Organisation de Coopération et de Développement Économiques
Organisation for Economic Co-operation and Development

09-Nov-2012

English - Or. English

NUCLEAR ENERGY AGENCY
RADIOACTIVE WASTE MANAGEMENT COMMITTEE

NEA/RWM(2011)13/REV1
Unclassified

Preservation of Records, Knowledge and Memory Across Generations

Reference Bibliography within NEA RKM Project

This bibliography aims at providing an overview over the work performed in the field of the preservation of records, knowledge and memory in relation with radioactive waste management, especially disposal. For each entry, an abstract outlining the relevance of the document to the topic of RK&M is provided. This bibliography is a living document that will be updated regularly during the lifetime of the RK&M project.

Please send any queries regarding this document to Claudio.pescatore@oecd.org

JT03330430

Complete document available on OLIS in its original format

English - Or. English

NEA RK&M Project
Preservation of records, knowledge and memory across generations
Reference bibliography

Last updated: 4 September, 2012

New additions since 2011 Workshop are preceded by [*]

INTRODUCTION

This bibliography aims at providing an overview over the work performed in the field of the preservation of records, knowledge and memory in relation with radioactive waste management, especially disposal. For each entry, an abstract outlining the relevance of the document to the topic of RKM is provided.

The following criteria are currently used to select the references:

- The document (or at least part of it) addresses the preservation of RKM in connection with the management of radioactive waste
- The document is publicly available or can be made available upon request
- One synthesis document (such as a report) is preferable to a list of papers with a similar content.
- Original documents (scientific reports and papers) are preferred to reviews or press coverage.

The bibliography should help the participants in the project to identify the topics of concern in the field of RKM and, eventually, the issues that have not yet been addressed.

The current bibliography is not meant to be an all-encompassing list that includes any generic reference that might be useful in the study of those topics. Therefore it does **not** include:

- general studies outside RWM , e.g. on memory loss, communication, or the history of institutions
- studies belonging to the field of RWM but that are only indirectly related to RKM preservation[1].

Unless stated otherwise, all documents are available from the Nagra Library, either on paper or in electronic form.

[1] For instance, the bibliography would not include studies of climatic changes at a specific site. Clearly, they would be relevant for the development of a marking system at that site, but they could be used for many other uses as well.

BIBLIOGRAPHY

- Adams M.R., Kaplan M.F. (1986): *Marker development for Hanford Waste Site disposal.* – Waste Management '86: Waste isolation in the U.S. technical programs and public education: proceedings of the symposium on Waste Management at Tucson, March 2-6, 1986; 1: General interest, p. 425-432.
  http://www.wmsym.org/archives/1986/V1/72.pdf

  Certain radioactive wastes, including stored wastes in single-shell tanks and pre-1970 solid waste burial grounds and contaminated soil sites, are currently located at the Hanford Site. The Hanford Defence Waste-Environmental Impact Statement is being prepared to assess options for the disposal of these wastes. In particular, barrier and marker systems are being designed and developed for placement over the wastes following site preparation. Archaeological analogues have been examined to provide guidance for the design of markers intended to communicate for up to 10,000 years. Materials, dimensions, and messages have been specified for both surface and sub-surface prototype markers. A prototype surface marker has been designed, and its procurement is pending. The integration of the barrier design and markers into a system has also been planned. Plans for placement of both surface and sub-surface markers have been completed.

- Advisory Committee on Nuclear Safety, Canada (2001): *Research in Support of Operational Safety at Nuclear Power Plants*. INFO-0724. ACNS, Ottawa.
  http://nuclearsafety.gc.ca/pubs_catalogue/uploads/ACNS27_E.pdf

  The ACNS has studied the potential safety-related consequences of a significant reduction in funding for nuclear power research and development (R&D) in Canada. The issues that were identified include in particular the need for a cooperative training program and for the retention of the corporate memory.

- Agence nationale pour la gestion des déchets radioactifs (ANDRA) (2009) : Documents available on ANDRA's website :
  Se souvenir [To remember]:

  http://www.andra.fr/pages/fr/menu1/les-solutions-de-gestion/se-souvenir-19.html
  Le papier permanent [Permanent paper]:
  http://www.andra.fr/pages/fr/menu1/les-solutions-de-gestion/se-souvenir/le-papier-permanent-82.html
  L'expérience du passé [The experience of the past] :
  http://www.andra.fr/pages/fr/menu1/les-solutions-de-gestion/se-souvenir/l-experience-du-passe-83.html

- Agence nationale pour la gestion des déchets radioactifs (ANDRA) (2009): *Centre de stockage de la Manche : Rapport définitif de sûreté - Année 2009. Phase de surveillance*. *["Centre de stockage de la Manche" facility (radioactive waste disposal facility, acronym*

CSM, located in the Manche district): Final Safety Report - 2009. Monitoring Phase]. SUR.RP.ACSM.08.0017.A. ANDRA, Chatenay-Malabry.
[not available online, available from ANDRA upon request]

The 2009 Safety Report represents the CSM final safety report. It was prepared to support the CSM's safety re-inspection (this installation is classified according to the Nuclear Safety Authority as Basic Nuclear Facility "INB no. 66") in its post-closure monitoring phase configuration. Accordingly, it takes stock of the lessons learnt from the initial years in this monitoring phase. It also takes into account all evolutions that have occurred in the regulations pertaining to nuclear facilities: Act n° 2006-686 dated June 13th, 2006 relative to transparency and safety in nuclear issues, and its application decree n° 2007-1557 dated November 2nd, 2007 relative to Basic Nuclear Facilities.

- Agence nationale pour la gestion des déchets radioactifs (ANDRA) (2008): *Centre de stockage de déchets radioactifs de la Manche (50), situé sur la commune de Diguelleville. Mémoire de synthèse pour les générations futures (destinée à maintenir une connaissance minimale aux générations prochaines et à toutes celles qui se succéderont jusqu'en 2500 au moins)*. ["Centre de stockage de la *Manche" facility (radioactive waste disposal facility – acronym CSM), located within the municipality of Diguelleville in the Manche district. Memory synthesis report for future generations (intended to retain minimal knowledge for upcoming and successive generations, at least up to the year 2500)*.] CSM Record DD.NSY.ADSQ.07.0017.A. ANDRA, Chatenay-Malabry.
http://www.andra.fr/download/site-principal/document/CSM_memoire_de_synthese_pour_les_generations_futures.pdf

  A synthesis report intended for future generations and presenting a history of radioactivity, a history of the CSM and of its forecast impact on the environment, as well as the policy conducted by Andra in order to preserve a memory of the site. This synthesis report remains a draft one for now and it is expected that a final version will be completed at a later time.ANDRA, Chatenay-Malabry.

- Agence nationale pour la gestion des déchets radioactifs (ANDRA), Charton P., Ouzounian G. (2008): A Challenge for Radioactive Waste Management: Memory Preservation. – *WM'08 Annual Waste Management Symposium: Proceedings*, February 24 -28, 2008, Phoenix, AZ.
http://www.wmsym.org/archives/2008/pdfs/8014.pdf

  For short-lived waste for which disposal facilities have a life expectancy of a few centuries, ANDRA has set up a system for memory preservation. Based on the historical analysis on a comparable timescale and on an appraisal of information-conservation means, a series of regulatory as well as technical provisions were made in order to ensure that sound information can be transferred to future generations. Requirements associated to the provisions deal mostly with the legibility and formulation of the information that must be decrypted and understood – and therefore preserved – at least during the lifetime of the facilities. The paper describes the achievement at the *Centre de la Manche* Disposal Facility.
  In the case of deep geological repositories for long-lived radioactive waste, it is much more difficult to consider how to maintain the richness of the information over the long timescales. Both the nature and the form of the information to be transferred must be revised. It would be risky indeed to base memory preservation over the long term on similar mechanisms beyond 1,000 years. Based on the heritage of a much more ancient history, we must seek to find appropriate means in order to develop surface markers and even more to ensure their conservation over long timescales. It will also be necessary, in

the light of the experiments and efforts made in order to decrypt ancient messages, to find suitable expression aimed at populations in a distant future.

- Agence nationale pour la gestion des déchets radioactifs (ANDRA), Afite (2007): *La mémoire industrielle au service des générations futures = Industrial Memory Serving Future Generations*. Symposium Tuesday December 11th, 2007. Reference: DD.TR.ADSQ.07.0032/A ANDRA, Chatenay-Malabry.
  [not available online, available from ANDRA upon request]

- Agence nationale pour la gestion des déchets radioactifs (ANDRA) (2006): *Disposal facilities: Preserving a collective memory for future generations.* ANDRA, Chatenay-Malabry. http://www.andra.fr/download/andra-international-en/document/editions/299.pdf

  Brochure explaining ANDRA's activities regarding memory preservation.

- Agence nationale pour la gestion des déchets radioactifs (ANDRA), Charton P. (2005): *From knowledge management (KM) to memory preservation over several centuries. Experience feedback from long-term archiving at the "Centre de la Manche" (CSM) disposal facility*. Reference: SUR.TR.ADSQ.05.0029/A. ANDRA, Chatenay-Malabry.
  [not available online, available from ANDRA upon request]

  Presentation at the Club of Agencies Meeting, Paris, 22-23 November 2005 (focus on knowledge management and very long term memory, with a visit of the historical archives centre from French National Archives).

- Agence nationale pour la gestion des déchets radioactifs (ANDRA) (2003): *Archivage à long terme du centre de stockage de la Manche : Versement initial : Liste des résumés du contenu de chaque boîte d'archives faits pour les archives nationales de France, centre des archives contemporaines de Fontainebleau*. DOC.LI.ADSQ.03.257. ANDRA, Chatenay-Malabry.
  [not available online, available from ANDRA upon request]

- Agence nationale pour la gestion des déchets radioactifs (ANDRA) (2003): *Procédure de définition et de mise en oeuvre des critères de sélection des données nécessaires à l'archivage à long terme du centre de stockage des déchets de faible et moyenne activité de l'Aube*. QUA.PR.ADCS.04.5002. ANDRA, Chatenay-Malabry.
  [not available online, available from ANDRA upon request]

- Agence nationale pour la gestion des déchets radioactifs (ANDRA) (2003): Archivage à long terme du centre de stockage de la Manche: *Présentation générale de l'archivage à long terme du centre de stockage de la Manche*. [Long-term Archiving at the "Centre de stockage de la Manche" radioactive waste disposal facility (CSM): *An overall presentation of long-term archiving at the "Centre de la Manche" waste disposal facility*]. DOC.NSY.ADSQ.03.240/A. ANDRA, Chatenay-Malabry.
  [not available online, available from ANDRA upon request]

  A presentation of documents introducing the initial filing of the CSM's detailed memory (2004), arranged according to three levels of access to data ("understanding", "researching", "knowing").

- Agence nationale pour la gestion des déchets radioactifs (ANDRA) (2003): Archivage à long terme du centre de stockage de la Manche: *Historique de l'archivage à long terme du centre de stockage de la Manche et de sa constitution*. DOC.NSY.ADSQ.03.243. ANDRA,

Chatenay-Malabry.
[not available online, available from ANDRA upon request]

- Agence nationale pour la gestion des déchets radioactifs (ANDRA) (2003): Archivage à long terme du centre de stockage de la Manche: *Messages aux générations futures*. DOC.NSY.ADSQ.03.246. ANDRA, Chatenay-Malabry.
  [not available online, available from ANDRA upon request]

- Agence nationale pour la gestion des déchets radioactifs (ANDRA) (2003): Centre de stockage de la Manche: *Conservation de la mémoire du centre.* DOC.NT.ADSQ.03.244. ANDRA, Chatenay-Malabry.
  [not available online, available from ANDRA upon request]

- Agence nationale pour la gestion des déchets radioactifs, Haas J. (2002): *French experience in long term memory preservation for Nirex seminar on March 5th 2002*. DQ/AQ/JH QUA.TR.ADQ.02.001/A. ANDRA, Chatenay-Malabry.
  [not available online, available from ANDRA upon request]

  A presentation of memory preservation policy at Andra repositories, implemented at the "Centre de la Manche" disposal facility (CSM) and considered within the framework of the HL-LLW project.

- Agence nationale pour la gestion des déchets radioactifs (ANDRA), Boursier F.O. (2000): Record and Archival System for the Monitoring Period of a Surface Disposal Facility. - American Nuclear Society: *WM '00: HLW, LLW, mixed wastes and environmental restoration - Working towards a cleaner environment*. Proceedings of Waste Management '00, February 27-March 2, 2000, Tucson, Arizona. American Nuclear Society, La Grange Park. Session 66, Paper 4.
  http://www.wmsym.org/archives/2000/pdf/66/66-4.pdf

  The French surface disposal facility *Centre de la Manche*, operated by ANDRA, remained in operation for 25 years. Shipments of waste packages stopped in 1994 and approval is pending for the facility's transition into its monitoring period. ANDRA has set up a structure responsible for identifying all data and documents deemed useful for the knowledge and understanding of the site. This paper presents that structure, its objectives and associated means. It also provides a detailed description of the constitution of the document collection, including sorting and identifying relevant items over the long term. The transfer of documents and data on a perennial support is also addressed, as well as details concerning archival storage. The maintenance of industrial "memory" is essential for safety purposes (in case of intervention during the monitoring period) and contributes to the improvement of public acceptance of the long-term waste management carried out at the disposal facility.

- Agence nationale pour la gestion des déchets radioactifs (ANDRA) (1995): *Selection Criteria for Data Required in Long-Term Archiving for Surface Repositories (Construction, operational and monitoring phases)*. NRPAGDA95007/D. ANDRA, Chatenay-Malabry.
  [also available in French : Critères de sélection des données nécessaires à l'archivage à long terme des centres de surface (phase de construction, d'exploitation et de surveillance. N RP AGDA 95 007.]
  [not available online, available from ANDRA upon request]

A presentation of the selection criteria for the data required in understanding and maintaining the “Centre de stockage de la Manche” waste disposal facility (CSM) during its post-closure monitoring phase, especially any technical documentation relating to the repository cap, the disposal structures, the waste packages and the structures of the separate underground gravity network (RSGE), as well as the documentation concerned with environmental monitoring. It also features plausible scenarios for incidents that could occur on the site and that have determined the selection criteria.

- Agence nationale pour la gestion des déchets radioactifs (ANDRA), Raimbault P., Valentin-Ranc C. (1993): How to mark repositories in geological formation. - *SAFEWASTE 93: International Conference on Safe Management and Disposal of Nuclear Waste*, Avignon, 13-18 June 1993, vol. 3, p. 212-221.
  [not available online – February 2011]

  This paper presents a general reflection on how to reduce the probability of inadvertent human intrusion in the future.

- Ahlen J., Ferguson F., Jackson D., McVay T., Scott L., Sexton J., Wilson D., Lewis P., Brian J., Fowler B. (1995): *Analytical Study of an Inadvertent Intrusion of the WIPP Site.* WIPP Inadvertent Intrusion Advisory Panel and New Mexico Junior College, September 5, 1995. [Not available at Nagra library, quoted in the WIPP CCA 1996]

- [*] Anderson K. (2005): Designing for deep time: how art history is used to mark nuclear waste. A thesis submitted in partial fulfilment of the requirements for the degree of Master of Science in Theory, Criticism and History of Art, Design and Architecture within the joint degree M.S./M.F.A. program School of Art and Design Pratt Institute October 2005. http://www.kellianderson.com/MSthesis.pdf

  A detailed overview over the history of markers in the USA since the beginnings.

