Deliverable 12.7:

Guidance and Guide-like documents on Geological Disposal of SNF, HLW and Long-lived Waste:

Contribution to the EURAD Roadmap Gap Analyses

Work Package 12

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Executive Summary

Within Work Package 12 (Guidance) of EURAD, activities aim to develop a comprehensive suite of instructional guidance documents that can be used by EU Member-States with radioactive waste management programmes, regardless of their phase or level of advancement with implementation of geological disposal.

This report summarizes the mapping of available guides and guide-like materials up to October 2022 on geological disposal of SNF, HLW and long-lived waste. It also contains a gap analysis, presented at the end of the document. This is very important as it is an input to the D12.5.

Several information sources have been analysed such as international organisations' publications, open websites; in addition, a thorough search through all EURATOM Framework programmes was performed.

As far as possible there are links made of the existing guides and guide-like documents to the themes, sub-themes and domains of the EURAD Roadmap (signposting). It provided a hierarchical structure that facilitates definition of topics for further guidance. All of this allows knowledge to be captured and presented with the level of detail that is required by the end-user, from a broad overview down to an increasing level of detail.

Almost 300 guidance and guide-like documents on geological disposal were screened.

The screening of the existing guides or guide-like technical documents indicated that much information already exists on topics related to RD&D and technical programme management towards implementation of geological disposal of radioactive waste. If one adds 'examples' then there are hundreds of documents more that could be included in every themes, subthemes and domains.

It was found that most of the EURAD Roadmap themes are at least touched upon in existing documents. It was, however, noted that the level of detail with which some topics are covered may be too low and that further development of these topics may be warranted. Furthermore, the information on some topics is currently scattered over a number of documents.

Further guidance can be developed using material that can be found in existing publications as a starting point.

Table of content

Abbreviations

ABS: As-Built State

AMIGO: Methods for Integrating Geological Information in the Safety Case

CFR: Code of Federal Regulations

CNSC: Canadian Nuclear Safety Commission

CoRWM: Committee on Radioactive Waste Management

D: Deliverable

DBD: Deep borehole disposal

DGR: Deep geological repository

DoE: U.S. Department of Energy

DSSC: Disposal System Safety Case

DT: Design Target

ENEF: European Nuclear Energy Forum

ENSI: Swiss Federal Nuclear Safety Inspectorate

ENSREG: European Nuclear Safety Regulators Group

EPRI: Electric Power Research Institute

ETSON: European Technical Safety Organizations Network

EC: European Commission

EU: European Union

GDF: Geological Disposal

GDF: Geological Disposal Facility

GSG: General Safety Guides

GSR: General Safety Requirements

GWPS: Generic Waste Package Specification

HI: Human Intrusion

HOF: Human and Organisational Factors

IAEA: International Atomic Energy Agency

ICRP: International Committee of Radiological Protection

IGD-TP: Implementing Geological Disposal of Radioactive Waste Technology Platform

IGSC: Integration Group for the Safety Case

INTESC: International Experiences in Safety Cases for Geological Repositories

JRC: Joint Research Centre (the European Commission's science and knowledge service)

KIF: Key Information File

KM: Knowledge Management

KP: Knowledge preservation

MS: Member State

NDA: Nuclear Decommissioning Authority (UK)

NIEA: Northern Ireland Environment Agency

OLCs: Operational Limits and Conditions

PGRC: Phased Geological Repository Concept

R&D: Research and Development

RD&D: Research Development and Demonstration

RK&M: Record, Knowledge and Memory

RMS: Records Management System

RMS: Requirements Management System

RW: Radioactive Waste

RWM: Radioactive Waste Management

RWM Ltd.: Radioactive Waste Management Limited (UK)

RWMC: Radioactive Waste Management Funding and Research Center (Japan)

RWMD: Radioactive Waste Management Directorate (UK)

SE: Safety Envelope

SER: Set of Essential Records

SFC: Spent Fuel Characterization and Evolution Until Disposal

SH: Stakeholder

SITEX: Sustainable network of Independent Technical Expertise for Radioactive Waste Disposal

SKB: Swedish Nuclear Fuel and Waste Management Company

SSG: Specific Safety Guides

SSI: Swedish Radiation Protection Authority

SSR: Specific Safety Requirements

STUK: Safety Authority of Finland

TSC: Transport Safety Case

TRU: TransUranic Waste

WAC: Waste Acceptance Criteria

WENRA: Western European Nuclear Regulators Association

WGWD: Working Group on Waste and Decommissioning

WIRKS: Waste Inventory Record Keeping Systems

WMO: Waste Management Organisation

WPS: Waste Package Specifications

1. Introduction

EURAD as a European joint programme in the field of RWM is managing three Knowledge Management WPs (WP11, WP12 and WP13) contributing to the expected KM goals.

Within Work Package 12 (Guidance) of EURAD, activities aim to develop a comprehensive suite of instructional guidance documents that can be used by EU Member-States with radioactive waste management programmes, regardless of their phase or level of advancement with implementation of geological disposal.

The starting point for selecting further guidance topics is a literature survey which can help in signposting and orienting users to what knowledge is needed and available when planning their geological disposal programme. The literature search is planned to be systematic and as comprehensive as possible. In order to establish a starting point related to the mapping of the available guidance and guide-like technical documents, a first step was to perform a detailed screening of:

- international regulation documents (ICRP and WENRA);
- international guides (IAEA);
- international guide-like technical documents (IAEA, OECD NEA, EC projects);
- national guides, and
- national guide-like technical documents.

Other main sources for the mapping are the former and running EC co-funded projects' documents. Open web was searched to obtain further information on the available material related to establishment and implementation of geological disposal.

The results of the analysed documents are then linked to the EURAD Roadmap themes, sub-themes and domains (signposting).

2. Thematic Literature Survey

Categorization of the documents in the screening is as follows:

- International regulation documents (IR);
- International guides (IG);
- International organizations' guide-like technical documents (ITD);
- National regulation documents (NR);
- National guides (NG);
- National guide-like technical documents (NTD);
- International compilation (IC);
- International meetings summary (IM)

An attempt was made to frame the screened documents into the EURAD roadmap structure. Some documents cannot be directly referred to the EURAD roadmap structure, these are indicated by asterisk.

Some of the listed documents are more than 20 years old. It is worth keeping some of them in to provide historic context to GD, but those IAEA documents that have been superseded are not indicated.

2.1 International organisations' documents

2.1.1 ICRP Publications

Date	Title	Type of doc	EURAD roadmap ID	Short description	Web
Published after 2000					
2006	**Assessing dose of the representative person for the purpose of radiation protection of the public** **ICRP Publication 101a**	IR	*	This report explains the process of estimating annual dose and recognises that a number of different methods are available for this purpose. These methods range from deterministic calculations to more complex probabilistic techniques. In addition, a mixture of these techniques may be applied. In selecting characteristics of the representative person, three important concepts should be borne in mind: reasonableness, sustainability, and homogeneity. Each concept is explained and examples are provided to illustrate their roles. Doses to the public are prospective (may occur in the future) or retrospective (occurred in the past). Prospective doses are for hypothetical individuals who may or may not exist in the future, while retrospective doses are generally calculated for specific individuals.	http://www.icrp.org/publication.asp?id=ICRP%20Publication%20101a

2006	**The optimisation of radiological protection-broadening the process,** **ICRP Publication 101b**	IR	*	This report is a consolidation and an evolution of the Commission's recommendations concerning the optimisation principle. After some background information on the foundation and evolution of the principle, this report describes the main characteristics of the process, addresses the issue of exposure distribution in that process, and provides the basic requirements for its application in operation and regulation. A description of decision-aiding techniques commonly used for practical implementation of the optimisation process is provided in Annex A.	http://www.icrp.org/publication.asp?id=ICRP%20Publication%20101b
2007	**The 2007 Recommendations of the** **International Commission on Radiological Protection** **ICRP Publication 103**	IR	*	The present Recommendations update the radiation and tissue weighting factors in the quantities equivalent and effective dose and update the radiation detriment, based on the latest available scientific information of the biology and physics of radiation exposure. They maintain the Commission's three fundamental principles of radiological protection, namely justification, optimisation, and the application of dose limits, clarifying how they apply to radiation sources delivering exposure and to individuals receiving exposure. The Recommendations also include an approach for developing a framework to demonstrate radiological protection of the environment.	http://www.icrp.org/docs/ICRP_Publication_103-Annals_of_the_ICRP_37%282-4%29-Free_extract.pdf

2008	**Radioactive Waste Management Regulating the Long-term Safety of Geological Disposal of Radioactive Waste: Practical Issues and Challenges – Workshop Proceedings –** **Paris, France 28-30 November 2006** **NEA No. 6423**	IM	*	The viewpoints expressed during the workshop have been summarised and address the necessity for diversity of regulatory processes; the basis and tools for assuring long-term protection; ethical responsibilities of one generation to later generations and how these can be discharged; and adapting regulatory processes to the long time frames involved in implementing geological disposal. The summary of viewpoints presented in these proceedings.	https://www.oecd-nea.org/jcms/pl_14444/regulating-the-long-term-safety-of-geological-disposal-of-radioactive-waste-practical-issues-and-challenges?details=true
2008	**Environmental Protection: the Concept and Use of Reference Animals and Plants** **ICRP Publication 108**	IR	*	In its latest recommendations for a system of radiological protection, the Commission considered it necessary and appropriate to broaden its scope in order to address, directly, the subject of protection of the environment. This publication introduces the concept of Reference Animals and Plants, and defines a small set. It discusses their pathways of exposure, and collates and discusses the adequacy of the best-available data relating to their dosimetry at different stages of their life cycles. In addition, this publication further develops and uses this information to derive sets of tabulated data (dose conversion factors, in terms of (µGy/day)/(Bq/kg)) that allow the dose to be calculated for 75 radionuclides that may be within, or external to, each organism.	http://www.icrp.org/publication.asp?id=ICRP%20Publication%20108

2013	**Radiological Protection in Geological Disposal of Long-Lived Solid Radioactive Waste** **ICRP Publication 122**	IR	*	The recommendations given apply specifically to GD of LL solid RW. The report explains how the ICRP system of radiological protection described in Publication 103 (ICRP, 2007) can be applied in the context of the GD of LL solid RW. The Recommendations include an approach for developing a framework to demonstrate radiological protection of the environment. This report describes the different stages in the lifetime of a GD facility, and addresses the application of relevant radiological protection principles for each stage depending on the various exposure situations that can be encountered. In particular, the crucial factor that influences the application of the protection system over the different phases in the lifetime of a disposal facility is the level of oversight or 'watchful care' that is present. The level of oversight affects the capability to control the source, i.e. the waste and the repository, and to avoid or reduce potential exposures. Three main time frames are considered: time of direct oversight, when the disposal facility is being implemented and is under active supervision; time of indirect oversight, when the disposal facility is sealed and oversight is being exercised by regulators or special administrative bodies or society at large to provide additional assurance on behalf of society; and time of no oversight, when oversight is no	https://pubmed.ncbi.nlm.nih.gov/23639723/

				longer exercised in case memory of the disposal facility is lost.	
Published before 2000					
1965	**Principles for the Disposal of Solid Radioactive Waste** **ICRP Publication 46**	IR	*	The application of the system of dose limitation recommended by the ICRP to the disposal of solid RW involves consideration of two special factors: the probabilistic nature of future exposures and the long timescales involved. This report takes into account the variable probabilities by generalising from a system of dose limitation to a system of risk limitation and showing how this can be applied. The long timescales involved in solid RW disposal are discussed in terms of truncation of calculations of collective dose equivalent, the weight to be assigned to future detriments and the use of utility values in quantifying the significance of exposures with a low probability of occurrence. The report also includes a discussion of exemption rules to be used in deciding whether a waste stream should be subject to control and of operational aspects of solid RW disposal. While still a basic source document, this report is supplemented and amended by ICRP Publications 77 and 81.	https://journals.sagepub.com/doi/pdf/10.1177/ANIB_15_4
1986	**Radiation Protection Principles for the Disposal of Solid Radioactive Waste, Annals of the ICRP Vol.15, No. 4.** **ICRP Publication 46**	IR	*	The application of the system of dose limitation recommended by the ICRP to the disposal of solid RW involves consideration of two special factors: the probabilistic nature of future exposures	https://journals.sagepub.com/doi/pdf/10.1177/ANIB_15_4

