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INFORMATION AND MEMORY FOR FUTURE DECISION MAKING - Radioactive waste and beyond.

A vision and discussion document on preserving information and memory over centuries and millennia in the context of sustainable development and the future human environment.

Abstract

The present text serves as a vision document helping start a broad-based reflection in Sweden and elsewhere on how to aid future generations maintain or regain awareness of some of the most relevant environmental legacies that they will inherit – notably nuclear waste. The document will provide a basis for discussion at a workshop being planned in Stockholm, 21-23 May 2019 on understanding and improving practices for preserving information and memory of projects that may entail long-term legacies for land use and the future human environment.

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1. Introduction

Sustainable development has been defined in many ways. The most frequently quoted definition is from the United Nations report "Our Common Future", also known as the Brundtland Report[1]. *"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."* One of the needs that future generations will have to meet is to make knowledgeable decisions, specifically concerning environmental legacies inherited from the past.

Current activities whose consequences will constitute a legacy for many generations include the management of various types of wastes. Nuclear waste is often pointed out to as an icon. Can it be managed safely for periods of time that may exceed 100 000 years? The management of hazardous materials of indefinite life-span, like dioxins and heavy metals, is another example of projects and legacies that have very long-term implications and for which similar questions may be asked. The disposal of some biological materials, like anthrax, also constitutes a long-lasting legacy. Even if current management approaches may not require human beings' continued attention or presence, ought we not facilitate the task of dealing with those legacies, if that is what future societies may want or need?

While the future is uncertain, it is quite certain that, in the future, at one time or another, institutional systems will be different, that major societal disruptions will take place, that values will be other than today's, that funds will either be unavailable or will be apportioned differently, and that information and memory are more likely lost than kept. We cannot prevent those changes from happening, we can however seek to develop and implement strategies that maximize future society's chances to make their own decisions based on exploitable information.

Concerning preservation of information and memory of current activities and their legacies we could ask:

- Should "enabling future generations make knowledgeable decisions about past environmental legacies" be recognized as a sustainable development goal?
- What could or should be done now to increase the chances that information and memory will survive for as long as practicable?
- Who would bear the responsibility? Who would carry out the task?

The present document is about helping start a broad-based reflection in Sweden and elsewhere on how to aid future generations maintain or regain awareness of some of the most relevant environmental legacies that they will inherit – notably nuclear waste. Such reflection would also identify difficulties and potential conflict of interests, and it would target achievements and potential paths forward. This reflection is timely in Sweden, in that the Swedish government is in the process of deciding about a repository for final disposal of spent nuclear fuel to last 100 000 years and the question is on the table on how to pass on information – what, by and to whom - about the final repository (see Box 1). A similar, deep underground repository for the indefinite isolation of mercury-tainted and other processing waste is slated to be operating shortly (see Box 2) and an underground repository for short-lived low- and intermediate-level radioactive waste is already in operation (see Box 1).

[1] http://www.un-documents.net/our-common-future.pdf

At the same time, according to the Swedish Geological Survey, "there are about 80,000 potentially or confirmed contaminated areas in Sweden. Approximately 1,300 of these are assessed to entail very great risks to human health or the environment and probably require measures." [2] When they will be remediated, the polluted soils will be disposed of in a number of deposits that will be constructed all over the country[3]. How then to ensure that future generations will remember that these places must be considered to be off-limits for housing, play grounds etc.? Besides, will all of these deposits function as planned? In this case too, the need arises to conceive an information and memory preservation strategy that will support future generations to make knowledgeable decisions, e.g., on land use.

The present text takes advantage of national and international thinking in the field of records, knowledge and memory (RK&M) preservation[4], including the findings of a recent, eponymous international project dealing more specifically with radioactive waste [1]. Nuclear waste, whose literature on the RK&M preservation subject is fairly large and recent [2], can act as a useful trigger for better understanding the wider questions at hand as well as suggest possible strategies and tools.

