# Geological disposal of radioactive waste: records, markers and people

## *An integration challenge to be met over millennia*

**C. Pescatore, C. Mays***

An issue that has long been on the radioactive waste management agenda is the means of marking a waste repository site, such that future generations will be able to comprehend its purpose and risks even if written records have been lost.

For years the main reason cited for needing such comprehension was to preclude unintentional future human intrusion into the repository and the ensuing exposure of the intruder to radiation. Such a future intruder could also cause damage to the repository system and endanger his own and subsequent generations.[1] More recently, other reasons have included the wish to maintain a certain degree of flexibility for future generations, in case the latter decide to retrieve the waste for motives that may go beyond safety, e.g., the economic exploitation of the energy potential that may remain in the waste.

* *Dr. Claudio Pescatore (claudio.pescatore@oecd.org) is principal administrator in the NEA Radiological Protection and Radioactive Waste Management Division. Ms. Claire Mays (claire.mays@oecd.org) is a consultant to the NEA on stakeholder involvement and decision making.*

The conceptualisation and design of markers of records by technologists has typically focused on durability and has assumed that the repository is – and will be – something totally separate from its cultural environment. A new vision is emerging, however, that it may be worthwhile to consider the repository as part of a societal fabric. The task of maintaining memory would thus be facilitated by measures that would foster community involvement and would go as far as foreseeing that these communities will in time build their own new markers to replace old ones that have become obsolete or are fading away.

It must be understood that the timescales over which the hazard exists are much longer than just a few thousands of years, and it must be accepted that the current generation's capacity to assure continued integrity cannot be projected indefinitely into the future, but rather diminishes with time. Hence, there is perhaps the need to conceptualise a "rolling future" in which each generation takes responsibility to ensure continuity and safety for the succeeding several generations, including a need for flexibility and adaptability to circumstances as they change. The issue of archives and markers that last as long as possible (the technological approach) continues to be a topical one.[2] However physical markers and archives may also be complemented by – or integrated within – a cultural tradition that could be sustained over

time starting with the planning of a repository and continuing through its implementation and beyond its closure.

## Overarching observation

Traditional approaches to markers and institutional controls for geological disposal were based on the premise that safety was best assured by keeping the facility apart and isolated from people and the surrounding community. Active controls, for example, could be envisaged to include fences and guards that would restrict access to the site even after closure. It was acknowledged that one cannot rely unquestioningly on future generations to maintain, monitor and interact with the installation; eventually, the institutional structures supporting such controls could disintegrate. To address this contingency, geological disposal concepts are founded on the concept of "passive safety", which can function even without further intervention or maintenance. Furthermore, markers and records would be put in place with the goal to pass on knowledge of the site and its hazards. The tacit assumption, nevertheless, was nearly always that such an understanding was meant to help keep people away from the site, thereby best providing "safety".

Yet in everyday life, the concept of safety implies an element of control and familiarity. Even if continued active controls may fade away, familiarity and elements of indirect control continue to be important to safety. Because safety is related to our ability to function freely (unimpeded by fear), safety is also related to quality of life. Hence, there has been an evolution in the very concept of disposal. In addition to the traditional actions for oversight and monitoring, preservation of information in archives and passive markers, repository projects now typically also include the elements of reversibility/retrievability as well as active participation by local communities in decision making.

The extension of this trend for greater participation by local communities in making decisions implies that disposal facilities can be made part of the fabric of the community rather than operated in isolation from it – and there is a growing awareness that such integration can contribute to, rather than undermine, safety. Our understanding from stakeholder dialogue is that not only should we not hide the facility, but we should recognise that it will be a central part of a host community and its identity. Today's overarching message is very simply, "Do not hide these facilities; do not keep them apart, but make them A PART of the community."

## The technological approach: preserving information

Past work on markers and records for geological disposal have focused on the durability and preservation of information as a prerequisite for preserving knowledge and understanding. Certainly, in order to be useable, information must first exist and must already be reasonably accessible.