				and the long timescales involved. This report takes into account the variable probabilities by generalising from a system of dose limitation to a system of risk limitation and showing how this can be applied. The long timescales involved in solid RW disposal are discussed in terms of truncation of calculations of collective dose equivalent, the weight to be assigned to future detriments and the use of utility values in quantifying the significance of exposures with a low probability of occurrence. The report also includes a discussion of exemption rules to be used in deciding whether a waste stream should be subject to control and of operational aspects of solid RW disposal. While still a basic source document, this report is supplemented and amended by ICRP Publications 77 and 81.	
1990	**ICRP Publication 60., 1990 Recommendations of the ICRP, Annals of the ICRP Vol.21, Nos. 1-3.**	IR	*	In publishing these recommendations, the Commission has had three aims in mind: to take account of new biological information and of trends in the setting of safety standards; to improve the presentation of the recommendations; and to maintain as much stability in the recommendations as is consistent with the new information.	https://journals.sagepub.com/doi/pdf/10.1177/ANIB_21_1-3
1993	**Protection from potential exposure: A conceptual framework", Annals of the ICRP Vol.23, No. 1.** **ICRP Publication 64**	IR	*	The ICRP, in its 1990 Recommendations, divided situations affecting radiation exposure of individuals into two broad categories: practices and intervention. The basic principles of radiation	https://journals.sagepub.com/doi/pdf/10.1177/ANIB_23_1

				protection are applied to these categories in different ways. The report is intended to provide a basis for the preparation of more detailed guidance related to specific practices.	
1997	**Radiological Protection Policy for the Disposal of Radioactive Waste, Annals of the ICRP Vol.27, Supplement, pp. 1–24.** **ICRP Publication 77**	IR	*	This report presents the basis of the Commission's policy and discusses policies other than those of the Commission for the disposal of toxic wastes. It reaffirms the Commission's current policy, and then aims to clarify the practical application of that policy to the disposal of RW. The issues discussed include the justification of a practice, the optimisation of protection, the use of collective dose assessed over long distances and times, the implications of potential exposure, and the distinction between practices and intervention.	https://journals.sagepub.com/doi/pdf/10.1177/ANIB_27_1S
1998	**Radiation Protection Recommendations as applied to the Disposal of Long-lived Solid Radioactive Waste, Annals of the ICRP Vol.28, No. 4, pp. 1–24.** **ICRP Publication 81**	IR	*	The report deals with the radiological protection of members of the public following the disposal of LL solid RW using the 'concentrate and retain' strategy. It covers options including shallow land burial and deep GD. Its recommendations apply to new disposal facilities. The report supplements, updates, and clarifies the material in ICRP Publication 46 from 1986, taking into account the most recent general recommendations of ICRP in Publication 60 and the general ICRP policy for disposal of all types of RW as described in Publication 77. It addresses the main protection issue: exposure that may or	http://www.sciencedirect.com/science/article/pii/S0146645399000172

				may not occur in the far future, and regards constrained optimisation as the central approach to evaluating radiological acceptability of a waste disposal system. In this context, optimisation is a judgmental, essentially qualitative process. Two categories of exposure situation are considered: natural processes and HI.	
1999	**Protection of the Public in Situations of Prolonged Radiation Exposure, Annals of the ICRP Vol.29, Nos. 1-2, Pergamon Press, pp.1–109,** **ICRP Publication 82**	IR	*	This report provides guidance on the application of the ICRP system of radiological protection to prolonged exposure situations effecting members of the public. It addresses the general application of the Commission's system to the control of prolonged exposures resulting from practices and to the undertaking of interventions in prolonged exposure situations. Additionally, it provides recommendations on generic reference levels for such interventions.	https://journals.sagepub.com/doi/pdf/10.1177/ANIB_29_1-2

2.1.2 IAEA safety requirements

Date	Title	Type of doc	EURAD roadmap ID	Short description	Web link
2006	**The Management System for Facilities and Activities** **GS-R-3** **Safety Requirements**	IR	**1.2.4**	This Safety Requirements publication defines the requirements for establishing, implementing, assessing and continually improving a management system. A management system designed to fulfil these requirements integrates safety, health, environmental, security, quality and economic aspects.	https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1252_web.pdf
2011	**Disposal of Radioactive Waste** **SSR-5** **Safety Requirements**	IR	**7.1.1**	This Safety Requirements publication is based on the premise that, in general, arrangements have to be in place to ensure that these related requirements are met. This Safety Requirements publication does set out some requirements that are closely related to these other thematic areas and which are of particular importance to the safety of RW disposal facilities. Guidance on the fulfilment of the safety	https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf

				requirements set out in this Safety Requirements publication is provided in several Safety Guides specific to different types of RW disposal facility.	
2016	**Governmental, Legal and Regulatory Framework for Safety, General Safety Requirements** **GSR Part 1 (Rev. 1)**	IR	**Theme 1**	This publication establishes requirements in respect of the governmental, legal and regulatory framework for safety. It covers the essential aspects of the framework for establishing a regulatory body and taking other actions necessary to ensure the effective regulatory control of facilities and activities utilized for peaceful purposes. Other responsibilities and functions, such as liaison within the global safety regime and on support services for safety (including radiation protection), emergency preparedness and response, nuclear security, and the State system of accounting for and control of nuclear material, are also covered.	https://www.iaea.org/publications/10883/governmental-legal-and-regulatory-framework-for-safety
2016	**Leadership and Management for Safety,** **General requirements for the management system are established** **GSR Part 2**	IR	**1.2.4**	The objective of this Safety Requirements publication is to establish requirements that support Principle 3 of Fundamental Safety Principles [1], in relation to establishing, sustaining and continuously improving leadership and management for safety, and an	https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1750web.pdf

				effective management system. This is essential in order to foster and sustain a strong safety culture in an organization. Another objective is to establish requirements that apply Principle 8, which states that "All practical efforts must be made to prevent and mitigate nuclear or radiation accidents."	

2.1.3 IAEA safety guides

Date	Title	Type of doc	EURAD roadmap ID	Short description	Web link
Published after 2000					
2008	**Management System for Disposal of Radioactive Waste** **GS-G-3.4**	IG	**1.2.4**	It provides for further elaborated guidance for facilities for disposal of RW. Appendix I: Aspects of management systems specific to the phases of operation, closure and post-closure active institutional control for disposal facilities for RW. Appendix II: Guidance on controlling the computer modelling of disposal facilities for RW.	http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1330_web.pdf

2010	**Licensing Process for Nuclear Installations** **SSG-12**	IG	**1.2.1** **1.2.2**	This Safety Guide describes how the licensing process should be applied at the various stages of the lifetime of a nuclear installation, with discussion of topics and required documents to be considered at each stage. Recommendations on the application by a regulatory body of a graded approach in the licensing process are also provided. It also describes the processes that should be undertaken to meet the regulatory and legal requirements in a MS to authorize the establishment of a nuclear installation and/or initiation of its activities. While this Safety Guide focuses on safety at nuclear installations, it is noted that integration of safety and security aspects should be considered and evaluated by the regulatory body in the licensing process.	https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1468_web.pdf
2010	**Developing Multinational Radioactive Waste Repositories: Infrastructural Framework and Scenarios of Cooperation, IAEA-TECDOC-1413**	IG	**1.1.1**	The report are: (1) to serve as reference publication for the Member States potentially interested in multinational repository concepts as hosting, partner or third party countries. (2) to provide an overview of the past history and the current status of multinational cooperation on repositories. (3) to describe different scenarios of cooperation that may be encountered for the implementation of multinational repositories, and discuss their benefits and challenges.	https://www-pub.iaea.org/MTCD/Publications/PDF/te_1413_web.pdf

				(4) to identify the benefits that multinational repositories could bring to some MSs, but also to record the potential drawbacks and the challenges to be faced. (5) to define the requirements that should be followed by interested MSs as hosting, partner and third party countries for pursuing such a cooperative effort. (6) to examine the potential role of international organizations in multinational repository development. (7) to propose further studies that could clarify open technical and institutional questions. (8) to formulate recommendations on how work in this area might proceed further.	
2011	**GD Facilities for Radioactive Waste** **SSG-14**	IG	**7.1.1**	This Safety Guide provides guidance for policy makers, regulatory bodies and operators concerned with the development and regulatory control of facilities for the GD of RW. It provides recommendations on how to meet the safety requirements for the disposal of RW established in SSR-5. This Safety Guide is primarily concerned with activities associated with the development of GDFs after a site has been selected. Whilst site characterization and site confirmation is addressed in this Safety Guide, site selection is not because it includes many	http://www-pub.iaea.org/MTCD/publications/PDF/Pub1483_web.pdf

				aspects that are non-technical and specific to the societal context.	
2011	**Viability of Sharing Facilities for the Disposal of Spent Fuel and Nuclear Waste, IAEA-TECDOC-1658**	IG	**1.1.1**	Ensuring that the benefits of nuclear power can be offered around the world on a much larger scale than at present requires that the complete nuclear fuel cycle, including the final disposal step, must be based to a far greater extent than hitherto on multinational cooperation. This has led to a number of new initiatives and projects which are described in the present report. The objective is then to assess their specific impacts on the viability of multinational facilities for disposal of spent fuel or of the waste products resulting from its processing.	https://www-pub.iaea.org/MTCD/Publications/PDF/TE-1658_web.pdf
2012	**The Safety Case and Safety Assessment for the Disposal of Radioactive Waste** Series, **No. SSG-23**	IG	**Theme 7.**	Methods for constructing scenarios are described. All potentially significant migration pathways from the facility have been considered and that possible evolutions of the system have been taken into account It should be explained and justified which scenarios are regarded as representing the normal or expected evolution of the system, and which scenarios address events and processes having a low or particularly uncertain probability of occurrence. To the extent possible, an indication of the likelihood of each scenario considered should be provided to help with assessing risk.	http://www-pub.iaea.org/mtcd/publications/pdf/pub1553_web.pdf
2013	**Options for Management of Spent Fuel and Radioactive Waste for Countries**	IG	**1.1.1**	The objectives of the publication are:	https://www-pub.iaea.org/MTCD/Publications/PDF/PUB1825_web.pdf

	Developing New Nuclear Power Programs, IAEA Nuclear Energy Series NW-T-1.24			— To describe the challenges associated with the safe, environmentally sound and economical management of spent fuel and different types of RW generated in connection with operation of a NPP; — To provide a background for establishing a national policy and technical strategies for managing SF and RW from NPPs; — To identify existing RW and SF management strategies and possible future developments, including multilateral or regional solutions; — To highlight the legal, political, economic and technical requirements contributing to a safe, feasible and acceptable implementation for each of these options; — To formulate, for countries with small or newly established nuclear power programmes, key messages and recommendations whose serious consideration will help these countries address the challenges associated with expanding nuclear power in a safe, secure and economical manner; — To identify future actions that could help countries with small or newly established nuclear power programmes move towards implementation of national and/or multilateral solutions to management of waste associated with NPPs.	