The present text also serves as an introduction and a vision document for a workshop being planned in Stockholm, 21-23 May 2019 on understanding and improving practices for preserving information and memory of current projects that may entail long-term legacies for the future human environment and land use. Intention is continue to circulate the text in the group that is currently organizing the workshop and update it as needed. Ideally, the final document will become the basis for additional development in the coming years both in Sweden and elsewhere.

During the last decades the issue of RK&M preservation has moved up on the agenda in Sweden and in other countries. Eventually, this may create a critical mass towards strengthening and enlarging current practices in records, knowledge and memory preservation in the context of sustainable development and the human environment for the benefit of future generations.

[2] Swedish Geological Survey, see page on contaminated areas at https://www.sgu.se/en/physical-planning/contaminated-areas/ (as of October 2018)

[3] Bodil Liedberg Jönsson, Personal communication

[4] Ideally, the terms records, knowledge, memory as well as other terms are defined. This is done in [6]. They are used rather more freely in this text in order not to be pedantic and to serve the needs of multiple audiences.

Box 1: *NUCLEAR WASTE IN SWEDEN*

In Sweden, today, 40% of the electricity is generated from nuclear power. [16] According to the Act (1984:3) on Nuclear Activities, the reactor owners bear the full technical and financial responsibility for ensuring that the Swedish radioactive waste and spent nuclear fuel are managed, and finally disposed of, in a safe manner. The Swedish Nuclear Fuel and Waste Management Company (SKB), owned by the nuclear industry, has the task to fulfil that mission.

The short-lived low- and intermediate-level waste is regularly disposed of in the existing, final repository (SFR) in Forsmark along with Swedish waste from the use of radioisotopes in medicine, research and industry. The spent nuclear fuel is stored at a central interim storage facility (the Clab) in Oskarshamn. A specially designed vessel, m/s Sigrid, assures the transportation of the various waste types from the nuclear power plants to the waste facilities. SKB issues a Research, Development and Demonstration program report every three years and submits it to the nuclear regulator, SSM, and the Government. The most recent report was published in 2016.

SKB´s method for final disposal of the spent nuclear fuel is known, since the early 1980s, as KBS-3. It involves encapsulating the spent nuclear fuel in copper canisters that are to be placed in deposition holes drilled in the floor of a system of tunnels located in bedrock about 500 metres below ground. The gap between the deposition holes and the copper containers is filled with a bentonite buffer. Later, the tunnels themselves will also be filled, including with bentonite blocks. The purpose of the three barriers (canister, bentonite and rock) is to maintain a stable environment around the spent fuel and isolate the radionuclides in the fuel from the biosphere. This project is now undergoing licensing.

In December 2017, after its main licensing hearing, the Land and Environment Court indicated that the aspect of memory keeping and communication with future generations ought to be developed further. Other Swedish institutions as well as the municipality of Östhammar, where the repository would be located, have expressed a similar view during the national consultation. SKB shares the opinion that a Swedish strategy needs to be developed and implemented and that the approach should involve other interested parties and should include a variety of mechanisms. The same viewpoint has been expressed internationally, notably by the RK&M project of the OECD\NEA, of which SKB, SSM, and Sweden National Archives are members and the Swedish National Waste Council is an observer.

Box 2: *INDEFINITE DISPOSAL OF SMELTING WASTE IN SWEDEN*[5]

In Sweden, the Boliden company is currently building the first deep repository worldwide specifically for mercury-tainted waste from smelting operations. Other processing waste from the smelting operations will also be disposed of in the same repository.

The repository is being built at 330 meters depth beneath the Boliden Rönnskär smelter. Operation may start by the of end of 2019 or the beginning of 2020.

[5] Information taken from https://www.boliden.com/news/Deeprepository (Sept. 2018)

2. "Future" is not yet a professional skill

Laws and regulations are issued with no time limit, awaiting to be replaced by new laws and regulations. Dams, harbors, bridges are constructed with no time limitation, yet it is known that they will have a limited life-span. Their safety will require ongoing attention and maintenance. Nuclear power was built without a previous strategy for long-term management of its waste. Today, the credo of any benevolent society towards dealing with its legacies is: *create, then maintain till the next generation; leave it to the future to do the same*. Amongst all possible futures, the choice is made in favor of a future that repeats itself, in which the relevant institutions and individuals would display a similar benevolent attitude and would have the knowledge, the records and the financial means to act further. This vision of the future as a rolling present, however, is highly uncertain over timescales stretching hundreds of years, let alone for thousands of years, as is the case for radioactive waste and other legacies. Present intentions may well go unfulfilled in a long-term perspective.