- Aoki K., Fujii N., Kageyama H., Yoshimura K., Ohuchi J., Tsuboya T., RWMC (2008): Durable Media for Long-Term Preservation of Geological Repository Records. – *WM’08 Annual Waste Management Symposium: Proceedings*, Feb. 24 -28, 2008, Phoenix, AZ. http://www.wmsym.org/archives/2008/pdfs/8320.pdf

  The concept of a record preservation system should be the combination of several methods, the “Relay System” and the “Permanent System”, in order to impart redundancy to the communication function. The former would maintain record preservation and communication functions in the framework of social systems whereas the latter would consist of durable storehouse facilities, recording media and markers/monuments and be independent of any social systems and human control.
  Several engraving experiments using laser technologies on durable artificial materials, such as silicon carbide, have been performed successfully. These technologies can be applied to not only documentary records – with a 500 page document reduced to a volume of 10 cm x 10 cm x 32 cm – but also to markers and monuments.

- Bandolin G., Sörlin S. (2007): Laddade landskap – värdering och gestaltning av teknologiskt sublima platser. SKB R-07-14. Svensk Kärnbränslehantering AB (in Swedish) http://www.skb.se/upload/publications/pdf/R-07-14webb.pdf

  This project (November 2004-January 2006) covered the design issues and questions about the values of place and landscape in which risk and danger are important elements. Another theme related to conservation issues, protection of monuments and memories,

and in such "dangerous places". An important feature of the project was to visit and describe the locations characterized by high technological experimentation and the presence of risk and danger.

Case studies:

- The power of the distance: Woomera, Australia.
- The time breeds new questions: Yucca Mountain and Nevada Test Site, Nevada, USA.
- Revaluations: Rocky mountain arsenal wildlife refuge in Denver, Colorado, USA.
- A mansion in Eurajoki: Posiva, Finland.
- Stories from fracture meager mountain: Forsmark and Oskarshamn, Sweden.
- "They will come back as an idea ...": About time, monuments and landscapes.

In connection to site visits in the USA and Australia, interviews and visits were performed to museums and other institutions and complemented by extensive literature studies.

- Battelle (1978): Institutions in long-term nuclear waste management.- *Nontechnical issues in waste management : Ethical, institutional, and political concerns*, PNL-2400. Battelle, Columbus (Ohio), Chapter IV, 43-64.
[not available online – February 2011]

  A number of concerns have been raised regarding the role that human institutions may have to play in the long-term management of nuclear wastes. Controversy exists concerning, first of all, the need for any human institutions to be involved in long-term management; secondly, there is substantial uncertainty about whether human institutions could actually carry out any functions that might be required of them over the long term. The major objective of this chapter is to provide a framework for thinking about institutional issues that may be involved in the long-term management of nuclear wastes. An attempt has been made to identify organisational functions that might be needed to insure the integrity of a waste repository over several centuries.

- [*] Benford G. (2000): Deep Time: How Humanity Communicates Across Millennia. HarperCollins (new ed.).
[not available online, not at Nagra Library, available through Amazon]

  The author first gives a summary of the different ways that humans have intentionally left evidence of their lives long after their death. He continues to chronicle recent and ongoing efforts to leave evidence of our civilization to future humans and in outer space. The second half of the book is about how future generations will interpret the environmental state of the planet as a monument to our current society and how we can take action to change the state of the planet.

- [*] Benford G. (1994): Comporting ourselves to the future: Of time, communication, and nuclear waste. *Journal of Social and Evolutionary Systems* 17(1), 91-113.
[not at Nagra, available through Elsevier – ref. suggested by ANDRA]
[Abstract]

- Benford G., Kiekwood C.W., Otway H., Pasqualetti M.J. (1991): *Ten thousand years of solitude? On inadvertent intrusion into the Waste Isolation Pilot Project Repository*. LA-12048-MS. Los Alamos National Laboratory (also reproduced in SAND 90-3063: Expert judgment on inadvertent human intrusion into the Waste Isolation Pilot Plant, App. D).

http://www.wipp.energy.gov/picsprog/documents/Ten%20Thousand%20years%20of%20Solitude.pdf

Credible types of potential future accidental intrusion into the WIPP are estimated as a basis for creating warning markers to prevent inadvertent intrusion. A six-step process is used to structure possible scenarios for such intrusion, and it is concluded that the probability of inadvertent intrusion into the WIPP repository over the next ten thousand years lies between one and twenty-five percent.

- Berndes S. (2001): *Wissen für die Zukunft: Ethische Normen der Auswahl und Weitergabe naturwissenschaftlichen und technischen Wissens.* Diss. Univ. Cottbus. LIT, Münster. [available at google.books.com]

  This dissertation addresses the issue of knowledge transfer in the field of natural sciences and technology. A case study is devoted to information management systems for the management of high-level waste.

- Berndes S., Korwachs K. (1996): Transferring knowledge about high-level waste repositories: an ethical consideration. – *High level radioactive waste management 1996: Proceedings of the seventh annual international conference*: Las Vegas, April 29-May 3, 1996, p. 494-498. [not available online]

- Berry W.E. (1983): *Durability of marker materials for Nuclear Waste Isolation Site*. BMI/ONWI-474. Batelle Columbus Laboratory.
  [not available online – February 2011]

  The US DOE's Office of Nuclear Waste Isolation has created the Human Interference Task Force (HITF) to investigate the problems connected to the closure and final marking of a filled repository. The task of the HITF is to devise a method of warning future generations, who may or may not have records of the repository's contents, not to mine or drill at that site unless they are aware of the consequences of their actions. Since the likelihood of human interference should be minimized for up to several thousand years, a durable marker system must be devised. Accordingly, this paper reviews the probable long-term performance of materials that might be used for nuclear waste isolation sites.

- [*] Bloomfield B.P., Vurdubakis T. (2005): The secret of Yucca Mountain: reflections on an object in extremis. - *Environment and Planning D: Society and Space*, 23/5, 2005, 735-756.
  [not available online – June 2012]

  The processes through which boundaries are made and unmade conceptually, socially, and materially have been of enduring interest to a wide range of social scientific disciplines including sociology, anthropology, geography, science studies, etc. The subject matter of this paper, the Yucca Mountain high-level nuclear waste repository in Nye county, Nevada, constitutes a case study of such processes taken to extremes. This, in turn, makes Yucca Mountain an interesting vantage point from which to (re)view the traditional ontological and epistemological preoccupations characteristic of social science, not so much in terms of abstract theory but rather in terms of concrete practical problems of spatial and temporal organisation. [Abstract by authors]

- Bowen-Shrire M., Eckerhall D., Jander H., Waniewska K. (2008): Bevarande av information om slutförvar för använt kärnbränsle – förslag till handlingsplan. SKB P-08-76, Svensk Kärnbränslehantering AB (in Swedish).
  http://www.skb.se/upload/publications/pdf/P-08-76webb.pdf

This report is a proposal for an action plan with the ultimate aim of ensuring that information about the repository for spent nuclear fuel can be preserved and transferred for future generations. Its purpose is to present ideas on tangible measures and guidelines for information preservation and transfer, in the short and long term.
The report deals with a number of aspects relating to information preservation as well as risks that can lead to the loss of important information. The main emphasis is on measures that need to be implemented in the near future to ensure that successive and direct information transfer is handled in a suitable manner, including:

- Designate a person responsible for information preservation.
- Work out guidelines for information preservation and transfer.
- Form a network with other organizations in Sweden.
- Initiate a dialogue with other countries, especially USA and France.
- Participate in seminars, conferences and workgroups on an international level within the IAEA and NEA.
- In a longer time perspective the following measures should also be implemented:
- Implement guidelines for information preservation and transfer.
- Document the archiving system.
- Establish a communication plan.
- Archive information about the repository.

- Bowen-Shrire M., Jander H., Waniewska K. (2007): Kunskapsbevarande för framtiden – Fas 1. SKB P-07-220, Svensk Kärnbränslehantering AB (in Swedish).
http://www.skb.se/upload/publications/pdf/P-07-220webb.pdf

  This report summarises the work done in the field of knowledge preservation regarding a repository for spent nuclear fuel in Sweden and in other selected countries. The purpose of the report is to provide a basis for a proposal for an action plan for knowledge preservation regarding a repository for spent nuclear fuel. The report is based upon identified key documents, interviews with key persons, and other relevant sources of information identified throughout the working process.
  The report covers the basic principles and methods for information preservation and transfer, and describes their advantages and disadvantages. The report also covers topics such as the time perspective, target groups, context, and discusses the difference between the concepts information and knowledge. The conclusions of the report include a number of recommendations for further work.

- Brenk Systemplanung GmbH (BS) (2009): *Radioactive Waste and Spent Fuel Data Collection, Reporting, Record Keeping and Knowledge Transfer by EU Member States*. Final Report. European Commission, Brussels, Belgium.
http://ec.europa.eu/energy/nuclear/studies/doc/2009_09_radiactive_waste.pdf

  This study provides an overview of the status of the implementation of national waste data collection systems in the EU Member States and makes recommendations for future waste management systems. Purposes for collecting and maintaining information on radioactive waste and spent fuel in the different countries are discussed. The study also addresses the level of information required at each step of the management process.

- [*] Bryan-Wilson J. (2003): Building a Marker of Nuclear Warning. – In: Nelson R.S. & Olin M. (eds.), *Monuments and memory, made and unmade*. University of Chicago Press. Chicago, pp. 183-204.
[availability: see below under Nelson & Olin]

Comments on the WIPP markers programme.

- Bundesamt für Energie, Buser M. (2010): *Forschungsprogramm Radioaktive Abfälle: Literaturstudie zum Stand der Markierung von geologischen Tiefenlagern*. BFE, Bern. http://www.news.admin.ch/NSBSubscriber/message/attachments/19773.pdf

  A literature study on the current status of science and technology regarding markers and more generally knowledge preservation in the field of radioactive waste management.

  [*] An updated English version is in preparation under the aegis of the OECD/NEA RK&M project.

- Clegg R., Pinner A., Smith A., Quartermaine J., Thorne M.C. (1997): Consideration of post-closure controls for a near surface low level waste disposal site. – *Proceedings of an international symposium on Experience in the Planning and Operation of Low Level Waste Disposal Facilities*: held in Vienna, 17-21 June 1996. Proceedings Series. IAEA, Vienna. [not available online – July 2010]

  The paper discusses potential intrusion scenarios within the framework of the programme of disposal of low level radioactive wastes by British Nuclear Fuels plc (BNFL) at Drigg, Cumbria. Although control of the site is anticipated for a period of about 100 years post-closure, eventually restrictions on access will lapse. Potential modes of intrusion into the Drigg site – leading to exposure to, and/or exhumation of, the wastes – have been studied. Although the most likely site uses, notably those involving agricultural activities, are unlikely to result in intrusion into the wastes, others, such a urban development, do have the potential to result in such intrusion. Overall, it is concluded that provided that a variety of documentary records are established, ranging from local council archives to mass produced maps, then memory of the site can realistically be assumed whilst civilisation continues to exist. However, if this first line of defence fails, markers constitute a second warning system. Finally, assessment calculations can be used to demonstrate that, even if these two lines of defence fail, risks from intrusion and radiation doses contingent upon intrusive events having occurred would not be unacceptably large.

- [*] Codée H. (2005): Safe is beautiful. - *CNS Waste Management '05*, Ottawa, Canada, May 8-11, 2005.
  [not available online, June 2012]

  This paper and the following describe how the HABOG storage facilities have been built into a work of art.

- [*] Codée H. (2003): Give the public something, something more interesting than radioactive waste. - *Proceedings of Waste Management WM '03*, February 23-27, 2003, Tucson, AZ, American Nuclear Society, La Grange Park, Session 17, Paper #37. http://www.wmsym.org/archives/2003/pdfs/37.pdf

- Csullog G. (2001): *Waste Inventory Record Keeping Systems (WIRKS) for the management and disposal of radioactive waste*. IAEA-TECDOC-1222. IAEA, Vienna. http://www-pub.iaea.org/MTCD/publications/PDF/te_1222_prn.pdf

  A waste inventory record keeping systems (WIRKS) represents part of an overall primary level information (PLI) set in support of radioactive waste disposal, which includes pre-disposal waste management activities.
  This publication provides technical guidance on developing and implementing nationally based WIRKS that consider issues such as (a) consistency in reporting for national and

international obligations, (b) the need to provide information to future generations and (c) the possibility of a future international archive for waste repository records.

- Deyo Y.E., Pauling T. (2006): Community Involvement as an Effective Institutional Control at the Weldon Spring Site, a U.S. Department of Energy Office of Legacy Management Site. – *Proceedings of Waste Management Symposium WM '06, February 26 - March 2, 2006*: Global Accomplishments in Environmental and Radioactive Waste Management: Education and opportunity for the next generation of waste management professionals. http://www.wmsym.org/archives/2006/prof6377.html

  The U.S. Department of Energy (DOE) Weldon Spring Site Remedial Action Project (WSSRAP) was conducted for the purpose of remediating a portion of a former trinitrotoluene and dinitrotoluene production plant that was operational from 1941 to 1945 and a former uranium refinery that was operational from 1957 to 1966. Surface remediation activities concluded in 2001 with the completion of 18 km2 on-site engineered disposal facility. In order to deal with the long-term surveillance and maintenance issues at the site, a plan was established for development of a comprehensive public involvement and education program. In August 2002, the Weldon Spring Site Interpretive Center opened to the public with exhibits about the history of the area, the remediation work that was completed, and a site information repository that is available to visitors. In addition, the Hamburg Trail for hiking and biking was constructed, including a series of historical markers. A ramp and viewing platform with informational plaques were constructed on the disposal cell. Science-oriented educational programs that directly relate to past remediation activities and present long-term surveillance and maintenance issues are presented to St. Louis area school groups and other community-based organizations. Other innovative programs have been developed to address daily maintenance issues at the site and to promote beneficial community re-use of the property.