2014	**Monitoring and Surveillance of Radioactive Waste Disposal Facilities:** **SSG-31**	IG	**5.5**	This Safety Guide provides recommendations and guidance on how to plan and perform monitoring and surveillance programmes for disposal facilities for RW. The Safety Guide considers monitoring and surveillance for near surface disposal facilities, for GD facilities and for facilities for the disposal of waste from mining and from mineral processing. The publication provides recommendations on how to use results from the monitoring and surveillance of RW disposal facilities over their entire lifetime. It covers the different objectives of monitoring and surveillance for the different periods of the lifetime of disposal facilities, from the initiation of work on a candidate site to the period after closure of the disposal facility.	https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1640_web.pdf
2017	**Communication and Consultation with Interested Parties by the Regulatory Body,** **General Safety Guides** **No. GSG-6**	IG	**1.1.3**	This Safety Guide provides recommendations on meeting the safety requirements concerning communication and consultation with the public and other interested parties by the regulatory body about the possible radiation risks associated with facilities and activities, and about processes and decisions of the regulatory body. The Safety Guide can be used by authorized parties in circumstances where there are regulatory requirements placed on them for communication and consultation. It may also be used by other organizations or individuals considering their	https://www.iaea.org/publications/11029/communication-and-consultation-with-interested-parties-by-the-regulatory-body

				responsibilities for communication and consultation with interested parties.	
2016	**Framework and Challenges for Initiating Multinational Cooperation for the Development of Radioactive Waste Repositories** **IAEA Nuclear Energy Series report**	IG	**1.1.1**	This publication describes the phased approach that would be needed to develop a multinational repository, indicating the decision processes to be undertaken by partners in the multinational project, both within a national context and in the scope of the joint endeavour. It touches on a wide range of legal and institutional aspects, including the contractual obligations among partners; economic and financial arrangements; liabilities; nuclear security; regulatory and legislative aspects; waste transportation arrangements; and social matters. The uncertainties and risks involved in the implementation of a multinational repository are addressed in a separate section. The discussion is thus particularly relevant for countries with small nuclear programmes and for countries planning to establish new nuclear programmes, as well as for countries without nuclear power plants but with long lived radioactive waste from medicine, industry and research. It is assumed that all countries involved in a multinational repository initiative have a coherent national disposal policy and strategy. This means that the multinational initiative would be treated initially as part of a dual track strategy including both national and multinational components.	https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1722_web.pdf

2018	**Functions and processes of the regulatory body for safety** **Safety Standards Series** **GSG-13**	IG	**1.2** **1.3**	This Safety Guide covers the core functions of the regulatory body, and the processes by which they are discharged, for all the stages of the lifetime of a facility or activity, from initial site evaluation and design through to release from regulatory control. While this Safety Guide is based on the regulation of authorized facilities and activities, many of the functions and processes also apply for any pre-authorization stages. However, in line with a graded approach, not all the regulatory controls and recommendations described will be applicable to all facilities and activities; even where regulatory controls are applicable, they will differ and vary in depth and scope in accordance with the facility and activity, as well as the lifetime stage.	https://www-pub.iaea.org/MTCD/Publications/PDF/P1804_web.pdf
2018	**Organization, Management and Staffing of the Regulatory Body for Safety** **GSG-12**	IG	**1.2** **1.3.2**	This Safety Guide provides guidance on the organizational structure, management and staffing of the regulatory body for ensuring the control of facilities and activities. Organization and management are of fundamental importance for regulatory bodies to be able to perform their functions effectively. This guidance is particularly important for those regulatory bodies having responsibilities covering a range of facilities and activities that give rise to radiation risks, or when interfaces are present between various regulatory	https://www-pub.iaea.org/MTCD/Publications/PDF/P1801_web.pdf

				authorities, which require effective coordination and cooperation.	
2018	**Establishing the Infrastructure for Radiation Safety** **SSG-44**	IG	**Theme 1**	The objective of this Safety Guide is to provide guidance on the establishment of a national radiation safety infrastructure that meets the IAEA safety standards. It provides recommendations, in the form of actions, on meeting the relevant safety requirements in an effective and integrated manner while taking specific national circumstances into full consideration. It sets out a holistic approach to the establishment of the national radiation safety infrastructure and provides advice for the application of IAEA safety standards for States having essentially no elements of a radiation safety infrastructure in place as well as those that already have some.	https://www.iaea.org/publications/11085/establishing-the-infrastructure-for-radiation-safety
2022	**Leadership, Management and Culture for Safety in Radioactive Waste Management** **No. GSG-16**	IG	**1.2**	This Safety Guide provides recommendations on meeting the requirements of GSR Part 2 to provide confidence that the requirements for predisposal management of RW established in GSR Part 5 and those for disposal of RW established in SSR-will be met. This Safety Guide supersedes IAEA Safety Standards Series Nos GS-G-3.3, The Management System for the Processing, Handling and Storage of Radioactive Waste , and GS-G-3.4, The Management System for the Disposal of Radioactive Waste.	https://www-pub.iaea.org/MTCD/Publications/PDF/PUB1979_web.pdf
Published before 2000					

1989	**Evaluating the Reliability of Predictions Made Using Environmental Transfer Models, Uncertainty analysis and sensitivity analysis are described in detail.** **Safety Series No. 100**	IG	**7.3.1** **7.3.2**	This safety practice publication provides guidance on the available methods for evaluating the reliability of environmental transfer model predictions. It provides a practical introduction to the subject, and particular emphasis has been given to worked examples in the text. It is Intended to supplement existing IAEA publications on environmental assessment methodology. Although the book addresses the subject of environmental dose assessment, the methods described are of general application and are equally useful in other areas where modelling techniques are applied.	https://www.iaea.org/publications/3703/evaluating-the-reliability-of-predictions-made-using-environmental-transfer-models
1994	**Siting of Geological Disposal Facilities,** Safety Series No. 111-G-4.1	IG	**6.1**	This safety guide, published under the IAEA's Radioactive Waste Safety Standards (RADWASS) programme, defines the process to be used and guidelines to be considered in selecting sites for deep geological disposal of RWs. It also addresses the social, economic and environmental factors to be considered in site selection. All data needed for the application of the guidelines are also specified.	https://gnssn.iaea.org/Superseded%20Safety%20Standards/Safety_Series_111-G_4.1_1994_Pub952e_web.pdf

2.1.4 IAEA guide-like technical documents

Date	Title	Type of doc	EURAD roadmap ID	Short description	Web link
Published after 2000					
2001	**Waste inventory record keeping systems (WIRKS) for the management and disposal of radioactive waste** **TECDOC-1222**	ITD	**1.4.1**	The objectives of this report are to: (1) discuss and provide technical guidance to MSs for the establishment of a WIRKS; and (2) identify a methodology for the compilation and management of appropriate records for a WIRKS. The information and technical guidance presented in this publication may assist MSs in ensuring that records for a WIRKS are identified and compiled at appropriate times during the pre-operational, operational and closure phases of their repositories.	https://www-pub.iaea.org/MTCD/Publications/PDF/te_1222_prn.pdf
2001	**Monitoring of Geological Repositories for High Level Radioactive Waste** **TECDOC-1208**	ITD	**5.5**	Data obtained from monitoring programmes will constitute an important component of the repository records that are expected to be preserved over a long period of time. A key point of discussion at present is how monitoring data might be used. This report focuses on the	https://www-pub.iaea.org/MTCD/publications/PDF/te_1208_prn.pdf

				different objectives that monitoring might have at various stages of a programme, from the initiation of work on a candidate site, to the period after repository closure. Each objective may require somewhat different types of information, or may use the same information in different ways. Having evaluated monitoring requirements, the report concludes with a brief evaluation of available monitoring techniques.	
2003	**Scientific and Technical Basis for the Geological Disposal of Radioactive Wastes** **TR 413**	ITD	**5.1** **5.4** **5.5**	This report focuses on the different functions of a repository within its life cycle and describes the processes relevant to the containment of LL RW and other criteria influencing the long-term integrity of the repository. It emphasizes the central role of safety and the importance of safety/performance assessments in the decision-making process during repository development.	https://www-pub.iaea.org/MTCD/Publications/PDF/TRS413_web.pdf
2003	**"Reference Biospheres" for Solid Radioactive Waste Disposal, IAEA-BIOMASS-6**	ITD	**7.3.1**	Theme 1 of the BIOMASS project was established with the objective of developing the concept of 'reference biospheres' into a practical system for application to the assessment of the long-term safety of repositories for RW. The outcome is the BIOMASS methodology developed through the construction of a number of example reference biospheres. The examples illustrate the use of the methodology and are also intended to be useful in their own right by acting as standard (or reference), stylized biospheres.	https://www-pub.iaea.org/MTCD/Publications/PDF/Biomass6_web.pdf

2004	**Records for radioactive waste management up to repository closure: Managing the primary level information (PLI) set.** **IAEA-TECDOC-1398**	ITD	**1.2.4** **7.2.2**	The objective of this document is to highlight the importance of the early establishment of a comprehensive records system to manage Primary Level Information as an integrated set of information, not merely as a collection of information, throughout all phases of RWM. The information presented in this document will assist MSs in ensuring that waste and repository records, relevant for retention after repository closure, are generated, identified, reviewed and actively managed during pre-closure phases so that they are available and useable at the appropriate time.	https://www-pub.iaea.org/MTCD/Publications/PDF/te_1398_web.pdf
2006	**Knowledge Management for Nuclear Industry Operating Organizations** **IAEA-TECDOC-1510**	ITD	**1.2.4** **7.2.2**	The purposes of this publication are: (1) To identify the fundamental elements needed for an effective KM system; (2) To share with nuclear industry operating organization managers the lessons learned in the industry regarding KM and, where they are judged to be relevant, by organisations outside the nuclear industry; (3) To provide guidance concerning methods for KM implementation This report applies to primarily to NPPs, but it may also prove to be useful to design organizations, regulatory bodies, and other nuclear-related groups.	https://www-pub.iaea.org/MTCD/Publications/PDF/te_1510_web.pdf

2006	**Data Requirements and Maintenance of Records for Spent Fuel Management: A Review.** **TECDOC-1519**	ITD	**1.2.4** **7.2.2**	The main objective of this TECDOC is to address the question of what data needs to be gathered and how it should be managed. In order to answer such a question, an appropriate approach has to be identified. The first step is to identify the issues relevant to SF 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.	https://www-pub.iaea.org/MTCD/Publications/PDF/te_1519_web.pdf
2006	**ASAM Regulatory Review Draft Report, "Guidance on the Regulatory Review of Safety Assessment for Radioactive Waste Disposal Facilities", RCM3.9**	ITD	**7.2.1** **1.2.1**	The main objective of this report is to identify conditions which affect public concern (either increase or decrease) and political acceptance for developing and implementing programmes for GD of long-lived RW. It also looks how citizens and relevant actors can be associated in the decision-making process in such a way that their input is enriching the outcome towards a more socially robust and sustainable solution. Finally, it aims at learning from the interaction how to optimise risk management addressing needs and expectations of the public and of other relevant SHs. In order to meet these objectives, factors of relevance for societal acceptance conditions are identified, described and analysed. Subsequently these factors are looked for in the real world of nuclear WM through cases in several countries. The diversity of characteristics of such	

				contexts increases insight in the way society and values of reference are influencing technological decision-making. These interrelated factors need to be integrated in step by-step decision making processes as emerging the last years in HLW disposal management.	
2007	**Factors Affecting Public and Political Acceptance for the Implementation of Geological Disposal,** **TECDOC-1566**	ITD	**1.1.3**	The main objective of this report is to identify conditions which affect public concern (either increase or decrease) and political acceptance for developing and implementing programmes for geologic disposal of LL RW. It also looks how citizens and relevant actors can be associated in the decision-making process in such a way that their input is enriching the outcome towards a more socially robust and sustainable solution. Finally, it aims at learning from the interaction how to optimise risk management addressing needs and expectations of the public and of other relevant SHs.	https://www-pub.iaea.org/MTCD/Publications/PDF/te_1566_web.pdf
. 2009	**Policies and Strategies for Radioactive Waste Management** No. **NW-G-1.1**	ITD	**1.1**	This guide has been prepared to help in developing or upgrading the contents of national policies and strategies for SF and RW management. An important strategy emphasis in the publication is on the means for reaching appropriate end points SF and RW management. The guide is intended for use by persons engaged in preparing and drafting national policies and strategies or updating existing ones, and is expected to be of use to all countries that have SF	https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1396_web.pdf

				and/or RW to manage, but in particular to developing countries which have yet to establish their national policies and strategies. In determining the elements of policy and strategy, the guide draws on, among other things, the IAEA Safety Standards and technical reports, and the national reports of Contracting Parties to the review meetings of the Joint Convention.	
2009	**Geological Disposal of Radioactive Waste: Technological Implications for Retrievability** **IAEA Nuclear Energy Series** **NW-T-1.19**	ITD	**5.5.3**	This document explores the technological implications of retrievability in geological disposal concepts. Scenarios for retrieving emplaced waste packages are considered and the document aims to identify and describe any related technological provisions that should be incorporated into the design, construction, operational and closure phases of the repository. The assessment of such technical provisions is based around a number of repository concepts currently under development in several MSs, thus reflecting considerations relevant to a variety of geological settings and repository designs. The aim is to identify and highlight the technical provisions and related considerations in relation to retrievability that are relevant in the various stages of the repository life cycle.	IAEA Nuclear Energy Series
2010	**Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Terrestrial and Freshwater**	ITD	**7.2.2**	This publication is primarily intended to provide IAEA MSs with data for use in the radiological assessment of routine discharges of radionuclides to the	https://www-pub.iaea.org/MTCD/Publications/PDF/trs472_web.pdf