The "future" is, in reality, a combination of succeeding futures states, each one prevailing with their own characteristics over certain periods of time. The transitions between these states may be long and subtle and may have an overall disruptive effect. In this sense, the "future" is a concept that is yet unexplored both in terms of RK&M preservation and for professions, such as heritage management, that are meant to conserve objects and knowledge of the past for the benefit of future generations. "Future" is not a work skill, yet, and it is *not* systematically developed and linked to management practices in those professions. Present-day heritage management practices may well prove less beneficial to the future than they actually could. [3] In particular, the assumption is currently made that the information that will be made available will also be sufficient and it will be as intelligible to people in the future as it was to those who left it originally or to those who re-worked it in the intervening time. For a variety of causes – natural and/or human[6,7] – archives may disappear or be insufficient, records enabling the memory of why certain decisions were taken may be lost, the information still existing may not be intelligible, and funds may no longer be available for performing whatever action may be needed. (see also Box 3 for terminology)

Box 3: *CONSERVATION VS PRESERVATION*

In preparing this text, we had to wrestle with two words, "conservation" and "preservation", respectively, that both describe actions in preparing for the future.

Conservation has a sense of keeping the original in as pristine conditions as possible; preservation has the additional sense of keeping the original purpose alive or facilitating new uses. Preservation includes conservation-practices; conservation does not include all preservation practices.

For instance, we may restore and conserve a book. Yet we may preserve its memory by more than just conserving the book, e.g., we may also place a copy in another place for others to use. Similarly, we "preserve" fish, pork, fruit by drying, salting, cooking but do not "conserve" the original specimens. Conservation applies when conditions are expected to be stable or not varying significantly, preservation is about strategizing and preparing to face important changes.

[6] See C. Jacobs' "*Archival and museum curatorship challenges for RK&M Preservation"* in [7].

[7] At the time of writing of this document we have witnessed the burning down of Brazil's National Museum with the loss of 20 million artifacts. "Some items in the collection are irreplaceable to science, as well as the country's national memory." (J. Gorman, in New York Times, 4 September 2018)

3. Building a repertoire of knowledge and options

Creating a repertoire of available options and knowledge can help identify and develop more durable information and memory preservation practices across the spectrum of likely or possible future states. The RK&M project of the OECD has provided numerous studies to that effect. [1][4] Their findings can be generalized beyond radioactive waste.

Overarching finding is that:

- *There is no single mechanism or technique that, by itself, is likely to achieve the preservation of RK&M across the many futures that are possible over centuries and millennia.*
    - Rather, in order to maximize the chance of survival over the various timescales that are involved, a multi-faceted approach needs to be formulated that incorporates different tools and mechanisms ranging from technical to administrative to societal provisions.
    - This multi-faceted approach should be constructed based on two modes of memory transmission: one that is based on the presence of direct intermediaries between generations, and one that would work in the absence of any such intermediaries. The two modes are described as "mediated" and "non-mediated" transmission.
    - Figure 1, reports 7 classes of possible tools or mechanisms. Namely: archives, libraries, time capsules, markers, cultural heritage, international mechanisms, and (technical) oversight provisions. Figure 1 also reports timescales for best expected efficacy of each tool as well as whether they serve the purpose of **R**ecord, **K**nowledge, or **M**emory preservation or of arousing **A**wareness **U**pon **D**iscovery. The figure also indicates whether each tool is more relevant to mediated (**M**) or to non-mediated transmission (**NM**).