- Eng T., Norberg E., Torbacke J. (et al.) (1996): *Information, conservation and retrieval*. SKB Technical Report 96-18. Swedish Nuclear Fuel and Waste Management, Stockholm. http://www.skb.se/upload/publications/pdf/TR-96-18webb.pdf

  The study deals with different aspects of information, conservation and retrieval of information on final repositories for nuclear waste. The role and history of the national and regional archives in Sweden is discussed. It is noted that large portions of the cultural heritage cannot be set aside for long-term preservation due to different reasons. Suggestions to the components to an action plan to stop the trend of decaying of valuable research material are given. Furthermore, some views on the democratic values concerning preservation and dissemination of information are given. The societal function of the historians to describe and explain, in cooperation with the archives, the country's past is pointed out, i.e. to analyse the chains of political, economic, social and cultural events that have shaped the country's history. In the third part a Nordic view is expressed of how to preserve and retrieve information on nuclear waste repositories. Present day waste management would benefit from an early identification of documents to be part of an archive for radioactive waste repositories. The same reasoning is valid for other toxic wastes. The industry as well as the companies operating the repository and the competent authorities, are I possession of a vast amount of information about the nuclear material and its history. Essential information must be extracted in order to establish independent archives of different sizes.
  The report includes the text Jensen (1993) "*Conservation and retrieval of information".*

- Eng T. (1993): *The value and need for long term conservation of information regarding nuclear waste repositories*. - High level radioactive waste and spent fuel management: proceedings of the 1993 International Conference on Nuclear Waste Management and Environmental Remediation: Prague, September 5-11, 1993, vol. 2, p. 711-714.
  [not available online]

  This paper discusses a system for best possible mitigation of human intrusion. With the present knowledge, this comprise the following parts: (a) development of planning procedures for long-term conservation of gathered information (present and future national and international archives, markers etc.); (b) continuous follow up of the state-of-the-art of information media; (c) preparations for national rules and regulations on nuclear waste information; (d) participation in international cooperation on issues concerning nuclear waste information keeping, transfer and retrieval.

- Engstroem-Laarouchi S. (2010): Means to reduce human activities at the site: markers, records... where do we stand? – *Workshop: Towards transparent, proportionate and deliverable regulation for geological disposal*, Tokyo, 20-22 January 2009. OECD Nuclear Energy Agency, Issy-les-Moulineaux, p. 175-178.
  [not available online – Proceedings can be ordered from the OECD bookshop]

  The main SKB activities related to preservation of information about a geological disposal are discussed. The aim of information preservation is to avoid damage by accident and allow for our and future generations to make informed decisions. In the draft action plan, which should be presented in connection with the applications for the site selection process in [2011], suggestions on implementation of preservation of information are given. They cover the type of information of interest to be preserved, time horizons to consider as well as the potential incidents or events to envisage, their possible consequences and the measures to mitigate these consequences. Target groups are identified as well as strategies for preservation (from generation to generation, directly into a distant future). Different media for archives are envisaged. An international perspective, including international co-operation, on information preservation is also discussed.

- Environmental-Social Advisory Services (ESAS), Atomic Energy Control Board (1997): *Comprehensive review of the literature on institutional controls to limit land use*. AECB, Ottawa.
  [not available online – February 2011]

  A literature search was conducted to identify case studies that would provide a basis for establishing the effective duration of institutional controls to limit land use and to identify the attributes that contribute to their effectiveness. The literature on a variety of active and passive institutional controls to limit land use on government lands and on private lands adjacent to government lands was reviewed. No case studies and little detailed information were found concerning the periods for which the institutional controls remained effective over the long-term or the aspects of the controls that contributed to their effectiveness in limiting land use. The information available in the literature is discussed and an extensive bibliography and recommendations regarding future work are provided.

- Fattah A. (1997): Requirements for records and reports related to safeguards for geological repositories. – *WM'97 : HLW, ILW, mixed wastes and environmental restoration - Working*

towards a cleaner environment. Proceedings of Waste Management 97, Tucson, Arizona, March 2-6, 1997.
http://www.wmsym.org/archives/1997/sess11/11-06.htm

For effective and efficient application of safeguards, the IAEA requires vital information on facility design and operation. Part of the required information will also flow from the other obligations, e.g. safety, waste disposal, environmental protection, etc. An integrated approach to document all required information will be an advantage to all concerned. The basic safeguards approach for a geological repository will consist of continuous Design Information verification (DIV) and application of integrated safeguards verification system for inventory verification. DIV should confirm the integrity of the repository area and detect any/all undeclared activities, inter alia, the presence of sensitive equipment and tunnelling in the vicinity of the repository. As part of records keeping, the facility has to maintain records of the content and location of each spent fuel container. The IAEA and the State should retain all safeguards relevant documentation and information (i.e. records of the complete inventory of nuclear material and/or previous operations of the repository) deemed necessary. These records should be kept for at least as long as safeguards exist for the nuclear material in the repository.

- Flüeler T. (ed.) (2005): Long-term knowledge generation and transfer in environmental issues: A challenge to a knowledge bases-society: Invited session. – *PISTA 2005: The 3rd international conference on politics and information systems: Technologies and applications*, July 14-17, 2005, Orlando, Florida, USA. International Institute of Informatics and Systemics. [not available online – February 2011]

  Includes in particular:

  McCarthy G.J., Upshall I.: Using contextual information frameworks to maintain knowledge of radioactive wastes.

  A contextual information framework is composed of interrelated information objects that represent “agents” in a broader information system. People, organisations, concepts, ideas, places, natural phenomena, events, cultural artefacts including records, books, works of art and radioactive waste could all be defined as entities and play the role of agents. The mapping of relationships between these entities creates a network that mimics what actually occurs in life. The selective use of entity and relationship types can convert otherwise impossibly complex socio-technical environments into information architectures or networks. This paper explores the application of this approach to the transfer of comprehensible information on radioactive waste to subsequent generations.

- Foote K.E. (1990): To Remember and Forget: Archives, Memory, and Culture. – *American Archivist*, Vol. 53, Summer 1990, 378-392.
  http://courses.ischool.utexas.edu/Winget_Megan/2010/Fall/INF381/Readings/Foote_RememberForget.pdf

  The idea of archives as collective memory is sometimes employed as a metaphor for discussing the social and cultural role of archives. It is argued here that the idea is more than a metaphor and is supported by theories that would view collections of documents and material artifacts as means of extending the temporal and spatial range of communication. Archives, along with other communicational resources such as oral and ritual tradition, help to transfer information—and thereby sustain memory—from generation to generation. Two examples illustrate the interrelationship of archives and memory within this broadened view of communication and culture. The first arises from attempts to find ways to warn future generations of the location of radioactive waste

repositories. The second revolves around pressure to efface from cultural landscapes evidence of tragic events that people wish to forget.

- Garfield S. (1994): «Atomic Priesthood» is Not Nuclear Guardianship, A Critique of Thomas Sebeok's Vision of the Future. - *Nuclear Guardianship Forum*, Issue 3, On the Responsible Care of Radioactive Waste Materials, Spring 1994. http://www.ratical.org/radiation/NGP/AtomPriesthd.html

  A review of Thomas A. Sebeok's report to the Bechtel Group's Human Interference Task Force (1984).

- [*] Goodenough W.H. (1999): Communicating 10,000 Years into the Future. *Human Organization* 58(3), 221-225. http://www.sfaa.net/malinowski/monograph/malinowski.pdf#page=412

  A personal record by an anthropologist who participated in the development of the WIPP markers.

- Hart J. (John Hart and Associates, P.A.) (2004): *Passive Institutional Controls Implementation Plan*. Waste Isolation Pilot Plant, Carlsbad/New Mexico. DOE/WIPP 04-2301. http://www.wipp.energy.gov/library/PICsImplementationPlan.pdf

  The U.S. Department of Energy (DOE) is implementing a program of Passive Institutional Controls (PICs) for the Waste Isolation Pilot Plant (WIPP). The purpose of the program is to indicate the location of the repository and the dangers associated with radioactive and hazardous materials contact, thus reducing the likelihood of inadvertent human intrusion into the repository. The EPA regulations specify that radioactive waste disposal systems must be designated by multiple PICs including permanent markers, long-term records and "other PICs" which DOE is calling "awareness triggers." This plan should serve as a tool to assist the DOE in managing activities included in the PICs program and help communicating with the regulators and the public.

- Hart J. (John Hart and Associates, P.A.) (2004): *Permanent Markers Implementation Plan*. Waste Isolation Pilot Plant, Carlsbad/New Mexico. DOE/WIPP 04-3302. http://www.wipp.energy.gov/library/PermanentMarkersImplementationPlan.pdf

  This plan is one of the three supporting documents to the *Passive Institutional Controls Implementation Plan*, presenting planned activities regarding permanent markers, including the establishment of performance specifications, the determination of testing needs, the definition of a strategy for making design decisions and the reassessment of the conceptual design. The conceptual design includes six marker components: Large Surface Markers, Small Subsurface Markers, Berm, Buried Storage Rooms, Hot Cell and Information Center.

- Hart J. (John Hart and Associates, P.A.) (2000): *Permanent Markers Monument Survey: Contractor report*. Waste Isolation Pilot Plant, Carlsbad (New Mexico). http://www.wipp.energy.gov/picsprog/documents/monument%20survey.pdf

  In its Compliance Certification Application (CCA) for the WIPP (DOE, 1996), the DOE provides details regarding the implementation of the permanent markers program. An important objective of the program is to develop information useful in optimizing the design of the marker systems by evaluating alternative configurations, alternative materials and aid in the development of final designs. One related activity identified in the

CCA is the survey of monuments within 150 miles of the WIPP site, to obtain any information useful in the selection of markers materials and the development of markers designs. This report documents the results of a survey performed to collect and compile information relevant to the assessment of the durability of ancient inscriptions made on various rock types also beyond the 150 miles from WIPP, but within similar climatological zones.

- Hart J. (John Hart and Associates, P.A.) (2000): *Permanent Markers Material Analysis: Contractor report*. Waste Isolation Pilot Plant, Carlsbad (New Mexico).
  http://www.wipp.energy.gov/picsprog/documents/Materials%20Analysis.pdf

  Many materials, both natural and man-made, have been suggested over the years for consideration as permanent markers. It is neither feasible nor desirable to test all of these materials. The report presents the results of a literature review in order to support determinations of the materials that most likely satisfy the design and performance requirements for marker systems and that warrant testing to confirm their selection. The work represented in this report was performed primarily as a literature review using information available through printed media (technical journals, text books, research reports), electronic media (worldwide web sites), and technical expert consultation. Inquiries were made to materials vendors concerning the availability of their materials and specifics pertinent to the material properties. Consultants and researchers with materials expertise assisted in directing the research and suggesting alternative materials and identifying those properties most important to marker performance.

- Hart J. (John Hart and Associates, P.A.) (2000): *Ancient Cementitious Materials: Contractor Report.* Waste Isolation Pilot Plant, Carlsbad (New Mexico).
  http://www.wipp.energy.gov/picsprog/documents/Ancient%20Cementitious%20Materials.pdf

  A literature review has been performed to investigate instances in which man-made cementitious materials have survived for very long time periods. The intent of this effort is to determine and document, when possible, the attributes of cementitious materials that allow them to survive for long periods. It is also intended to illustrate that cementitious materials were used as effective building materials thousands of years ago and many of those materials have lasted throughout the centuries.

- Health and Safety Executive, United Kingdom (2010): *The management of higher activity radioactive waste on nuclear licensed sites: Part 3d: Managing information and records relating to radioactive waste in the United Kingdom*. Joint guidance from the Health and Safety Executive, the Environment Agency and the Scottish Environment Protection Agency to nuclear licensees.
  http://www.hse.gov.uk/nuclear/wastemanage/rwm-part3d.pdf

  It is essential to ensure that licensees both now and in the future, are equipped with the knowledge and records they need to manage radioactive waste safely, over long timescales and through changes in the organisations responsible for the waste. This guidance covers existing national and international standards and practices for managing information. It also discusses some of the specific issues associated with managing information about radioactive waste over the long term. This document provides an overview of the relevant policy drivers, regulatory requirements and expectations relating to managing information and records about higher activity radioactive wastes on licensed nuclear sites.

- Hora S.C., von Winterfeldt D., Trauth K.M. (1991): *Expert judgment on inadvertent human untrusion into the Waste Isolation Pilot Plant*. SAND90-3063. Sandia National Laboratories, Albuquerque.
  http://www.wipp.energy.gov/picsprog/Test1/SAND90-3036%20Expert%20judgement,%20human%20intrusion.pdf

  Four expert-judgment teams have developed analyses delineating possible future societies in the next 10,000 years in the vicinity of the Waste Isolation Pilot Plant (WIPP). Expert-judgment analysis was used to address the question of future societies because neither experimentation, observation, nor modelling can resolve such uncertainties. These assessments include detailed discussions of the underlying physical and societal factors that would influence society and the likely modes of human-intrusion at the WIPP, as well as the probabilities of intrusion. Technological development, population growth, economic development, conservation of information, persistence of government control, and mitigation of danger from nuclear waste were the factors the teams believed to be most important. Likely modes of human-intrusion were categorized as excavation, disposal/storage, tunnelling, drilling, and offsite activities. Each team also developed quantitative assessments by providing probabilities of various alternative futures, of inadvertent human intrusion, and in some cases, of particular modes of intrusion.

- [*] Hora S.C., von Winterfeldt D. (1997): Nuclear Waste and Future Societies: A Look into the Deep Future. - *Technological Forecasting and Social Change* 56(2), 155-170. [available for purchase through Elsevier]

  Inadvertent human intrusion is thought to be a significant, if not the most significant, threat to nuclear waste held in repositories. As part of the effort to access the safety of the first United States repository, the Waste Isolation Pilot Plant near Carlsbad, New Mexico, four interdisciplinary teams of experts were brought together to provide insights into the modes and likelihoods of such intrusions as far as 10,000 years in the future. A formal expert elicitation process was used in obtaining their judgments. The teams provided scenarios that, although formed using different approaches, reflected several central themes. These themes are the uncertainty about the need for resource exploration in the future, the rate at which technology develops or declines in future, the likely failure of government control of radioactive waste sites, and the preservation and potential loss of memory about nuclear waste. Identifying possible futures enhances the ability to construct a repository that will be robust against many different potential threats. [Abstract: Elsevier website]

- Human Interference Task Force, HITF (1984): *Reducing the likelihood of future human activities that could affect Geologic High-Level Waste Repositories*. BMI/ONWI-537. Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, Ohio
  http://www.osti.gov/bridge/servlets/purl/6799619-fpYg48/6799619.pdf

  Methods are discussed for achieving long-term communication by using permanent markers and widely disseminated records, with various steps taken to provide multiple levels of protection against loss, destruction, and major language/societal changes. Also developed is the concept of a universal symbol to denote Caution - Biohazardous Waste Buried Here. If used for the thousands of non-radioactive biohazardous waste sites in this country alone, a symbol could transcend generations and language changes, thereby vastly improving the likelihood of successful isolation of all buried biohazardous wastes.

- International Atomic Energy Agency (2010): *Technological implications of international safeguards for geological disposal of spent fuel and radioactive waste*. IAEA Nuclear Energy Series NW-T-1.21. IAEA, Vienna.
  http://www-pub.iaea.org/MTCD/publications/PDF/Pub1414_web.pdf

  Repository safeguards measures should be part of the repository planning and design from the outset of a project to facilitate installation of IAEA equipment and to ensure that safeguards measures do not unduly disturb facility operations. Minimizing the risk of loss of continuity of knowledge is a must.
  A prerequisite for ensuring that all stakeholders are aware of both safety and safeguards requirements, can plan their activities accordingly, and can avoid conflicts, is the early establishment of appropriate and effective communication channels. Safeguards approaches that integrate the traditional safeguards measures with information analysis and complementary access to related safeguards relevant locations in the State are currently being developed by the IAEA.

