Radioactive Waste Management and Decommissioning
NEA/RWM/R(2023)3
June 2025
www.oecd-nea.org

Remembering the Past in the Future: Building Awareness of Radioactive Waste Repositories Together - Workshop Proceedings

Tabloo, Dessel, Belgium
22–24 November 2022

OECD
BETTER POLICIES FOR BETTER LIVES

NEA
NUCLEAR ENERGY AGENCY

Nuclear Energy Agency

NEA/RWM/R(2023)3

Unclassified **English text only**

17 June 2025

NUCLEAR ENERGY AGENCY

Radioactive Waste Management Committee

Remembering the Past in the Future: Building Awareness of Radioactive Waste Repositories Together

Workshop Proceedings

22-24 November 2022, Tabloo, Dessel, Belgium

This document is available in PDF format only.

JT03568273

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

The OECD is a unique forum where the governments of 38 democracies work together to address the economic, social and environmental challenges of globalisation. The OECD is also at the forefront of efforts to understand and to help governments respond to new developments and concerns, such as corporate governance, the information economy and the challenges of an ageing population. The Organisation provides a setting where governments can compare policy experiences, seek answers to common problems, identify good practice and work to co-ordinate domestic and international policies.

The OECD member countries are: Australia, Austria, Belgium, Canada, Chile, Colombia, Costa Rica, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Türkiye, the United Kingdom and the United States. The European Commission takes part in the work of the OECD.

OECD Publishing disseminates widely the results of the Organisation's statistics gathering and research on economic, social and environmental issues, as well as the conventions, guidelines and standards agreed by its members.

NUCLEAR ENERGY AGENCY

The OECD Nuclear Energy Agency (NEA) was established on 1 February 1958. Current NEA membership consists of 34 countries: Argentina, Australia, Austria, Belgium, Bulgaria, Canada, Czechia, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, Norway, Poland, Portugal, Romania, Russia (suspended), the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Türkiye, the United Kingdom and the United States. The European Commission and the International Atomic Energy Agency also take part in the work of the Agency.

The mission of the NEA is:

- to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes;
- to provide authoritative assessments and to forge common understandings on key issues, as input to government decisions on nuclear energy policy and to broader OECD policy analyses in areas such as energy and sustainable development.

Specific areas of competence of the NEA include the safety and regulation of nuclear activities, radioactive waste management and decommissioning, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information. The NEA Data Bank provides nuclear data and computer program services for participating countries.

Foreword and acknowledgements

The workshop "Remembering the past in the future: Building awareness of radioactive waste repositories together" was hosted at the Tabloo Visitor Centre in Dessel, Belgium. The Nuclear Energy Agency (NEA) expresses its gratitude to the host, the NEA Expert Group on Awareness Preservation (EGAP) members, and the local stakeholders of Mol and Dessel for their participation and contributions.

This summary report was drafted by Meritxell Martell (Merience, Spain) with the support of Yuko Maehashi (NEA) and Morgan Packer (NEA). It has been reviewed and approved by the members of the Programme Committee. The report was approved by the NEA Radioactive Waste Management Committee on 8 April 2024.

The NEA Secretariat and EGAP Chair thank all the presenters and participants of the workshop, as well as all members of the Programme Committee, for their work in planning and delivering a successful workshop.

Table of contents

Table of abbreviations and acronyms **5**
Executive summary **7**
Background **8**
Scope and workshop objectives **9**
Organisation and final programme **10**
Introduction **11**
Opening remarks **12**
Introductory session: Where do we stand? **13**
Session 1. Awareness preservation processes at nuclear heritage sites **18**
Session 2: Existing regulatory approaches in awareness preservation and key challenges **24**
Session 3. Approaches for an unknown future **29**
Session 4: Conceptualising remembrance across generations **36**
Next steps for awareness preservation – Nuclear message **40**
Next steps for awareness preservation – A roundtable discussion **41**
Conclusions and ways forward **44**
References **45**
Agenda of the workshop **46**

Table of abbreviations and acronyms

ANDRA	National Agency for Radioactive Waste Management (France)
ASN	Nuclear Safety Authority (France)
BASE	Federal Office for the Safety of Nuclear Waste Management (Germany)
BEIS	Department of Business, Energy and Industrial Strategy (United Kingdom)
BFI	British Film Institute
BGE	Federal Company for Radioactive Waste Disposal (Germany)
BMU	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Germany)
CEO	Chief Executive Officer
DGR	Deep geological repository
DiP	Decision in Principle
EGAP	Expert Group on Awareness Preservation (NEA)
ENSI	Swiss Federal Nuclear Safety Inspectorate
EPA	Environmental Protection Agency (United States)
EU / EC	European Union / European Commission
EURAD	European Joint Programme on Radioactive Waste Management
FANC	Federal Agency for Nuclear Control (Belgium)
FEPs	Features, events and processes
FSC	Forum on Stakeholder Confidence
HLW	High-level radioactive waste
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiation Protection
IDKM	Information, Data and Knowledge Management
IGD-TP	Implementing Geological Disposal Technology Platform
KIF	Key information file
KYT	National Nuclear Waste Management Programme in Finland
LEED	Leadership in Energy and Environmental Design
LILW	Low- and intermediate-level waste
LLW	Low-level radioactive waste
LTS&M	Long-term surveillance and maintenance
MEAE	Ministry of Economic Affairs and Employment (Finland)
NAGRA	National Co-operative for the Disposal of Radioactive Waste (Switzerland)
NDA	Nuclear Decommissioning Authority (United Kingdom)
NEA	Nuclear Energy Agency
NGO	Non-governmental organisations
NRC	Nuclear Regulatory Commission (United States)
NUMO	Nuclear Waste Management Organization (Japan)
ONDRAF/NIRAS	Belgian Agency for Radioactive Waste and Enriched Fissile Materials
POSIVA	Radioactive Waste Management company (Finland)
PURAM	Public Limited Company for Radioactive Waste Management (Hungary)
Q&A	Questions and answers
R&D	Research and development

RK&M	Records, knowledge and memory
R&R	Reversibility and retrievability
RW	Radioactive waste
RWM	Radioactive waste management
RWMC	Radioactive Waste Management Committee (NEA)
RWMD	Radioactive Waste Management and Decommissioning
RWM Ltd	Radioactive Waste Management Limited (United Kingdom)
SER	Set of essential records
SFOE	Swiss Federal Office of Energy
SITEX	Sustainable network of Independent Technical Expertise of radioactive waste disposal
STUK	Radiation and Nuclear Safety Authority (Finland)
SÚJB	State Office for Nuclear Safety (Czechia)
SÚRAO	Radioactive Waste Management Agency (Czechia)
TSO	Technical support organisation
UK	United Kingdom
URL	Underground Research Laboratory
US	United States
US DOE	United States Department of Energy
VHS	Video home system
VR	Virtual reality
VTT	VTT Technical Research Centre of Finland Ltd
WG	Working Group
WIPP	Waste Isolation Pilot Plant (United States)

Executive summary

Rebecca Tadesse, Head of the Division of Radioactive Waste Management and Decommissioning (RWMD) at the Nuclear Energy Agency (NEA) and Martin Kunze, NEA Expert Group on Awareness Preservation (EGAP) Chair, opened the workshop by underlining the importance of memory preservation and the work undertaken by the NEA over the last decade on this subject.

In the introductory session, different initiatives and organisations were presented, including the NEA Forum on Stakeholder Confidence (FSC), the International Atomic Energy Agency (IAEA), the Belgian partnerships MONA and STORA, the RK&M Initiative and the European Joint Programme on Radioactive Waste Management (EURAD).

Session 1 focused on awareness preservation processes at nuclear heritage sites. Contributions from Belgium, Japan, the United Kingdom, and the United States were presented. The keynote session was given by Professor Rosemary A. Joyce from the University of California on humanising how we think about persistent materials.

Session 2 brought further existing regulatory approaches in awareness preservation and key challenges. This session contained contributions from Finland, France, Sweden and Switzerland.

Session 3 suggested approaches towards the unknown future, with examples such as sound mapping and the nuclear archive, markers, a magazine for the future, radioactive heritage objects, the Memory of Mankind project, and the role of art.

Session 4 focused on conceptualising remembrance across generations. It included reflections from academics on remembrance, on history versus heritage, the history of scientific prediction, and future literacy.

The last session started with a presentation on the nuclear message by Martin Kunze, and was followed by group discussions on key topics related to awareness preservation on radioactive waste management (RWM): why preserve, what to preserve, who should be involved, where should preservation take place, how should we preserve, and what are the crucial next steps.

Background

The NEA Expert Group on Awareness Preservation (EGAP) focusses on how knowledge in regard to managing high-level radioactive waste could be passed on to future generations. EGAP is also working on new concepts and alternative approaches for a comprehensive strategy on awareness preservation. Progress towards viable and shared records, knowledge and memory (RK&M)/awareness preservation strategies have been documented in the final report of the NEA initiative on the *Preservation of Records, Knowledge and Memory Across Generations* (NEA, 2019), where a number of tools and techniques are presented as the "RK&M toolbox".

In order to disseminate and discuss preliminary results, receive feedback and broaden the discussion to include various stakeholders, EGAP organised the workshop entitled "Remembering the past in the future: Building awareness of radioactive waste repositories together" from 22-24 November 2022. This workshop was held in Tabloo, a multifunctional visitor centre developed near the site of a future radioactive waste disposal facility for low- and intermediate-level short-lived waste, in Dessel, Belgium. Tabloo was developed in close collaboration between the Belgian National Agency for Radioactive Waste and Enriched Fissile Material (ONDRAF/NIRAS) and local community partnerships – serving as a concrete example of a local approach to awareness preservation of a nuclear repository.

This document summarises the main issues presented and discussed in each of the workshop sessions. It does not compile every detail in each presentation, but focusses on the main points addressed by each presenter and subsequent discussions.

Scope and workshop objectives

Workshop objectives included:

1. Sharing perspectives: Present concrete outcomes of EGAP work from 2020-2022 and solicit input from various stakeholders to receive feedback, to broaden the discussion and to be taken into account in the present report.
2. Fostering a community of practice: Invite abstracts for appropriate session topics (not limited to nuclear instances) from stakeholders/participants in order to gather diverse perspectives and demonstrate a community of practice.
3. Contributing to awareness preservation by disseminating seeds of awareness within society: Namely, provide participants with a flyer/pamphlet to take away from the workshop.

Organisation and final programme

The Programme Committee was comprised of the following individuals:

- Ayako ARAKI (NUMO, Japan)
- Anna BERGSTEN (Osthammar, Sweden)
- Jean-Noël DUMONT (Andra, France)
- Robbe GEYSMANS (SCK CEN, Belgium)
- Gabriella HONTI (PURAM, Hungary)
- Stephan HOTZEL (BASE, Germany)
- Martin KUNZE (Memory of Mankind, Austria)
- Pascale KÜNZI (SFOE, Switzerland)
- Yuko MAEHASHI (NEA)
- Benjamin OFFEN (BASE, Germany)
- Morgan PACKER (NEA)

The final programme was split into four sessions, an introductory session and a final roundtable discussion, covering:

- Introductory session: Where do we stand?
- Session 1: Awareness preservation processes at nuclear heritage sites.
- Session 2: Existing regulatory approaches in awareness preservation and key challenges.
- Session 3: Approaches for an unknown future.
- Session 4: Conceptualising remembrance across generations.
- Discussion session: Next steps for awareness preservation.

A visit to the HADES Underground Research Laboratory (URL) took place on 24 November 2022. HADES is the oldest underground laboratory in Europe, located in boom clay at a depth of 225 metres. The HADES URL plays a central role in research on the safety and feasibility of geological disposal of radioactive waste, with experts using it to develop and test industrial technologies for building, operating and closing a waste repository in deep clay.