Records that have to last thousands of years will need renewal from time to time. Paper lasts about 1 000 years. We have the record of ancient books because these were re-copied over timescales that are compatible with the shelf life of paper. Records such as microfilm, magnetic and optical tapes are not as durable in that recording and play-back technology constantly require new supports. Who is using floppy disks these days? Hence, another message: when dealing with large timescales, the recording technology should be as basic as possible. Stone, such as "The Rosetta Stone" is another, non-paper example of "basic" technology.

Besides the challenges associated with the physical limitations of the technological media and of the readability of the information, we need to face the challenge of weathering institutional and political changes. The best strategy here is to intentionally maintain duplicate records in several sites, including internationally. The Rosetta Stone is probably an example of duplicate records. National legislations typically require archiving of repository information in multiple venues.

To fully achieve the goal of knowledge transfer to future generations, however, we must ensure not only that information is available, but also that it is understandable. This is a significant challenge. In all cases, there will be the issue of the interpretation of the information that is being provided. For instance, it takes specialists to interpret medieval inscriptions, and it took Champollion to decrypt the Egyptian hieroglyphs starting with those on the Rosetta Stone. Once again, this re-interpretation would take place quite naturally if records were renewed intermittently, as was the case for the writings in the ancient books.

As a minimum, there ought to be a strategy to maintain awareness. Partial duplicate records will be derived from other institutional sources, such as land use control records, mining archives and regulatory archives. These will offer the opportunity to triangulate knowledge.

One simple way for ensuring that awareness of the repository is widely preserved is to have it

included on maps. Maps are constantly renewed and updated and daily use is made of them. Another way is to foresee passive markers with minimum amount of information but constructed in such a way as to be evocative and to make people want to look for more information. For each repository, one may need more than just one marker as the principle of duplicate record still applies. Markers can be placed both on the surface – where people may constantly interact with them – and under the surface, to inform and/or warn off intruders in the case of excavation.[3]

Above and beyond such tangible actions as placing duplicate records in order to maintain awareness, there is a growing recognition that more cultural mechanisms – more informal but potentially self-propagating and highly persistent – could contribute substantially.

## A new central actor?

Institutions, implementers and regulators have been discussed, but where does the greatest interest lie in keeping memory alive? Who is most likely to be willing to attend to and to renew and re-interpret the records? It must be the local communities for whom the facility is a constant presence. Ideally, the facilities should be seen by these communities not as a long-standing threat but as something that belongs to the local, social fabric and requires respect, as well as a source of added value (cultural, amenity or economic).

The report of the NEA Forum on Stakeholder Confidence (FSC) entitled ***Fostering a Durable Relationship Between a Waste Management Facility and its Host Community***[4,5] explores the means by which a facility can respond to the requirement of providing added value and, with it, a basis for a continued relationship – which could extend over the centuries and millennia – with the facility and its site. Could one, for instance, memorialise the facility? If a monument could be made of it – or of its (symbolic) image – that had a distinctiveness and aesthetic quality, would this not be one reason for communities to proudly own the site and maintain it? A major question is, thus, whether the surface facility and its surroundings should become the ultimate marker of the existence of the underground repository.

In the 1st century BC, classical Roman architect Vitruvius outlined what good architecture should achieve. He stated that a structure must exhibit the three qualities of *firmitas, utilitas* and *venustas:* it must be strong or durable, useful and beautiful. These are qualities that can be sought for the radioactive waste management installation, for both the physical building structures, and for what the installation can bring to the community.

The FSC looked into designing and implementing facilities in ways that provide added cultural and amenity value to the local community and beyond. By cultural and amenity value we mean: agreeable additions to quality of life, through such features as distinctiveness, aesthetic quality, convenience and meaningfulness; through providing opportunities for residents and visitors to meet, learn, relax, enjoy; through fostering community improvements in areas like educational level, image definition or problem-solving capacity.