- International Atomic Energy Agency (2008): *Long Term Preservation of Information for Decommissioning Projects.* Technical Reports Series No. 467. IAEA, Vienna. http://www-pub.iaea.org/MTCD/publications/PDF/trs467_web.pdf

  Includes information on preservation of various media (paper, microfilms, electronic, etc.) which may be useful for any information preservation project.

- International Atomic Energy Agency (2007): *Retrieval, Restoration and Maintenance of Old Radioactive Waste Inventory Records*. IAEA-TECDOC-1548. IAEA, Vienna. http://www-pub.iaea.org/MTCD/publications/PDF/te_1548_web.pdf

  This report was developed to provide guidance on a methodology to retrieve, assess, verify and restore the historical radioactive waste inventory records for those storage and disposal facilities where adequate records are not available. A variety of circumstances that may require the records to be re-assessed or retrieved is discussed. The role of a quality management system (QMS), which may impose corrective actions, including revision of waste records as part of an overall facility upgrading programme is introduced. The general guidance provided on the waste inventory data retrieval process integrates, in a systematic way, various methods and technical issues, including conversion of old activity and radiation units, and prioritization of data retrieval activities.

- International Atomic Energy Agency (2007): *International conference on knowledge management in nuclear facilities*, 18-21 June 2007. IAEA, Vienna
  Book of extended synopses available at:
  http://inisdb.iaea.org/inis/php/download.php?s=p&rn=38067938

  Awareness of the importance of nuclear knowledge management in addressing the challenges the industry is facing has grown significantly in past years, both in the industry and in regulatory authorities. Knowledge management is becoming an important element of the organizational behaviour of the nuclear industry. In 2002, the IAEA General Conference adopted a new resolution on Nuclear Knowledge, emphasizing the importance of nuclear knowledge management. The resolution was reiterated in subsequent years. This conference is organized in response to those resolutions. The objectives of the conference are to: - Take stock of the recent developments in nuclear knowledge management. - Demonstrate and discuss the benefits of nuclear knowledge management in promoting excellence in operation and safety of nuclear facilities. -

Promote the use of nuclear knowledge management in the nuclear industry. - Provide insights and recommendations to the nuclear community.

- International Atomic Energy Agency (2007): Drop it and run! New symbol warns of radiation dangers and aims to save lives. - *IAEA Bulletin* 48 / 2, 70-72. http://www.iaea.org/Publications/Magazines/Bulletin/Bull482/48202087072.pdf

  Presentation of a new symbol to help warn people about the dangers of radioactive sources.

- International Atomic Energy Agency (2006): *Knowledge management for nuclear industry operating organizations*. IAEA-TECDOC-1510. IAEA, Vienna. http://www.iaea.org/inisnkm/nkm/documents/te_1510_web.pdf

  The purposes of this publication are to identify the fundamental elements needed for an effective knowledge management (KM) system; to share with nuclear industry operating organization managers the lessons learned in the industry regarding KM; to provide guidance concerning methods for KM implementation. In this report, KM is mainly considered from the point of view of NPP operation, but considerations regarding the facility life cycle are also included.

- International Atomic Energy Agency (2006): *Data Requirements and Maintenance of Records for Spent Fuel Management: A Review*. IAEA-TECDOC-1519. IAEA, Vienna. http://www-pub.iaea.org/mtcd/publications/pdf/te_1519_web.pdf

  This report addresses the question of what data needs to be gathered and how it should be managed. The first step is to identify the issues relevant to spent fuel management, including those required for safety analyses. The second step is to describe those issues in terms of data parameters suitable for use in database systems that could be operated either by the utilities or on a national basis. As a first step in the implementation of these objectives, the various stages in the spent fuel management routes are identified, with a focus on the data needed at each stage which could affect subsequent safe handling and treatment of the spent fuel. This objective entails a subsequent question on how to manage those data for the long term to pass it to future generations.

- International Atomic Energy Agency (2006): *The Management System for Facilities and Activities*. IAEA Safety Standards No. GS-R-3. IAEA, Vienna. http://www-pub.iaea.org/MTCD/publications/PDF/Pub1252_web.pdf

  General safety standard on quality assurance requirements.

- International Atomic Energy Agency (2006): *Managing nuclear knowledge.* Proceedings of a workshop, Trieste, 22-26 August 2005. STI/PUB/1266. IAEA, Vienna. http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1266_web.pdf

  Include sessions on policies and strategies in nuclear science and technology, managing nuclear information resources, human resources and knowledge transfer in the nuclear sector, managing and preserving knowledge in the nuclear sector, networking for education, training and knowledge transfer.

- International Atomic Energy Agency (2006): *Managing nuclear knowledge: Strategies, information management and human resource development*, 7-10 September 2004, Saclay, France. IAEA, Vienna.

http://www-pub.iaea.org/MTCD/publications/PDF/Pub1235_web.pdf

In recent years, a number of trends have drawn attention to the need for better management of nuclear knowledge. The objective of this conference is to reach a clear and common understanding of issues related to nuclear knowledge management for sustaining knowledge and expertise in nuclear science and technology. The conference will provide a forum for professionals and decision makers in the nuclear sector, comprising industry, governments and academia as well as professionals in the knowledge management and information technology sectors.

- International Atomic Energy Agency (2005): *Methods for maintaining a record of waste packages during waste processing and storage*. Technical Reports Series 434. IAEA, Vienna. http://www-pub.iaea.org/MTCD/publications/PDF/TRS434_web.pdf

  To declare compliance of a waste package with waste acceptance criteria, a system for generating and maintaining records should be established to record and track all relevant information, from raw waste characteristics, through changes related to waste processing, to final checking and verification of waste package parameters. In parallel, records on processing technology and the operational parameters of technological facilities should adhere to established and approved quality assurance systems. Records generated during waste processing are a constituent part of the more complex system of waste management record keeping, covering the entire life cycle of radioactive waste from generation to disposal and even the post-closure period of a disposal facility. This report covers all the principal aspects of the establishment and maintenance of records during waste processing and storage.

- International Atomic Energy Agency (2005): *Standard Format and Content for Safety Related Decommissioning Documents*. Safety Reports Series No. 45. IAEA, Vienna. http://www-pub.iaea.org/MTCD/publications/PDF/Pub1214_web.pdf

  The decommissioning plan brings together all the information on the proposed decommissioning activities and identifies relevant safety issues. The present Safety Report provides information on the content and format for the decommissioning plan and supporting safety related documents. Its scope includes information that is relevant to all types of nuclear facilities, ranging from nuclear power plants and reprocessing facilities to university laboratories and manufacturing plants. By using a graded approach in the application of this Safety Report, the owner of a facility can provide the information necessary to allow the regulatory body to determine if the decommissioning activities have been properly evaluated with respect to safety.

- International Atomic Energy Agency (2004): *Records for radioactive waste management up to repository closure: Managing the primary level information (PLI) set*. IAEA-TECDOC-1398. IAEA, Vienna.
  http://www-pub.iaea.org/MTCD/publications/PDF/te_1398_web.pdf

  Waste and repository records, relevant for retention after repository closure, should be generated, identified, reviewed and actively managed during pre-closure phases so that they are available and usable at the appropriate time. This publication addresses the establishment and management of the primary level information (PLI) set up to the point of closure of a repository. Specifically, it (1) describes the importance of establishing a coordinated, integrated and well-managed PLI set, (2) provides a basic overview of the components of a PLI set, and (3) provides general guidance on the management of and responsibility for the PLI set.

- International Atomic Energy Agency (2003): *Predisposal management of high level radioactive waste: Safety guide*. IAEA Safety Standards Series WS-G-2.6. STI/PUB/1151. IAEA, Vienna.
  http://www-pub.iaea.org/MTCD/publications/PDF/Pub1151_web.pdf

  This general safety guide on predisposal management of HLW includes a chapter on record keeping and reporting.

- International Atomic Energy Agency (2003): *Record keeping for the decommissioning of nuclear facilities: Guidelines and experience*. Technical Reports Series 411. IAEA, Vienna.
  http://www-pub.iaea.org/MTCD/publications/PDF/TRS411_scr.pdf

  Record keeping is an integral part of overall QA or quality management programmes. The objective of this report is to provide information, experience and assistance on how to identify, select, update as needed, manage (Record Management System) and maintain records to assist in the decommissioning of nuclear facilities (commercial and research facilities), including for the decommissioning plan.

- International Atomic Energy Agency (2003): *Predisposal management of low and intermediate level radioactive waste*. Safety guide. IAEA Safety Standards Series No. WS-G-2.5. IAEA, Vienna.
  http://www-pub.iaea.org/MTCD/publications/PDF/Pub1150_web.pdf

  Includes a chapter on record keeping and reporting.

- International Atomic Energy Agency (2002): *Documentation for Use in Regulating Nuclear Facilities*. IAEA Safety Standards Series No. GS-G-1.4. IAEA, Vienna.
  http://www-pub.iaea.org/MTCD/publications/PDF/Pub1132_scr.pdf

  This Safety Guide provides recommendations for regulatory bodies and operators on the documentation to be prepared for regulatory processes for nuclear facilities, and on how to ensure that such documentation is of sufficient quality and provides correct information in an appropriate way to serve its intended purpose. It covers the documentation required in the regulatory process for nuclear facilities such as enrichment plants and fuel manufacturing plants, nuclear power plants, other reactors such as research reactors and critical assemblies, spent fuel reprocessing plants, and radioactive waste management facilities such as treatment, storage and disposal facilities. This publication also covers issues relating to the decommissioning (or closure) of nuclear facilities.

- International Atomic Energy Agency (2002): *Issues relating to safety standards on the geological disposal of radioactive waste*: Proceedings of a specialists meeting held in Vienna, 18-22 June 2001. IAEA-TECDOC-1282. IAEA, Vienna.
  http://www-pub.iaea.org/MTCD/publications/PDF/te_1282_prn/t1282_part1.pdf

  See in particular Appendix A.6. Human intrusion, A.7. Reversibility and Retrievability, A.8. Monitoring and Institutional Control as well as the corresponding chapters 2.5, 2.6, 2.7, 4.2, 4.3 and 4.4.

- International Atomic Energy Agency (1999): *Maintenance of records for radioactive waste disposal*. IAEA-TECDOC 1097. IAEA, Vienna.
  http://www-pub.iaea.org/MTCD/publications/PDF/te_1097_prn.pdf

This report describes the requirements for presenting information about repositories for radioactive waste including long lived and transuranic waste and spent fuel. The report discussed topics of identification, transfer and long term retention of high level information pertaining to the repository in a records management system (RMS) for retrieval if it becomes necessary in the future.

- International Atomic Energy Agency, Working Group on Principles and Criteria for Radioactive Waste Disposal (1996): *Issues in radioactive waste disposal: second report*. IAEA-TECDOC-909. IAEA, Vienna
  http://www-pub.iaea.org/MTCD/publications/PDF/te_909_web.pdf

  This report briefly mentions the preservation of information and knowledge as a means to deter human intrusion and allow future generations to take informed decisions. It also addresses the issue of safeguards.

- International Council on Archives, McCarthy G., Upshall I. (2006): *Radioactive Waste Information: Meeting our obligations to future generations with regard to the safety of waste disposal facilities*. ICA Study 18. ICA, Paris.
  http://www.wien2004.ica.org/sites/default/files/Study%2018%20Final%20version%20PDF.pdf

  This study is the result of a project run by the International Atomic Energy Agency (IAEA) from 2002 to investigate the issues surrounding the preservation and transfer to future generations of information important to the safety of radioactive waste disposal facilities. The study highlights the critical role played by contextual information and suggests means by which it may be better utilized. (see also Upshall & McCarthy 2007)

- Jensen M. (1994): Informing future societies about nuclear waste repositories. – *Radwaste Magazine*, Apr 1994, v. 1(2), p. 51-61.
  [Not available online – July 2010]

  In 1990 a working group of the NKS (the Nordic nuclear safety program) was formed and given the task of established a basis for a common Nordic view of the need for information conservation for nuclear waste repositories. The Group investigated what type of information should be conserved, in what form the information should be kept, the quality of the information, and the problems of future retrieval of information, including retrieval after very long periods of time. Topics covered include the following: scientific aspects including social context of scientific solutions, information management, systems for conservation and retrieval of information including the problems of prediction, archives, markers, archives vs. markers, and continuing processes in society. Archive media including paper documents, microfilm, digital media, media lifetimes.

- Jensen M. (1993): *Conservation and retrieval of information: elements of a strategy to inform future societies about nuclear waste repositories: final report of the Nordic Nuclear Safety Research project KAN-1.3.* Nordic Nuclear Safety Research, Stockholm.
  http://www.nks.org/scripts/pdfsearchbackend.php?Mode=getpdf&id=111010000274972&hash=7cf8e6135320cdfa034eb2634e63fb9d

  KAN-1.3 was a project within the NKS programme (Nordic Nuclear Safety Research), in the subarea Nuclear power waste and decommissioning (Kärnkraftens Avfall och Nedläggning – KAN). The project examined the issue of preservation of information relating to a repository for radioactive waste, by investigating what information should be preserved regarding both content and form, and how information can be protected by identifying possible threats and strategies against such threats.

For long-term information transfer, one strategy links information through successive transfers of archived material and other forms of knowledge in society. Another strategy - such as marking the site with a monument - relies upon a direct link from the present to the distant future. Digital methods are not recommended for long-term storage, but digital processing may be a valuable tool to structure information summaries, and in the creation of better long-lasting records. Advances in archive management should also be pursued to widen the choice of information carriers of high durability. In the Nordic countries, during the first few thousand years, monuments at a repository site may be used to warn the public of the presence of dangerous waste. But messages from such markers may pose interpretation problems as we have today for messages left by earlier societies such as rune inscriptions. Since the national borders may change in the time scale relevant for nuclear waste, the creation of an international archive for all radioactive wastes would represent an improvement as regards conservation and retrieval of information.

- Johansson P, Lisberg Jensen E. (2006): *Identitet och trygghet i tid och rum – kulturteoretiska perspektiv på kärnavfallsfrågans existentiella dimensioner*. SKB R-06-119. Svensk Kärnbränslehantering AB (in Swedish)
  http://www.skb.se/upload/publications/pdf/R-06-119webb.pdf

  Interviews and textual analysis investigate the underlying thoughts about structures related to time and space, discussed in connection with the planned final repository for spent nuclear waste in Östhammar and Oskarshamn. Through metaphor, argument and discourse analysis that characterized the debates and texts, as well as informants' own formulations, different conceptions have appeared. A somewhat surprising result was the great unity of the material with however clear dividing lines. With regard to the perception of time, the period up to the decision to build a repository as well as the actual construction period (”societal time”) can be apprehended, but the long-term “repository time” is incalculable. Depending on the type of time envisaged, opinions differ on the responsibilities towards future generations.