	Environments **TRS 472**			environment. Some of the data may also be useful for assessing the impact of accidental releases and of releases in the far future.	
2011	**Comparative Analysis of Methods and Tools for Nuclear Knowledge Preservations** **Nuclear Energy Series No. NG-T-6.7**	ITD	**7.2.2**	This report discusses KP in the context of nuclear knowledge management (KM) in nuclear facilities. The specific objectives of this publication are to: — Increase awareness of methods and best practices in the preservation of critical nuclear sector knowledge. In particular, methods and tools to capture, interpret, analyse and disseminate data and information, as well as the knowledge ultimately derived from them are explored; — Summarize the findings of a benchmark survey conducted to determine the current status of nuclear KP in Member States; — Document various commonly used KP methods and tools and provide guidance on their typical uses and potential benefits; — Examine specific case studies of KP initiatives to provide useful examples of current best practice in knowledge preservation.	https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1494_web.pdf
2011	**SH involvement throughout the life cycle of nuclear facilities, IAEA Nuclear Energy Series NG-T-1.4**	ITD	**1.1.3**	This report demonstrates the importance of SH involvement throughout the life cycle of all nuclear facilities; including operating reactors, temporary spent fuel storage facilities and final RW.	https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1520_web.pdf

				The report explains how involving SHs in decision making processes, even for those SH groups that do not have a direct role in making those decisions, can enhance public confidence in the application of nuclear science and technology. In addition, this report presents general guidance on SH involvement.	
2011	**Position Paper of the GEOSAF Working Group on Operational Safety, GEOSAF project**	ITD	**5.4**		
2011	**GEOSAF - The International Inter-comparison and Harmonisation Project on** **Demonstrating the Safety of Geological Disposal. Final report**	ITD	**5.4**		
2013	**Characterization of Swelling Clays as Components of the Engineered Barrier System for Geological Repositories Results of an IAEA Coordinated Research Project 2002–2007** **IAEA-TECDOC-1718**	ITD	**3.4.1**	In order to facilitate and accelerate the process of swelling clay identification, characterization and evaluation for potential suitability for DGR applications, the IAEA established a CRP that brought together specialists from MS with advanced EBS development programmes with representatives from MS with less advanced programmes. The participants in this CRP have worked through the initial stages of swelling clay identification, characterisation and qualification as it relates to use in an EBS. This was accomplished via a co-operative process of materials testing and information exchange, whereby the	https://www-pub.iaea.org/MTCD/Publications/PDF/TE-1718_web.pdf

				participating MS utilized their technical expertise to complete a preliminary assessment of previously un- or incompletely characterised candidate clays being considered for EBS use. The CRP resulted in identification of several potential deposits of swelling clay that have the potential for use as components of the EBS. Some of these materials are potentially suitable for use in an SKB type highly compacted bentonite buffer while others may be more suitable for use in tunnel and shaft backfilling applications.	
2013	**The use of numerical models in support of site characterization and performance assessment studies of geological repositories** **Results of an IAEA Coordinated Research Project 2005–2010** **TECDOC 1717**	**ITD**	**6.2.2** **7.3.1**	The specific activities of the CRP were for participating MSs to: – Identify issue to be addressed by a comprehensive modelling study; – Review existing geological, hydrological, and geochemical data and their suitability for – site characterization and/or hypothesis testing; – Analyse different types of data (hydraulic, geochemical, isotopic, thermal, seismic, etc.)for incorporation into conceptual and numerical model development; – Perform data integration and model calibration exercises; – Conduct, when possible, deterministic and/or stochastic model prediction including sensitivity and uncertainty propagation analyses;	https://www-pub.iaea.org/MTCD/Publications/PDF/TE-1717_web.pdf

				– Identify key features and parameters that may need further characterization; – Recommend test design suitable for identification of relevant features and parameters;	
2013	**Managing Regulatory Body competence** **IAEA Safety Report No.1635**	**ITD**	**1.3.2**	The objective of this Safety Report is to provide guidance based on IAEA safety requirements on managing the competence of the regulatory body in order for it to perform its functions. Additionally, this publication gives guidance on establishing training and development programmes for regulatory staff. There is a wide range of management and regulatory styles among regulatory bodies, influenced by States' legislation and culture, jurisdiction of the regulatory body and ways of working. The guidance provides advice commensurate with the requirements of these different styles and jurisdictions, and is broadly applicable to regulatory bodies responsible for all types of facility and activity. Guidance provided here in the present tense indicative, describing good practices, represents expert opinion.	www-pub.iaea.org/MTCD/Publications/PDF/Pub1635_web.pdf
2014	**Planning and Design Considerations for Geological Repository Programmes)** **TECDOC-1755**	ITD	**5.1**	The scope of this report deals with the planning and design considerations for GD programmes. The report covers SF, HLW, ILW and some LLW identified for underground disposal. Topics covered:	https://www-pub.iaea.org/MTCD/Publications/PDF/TE-1755_web.pdf

				– a brief overview of a conceptual roadmap for a geological repository development programme; – the key inputs for repository programme planning; – implementation of the programme and its evolution with time. addressing key considerations at the various phases set out in the roadmap of Section 2. Section 5 identifies lessons learned relating these to country specific information, which is detailed in Annex.	
2015	**Methodology for the systematic assessment of the regulatory competence needs (SARCON) for regulatory bodies of nuclear installations** **TECDOC-1757**	ITD	**1.3.2**	The objective of this technical report is to provide information on specific and practical means to support the implementation of the IAEA safety standards in the area of ensuring regulatory competence. It provides guidance for Competence Needs Assessment and offers a step-by-step approach to develop competence profiles for specific regulatory tasks or positions and to analyze existing and required regulatory competences for individuals or organizational units in order to identify gaps and thus competence and training needs. This technical document need to be examined with regard to the process of establishing and building competence, in addition to maintaining competence for their organizations.	https://www-pub.iaea.org/MTCD/Publications/PDF/TE-1757_web.pdf
2016	**Framework and Challenges for Initiating Multinational Cooperation for the**	ITD	**1.1.1**	This publication aims to build on previous work by providing information to politicians and decision makers on the	https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1722_web.pdf

	Development of a Radioactive Waste Repository, **Nuclear Energy Series No NW-T-1.5**			decisions needed in relation to multinational repository projects.	
2017	**Selection of Technical Solutions for the Management of Radioactive Waste** **TECDOC-1817**	ITD	**Theme 2**	The objectives of this publication are to identify and critically review the criteria to be considered while selecting waste management technologies; summarize, evaluate, rank and compare the different technical solutions; and offer a systematic approach for selecting the best matching solution. This publication covers the management of RW from all nuclear operations, including waste generated from research reactors, power reactors, and nuclear fuel cycle activities including HLW arising from reprocessing and SF declared as waste, as well as LLW and ILW arising from the production and use of radionuclides in industry, agriculture, medicine, education and research.	https://www-pub.iaea.org/MTCD/Publications/PDF/TE-1817_web.pdf
2017	**Knowledge loss risk management in nuclear organizations,** **No. NG-T-6.11**	ITD	**1.2.4** **7.2.2**	This publication addresses the establishment, implementation and improvement of KM programmes and focuses on providing specific methods and tools for managing critical knowledge loss in nuclear related organizations. Guidance provided here, describing good practices, represents expert opinion but does not constitute recommendations made on the basis of a consensus of MSs.	https://www-pub.iaea.org/MTCD/Publications/PDF/17-35661_PUB1734_web.pdf

2018	**Options for Management of Spent Fuel and Radioactive Waste for Countries Developing New Nuclear Power Programmes** **No. NW-T-1-24 (Rev. 1)**	ITD	**1.1.1** **1.4.1** **1.5.2**	– Topics covered: – a brief review of existing advisory guidance on policies, strategies and programmes for management of SF and RW; – summary of RW and SF inventories that arise from the nuclear fuel cycle. – an overview of the management practices required for the storage and disposal of the waste. – discussion on the need for an integrated approach to managing all waste that will arise. – a brief review of a range of possible strategies which reflect national choices to be made by countries embarking on nuclear power, and examines the political, legal, societal, economic and technical challenges associated with each strategic option; – overarching strategic guidance on how a country embarking on a nuclear power programme might address the challenges relating to SFM, specific comments on the transition from a non-nuclear power country, and specific recommendations on what steps can be carried out to ensure that this transition is smooth and safe.	https://www-pub.iaea.org/MTCD/Publications/PDF/PUB1825_web.pdf
2018	**The management of site for radioactive waste disposal facilities** **IAEA Nuclear Energy Series** **IAEA NUCLEAR ENERGY SERIES**	ITD	**6.1.1** **6.2.1** **6.2.2**	This publication is intended to support the sharing of knowledge between MSs and provide a platform for initiating well-planned and tightly-focused site specific investigations in the large number of MSs with a need for disposal facilities for RW.	https://www-pub.iaea.org/MTCD/Publications/PDF/P1496_web.pdf

	No. NW-T-1.2			In advance of any decisions about the use of particular investigation technologies and techniques, it is essential MSs considering the planning and implementation of site investigations go about the task in a strategically orientated manner, with a clear understanding of the reasons why site data and information need to be collected and how they will be used. Without this clear understanding and without sufficiently detailed planning, resource use (human effort, equipment, finances and time) is unlikely to be optimised, the rationale for decisions will be unclear and confidence in the implementing organisation may be significantly diminished. There may also be safety implications. Thus the principle aim for the publication is to provide guidance to MSs on the need for a requirements driven approach to the planning and implementation of site investigations and to highlight the significance of key management issues to be addressed in designing and undertaking site investigation projects that are required to characterise sites for RW disposal facilities.	
2020	**Design Principles and Approaches for Radioactive Waste Repositories,** **NW-T-1.27**	ITD	**5.1.1** **5.1.2** **5.1.3** **5.1.4**	This publication provides an overview of design principles and approaches that have either already been fully implemented, or are in the implementation phase, in several MSs. Examples of mature designs are provided for a wide range of RW types	https://www-pub.iaea.org/MTCD/Publications/PDF/PUB1908_web.pdf

				and geological settings. Potential repository solutions are based on the characteristics of the waste, such as volume and radiotoxicity, and available conceptual disposal options. The report provides further guidance with a focus on the technical, scientific and programmatic aspects of implementing a disposal solution.	
on line	**Nuclear Communicator's Toolbox**	ITD	**1.1.3**	The Nuclear Communicator's Toolbox has been designed for scientists, engineers and communication professionals who work in the field of nuclear science and technology applications or regulate their safe and secure use. It offers tools to support effective communication on the benefits and risks associated with the use of nuclear technologies. This resource is intended for a variety of nuclear programmes and nuclear activities, including the use of radioactive sources in medicine or industry as well as more complex nuclear fuel cycle activities. Meaningful communication about nuclear matters fosters understanding and demonstrates how science supports society worldwide.	https://www.iaea.org/resources/nuclear-communicators-toolbox