Introduction

The workshop "Remembering the past in the future: Building awareness of radioactive waste repositories together" was held in Dessel, Belgium, on 22-24 November 2022. Approximately 85 experts attended, with representatives from 16 member countries (Australia, Austria, Belgium, Denmark, Finland, France, Germany, Japan, Lithuania, the Netherlands, Poland, Spain, Sweden, Switzerland, the United Kingdom and the United States) and the International Atomic Energy Agency (IAEA).

Work performed by EGAP from 2020 to 2022, combined with abstracts submitted from stakeholders from different perspectives beyond the nuclear field, gave rise to an outline programme for the workshop (see Annex I). Four broad topics were identified as being of particular interest to the emerging community of practice, warranting further discussion at the workshop. These topics were:

- Awareness preservation processes at nuclear heritage sites.
- Existing regulatory approaches in awareness preservation and key challenges.
- Approaches for an unknown future.
- Conceptualising remembrance across generations.

The workshop followed up on these key issues through presentations and moderated discussions, devoting one session to each of the four topics. In addition, the workshop began with an introductory session on the question "Where do we stand?", which brought forward a number of national and international initiatives on engagement and for memory preservation.

Throughout the workshop, two artists were featured in a temporary exhibition at Tabloo. Cécile Massart exhibited a series of photographs and a compilation of drawings created during her travels to radioactive waste management sites throughout the world, presenting the "(un)consciousness" of the landscape to the public. Daniel Beck presented audiovisual tools and sound recordings as part of his research to discover how the interplay of sound and naturally occurring environmental effects such as temperature, humidity and radioactivity can influence our understanding of "place" within the natural environment.

The workshop concluded with a session using discussion groups to consider the next steps for awareness preservation.

Opening remarks

Rebecca Tadesse, Head of the Division Radioactive Waste Management and Decommissioning at the Nuclear Energy Agency (NEA), and Martin Kunze, Chair of the NEA Expert Group on Awareness Preservation (EGAP) and founder of Memory of Mankind in Austria, provided opening remarks and highlighted the participation of Tabloo, MONA and STORA, SCK CEN Master of Ceremonies Robbe Geysmans, the EGAP Programme Committee, NEA staff and invited speakers. EGAP's current mandate is to build a platform for knowledge exchange and to engage relevant stakeholders into the process. In this regard, the Forum on Stakeholder Confidence (FSC) provides an ideal setting for direct stakeholder exchange to build confidence in RWM facilities.

Introductory session: Where do we stand?

During the workshop's introductory session, about the "state of the art" in international thinking, concepts and guidelines on the preservation of awareness of nuclear repositories provided an overview of the results of the NEA RK&M Initiative. Complementary keynotes from the FSC, the IAEA, local partnerships in Dessel and Mol, and the EURAD project were presented to cover perspectives that contribute to a holistic view of RK&M and awareness preservation, and the participatory processes involved.

Building bridges between the Forum on Stakeholder Confidence (FSC) and EGAP

Pascale Künzi, Specialist for Stakeholder Involvement, Swiss Federal Office of Energy (SFOE), Switzerland

The FSC was established in 2000 to facilitate an open dialogue among member countries in order to analyse, document and develop recommendations for stakeholder involvement in developing and implementing RWM programmes. Currently, the FSC consists of 80 members from 21 countries and includes government policy officials, regulatory officials, implementers, R&D specialists, industry representatives and the IAEA. The FSC organises annual plenary meetings, national workshops, joint events with other NEA working groups (WG), webinars on topics that are of interest for the members and publications, and participates in different conferences and workshops.

One of the crucial topics of the FSC and EGAP is youth involvement in RWM programmes. Involving younger generations is key to awareness preservation. The FSC members recognise the need to build bridges to the future from the past, preserving awareness of RWM sites. As the competent working group at NEA to involve stakeholders in dialogue on RWM, the FSC can greatly contribute to awareness preservation.

Communication and stakeholder engagement for radioactive waste disposal: IAEA approach

Irena Chatzis, Communication Officer, Department of Nuclear Energy, International Atomic Energy Agency

Public perceptions and concerns about RWM remain one of the most influential factors for the public acceptance of nuclear power. Hence, understanding stakeholders' opinions, awareness and knowledge regarding radioactive waste and its management and, in particular, waste disposal, as well as addressing their concerns, is crucial for decision making and for the success of a nuclear power programme. Stakeholder engagement aims to address the views and concerns of stakeholders, develop understanding between stakeholders, enhance understanding of the decisions taken, develop mutual trust and, ultimately, strengthen civil society. Stakeholder engagement is beneficial to reaching better-informed, sound and widely-accepted decisions and to build confidence in the decision-making process. However, there are different methods and levels of stakeholder engagement and no one size fits all.

The definition of stakeholder is anyone who has an interest in, or is affected by, a given issue or decision. Consequently, the list of stakeholders in nuclear projects is long and changes as priorities evolve over time; hence, communication plans need to change and adjust accordingly. The young generation is important, especially given the long-time scales of the projects.

The principles of stakeholder engagement include:

- building trust;
- demonstrating accountability, openness and transparency;
- practicing early and frequent communication;
- communicating about both benefits and risks.

The IAEA has developed a comprehensive programme to build capacity in member states to plan, design and implement stakeholder engagement activities. This programme includes communication and stakeholder engagement for new and expanding nuclear programmes but also other aspects of the nuclear fuel cycle, including uranium mining and radioactive waste repositories. Overall, the IAEA offers a wide range of products and services to support member states throughout the life cycle of all nuclear facilities, such as publications, training courses and workshops, the nuclear communicator's toolbox, the radiation safety navigator, expert missions, webinar series and technical meetings. The IAEA will organise in 2025 its first International Conference on Stakeholder Engagement for Nuclear Power Programmes and plans to launch a Stakeholder Engagement Advisory Service in the near future.

Belgian partnerships: Aspects of living memory

Kris van Dijck, Member of Parliament, Mayor of Dessel and Chair of STORA partnership

Mark Loos, member of MONA, member of Preservation of Memory Working Group of ONDRAF

Dessel and Mol are two small communities in Belgium with 10 000 and 30 000 inhabitants, respectively, in a highly densely populated area with a tradition of hosting nuclear activities. In the beginning of 2000, the radioactive waste management agency ONDRAF/NIRAS launched an active participative process with the local communities to develop a safe, technologically feasible and socially acceptable option for a surface disposal facility for short-lived low and intermediate level radioactive waste. For this, the local partnerships of STORA in Dessel and MONA in Mol were set up as formal agreements between the parties, with a management board and several working groups dealing with the different aspects of the project. The partnerships STORA in Dessel and MONA in Mol developed an integrated disposal project for low and intermediate short-lived radioactive waste based on a voluntary basis. The essence of ONDRAF/NIRAS approach with the partnerships is collective design and collective realisation.

STORA and MONA assessed the technical and social feasibility of the project proposed by the radioactive waste management agency ONDRAF/NIRAS. The partnerships and their community councils agreed on a number of socio-economic conditions upon accepting the presence of a repository in their community, including:

- the technical concept of low- and intermediate-level short-lived waste (category A waste) had to be developed in co-design;
- the local conditions for the acceptability of such storage and disposal site were safety first as well as:
    - developing Tabloo as a communication centre but also a community centre, a house for local people;
    - a local fund for community projects for Dessel and Mol;

- continued participation of partnerships in the process;
- LIBRA collaboration with schools and universities;
- health monitoring projects (3xG) to follow up the local pollution and the local health situation;
- biomonitoring from 0 to 18 years, measuring the level of pollutants in children's bodies;
- optimising nuclear emergency planning;
- nuclear know-how and employment, beyond waste disposal;
- protection of the environment, the fauna and flora in the vicinity of the storage site and improving the ecological value of the site.

These Belgian partnerships promote the creation of long-lasting added values for people over 300 years, as long as waste remains active. In almost every one of the conditions listed above, there is an aspect of living memory inherently present. For instance, Tabloo involves an ongoing commitment to communicate transparently about RWM. In Esperanto, the word Tabloo means table, which symbolises that the structure of the table will stay as a landmark in the area, once the role assigned to the visitor centre is no longer necessary. This will enhance the memory of the site.

One of the current challenges for the partnerships is to involve young people from the Dessel and Mol region more actively in the sustainable management of RW. Within the partnership there is a temporary working group (WG) which has developed the project "Reporters of tomorrow" with primary school students to imagine the future landmark and try to transmit the history to future generations.

Results of the NEA RK&M Initiative (2011-2019)

Stephan Hotzel, Scientific Officer, Federal Office for the Safety of Nuclear Waste Management (BASE)

The NEA RK&M Initiative was launched by the RWMC in 2011 and involved 21 participating organisations from 14 countries until 2018. The scope of the RK&M Initiative is encapsulated in how, through RK&M preservation, it may be possible to reduce the likelihood of inadvertent human intrusion, and to support the capacities of future members of society to make their own informed decisions long after repository closure. The RK&M Initiative aimed to develop a theoretically founded broad based understanding of awareness preservation. The project created a practice-oriented toolbox of concrete RK&M preservation methods. The toolbox consists of a set of 9 approaches, comprised of a set of 35 mechanisms. Two of these mechanisms are novel concepts: 1) the key information file (KIF), designed to be a summary file (about 40 pages) for wide dissemination and use; and 2) the set of essential records (SER), which consists of a dedicated set of records, with the selection based on anticipated future needs.

The RK&M bibliography (NEA, 2018) showed that "communicating with the future" in the context of radioactive waste management became of interest starting in the 1970s. At that time, the three most popular themes were: the Atomic Priesthood project; Ray Cats and the Landscape of Thorns. The rationale changed over time from dictating the future to informing future generations. The question was "How can we remember across generations where, why and how RW is disposed of?"

The concept of oversight was brought by the NEA to the International Commission on Radiation Protection (ICRP) during the Reversibility & Retrievability (R&R) project. In its

international guidance on radiological protection in geological disposal of RW, the ICRP (2013) put forward the concept of oversight as "watchful care" of the repository, which means, society keeping an eye on the technical system, plans and decisions. The ICRP differentiates between direct, indirect and no oversight, which is linked to direct or indirect or no control of the source by humans from the radiological protection philosophy. Although there is no plan to lose oversight, planning must be made for potential loss.

The concept of timescales in the RK&M Initiative includes:

- Short term: starts now up to repository closure (around 100 years).
- Medium term: after closure, when oversight is exercised, around 1 000 years and as long as memory is still alive.
- Long term: after oversight is lost (up to time of concern in safety regulations). The long term is the real challenge as it takes place without intermediaries.

The current bibliography is mostly focused on the short or very long term, but there are few references to the medium term. The goal of the RK&M Initiative was to close this gap and investigate intermediate timescales, as they are crucial for awareness preservation and passing information from generation to generation.

The fundamental rationale for motivating preservation across generations (ethical principles) include:

- protection of humans and the environment to prevent inadvertent intrusion by future generations;
- preservation of conditions for informed decision making to enable future generations to make informed decisions about a repository.

Both the ICRP and RWMC endorse these principles. However, the whole RW community may not fully share these principles, since two counter-arguments are frequently raised: forgetting would be good for safety, and unlimited RK&M preservation would make RWM unsustainable.

It is important to highlight that RK&M preservation indeed supports passively safe disposal and does *not* jeopardise safety or the sustainability principle: firstly, "remembering to forget" is impossible as forgetting cannot be imposed and it would not solve the problem of the possibility of inadvertent intrusion; and secondly, "*no* burden on future generations" is an impossible demand as future generations will live with the RW produced anyway. No *undue* burden is the aim of responsible RWM, and RK&M preservation is one of the means to achieve just that.