- Kaplan M.F.(1986): *Mankind's future: Using the past to protect the future. Archaeology and the disposal of highly radioactive wastes*. – Interdisciplinary Science Reviews, vol. 11, no. 3, 1986, p. 257-268.
  [not available online – February 2011]

  In this review it is shown how archaeology can provide a basis for designing a segment of the disposal system – the marking of the site to minimize future human interference.

- Kaplan M.F. (1982): *Archaeological Data as a Basis for Repository Marker Design*.
  MI/ONWI-354.
  [not available online – February 2011]

  A discussion is presented about the issues involved in human interference with the repository system and the communication of information. A separate chapter summarizes six ancient man-made monuments including: materials, effects of associated textual information on our understanding of the monument, and other features of the ancient monument relevant to marking a repository site. This information is then used to provide the basis and rationale for a preliminary marker system design, including the marker message, presented in a final chapter.

- Kawata T., Umeki H., Osawa H., Seo T., Tsuboya T., Tanabe H., Yoshimura K., Asano H., Ohuchi J. (2007): Knowledge management in the Japanese high-level waste disposal

programme. IAEA-CN-153/1/O/01. – *International conference on knowledge management in nuclear facilities*, 18-21 June 2007. IAEA, Vienna.
http://www.iaea.org/inisnkm/nkm/documents/nkmCon2007/fulltext/FP/IAEA-CN-153-1-O-01fp.pdf

Planning and implementing disposal of high-level radioactive waste (HLW) is a multidisciplinary field. A wide range of relevant knowledge is needed to develop an associated safety case. Here, the term "knowledge" encompasses all of the science and technology (implicitly including social science, economics, etc.) which underpins a repository project. Knowledge management covers all aspects of the development, integration, quality assurance, communication and maintenance/archiving of such knowledge - including data, information, understanding and experience. In order to ensure that required knowledge is accessible to all stakeholders, including the implementer, the regulator, political decision-makers and the general public and that gaps can be identified and prioritised, it is important that knowledge bases are structured in a clear and logical manner. This paper describes the current status of knowledge management activities in the Japanese HLW disposal programme and provides a perspective on some of the developments in this field planned for the future.

- Kazutoshi S., Hajime T., Jin Ohuchi, Takao Tsuboya (2003): *Record preservation study on geological disposal: Significance and technical feasibility*. RWMC Technical Report RWMC-TRE-03001. Radioactive Waste Management Center RWMC, Tokyo.
http://www.rwmc.or.jp/library/pdf/RWMC-TRE-03001.pdf

  In Japan, the Specified Radioactive Waste Disposal Act (2000) requires that the Minister of Economy, Trade and Industry should preserve permanently all records of geological disposal. Apart from providing information necessary for decision making on the repository (during the first several hundreds to about one thousand years) and preventing future generations from unintentional access to the repository, preserving records is considered important to build public confidence in geological disposal as well as in terms of intergenerational equity. This study examined several methods to communicate messages for future generations that are quite different from our own in terms of social systems, culture, values, languages, level of knowledge, etc. as well as for the future in which national systems for record preservation is maintained.

- [*] Kliewer G. (1992): The 10,000-Year Warning. - *The Futurist* 26(5), 17- (3 pages). Washington.
[not available online]

  WIPP marker system.

- [*] Krupar J. (2007): Burying Atomic History: The Mound Builders of Fernald and Weldon Spring. - *The Public Historian*, 29(1), 31-58.
[not available online]

  The Fernald, Ohio and Weldon Spring, Missouri uranium refinery sites performed critical functions in the nation's nuclear weapons manufacturing complex during the Cold War. Now, the U.S. Department of Energy has created two radioactive tombs on the former grounds of these industrial centers. These mounds may be viewed as unofficial monuments to the billions spent building and maintaining the country's atomic arsenal. Radioactive contamination precludes the adaptive reuse of Fernald and Weldon Spring. Yet these two sites reside in counties that continue to experience steady population growth. The present and future generations need to be informed about the activities

conducted at the sites for health, environmental, and educational reasons. Policy choices made by federal government officials concerning Weldon Spring and Fernald indicate a pattern shift from disclosure/preservation to exclusion/destruction by 2005. [Abstract by author]

- [*] La Porte T., Keller A. (1996): Assuring Institutional Constancy: Requisite for Managing Long-Lived Hazards. - *Public Administration Review*, 56(6), 535-544.
  [not available online]

  What role do demands for constancy play in the operations of public agencies? Institutional constancy of agencies and firms is discussed as a concept and an increasingly important political requirement for the operation of hazardous systems in the United States. Situations that increase demands for it are outlined and a basis for analysis and improving constancy is proposed. [Abstract by author]

- Lomberg J., Hora S. C. (1997): Very long term communication intelligence. The case of markers for nuclear waste sites. – *Technological Forecasting and Social Change*, vol. 56, n° 2, p. 171-188.
  [not at Nagra Library, available online from ScienceDirect]

  Two interdisciplinary teams have addressed the issues of physical durability and cognitive intelligibility of markers for a U.S. government site in New Mexico. Preliminary design criteria have determined which materials are best suited to constitute markers of different sizes and shapes. A variety of linguistic, symbolic, and pictographic approaches to content have been suggested. Additional study and testing of both materials and messages is required. International standardization of marker strategies is extremely desirable.

- [*] Mann W.B. (1986): Identification of nuclear-waste sites over ten millennia. *Nuclear and chemical waste management* 6, 95-100.
  [not available online]

- [*] Marshall A. (2008): Leaving messages about our radioactive waste for future generations. – In Lattefer A.P. (ed.), *Nuclear Waste Research: Siting, Technology and Treatment*. Nova Science Publishers, 37-45.
  [not available online, not at Nagra]

- Marvy A., Lioure A., Heriard-Dubreuil G., Gadbois S., Schneider T., Schieber C. (2003): A look at new key performance criteria that could most affect the safety of long term storage of nuclear waste: A case study commissioned by CEA. Paper IAEA-CN-90/11.- *International conference on Issues and trends in radioactive waste management: Vienna, 9-13 December 2002*. IAEA, Vienna, p. 47-51.
  Available through INIS: http://inisdb.iaea.org/inis/php/download.php?s=p&rn=34016251

  As part of the work scope set in the French law on high level long lived waste R&D passed in 1991, CEA conducted research work to establish the scientific basis and assess the feasibility of long term storage as an option for the safe management of nuclear waste for periods as long as a few centuries. This goal was a significant departure from current industrial practice where storage facilities are usually built to last only a few decades. The case study looks into several past and actual human enterprises conducted over significant periods of time – one dating back to the end of the 18th century – and identified off the nuclear field. As a result the study group obtained a set of performance

criteria relating to issues like responsibility, securing funds, legal and legislative implications, economic sustainable development, all being areas which are not traditionally considered when technical studies are conducted.

- Massart C. (2004): How plural interests, values and knowledge could be translated into a concrete radwaste disposal project design: an artist's vision. – *Dealing with interests, values and knowledge in managing risk: Workshop proceedings*, Brussels, Belgium 18-21 November 2003. OECD/NEA, Paris, 117-121.
  [Not available online – can be ordered from the OECD bookshop]

  Professor and Artist, C. Massart operates from the understanding that a proper role for art in radioactive waste management projects can help change the view of waste disposal by stakeholders and the broader public. She has investigated both the artistic aspects of waste management facilities themselves as well as artistic visions of themes associated with radioactive waste. For the past ten years, Professor Massart has been working on a project titled, "An archived site for alpha, beta, gamma." She has explored three separate topics in which using art as a vehicle for communication offers an alternative and perhaps improved method for communicating over the more "traditional" verbal and written communications. The first was to portray radioactive decay not by measurements or comparisons to other risks, but to use the gradual lightening of colours to depict the gradual and natural decay of radioactivity with time in an artistic piece. Second, she demonstrated the possibilities for art to help maintain archives for the future, a key knowledge preservation activity for a programme that will span generations. Third, she showed the possibilities for art to influence markers that would ultimately be placed at waste management sites, preserving the continuity of knowledge regarding such sites.

- Maxeiner H. (2002): "Dokumentationssystem für radioaktive Materialien der Schweiz = Swiss documentation system for radioactive materials".- *Praxis des Strahlenschutzes: Messen, Modellieren, Dokumentieren: 34. Jahrestagung des Fachverbandes für Strahlenschutz e.V., Kloster Seon, 21.-25. April 2002*. Fachverband für Strahlenschutz, Jülich.
  [available from Nagra upon request]

  This paper describes the Swiss "Information System for Radioactive Materials (ISRAM)", that documents all relevant work steps, from planning of conditioning procedures through transport to interim storage, as well as the results of characterisation programs. The spectrum of wastes and materials covered by the system ranges from operational waste from the nuclear power plants (including activated reactor internals) through wastes from medicine, industry and research to vitrified waste from reprocessing and spent fuel.

- [*] McCarthy G. (2005): Report on the International Atomic Energy Agency 'Draft Safety Report on Preservation and Transfer to Future Generations of Information Important to the Safety of Waste Disposal Facilities'. - *Cooperation on Archives of Science in Europe. Newsletter*, 11, June 2005.
  http://www.sac.cat/ficha_notes.php?sitelang=ca&idnoti=366&pw=gavan

- Merz E. (1985): Endlagerung: Übermittlung der Kunde vom Atommüll in ferne Zukunft. – *Atomwirtschaft, Atomtechnik*, May 1985, p. 234.
  [not available online – February 2011]

  Critical review of Sebeok (1984) and Tannenbaum (1984).

- [*] Moser C., Stauffacher M., Krütli P., Scholz R.W. (2012): The crucial role of nomothetic and idiographic conceptions of time: Interdisciplinary collaboration in nuclear waste management. – *Risk Analysis* 32 / 1, 138-154.
  [not available online, June 2012]

  This paper sums up the results of interviews with scientists from various disciplines, on the subject of the perception of time. Knowledge preservation is only marginally mentioned.

- [*] National Research Council, Committee on the Remediation of Buried and Tank Wastes, Board on Radioactive Waste Management (2000): *Long-Term Institutional Management of U.S. Department of Energy Legacy Waste Sites.*
  [can be downloaded from https://download.nap.edu/catalog.php?record_id=9949)

  See in particular Chapter 5, Stewardship activities. This document deals in particular with the collection and dissemination of information related to the monitoring and remediation phase of residually contaminated sites. It also lists problems that can arise in conducting long-term stewardship activities.

- National Security Technologies ST (2007): *Passive Barriers to Inadvertent Human Intrusion for Use at the Nevada Test Site*. DOE/NV/25946-206. NST, Las Vegas.
  http://www.osti.gov/bridge/servlets/purl/917998-fysXWd/917998.pdf

  The primary purpose of this study was to identify types of engineered passive barriers that could deter future intrusion into buried low-level radioactive waste, particularly intrusion by drilling water wells. The study considered drilling technology, many natural and man-made materials, and both underground and above-ground barriers. Based on cost and effectiveness, the report recommended underground barriers consisting of a layer of rubble or tires. An aboveground barrier mound might also prove effective, but would cost more, and may become an attractive nuisance (e.g., might, after their purpose has been forgotten, encourage exploration for the sake of satisfying curiosity). Advances in drilling technology could render any engineered barriers ineffective if there is motivation to penetrate the barriers.

- [*] Nelson R.S. & Olin M. (eds.) (2003): *Monuments and memory, made and unmade*. University of Chicago Press. Chicago.
  [not available online]

  How do some monuments become so socially powerful that people seek to destroy them? After ignoring monuments for years, why must we now commemorate public trauma, but not triumph, with a monument? To explore these and other questions, Robert S. Nelson and Margaret Olin assembled essays from leading scholars about how monuments have functioned throughout the world and how globalization has challenged Western notions of the "monument." Examining how monuments preserve memory, these essays demonstrate how phenomena as diverse as ancient drum towers in China and ritual whale-killings in the Pacific Northwest serve to represent and negotiate time [summary: Internet]
  See in particular Bryan-Wilson J.: Building a Marker of Nuclear Warning, pp. 183-204.

- Nolin J. (1993): *Communicating with the future: implications for nuclear waste disposal*.- Futures, 1993, Bd. 25, Nr. 7, S. 778-791.
  [available through ScienceDirect]

Can we transmit a message about nuclear waste - warnings or instructions - to be received thousands of years from now? Can we ensure that crucial information will be available and intelligible at a critical moment? This article combines the debate generated by these questions with a discussion on knowledge in context. Two perspectives are introduced: in one it is claimed that knowledge can survive through different contexts; in the other it is argued that the importance of context is such that time will render our messages incomprehensible. These perspectives are linked to two alternatives, both discussed within the context of US and Nordic nuclear waste management. One is the 'long-term concept' of a marker or an archive that conserves the information once and for all. The other is a 'short-term' concept that suggests a continuous recoding of the messages in new contexts in order to 'keep it alive'. Finally, a combination of these alternatives is discussed.

- [*] Nora P. (1989): Between Memory and History: Les Lieux de Mémoire. *Representations* 26 (Spring 1989), 7-25.
  [not available online]

- [*] Nuclear Decommissioning Authority, Upshall I. (2010): *Requirements Framework for Managing Information Relating to Radioactive Waste on Nuclear Decommissioning Authority Sites*, Document No. 13006659. NDA, Didcot (UK).
  [not available online, available from the NDA on request]

  The purpose of the document is to bring together a framework for managing information and records concerning the UK's inventory of radioactive waste. It sets out a series of requirements that custodians of these records and information are expected to consider and, where applicable, to implement measures that ensure the requirements are adequately addressed.

- OECD Nuclear Energy Agency (2011-2014): Project on "Long-term preservation of records, knowledge and memory across generations"

  For a list of publications see the section "On-going initiatives / Projects" at the end of this document. Current versions of the documents can be obtained from the NEA.

- OECD Nuclear Energy Agency (2010): *More than just concrete realities: The symbolic dimension of radioactive waste management.* OECD/NEA, Paris.
  http://www.oecd-nea.org/rwm/reports/2010/nea6869-symbolic.pdf

  The concept of landscape embraces the feeling of home, amenity, peace, memory, family, accomplishment and protection. Landscape is also linked to food production and shelter, because the land provides our foodstuff and represents the territory where we live. It is part of our ancestral memory. Protests to RWM facilities have a component of adverse emotions in response to perceived changes in the physical and mentally-constructed landscape of everyday's life.

- OECD Nuclear Energy Agency (2010): R*adioactive waste repositories and host regions: Envisaging the future together*. Synthesis of the FSC national workshop and community visit Bar-le-Duc, France 7-9 April 2009. OECD/NEA, Paris.
  http://www.oecd-nea.org/rwm/reports/2010/nea6925-repositories-host-regions.pdf

  Adding Value through Design and Process: Any long-term radioactive waste management project is likely to last decades to centuries. It requires a physical site and will impact in a great variety of ways on the surrounding community over that whole period. The societal

durability of an agreed solution is essential to success. This report identifies a number of design elements (including functional, cultural and physical features) that favour a durable relationship between the facility and its host community by improving prospects for quality of life across generations. Memorialisation is one aspect of the cultural design features.