A number of basic design elements to foster a durable relationship between the facility and its host community were identified based on the analysis of input from 32 stakeholder contexts (interviews, questionnaires) and FSC experience. Such design elements include functional, cultural and physical features. These features tend to maximise the potential of a facility to be "adopted" by the members of the host community, by fitting in, adapting to and, moreover, contributing directly to their preferred way of life.

### *Adding value through functional, cultural and physical design features*

Function concerns the uses to which an installation may be put. The radioactive waste management facility must serve the primary purpose of ensuring safe and secure long-term management of radioactive waste. Careful multi-functional design then can add value by allowing appropriate parallel uses that are of direct interest to residents and visitors. In the same vein, while in operation, parallel uses of radioactive waste management installations may add scientific value. Zero-gravity experiments are carried out at Japan's Tono Mine underground laboratory. Laboratory facilities at Spain's El Cabril and the US Waste Isolation Pilot Plant are available for regional environmental analysis or monitoring. Additionally, when creating a new facility, it is necessary to foresee the end of its useful life. If future needs are not anticipated, there is a risk that the facility will become a liability for the community. An adaptable, flexible facility can provide enjoyment during its operation and also make possible at reasonable cost the transition to a full community facility when its industrial use is no longer needed.[5] Along with careful planning for radiological safety on site, adaptability and flexibility will leave development pathways open.

The UNESCO Universal Declaration on Cultural Diversity defines culture as "the set of distinctive spiritual, material, intellectual and emotional features of society or a social group, encompassing, in addition to art and literature, lifestyles, ways of living together, value systems, traditions and beliefs". In this way, culture may be assimilated to shared meaning and practices. Cultural value is found in arrangements that reflect and strengthen a given society's knowledge, tastes, aspirations, ethical views or beliefs. It lies in all that is meant to help to transmit an honoured legacy, to communicate symbolic meaning or to advance ideals. Amongst the cultural design features, distinctiveness may be mentioned, indicating that the facility or site is attractive and like no other, and has the potential of becoming an icon, lending a positive reputation and drawing visitors. Other cultural features include aesthetic quality and understandability, whereby the installation can be tied in with existing knowledge and related to everyday life. Memorialisation is another cultural feature, meaning that both physical and cultural markers identify the site and tell its story, so that people will grasp and remember what is there.

Technical features will provide the agreed level of protection (the primary condition set by stakeholders consulted for the FSC study). Physical design elements will help create the feeling of security (another part of what community and regional stakeholders expect). Physical design features can be combined to create harmonious integration of the installation into its geographic setting, and increase overall amenity: enhancing attractiveness and overall satisfaction. Accessibility means that the site and facility are not barricaded, but are open and welcoming. Communities like Port Hope have pointed out that if a site that is licensed to operate can be freely visited, walked through or enjoyed for other uses, it clearly must be safe. It no longer seems to impose restraints on the user, nor shuts people out in an alarming way. It accomplishes its goal of protection without emphasizing danger.

Certainly, especially during operation, each and every area of a radioactive waste management facility cannot be made open to the public. Areas restricted for the necessities of safety and security need not benefit from the same degree of functional, cultural and physical design input. Still, the radioactive waste management facility and site should be considered in a holistic manner, in order to maximise the added value that it is possible to achieve with reasonable effort.

### *Adding value through the planning and implementation process*

Local stakeholders who take an active role in site investigations, or who participate with implementers in formal partnerships, report that the very process of working out the desired features of a radioactive waste management facility and site can bring added value to the community. Social capital – networks, norms and trust – is built up, equipping the community to face other decisions and issues. Local stakeholders may also focus their work on community identity, image and profile. Even when not favourable to hosting a radioactive waste management facility, communities can use the opportunity to develop quality-of-life indicators and reflect on the direction they want to take in coming years. Other benefits that may be accrued are an enhanced educational level in the host community related to the influx of highly skilled workers. Not least important, when host communities demand training and participate in monitoring site development and operations, they are building their capacity to act as guardians and therefore ensure another layer of defence in depth.[6]

### *Early reflection is best*

It takes time to work out new ideas, new possibilities and where the communities' own interests lie. Integrative reflection on technical and socio-economic aspects, and on cultural and amenity value that could be added by a radioactive waste management facility, is best started from the very first planning stages even before final siting agreement is reached. The information, concepts and ideas gained from this reflection will form a part of the basis on which a local community may agree to become a candidate and then actively engage in the final siting stages.