The RK&M Initiative concluded that there is no single mechanism or technique that, by itself, is likely to achieve the preservation of RK&M over all timescales. Rather, an integrated set of technical, administrative and societal mechanisms is needed, using both mediated and non-mediated transmission. This integrated approach increases the survivability of a recognisable message. The toolbox of 35 RK&M preservation mechanisms presented in the RK&M Initiative's final report (NEA, 2019) can be used as a starting point. The latter report constitutes a general guide to the RK&M preservation topic. It provides the basis for necessary discussions and eventual decisions on the implementation of RK&M preservation strategies in a national context.

Knowledge management in European Joint Programme – EURAD

Niels Belmans, EURAD representative and SCK CEN Academy Project leader, Belgian Nuclear Research Centre (SCK CEN), Belgium

The European Joint Programme on Radioactive Waste Management EURAD[1] aims to achieve a step change in European collaboration towards safe RWM. As part of this step change, EURAD has developed a sustainable knowledge management programme which consists of five parts:

- A roadmap is constructed as a framework to structure knowledge. It follows a timeline with all steps to construct a repository until post-closure: initiation, site selection, site characterisation, construction, operation and closure. In order to navigate with the knowledge, different levels of knowledge and technical aspects have been defined depending on the step.
- State of knowledge includes the expert's views on the most relevant knowledge and associated uncertainties in a specific domain applied in the context of the RWM programme. For this, the EURAD Wiki is created.
- Guidance on best practice and lessons learnt provides orientation in the field, existing knowledge resources as well as existing international co-operation and networking.
- Training and mobility are possible through the school of RWM, which co-ordinates all activities, based on the needs of end users (i.e. professionals, students and next generation of experts). There is also a training portfolio linked to the EURAD roadmap.
- Networking and tools are available to connect people to other people, and people to content. For the PhD community, the tools available include a discussion forum, a list of events, an overview of PhD research performed, mobility actions available and upcoming courses.

The training courses are, as far as possible, organised in collaboration with existing networks and organisations (e.g. IGD-TP, SITEX, IAEA) to avoid duplication and be complementary to the ongoing programmes.

Questions and answers

This questions and answers (Q&A) session explored ideas on how to approach the young generation in practice. For the NEA, the involvement of youth is an important topic. The task group within the FSC on youth involvement published a flyer on this topic entitled "Intergenerational connection in radioactive waste management: Involving children and youth" (NEA, 2022). Young people also participated at the national workshop in Switzerland in 2016 and in Belgium in 2022. Similarly, at the IAEA, the youth are invited to participate in each of the conferences to give them visibility. Contests are organised, for instance, on how young people imagine nuclear power in the future. Connecting nuclear energy to broader topics of energy production and climate change might facilitate youth involvement. In the case of the partnership STORA in Dessel, youth organisations have a seat and a vote as part of the three represented segments of society (i.e. politicians, economics and cultural-social organisations).

[1] Further information on https://www.ejp-eurad.eu/ (last accessed 2 May 2023).

Session 1. Awareness preservation processes at nuclear heritage sites

The nuclear field has created and continues to create tangible and intangible legacies for current and future generations. Radioactive waste, decommissioned nuclear sites, nuclear accidents, and cultural artefacts are some of the examples in which nuclear energy might continue to have an impact on the future. An important issue in this context is whether and how awareness should be preserved on such legacies. This session explored awareness preservation processes in the context of different nuclear heritage projects and sites. Presentations focused on the following questions:

- What awareness preservation approaches have been used in specific nuclear contexts? With which objective(s)?
- What are potential benefits or pitfalls of certain awareness preservation approaches?
- Which assumptions on future use(s) are reflected in different preservation approaches?
- How are nuclear activities framed in/through awareness preservation, and which elements might (un)intentionally be omitted?

Benjamin Offen, Chair of Session 1, provided an introduction to the session and explained how awareness and memory preservation could be done with stakeholders and the local community.

Japanese memorial awareness and efforts for the future

Ayako Araki, Nuclear Waste Management Organization of Japan (NUMO), Japan

The Fukushima Daichii accident provided the following lessons post-tsunami:

- Tsunami stones tell important lessons from the past, such as: “when an earthquake occurs, run away to a higher place”.
- It is important to know the existence of, and learn lessons from, monuments for future generations. A stone monument established 100 years ago was useful to prevent damage in Iwate prefecture in Northeast Japan.
- A new map symbol is needed to contain easy-to-follow instructions. In addition, guiding visits to stone monuments and gaining access to information about past disasters is crucial. Local governments should engage further in these efforts.
- There are several memorial parks along the coast. In the Fukushima memorial park, there is a viewpoint indicating the height of the tsunami (16.5 m).
- Storytellers are memory keepers. For instance, the survivors of Hiroshima share their experience for a peaceful world.

The examples of awareness preservation above show it might be possible to forget something and that it is necessary to find ways to remember in daily life (for instance, monuments may be places to pray, gather, relax, clean, etc.).

Archives and artefacts: Long-term preservation at the Nuclear Decommissioning Authority

Michelle Donoghue, Information governance manager, NDA, United Kingdom

NDA Archive Limited, one of subsidiaries of NDA in charge of archives, was established to properly manage the NDA records. The NDA Heritage Strategy allows the organisation to work closely with a broad range of stakeholders to decide what tangible artefacts and assets are of value to the communities and how to share them now and in the future.

Nucleus, the nuclear archive in Scotland, opened in 2017 and is managed through a commercial partner agreement. It has been developed as a site of living archiving to manage records related to geological disposal and low-level radioactive waste disposal. The location in a small town of 7 000 inhabitants close to the Dounreay nuclear power plant is key for social economic purposes. The work is carried out in partnership with the community. The challenge is to balance community access and maintaining security and top-secret information. The "hub and spokes model", based on a centralised inventory and management with dispersed and offsite storage, is used to make sure the records are kept in appropriate places. The challenges are diverse and include decisions on what is of value, how to make things available when required, and questions of capacity, longevity and how to keep the full context of a record.

Tabloo – A unique visitor and meeting centre in the Campine

Anne-Lize Kochuyt, coordinator, Tabloo Visitor Centre, Belgian National Agency for Radioactive Waste (ONDAF/NIRAS), Belgium

The saying by Mahatma Gandhi "whatever you do for me, but without me, you do against me" is illustrative of the importance of working in partnerships to deliver results, such as at Tabloo. Tabloo opened in March 2022 and is the result of a long and prosperous participative journey that ONDRAF/NIRAS took in partnership with the local community.

Tabloo is based on four pillars:

- A unique theme: RWM.
- Being a place of memory of the disposal site that will be next to Tabloo.
- Being an immersive experience to explore and discover.
- Being a destination not only as a science centre as the centre for the small community of Dessel (10 000 inhabitants). Tabloo is part of the community and inhabitants visit it.

Tabloo was co-designed as a communication centre in partnership between STORA and MONA and ONDRAF/NIRAS. A working group was formed, with experts and local residents working on different themes for a period of 7 years, starting in 2014. During that time, contact with the local community continued and inhabitants could provide feedback to the working group. Different communication and exhibition centres in Belgium and abroad were visited to generate ideas.

The co-design was the result of a participation consisting of four steps: 1. Conversation (without convention); 2. Discussion (two parties have opinions but also potentially disagreements); 3. Dialogue (parties are on equal footing, listen to others, research the proposals of the other party), 4. Dream dialogue (creativity-flow, work on a new idea, with

the group being more important than the individual). This last stage is the goal to achieve, because the concept is built and supported by every party.

In addition to four permanent thematic exhibitions, Tabloo features temporary exhibitions related to radioactivity in combination with local partners. At present, there are three projects of living memory that aim to maintain support for local residents, retain knowledge of the repository and remember the landscape. These projects are:

- A temporary exhibition on changing landscapes with paintings by Jacob Smits (1855-1928) in contact with a contemporary artist working with the landscape.
- "Musica", a five-year art experience project with and for the local residents. Local residents participate in a workshop in which they seek to outline a project guided by an expert in music and sound art. Every year four projects will be elaborated and at least one of these will be taken to the visitor centre.
- "Reporters of tomorrow", an educational project organised with primary school students (11-12 years old). The students talk to their grandparents and ask for a story that is worth remembering. All these stories are then gathered in Tabloo.

Evolution of community engagement leads to provision of public services at the remediated Fernald Preserve, Ohio (United States)

Brian Zimmerman, Site Manager, Office of Legacy Management, Department of Energy (DOE), United States

The DOE Office of Legacy Management provides a consistent framework for managing sites once remediation is completed by the Office of Environmental Management, Nuclear Regulatory Commission (NRC) or US Army Corps of Engineers. Legacy Management stewardship responsibilities include:

- long-term surveillance and maintenance (LTS&M);
- continued operation and remediation of groundwater treatment systems;
- preservation, protection and sharing of records and information;
- management of natural and historic assets and striving for beneficial reuse of the sites;
- engagement and consultation with the public, governments, including tribal nations and other interested parties;
- use of science and technology to make LTS&M more effective and efficient and further reduce risks.

Legacy Management currently has 101 sites. One of these sites is the Fernald Preserve located in Southwest Ohio. It was once a farmland that was turned into a Feed Material Production Center that operated secretively to produce high purity uranium metal for the Atomic Energy Commission. It had 3 000 employees which produced 250 000 US tons (227 000 tonnes) of uranium metal for weapons complex from 1951-1989. During the 1980s, contamination became evident and the DOE recognised the benefits of a remediation project if stakeholder groups reached consensus on cleanup levels, waste disposition and remediation methods, as well as future land use.

The Fernald citizens advisory board was established in 1997 (previously called Fernald Citizens Task Force from 1993 to 1997) representing a broad spectrum of interests and backgrounds from the entire regional community. The group used impartial facilitators and

had the mission to give the public a role in decision making. This advisory board held more than 60 meetings per year between 1994 and 1998.

The site was later renamed the Fernald Environmental Management Project. Stakeholders agreed on the need for an onsite disposal facility and agreed that the end state would be an undeveloped park with emphasis on wildlife (industrial and/or commercial use). The Fernald citizens advisory board agreed on the need to construct an onsite disposal facility which yielded an estimated USD 2 billion in cost savings by only transferring 15% of waste to offsite disposal locations while keeping 85% of soil/debris onsite at the disposal facility. Remediation was completed in 2006 and the Fernald Preserve opened to the public in 2008 as an undeveloped park with an emphasis on wildlife.

The Fernald Preserve strives to be a community asset. It is open to the public and has 11 km of hiking trails. There are restrictions on ground water and land use. An old warehouse was repurposed into a 10 000 square foot platinum-certified US Green Building Council Leadership in Energy and Environmental Design (LEED certified) visitors centre with a community room free of cost for nonprofit groups. The visitors centre offers a series of exhibits focused on the Cold War uranium metals production industry, the subsequent environmental cleanup and today's ongoing legacy management.

In order to preserve information, a site environmental report is developed every year with all data collected at the site. Each year, a community meeting is organised to review the data and answer questions from the public. Legacy Management holds routine meetings at least quarterly with site regulators and stakeholders. The site's interpretive services have increased digital content production and engagement, particularly during and after the COVID-19 pandemic.

Current challenges in awareness preservation at the Fernald Preserve include: transforming population and stakeholders through technology and digital engagement, technological innovation (some residents would like more face-to-face interaction), content creation (history versus future) and marketing (spreading the word and reaching the target audience).

Questions and answers

The Q&A session addressed the following topics:

- How can future generations be included in the efforts on awareness preservation? The example offered by Tabloo with the project "reporters of tomorrow" shows that every generation will pass something on to the next one. It is a compelling story that attracts the attention and interest of young people, who return to see what is happening.
- Does the disaster in Fukushima create a stronger desire for memory preservation? Disaster can be effective in some situations. While the preservation of memory sometimes evokes negative feelings among people, it is also necessary. In the case of the Fernald Preserve, stakeholders are interested in transparency but mistrust still lingers. Today's strongest advocates are once the site's harshest critics. Stakeholders are proud of the site and of what they have done. The staff at Fernald Preserve communicates this pride. The idea is not to lose the history of the site, but rather to focus on the positive aspects of the work that has been done.