Other findings include:

- *In the context of any long-term legacy – such as radioactive waste disposal – the goal is to preserve information to be used by future generations to maintain technical and societal oversight of the legacy for as long as practicable and to regain oversight, should there be a break in "watchful care".*
    - Oversight is a synonym for "watchful care". It refers to society "keeping an eye" on the technical system used for the legacy and on its past implementation of plans and decisions. This concept provides a useful framework to view technical monitoring activities and societal engagement as parts of a unified whole. [18]
    - Oversight may take many forms and be a combination of several mechanisms. For instance, it could combine regulatory supervision, independent monitoring of pathways for radionuclide release, active preservation of archival information, societal awareness through cultural heritage such as lore and local history societies. Several technical oversight mechanisms are identified in Figure 1. The connection between oversight and monitoring is explored in [18,19]. See also Box 4 on the concept of Heritage Value.
    - The concept of oversight, was adopted by the International Commission on Radiological Protection (ICRP) from the Retrievability and Reversibility project of the NEA. [18] According to the ICRP and to the NEA Committees on Radioactive Waste Management Committee and Radiation Protection and

Public Health [20], concerning the repository legacy, it ought not be planned to cease oversight, whereas the potential loss of oversight needs to be anticipated and planned for[8].

Box 4: *MEMORIALIZATION BY CREATING HERITAGE VALUE*

One way to keep memory alive is not to hide the various legacy sites, but make them part of the cultural heritage of the region, so that a durable a durable relationship is built between these projects and the host community or region. [17] Creating heritage value is about creating a durable relationship through projects that are "owned" by the community across generations.

Heritage Value comes from injecting elements that favor memorialization of a project or legacy such as, amenity, multi-functionality, re-use, etc. in tune with the vision that the community or region holds of itself and of its aspiration. Heritage is also created when the societal structures that were formed to accompany the project create a dynamic that can be relied upon for later projects.

The Eiffel Tour provides one example of what "heritage value" may mean. Namely, across generations, the Eiffel Tour symbolizes the achievements of the human intellect; lends itself to multiple uses, e.g., telecommunications and tourism; it has aesthetic value; it brings permanent luster - besides jobs and revenues to its region; it has national and international appeal. Classical benefit packages and infrastructure typically associated to technical projects do not include the Heritage Value component.

Heritage Value should be recognized as important from the start of a project, and it is best built in with the help of the host community or region. Which are then the elements that could be identified as bringing heritage value? Are these elements expensive components of a project? How to create interactive structures around a project and dealing with Heritage Value? Which are examples of existing projects where Heritage Value has been brought in? Which could be counterindications to creating Heritage Value? Can the introduction of Heritage Value help meet some of the Targets of UN Agenda 2030?

The aspect of fostering a durable relationship through Heritage Value (Added Value in NEA terminology) was introduced and developed by the NEA/OECD Forum on Stakeholder Confidence in the area of radioactive waste management. [13] Time capsules, mentioned earlier in this text, could also be conceived to create Heritage Value [4] [14].

[8] The international support in favor of uninterrupted oversight and of RK&M preservation provisions in the field of radioactive waste disposal is outlined in three important documents issued between 1997 and 2014. See [4]

- *The knowledge we currently have in society is not geared towards understanding and dealing with the longer term*.
    - The terminology used for contemporary activities is not necessarily appropriate for use for the long-term. [5] In order to ensure consistent terminology in their own documentation, the RK&M project developed its own reasoned glossary.[6] This may be of example to others.
    - Dividing up the future in a number of time-scales or periods is a useful technique for debating relevant preservation issues, i.e., for determining for how long certain tools may be best relied upon. [4]
    - The RK&M project divided the future into 3 reference periods, referred to as short-, medium-, and long-term. The successful Verdun conference [7] of 2014, which has been the largest and most important gathering on RK&M so far, was structured along those different time-scales. Figure 1 attributes each identified tool to one of those timescales.