2015	**GEOSAF I.** **The International Intercomparison and Harmonisation Project on** **Demonstrating the safety of geological disposal** **Working material**	ITD	**7.2.1**	GEOSAF gave particular attention to the evolution of the SC with the development of a disposal project and particularly to the regulatory expectations on the development of the SC in order to enable decisions to be made as part of the licensing process. Whilst the project addressed the elements of the SC necessary for safety demonstration and the work necessary to support the various safety arguments, it also considered the process of reviewing and evaluating the SC by regulatory authorities TSOs and the needed resources for conducting this technical review. That is the reason why the project involved regulatory authorities, technical safety organizations and WMOs responsible for the development and operation of GDFs.	https://www.iaea.org/topics/disposal/international-project-on-demonstrating-the-safety-of-geological-disposal https://www.iaea.org/sites/default/files/19/02/geosaf-i-final-report.pdf http://www-ns.iaea.org/downloads/rw/projects/geosaf/draft-finalreport.pdf http://wwwns.iaea.org/downloads/rw/projects/geosaf/companion-report-on-operationalsafety.pdf
2015	**GEOSAF I** **Managing integration of pre-closure** **activities and post-closure safety in the Safety Case for geological disposal**	ITD	**7.2.1**	This document highlights the value of an integrated safety case for both pre-closure and post-closure phases. Section 3 presents an approach to understand the link between post-closure safety functions and operational activities. It provides a conceptual view on the concepts of Safety envelope, Design Target and As-built State which should inform the safety arguments presented within the SC. Section 4 describes a conceptual method for compliance control (e.g. monitoring, management systems and uncertainty management) by taking into account the relationships between pre-closure activities and post-	https://www.iaea.org/sites/default/files/19/02/geosaf-2-tecdoc-draft.pdf

				closure safety. Section 5 discusses a process for managing deviations.	
2015	**GEOSAF II** **Task Group on Operational Safety, progress report**	ITD	**7.2.1**	The follow-up project, GEOSAF II, was initiated with the objective to reach a common understanding of views and expectations regarding operational safety for GD of RW and the implications of pre-closure activities on post-closure safety. This Technical Document forms one of the outcomes of the GEOSAF II Project.	http://www-ns.iaea.org/downloads/rw/projects/geosaf/geosaf_report_task_group.pdf
2015	**GEOSAF II** **The International Inter-comparison and Harmonisation Project on** **Demonstrating the safety of geological disposal**	ITD	**7.2.1**	Existing guidance on production of SCs for GD concentrate on the SC for the post-closure period. Many MSs have guidance on production of operational SCs for nuclear facilities but there is to date no guidance for the SC of an operational SC for a GD facility. A particular challenge is to define the interface between the operational and post-closure cases so that the one hands over to the other. The GEOSAF II project has been established to define a structure and methodology for a GD SC, integrating both the operational and post-closure phases and clearly demonstrating the form of the "handshake" as the facility transitions from operations to post-closure.	
2020	**GEOSAF Part III., Demonstration of the operational and long-term safety of geological disposal facilities for radioactive waste, Terms of Reference**	ITD	**7.2.1**	GEOSAF III explore existing standards and cover practical illustrations of the use and development of the following aspects identified in GEOSAF II:	https://www.iaea.org/sites/default/files/19/02/geosaf-3-draft-tor.pdf

				– the identification of gaps in guidance of operational safety – the Safety Envelope (SE) – the Design Target (DT) – the As-Built State (ABS) – Derivation of DT with respect to uncertainty – Management of deviations from the DT and the SE **Requirements management** – Decision on corrective actions – OLCs for the operational phase – WAC – QC/QA & Monitoring One objective is to examine whether guidance on operational safety of GD facilities exists, and if so, whether or not such information is readily accessible in a small number of well identified documents. A second objective is that guidance for identifying and using those aspects in the SC will ultimately lead to a practical illustration of how the SC may be updated during the operational phase of a GDF.	
2020	**Roadmap for Developing a Geological Disposal Programme, Draft version, IAEA Nuclear Security Series No. xxx, IAEA, in preparation**	IG	**1.1**		

2021	**Stakeholder engagement in nuclear programmes** **No. NG-G-5.1**	IG	**1.1.3**	This publication provides theoretical and practical guidance on the development and implementation of SH engagement programmes and activities. It also includes tools such as templates to help establish a SH engagement programme and identify associated activities, including tools for SH analysis (behaviours, motivation and values). As such, it provides basic guidance which can be further developed and adjusted to each specific type of facility, moment in its life cycle, and/or the group of SHs with which to engage.	https://www-pub.iaea.org/MTCD/Publications/PDF/PUB1967_web.pdf
2022	**Communication and stakeholder Involvement in radioactive Waste disposal** **No. NW-T-1.16**	ITD	**1.1.3**	The main objective of this publication is to provide practical guidance on communication and SH involvement associated with RW disposal for interested MSs, especially those embarking on, re-launching or revising a disposal programme. Recognizing the situational nature of communication and SH involvement, and their need to be in phase with the specific national, social and political circumstances, such practical guidance is provided through two associated objectives. The first is to revisit the broad principles, responsibilities and phases widely recognized as providing a robust framework for communication and SH involvement in a disposal development and implementation process. The second is to collect, analyse and group lessons learned from both progresses made and difficulties encountered in national	https://www-pub.iaea.org/MTCD/Publications/PDF/PUB1920_web.pdf

				programmes, to illustrate how practical implementation could be designed in response to specific challenges.	
	REPORT of the GEOSAF Working Group on Operational Safety	IG	**Theme 7.**	After decades of post-closure safety development, little work has been undertaken internationally to develop a common view on the safety approach related to the operational phase of a geological disposal facility. General guidance in this regard can be found in e.g. IAEA General Safety Requirements No.GSR-4, Safety Assessment for Facilities and Activities [A], and IAEA Specific Safety Requirements No.SSR-5, Disposal of Radioactive Waste. The guidance in those documents are however quite generic in nature and does not provide for detailed guidance on how to practically develop assessment of hazards occurring during operational phase and address interaction between operational and post closure safety. Thus, GEOSAF decided to launch a programme of work on this.	https://www.iaea.org/sites/default/files/19/02/companio n-report-on-operational-safety.pdf
	The management of site investigations for radioactive waste disposal facilities, IAEA draft	IG	**6.1**	This publication is intended to support the sharing of knowledge between MSs and provide a platform for initiating well-planned site specific site investigations in the large number of MSs with a need for near-surface and geological disposal of RW. A second objective is to provide information on the state of the art regarding the various data acquisition technologies and interpretation techniques that are potentially available	

				to support site investigations, including detailed information about the constraints and added benefits associated with particular methods. Such a compilation in the context of RW disposal does not currently exist in the international literature. This publication provides a discussion of alternative site investigation strategies and key management considerations, as well as a summary of the various data acquisition and analysis technologies/methods available to be used during siting studies to discriminate between potential sites and for site confirmation (as well as on-going site investigation/monitoring during and after repository construction). The report will include the specific objectives, assumptions, uncertainties, limitations, logistical requirements and additional benefits associated with each method as they relate to the various stages of a site investigation programme. Selected examples of site investigation programmes will also be provided as case studies. An appendix is to be provided with an exhaustive listing of technologies and techniques, together with the key attributes for each technology and interpretation technique.	
	GEOSAF: International Intercomparison and Harmonization Project on Demonstrating the Safety of Geological	IG	**Theme 7.**	The GEOSAF Steering committee set up a working group dedicated on Operational Safety in 2010, considering that little work had been performed so far on that subject at the international level.	https://www.iaea.org/sites/default/files/19/02/geosaf-i-position-paper.pdf

	Disposal, Report of the GEOSAF Working Group on Operational Safety (draft)			This group was established to focus on hazards identification for the operational phase of a geological disposal facility and on the methodology used for the safety assessment. Both items are arguments incorporated into the safety case of a geological disposal facility.	
Published before 2000					
1991	**Guidelines for the Operation and Closure of Deep Geological Repositories for the Disposal of High Level and Alpha Bearing Wastes** **TECDOC-630**	ITD	**5.4** **5.5**	The main objective of this document is to summarize the basic principles and approaches to the operation and closure of a deep geological repository for disposal of HLW and alpha bearing RWs, as commonly agreed upon by MSs. This report is addressed to administrative and technical authorities as well as to specialists planning for the operation and closure of geological repositories for disposal of such wastes.	http://www-pub.iaea.org/MTCD/publications/PDF/te_630_web.pdf
1993	**Report on Radioactive Waste Disposal, Technical Reports Series No. 349**	ITD	**Theme 7.**	The purpose of this report is to provide an overview of the current knowledge in the field of RW disposal, limiting itself to the essential topics in this field. It covers the basic principles associated with the state of the art of near surface and deep geological RW disposal, including examples of prudent practice, and provides basic information on performance assessment methods.	https://www.iaea.org/publications/1453/report-on-radioactive-waste-diposal
1996	**Working Group on Principles and Criteria for Radioactive Waste Disposal: Issues in radioactive waste disposal: second report.**	ITD	**1.2.4**	This report discusses issues related to long time-scale underground disposal of RWs. The chapters are devoted to the following issues: (1) Post closure issues	http://inisdb.iaea.org/inis/php/download.php?s=p&rn=28022158

	TECDOC-909			of underground repositories, e.g., record keeping and markers, public reassurance and prevention of misuse. (2) Optimization of radiation protection by optimizing RWM, siting analysis, repository design etc. (3) An interface between nuclear safeguards and RWM by safeguarding conditioning of SF, during operational phase of repository and post-closure phase of the repository	
1996	**Issues in Radioactive Waste Disposal** **TECDOC-909**	ITD	**Theme 7.**	The topics discussed in this report are all, in some way, related to the long time-scales that have to be considered in relation to the safety of underground repositories for RW. Indeed, this is the single and unique feature of the repositories, which when compared to other types of engineered structures, requires special consideration and new approaches to establishing safety. It addresses possible actions which might be considered for the purpose of ensuring the continuing safety of geological repositories in the period after they have been finally closed.	https://www-pub.iaea.org/MTCD/Publications/PDF/te_909_web.pdf
1999	**Maintenance of records for radioactive waste disposal** **TECDOC 1097**	ITD	**7.2.2**	The IAEA has prepared this technical report to respond to the needs of MSs having repositories or involved in or considering the development of repositories. In many countries policies and systems for record keeping and maintenance of information related to disposal are the subjects of current interest. This report describes the requirements for presenting information	https://www-pub.iaea.org/MTCD/publications/PDF/te_1097_prn.pdf

				about repositories for RW including LL and TRU and SF if it is declared as a waste. The report discussed topics of identification, transfer and long-term retention of high-level information pertaining to the repository in a RMS for retrieval if it becomes necessary in the future.	

2.1.5 OECD NEA

Date	Title	Type of doc	EURAD roadmap ID	Short description	Web link
2000	**Features, Events and Processes (FEPs) for Geologic Disposal of Radioactive Waste, An International Database**	ITD	**7.3.3**	Information on the features, events and processes that has been assembled at the international level by working groups of the OECD NEA are presented.	https://www.oecd-nea.org/jcms/pl_13398/features-events-and-processes-feps-for-geologic-disposal-of-radioactive-waste
2001	**Scenario Development Methods and Practice: An Evaluation Based on NEA Workshop on Scenario Development – Madrid, May 1999**	IM	**7.3.3**	Analysis of the long-term safety of RW repositories, using performance assessment and other tools, is required prior to implementation. The initial stage in developing a repository SA is the identification of all factors that may be relevant to the long-term safety of the repository and their combination to form scenarios. This report is a review of developments in scenario methodologies based on q large body of practical experience in SAs.	https://doi.org/10.1787/9789264193536-en.

