical safety case, but it provides reassurance of safety as well as the ability to make informed choices in the future.

Further avenues for investigation

The position of the RK&M Project on safety will be tested and developed further with the help of other audiences.

¹⁷ICRP (2013), “Radiological protection in geological disposal of long-lived solid radioactive waste”.

GUIDING PRINCIPLES

Long-term projects of any nature are vulnerable to risks of Records, Knowledge & Memory (RK&M) loss. The international community of radioactive waste professionals is dedicating efforts towards the preservation of RK&M across generations. At the end of its first phase of work, the OECD-NEA RK&M project has reviewed the basic tenets in the field and offers the following suggestions as guiding principles for any project meant to preserve RK&M across generations in the context of geological repositories of radioactive waste.

Foundations for RK&M Preservation

- There is no intention to forsake repositories for geological disposal of radioactive waste, before or after closure. The RWMC accepts and adopts the ICRP-122¹⁸ position on the relevance of maintaining oversight over geological disposal of radioactive waste for as long as practicable.
 - Oversight is a general term for "watchful care" and refers to society "keeping an eye" on the technical system and the actual implementation of plans and decisions.
 - Oversight includes regulatory supervision, institutional control, preservation of records, and societal memory-keeping of the presence of the facility.
- The repository, once its closure is authorised, should be safe by itself. Safety – meaning no significant threats to human health or the environment – should be independent of any forms of oversight.
- Once the current institutions – implementers, regulators, and others – have fulfilled their legal mandates, repository oversight will be continued by other institutions and stakeholders.
- Any strategy for the preservation of RK&M should take into account the possibility of major discontinuities in future society.

Guiding Principles on RK&M preservation

- Keeping RK&M of a radioactive waste repository after closure is meant to perpetuate the ability of future society to take informed decisions regarding the repository and its contents and to prevent inadvertent human intrusion.
- Enabling future society to make informed decisions is part of responsible, sustainable radioactive waste management, is in line with a prudent approach regarding safety and has ethical foundations.
- The future RK&M preservation needs to be prepared for while the interest-level is high and funding is available.

¹⁸ ICRP (2013), "Radiological protection in geological disposal of long-lived solid radioactive waste".

- The long period of the operational phase of the repository creates an opportunity for reflection and for the development of workable RK&M strategies.
- During the operational phase the institutional stakeholders must prepare for the post-closure phase, when their own roles will be reduced and other stakeholders with new responsibilities, especially in the area of RK&M preservation, will enter the scene. The institutional stakeholders should facilitate the preparation and implementation of:
 - Archives
 - Administrative restrictions on land use
 - Regular reporting by governments under one or more [international mechanisms](#) (strategic article in this document) and agreements.
- A systemic approach should be formulated whereby the various components of the RK&M system complement each other, provide for redundancy of message communication, and maximise the survivability of a recognizable and comprehensible message.
 - There is no single best means of preservation over all time scales. All available communication channels should be explored.
 - Records will be used by others than the original providers, and attention should be paid to the needs of future users in terms of facilitating readability and intelligibility, providing, in particular, relevant information on the context in which the records were created.
 - The various components of the RK&M system should apply robust, simple and understandable techniques and support materials, and should not rely on technological provisions alone.
 - RK&M preservation approaches should include provisions for knowledge reconstruction and for providing information to future generations with and without requiring the involvement of intermediate generations.
 - Regulatory guidance and supervision should be developed to support the systemic approach to RK&M preservation.
- Synergies should be sought with societal institutions and international bodies and agreements that are likely to survive beyond the closure of the repository and can thus contribute to RK&M preservation.
 - Mechanisms outside radioactive waste management constitute an additional resource for waste management organizations and governments.
- A concerted approach at the international level will contribute to the further development of national strategies.

INTERNATIONAL MECHANISMS

The RK&M Glossary defines international mechanism as follows: "*A mechanism for RK&M preservation that has international influence, scope or support and is based on international cooperation. Commentary An international mechanism can be governmental (IGM) or non-governmental (INGM). An IGM consists of entities and activities that are based on mutual agreements between a number of national governments; an INGM consists of entities and activities that bring together non-governmental, private or commercial organisations.*"

In the course of the project, attention has been devoted to determining whether international mechanisms may help preserve RK&M in the short and medium-term. To this end, a few existing mechanisms have been identified and presentations were made during the course of the project, namely on the UNESCO Memory of the World Register and on the IAEA INIS base. A study was also compiled, on existing mechanisms which may be of interest for maintaining and developing oversight, and for keeping memory in the short and medium-term. The aim of this study was to identify key questions to be addressed for the elaboration of a mechanism dedicated to RK&M in the radioactive waste management (RWM) realm.