- OECD Nuclear Energy Agency (2007): *Fostering a durable relationship between a waste management facility and its host community. Adding value through design and process*. OECD/NEA, Paris.
  http://www.oecd-nea.org/rwm/reports/2007/nea6176-fostering.pdf

  Any long-term radioactive waste management project is likely to last decades to centuries. It requires a physical site and will impact in a great variety of ways on the surrounding community over that whole period. The societal durability of an agreed solution is essential to success. This report identifies a number of design elements (including functional, cultural and physical features) that favour a durable relationship between the facility and its host community by improving prospects for quality of life across generations. Memorialisation is one aspect of the cultural design features.
- OECD Nuclear Energy Agency (1995): *Future human actions at disposal sites: safety assessment of radioactive waste repositories = Les actions humaines futures sur les sites d'évacuation*. OECD/NEA, Paris.
  http://www.oecd-nea.org/rwm/reports/1995/nea6431-human-actions.pdf

  This report is concerned with the treatment in post-closure safety assessments of future human actions that have the potential to disrupt or impair significantly the ability of radioactive waste disposal systems to contain the wastes. The report addresses in particular administrative and practical countermeasures to reduce the consequences and likelihood of future disruptive human actions.

- Ohuchi J., Torata S., Tsuboya T. (2006): Robust record preservation system on geological repository. IAEA-CN-123/03/O/02. – *International conference: Managing nuclear knowledge: Strategies, information management and human resource development*, Saclay, 2004. IAEA, Vienna.
  http://www.iaea.org/km/cnkm/papers/ohuchi.pdf

  Although we cannot predict the future of society we need robust and redundant systems for preserving records that should be accessible, retrievable and understandable for future generations. The balance of active and passive system was considered. It was also found that long-term record preservation may be useful to communicate with the current generation, as a “meta-signal”, in addition to aiming at warning and allowing decision-making. Finally, the laser-engraving technology on silicon carbide was presented as an alternative to paper and maybe to microfilm. Another case study concerned the future generations’ accessibility to the preserved records.

- Ohuchi J., Sugiyama K., Asano H., Tsuboya T. (2003): Conceptual system of robust record preservation on geological disposal.- *Process through cooperation: Proceedings of the 10th International high-level radioactive waste management conference*: March 30 - April 2, 2003, Las Vegas, Nevada, p. 1227-1234.
  [not available online – February 2011]

  See above, Ohuchi et al. (2004)

- [*] Pasqualetti M.J. (1997): Landscape Permanence and Nuclear Warnings. *Geographical Review* 87(1), 73-91.

[not available online]

From the perspective of a human lifetime, the hazards of some nuclear wastes are permanent, so the warnings we place at contaminated nuclear sites must be permanent too. I address questions of how best to provide one hundred centuries of public warning at the first facility for permanent disposal, the Waste Isolation Pilot Plant in New Mexico. Scenarios of intrusion developed to guide the design of warning markers predicted that most of the changes in the area will be social and cultural. Because blatant and permanent markers will increase, not reduce, the probability of inadvertent intrusion, the most appropriate warning is a "landscape of illusion." Such a landscape needs not permanent surface markers but underground warning devices beneath a soft surface marker. No warning can guarantee deterrence for 10,000 years, however. [Abstract by author]

- Pastina B. (2004): Implementing long-term stewardship: a national challenge. - *IICER Workshop "Long-Term Performance Monitoring of Metals and Radionuclides in the Subsurface: Strategies, Tools and Case Studies"*, April 21, 2004.
  http://www.cistems.fsu.edu/PDF/pastina.pdf

  The purpose of this paper is to report on a National Academies workshop on long-term stewardship, held on March 16, 2004. The workshop was organized as a result of growing concerns among certain federal agencies and stakeholder communities over the environmental liabilities left behind at contaminated sites after cleanup ends. Long-term stewardship is a national challenge with thousands of sites with residual radioactive or chemical contamination requiring long-term stewardship. Views on cleanup end states differ significantly between the "remediator" and the "steward;" there appears to be significant challenges for periodic reviews of selected remedies, and there might be a need for policy changes in long-term stewardship regulations; also, different sites have different long-term stewardship needs but there are lessons to share. There appears to be a need for advice on the use of science and technology during cleanup and stewardship to reduce environmental liabilities.

- Paztor S.B., Hora S.C. (1994): Lessons from the Vatican archives for repository recordkeeping.- *Radwaste Magazine*, 1994, Bd. 1, Nr. 3, p. 39-47. (This article is excerpted from a longer report by the same authors, "The Vatican Archives: A study of its history and administration", NKS/KANN 1.3(91)6, available from the Swedish Radiation Protection Institute).
  [not available online – February 2011]

  The Vatican Archives, one of the world's oldest document repositories, contains documents dating back to the ninth century and continuous documentation of the administration of the Roman Catholic Church from the twelfth century. By assessing the strengths (private collection in a politically neutral city-state) and weaknesses (inadequate protection from environmental threats, lack of adequate access system, rather haphazard policy regarding outside access to documents) of the Vatican Archives, valuable lessons can be learned for the design and management of an archival system for nuclear waste records.

- Pescatore C., Mays C. (2009): Records, Markers and People: For the Safe Disposal of Radioactive Waste. – In: *VALDOR 2009: Values in Decisions on Risk, Stockholm (Sweden) 8-11 Jun 2009: Proceedings*.
  Available through INIS: http://inisdb.iaea.org/inis/php/download.php?s=p&rn=41021980

The timescales over which the hazard exists from radioactive waste (as well as from other wastes) 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 of the disposal facility cannot be projected indefinitely into the future, but rather diminishes with time. There is therefore 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. 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 tose residing there, now and in the future. 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.

- Pescatore C., Mays C. (2008): Geological disposal of radioactive waste: records, markers and people: An integration challenge to be met over millennia. – *NEA News* no. 26, 2008, 26-30.
  http://www.oecd-nea.org/pub/newsletter/2008/Geological%20Disposal.pdf
  [See above, Pescatore & Mays 2009]

- Posner R. (ed.) (1990): *Warnung an die ferne Zukunft : Atommüll als Kommunikationsproblem* [Warnings to the far future. Radioactive wastes as a communications problem]. Raben Streifzüge. Raben Verlag, München, 1990. [not available online – February 2011]

  Inquiries were launched in the USA, in Poland, France, Hungary, Brazil, and the Federal Republic of Gemany to find semiotic solutions to problems arising from the communication of radioactive waste locations and dangers to posteriority. How can information be communicated over a period of 10000 years? What has been communicated to us from the past 10000 years? It seems to be sure that neither natural nor artificial barriers nor remnants (e.g. skeletons) or sources (today's communication), but only explicit messages will keep intelligent creatures from intrusion into radioactive waste depositories. Among the subjects dealt with are: Pandora's box and how to prevent its opening; mathematical coding on living sign matter; living detectors and complementary signs: “ray cat”, “broken eye”, and nuclear sirens; the three-chamber system: a way to the democratic organization of collective knowledge and conscience which can survive millennia.
  Includes in particular:

  - Roland Posner: Mitteilungen an die ferne Zukunft. Hintergrund, Anlass, Problemstellung und Resultate einer Umfrage
  - Thomas A. Sebeok: Die Büchse der Pandora und ihre Sicherung: Ein Relaissystem in der Obhut einer Atompriesterschaft
  - Stanislaw Lem: Mathematische Kodierung auf lebendem Trägermaterial
  - Françoise Bastide / Paolo Fabbri: Lebende Detektoren und komplementäre Zeichen: Katzen, Augen und Sirenen
  - Vilmos Voigt: Konzentrisch angeordnete Warntafeln in zunehmend neueren Sprachformen
  - Philipp Sonntag: Künstlicher Mond am Himmel und Datenbank im Keller

- Wulf Rehder: Sicherung gegen Kodebrecher durch Randomisierung
- Percy H. Tannenbaum: Staffelung der Informationsquellen nach Inhalt und Entfernung von den Lagerstätten
- David B. Givens: Was wir aus der Menschheitsgeschichte lernen können
- Marshall Blonsky: Wes Geistes Kind ist die Atomsemiotik?
- Susanne Hauser: Problematisch sind nicht nur die Antworten, sondern bereits die Voraussetzungen

- [*] Powell J., Griffiths G., Walpole S., Lutz M. (2009): The Fernald Preserve Visitors Center: The Fernald Experience - Revealing, Engaging, and Preserving. - *WM2009 Conference*, *March 1–5, 2009, Phoenix, Arizona.*

  http://www.wmsym.org/archives/2009/pdfs/9426.pdf

  The U.S. Department of Energy (DOE) Office of Legacy Management's public involvement activities at the Fernald, Ohio, site include continued communication about groundwater remediation, the management of legacy waste, and the future of the Fernald site. The completion of the Fernald Preserve Visitors Center, in August 2008, ensures that information continues to be readily available and effectively communicated to the public. A primary goal of the Visitors Center is to function as an informational and educational center within the surrounding community, with the information available at the Visitors Center serving as an institutional control. By offering information on a variety of topics, from the site's history to its current condition, the Visitors Center increases public awareness and helps prevent unsafe disturbances to and uses of the site. The Office of Legacy Management maintains and operates the Visitors Center, continues to solicit stakeholder opinion, and will periodically reevaluate the use of the Visitors Center and its programming. [Abstract by author]

- [*] Schröder J., Pescatore C. (2012): Preservation of Records, Knowledge and Memory across Generations. An emerging multidisciplinary work area and an NEA project. – *WM2012 Conference, February 26 – March 1, 2012, Phoenix, Arizona, USA*
  [not available online, June 2012]

- Sebeok Th. A. (1984): *Communication measures to bridge ten millenia*. BMI/ONWI-532. [not available online – February 2011]

  The Department of Energy created the Human Interference Task Force (HITF) in 1980 to investigate the problems connected with the postclosure, final marking of a filled nuclear waste repository. The task of the HITF is to devise a method of warning future generations not to mine or drill at that site unless they are aware of the consequences of their actions. Since the likelihood of human interference should be minimized for 10,000 years, an effective and long-lasting warning system must be designed. This report is a semiotic analysis of the problem, examining it in terms of the science or theory of messages and symbols. Because of the long period of time involved, the report recommends that a relay system of recoding messages be initiated; that the messages contain a mixture of iconic, indexical, and symbolic elements; and that a high degree of redundancy of messages be employed.

- Sheats D.G. (1992): Records Management in support of the licensing process for the high level radioactive waste facility. – *Proceedings of High Level Radioactive Waste Management*, Volume 1, La Grange Park, IL (United States). American Nuclear Society, p. 2083-2087. [not available online – February 2011]

This paper reports that the Yucca Mountain project is imposing a unique set of requirements of the Records Management (RM) Program. Not only must RM function in the traditional role as archivist, but, in relationship to the Licensing Support System (LSS), perform the function of Information Manager. As information Manager, it becomes vitally important that RM fully understand the Licensing Process and the regulatory requirement imposed by the process.

- Schiesswohl S., Bahrke C., Deyo Y., Uhlmeyer T. (2007): Long-Term Stewardship: Institutional Controls on Department of Energy Sites. – Pr*oceedings of Waste Management Symposium WM07, February 25 - March 1, 2007*: Global Accomplishments in Environmental and Radioactive Waste Management: Education and opportunity for the next generation of waste management professionals. American Nuclear Society, La Grange Park. http://www.wmsym.org/archives/2007/pdfs/7462.pdf

  The U.S. Department of Energy (DOE) has managed the Long Term Stewardship and Maintenance activities at DOE sites since 1988. DOE's Office of Legacy Management (LM) was established in December 2003, and its specific mission is to manage the DOE's post-closure responsibilities and ensure the future protection of human health and the environment. LM has control and custody for legacy land, structures, and facilities and is responsible for maintaining them at levels suitable for their long-term use. LM uses a wide range of institutional controls (ICs) as part of efforts to appropriately limit access to, or uses of, land, facilities and other real and personal property assets; protect the environment; maintain the physical safety and security of DOE facilities; and prevent or limit inadvertent human and environmental exposure to residual contaminants and other hazards. DOE is using a 'defense in depth' strategy which uses multiple mechanisms to provide 'layering' for additional durability and protectiveness: Proprietary controls, Governmental controls, Enforcement and permit tools with IC components, Informational devices. An additional practice that supports ICs at LM sites entails the use of engineered controls, such as fences, gates, access controls, etc.

- Schneider T., Schieber C., Lavelle S. (eds.) (2006): *Long term governance for radioactive waste management*, Final report of COWAM2, WP4. COWAM2-D4-12 CEPN - R – 301. December 2006.
  http://www.cowam.com/IMG/pdf_cowam2_WP4.pdf

  The purpose of COWAM2 Work Package 4 (WP4) on "long term governance" was to identify, discuss and analyse the institutional, ethical, economic and legal considerations raised by long term radioactive waste storage or disposal on the three interrelated issues of: (i) responsibility and ownership of radioactive waste over long term, (ii) continuity of local dialogue between stakeholders and monitoring of radioactive waste management facilities, and (iii) compensation and sustainable development. The aim of WP4 was to propose guidelines in order to better address long term issues in decision-making processes and start long term governance.

- Sigurdson B.E., Snider R.C., Bilokury M.R. (2003): Issues and considerations on the development of an institutional control policy for uranium mines within Northern Saskatchewan. Paper IAEA-CN-90/60. – *International conference on Issues and trends in radioactive waste management*: Vienna, 9-13 December 2002: Contributed papers. IAEA, Vienna, p. 308-313.
  [not available online – February 2010]

There is currently no clear provincial policy with respect to a proponent's application for release from a reclaimed and decommissioned site, and the resulting provincial responsibility for the long-term management and maintenance of the site once a release has been granted. Another policy issue has been identified with respect to the long-term institutional control of previously abandoned uranium mine sites.

- Sprenger F. (2007): *Atommüllendlager: Medien, Zeit und Raum eines Kommunikationsproblems*. Ruhr-Universität Bochum, Fakultät for Philologie.
[not available online]

  General overview on communication issues over long timescales, focussing in particular on information theory, media and memory.

- Sumerling T. (2005): *Control, Loss of Control, Causes, Putative Scenarios and Option Performance: Support to CoRWM – Task TS108/4*. SAM-J114-TN1, Version 2, 7 November 2005.
[unpublished, available from Nagra upon request]

  Review of existing literature regarding loss of control.

- Svensk Kärnbränslehantering AB (2010): *Handling of future human actions in the safety assessment SR-Site*. Technical Report TR 10-53. SKB, Stockholm.
http://www.skb.se/upload/publications/pdf/TR-10-53webb.pdf

  This report documents the future human actions, FHA, considered in the long-term safety analysis of a KBS-3 repository. The report is one of the supporting documents to the safety assessment SR-Site. The purpose of this report is to provide an account of general considerations concerning FHA, the methodology applied in SR-Site to assess FHA, the aspects of FHA needed to be considered in the evaluation of their impact on a deep geological repository and to select and analyse representative scenarios for illustrative consequence analysis. The main focus of this report is a time period when institutional control has ceased to be effective, thereby permitting inadvertent intrusion. However, a brief discussion of the earlier period when the repository has been closed, sealed and continuously kept under institutional control is also provided.