- *There exist a number of international mechanisms that can foster memory preservation, possibly for hundreds of years.*
    - Several classes of international mechanisms are identified in Figure 1.
    - Eleven international mechanisms –- set up either through the United Nations Educational, Scientific and Cultural Organization (UNESCO), or the United Nations Economic Commission for Europe (UNECE), or the International Atomic Energy Agency (IAEA) or the European Commission (EC) – have been specifically analyzed [8] from the viewpoint of radioactive waste disposal.
    - As an example from the RK&M preservation sphere, Germany utilizes the Hague convention to protect its "Barbarastollen" underground archive containing the ultimate documentation of German cultural heritage. The entire Barbarastollen complex is buried under 400 meters of rock. It is intended to survive a nuclear war. It is estimated that its contents should survive on their own for at least 500 years without any serious damage.
        - Barbarastollen is one of only five such sites worldwide, the others being the Vatican City and three refuges in the Netherlands[9].

- *The regulatory aspects of long-term RK&M preservation are much in need of formulation and systematization.*
    - Transfer of responsibilities is an important area deserving attention. [9] Typically, much information is lost when responsibilities change, both during the course of a project and when the project ends and other institutions, with a new mandate, take over.

- *The period of time of a few centuries that will follow the end of a project – such a repository closure – is rarely specifically addressed in the memory preservation literature*
    - This may be an example of over-reliance on the "rolling present" approach. (see also previous point on regulation). The "Barbarastollen" example above represents its antithesis.

[9] See German or English Wikipedia on Barbarastollen.

Figure 1, dating from 2015, usefully summarizes the above findings in tabular form. The reported list of 7 classes of RK&M tools needs enlarging and updating. For instance, "museums" are missing as a tool, and they should be added to the list [10], perhaps in their own category. A list of 9 classes tools is being released by the RK&M project in 2019 (see Box 5).

Once the full range of tools have been identified, their role vis-à-vis one another could be charted and an optimal path chosen in order to maximize chances for survival. An example of these charts, looking at the period beyond a few hundred years, is provided in Figure 2. Figures 1 and 2, together, point to time capsules as a possibly important, new tool for RK&M management and preservation over the long term. (see also [4], [14]) "Barbarastollen", mentioned above, may classify as a "time capsule".

Box 5: *UPDATE OF MEMORY PRESERVATION TOOLS*

The NEA RK&M initiative is about to release its final report [21] with an updated list of 9 classes grouping 35 mechanisms. Memory institutions (archives; libraries; museums). Namely:

1. Markers (both above and below the surface)
2. Time capsules (both with and without opening strategies)
3. Culture, education and art (e.g. cultural heritage; alternative reuse of the disposal site; education, research and training; works of art)
4. Knowledge management (e.g. knowledge retention tools; knowledge sharing philosophy)
5. Oversight provisions (monitoring; clear and planned responsibilities; land use controls)
6. International mechanisms (e.g. international regulations and agreements; international inventories and catalogues)
7. Regulatory framework (national regulatory framework; safeguards)
8. Dedicated record sets and summary files

The first 8 classes and mechanisms recall those of Figure 1 in this document. The 9th class, "Dedicated record sets and summary files", identifies two new mechanisms developed by the RK&M initiative itself. They are

- Set of Essential Records or SER – a unique set of records, selected during the repository lifetime, together aimed at providing sufficient information for current and future generations to ensure an adequate understanding of the repository system and its performance.
- Key Information File or KIF – a single document, produced in a multidisciplinary and participatory manner, intended to inform present and future stakeholders without specialized knowledge.

Figure 1. Classes of RK&M tools; the transmission mode they serve best; whether these tools are more fit for records or knowledge or memory transmission or for arousing awareness upon discovery; the reference period of time for their efficacy. (see Ref [4])