This analysis shows that international mechanisms can contribute significantly to the preservation of RK&M. In this context, it could be envisaged, starting from existing mechanisms, to develop dedicated mechanisms, referring to various themes connected to preservation of RK&M in RWM.

Summary of work

Considering the mediated transmission channel of the dual-track strategy, international mechanisms may be one of the levels, besides local and regional/national mechanisms.

During the course of the project, presentations were made on this theme, namely, on the UNESCO Memory of the World Register, on the IAEA INIS base, and on the Memory of Mankind project.

A commissioned study was also carried out aiming to investigate the organisation of existing international mechanisms in order to identify their possible utility for RK&M preservation in the short and medium-term for RWM. This review covered a set of international mechanisms in at least one of the following fields:

- Information and Heritage preservation (UNESCO World Heritage Convention, UNESCO Memory of the World Register, EC INSPIRE Directive on spatial information);
- Environment preservation (Espoo, Aarhus and OSPAR Conventions);
- Radioactive waste and materials management (mechanisms linked with IAEA, EC Directive on management of spent fuel and radioactive waste).

The mechanisms were reviewed according to the following analytical grid:

- Organisation of the international mechanism: (i) Type of mechanism and involved parties;(ii) Common goal and ethical charter; (iii) Financial mechanism and its sustainability; (iv) Multi-level responsibility and decision-making process
- Contribution of the international mechanism to: (i) Development and mobilisation of expertise; (ii) Local sustainable development; (iii) Organisation of oversight and knowledge preservation

A synthesis table was established, and further amended by the project group.

Project learning

The main conclusion from this work at this stage is to show the value of developing an international mechanism to cope with the specific issues of RK&M in RWM but in connection with existing international mechanisms.

This work shows also the importance of multilevel governance, at international, national and local level, and that involving the various stakeholders, beyond Member States, may play a key role in reaching the objectives of the mechanism. The establishment of advisory bodies, composed of networks of international experts, contributes to the development of expertise and its sustainability. The development of a database system in an international structure grouping different sources of information and aiming at disseminating the information through national centres would be also worth being investigated.

The commissioned study notices that most of the mechanisms encourage the development of an “active memory” registered in various records kept by various stakeholders at various levels. It concludes that international mechanisms can contribute significantly to the preservation of RK&M, and suggests identifying the necessary adaptation the existing mechanisms to cope with RK&M issues in RWM and to explore the conditions of implementation of an international mechanism in this domain (notably concerning the partnership, the funding, the development and mobilisation of expertise).

Avenues for further inquiry

- With a view to the medium and long term, continue the investigation of the potentialities of existing international mechanisms linked to RK&M preservation in RWM, in order to build a comprehensive set of relevant international mechanisms.
 - New ones vis-à-vis Phase-I have been identified already, for example the IAEA Net-Enabled Radioactive Waste Management Database (NEWMDB), the Hague Convention of 1954 for the Protection of Cultural Property in the Event of Armed Conflict, the Intangible Cultural Heritage Convention of 2003.
 - Renew contacts with the IAEA & EURATOM safeguards groups on memory aspects.

- Continue to identify and build relationships to other stakeholders that may have set up similar international mechanisms, e.g., companies that manage hazardous waste, seed banks, etc.
- Considering that the subject of RK&M for radioactive waste repositories in the short and medium-term consists of (i) emplacing radioactive waste packages and radioactive materials (ii) in a geological layer (iii) in order to protect mankind and the environment (iv) and preserve the related records, knowledge and memory, a systematic research of additional, relevant mechanisms that could be helpful will be based on four tracks:
 - Mechanisms devoted to controlling radioactive waste and materials circulation
 - Mechanisms devoted to sharing knowledge on geology
 - Mechanisms related to environment protection
 - Mechanisms related to cultural heritage preservation.
- Relevant mechanisms may be commercial or semi-commercial projects, not only institutional.
 - For example, referring to the second track above (geology), the Solution Mining Research Institute (SMRI). Established in 1958, the Solution Mining Research Institute (SMRI) is interested in the production of salt brine and the utilisation of the resulting caverns for the storage of oil, gas, chemicals, compressed air and waste; the solution mining of potash and soda ash are also of interest. SMRI is a non-profit, worldwide organisation with more than 150 member organisations in Asia, Australia, Europe, and North and South America.
 - Another example is the International Society for Photogrammetry and Remote Sensing (ISPRS), which is an international non-governmental organisation that enhances international cooperation between the organisations worldwide with interests in photogrammetry, remote sensing and spatial information sciences. Established in 1910, ISPRS is the oldest international umbrella organisation in the field of “information from imagery”.
- The analysis of the mechanisms will be deepened on the products and activities triggered by the mechanisms (cooperation, database, expertise...). Namely, attention will be devoted to identifying possibilities of cross reference or index used to locate information. The possibilities related to land registers could be investigated.