Institutions generally cannot commit to the final form of a radioactive waste management facility before a specific site is agreed, nor to the ultimate fate of the facility and site. Likewise, the relationship between a community and a facility or site will depend in part upon external events (for instance, safety performance in the nuclear or radioactive waste management realm; attitudes and statements by political actors, etc.). Still, feasibility studies and social science investigations early in the decision-making process can provide meaningful preparation. Such an approach is coherent with the UNECE Aarhus Convention, which has given many European citizens formal rights to participate in decision making about their environment.

A presentation by Janet Kotra (US NRC) at the June 2007 meeting of the FSC indicated that the

mandated need to install "permanent" markers can only be fulfilled if one acknowledges that the markers themselves will evolve over time. Namely, they will become part of the local, subsequent cultures, and they will (or ideally should) be renewed as their materials are degraded, or as their significance evolves. This emphasizes again the importance of integrating the disposal system into the community: renewal (as compared to "durability") depends on future people to take action. The awareness of future people of such markers and their understanding of the meaning of the markers is more likely to persist if it is part of daily community life than if it is something kept apart, isolated and forgotten.

## Conclusions

The timescales over which the hazard exists are much longer than just a few thousands of years, and it must be accepted that the current generation's capacity to ensure continued integrity cannot be projected indefinitely into the future, but rather diminishes with time. At the same time there is a common understanding that we should not "walk away" from these facilities or conceal them, even when we think they will be safe. In fact, the sense of safety will come from continuing, over time, some element of familiarity and control – hence the need to conceptualise a "rolling future" in which each generation takes responsibility to ensure continuity and safety for the succeeding several generations, including a need for flexibility and adaptability to circumstances as they change.

The issue of archives and markers that last as long as possible (the technological approach) continues to be a topical one. However, physical markers and archives may be complemented by – or integrated within – a cultural tradition that could be sustained over time starting with the planning of a repository and continuing through its implementation and beyond its closure. The mandated need to install "permanent" records and markers can only be fulfilled if one acknowledges that these will evolve over time. Namely, they will become part of the local, subsequent cultures, and they will (or ideally should) be renewed as their materials are degraded, or as their significance evolves.

Because a radioactive waste management repository and site will be a permanent presence in a host community for a very long time, a fruitful, positive relationship must be established with those residing there, now and in the future. Simply put, designers have to make the radioactive waste management facility and site to suit people's present needs, ambitions and likings, and to provide for evolution to match at reasonable cost the needs and desires of future generations. The challenge is to design and implement a facility (with its surroundings) that is not only accepted, but in fact becomes a part of the fabric of local life and even something of which the community can be proud. Parts of the facility and its surroundings may thus become themselves welcome markers of the existence of a waste repository underground. ■

### Notes

1. This would also be the case for a large class of chemically hazardous wastes, but the issue does not seem to be a prominent one in that field.
2. See the proceedings of the workshop on "Record Management and Long-term Preservation and Retrieval of Information Regarding Radioactive Waste" held in Rome, 27-28 January 2003 (available from SKB, Sweden and the NEA).
3. See for example: T.L. Tolan, "The Use of Protective Barriers to Deter Inadvertent Human Intrusion into a Mined Geologic Facility for the Disposal of Radioactive Waste", Sand91-7097, Sandial National Labs, June 1993.
4. NEA (2007), *Fostering a Durable Relationship Between a Waste Management Facility and its Host Community: Adding Value through Design and Process*, OECD/NEA, Paris.
5. See also www.nea.fr/html/pub/newsletter/2007/NEA_News-25-1-fostering.pdf.
6. See www.nea.fr/html/pub/newsletter/2007/NEA_News-25-1-regional-development.pdf.