Keynote session: Things that last – Humanising how we think about persistent materials

Professor Rosemary Joyce, University of California

Professor Rosemary Joyce built on the exploration of the expert advisory process for the US Waste Isolation Pilot Plant (WIPP) presented in her book *The Future of Nuclear Waste – What Art and Archaeology Can Tell Us About Securing The World's Most Hazardous Material* (Joyce, 2020) to examine how humans think about materials that are by-products of intentional activities. This is the question of how materials become seen as waste, rubbish or problems. One of the challenges faced is acknowledging a continuing responsibility of care for potentially dangerous matter.

In planning for nuclear waste repositories, the United States government addressed the challenge of marking sites of waste disposal to prevent contamination in the future. Consulting with 29 experts in language, communication and anthropology about imagining future scenarios, the Department of Energy sought, during the 1980s and 1990s, to develop plans that would satisfy demands from the Environmental Protection Agency for a marker system that would be effective long into the future. Expert consultants proposed two very different designs: one based on archaeological sites recognised as cultural heritage monuments; the other proposing that certain forms evoke universal feelings. The Department of Energy opted for a design based on archaeological ruins, cited as proof human-made markers could last and communicate warnings for thousands of years. The book of Professor Rosemary Joyce explores the commonsense assumptions the experts made about their archaeological models, and shows how they are contradicted by what archaeologists understand about these places and things. The book alternates between discussions of archaeological marker designs and reflections on the alternative proposal based on archetypes intended to arouse universal responses. Recognising these archetype designs as similar in scale and form to land art projects, it compares the way government experts proposed their designs would work with views of modern artists and critics. Drawing on the views of Indigenous people who disproportionately are asked to accommodate such projects, the book explores concessions within the project that only oral transmission is likely to ensure such sites remain identifiable long into the future. As such, the role of the people as caretakers of memory and the reproduction of knowledge over time hinted at in a few places by the WIPP experts is critical.

During her presentation, Professor Rosemary Joyce further explored these commonsense assumptions the experts made about their archaeological models and showed how they are contradicted by what archaeologists understand about these places and things. This requires the need to rethink "durable" (mainly geologic) matter as changing more slowly, but as continuously, like organic beings – never stable, never inert. She considered how these misconceptions come together with respect to the question of safeguarding the by-products of nuclear technologies, and created a temptation to conceal, remove and isolate such material.

With this book, Professor Joyce forms the thinking on "how we might better understand long-term traces of humans on landscapes" by "viewing past, present, and future as mutually constituted, but not deterministically shaped, always providing for emergent understandings that transform how we embrace the material worlds of which we are part" (p. xvii).

Questions and answers

The Q&A session addressed the following topics:

- Does climate crisis offer a counternarrative to keeping memory alive and how to counter this narrative? Anthropology is a way of exemplifying things, and people have a repertoire of storytelling that must be tapped into. The idea of "public outreach" has shifted to "collaborative scholarship": it gives power to experts to determine the conversation and it is necessary to frame this conversation. It is possible to talk about "sea level rising" instead of "climate change". Narratives are powerful and are not necessarily self-evident to other people. All science is narrative. It is necessary to bring these narratives to people's daily lives and not try to offer counternarratives. Experts should not tell people how to think but should change the language they use to convey the expertise. It is necessary to move away from an anthropocentric view to a geocentric view. The example of thinking from the perspective of a mountain was presented in which it is possible to envisage it through either the lens of distress or perhaps through the lens of endurance (e.g. volcanic eruptions are destructive and constructive at the same time). It is necessary to displace the centrality of the human in the focus of the conversation.

- It is not an apology, but memory of disaster, which is traumatic. However, it is not destructive for the community.

Session 2: Existing regulatory approaches in awareness preservation and key challenges

This session discussed the place of regulatory provisions in the overall system for awareness preservation regarding radioactive waste repositories. It explored the interactions of regulatory and participatory processes, providing an overview of the regulatory situation, recognising challenges and giving examples for the solutions.

In various national programmes, the regulatory framework defines a set of provisions that should be implemented for knowledge and awareness preservation over the life cycle of radioactive waste repositories. A visionary section of the RK&M Initiative's final report (NEA, 2019) offers fictional examples of systemic strategies for RK&M preservation. Therein, activities in response to the regulation have been qualified as "compliance activities". Any RK&M system that does not comply with these legal requirements is likely to be judged to be incomplete or non-compliant. Other activities that may be implemented by a national programme are named as "best practice activities" (which can be regarded as "core mechanisms" and should therefore attract priority funding) and "supporting activities" (to optimally reach diversity and inter-connectedness among approaches and mechanisms, and to optimally support contextual adaptability). The ambition of this session was to discuss the interactions between such compliance activities on the one side, and best practice and supporting activities on the other side, with a special focus on participatory processes.

Speakers presented the following aspects:

- A global overview of the status of regulatory requirements with regard to knowledge and awareness preservation in the various national programmes; what kind of requirements are set, and what is the role devoted to dedicated sets of records, in participatory processes?
- The contribution of participatory processes required by regulation in the nuclear sector to RK&M preservation regarding radioactive waste repositories; the successive phases of a disposal programme may be considered, e.g. during the licensing phase, operation, or during post-operation oversight.
- The contribution of participatory processes not explicitly required by regulation in consolidating the regulatory provisions, e.g. by making the dedicated sets of records more robust or by fostering awareness of the repositories.

Marking of a repository and stakeholder interaction - The Swiss case

Felix Altorfer, Head of Waste Management Division, Swiss Federal Nuclear Safety Inspectorate, Switzerland

The regulatory framework in some countries defines a set of provisions that should be implemented for knowledge and awareness preservation over the life cycle of radioactive waste repositories. In Switzerland, the Nuclear Energy Act has two important articles for awareness preservation: Article 40 related to the protection of a deep geological repository (DGR) through which the Federal Council is responsible for ensuring that the repository is permanently marked, and Article 69 related to closure, which states that when closing the repository, the owner in particular must ensure that the marking of the DGR is permanent. However, the questions which arise are: what does permanently marked mean and how to ensure this? The regulatory authority that monitors the safety has to decide how to permanently mark the site.

The guideline G03 "DGR" of the Swiss Federal Nuclear Safety Inspectorate (ENSI) states that permanent marking as a concept has to be submitted with the construction licence application, probably in the 2040s, and has to be specified in subsequent licensing steps. Marking is a means to reduce human intrusion into the DGR. Permanent marking of a DGR must not compromise long-term safety to prevent people in the future from approaching the facility.

The local roman milestone found in 1534, with inscriptions in Latin, can be used as an example of permanent marking which worked in the past. It was completely decoded and is now readable by society. A combination of multiple ways can be used to preserve knowledge and ensure that all records concerning the repository, the waste stored therein and the designated protection zone are duly preserved, and corresponding data is passed on to the countries or international organisations.

Combining documentary provisions required by regulation and societal interactions for a robust system dedicated to memory and knowledge transmission

Jean-Noël Dumont, Senior Advisor and Programme Manager, Memory for Future Generations, National Agency for Radioactive Waste Management (Andra), France and Florence Poidevin, Programme Manager, Memory for Future Generations, National Agency for Radioactive Waste Management (Andra), France

There are three reasons for preserving memory:

- To avoid involuntary human intrusion. Repositories are based on passive safety and there is no requirement for human action. However, waste remains dangerous and intrusion must be avoided.
- To facilitate the decisions of future generations. Detailed knowledge must be conveyed to allow successors to maintain, modify or improve the disposal centres, to understand the solutions implemented to reassess them, etc.
- To pass on a cultural heritage. Memory must be preserved to enable future generations to understand past events, in the same way as other types of heritage.

Additionally, three important concepts to decide how long to preserve memory include: knowledge management (short- or medium-term perspective), knowledge preservation and awareness preservation.

The implementation of Andra's Memory for Future Generations programme is based on four pillars:

- Archives and regulatory provisions: There are different laws and regulatory provisions to preserve memory, such as the French Environment Law relating to a nuclear waste repository, the provision of a first version of a Summary Memory File when entering the closure phase, and a Detailed Memory File when entering the surveillance phase that follows a closure.
- Societal interactions: Andra has created memory reflection groups, uses different media channels and has direct communication with the public.
- Studies and research: In 2015, 2016 and 2018-19, Andra funded a number of art and memory projects. In 2022, the residency "une technogonie" by Juliette Nier aimed to create a myth to explain the genesis of radioactive waste and tell it through shadow theatre.
- International collaboration: Andra participated in the RK&M Initiative and Information, Data and Knowledge Management (IDKM) roadmap.

Post-closure-related responsibilities and plans of licence holders and authorities in Finland for knowledge and awareness preservation

Sami Naumer, Research Scientist, VTT, Finland

In Finland, there are two operational low-and intermediate-level waste (LILW) repositories, one spent fuel repository under construction and one very low-level waste repository planned. Closure is upcoming in 2060 for one LILW repository (Loviisa) and in 2100 for a spent fuel repository in Onkalo. While the closure of nuclear waste repositories in Finland is still decades in the future, some aspects should be planned prior to closure to most effectively meet strategic aims according to current regulations. A recent study sought to analyse existing Finnish and international closure- and post-closure-related requirements, rules and legislations that define responsibilities for the involved parties such as licence holders and authorities.

The national nuclear waste management programme (KYT) has not developed post-closure knowledge preservation plans (MEAE, 2023). The Ministry of Economic Affairs and Employment (MEAE) has the responsibility to create knowledge preservation plans. Although protective zones have been established around the LILW and high-level radioactive waste (HLW) repositories, the duration over which the protective zones should be maintained after repository closure is still pending. The long-term plans for preservation and administration of information and the national archives to preserve the data are currently only on paper and not implemented. The regulatory authority STUK already provides the location of the repository to the registries. Detailed plans will be included in the closure plan later in the process.

Retrievability is not required by law but the Decision in Principle (DiP) considers the need for maintaining retrievability of spent nuclear fuel canisters from the repository. Regulatory provisions of STUK from 2018 include data and knowledge preservation requirements, but there are still open issues. For instance, it is unclear when the data will be provided to STUK and the State. So far, knowledge preservation-related plans in Finland are lacking; responsibilities are defined in regulations but only apply to technical data. Currently, operational data are being stored and larger questions of knowledge and memory preservation have not been addressed in the legislative or regulatory framework.

They do things differently in Finland - Exploring the Finnish approach to awareness preservation

Petri Paju, Adjunct Professor, University of Turku, Finland

As Finland expects to start operating the world's first repository for spent nuclear fuel at Olkiluoto in southwest Finland within a few years, it is timely to ask how awareness preservation stands within the country. The NEA's studies about RK&M preservation regarding nuclear waste management do not often cover Finland. Finland's non-appearance applies to both research publications and other materials. The movie *Into Eternity* (2010) which Michael Madsen and his crew filmed at ONKALO in Olkiluoto is the one major exception. The project "final disposal of spent nuclear fuel and societal memory" aimed to find out how the Finnish experts prepare for the preservation of knowledge and memory about final disposal and map what kind of solutions have been and are being prepared elsewhere. The purpose was to better ensure that knowledge and memory is preserved for future generations. This project was part of the Finnish research programme 2021-2022.

The researcher Petri Paju conducted interviews with different authorities as well as with representatives from Posiva, researchers, museum, archives and VTT. These interviews enabled him to identify talks and essays from 1981 on nuclear semiotics and from 1986 on the ethical acceptability of a final disposal. Other documents identified included the

Government Decision 398/1991, which anticipated the permanent preservation of waste package information; in 1993, there was a Nordic project on knowledge preservation; and in 2001, retrievability was discussed and included in the DiP.

Generally, experts perceive preservation as important but forthcoming in a distant future as there are more urgent issues. However, in the RK&M project, the NEA suggests a proactive preservation strategy, which starts early and applies the principle of redundancy. Finnish experts stress that Onkalo is a passive system, designed to be safe, and memory distortions or forgetting could later turn markers into a danger.