References

- Schneider, T., S. Andresz and C. Reaud (2013), “International mechanisms to support records, knowledge and memory (RK&M) preservation over the short and medium term”, May 2013, Ref. CEPN: NTE 13/01.
- OECD NEA (2012), “The Preservation of Records, Knowledge and Memory (RK&M) Across Generations: Improving Our Understanding - Workshop Proceedings, 12-13 September, Issy-les-Moulineaux, France”, NEA/RWM/R(2013)3.

MARKERS

Marking is a reoccurring topic in the discussions surrounding the long-term, geological disposal and RK&M. The RK&M project has held dedicated discussions during project meetings and workshops, and sponsored two studies on markers in the long-term context: a literature review¹⁹ and reflections on the role of traditional tsunami warning stones in Japan²⁰. This article summarises the Phase-I project work and learning in the area of markers.

Summary of work

What is a marker?

The RK&M project glossary defines a marker as "A long-lasting object that indicates an area of influence, power or danger. It is placed strategically at or near the site for immediate recognition or for discovery at a later time. *Commentary:* In the RK&M dual track strategy, a marker is an object meant to reach to future generations in the medium to long term. Any marker is conceived to be immobile (i.e., in permanent association with a site), robust, in order to maximize survivability on its own, and providing messages that are likely to be understandable across generations." A marking system can range from a simple stone to a contrived and monumental multi-component system²¹.

Regulation

At present, the use of markers is stipulated in legislation in Switzerland and in regulation in the United States. The Swiss Nuclear Energy Act of 21 March 2003 stipulates that a "repository be permanently marked"²². The American Code of Federal Regulations on passive institutional controls states that "Any compliance application shall include detailed descriptions of the measures that will be employed to preserve knowledge about the location, design, and contents of the disposal system. Such measures shall include: ... Identification of the controlled area by markers that have been designed and will be fabricated and emplaced to be as permanent as practicable ..."²³ So far, no other country requires the use of markers. Markers are mentioned in UK regulatory guidance – in connection with possible measures to avoid human intrusion. The text is as follows: "We recognise that it is not easy to judge the benefits of these measures

¹⁹Buser, M. (2013), "Literature Survey on Markers and Memory Preservation for Deep Geological Repositories", December 2013, <http://www.oecd-nea.org/rwm/docs/2013/rwm-r2013-5.pdf>.

²⁰OECD NEA (2014) "Markers – reflections on intergenerational warnings in the form of the Japanese tsunami stones" NEA/RWM/R(2014)4.

²¹Buser, M. (2013), "Literature Survey", p.31.

²²Swiss Nuclear Energy Act (NEA) of 21 March 2003, Art.40 § 7, available online at <http://www.admin.ch/ch/e/rs/7/732.1.en.pdf#page=17>.

²³US Code of Federal Regulations - CFR 40 § 194.43: Passive institutional controls, available online at <http://www.ecfr.gov/cgi-bin/text-idx?SID=b17711606a76b42aba69499af2505566&node=40:26.0.1.1.4.3.7.14&rgn=div8>.