2003	**Engineered Barrier Systems and the Safety of Deep Geological Repositories:** **State-of-the Art Report** **In co-operation with the EUROPEAN COMMISSION** **EUR 19964 EN**	ITD	**3.4.1**	Specific objectives of the IGSC-EBS project are: – To understand the relationship between the functions to be served by the EBS and its design in different repository contexts. – To compare different methods of characterising EBS properties. – To compare different approaches to modelling the EBS. – To compare different means of evaluating EBS performance. – To compare different engineering approaches to similar problems. – To compare techniques for evaluating, characterising, and modelling interactions between the EBS and near-field host rock.	https://www.oecd-nea.org/jcms/pl_13634/engineered-barrier-systems-and-the-safety-of-deep-geological-repositories?details=true
2003	**Engineered Barrier Systems and the Safety of Deep Geological Repositories** **State-of-the-art Report** **ISBN 92-64-18498-8**	ITD	**3.4.1**	Repositories for the disposal of RW generally rely on a multi-barrier system to isolate the waste from the biosphere. This multi-barrier system typically comprises the natural geological barrier provided by the repository host rock and an EBS. The EBS project being conducted by the NEA Integration Group for the Safety Case (IGSC) seeks to clarify the role that an EBS can play in the overall safety case for a deep geological repository. It is in this context that the European Commission and the NEA have prepared the present report, which describes the state of the art for EBSs and provides a common basis of understanding from which to plan future	ttps://www.oecd-ilibrary.org/nuclear-energy/engineered-barrier-systems-and-the-safety-of-deep-geological-repositories_9789264103450-en

				programmes. It is based on answers to a questionnaire received from 13 countries and 17 organisations.	
2004	**Stability and Buffering Capacity of the Geosphere for Long-term Isolation of Radioactive Waste, Application to Argillaceous Media, "Clay Club" Workshop Proceedings** **Braunschweig, Germany** NEA No. 5303	IM	**4.1.2**	The workshop focused on clay specific issues and considered the whole spectrum of argillaceous media envisaged as host formations, i.e. from poorly indurated, soft clays to hard, potentially fractured clays. A further important objective was to evaluate the extent to which there is confidence about the required level of stability, whether it is known what evidence to look for, and if there are adequate tools to carry out long-term investigations. The workshop focused mostly on natural events.	https://www.oecd-nea.org/upload/docs/application/pdf/2020-11/nea5303-stability-buffering.pdf
2004	**The Handling of Time Scales in Assessing Post-closure Safety, Lessons Learnt from the April 2002 Workshop in Paris**	IM	**Theme 7**	The report is aimed at interested parties that already have some detailed background knowledge of SA methodologies and SCs, including SA practitioners and regulators, project managers and scientific specialists in relevant disciplines. Its aims are: – to review the current status and ongoing discussions on the handling of issues related to timescales in the deep GD of long-lived RW. – to highlight areas of consensus and points of difference between national programmes; and – to determine if there is room for further improvement in methodologies to handle these	https://www.oecd-nea.org/upload/docs/application/pdf/2020-11/6424-considering-timescales.pdf

				issues in SA and in building and presenting SCs.	

2004	**Engineered Barrier Systems (EBS):** **Design Requirements and Constraints** **Workshop Proceedings** **Turku, Finland, 26-29 August 2003** NEA No. 4548	IM	**3.4.1**	The design of a disposal system needs to take account of stakeholder's views regarding the objectives and requirements of the system. It must also be possible to demonstrate that the disposal system design provides an acceptable solution of the RWM problem. In developing the details of the design for an EBS, various requirements and constraints have to be considered. Relevant constraints include disposal site characteristics, the nature of existing waste packages, the waste inventory, available technologies, available understanding of processes and related uncertainties, and the need for operational safety and flexibility. Although safety has the highest priority in the process of repository development, business requirements also have to be considered. There may be various alternative ways of fulfilling the requirements but at significantly different costs.	https://www.oecd-nea.org/upload/docs/application/pdf/2020-11/nea4548-ebs.pdf
2004	**The Regulatory Control of Radioactive Waste Management** **Overview of 15 NEA Member Countries** NEA No. 3597	ITD	**1.2.1** **1.2.2**	This document provides information about the regulatory control of RW management in NEA member countries. It covers the management of RW from all sources other than natural sources. Thus, the sources include all types of nuclear facilities, such as power reactors, research reactors, nuclear fuel cycle facilities, etc., as well as medical, research and industrial sources, and	https://www.oecd-nea.org/jcms/pl_13622/the-regulatory-control-of-radioactive-waste-management?details=true

				defense-related sources where appropriate.	
2004	**Stepwise Approach to Decision Making for Long-term Radioactive Waste Management: Experience, Issues and Guiding Principles,** **NEA No. 4429**	ITD	**1.1.2**	This report is meant to help build closer ties between the RW management and the social science communities, contributing to the reflection on stepwise decision making through the provision of several perspectives supported by an extensive set of references. Overall, it is observed that there is convergence between the approach taken by the practitioners of RWM and the indications received from field studies in social research. A strong basis for dialogue across disciplines thus exists and general guiding principles can be proposed, at least as a basis for further discussion.	https://www.oecd-nea.org/upload/docs/application/pdf/2020-01/rwm2004-6-rev1.pdf
2004	**Post-closure safety case for geological repositories, Nature and purpose** **NEA No. 3679**	ITD	**7.2.1**	The report presents some general considerations and some specific illustrative examples, but is not intended to be prescriptive. It describes the elements of the safety case and discusses a number of general considerations for its presentation and deals with the high-level approach adopted for achieving safe disposal – the safety strategy – and its elements, namely the management strategy, the siting and design strategy and the assessment strategy. The report deals with the information and analysis tools for safety assessment – the assessment basis.	https://www.oecd-nea.org/upload/docs/application/pdf/2019-12/nea3679-closure.pdf

				Finally, it describes the types of evidence, analyses and arguments that can contribute to a safety case, and how these are synthesised for the purposes of making a safety case, as well as the issue of confidence.	
2005	**Management of Uncertainty in Safety Cases and the Role of Risk (Proc. Workshop, Stockholm**	IM	**7.3.2**	These workshop proceedings discuss different approaches to treating uncertainties in safety cases for RWM facilities, and more specifically how concepts of risk can be used in both post-closure safety cases and regulatory evaluations. This report includes a synthesis of the plenary presentations and the discussions that took place during the workshop.	https://www.oecd-ilibrary.org/nuclear-energy/management-of-uncertainty-in-safety-cases-and-the-role-of-risk_9789264008793-en
2007	**Regulating the Long-term Safety of Geological Disposal, Towards a Common Understanding of the Main Objectives and Bases of Safety Criteria** **NEA No.6182**	ITD	**1.1.3** **1.2.2**	This report summarises the work of the Long-term Safety Criteria initiative as of the end of 2006, with the aim to help foster a common understanding of the objectives and issues related to long-term regulatory criteria for RW disposal. It is hoped that the report may also contribute to clearer communication and public understanding of regulatory criteria, and provide important and useful guidance to national programmes that are developing or refining these criteria.	https://www.oecd-nea.org/upload/docs/application/pdf/2020-11/nea6182-regulating.pdf
2007	**Safety Cases for Deep Geological Disposal of Radioactive Waste: Where Do We Stand?** **Symposium Proceedings Paris, France** **23-25 January 2007**	IM	**7.2**	The aims of the symposium were to: Share practical experiences on preparing for, developing and documenting a SC both at the technical	https://www.oecd-nea.org/upload/docs/application/pdf/2020-11/ne6319-safety.pdf

	NEA No. 6319			and managerial levels (testing the concept of a SC). Share experiences on the regulatory perspective. What are the regulatory requirements and expectations of the SC? Does the SC provide answers? Highlight the progress made in the last decade, the actual state of the art and the observed trends. Assess the relevance of the international contributions in this field. Receive indications useful to the future work programmes of the NEA and other international organisations.	
2008	**The Evolving Roles of Geoscience in the Safety Case: Responses to the AMIGO Questionnaire, A report of the NEA Working Group on Approaches and Methods for Integrating Geological Information in the Safety Case (AMIGO)** **NEA/RWM/IGSC(2008)2**	ITD	**7.2**	This report summarizes the results of a questionnaire circulated to AMIGO participants to capture elements of that practical experience and to collect current geoscience knowledge and reasoning that supports a safety case. The information is pertinent to long-term RW management programs which must consider safety over time frames extending up to 10^6 years. Specific goals of the AMIGO questionnaire were to: i) collect examples of geoscientific lines-of-evidence that directly support or convey confidence in the performance of the repository in varied geologic settings; ii) consider techniques used for effective communication of geoscientific reasoning and perspectives that support the SC for a DGR;	https://www.oecd-nea.org/upload/docs/application/pdf/2020-01/rwm-igsc2008-2.pdf

				iii) identify methods and procedures that provide the geoscientific basis for the SC, notably the geo-synthesis or integration of multi-disciplinary geoscientific information and approaches that can constrain non-uniqueness and uncertainty in the description of the geosphere; and iv) explore methods related to planning and organizing, to improve the manner in which geoscience information is collected and communicated.	
2008	**Moving Forward with Geological Disposal – A Collective Statement by the NEA Radioactive Waste Management Committee** **NEA No. 6433**	ITD	**1.1.1** **1.5.2**	The RWMC expresses herewith, in a concise form, its collective views on why geological disposal remains an appropriate waste management choice for the disposal of the most hazardous and long-lived RWs, on the current status of geological disposal, on challenges and opportunities for implementation, and expectations for further developments.	http://bit.ly/1jzKJfw
2008	**The concept of optimisation for geological disposal of radioactive waste** **A Concise Review of National and International Guidance and Relevant Observations**	ITD	**5.2.2**	The present document summarizes and reviews the concepts relevant to the 'optimisation' of GD systems as they are outlined in national and international guidance as well as in the work of NEA groups. Important sources of information have been the guidance documents by the ICRP, the IAEA, the Integrated Prevention, Pollution and Control Directive of the European Commission, and documentation from initiatives of the RWMC-RF and the IGSC. The document also presents a set of observations and	https://www.oecd-nea.org/jcms/pl_18670/the-concept-of-optimisation-for-geological-disposal-of-radioactive-waste-a-concise-review-of-national-and-international-guidance-and-relevant-observations?details=true

				key questions regarding the basic concepts relating to 'optimisation' especially as it relates to the long term. Overall, the study shows that, when dealing with the concept of optimisation, there exists ample scope to clarify concepts, facts and possibilities and to ensure that regulatory guidance is sufficiently precise and implementable.	
2008	**Timing of High-level Waste Disposal** **NEA No. 6244**	ITD	**Theme 1.**	There is a wide range of factors which affect the timing of HLW disposal. The study examines how social acceptability, technical soundness, environmental responsibility and economic feasibility impact on the timing of HLW disposal and can be balanced in a national RWMt strategy taking the social, political and economic environment into account. It shows examples of strategic responses to public concerns and requirements regarding a national RWM approach.	https://www.oecd-nea.org/jcms/pl_14254
2009	**International Experiences in Safety Cases for Geological Repositories (INTESC)** **NEA No. 6251**	ITD	**Theme 7.**	The NEA project on International Experiences in Safety Cases for Geological Repositories (INTESC) analysed existing safety cases, and their elements, to provide an overview of progress during the last decade, to identify key concepts and to give insight into regulatory expectations on the contents and review of SCs. This report documents the outcomes of the INTESC project. It takes account of the responses to a detailed survey of NEA member countries as well as the results of a technical workshop. The project has	https://www.oecd-nea.org/jcms/pl_14264/international-experiences-insafety-cases-for-geological-repositories-intesc-cd-rom

				shown that the purpose and concept of a SC are generally understood, accepted and adopted by RWM programmes worldwide. Programmes are preparing SCs in line with most of the elements suggested by the NEA, although there are some differences in interpretation and presentation. Some important trends are emerging, such as the use of safety functions and the role of a geosynthesis. Further development of some aspects and tools, such as QA programmes and RMSs, can be expected as safety cases are further refined to support programmes moving towards implementation of geological disposal.	
2009	**Considering Timescales in the Post-closure Safety of Geological Disposal of Radioactive Waste** **NEA No. 6424**	ITD	**Theme 7**	Approaches to handling timescales for the geological disposal of RW are influenced by ethical principles, the evolution of the hazard over time, uncertainties in the evolution of the disposal system (and how these uncertainties themselves evolve) and the stability and predictability of the geological environment. Conversely, the approach to handling timescales can affect aspects of repository planning and implementation including regulatory requirements, siting decisions, repository design, the development and presentation of SCs and the planning of pre- and post-closure institutional controls such as monitoring requirements. This is an area still under discussion among NEA member countries. This report reviews the current	https://www.oecd-nea.org/jcms/pl_14446