In December 2021, Posiva applied for an operating licence for a spent nuclear fuel disposal facility. While some attention was directed to knowledge preservation and markers, this was not in the application but in a Future Human Actions Working report of November 2021. In this report, Posiva foresees that the disposal facility will be inland in 4 000 years due to land uplift and covered under a continental ice sheet in 100 000 years. The question remains whether to continue with the Finnish approach of postponing attention to knowledge preservation or to revisit this approach, for instance including these topics in the period safety reviews.

Information and knowledge preservation over generations in a regulatory context

Carl Henrik Pettersson, Investigator, Swedish Radiation Safety Authority, Sweden

In Sweden, regulations concerning information preservation over generations are currently being updated. There is a discussion on how responsibilities should be transferred to government. The operator is responsible for records preservation before closure.

The implementer is responsible for the following four requirements:

1. Before closure, the likelihood of inadvertent disturbance must be reduced through the design safety features (through repository depth, avoiding sites with extractable mineral assets and construction solutions).
2. Information regarding the repository in both a technical context and a social context must be identified, documented, preserved and updated until closure. The information must be archived in at least two geographically separated locations.
3. An action plan must be developed for information preservation containing: a summary of the information identified in bullet point (2); description of how the information is identified, documented and preserved in a structured manner with the aim of being understandable in as far into the future after the geological repository has been closed; description of how this work is done from an organisational and managerial point of view, until the licensee hands over responsibility for the finally closed repository; description of results from external monitoring of methods for transferring information and knowledge about the final repository to future generations after final closure; initial preparations for transfer of responsibilities.
4. A plan for closure and decommissioning must be created that includes a description of the planned end state after closure and decommissioning of the facility, with justification and description of how the final permit is anchored with other concerned authorities and concerned stakeholders.

After closure, the regulator is responsible for implementing any oversight measures deemed necessary and taking over the responsibility for the information. The Swedish Radiation Safety Authority is currently exploring how RK&M preservation can be addressed through regulations in an ongoing regulatory update for geological repositories.

Questions and answers

The Q&A session addressed the following topics:

- Markers, like tsunami stones, seem quite positive. However, there might be arguments against markers (e.g. local communities might not like them or there are worries that they would not be recognised as markers in the future). Markers should not be expected for eternity and are part of a broader strategy for information preservation, as one piece in a puzzle. Markers or monuments are part of the broader concept of safety (i.e. safety by inclusion rather than by exclusion). Markers do not necessarily need to imply danger, but are something to be considered, to bring people's attention to the repository.
- Do regulatory authorities ask the community what they would expect to be developed after closure? In Sweden, concerned stakeholders and authorities should be involved in the discussion around the end state of the site, but this is still ongoing.

Session 3. Approaches for an unknown future

Efforts have been made to convey information about the modern world to future generations, societies or civilisations on a global basis or in specific countries. It is impossible to predict when, where and how such information is received. However, various approaches have been developed, regarding not only the transmission method but also the material of the recording media and the expression method, such as characters and symbols. This session examined approaches, considering different intended durations of time, i.e. those that are to be used for decades or hundreds of years, and those that are to be used for thousands or millions of years.

Sound mapping project and the nuclear material archive

Daniel Beck, PhD Student, London College of Communication, United Kingdom

This presentation focused on two works of art made in partnership with the British Film Institute (BFI) National Film Archive. Situated within a Cold War era Ministry of Defence nuclear facility, the BFI's Master Film Store contains thousands of tons of film and television media. In order to preserve both the content and material integrity of this media, a world leading cold storage facility sits at the centre of a large site scattered with bunkers, storage rooms and operational relics of its nuclear history. Both pieces presented sought to offer new ideas for the preservation and understanding of nuclear histories, exploring the potential for artworks and cultural archives to act as conduits for the preservation of post-atomic consequences.

The practice was presented in printed format as a sound mapping project that combines images and interviews with nuclear era veterans, archivists and technologists, with field recordings taken at each of the bunkers, workshops, woodlands and modern storage facilities throughout the site. In addition to this, a further project presented a collection of audiovisual webpages designed to inherit the nuclear half-lives of radioactive materials, transmediated to 35 mm film print and video home system (VHS) tape. The project explores the potential for film and sound-based media to act as witnesses to the legacies of nuclear materials and questions the role the archive can play in preserving these for the future.

Markers that convey a message: Communicating with future generations

Arne Berckmans, Project Manager, ONDRAF/NIRAS, Belgium

Within the framework of obtaining a master's degree in product development, a student of Antwerp University designed and tested a marker for its efficiency in conveying a message to future generations that deters intrusion into the tumuli. The marker was imagined to be positioned next to the tumuli, covering the low-level radioactive waste (LLW) repository in Dessel. The theoretical part of the study focused on determining what parameters influence the chances of survival of a marker and its message, the characteristics of the marker itself, the different ways of communication, a vision of how the far future would look and reasons for loss of data.

Based on the above insights gained and using the principles of integrated product design, several concepts of a marker were developed that led to a final design. The marker had to carry a positive and a negative message and should function as a standalone, assuming that all other forms of communication cease to exist. The efficiency of the message integrated within the marker was verified using virtual reality (VR) technology. A small sample of 12 public volunteers, unaware of the reason for the tumuli or the contents, were asked to

answer questions after viewing a 3D VR model of the marker. Results were encouraging in that the majority of interviewees understood that not disturbing the tumuli was a better idea than trying to gain access to its contents. Tumuli might be enough as a marker. However, future generations will decide whether or not to put a marker.

Magazine of the century – A communication experiment

Barbara Habermacher, Documentalist, Nagra, Switzerland

In the fall of 2022, the National Cooperative for the Disposal of Radioactive Waste (Nagra) announced its siting proposal for a DGR. At the same time, Nagra launched the project of the "Magazine of the Century". This project foresees publishing an issue of the "Magazine of the Century" once a year for the next one hundred years until the closure of the DGR. The journalistic and creative examination of the topic of radioactive waste disposal will document how society and science solve this important task. The journal will thus serve as a chronicle of the social and ethical aspects surrounding the repository.

The first issue was published in June 2022 and was written by a journalist who investigated how Switzerland views the DGR. Different people have their say: an author, a politician, Nagra's CEO and a critic. Together with the magazine, a special website was launched where everyone is invited to leave a message for future generations to read. In one hundred years, these messages will be released to the public to reveal what was considered to be important one hundred years ago. The magazine will be archived digitally, on paper and on microfilm.

The magazine is part of Nagra's corporate communication and seeks transparency in Nagra's projects. It is a chronicle for future generations, a message to the future and an important source of knowledge. It documents social issues, such as how people feel about disposal of RW. It is also a creative experiment as it can be a playful way to approach time dimensions. It tries to contrast and unite a fast-moving world with long-term stories. The design will change over the years and will be adapted to current trends. Finally, the magazine is also an experiment in archiving methods: it will be saved in microfilm, digitally and stored in the repository as a time capsule. Everyone will be involved in passing on a message to future generations.

Nuclear heritage: Material practices anticipating and resourcing distant futures in the present

Gabriella Katalin Ivacs, Head of Section, Archives and Records Management, IAEA

Intergenerational learning can be challenging, particularly in the context of RWM due to the long timescales. Using archives may be a way to facilitate the engagement of youth in the topic of RWM. Archives offer the possibility to organise, reorganise, create, digitise, classify and declassify knowledge. Therefore, there is a certain degree of intervention in the way heritage is presented to the public and this can be a motivation for young people to become involved. Additionally, the appraisal process of governing the archive is no longer with the creator or administrator, as it was in the 1980s, but public and communities are involved in the process of building the archive.

The definition of cultural heritage needs to be updated in order to consider focusing on the process and adjusting it constantly. Heritage does not mean that certain practices or materials are over, rather they require attention and cultivation, and have to adjust to cultural discourse. The process of managing heritage is constantly evolving and never finishes. Therefore, a strategy to preserve information engaging all institutions, like archives, museums, libraries, etc., is crucial.

Considering nuclear waste as a heritage management challenge is a sensitive subject. The integrity of preserving the information and having reputable data is of paramount importance. Provenance, governance and integrity have to be undertaken jointly by the public and the personnel who understand archives.

"Marking" the Australian nuclear fuel cycle as future cultural and environmental heritage

N.A.J. Taylor, Alfred Deakin Postdoctoral Research Fellow, Deakin University, Australia

Earth can be considered a nuclear archive, based on the history of the nuclear age or its future. HLW repositories are intended to be sealed and passively monitored (without human intervention) for the next 100 000 or more years. While technical solutions have been established to manage the ecological risk, there is broad agreement that the risk of (human) intrusion remains. The extent to which these sites should be archived by the establishment of "markers" remains an open question. It is still not clear what symbols, texts, images and warnings used today as markings will help to communicate to beings after tens and hundreds of thousands of years into the future. Whether the intruders will comprehend – and agree with – the warnings delivered by present-day humans remains unclear.

The presentation by Mr Taylor was part of a three-year project focusing on transdisciplinary concerns based on approaching the Australian nuclear fuel cycle as future cultural and environmental heritage. Specifically, the project is the first systematic study of the limits and possibilities of far-future nuclear communication in relation to the Australian nuclear fuel cycle. Focusing on Australia is both theoretically interesting and empirically important since it contains more than one third of the world's known uranium, as well as the world's oldest continuous cultures on Earth's most arid and stable bedrock. Australia is a critical site for the conception of the nuclear fuel cycle as a future cultural and environmental heritage. In so doing, the empirical innovation of foregrounding Australia's nuclear archive is met by the conceptual innovation of addressing contemporary concerns with interdisciplinary methods and theories. The central question being researched is: what methods and means can be identified in Australia that advance international best practice for communicating nuclear heritage into the far future? For this, it is important to look at the connection of Indigenous peoples to cultural landscape. The land is a sacred entity, the great mother of all humanity, and relationships are the most important connection between land and people and the peoples themselves.

Questions and answers

The Q&A session focused on the question of whether archaeologists of the future should enter the DGR. There was not a clear answer to this question. Deciding about the future can be difficult. On the one hand, it was stated that it is necessary to create the environment and the context for archaeologists of the future to enter if they want to. Future generations should have the possibility of retrieving because they have the right to know. On the other hand, it was also stated that it is necessary to create a context that prevents future generations from entering the repository. In this regard, markers cannot prevent intrusion because of human nature which may want to see what is inside. Marking research is evolving and signs can be changed. It might seem more appropriate to use well-known markers to help many people understand its meaning at present and convey the message to the future generations.

How to create specific storages to preserve radioactive heritage objects?

Thomas Beaufils, Lecturer, University of Lille, France

Every year, national radioactive waste management agencies take charge of hundreds of radioactive objects linked to the history of science and radioactivity. These radioactive objects are definitively stored, without having been studied by researchers, in nuclear waste storage sites. While most of them are ordinary, others are rare and of great heritage value. The law in this area is today inflexible: health law always takes precedence over heritage law. Furthermore, there is no real definition of what radioactive heritage is. One of the major problems is that there is no official or scientific institution to decide to throw away or preserve these objectives. Every time someone touches these objects, degradation can start and the objects can lose patrimonial interest. Today, hardly any museum is capable of recovering these rare objects in good condition.

Some of the radioactive material from Marie Curie's work was decontaminated, but if all these materials were decontaminated, there would be no physical or detectable trace left of the unique characteristics of her pioneering work. It is important to keep the radioactive nature of these objects, not only the content of letters but the radioactive environment in which the letters were written in the case of the Marie Curie material, as historical radioactivity tends to become rare.