[any practical measures that might reduce the likelihood of human intrusion] and that some measures, such as providing a marker at the surface, might have the opposite of the intended effect.²⁴

Marker materials

The integrity of markers depends on the durability of the medium in the environment where they are deployed, including for instance extreme events or acts of vandalism²⁵. With regard to materials, adaptation to the natural environment and / or the use of non-recyclable and non-reusable materials has been suggested²⁶. In line with historical markers in other fields (archaeological artefacts), a lot of focus has been dedicated to large surface markers in the form of monuments. However, a wealth of ideas, technologies and materials has been proposed for marking a repository, both on surface and sub-surface (e.g. berms, magnets, radar reflectors, small ceramic tokens, tracers, acoustic signals, marking of disposal shafts and waste containers, biological marking)²⁷. In addition to deliberately placed markers, the ‘archaeology of landscapes’ was also put forward throughout the RK&M project²⁸. Residual surface features such as bund walls built to preserve visual amenity, altered water courses or access routes for road and rail were noted to leave scars on the landscape representing visual clues to previous activity²⁹. It has also been suggested that geological disposals mark themselves by means of their content and/or artificial barrier materials, implying the possibility of a message based on radioactivity or on other physical properties of disposal components, e.g. gravitational magnetism³⁰. These ideas, however, lack endorsement by the project.

The role and functioning of markers

Project members agreed that, even if it is technically possible to find or manufacture marking materials with a very long lifetime, it is notably the passing of messages over long time scales that needs more and dedicated reflection. The Project literature review shows that much debate on markers took place in the 1980s in the USA, with more additional international literature in the 1990s. This historical literature typically describes a marker as a long-term, non-mediated means to deter human intrusion into geological repositories³¹. A reoccurring question, however, is whether, on the contrary, markers would not entice intrusion by arousing curiosity³². It is also possible that they would be removed or ignored.³³These

²⁴UK Environment Agency (2009), “Guidance on Requirements for Authorisation for disposal facilities for solid radioactive wastes”, online available at <http://www.environment-agency.gov.uk/business/sectors/99322.aspx> (see para. 6.3.42).

²⁵See, for instance, Buser, M. (2013), “Literature Survey”, pp. 19, 23, 28, 77 and OECD NEA (2014), “Markers – reflections on intergenerational warnings in the form of the Japanese tsunami stones”.

²⁶Buser, M. (2013) “Literature Survey”, p. 72ff.

²⁷Ibid., p. 52ff.

²⁸RK&M April 2013 Project Meeting Summary Record, p. 11, online available at <http://www.oecd-nea.org/rwm/rkm/documents/summary-record-rkm-2013-4.pdf>.

²⁹RK&M 2012 Workshop Proceedings, p. 98.

³⁰Ibid., pp. 44, 109.

³¹Buser, M. (2013) ‘Literature Survey’, pp. 20, 23, 28.

³²Ibid., pp. 32-35.

ambiguities have encouraged RK&M project members to also reflect on markers' medium-term functioning as part of a dual track strategy. Agreement exists that the conceptual and material work on markers needs to be embedded within a systemic approach whereby the various components of the RK&M system complement each other, provide for message redundancy, and maximize the survivability of a recognizable message Collective Statement. Such a systemic approach includes considering the international level to provide shared methods and meanings and creating socio-cultural links between the waste and the siting communities³⁴. Markers could play a role in creating such links, by integrating them in mediated, memory regenerative processes (e.g. education³⁵, “sacrificial layer” idea (Long Now Foundation paper), restricted land use functions³⁶, rituals³⁷, and/or by being conceived as mediated objects themselves, for instance by providing the opportunity for renewal and regeneration³⁸.

The messages of markers

One of the important principles of the RK&M project is that future generations have the right to be informed. The RK&M project thus supports the idea that markers, if used, should be part of a concerted effort to help preserve RK&M, rather than simply scare future generations. Depending on their material, structural design and intended time scope, the information markers are intended to carry can range from ‘this is man-made’ to much more elaborate messages in the context of a systemic approach.

Project learning

There are at present no straightforward, conclusive answers to the objectives, messages and methods of marking. It is acknowledged that even if markers remain intact and traceable over time, future neglect or misunderstanding of their message cannot be ruled out (e.g. drift in meaning due to cultural and aesthetic interpretations, or even of deliberate falsification of messages (Markers Literature Review, D2))³⁹. In any case it seems hardly possible to reach consistent responses before an overall systemic approach for RK&M preservation is formulated.

³³ OECD NEA (2014), “Markers – reflections on intergenerational warnings in the form of the Japanese tsunami stones”.

³⁴ OECD NEA (2011), “Preservation of Records, Knowledge and Memory across Generations. An International Project of the NEA/RWMC”, Collective statement, p. 1, online available at <http://www.oecd-nea.org/rwm/rkm/documents/rkm-collective-statement-en.pdf>

³⁵ OECD NEA (2014), “Markers – reflections on intergenerational warnings in the form of the Japanese tsunami stones”, NEA/RWM/R(2014)4.