Class of RK&M tool	RK&M tool	Mostly Mediated (M) or Non-mediate (NM)	Records (R), Knowledge (K), Memory (M), Awarness upon discovery (AuD)	Short (ST), Medium (MT), Long (LT) Term
Archives	National archives	M	R	ST, MT, LT
	Regional/local archives	M	R	ST,MT
	Land registries	M	R	ST,MT
	Specialized archives	M	R	ST,MT
Libraries	National library	M	R	ST,MT
	regional	M	R	ST,MT
	academic	M	R	ST,MT
	others	M	R	LT
Time Capsules	Large size, visible	NM, M	R,K,M	MT, LT
	large size, non visible	NM, M	R,K,M,AuD	MT, LT
	Small size	NM	R, AuD	MT, LT
Markers	Surface traces	NM	AuD	MT, LT
	Surface markers	NM	M	MT, LT
	Sub-surface markers	NM	AuD	MT, LT
	Monuments	NM	M	ST, MT, LT
Cultural heritage	Local cultural heritage	M	M	MT, LT
	Regional Industrial heritage	M	M	ST, MT, LT
	International Heritage	M	M	ST, MT, LT
	Traditions and rituals	M	M	ST, MT, LT
	Local history and enactement societies	M	M	ST, MT, LT
	Endowed Unv.. Chair	M	R,K,M	ST, MT
International mechanisms	For controlling radwaste and materials	M	R,K,M	ST, MT
	For sharing knowledge on geology	M	R,K,M	ST, MT
	Related to environmental protection	M		ST, MT
	Related to cultural heritage preservation	M	R	ST, MT
Oversight provisions	Monitoring	M	R,K,M	ST,MT
	intermittent safety reviews	M	R,K,M	ST
	Transfer of responibilities	M	R,K,M	ST
	Updating key repository documents	M	R,K,M	ST
	Training of personnel	M	R,K,M	ST
	Land use restrictions	M	R,M	ST
	Placing signs on maps	M	M,AuD	ST

Figure 2: Example of a relationship table between RK&M tools in the long-term period. Tools may be redundant, reinforcing, independent or supporting one another (see Ref [4])

Class of tool → Tool		Archives	Libraries	Time Capsules			Markers				Cultural heritage				
		National archives	Long term (religious, ...)	Large size, visible	Sub-surface, large size	Small size at depth	Surface traces	Surface markers	Sub-surface markers	Monuments	Local cultural heritage	Regional Industrial heritage	International Heritage	Traditions and rituals	Local history and enactement societies
Archives	National archives		C	R	R	S	S	S	S	S	S	S	S	S	C
Libraries	Long term (religious, ...)	C		S	S	S	S	S	S	C	C	S	S	R	S
Time Capsules	Large size, visible	R	I		R	S	S	S	S	S	I	I	I	I	I
	Sub-surface, large size	R	I	R		S	S	S	S	S	I	I	I	I	I
	Small size at depth	C	I	S	S		I	I	I	I	I	I	I	I	I
Markers	Surface traces	I	I	I	I	I		I	I	I	I	I	I	I	I
	Surface markers	I	I	S	S	I	I		S	S	I	I	I	I	I
	Sub-surface markers	I	I	I	I	I	I	I		I	I	I	I	I	I
	Monuments	S	C	S	S	I	I	I	I		I	I	I	I	I
Cultural heritage	Local cultural heritage	I	C	S	S	I	S	S	S	S		S	S	S	S
	Regional Industrial heritage	I	S	S	S	I	S	S	I	S	S		S	S	S
	International Heritage	C	S	C	C	I	S	S	I	S	S	S		S	S
	Traditions and rituals	I	R	I	S	I	I	S	I	S	S	S	S		S
	Local history and enactement societies	C	S	S	S	S	S	S	S	S	S	S	S	S	

R = Redudancy: When the two strategic components contain redudant records
C = Reinforcing: when the two strategic components contain different records providing similar or complementary information
S= Support: When one of the two strategic components may point to the other one
I = Independent: When one of the two strategic components likely does not relate to the other one

4. Questions and sub-questions for debating and developing further

Based on the previous sections, a number of questions are identified for further debate. They are divided in 3 categories:

Principles

- Do we agree that enabling future generations to make informed and knowledgeable decisions is a valid sustainable development goal in the context of the protection and use of the future human environment?[10]
    - Namely, do we agree to the statement that "The future belongs to all, and all interested parties should do their part in preserving options and freedom of choice for future generations in dealing with past legacies. Freedom of choice rests on access to intelligible records, exploitable knowledge and renewed memory of past actions and decisions. Institutional and non-institutional players should determine and communicate their role in preserving RK&M and take relevant, coordinated actions".
    - Ought this *new* goal not be added to the already existing principles, e.g., those in the UN "Agenda 2030" [12]?