Thousands of radioactive heritage objects are stored in museums, often without proper knowledge or management. This lack of awareness can result in museum employees being contaminated or irradiated, making it imperative for systematic checks to be conducted to prevent such situations. In Europe, radioactive materials are generally hidden. A specific case is the Netherlands, where the radioactive waste management agency COVRA has a specific place for radioactive heritage objects within the nuclear waste storage facilities. Radioactive objects, like a glass bulb containing radium that belonged to Marie Curie, are shown to the public. In the United States, ORAU is the museum of radiation and radioactivity from Oak Ridge Associated Universities in Tennessee. ORAU has been deemed the official repository for historical radiological instruments by the Health Physics Society.

Preserving and exhibiting radioactive heritage would allow for a better understanding of radioactivity by the general public. Lessons need to be learnt on how to safely keep these radioactive heritage objects, while taking care of the precepts of preventive conservation and keeping the integrity of the object intact. The creation of national and European inventories of radioactive objects in museums and a commission of European worldwide experts to decide on radioactive objects to be preserved would help the preservation of radioactive heritage. Similarly, the creation of specialised teams of experts responsible for properly packing, transporting and storing these heritage objects in designated reserves would facilitate the study of these valuable artefacts by present and future archaeologists and historians.

Art and intergenerational knowledge transfer

Ele Carpenter, Professor, Umeå University, Sweden

Ele Carpenter presented two projects that demonstrate how contemporary visual art creates intergenerational knowledge about nuclear sites in the United Kingdom and Australia. The history is continuously rewritten by each generation and provides warning to properly embed knowledge in a global and colonial historical context.

The first project focuses on the highly developed cultural forms of Indigenous intergenerational knowledge transfer about Sickness Country, where uranium lies very

close to the surface of the earth in the Kakadu National Park. The artists, Alex Ressel and Kerri Meehan, are working in collaboration with aboriginal artists in Gunbalanya, Arnhem Land, in the Northern Territory of Australia, and are interested in following the material trace of uranium mined from their lands for the European nuclear industry and its eventual reburial as waste. The warnings and culture about how to behave safely in the landscapes are embedded in images and stories over the generations.

The second project presented was that of Gabriella Hirst, an Australian artist living and working in London and Berlin. Her public artwork "An English Garden" in Gunners Park, Shoeburyness, 2021 was a memorial to the British nuclear test in Montebello and was removed on the insistence of local councillors, causing a political debate in the United Kingdom. The artwork demonstrates the importance of understanding the United Kingdom's nuclear history; and highlights the importance of global solidarity between nuclear communities to share, understand and gain recognition for the way in which knowledge of nuclear sites and histories can have agency in the present, and provide evidence in the future.

In both cases, the political environment influences knowledge transfer and the development of strategies for preservation. It is vital that work on effective RK&M include strengthening public and democratic institutions, frameworks and traditions.

Memory of Mankind (MOM)

Martin Kunze, Founder, Memory of Mankind, Austria

The idea that the only written remains of our era might be the manufacturer embossings on the bottom of stainless steel pots triggered the idea to use ceramics as durable data carriers by using a technology which has been developed to print company logos on coffee cups: 20x20 cm high quality white bathroom tiles with a colour print with ceramic toner, fired onto the surface. These most durable data carriers of humanity are stored in ceramic boxes deep in a vault within the oldest salt mine in Hallstatt, Austria, which is part of a UNESCO World Heritage site. These possibilities make it possible to pass on what is considered most important from the present era. The contents are compiled by entities that use the memory of humanity as a medium to store information for the long term and by individuals worldwide who upload text on the webpage to be sent to the future, yielding a history of mankind that is told bottom-up.

Future generation potential information needs

Carl Henrik Pettersson, Investigator, Swedish Radiation Safety Authority, Sweden

The RK&M Initiative emphasised that handing down a message is not enough, but it is necessary to keep that message understandable, accessible and relevant over time. Thus, the processes for assuring this are equally important. This presentation unpacked the important question raised about how long such a message needs to be available to future generations and for what reasons. Due to safety reasons, the value of information related to a repository for radioactive waste will decrease with time as a function of the radioactive decay. The number of years that a message needs to be available to future generations can depend on the nature of waste. For instance, for spent nuclear fuel, that could be 1 000 to 10 000 years (i.e. 30 to 300 generations). The time that a message needs to be preserved for is equal to the oldest writings in human history. Besides safety reasons, the value of the information to future societies can also be seen from an ethical perspective, for example providing future generations freedom of action regarding the management of the waste. One way to make information understandable is to have successive information transfers, connecting each generation with the next.

When developing scenarios for future human actions in post-closure safety assessment, the top-down methodology could be used to explore future generations' potential information needs, i.e. safety functions are first identified and then the focus would be on these conditions, whether it be a single condition or a combination of conditions, that can affect these safety functions (NEA, 2012)At present, drilling activities and excavation work have the greatest potential to affect the repository performance and safety.

The Future Human Actions analysis of factors and actions that can affect nuclear safety is a tool for strategic foresight. This analysis could be performed in the stepwise licensing process as part of the safety case. Continuously updating what information to preserve is a way to adapt to future knowledge and, therefore, absorb change.

Consciousness of the landscape

Cécile Massart, Artist-Researcher, Belgium

Cécile Massart showed her photos made at radioactive waste sites, with a summary of exhibitions and videos designed to link to reports on the topic. Whether in a gallery, museum, cultural centre, or company office, these works present the possibility of perceiving the public's lack of knowledge at times, discuss environmental issues, technologies used, future changes in the landscape, transformations, migrations and politics. These elements represent the main triggers outlined in a study which started in 1994, with Cécile Massart's research on memory transmission for the future. Her book entitled "COVER" (Massart, 2010) is a compilation of drawings created during her travels to RWM sites throughout the world and a testimony to vanished civilisations. The artist wants to make visible and identifiable the markers intended for low-level radioactive waste sites. This project helped to reflect on the markers for Andra's LILW the Manche disposal facility.

Following an artistic residence at the Waste Isolation Pilot Plant (WIPP) and at Beatty, Nevada next to Yucca Mountain, Cécile drew seven concepts entitled "LABORATORIES". These drawings consist of environmental structures that are situated near high-level radioactive waste repository sites under construction and are visible to everyone in the landscape.

Cécile Massart calls upon artists and researchers of all disciplines to develop a nuclear culture for memory preservation which she calls "BatLab". This platform of artistic activities, archiving and knowledge transfer would unite researchers from various disciplines to discuss modes of transmitting memory (e.g. film, wanderings, songs, markings, tools, technology) in connection with universities, art schools, rural associations, communities, etc.

Questions and answers

The session on Q&A revolved around the following questions:

- Related to the memory of mankind presentation: the salt mine will close over time; what will happen to the archive? The salt mine will close for natural reasons to protect against eventual threats. The memory of mankind token is a treasure map and buried because only society with technical knowledge should find this archive. The tablets are not destroyed in the salt mine.
- Regarding the participative approaches and the political controversies: where is the limit for dialogue with people? Where to draw the lines on what is acceptable or not? The audience was informed by a participant about how political sensitivities around a nuclear culture artwork in the United Kingdom had led to attempts to shut down dialogue, and how the artist responded. It was further explained how artist

Gabriella Hirst responded to the removal of her English Garden public artwork about British nuclear colonial history by organising the Rose Garden conference. The online event brought together participants with very different experiences of British nuclear activities in Australia to share their stories (from the atomic veterans' association in Britain representing families of veterans who were drafted to Montebello, to Aboriginal elders in Australia who also witnessed the atomic explosion). It was stated that some of aspects of Britain's nuclear past might not receive much attention because they are deemed as shameful. The question was raised as to whether this is a legitimate view. Building alliances between communities and continents through art is important to enable discussion. It was argued that there is a strong artistic, historical and political case for Gabriella Hirst's English Garden artwork to be reinstated.

- How can data be trusted by future generations? There is no one solution but multiple solutions and redundancy (e.g. distributed archives, safe and multiple copies in different locations). Information should be distributed by creating a network of people who remember and can then go back to the site. Building an ecosystem where all have a role seems a possible way forward.
- As an artist, did ideas change after being in WIPP? Cécile Massart noted that the desert was disquieting. WIPP is built on fossilised soil and the social context was different, though the experience enriched her work in the laboratory. The population will not be the same in 100 years' time and the question which arises is how to start projecting memory in the future. Archives can be well designed but it is necessary to start visually working on the site right away. For Ele Carpenter, the laboratory is an interdisciplinary space for people to work. Site markers are going to be redundant quickly. Instead, the configuration of the community on the site is more important, involving them in commissioning, archiving, documenting, exhibiting, organising publications, dialogues, events, soundtracks, etc. This community building, layering a networking and distributing knowledge through communities and experience is paramount and is embedded in the artwork.
- Is retrievability an option? Retrievability opens up different responsibilities for a site and RWM agencies have to manage the safety case in the future. The responsibility and financing are retained within the nuclear industry and should be considered in the process. There is a relationship between retrievability and intergenerational knowledge. The purpose of repositories is to balance isolation and containment of waste but also make it retrievable. From a technical point of view, the concept of oversight is important: people must keep an eye on the site, grounded in ICRP advice. Oversight must continue but if the transfer is broken, this is an accident. By calling RW a valuable material (e.g. copper and stained steel), the notion of recycling might be incorporated into this nuclear material repository and future generations could make use of it.

Session 4: Conceptualising remembrance across generations

This session aimed to discuss new developments that may be important for awareness preservation per se or for understanding mechanisms behind successful long-term memory. Speakers presented developments within the following areas:

- Futures literacy: Discussed within EGAP as a skill for appreciating and accommodating for possible futures, instead of attempting to impose present thought on the future.
- Cultural heritage: When examining heritage processes, it is important to consider what cultural heritage does or is expected to do rather than what it is or was originally intended to do. The lens of heritage processes presents a view of cultural heritage that integrates change over time, recognising that in the future heritage may not exist as it does today.
- Semiotics: Communicating a message to recipients in a distant future requires addressing the issue of language evolution. Speakers will present reflections on how signs can be defined that will be understandable over a long period of time, in relation with the content of the message to be sent.

New developments were presented and the potential application and importance of these developments for awareness preservation were discussed during this session.

Memory and time – Reflecting on remembrance and narrating the past

Carina Green, Lecturer in Sociology, Örebro University, Sweden

The presentation revolved around the concept of memory, drawing primarily on anthropological understandings of "social memory". Memory is seen as constructed in specific cultural and societal contexts. Memory is not merely a narration of the past, but rather a reflection of how the present is understood and how futures are imagined. Moreover, memory is intrinsically linked to ontological notions of time and space, and thus differs among human societies. Different groups have different needs to remember the past. In a society that has a circular understanding of time, time does not exist in the same way as a society where time is linear. In these societies with circular time, there is no incentive for change, less discussion about progress, and memory is more stable.

In relation to nuclear waste repositories, valuable tools can be gained to imagine how RW could be communicated and remembered, by reflecting on the creativeness of memory and on diverse ontological notions of time. Understanding what (social) memory is and how it works is vital to understand how risk is to be communicated into the far future. Ontological differences of understanding time/space and human/non-human relations show the contextuality and complexity of remembering. Emotional narratives rather than factual/technical data are more effective to communicate risks. Imagination is needed to think of ways to deliver messages to civilisations in the far future and for them to interpret these correctly. In the future, people will narrate the past in a way that makes sense of their present but how to control that is currently not known. Any attempts to image how future generations will be reached by the current communication might be useful to make sense of the present.

History or heritage? Understanding cultural processes over time

Cornelius Holtorf, Professor and UNESCO Chair on Heritage Futures, Linnaeus University, Sweden

There are two different ways of thinking about remembrance over time or about awareness preservation. On the one hand, there is the approach of "history" (e.g. public history) which seeks to gain and maintain knowledge of the past in the present (including future presents). According to this way of thinking, such knowledge is valuable in its own right, and due to historical research, it is being improved continuously. This approach seeks to operate as much as possible isolated from the contemporary context and is concerned neither with the shifting meanings of the past nor with whom or what this knowledge benefits in society.