³⁶ RK&M 2012 Workshop Proceedings, p. 63ff.

³⁷ Ibid., p. 75ff.

³⁸ Ibid., p. 26f.

³⁹ Buser, M. (2013) “Literature Survey”, p. 62f.

Avenues for further inquiry

- The topic was explored in Phase I and deserves further investigation.
- Important questions are:
 - Which role can markers play for RK&M preservation and on which time periods?
 - How can they be part of a systemic approach to RK&M preservation?
 - Is international standardisation of at least some types of markers a good idea?
 - Time capsules will be looked at as a type of markers having potential to carry information that goes beyond a simple concise message.

MONITORING AND RKM PRESERVATION

Disposal of long-lived radioactive waste in engineered facilities built in stable, deep geological formations is the reference means for permanently isolating the waste from the biosphere. Although this management method is conceived to be intrinsically safe and final, i.e., not depending on the presence and intervention of man for fulfilling its safety goal, there is no intention to forgo, at any time, knowledge and awareness either of the repository or of the waste that it contains. Preservation of RK&M is thus an essential part of future societal oversight of the repository. The concept of oversight provides a useful framework to view technical monitoring activities and societal engagement as parts of a unified whole. Monitoring serves the purpose of oversight and is part of the latter. The concept of oversight will be discussed in more detail in future versions of this strategic article.

Summary of work

Two studies on monitoring were completed in Phase-I: a technically oriented one entitled “Monitoring of Geological Disposal Facilities”⁴⁰ and a societal-oriented one entitled “Local communities’ expectations and demands on monitoring and the preservation of records, knowledge and memory of a deep geological repository”⁴¹.

What is monitoring?

The Cambridge English dictionary online⁴², defines monitoring as “to watch and check a situation carefully for a period of time in order to discover something about it”. For monitoring of deep geological repositories in the post-closure phase we can draw inspiration from currently closed near-surface disposal facility. In France, the arrangements, established in 2003, for the Centre de la Manche during the “surveillance” phase are as follows⁴³:

⁴⁰ Nachmiller, L. (2013) "Monitoring of Geological Disposal Facilities (Overview of the current status)", RK&M Workshop Proceedings, 12-13 September 2012, NEA RWM/R (2013)3, online available at <http://www.oecd-nea.org/rwm/reports/2013/rwm-r2013-3.pdf#page=28>.

⁴¹ RWMC (2014) "Local communities’ expectations and demands on monitoring and the preservation of records, knowledge and memory of a deep geological repository", NEA RWM/R (2013)4, 7 February 2014, online available at <https://www.oecd-nea.org/rwm/docs/2013/rwm-r2013-4.pdf>.

⁴² "monitor (verb)". Cambridge Dictionaries Online. 3 February 2014, online available at http://dictionary.cambridge.org/dictionary/british/monitor_5?q=monitoring.

⁴³ Décret n°2003-30 du 10 janvier 2003 autorisant l'Agence nationale pour la gestion des déchets radioactifs (ANDRA) à modifier, pour passage en phase de surveillance, le centre de stockage de déchets radioactifs de la Manche (installation nucléaire de base n° 66), situé sur le territoire de la commune de Digulleville (Manche), online available at <http://www.legifrance.gouv.fr/affichTexte.do?cidTexte=LEGITEXT000005633870&dateTexte=20081222>

- Monitoring of the facility and its environment, enforcement of land restriction and archiving is performed by the waste management agency (Andra) under the prescription of a monitoring plan (“plan de surveillance”) approved by the regulator.
 - Andra provides a yearly report on the application of the monitoring plan.
 - Every 10 years, Andra submits to the government an updated safety case and a new monitoring plan that may include less stringent monitoring conditions based on experience so far.
- The national regulator performs regular inspections and sampling.
- The Local Information Committee, which includes local representatives, elected officials and members of associations for the protection of the environment, performs independent investigations including monitoring of the environment.

Implementers, regulators, policy makers, local communities may thus be variously engaged in the monitoring activities that contribute to societal oversight of the facility. From this point of view, it is observed that monitoring serves the purpose of oversight and is part of oversight.