- [*] Tall Bear K. (2001): Tribal social & cultural institutions for long-term stewardship of hazardous sites. Presented at the National Academy of Sciences National Research Council Board on Radioactive Waste Management, Washington, D.C., 3 April 2001 and at the Roundtable on tribal issues and opportunities related to the long term stewardship of contaminated federal facilities, Lakewood, Colorado, 14-15 March 2001.
http://www.iiirm.org/publications/Articles%20Reports%20Papers/Environmental%20Protection/socialcul.pdf

- Tannenbaum P.H. (1984): *Communication Across 300 Generations: Deterring Human Interference with Waste Deposit Sites*. BMI/ONWI-535.
[not available online – February 2011]

  A variety of informational sites are suggested. Attention then turns to the recipients of such messages, recognizing from the outset that the psychological/perceptual makeup of individuals across the next 300 or so generations is virtually impossible to predict, particularly since new technologies may well alter that makeup in the future. Nevertheless, current evidence suggests that certain human characteristics may be considered universal, and that these suggest the incorporation of selected sign

signification into the message system. There are other such characteristics that, while probably not intrinsic, can probably be acquired with a minimum of formal training. That still leaves much of the message content to be deliberately created and, hence, learned. The common trefoil or other developed biohazardous signs emerge as the best candidates for a generic base symbol for the buried material.

- [*] Taylor B.C., Kinsella W.J., Depoe S.P. (eds) (2007): Nuclear Legacies: Communication, Controversy, and the U.S. Nuclear Weapons Complex. Lexington Books.

  In part 2, which emphasises organisational aspects of nuclear weapons production, Jason Krupar and Stephen Depoe compare historical preservation efforts at the Nevada test site near Las Vegas, the uranium refinery in Fernald, and the plutonium trigger factory at Rocky Flats near Denver. Only the Atomic Testing Museum in Las Vegas managed to attract federal monies, but it was immediately criticized as presenting a revisionist version of cold war history. By contrast, the Rocky Flats Virtual Exhibit, an online museum created without federal funding, presents an alternative, and much more critical, account of the nuclear age. Laura A. McNamara's essay focuses on attempts to preserve knowledge about designing reliable nuclear weapons since the 1992 testing moratorium. On the basis of fieldwork at Los Alamos, she explores how nuclear weapons designers constitute, maintain, and modify their community of knowing.

- Theis S. (2002) : Die Dokumentation radioaktiver Abfälle im Lichte einer mehrere Jahrzehnte andauernden Zwischenlagerung = The documentation of radioactive waste in the view of several decades of interim storage.- *Praxis des Strahlenschutzes: Messen, Modellieren, Dokumentieren: 34. Jahrestagung des Fachverbandes für Strahlenschutz e.V., Kloster Seon, 21.-25. April 2002*. Fachverband für Strahlenschutz, Jülich.
  [not available online – February 2011]

  Except for the operational documentation of the waste producer and conditioner the properties of radioactive waste packages have been described from the very beginning of their production according to the acceptance criteria of the final repository which was available at the time being. In chronological order the respective repository projects were Asse, Konrad and Morsleben. Further requirements from interim storage had not been considered as necessary. After changing the German repository policy in autumn 1998 a prolonged period of several decades without an operating national repository must be considered. Hence the operators and supervising authorities of the existing interim storage facilities formulated additional requirements especially regarding qualification of the waste containers and additional details of several chapters of the waste documentation.

- Tolan T.L. (1993): *The use of protective barriers to deter inadvertent human intrusion into a mined geologic facility for the disposal of radioactive waste: a review of previous investigations and potential concepts*. Contractor Report. SAND91-7097. Sandia National Laboratories, Albuquerque.
  [not available online – February 2011]

  Sandia National Laboratories is evaluating the feasibility of developing protective barrier system for the Waste Isolation Pilot Plant (WIPP) to thwart inadvertent human intrusion into this radioactive-waste disposal system for a period of 9,900 years after assumed loss of active institutional controls. The protective barrier system would be part of a series of enduring passive institutional controls whose long-term function will be to reduce the

likelihood of inadvertent human activities (e.g., exploratory drilling for resources) that could disrupt the WIPP disposal system.

- [*] Tonn B.E. (2004): Integrated 1000-year planning. - *Futures* 36(1), 91-108.
  [not available online]

  This paper develops the concept of integrated 1000-year planning. The products of 1000-year planning, referred to as 1 000-year plans, are intended to deal with issues on a global scale and address the survival of humanity and the protection of the earth's environment. One thousand years is an appropriate global planning horizon because it is long enough to unmask big picture problems that appear to be invisible to today's societies. Furthermore, this time horizon encourages the perspective that over the long-term, many problems that seem unsolvable today, and therefore receive little attention and few resources, can indeed be overcome. Topics of 1000-year plans are numerous and include: energy, land use, carbon management, oceans, biodiversity, nuclear and hazardous waste, water, human Settlements, near-earth objects, and space exploration. The argument is made that responsibilities for action by current generations to benefit future generations be based on risk assessments and risk thresholds. In the near-term, 1000-year planning must be driven by an international grassroots coalition of scientists, policy analysts, environmentalists, planners, and concerned citizens. [Abstract by author]

- [*] Tonn B.E. (2001): Institutional designs for long-term stewardship of nuclear and hazardous waste sites. - *Technological Forecasting and Social Change* 68, 255–273.
  [not available online]

  This article evaluates several designs for an institution to act as the steward for legacy sites. To offer lessons learned about the characteristics of long-lasting human institutions, several that have existed for hundreds and thousands of years are reviewed, including the Dominican monastic order, the Sangha community of Buddhist monks, and universities such as those located in Oxford and Paris. Six alternative institutional designs are evaluated over a set of four evaluation criteria. It is recommended that the United States establish a new type of secular nonprofit institution, entitled The Stewardship Institution, to act as steward for the sites. This option is judged most able to focus on the mission of stewardship, meet its technical challenges, survive inevitable periods of political and economic instabilities, and meet current generation cost and implementation concems. Other institutions considered include a consolidated national stewardship organization, a religious organization, and a new state of the union called the Legacy State. [Abstract by author]

- Trauth K.M. (1994): WIPP marker development. - *Radwaste Magazine*, vol. 1, No. 2, April 1994, p. 46-52.
  [not available online – February 2011]

  Development of permanent, passive markers for the Waste Isolation Pilot Plant. Work carried out at Sandia National Laboratories [see also Hart 2004, Hart 2000, US DOE 2000, US DOE 1996]

- Trauth K.M., Hora S.C., Guzowski R.V. (1993): *Expert judgment on markers to deter inadvertent human intrusion into the Waste Isolation Pilot Plant*. Sandia Report SAND92-1382. Sandia National Laboratories, Albuquerque.
  http://www.wipp.energy.gov/picsprog/Test1/SAND%2092-1382.pdf

Sandia National Laboratories charged a panel of outside experts with the task to design a 10,000-year marking system for the WIPP (Waste Isolation Pilot Plant) site, and estimate the efficacy of the system against various types of intrusion. The goal of the marking system is to deter inadvertent human interference with the site. The panel of experts was divided into two teams. This is the report of the A Team; a multidisciplinary group with an anthropologist (who is at home with different, but contemporary, cultures), an astronomer (who searches for extra-terrestrial intelligence), an archaeologist (who is at home with cultures that differ in both time and space from our own), an environmental designer (who studies how people perceive and react to a landscape and the buildings within them), a linguist (who studies how languages change with time), and a materials scientist (who knows the options available to us for implementing our marking system concepts). The expert panel identified basic principles to guide current and future marker development efforts: (1) the site must be marked, (2) message(s) must be truthful and informative, (3) multiple components within a marker system, (4) multiple means of communication (e.g., language, pictographs, scientific diagrams), (5) multiple levels of complexity within individual messages on individual marker system elements, (6) use of materials with little recycle value, and (7) international effort to maintain knowledge of the locations and contents of nuclear waste repositories. The efficacy of the markers in deterring inadvertent human intrusion was estimated to decrease with time, with the probability function varying with the mode of intrusion (who is intruding and for what purpose) and the level of technological development of the society. The development of a permanent, passive marker system capable of surviving and remaining interpretable for 10,000 years will require further study prior to implementation.

- Und in alle Ewigkeit: Kommunikation über 10 000 Jahre: Wie sagen wir unsern Kindeskindern wo der Atommüll liegt? – *Zeitschrift für Semiotik*, Bd 6, Heft 3, 1984. Abstracts available at: http://ling.kgw.tu-berlin.de/semiotik/deutsch/zfs/Zfs84_3.htm

  Special issue of „Zeitschrift für Semiotik“, later revised and published as Posner 1990.

- United Kingdom Nirex Ltd (2005): *Societal stability and implications for radioactive waste management*. UK Nirex Ltd Technical Note no. 483990. Nirex, Harwell (Didcot). http://www.nda.gov.uk/documents/upload/Societal-stability-and-implications-for-radioactive-waste-management-A-Technical-Note-2005.pdf

  Includes in particular a list of factors that appear to have either promoted or acting against longevity of organisation or survival of an artefact. States in particular that “in many cases forgetting the existence of the artefacts has been the most effective method of preservation.”

- United States Department of Energy / Waste Isolation Pilot Plant (2000): *Permanent Markers Testing Program Plan: Contractor report*. DOE/WIPP 00-3175. Waste Isolation Pilot Plant, Carlsbad (New Mexico).
  http://www.wipp.energy.gov/picsprog/Test1/PM%20Test%20Plan.pdf

  This plan describes the testing program for the marking systems planned at the Waste Isolation Pilot Plan. The program should develop information useful in materials selection and in the development of final designs. Testing will help to determine the effectiveness and durability of selected and alternative materials and design configurations. See also Hart (2004).

- United States Department of Energy / Waste Isolation Pilot Plant (1996): *Title 40 CFR Part 191: Compliance Certification Application for the Waste Isolation Pilot Plant: Appendix PIC: Passive Institutional Controls Conceptual Design Report.* Waste Isolation Pilot Plant, Carlsbad (New Mexico).
  http://www.wipp.energy.gov/picsprog/Test1/CCA_Appendix_PIC.PDF

  This report describes the US DOE's plan for addressing the PIC requirements of 40 CFR 191.14(c) in the operation of the Waste Isolation Pilot Plant (WIPP). It presents the conceptual design for permanently marking the Waste Isolation Pilot Plant (WIPP), establishing records, and identifying other practicable controls to indicate the dangers of the wastes and their location.

- Upshall I., McCarthy G.J. (2007): The development of a contextual information framework model as a potential IAEA strategy to maintain radioactive waste knowledge . – *Proceedings of Waste Management Symposium WM07, February 25 - March 1, 2007*: Global Accomplishments in Environmental and Radioactive Waste Management: Education and opportunity for the next generation of waste management professionals. American Nuclear Society, La Grange Park.
  http://www.wmsym.org/archives/2007/pdfs/7374.pdf

  Effective inter-generational transfer of information on radioactive waste repositories using 'conventional' techniques will be highly dependent on societal stability – something that cannot be guaranteed over long periods of time. Our understanding of 'inter-generational transfer' should extend beyond the simple physical transfer of records into an archival repository towards the establishment of a working culture that places sufficient contemporary information into a form that ensures it remains accessible, and ultimately enhances, the knowledge of future generations. The IAEA has embraced the contextual information framework as a potentially viable approach to this particular challenge. A contextual framework comprises 'entities' that exhibit one or more definable relationships with a particular 'event'. People, organisations, concepts, ideas, places, natural phenomena, events themselves, cultural artefacts including records, books, works of art can all be conceptualised as entities. An IAEA Safety Report entitled 'Preservation and Transfer to Future Generations of Information Important to the Safety of Waste Disposal Facilities', should be published shortly.

- Upshall I.R., Wisbey S.J. (2003): The long-term management of information on records on radioactive waste packages in the United Kingdom. Paper IAEA-CN-90/59. – *International conference on Issues and trends in radioactive waste management*: Vienna, 9-13 December 2002. IAEA, 303-307.
  Available through INIS: http://inisdb.iaea.org/inis/php/download.php?s=p&rn=34016299

  Careful consideration must be given to the type and form of the information associated with the creation, conditioning and packaging of radioactive waste and the threats to its continued integrity. United Kingdom Nirex Limited (Nirex), in association with experts in records media and management, has undertaken a programme of work to consider the range of media currently available, the threats to media integrity and the implications of a general move towards 'electronic' records. The results of this study are being used to develop an information management system strategy, capable of retaining data for all future phases of radioactive waste management.

- [*] van Wyck Peter C. (2004): *Signs of Danger: Waste, Trauma, and Nuclear Threat*. University of Minnesota Press.

[not available online, not at Nagra, available for purchase through Amazon]

History of WIPP to 1999.

- Wagner S., Beauheim R.L., Pfeifle T.W., Bethel B., Sosa-Yates G., Williams C.V., Milligan M., Fox M. (2002): *WIPP case study: Compliance Monitoring, Passive Institutional Controls, and Record Keeping*. SAND 2002-2010. Sandia National Laboratories, Albuquerque, New Mexico.
  http://www.osti.gov/bridge/servlets/purl/801375-2b1WnW/native/801375.pdf

  The WIPP Case Study describes the compliance monitoring program, record keeping requirements, and passive institutional controls that are used at the Waste Isolation Pilot Plant (WIPP). Within the Case Study, the PIC Task Force assessed the effectiveness of PICs in deterring inadvertent human intrusion and developed a conceptual design for permanently marking the WIPP, establishing records, and identifying other practicable controls to indicate the dangers of the wastes and their location. The marking system should provide information regarding the location, design, contents, and hazards associated with WIPP. This paper discusses these controls including markers, records, archives, and government ownership and land-use restrictions.

- Warner P.J. (1997): United States of America activities relative to the International Atomic Energy Agency (IAEA) Initiatives: Records management for deep geologic repositories. – 1997 Waste Management Conference, March 2-7, 1997. Tucson, Arizona, 1-16. http://www.wmsym.org/archives/1997/sess35/35-01.htm

  Presentation of IAEA activities related to the preparation of TECDOC 1097.

- Warner P.J. (1997): *Traceability and retrievability: Documentation, the bridge from science to compliance.* – DOE Records Management Conference: Illuminating our legacy, focusing our future, Las Vegas, 23-26 June 1997. SAND 97-0485. DOE, Washington D.C.
  http://www.osti.gov/bridge/servlets/purl/510334-SkbrUN/webviewable/510334.pdf

  In this day of regulatory compliance, the fact that good science was practiced and documented is, in and of itself, not enough to assure a successful licensing or permitting result. A new level of documentation that clearly walks a non-project reviewer through the traceability of all activities and decisions is required for successful acceptance of scientific results. Compliance reviewers (whether the Nuclear Regulatory Commission (NRC), Environmental Protection Agency (EPA), etc.) expect to verify the results of the scientific and program activities without the physical presence of the person or persons that conducted the activity. Traceability of activities and associated decisions through the retrieval of all associated records is a must. This presentation is based on lessons learned from the various quality assurance (QA) audits and program reviews of Sandia National Laboratories, Nuclear Waste Management Programs Center, scientific and programmatic documentation. The authors build a bridge from science to compliance from lessons learned.