The alternative approach is associated with "cultural heritage" and asks about the significance of the past in the present (or indeed in the future: the realm of heritage futures). According to this second line of thinking, manifestations of the past occur in societies because they play certain useful roles, which change over time. This approach asks about (re-)interpretations, (re-)uses, and (re-)creations of the past in specific contemporary contexts but it is not primarily concerned with the question of whether any such manifestations are historically accurate or not. The difficulty in the context of preserving awareness of radioactive waste repositories is that many desire solutions based on the approach of "history" (maintaining knowledge of the past) when at the same time just as many expect that repositories and associated media of communication will end up as "cultural heritage" (manifesting reinterpretations of the past).

In summary, it is important to move away from anticipating future history to anticipating cultural heritage practices, engaging with change early on and having a continued dialogue. The future should not be colonised with the perceptions and values of the current generations. Rather, promoting alternative ways of thinking of the world and embracing changing perceptions, values and forms of awareness over time could be more helpful for awareness preservation. This is possible by facilitating meaning and awareness in different future contexts through dialogues of translation between different knowledge systems and understandings.

Orchestrating nuclear futures: Lessons from the history of scientific prediction

Egle Rindzevičiūtė, Lecturer, Kingston University, United Kingdom

One of the greatest challenges facing the nuclear sector is planning for the extreme long term, which is required to secure the safety of RW. The long term, however, has been notoriously inconvenient for modern governance: neither the epistemology of scientific prediction nor the cyclical nature of political process bodes well with the requirements of the long term. In the context of RWM, there is an additional challenge of complexity pertaining to technoscientific, material, social and political uncertainties.

This presentation revisited the history of the modern scientific prediction, a form of knowledge that deals with complexity and uncertainty explored in the presenter's book "The Will to Predict: Orchestrating the Future Through Science" (Rindzevičiūtė, 2023). She argued that there is a need to raise awareness of different models of scientific prediction as they inform policy and management decisions at different levels of complexity. Scientific prediction is about managing complexity and nuclear heritage is about recognising complexity (social, cultural, political, etc.). Hence, scientific prediction could be a useful epistemological tool to engage in the management of nuclear legacies. Governing the long term, from this perspective, is striving for an appropriate orchestration of scientific predictions. Predictive knowledge requires a particular form of orchestration of scientific expertise (i.e. data production, interpretation, communication). It is possible to

orchestrate the long-term nuclear futures through scientific prediction: it is imperative to engage with prediction and how it can be best organised to take care of radioactive materials. It is useful to embrace continuous adjustment of knowledge and its performative function, address the problem of synchronisation of different types of predictions and improve the prediction literacy.

Futures literacy – Why it matters to pass on information on high-level radioactive waste to future generations

Anders Högberg, Professor, Linnaeus University, Sweden

Futures literacy empowers decision making. Futures literacy is a capacity that is learnt or obtained in other ways to visualise a variety of possible futures that are different from the present and to be in control of theoretical and practical tools for acting in the present in relation to its futures. It is an ability that develops with knowledge and experience. Futures literacy is not about predicting the future or controlling it, but rather it is about becoming better at understanding the roles of the future in contemporary society and its practices, and how such practices enable the realisation of a variety of futures. It is a means to unlearn what is normally not questioned, usually assumptions about a continuity from the present into the future.

Futures literacy creates an awareness of the anticipatory assumptions concerning the future which present-day decisions (often un-reflected) tend to be based on. It is a capacity that liberates people from the tight shackles of "presentism": i.e. the unquestioned and disabling assumption that the current status quo is timeless. In developing futures literacy, the ways in which past knowledge and future expectations shape understanding and action in the present are clarified. For example, museums have a role in tangible and intangible heritage in the past and preserve for eternity for the future generations. However, if museums have to become an RK&M preservation mechanism, they should be activated in specific futures. Developing ways to work with the future are still lacking and another layer of complexity needs to be added.

Questions and answers

The session on Q&A revolved around the following points:

- Radioactivity is part of the environment and will be so forever. What is the message that should be conveyed to coming generations? Future generations will live in an environment with radioactivity and will learn how to deal with it. Why is it necessary to think about learning processes and how the messages are transformed? No individual will manage to go down the repository alone; it will take a society to investigate what is in there. There will be scientists and experts who can understand what it is and how to manage it.
- The main positive aspect of considering the long term is that it reveals what is not known and helps generate better knowledge. Understanding the consequences of particular decisions is a useful exercise to build knowledge of what is occurring in the present. In addition, most countries are asking the nuclear sector to come up with answers to inform future generations. In these future studies, it will be necessary to develop new ways of thinking as it is wrong to think current knowledge is complete. It is preferable to make decisions that are open enough for the future to re-evaluate. Narrowing the decision too much will result in future generations needing to act based on the current knowledge.
- Prediction exercises make it clear that uncertainty is inevitable. Making sure that people do not enter places that should be inaccessible because they would be at risk

is a practical, technical problem. The question is how to convey this message and make it understandable in the future. It is a semiotic problem. Messages could be misunderstood in the future. There are two different and separate discussions: one of history and one of heritage. These discussions are not mingled and do not embrace uncertainty. How is it possible to translate languages, thoughts and approaches to complete current understanding? Future generations can be urged to take certain actions through messages. It is necessary to consider how to organise the knowledge system and how to stabilise heritage beyond management.

- The RK&M methodology is made to embrace uncertainty and there are a variety of options: Oversight must continue, and therefore updating documents, museums, land registries, markers, etc., will help this oversight function. Everything seems to become increasingly complex, making it difficult to act on a practical level. There might be some frustration with how these layers of complexity make awareness preservation (un)feasible. However, the museums' work does not need to change as these institutions are reference points of information and places that support and duplicate information. Ideally, there is a strategy that embraces uncertainty.

Next steps for awareness preservation – Nuclear message

Martin Kunze, Founder, Memory of Mankind, Austria

The challenge of creating a compact description about a nuclear waste repository is the uncertainty about future languages and writing systems – or rather the certainty that they will be significantly distinct from the ones used today. How can information be passed on about the location, characteristics and content of a nuclear waste repository that will still be comprehensible in one million years?

Given that the addressees of a nuclear message are assumed to have the technical means to be able to intentionally intrude into a geological repository, their stage of understanding the universe and the fundamental forces must be at least similar to those of today's society. A nuclear message needs to be low-cost, with many copies, recognisable as a message, comprehensible for the informed, without making sense to the non-informed (only those with similar understanding of the world) and robust enough to outlive 30 000 generations. A basic nuclear message for a DGR should explain the characteristics of the content, amount of material, location, depth, architecture, date of initial operation, and give hints about the KIF.

This is the core of a new concept to use "universal icons" derived from phenomena that are equal throughout the cosmos. For example, the Periodic Table of Elements must look similar in any technically industrialised civilisation. The table of elements is not at all an arbitrary list but is based on the characteristics and properties of matter. A periodic system seems a simple but efficient method to describe the nuclear message.

Future highly advanced civilisations can be assumed to be able to correctly interpret the nuclear message that today's civilisation will leave behind.

Next steps for awareness preservation – A roundtable discussion

There were six roundtables organised on six topics and one moderator per group. Participants joined three different rounds of discussions, which lasted 20 minutes each. The summaries of the discussions in the roundtables were presented to the participants at the end of the session and are summarised below.

Why preserve awareness?

The rationale for preservation could be related to:

- the emotional motivation for preservation: the actions taken today could be a source of motivation for future generations;
- the responsibility as human beings to prevent suffering and transmit safety;
- the need to foster dialogue between stakeholders and to include certain voices that do not traditionally participate in decision making in the discussion around heritage;
- the need to inform future generations as well as to transmit heritage moving forward;
- the possibility of retrievability.

Humanity has the capacity to forget. Therefore, it is important to preserve information to be available not just for today but for future generations.

How to preserve awareness?

Preservation could be undertaken in a multi-layered way: at the international level through international or umbrella organisations like the IAEA, NEA or UNESCO, and at the local level through local communities. A combination of several approaches at the same time will result in higher chances of success. These approaches include, among others, the tools indicated in the RK&M report, museums, monuments, time capsules, archives, libraries, memory institutions, education and training, knowledge sharing in communities, artists collaborating, etc. It is also important to trust less physical objects, technology or material artefacts for preservation and to learn more from discursive ways of passing on memory, like storytelling and narratives.

Consideration of the message to convey is crucial. For instance, emotions can connect people to the object or artefact to be preserved. One of the biggest factors in the survival of historical objects is beauty. The Mona Lisa painting, for example, has survived for centuries. It has acquired a certain status for being preserved without there necessarily being this intention when it was created. Additionally, changing or updating regulations or procedures to protect historical radioactive objects might help with awareness preservation.

The discussions did not lead to an agreement regarding whether there is a difference between short-lived and long-lived repositories in terms of awareness preservation methods. It may be easier to preserve awareness in the short term than in the long term, but the methods used might be different.

Overall, different people should be involved in the decision on how to preserve awareness in the short and long term. Currently, awareness preservation is seen as a way of offering choices to future generations on what to do with the waste. However, it may be wiser to

offer future generations more choices on how the manage the awareness, even if this might lead to the loss of this awareness.

What to preserve?

Different targets can be preserved for the future for different target audiences: repositories, stories about people, nuclear technology (good and bad sides), artefacts, detailed knowledge about where radioactive waste is stored and how, etc. It is important to preserve the complete or authentic image to have an entire picture of nuclear technology.

Considering the intended goal of the message is crucial as it impacts what knowledge should be preserved. Additionally, it is worthwhile to identify the minimum knowledge that must be preserved.

Part of the stories to be conveyed include:

- the reason why nuclear energy was used and why the waste was stored in a DGR;
- uncomfortable stories (e.g. bombing, nuclear weapons testing, military knowledge);
- the impact of RW in societies as a whole and in smaller groups of people;
- classified information;
- daily lives of people who interacted with nuclear objects;
- how technology has evolved over time and how people have interacted with this technology (e.g. in Fukushima and Chernobyl, the protective gear used);
- benefits and dangers of nuclear technology.

There was no agreement on whether a distinction should be made on what to preserve for short-lived and long-lived radioactive waste repositories.

Another open question was whether it might be better to forget.

Where should preservation take place?

Preservation could take place at all levels (locally, regionally, nationally, internationally), not just in one place but in several places, including at repository sites. Blockchain could be an approach to maintain information in different places. Concrete places should not be the only location considered; living stories are also paramount for preservation.

Decisions on where to preserve should factor in a number of variables, such as whether an ice age is currently occurring, terrorism, changing institutional frameworks, sea level rise, loss of knowledge, etc. Developing relationships among countries (e.g. partnership models, bilateral agreements) can be useful mechanisms to preserve information. In addition, the relationship with local communities is important for communicating about information preservation.

Who should be involved?

In order to define who should be involved, the definition of stakeholders put forward by the FSC can be used: “anyone with a role or an interest in an issue”. In this regard, some institutions have a role as they are required to be involved, like implementers and regulatory authorities. It is a collective problem which needs to be solved collectively. Therefore, engagement should be as broad as possible and at all levels, from global to local, from the ministry of education to teachers, international organisations (new or existing), and local communities, etc. Local stakeholders are key in passing information and knowledge in the

long term. Other people who can offer practical solutions, like graphic designers or artists, can create artistic works. Offers can be made to the wider public to become involved in this process, though not everyone might be interested. Both international collaboration and exchanging ideas are fruitful for the short and the long run.

What are the next steps?

Starting with the RK&M list of tools available (NEA, 2019), concrete examples could be developed of, for instance, museums, markers, symbols, etc., for awareness preservation. It is necessary to clarify the reasons for preserving and helping organisations plan for preservation. The process of preservation should be started immediately and can be further developed in the future. Better communication is needed now for preservation. International collaboration to develop practical guidelines on how to approach awareness preservation, including communication and establishing dialogues in the current and future generations and involving artists and museums in memory preservation, seems pertinent. In this regard, international conferences are fruitful.