Project learning

Oversight can be exercised through monitoring of technical parameters and through technical analyses of those data; oversight can also be exercised through monitoring of institutional provisions meant to be protective of the repository, e.g., land withdrawal provisions established by law; additionally, oversight can also be exercised, in a broader sense, through monitoring agreements made with the local hosts.

The implementation of a disposal project is viewed as an incremental process, with different phases, in which there is a gradual transition between various forms of oversight during the pre-operational, operational and post-operational phases. Planning for oversight, both direct and indirect, and therefore also for monitoring, should start when the siting procedure begins. Although monitoring is understood, in technical circles, as referring to the collection of technical data, there may be parameters that are not strictly technical or that may be technical but the measurement of which is carried out by players other than the regulator or operator; all these parameters involve the provision of information and the keeping of it. In order to find an optimal oversight approach, it is important to harmonise social and technical demands from the beginning.

Avenues for further inquiry

- Case studies: US DOE-Legacy Management, Centre de la Manche, others. What is monitored, evolution of the allocation of responsibilities, role of monitoring in RK&M preservation.

REGULATION

The work done in the area of regulation during Phase I of the RK&M project is described as well as suggestions for further work in this area. The main output consisted of a catalogue of relevant legislative and regulatory requirements from NEA member countries, the EU and the IAEA. Other project documents also bear on regulatory aspects, such as the study on monitoring, the strategic article on the connection to safety, the study on records and memory loss in hazardous waste disposal etc. As a general rule, it may be observed that existing regulations in the area of RK&M preservation are to a significant extent focused on the very-short-term and short-term. There is currently no emergent trend to be seen in how to regulate, for the medium and the long-term, the preservation of RK&M for the final disposal of radioactive waste. At the same time, it has also been found that a frequent reason for loss of records and memory in the short-term could be attributed in part to insufficient regulation, inadequate enforcement, and attitudes.

Summary of work

The “regulatory” catalogue

A catalogue of legislation, regulation and regulatory guidance governing the preservation of RK&M for geological disposal in 12 NEA member states, the EU and the IAEA was prepared. Maintaining and updating the catalogue will be an ongoing task over the years. The catalogue is a factual collection of information, not a normative study. Because of the differences in legal structures and regulatory frameworks among countries, differences are not unexpected. Nonetheless, a most striking feature is the lack of similarity among both the terminology used and the actual requirements in the different countries, to the point that it is difficult to discern trends or perform a thematic analysis of the existing requirements. A few observations that can still be made, however, at a general level:

- All countries have some regulatory requirements for preservation of records, usually pertaining to records that contain information in support of licensing, and in particular information supporting safety analysis. These requirements are often specific for records that are required in the very-short-term in support of current licensing activities.
- In all countries, the safety analysis must demonstrate that long-term safety criteria will be met even if RK&M are not preserved. The requirement for preservation of records supporting safety analysis can, in this respect, be viewed as primarily a licensing requirement rather than a safety requirement.
- In many countries (including the IAEA requirements document for waste disposal SSR-5), the role of preservation and transmission of RK&M in the long-term is reflected, at least tacitly, in regulatory requirements for archiving of records as an additional element of safety assurance. Also, institutional presence and oversight in the medium-term is, however, often either implicitly or explicitly assumed, e.g. in assumptions regarding human intrusion.
- In countries where preservation of memory of the existence and location of a repository is explicitly reflected in legal requirements additional to the requirements for preservation of records, those memory-related requirements may range from general (e.g. the EU waste Directive’s requirement for national programmes to describe “the means to be employed to preserve knowledge of that facility in

the longer term”) to specific requirements for the establishment of protection zones (e.g. Finland, Switzerland, the US) or marker systems (e.g. Switzerland, the United States).

- Preservation of “knowledge” as the term is defined in the project’s glossary (i.e. the ability to understand and utilize records and information) is not addressed in legal or regulatory requirements.

Project learning

In general, regulations appear to concern themselves primarily with the period during which existing regulatory frameworks are expected to continue, i.e., up to the time of closure. The level of specificity and detail is greatest in regulations dealing with RK&M preservation in the very short and short terms, i.e. in support of current licensing needs. Transfer of responsibilities to other oversight bodies or agencies, if mentioned at all, is usually covered at a basic level only; for example, while many regulatory frameworks contain provisions to ensure the right of access of regulators to records, issues of transparency and the right of access to those records by subsequent oversight bodies are less often dealt with. An important result of the study on the key factors for loss of records, knowledge and memory is that the most important negative factors arise from the lack of human actions. In particular, if regulatory oversight is lacking or poorly carried out, there is a high likelihood of loss of records and memory. Institutional oversight and control is often divided among several institutions, and this is particularly likely to be the case in the long-term. Loss of records and memory often takes place during transitions of responsibility between organisations. In light of these findings, the anticipated future development and elaboration of regulatory requirements for the medium and long-term takes on added importance.