				status and ongoing discussions of this issue.	
2010	**Regulation and Guidance for the Geological Disposal of Radioactive Waste** **A Review of the Literature and Initiatives of the Past Decade** **NEA N°6405**	ITD	**1.2.1** **7.1**	This paper provides in a concise form an overview of the development of regulation and guidance at both national and international levels, on international and multi-national initiatives for developing recommendations and common views on regulatory issues, as well as an overview of the experience of regulatory review of some of the safety studies produced during the last decade. This paper reviews the evolution of these initiatives and issues over the past decade or so focusing on the major areas addressed in the Cordoba workshop, notably, RW disposal criteria, performance assessment trends, and the conduct of the regulatory process.	https://www.oecd-nea.org/upload/docs/application/pdf/2019-12/nea6405-regulation-guidance-eng.pdf
2010	**Optimization of GD of Radioactive Waste** **National and International Guidance and Questions for Further Discussion** **NEA No. 6836**	ITD	**1.1.4**	As national GD programmes progress towards implementation, the concept of “optimisation” and related requirements are receiving increased attention This report summarises and reviews the concepts relevant to the “optimisation” of GD systems as they are outlined in national and international guidance. It also presents a set of observations and key questions. Overall, the report shows that, when addressing “optimisation”, there is ample scope for clarifying concepts, facts and possibilities and for ensuring that regulatory guidance is sufficiently precise and implementable. The intention is that this report should	https://www.oecd-nea.org/upload/docs/application/pdf/2019-12/nea6836-optimisation-eng.pdf

				serve as a basis for discussion within and beyond NEA committees and expert groups.	
2010	**Geoscientific Information in the Radioactive Waste Management** **Safety Case: Main Messages from the AMIGO Project** **NEA No. 6395**	ITD	**Theme 7**	The importance of geoscientific information in selecting a site for geological disposal has long been recognised, but there has been growing acknowledgement of the broader role of this information in assessing and documenting the safety of disposal. The OECD/NEA Approaches and Methods for Integrating Geological Information in the Safety Case (AMIGO) project has demonstrated that geological data and understanding serve numerous roles in safety cases. The project, which ran from 2002 to 2008, underscored the importance of integrating geoscientific information in the development of a disposal safety case and increasingly in the overall process of repository development, including, for example, siting decisions and ensuring the practical feasibility of repository layout and engineering.	https://www.oecd-nea.org/jcms/pl_14414
2010	**Towards Transparent, Proportionate and Deliverable Regulation for Geological Disposal: Main Findings from the RWMC Regulators'** **Forum Workshop, Tokyo, 20-22 January 2009** **NEA/RWM/RF(2009)1**	IM		The workshop findings help complete our understanding of the status of long-term safety regulations worldwide and provide the basis for deciding which issues deserve the highest priority and which ones are closer.	https://www.oecd-nea.org/upload/docs/application/pdf/2019-12/6825-towards-transparent.pdf

2011	**Research and development basis for the safety of geological repositories** **(draft report)**	ITD	**1.2.5**	The main objective of this report is to illustrate the scope and relevance of the R&D effort and to allow a judgement to be made on the maturity of the knowledge base of current SCs. Intention is also to help national WMOs assess their R&D programmes, which may lead to new areas of research to be covered either collaboratively or in individual national programmes. In this context, it must be recalled that, in a research sense, any topic may always benefit from further investigations, yet decisions will need to be made on priorities. It is also important to note that disposal projects are going to be implemented over timescales of decades if not centuries. Continuing R&D activities, therefore, are not a sign of immaturity or lack of confidence, but a gage of continuing commitment to learning and to improving approaches, if needed. General scientific developments may require to revisit even closed‘ topics from time to time, in order to demonstrate that the scientific basis for decisions is still valid or with a view to further increase margins of safety or to be prepared for the previously unforeseen.	
2012	**Methods for Safety Assessment of Geological Disposal Facilities for Radioactive Waste** **Outcomes of the NEA MeSA Initiative** **NEA No. 6923**	ITD	**7.3**	The goals of the NEA project were to examine and document methods used in safety assessment for radioactive waste disposal facilities, to generate collective views based on the methods’ similarities and differences, and to identify future work. The project reviewed a number of approaches used by various national and	https://www.oecd-nea.org/jcms/pl_14608/methods-for-safety-assessment-of-geological-disposal-facilities-for-radioactive-waste

				international organisations. Following the comprehensive review, a generic SC with a SA flowchart was developed and is presented herein. The elaboration of the safety concept, the use of safety functions, the implication of uncertainties and the formulation of scenarios are also discussed.	
2012	**Geological Disposal of Radioactive Waste: National Commitment, Local and Regional Involvement** **A Collective Statement of the OECD Nuclear Energy Agency Radioactive Waste Management Committee Adopted March 2012** **NEA No. 7082**	IG	**1.1.3**	While proceeding to geological disposal is a technical endeavour, planning for it and overseeing its implementation include more than just technical aspects. Geological disposal of RW is a societal endeavour as well and therefore comes under discussion and deliberation on national, regional and local levels. This collective statement examines the links between national commitment to a radioactive waste management solution, and local and regional involvement, with the objective of developing confidence in waste management options.	https://login.oecd-nea.org/jcms/pl_14794/geological-disposal-of-radioactive-waste-national-commitment-local-and-regional-involvement?details=true
2013	**Indicators in the Safety Case** A report of the Integrated Group on the Safety Case (IGSC) NEA/RWM/R(2012)7	ITD	**7.1.2**	The main purpose of this Status Report is to increase awareness and understanding of the potential applications of indicators in the safety case, and provide support for further development in the area. Some guidance on the possible use of indicators is given but it is not the objective to seek to propose a 'standard' approach or terminology. This would be neither sensible nor possible given the differences in national regulations concerning their requirements for how	https://www.oecd-nea.org/jcms/pl_19198/indicators-in-the-safety-case-a-report-of-the-integration-group-on-the-safety-case-igsc?details=true

				indicators should be applied. For the sake of clarity, however, in this report an important distinction is made between primary and complementary indicators. A primary indicator (typically annual dose or risk) is one that is compared to a legally or regulatory defined radiological constraint, whilst all other indicators that may be used in a safety case are referred to in this report as complementary indicators.	
2013	**The Nature and Purpose of the Post-Closure Safety Cases for Geological Repositories** **NEA No. 78121** **NEA/RWM/R(2013)1**	ITD	**7.2.1**	This document, like its 2004 predecessor, defines and discusses the purpose and general contents of post-closure SCs for geological repositories for long-lived RW. The aim of this update is to make this document a more useful point of reference for those involved in the development of safety cases and for those with responsibility for, or interest in, decision making in RWM. It is hoped that this document will be of interest to safety experts in other fields of applied science and engineering.	https://www.oecd-nea.org/rwm/reports/2013/78121-rwn-sc-brochure-old.pdf
2014	**The Safety Case for Deep Geological Disposal of Radioactive Waste:** **2013 State of the Art** Symposium Proceedings, 7-9 October 2013 NEA/RWM/R(2013)9	IM	**7.2.1**	The purpose of this second symposium was to determine and document evolution in the state-of-the-art since the first symposium in 2007. Six years after the previous symposium was an opportune time for stocktaking: there had been major developments in a number of nations pursuing GD programmes, and significant experience had been obtained both in preparing and reviewing cases for	https://inis.iaea.org/collection/NCLCollectionStore/_Public/46/027/46027302.pdf https://www.oecd-nea.org/jcms/pl_19432/the-safety-case-for-deep-geological-disposal-of-radioactive-waste-2013-state-of-the-art

				the operational and long-term safety of proposed and operating repositories. There was also new insight into the bases for regulations, and new advice came from organisations such as the ICRP, the EC, IAEA, and the WENRA. The NEA Regulators' Forum (RF) has published widely on the basis for and issues in regulations. Societal decision-making had also seen an increase in understanding through experience.	
2014	**Control, Oversight and Related Terms in the International Guidance on Geological Disposal of Radioactive Waste – Review of Definitions and Use**	IG	*	The objective of the document is to review terms or expressions that have been used so far in international guidance (IAEA, ICRP, and OECD/NEA) in connection with the concept of "control". The Annex provides actual literature quotes. For each example a commentary is provided.	https://www.oecd-nea.org/jcms/pl_19460/control-oversight-and-related terms-in-the-international-guidance-on-geological-disposal-ofradioactive- waste-review-of-definitions-and-use
2014	**Vision Document for the Radioactive Waste Repository Metadata** **Management (RepMet) Project,** NEA/RWM(2014)2	ITD	**7.2.2**	The goal of RepMet is to recommend sets of metadata that can be used by national RW programmes to manage RW repository data, information and records in a way that is both harmonised internationally and suitable for long-term management and use (e.g. for the development of SCs). The initiative has produced a set of guiding principles and practical advice on capturing and generating metadata, including the use of relevant standards. The publication introduces the concept of metadata, explaining why it is valuable in	https://www.oecd-nea.org/upload/docs/application/pdf/2019-12/7378-metadata-rwm.pdf

				data management and in particular for RWM organisations, and providing advice on issues arising when implementing metadata as part of data management.	
2014	**Radioactive Waste Management** **Stakeholders Map in the European Union, JRC Science and policy reports**	ITD	**1.1.3**	The present report shall be seen as a first step in the direction of systematising available information regarding the wide range of SH groups, with specific roles and responsibilities, involved in RWM at national level. This report was prepared on the basis of a review of a full range of publications, reports, databases and web pages to identify the key SHs in RWM in the MSs. The report seeks to gain an in-depth understanding of different RWM systems in the MSs, highlighting national RWM actors and the relationships existing among them, together with their responsibilities and lines of accountability. For this, a detailed mapping effort has been undertaken for each MS. It is important to ensure that there are adequate interdependences among all parties for an effective and efficient RWM system. The report also shows, through geographical maps, the location of RWM facilities in each country.	https://core.ac.uk/reader/38628048
2014	**Summary Record of the Meeting of the Task Group "Set of Essential Records" of the RWMC's Initiative** "Preservation of Record, Knowledge and Memory Across Generations" (RK&M)	ITD	**7.2.2**	This document is the summary record of the meeting of the task group "Set of Essential Records" within the RWMC's initiative "Record, Knowledge and Memory Preservation Across Generations" (RK&M). The main aim of	https://www.oecd-nea.org/upload/docs/application/pdf/2020-01/rwm-rkm2014-6.pdf

	NEA/RWM/RKM(2014)6			the meeting was to discuss the current understanding of the SER objectives.	
2014	**Preservation of Records, Knowledge and Memory across Generations (RK&M)** **Monitoring of Geological Disposal Facilities: Technical and Societal Aspects** **NEA/RWM/R(2014)2**	ITD	**7.2.2**	The study report has three objectives: – To present in a comprehensive way the general monitoring information, practices and approaches used in the various national GD programmes and elaborated in a number of international projects; – To explore the role, needs and expectations of local communities regarding monitoring and RK&M preservation of DGRs; – Based on the above review, to identify lessons learned and the rationale for monitoring GD projects throughout their lifecycle stages.	https://www.oecd-nea.org/jcms/pl_19442
2014	**Loss of information, records, knowledge and memory – key factors in the history of conventional waste disposal** **NEA/RWM/R(2014)3**	ITD	**7.2.2**	The RK&M project was launched in 2010, and is seeking, among other things, to gain insights into the factors influencing the loss and recovery of knowledge and memory preservation in areas other than nuclear wastes. One area with similar characteristics, and therefore well-suited for comparisons, is that of landfills and old industrial or disposal sites for hazardous wastes. This report presents the results of an analysis of selected case studies of landfills and contaminated sites in Europe and other industrialized nations.	https://www.oecd-nea.org/jcms/pl_19472
2015	**International Mechanisms to Support Records, Knowledge and Memory**	ITD	**7.2.2**	The aim of this analysis is to investigate the potential usefulness of mechanisms	https://www.oecd-nea.org/jcms/pl_19622