- Do we agree with the recommendations to preserve awareness about any long-term

[10] This goal is recognized as an important principle in the nuclear waste literature. See [11]

legacy?
    - May this principle be formulated in law, e.g., a requirement that oversight of a repository legacy and of any other long-term legacy should not be relinquished?
    - Why not just "dropping the key"? What issues may arise if memory was lost, e.g., if we un-forget a specific risk or remember a potential asset?

Overarching questions

- Is it agreed that, when it comes to memory preservation and survival, that – taken only on its own – the current "rolling present" approach may not be a fully reliable means to deal with the future? To whom should this finding be communicated?
    - Sometimes mechanisms exist to maintain awareness, e.g., the safeguards agreements to protect spent fuel from being diverting to non-peaceful uses. In those cases, do these mechanisms go beyond the rolling-present approach? Also, to what extent should these mechanisms be shrouded in secrecy?
- Is the memory topic, especially concerning future environmental legacies, sufficiently addressed in law and regulation?
    - Who is responsible, e.g., in Sweden, for a specific legacy after the activity leading to it has ended? Is it sufficient to say "The State"?
    - For each specific legacy how to identify the relevant actors that will influence how information is going to be passed on to the future? Do these actors include only "institutional" actors or also society at large?
    - How can these actors be structured? Who would do what and with which authority and funding?
    - How to come up with the right questions in updating current law and regulation? How to open discussions with all stakeholders?
    - Is stewardship an option for the long-term? Which are the commonalities and differences between the concepts of stewardship, perpetual care and oversight (see Section 3 above)? Do they apply equally to all types of environmental legacies?
- Do host communities and municipalities, as well as host regions, accept that they also could have a local role to play in informing future generations on certain decisions made today, on what the subsurface of their community may conceal, etc.?
- Should the relevant actors not clarify their intentions regarding the future, i.e., over the next decades, centuries and beyond?
    - Which are their expectations? Which are the target audiences? What kind of solutions do they entail?
    - How robust is the system, e.g., one day when responsibilities may be shifted to others?
    - What kind of changes in current practices and management culture would these intentions entail?

Practical questions

- How to build up a reference repertoire of options and relevant knowledge that could be used to improve current management practices within institutions dealing with "the future" and that would support oversight of environmental legacies over centuries and millennia?
    - What is the significance in this context of cross-sectoral collaborations and partnerships between different public, public-private and civil society bodies in

society? How can very different players become partners and learn from each other?

- Is it sufficient to just pass large amounts of non-structured documentation to the archives?
    - What would need archiving?
    - How to structure the information to be passed on to future generations?
    - Are current archiving guidelines good enough for maintaining not only written documentation but also other records such as software tools and hard samples[11]?
    - Would it not be useful to select and/or produce specific documents, taking as well the different readerships into account[12]? Who would make this selection?
    - Who would keep updating the information both for content and to ensure that it stays intelligible?
    - Should consideration be given to setting up a national platform to be collecting and discussing issues?
- What if a rolling present is not realized? Which RK&M preservations strategies could cope with that? On which time scales?
- Which are the identified main preservation issues and potential solutions?
- Would it not be wise to connect institutional records keeping with knowledge and memory preservation by society, so that society at large may also exercise some form of oversight?
- What is the expected role of non-institutional actors, e.g., host municipalities?
    - Is local archiving the only, or the good, solution?
    - Is local archiving coordinated with other levels of archiving, notably with the national archives?

5. Guiding principles and practical goals

The May 2019 workshop in Stockholm could become the venue for formulating and communicating a chart of guiding principles and practice goals to inform future work in the area of RK&M preservation in connection with legacies that present society may bequeath to future generations. A draft future chart, modelled on [11], is suggested as follows:

Principles

- Enabling future members of society to make their own informed and knowledgeable decisions is part of responsible, ethically sound management of environmental legacies in the context of sustainable development. It is also in line with a prudent approach regarding safety.
- The future belongs to all, and all interested parties should do their part in preserving options and freedom of choice for future generations when dealing with environmental legacies that will be transferred to the future.
- Freedom of choice rests on access to intelligible records, exploitable knowledge and renewable memory of past actions and decisions.