Avenues for further inquiry

- The role of regulators and other oversight bodies in ensuring that RK&M will be preserved for long periods of time needs to be better understood and discussed, especially in light of the recent (June 2013) release of the ICRP-122 guidance document and its recommendations regarding the need to maintain oversight a geological repository for as long as practicable.
 - The work on regulatory aspects should be undertaken in the first place by groups such as the RWMC’s Regulators’ Forum.
 - Since some of the issues related to preservation of RK&M in the long-term may transcend the typical boundaries of responsibility of present-day regulators, the roles of other policy-making national and local institutions merit further investigation.
- The RK&M project will liaise with regulators and ensure adequate representation of regulators in the discussions, and will address the implications for RK&M of factors such as sharing of responsibility among institutions and transfers of responsibility for oversight, e.g., at the time of closure.
 - It would be useful to study the question of how policy makers and regulators formulate and put in place requirements to ensure that applicants address medium and long-term preservation of RK&M in their repository projects and what role this has in the stepwise licensing process.
- It will be useful to investigate the potential role of international governmental mechanisms and their interactions with regulatory aspects of RK&M preservation.

TERMINOLOGY

The terminology used to address today’s concepts and activities may be understood in a different way when referring to the long term. Terms may convey multiple meanings and be used differently by both writers and readers. Defining terminology is thus essential when addressing RK&M preservation and the various timescales that are of interest. The RK&M glossary represents a peer-reviewed set of terms and definitions serving the purpose of achieving efficient communication on, and better understanding of, RK&M issues within and beyond the RK&M project. The glossary is being constantly updated and developed.

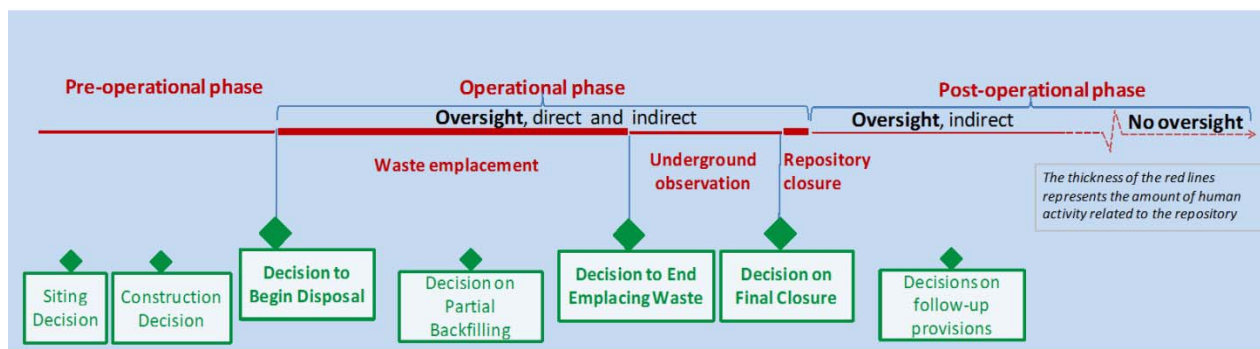
Summary of work

The RK&M glossary of key terms

The RK&M project has produced a glossary that defines important key terms and concepts used in the project. The glossary provides useful guidance on terminology in the area of RK&M preservation for geological disposal, including the pre- and, especially, post-closure phases of the repository. The glossary is being constantly updated and further developed by the project team and serves as a common reference in order to achieve clear and consistent communication within and outside the RK&M project and to help understand the key RK&M issues better.

Some of the terms in the glossary can be found used in other contexts and in international texts, but not necessarily in a consistent fashion across the literature. The RK&M glossary definitions are not meant to capture an apparent mainstream use of the terms. The definitions that are provided aim at addressing the key aspects of the respective concept in a clear, consistent and unambiguous manner. The guiding principles in preparing glossary entries are 1. usefulness within the wider RK&M preservation context, 2. understandability, 3. internal consistency with respect to other glossary entries, and 4. unambiguousness. Each definition should not be seen in isolation, but as complementary to the definition of other terms in the glossary.