A vision regarding awareness preservation, even if not perfect, is needed. It is preferable to start a process of awareness preservation now and develop it further over the years than to wait to define a perfect vision.

Conclusions and ways forward

A key part of the EGAP workshop was to present outcomes of the expert group's work from 2020 to 2022, and solicit input from various stakeholders to broaden the discussion and gather diverse perspectives. There was a significant amount of interaction among participants and detailed discussions during the sessions. The workshop fulfilled its goal of informing stakeholders of the significance of awareness preservation and explored effective strategies for awareness preservation in radioactive waste management and geological disposal. One of the main conclusions of the workshop was that "communication with the present and not only with the future is important for memory preservation".

EGAP will develop practical guidance for writing a KIF, based on the dedicated report of the RK&M initiative and the lessons learnt by the radioactive waste management agencies who have already developed or revised their KIF for their repositories, like Andra in France or SKB in Sweden. This will allow national and international stakeholders to progress with the practical implementation of awareness preservation tools.

Building from the existing draft RK&M Catalogue (NEA, 2019), EGAP will assess whether the current regulations address awareness preservation and will update the content of the catalogue, keeping in mind that the catalogue should be understood as "a snapshot in time" rather than a normative study.

To progress in the practical implementation of awareness preservation tools, EGAP considers that a nuclear message could be provided that uses "universal icons" to point to a particular location and to explain in general terms the contents of a nuclear waste repository. The purpose of developing the concept for a nuclear message is to spark discussions regarding the relationship of the nuclear message with other RK&M preservation approaches and to develop it further.

The suggestions provided by EGAP represent a significant contribution to the field of RK&M preservation and have the potential to positively impact both national and international efforts in this area. The comprehensive and practical nature of the suggestions put forth in this workshop are likely to serve as a valuable resource for policymakers and practitioners at all levels to advance the development and implementation of effective awareness preservation tools in a range of settings.

References

ICRP (2013), *Radiological protection in geological disposal of long-lived solid radioactive waste*, ICRP Publication 122, Ann. ICRP 42(3).

Joyce, R. (2020), *The Future of Nuclear Waste: What Art and Archaeology Can Tell Us about Securing the World's Most Hazardous Material*. New York; online edn, Oxford Academic, 18 Mar. 2021, https://doi.org/10.1093/oso/9780190888138.001.0001, accessed 2 May 2023.

Massart, C. (2010), *Cover,* Exhibitions International.

MEAE (2023), *KYT2022 Finnish Research Programme on Nuclear Waste Management 2019–2022 Final Report*, Ministry of Economic Affairs and Employment of Finland Helsinki, https://julkaisut.valtioneuvosto.fi/handle/10024/164868.

NEA (2022), "Intergenerational connections in radioactive waste management: Involving children and youth", OECD Publishing, Paris, www.oecd-nea.org/jcms/pl_61421.

NEA (2012), *Methods for Safety Assessment of Geological Disposal Facilities for Radioactive Waste*, OECD Publishing, Paris.

NEA (2019), *Preservation of Records, Knowledge and Memory Across Generations: Final Report of the RK&M Initiative*, NEA No. 7421, OECD Publishing, Paris, www.oecd-nea.org/jcms/pl_15088.

NEA (2018), "Preservation of Records, Knowledge and Memory Across Generations - Reference Bibliography", OECD Publishing, Paris, www.oecd-nea.org/jcms/pl_19858.

Rindzevičiūtė, E. (2023), *The Will to Predict. Orchestrating the Future Through Science*, Cornell University Press, New York.

Agenda of the workshop

Tuesday, 22 November 2022

Master of Ceremonies: *Robbe Geysmans, Sociologist, Belgian Nuclear Research Centre (SCK CEN), Belgium*

09:00-09:15 **Opening remarks**

Rebecca Tadesse, Head of Division, Radioactive Waste Management and Decommissioning (RWMD), Nuclear Energy Agency (NEA)

Martin Kunze, Founder, Memory of Mankind, Austria; Chair of the NEA Expert Group on Awareness Preservation (EGAP)

Introductory Session: Where do we stand?

09:15-10:50 **Building bridges between the Forum on Stakeholder Confidence (FSC) and EGAP**

Pascale Künzi, Specialist for Stakeholder Involvement, Swiss Federal Office of Energy (SFOE), Switzerland

Communication and stakeholder engagement for radioactive waste disposal: IAEA approach

Irena Chatzis, Communication Officer, Department of Nuclear Energy, International Atomic Energy Agency (IAEA)

Belgian partnerships: Aspects of living memory

Kris van Dijck, Member of Parliament; Mayor of Dessel, Belgium; Chair of STORA & Mark Loos, Member of MONA

Results of the OECD-NEA RK&M Initiative (2011-2019)

Stephan Hotzel, Scientific Officer, Federal Office for the Safety of Nuclear Waste Management (BASE), Germany

Knowledge management in European Joint Programme - EURAD

Niels Belmans, EURAD Representative; SCK CEN Academy Project Leader, Belgian Nuclear Research Centre (SCK CEN), Belgium

10:40-11:10 *Coffee Break*

Session 1: Awareness preservation processes at nuclear heritage sites

Chair: *Benjamin Offen, Scientific Officer, Federal Office for the Safety of Nuclear Waste Management (BASE), Germany*

11:10-13:00

Japanese memorial awareness and efforts for the future

Ayako Araki, Nuclear Waste Management Organization of Japan (NUMO), Japan

Archives and artifacts – Long-term preservation at the Nuclear Decommissioning Authority

Michelle Donoghue, Information Governance Manager, Nuclear Decommissioning Authority (NDA), United Kingdom

Tabloo - A unique visitor and meeting centre in the Campine

Anne-Lize Kochuyt, Coordinator, Tabloo Visitor Centre, Belgian National Agency for Radioactive Waste (ONDRAF/NIRAS), Belgium

The evolution of community engagement leads to the ongoing provision of public services at the remediated Fernald Preserve, Ohio, Site (United States)

Brian Zimmerman, Site Manager, Office of Legacy Management, Department of Energy (DOE), United States

13:00-14:15 *Lunch*

Keynote Session

14:15-15:00 **Things that last – Humanising how we think about persistent materials**

Rosemary A. Joyce, Interim Director of Global, International, and Area Studies; Distinguished Professor of Anthropology, University of California, Berkeley, United States

Session 2: Existing regulatory approaches in awareness preservation and key challenges

Chair: *Rebecca Tadesse, Head of Division, Radioactive Waste Management and Decommissioning, Nuclear Energy Agency (NEA)*

15:00-16:00 **Marking of a repository and stakeholder interaction - The Swiss case**

Felix Altorfer, Head of Waste Management Division, Swiss Federal Nuclear Safety Inspectorate, Switzerland

Combining documentary provisions required by the regulation and societal interactions to create a robust system for memory and knowledge transmission

Jean-Noël Dumont, Senior Advisor and Programme Manager, Memory for Future Generations, National Agency for Radioactive Waste Management (ANDRA), France Florence Poidevin, Programme Manager, Memory for Future Generations, National Agency for Radioactive Waste Management (ANDRA), France

Post-closure related responsibilities and plans of licence holders and authorities in Finland on knowledge and awareness preservation

Sami Naumer, Research Scientist, VTT, Finland

16:00-16:30 *Coffee Break*

16:30-17:40 **They do things differently in Finland - Exploring the Finnish approach to awareness preservation**

Petri Paju, Adjunct Professor, University of Turku, Finland

Information and knowledge preservation over generations in a regulatory context

Carl Henrik Pettersson, Investigator, Swedish Radiation Safety Authority, Sweden

Wednesday, 23 November 2022

Session 3: Approaches for the unknown future

Co-Chairs:

Pascale Künzi, Specialist for Stakeholder Involvement, Swiss Federal Office of Energy (SFOE), Switzerland; Morgan Packer, Specialist, Radioactive Waste Management and Decommissioning, Nuclear Energy Agency (NEA)

09:00-10:45

Sound mapping project and the nuclear material archive
Daniel Beck, PhD Student, London College of Communication, United Kingdom

Markers that convey a message: Communicating with future generations
Arne Berckmans, Project Manager, ONDRAF/NIRAS, Belgium

Magazine of the century – A communication experiment
Barbara Habermacher, Documentalist, Nagra, Switzerland

Nuclear heritage: Material practices anticipating and resourcing distant futures in the present
Gabriella Katalin Ivacs, Head of Section, Archives and Records Management, IAEA

"Marking" the Australian nuclear fuel cycle as future cultural and environmental heritage
N.A.J. Taylor, Alfred Deakin Postdoctoral Research Fellow, Deakin University, Australia

10:45-11:15 *Coffee Break*

Session 3: Approaches for the unknown future (continued)

11:15-13:00

How to create specific storages to preserve radioactive heritage objects?
Thomas Beaufils, Lecturer, University of Lille, France

Art and intergenerational knowledge transfer
Ele Carpenter, Professor, Umeå University, Sweden

Memory of mankind
Martin Kunze, Founder, Memory of Mankind, Austria

Future generation potential information needs
Carl Henrik Pettersson, Investigator, Swedish Radiation Safety Authority, Sweden

Consciousness of the landscape
Cécile Massart, Artist-Researcher, Belgium

13:00-15:00 *Lunch Break & Interactive Visit to Tabloo's Exhibition*

Session 4: Conceptualising remembrance across generations

Co-Chairs:

Cornelius Holtorf, Professor and UNESCO Chair on Heritage Futures, Linnaeus University, Sweden; Anders Högberg, Professor, Linnaeus University, Sweden

15:00-16:15 **Memory and time – Reflecting on remembrance and narrating the past**
Carina Green, Lecturer in Sociology, Örebro University, Sweden

History or heritage? Understanding cultural processes over time
Cornelius Holtorf, Professor and UNESCO Chair on Heritage Futures, Linnaeus University, Sweden

16:15-16:30 *Coffee Break*

16:30-17:40 **Orchestrating nuclear futures: Lessons from the history of scientific prediction**
Egle Rindzeviciute, Lecturer, Kingston University, United Kingdom

Futures literacy – Why it matters for passing on information on high level radioactive waste to future generations
Anders Högberg, Professor, Linnaeus University, Sweden

Thursday, 24 November 2022

Next steps for awareness preservation

09:00-09:20	**Nuclear message** *Martin Kunze, Founder, Memory of Mankind, Austria*
09:20-09:30	**Introduction to roundtable discussion** *Pascale Künzi, Specialist for Stakeholder Involvement, Swiss Federal Office of Energy (SFOE), Switzerland* *Robbe Geysmans, Sociologist, Belgian Nuclear Research Centre (SCK CEN), Belgium*
09:30-09:50	*Coffee Break & Break out into discussion groups*
09:50-11:50	**Next steps for awareness preservation – A roundtable discussion** *Group discussions and interactions on key topics related to awareness preservation on radioactive waste management, such as:* - *Why preserve?* - *What to preserve?* - *Who should be involved?* - *Where and how should preservation take place?* - *What are the crucial next steps?*
11:50-12:00	**Closing remarks** *Martin Kunze, Founder, Memory of Mankind, Austria*
12:00-13:30	*Lunch*

EGAP Workshop site visit
24 November 2022

13:30-16:30 **Site visit to HADES Underground Research Laboratory (URL)**

HADES is the oldest underground laboratory in Europe, located in the boom clay at a depth of 225 metres. HADES URL plays a central role in research into the safety and feasibility of geological disposal of radioactive waste, where experts use it to develop and test industrial technologies for building, operating and closing a waste repository in deep clay.

Due to capacity limitations underground, the site visit was limited to 30 participants on a first-come, first-serve basis.