[11] The analysis of the Yucca Mountain archiving is an interesting case study to this effect. [15]

[12] The Verdun conference [7] (see, p. 19) supported a rationalization of the documentation in at least three tiers. Progress in defining the topmost tier, the so-called Key Information File (KIF), is expected in the RK&M project. (see Box 5). The bottom layer is the ensemble of all documents produced in the waste disposal program with limited structuring. The intermediate tier, described as the "set of essential records" (See Box 5).

- The relevant institutions ought not to plan the ending of oversight, whereas the potential loss of oversight needs to be anticipated and planned for.
- Any strategy for the preservation of RK&M should integrate the possibility of major discontinuities in the future.

Practical Goals

- Institutional and non-institutional players should to determine and communicate their role in preserving RK&M and take relevant, coordinated actions. Ideally, law helps identify roles and goals and regulation guides practice.
    - Regulatory guidance and supervision should be developed to support RK&M preservation.
- Preparing for future RK&M preservation is best addressed while a project leading to a legacy is being designed, implemented and funded.
    - The operational phase of some of these projects creates an opportunity for the development of inclusive and workable RK&M strategies.
    - During the operational phase, institutional stakeholders must prepare for the ending phase, when their own roles will be reduced and new roles will be played increasingly by other stakeholders – especially in the area of RK&M preservation. Responsibilities ought to be determined ahead of time.
    - During the operational phase, the institutional stakeholders can facilitate the preparation and implementation of archives; administrative restrictions on land use; regular reporting by governments under one or more international mechanisms or agreements, etc.
- There is no single best means of RK&M preservation over all timescales. All available communication channels should be explored and a few retained for the final preservation strategy.
    - RK&M preservation approaches should include provisions for knowledge reconstruction and for providing information to future generations with and without requiring the involvement of intermediate generations.
    - Records will be used mostly by future members of society and attention should be given to the needs of these users in terms of facilitating readability and intelligibility, providing, in particular, relevant information on the context in which the legacy and the records were created.
    - The various components of the RK&M system should apply robust, simple and understandable techniques and support materials, and should not rely on technological provisions alone.
    - Overall, a multi-faceted approach should be formulated for the RK&M preservation of each project whereby the various components of the RK&M system complement each other, provide for redundancy and maximize the chances of survival of a recognizable and comprehensible message.
- Synergies should be sought with other societal institutions and international bodies.
    - There are important benefits to be gained from partnerships and collaborations between different players and sectors in society.
    - Agreements should be reached that are likely to survive beyond the end of the operational phase and can thus contribute to RK&M preservation.
    - A concerted approach at the international level may contribute further to the development of national strategies.
    - Synergies and lessons to be learned should be sought wider than just the specific legacy of concern.

6. Conclusions

Enabling future members of society make their own informed and knowledgeable decisions is part of responsible, ethically sound legacy management that is in line with sustainable development and the safety of the human environment. This principle ought to become another, recognized principle of sustainable development.

It turns out that even in professions that are meant to deal the future, "the future" is *not* systematically developed and linked to current management practices. Present-day heritage and memory management may well prove less beneficial to the future than they actually could. Further progress in this area should be accomplished, knowing that human activities may result in undesirable legacies that will last centuries to millennia and longer. A conceptual basis and working methodology need to be built to complement, and improve upon, the "rolling present" approach.

The field of radioactive waste management has identified an important repertoire of knowledge, which the present text has reviewed and generalized so that the broader area of RK&M management could be rationalized from a higher viewpoint. A chart of guiding principles and practical goals to inform future work is being proposed to this effect. Once reviewed, revised and accepted, these guiding principles and practical goals could become the basis for future, constructive developments in Sweden and elsewhere.

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