- Warner P.J. (1996): International Atomic Energy Agency (IAEA) Initiatives: Records management for deep and near surface geologic repositories.- *NIRMA Symposium*, August 25-28 1996. SAND 96-2008C.
  http://www.osti.gov/bridge/servlets/purl/366468-5qdZON/webviewable/366468.pdf

  Presentation – aimed in particular at DOE and NARA (National Archives and Records Administration) – of IAEA activities related to the preparation of TECDOC 1097.

- Waste Isolation Pilot Plant WIPP (2007): How will future Generations be warned? http://www.wipp.energy.gov/fctshts/PICs.pdf.

  Factsheet describing the various Passive Institutional Controls (PICs) planned at WIPP.

- [*] Weinberg A. (1972): Social Institutions and Nuclear Energy. *Science*, Vol. 177, 7 July 1972.
  [not available online]

- [*] Weinberg A.M. (1999): Scientific Millenarianism. *Proceedings of the American Philosophical Society* 143(4), 531-539.
  [not available online]

- Weitzberg A. (1982): *Building on existing institutions to perpetuate knowledge of waste repositories*. BMI/ONWI-379.
  [not available online – February 2011]

  Purpose of this report is to examine the function of several existing institutions and to show how they could be effectively used to transmit information about waste repositories for long times into the future. Scope of this report is limited to a discussion of four institutional approaches to the dissemination and retention of information: Widely distributed maps, the marker system of the National Geodetic Survey, the archiving of documents, and one-call systems designed to protect underground utility installations from inadvertent damage by the public.

- Wing N.R., Corpus F.M., Peterson K.L., Tallman A.M. (1995): *Physical Stability of Long-Term Surface Barriers - Assessment of Potentially Disruptive Natural Events.* BHI-00145. Bechtel Hanford Inc., Washington.
  http://www.wipp.energy.gov/picsprog/Test1/physical%20stability%20longterm%20barriers.pdf

  The report addresses the various natural events that might affect the long-term stability of the surface barriers at Hanford. Though the report does not specifically concern markers, the natural events listed here are also likely to affect surface monuments.

- Wise M., Gray D., Upshall I. (2005): For the record: UKAEA chose to use "permanent paper" to store information on decommissioning wastes from the Windscale Advanced Gas-Cooled Reactor.- *Nuclear Engineering International* 50 / 616, 24-27.
  http://www.neimagazine.com/story.asp?storyCode=2031820

  Radwaste management requires continued access to comprehensive and reliable information over decades and perhaps centuries. The UKAEA has chosen to use ‘permanent paper’ in preference to electronic systems

- [*] Wray M. (2006): A Blast from the Past: Preserving and Interpreting the Atomic Age. - *American Quarterly* 58(2): 467-483.
  [not available online]

- Yucca Mountain Project (2005): [Fact Sheet:] *The Monumental Task of Warning Future Generations*. Office of Civilian Radioactive Waste Management, Yucca Mountain Project, Las Vegas (Nevada).
  http://www.osti.gov/bridge/servlets/purl/840146-ybac68/webviewable/840146.pdf

The Nuclear Regulatory Commission (NRC) requires that the monuments or markers accurately identify the location of the repository, be designed to be as permanent as practicable and convey a warning against intrusion into the underground repository. This report discusses the following issues: (1) Post closure issues of underground repositories, e.g., record keeping and markers, public reassurance and prevention of misuse. (2) Optimization of radiation protection by optimizing radioactive waste management, siting analysis, repository design etc. (3) An interface between nuclear safeguards and radioactive waste management by safeguarding conditioning of spent fuel, during operational phase of repository and post-closure phase of the repository.

Various media

- Madsen Michael (2010): *Into Eternity* (documentary film).

  Director Michael Madsen follows the construction of the Onkalo Waste Repository on the island of Olkiluoto, Finland. He questions Onkalo's intended eternal existence, addressing an audience in the remote future. Into Eternity raises the question of the authorities' responsibility of ensuring compliance with relatively new safety criteria legislation and the principles at the core of nuclear waste management. The film explores the question of preparing the site so that it is not disturbed for 100,000 years.
  http://www.intoeternitythemovie.com/

- Desert Space Foundation, Nevada (2003): *Universal Warning Sign: Yucca Mountain* (exhibition).

  The Desert Space Foundation presented an exhibition comprised of winning designs in a variety of media that engage the challenge of creating an effective universal warning sign/permanent marker for the proposed high-level nuclear waste repository at Yucca Mt., Nevada. The purpose of the warning sign is to deter intentional or inadvertent human intrusion or interference at the site and to effectively communicate over the course of the next 10,000 years (the projected duration of the volatility of the waste) that the integrity of the site must not be compromised in any way in order to safeguard humanity from the release of the radiation contained within.
  http://www.desertspace.org/wwwroot/warning_sign/index.html

- Don't dig here, James Crosby
  http://www.youtube.com/watch?v=cg-dEcilplY

- Discussion with illustrations of both the Yucca and WIPP marker concepts on a private (personal) website
  http://www.damninteresting.com/this-place-is-not-a-place-of-honor

- [*] James L. Acord, sculptor, 1943-2011. J.L. Acord included nuclear material in his sculptures.
  http://jameslacord.com/
  See also Acord J.L. (1993): Art in the nuclear age. – *Waste management '93: Working toward a cleaner environment : waste processing, transportation, storage and disposal, technical programs and public education; proceedings of the Symposium on Waste Management at Tuscon, Arizona*, February 38-March 4, 1993, p. 15.

http://www.wmsym.org/archives/1993/V1/4.pdf

- [*] Cécile Massart, artist
  http://cecile-massart-lisibilite-dechets-radioactifs.com/en/

- [*] Two examples of «nuclear memorials» : Weldon Spring and Fernald

  Weldon Spring Site Interpretive Center
  http://www.lm.doe.gov/Weldon/Interpretive_Center/Interpretive_Center_and_Educational_Opportunities.pdf

  Fernald Preserve Visitors Center
  http://www.lm.doe.gov/Fernald/Sites.aspx

  Fernald Citizen Advisory Board 1993 – 2006 (History of project; see also Krupar 2007)
  http://www.lm.doe.gov/land/sites/oh/FernaldCAB/index.htm

On-going initiatives

Meetings and conferences

Workshop on «Record management and long-term preservation and retrieval of information regarding radioactive waste», held in Rome, January 27-28, 2003.
The proceedings (overheads and papers) were produced as a CD by SKB, Stockholm, 2003 and distributed to the participants.

IAEA Consultants Meetings, Vienna, Austria, March 2002, February 2004, April 2005

IAEA Technical Meeting, Vienna, Austria, June 2004

Club of Agencies Meeting, Paris, 22-23 November 2005 (focus on knowledge management). [overhead presentation available from participants]

NEA Forum on Stakeholder Confidence
The issue of memory and records is often looked at in connection with building a durable relationship to a facility.

Club of Agencies Meeting, Forsmark, 18-19 November 2009 (session on data preservation)

[*] WM2012 Conference, February 26 – March 1, 2012, Phoenix, Arizona, USA: Special session

Projects

OECD/NEA Project on Long-term preservation of records, knowledge and memory across generations. 2010 – 2013.

- Long-term preservation of information and knowledge: Vision for the RWMC Project on “Preservation of RK&M across generations”. NEA/RWM(2011)6/REV2
- 2010 survey on Long-term preservation of information and memory for geological disposal of radioactive waste 18 May 2010. NEA/RWM(2010)7

- [Collective statement]. Status as of 2012.
- Draft glossary of key terms.

Current versions of the documents can be obtained from the RK&M Website. http://www.oecd-nea.org/rwm/rkm/

Waste Isolation Pilot Plant, PICs: http://www.wipp.energy.gov/picsprog/PICs_general.htm

[*] ANDRA, Groupement de laboratoires "Transgenerational transfer and long-time scales", "Knowledge and memory". Contact: Luis Aparicio, ANDRA.
Includes Review of academic literature and benchmarking on very long-term memory associated with RWM, Markku Lehtonen-SPRU, University of Sussex (not publicly available (?))

Relevant treaties, agreements and convention

Council of Europe (2000): European Landscape Convention
http://www.coe.int/t/dg4/cultureheritage/heritage/landscape/default_en.asp
The European Landscape Convention – also known as the Florence Convention, – promotes the protection, management and planning of European landscapes and organises European co-operation on landscape issues. The convention was adopted on 20 October 2000 in Florence (Italy) and came into force on 1 March 2004 (Council of Europe Treaty Series no. 176).

International Atomic Energy Agency (1997): Joint Convention on the safety of spent fuel management and on the safety of radioactive waste management. INFCIRC/546. IAEA, Vienna.
http://www.iaea.org/Publications/Documents/Infcircs/1997/infcirc546.pdf

International Atomic Energy Agency (1970): Treaty on the Non-Proliferation of Nuclear Weapons (NPT). INFCIRC/140. IAEA, Vienna.
http://www.iaea.org/Publications/Documents/Infcircs/Others/infcirc140.pdf

United Nations Economic Commission for Europe (1998): Convention on access to information, public participation in decision-making and access to justice in environmental matters: Done at Aarhus, Denmark, 25 June 1998. UN-ECE [Aarhus Convention].
http://www.unece.org/fileadmin/DAM/env/pp/documents/cep43e.pdf

[*] Supplementary list

This new heading was created to house a series of references to publications and projects that are not directly related to the preservation of RK&M in the context of radioactive waste management, but maybe useful to broaden the discussion. They will eventually be collected into a separate list.

1. Publications

- Weisman A. (2007): The World without Us. Thomas Dunne Books, New York. More information at http://www.worldwithoutus.com/about_book.html
  [not available online, not at Nagra. Reference suggested by CP]

  Weisman explains how our massive infrastructure would collapse and finally vanish without human presence; what of our everyday objects may become immortalized as fossils; how copper pipes and wiring would be crushed into mere seams of reddish rock; why some of our earliest buildings might be the last architecture left; and how plastic, bronze sculpture, radio waves, and some man-made molecules may be our most lasting gifts to the universe. This

book has given rise to a series of TV documentaries on “Life After People”. See below and http://en.wikipedia.org/wiki/Life_After_People

- Yates F. A. (1987): L'art de la Mémoire. Nrf Gallimard, Paris.
  [not available online, not at Nagra. Reference suggested by CP]

  This book is about the art of memorizing anything. It utilises as its basis architectural features, so that each part of a building may be associated, say, to a different part of a speech to be given. Can these techniques teach us anything about building monuments that favour memory?

2. Various media

- de Vries David (2008-2010: Life after People (20 episodes documentary film)

  Life After People premiered as a two-hour special on January 21, 2008 on the History Channel. The documentary and subsequent series were both narrated by James Lurie.
  The program does not speculate on how humanity may disappear, stipulating only that it has, and that it has done so suddenly, leaving everything behind including household pets and livestock that have to fend for themselves. The thought experiment is based on documented results of the sudden removal of humans from a geographical area and the results that have occurred when people discontinue the maintenance of buildings and urban infrastructure.
  The series' episodes thematically offer examples of structural and biological decay. The focus is on specific locations like religious icons, bridges and dams, and government buildings, and the fate of certain related objects, such as artefacts, documents and human bodies. The fate of some kinds of flora and fauna are covered as well. Each episode also contains a segment in which experts examine real locations that have been abandoned by people, including ghost towns and other sites of deterioration, where the deterioration has been caused by events similar to those outlined in the episode. Although the fates of landmarks around the world are speculated upon, the main focus is on situations that may occur at locations in the United States.
  The various events that may occur after people disappear suddenly are depicted using CGI dramatizations. Structures covered include the Egyptian pyramids, the Empire State Building, the Willis Tower, the Space Needle, the Eiffel Tower, the Burj Khalifa, the Golden Gate Bridge, the Gateway Arch, Taipei 101, the USS Constitution, the Hoover Dam, the Sydney Harbour Bridge, Grant's Tomb, John Hancock Center and Air Force One. The time line of predicted events begins approximately one day after the disappearance of mankind and extends up to one hundred million years into the future.
  http://en.wikipedia.org/wiki/Life_After_People

- Aftermath: Population Zero (2008). Documentary film
  This is a Canadian series also inspired, like Lifer after People, by the book by Alan Weisman. In addition to Life After People, Aftermath depicts what would happen if various modes of transportation—such as automobiles, planes, and trains—are abandoned in mid-motion when their passengers and operators instantly disappear, not unlike the Rapture in Christian eschatology. Also, Aftermath shows what would happen if a nuclear power plant's spent fuel rods are left without the cooling equipment governing its condition. Life After People suggest that nuclear power plants would safely shut down with no ill effects with no mention of what would happen to spent fuel rods in storage. However, in an episode of Life After People: The Series, "Toxic Revenge", spent fuel rods are shown 10 days after people heating up and exploding the reactors containing it. Aftermath also shows that the nuclear power plants themselves would shut down without incident, but the spent fuel rod storage in separate

buildings would eventually blow up and spread radiation into the air and the surrounding countryside after the backup safety devices fail, due to lack of fuel a few days after the main power plant supplying power shutdown.
http://en.wikipedia.org/wiki/Aftermath:_Population_Zero

3. Technology and Memory

3.1 Supranational projects and events

IAEA: International Nuclear Information System (INIS)
INIS (operated by the IAEA in collaboration with over 150 countries) hosts one of the world's largest collections of published information on the peaceful uses of nuclear science and technology. It offers online access to a unique collection of non-conventional literature.
http://www.iaea.org/inis/

IAEA: Nuclear Archive project (NuArch)
The IAEA maintains Internet Archive of freely available web-based nuclear related information (NuArch). Documents are stored from pre-selected sources in knowledge repository and are available for retrieval. At present, NuArch contains more than 2.2 millions documents.

Long Now Foundation and 10,000 year clock
http://longnow.org/clock/

UNESCO: Memory of the World Programme
http://www.unesco.org/new/en/communication-and-information/flagship-project-activities/memory-of-the-world/homepage/
See in particular the Memory of the World Register:
http://www.unesco.org/new/en/communication-and-information/flagship-project-activities/memory-of-the-world/register/

UNESCO Conference: The Memory of the World in the Digital age: Digitization and Preservation, 26-28 September 2012, Vancouver, British Columbia, Canada
http://www.unesco.org/new/en/communication-and-information/events/calendar-of-events/events-websites/the-memory-of-the-world-in-the-digital-age-digitization-and-preservation/

3.2 National Organisations / Discipline History Centres

American Institute of Physics (AIP)
http://www.aip.org/

Australian Science and Technology Heritage Centre, University of Melbourne, Australia
http://www.austehc.unimelb.edu.au/
The AUSTEHC is devoted to the preservation, promotion and development of the heritage of Australian science, technology and medicine. Established in 1985.

Archives of the National Research Council Canada
http://www.nrc-cnrc.gc.ca/main_e.html
Canadian Institute for Scientific and Technical Information.

Swedish Center for History of Science
http://www.cfvh.kva.se/engelska/index.htm