Fig. 1: Repository life phases and examples of associated decisions



Project learning

Core terminology

Core terminology for the project includes the definitions of records, knowledge and memory, of the reference timescales for RK&M, and of the concepts of oversight and control. These definitions take into account the following aspects:

RK&M

Data–Information–Records–Knowledge–Memory constitute a hierarchical order in terms of what could be called “quality level of data processing”. The differences between these five terms are important and have implications for preservation issues. Data is preserved in a different way and over different timescales than, e.g., memory.

At the focal point of this group of key terms is “knowledge”. In everyday language, but also in some international texts, it has come to designate “what is known”. Therefore it is easily confused with other concepts, particularly with “information” or “memory”, as defined by the RK&M project (see analysis in [... link after WM14]). The glossary definition of knowledge — by being restrictive — removes the ambiguities while still being in general agreement with the common understanding of the term.

Reference Timescales

The reference timescales short, medium, and long term are linked to the following life phases of the repository, respectively: operational and pre-operational phase (short term); post-operational phase with indirect oversight (medium term) and post-operational phase without oversight (long term). It is certainly uncommon to call a time span of approximately 100 years the “short term”. However, in relative terms “short”, “medium” and “long term” is appropriate. Moreover, linking the reference timescale to the type of oversight that can be envisaged has considerable advantages:

- Strategies for RK&M preservation vary mainly according to the type of oversight conditions, and hence according to the reference timescale.
- The question of how long a type of oversight can reasonably be assumed (e.g., how long the medium term will last) is not of primary importance for setting up a strategic action plan for RK&M preservation.
- To prepare for a potential no-oversight period is stipulated in recent international recommendations by the ICRP. Again, the absolute number of years to prepare for (i.e. how long provisions for the long term make sense) is not of primary importance.
- Comparison with examples of record loss in the past can be made according to the relevant timescales even though the absolute number of years involved are different.

Control and Oversight

“Control” is a core concept in the international system of operational, radiological protection. It may refer to

- controlling the radioactive source (or some physical parameters influenced by the source) so that it does not disperse, or to
- controlling access to the radioactive source in order to prevent radiological exposure or as safeguard.

In all cases, essential to the operational concept of control, is the possibility to apply corrective actions. The word “control” is thus also strongly correlated to regulatory presence.

The use of the word “control” does not extend unambiguously to the periods of time when the repository is partially or totally closed and when the regulatory function is reduced or absent. Who or what is then the controller? Who takes what kind of corrective actions? This ambiguity is noted in an analysis of the use of the word “control” in international texts on repository performance [...link after WM14].

To resolve the ambiguity, the new ICRP recommendations⁴⁴ use two clearly defined concepts: “oversight” and “built-in control”. “Oversight” is a general term for “watchful care” and refers to society “keeping an eye” on the technical system and the actual implementation of plans and decisions. Oversight includes regulatory supervision, institutional control, preservation of records, and societal memory keeping of the presence of the facility. Oversight is always carried out by people and can have different levels of institutional involvement. “Built-in control” is the ensemble of functions by which the system, as built, reacts to external and internal solicitations and avoids or limits the dispersion of radioactivity. These two controlling functions can be present at the same time and are now clearly distinguished.

The RK&M glossary accepts the ICRP concepts and devises definitions of "control" and "oversight" that are consistent with each other. The given definition of "control" is fully applicable to

- "built-in control", which complements oversight,
- "regulatory control", which is a measure of (usually "direct") oversight, and to
- "institutional control", which is a measure of (usually "indirect") oversight.

Specifically, the RK&M glossary limits the use of the word “control” to indicate the function of controlling. Control, as a function, is always active – be it performed by people or inanimate objects, and the use of the adjectives "active" and "passive" in connection with control is not endorsed by the project.

⁴⁴ ICRP (2013), “Radiological protection in geological disposal of long-lived solid radioactive waste”, ICRP Publication 122.

Avenues for further inquiry

The glossary is an important component of the RK&M project. It will be further developed by adding new keywords as necessary and continuously scrutinizing the definitions in practice for their usefulness, understandability, consistency and unambiguousness.

- The existing definitions will continue to be refined.
- New definitions will be added as needed.