	Preservation Over the Short and Medium Term **NEA/RWM/R(2015)2**			that have international influence, scope or support and are based on international co-operation, for the preservation of records, knowledge and memory (RK&M) about radioactive waste in the short and medium term.	
2015	**Fostering a Durable Relationship Between a Waste Management Facility and its Host** **Community**	ITD	**1.1.3**	This second edition of Fostering a Durable Relationship Between a Waste Management Facility and its Host Community: Adding Value Through Design and Process highlights innovations in siting processes and in facility design – functional, cultural and physical – from different countries, which could be of added value to host communities and their sites in the short to long term. These new features are examined from the perspective of sustainability, with a focus on increasing the likelihood that people will both understand the facility and its functions, and remember what is located at the site. This 2015 update by the NEA FSC will be beneficial in designing paths forward for local or regional communities, as well as for national RWM programmes.	https://www.oecd.org/about/publishing/fostering-a-durable-relationship-between-a-waste-management-facility-and-its-host-community-9789264249875-en.htm
2015	**Radioactive Waste Management and Constructing Memory for Future Generations** **Proceedings of the International Conference and Debate, 15-17 September 2015, Verdun, France**	IM	**7.2.2**	These proceedings include i) an introduction outlining the RK&M initiative; ii) a synthesis of the conference providing an overview of the talks that were delivered, of the art work that was exhibited and of the group discussions that took place; iii) lessons and conclusions for the RK&M initiative.	https://www.oecd-nea.org/upload/docs/application/pdf/2020-12/7259-constructing-memory-2015.pdf

2015	**Record Keeping Guidance**	ITD	**7.2.2**	The purpose of this note is to set out guidance that will encourage appropriate standards for record keeping by businesses offering services or products via the Internet. It is aimed specifically at record keeping requirements for e-commerce although its principles apply equally to all computerised record keeping.	https://www.oecd.org/ctp/administration/31663114.pdf
2016	**National Inventories and Management Strategies for Spent Nuclear Fuel and Radioactive Waste, Methodology for Common Presentation of Data** **NEA No. 7323**	ITD	**1.4.1**	Report is review of the RW and SF management strategies of NEA member countries with the goal of developing a common presenting format for national inventory data related to RW and SF management strategies that have been established in member countries. The expert group was thus tasked with developing a methodology to support the Status and Trends Project, which is planning to publish a global spent fuel and RW inventory. This report provides a presenting scheme and a methodology for SF and for RW arising from reprocessing.	https://www.oecd-nea.org/upload/docs/application/pdf/2019-12/7323-radioactive-waste-inventory-strategy.pdf
2016	**Scenario Development Workshop Synopsis** **Integration Group for the Safety Case** **NEA/RWM/R(2015)3**	IM	**7.3.3**	This report provides an overview of the state of the art in scenario development related to the long-term safety of geological repositories for RW.	https://www.oecd-nea.org/jcms/pl_19690/scenario-development-workshop-synopsis-integration-group-for-the-safety-case
2016	**International Conference on Geological Repositories**	IM	**Theme 1.**	Building upon the success of previous conferences held in Denver (1999), Stockholm (2003), Berne (2007) and	https://www.oecd-nea.org/upload/docs/application/pdf/2019-12/7345-icgr2016-synthesis.pdf

	Conference Synthesis 7-9 December 2016 Paris, France			Toronto (2012), the 2016 International Conference on Geological Repositories (ICGR 2016), brought together high-level decision makers from regulatory/local government bodies, waste management organisations and public SH communities to review current perspectives of geological repository development.	
2017	**Communication on the Safety Case for a Deep Geological Repository**	IG	**7.2.1**	Communication has a specific role to play in the development of deep geological repositories. Building trust with the SHs involved in this process, particularly within the local community, is key for effective communication between the authorities and the public. There are also clear benefits to having technical experts hone their communication skills and having communication experts integrated into the development process. This report has compiled lessons from both failures and successes in communicating technical information to non-technical audiences. It addresses two key questions in particular: what is the experience base concerning the effectiveness or non-effectiveness of different tools for communicating SC results to a non-technical audience and how can communication based on this experience be improved and included into a SC development effort from the beginning?	https://www.oecd.org/about/publishing/communication-on-the-safety-case-for-a-deep-geological-repository-9789264274150-en.htm
2017	**National Inventories and Management Strategies for Spent Nuclear Fuel and Radioactive Waste**	ITD	**1.4** **1.4.1**	The Status and Trends Project set out to establish an instrument that would provide a better understanding of the	https://www.oecd-nea.org/jcms/pl_15054/national-inventories-and-management-

	Extended Methodology for the Common Presentation of Data **NEA No. 7371**			global picture SF and RW management, and the main contribution of the NEA would be to create a methodology that would help provide this understanding. The primary objectives: – Develop a methodology to ensure consistency of national RW inventory data when it is included in a common presenting scheme; – Support NEA members in preparing their national report – Propose the method mentioned above to be used as a tool for presenting SF/RW data when preparing publications in the context of the joint "Status and Trends" Project.	strategies-for-spent-nuclear-fuel-and-radioactive-waste?details=true
2017	**Sourcebook of International Activities Related to the Development of Safety Cases for Deep Geological Repositories** **NEA No. 7341**	ITD	**7.2.1**	The specific objectives of this sourcebook are: i) to document recent international activities conducted by the NEA, the EC and the IAEA in developing SCs so as to help avoid duplication in work, ii) to assist in the dissemination of international publications on developing or integrating information for safety cases, and iii) to inform the NEA IGSC in designing its future programme of work.	https://www.oecd-nea.org/upload/docs/application/pdf/2020-12/7341-sourcebook-safety-cases.pdf
2018	**Managing Information and Requirements in Geological Disposal Programmes** **NEA/RWM/R(2018)2**	ITD	**1.2.4** **7.2.2**	The main goal of this IGSC study is to examine how information and requirements management is implemented and executed in the various member organisations, including similarities and differences and to identify potential areas of collaboration. The document reports some first observations	https://www.oecd-nea.org/upload/docs/application/pdf/2020-07/managing_information_and_requirements_in_geological_disposal_programmes_2020-07-07_16-47-4_589.pdf

				on the topic, based mainly on the responses to a questionnaire prepared by JAEA and ONDRAF/NIRAS.	
2018	**Preservation of Records, Knowledge and Memory (RK&M) Across Generations** **Reference Bibliography** **NEA/RWM(2011)13/REV5**	ITD	**7.2.2**	This bibliography aims at providing an overview over the work performed in the field of the preservation of records, knowledge and memory (RK&M) in relation with RWM, especially disposal.	https://www.oecd-nea.org/jcms/pl_19858
2019	**Preservation of Records, Knowledge and Memory (RK&M) Across Generations: Developing a Key Information File for a Radioactive Waste Repository**	ITD	**7.2.2**	It describes one component of the lasting record, known as the key information file (KIF). The concept of a KIF emerged in response to the challenge presented by the expected large volumes of RK&M material that national disposal programmes are likely to generate. The KIF is intended to form part of an integrated RK&M system, providing an overview of a single disposal facility, with enough information for educated readers to identify and appreciate the associated hazards. It is a single, short document, produced in a standard format across national programmes. Widely distributed and openly available, it is intended to be introduced in several languages.	https://www.oecd-nea.org/jcms/pl_15060
2019	**Operational Safety of Geological Repositories** **Proceedings of the Joint NEA/IAEA Workshop, 29 June-1 July 2016** **OECD Conference Centre** **NEA/RWM/R(2019)6**	IM IG	**Theme 7.**	This report provides an overview of the state of the art in providing and evaluating the operational safety of geological repositories for RW. It is structured as follows: – summarises past and ongoing work of international organisations, including the NEA and the IAEA, on topics related to operational safety.	https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=NEA/RWM/R(2019)6&docLanguage=En

				– discusses the requirements and guidance related to operational safety provided by national regulations and international bodies. – addresses the relationships between long-term safety, operational safety and repository design. – describes the process of operational SA and the management of operational risks.	
2019	**NEA Integration Group for the Safety Case (IGSC)** **Summary of the Topical Session on "Considerations for Updating a Safety Case"**	ITD	**7.2.1**		https://www.oecd-nea.org/upload/docs/application/pdf/2021-07/summary_record_of_the_topical_session_of_the_21st_meeting_of_the_igsc.pdf
2019	**International Features, Events and Processes (IFEP) List for the Deep Geological Disposal of Radioactive Waste** **NEA/RWM/R(2019)1**	ITD	**7.3.3**	The NEA International FEP (IFEP) List is a comprehensive and structured list of generic FEPs, relevant to assessments of the post-closure safety of any DGR, which has been assembled through a long-term international collaboration between RWMOs in the framework of the NEA. It is intended to support national programmes in the production of their safety cases through the provision of a comprehensive and internationally accepted list of factors that may need to be considered when assessing the post-closure safety of DGRs.	https://www.oecd-nea.org/jcms/pl_19906/international-features-events-and-processes-ifep-list-for-the-deep-geological-disposal-of-radioactive-waste-version-3-0

2019	**RepMet Tools and Guidelines** **A Report of the Radioactive Waste Repository Metadata Management (RepMet) Initiative**	ITD	**7.2.2**	The Radioactive Waste Repository Metadata Management (RepMet) initiative was launched in 2014 by the Integration Group for the Safety Case (IGSC) of the RWMC at the OECD NEA. RepMet analysed and investigated the application of metadata, a fundamental tool of modern data and information management, within national programmes for RW repositories. Based on this analysis it was realised that there is a great need and potential for metadata management and harmonisation.	https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=NEA/RWM/R(2019)5&docLanguage=En
2019	**Preservation of Records, Knowledge and Memory (RK&M) Across Generations:** **Final Report of the RK&M Initiative** **NEA No. 7421**	ITD	**7.2.2**	NEA RWMC launched an initiative on the "Preservation of Records, Knowledge and Memory (RK&M) Across Generations" in 2011. The objective of the initiative was twofold: to develop a theoretically founded, broad-based understanding – technical, managerial, institutional, societal and cultural – of the issue, and to develop a practice-oriented "toolbox" of concrete RK&M preservation methods, a "menu" that will allow people to identify various approaches and mechanisms to develop a strategic action plan for RK&M preservation across generations.	https://www.oecd-nea.org/upload/docs/application/pdf/2019-12/7421-rkm-final.pdf
2020	**National Inventories and Management Strategies for Spent Nuclear Fuel and Radioactive Waste, Final Methodology NEA No. 7424**	ITD	**1.4** **1.4.1**	The diversity in classification schemes across countries has restricted the possibility of comparing waste inventories and led to difficulties in interpreting WM practices, both nationally and internationally. To help improve this situation, the OECD NEA	https://www.oecd-nea.org/jcms/pl_60915/national-inventories-and-management-strategies-for-spent-nuclear-fuel-and-radioactive-waste?details=true

				developed a methodology that ensures consistency of national RW and SF inventory data by presenting them in a common scheme in direct connection with accepted management strategy and disposal routes. This report provides the final version of the methodology and presenting scheme for SF and the RW of all existing types. Additionally, there are recommendations in the report on how to enhance the comparability of national inventory data using the NEA methodology. The NEA support for joint efforts of the IAEA and the EC on harmonisation of the reporting process by member countries to the Joint Convention and European Council Directive 2011/70 EURATOM is also presented in the report.	
2020	**Management and Disposal of High-Level Radioactive Waste: Global Progress and Solutions** **NEA No. 7532**	ITD	**Theme 1.**	The report is a policy-level compendium of the status of knowledge, technological developments, safety standards, rules and requirements applicable to evaluating the feasibility of DGRs. It summarises how the international scientific community has intensively collaborated to bring sound arguments and evidence into the debate that SNF/HLW will not cause harm to either humans or the environment. It also documents how DGRs are moving forward in several countries after the case for their feasibility was accepted by scientific and regulatory authorities and other SHs - including through public	https://oecd-nea.org/upload/docs/application/pdf/2020-07/7532-dgr-geological-disposal-radioactive-waste.pdf

				consultations. There is now confidence, based on science, in humankind's ability to safely manage and dispose of SNF/HLW. This confidence can only contribute to the overall sustainability of nuclear energy.	
2020	**Multifactor Optimisation of Predisposal Management of Radioactive Waste** **NEA/RWM/R(2020)3**	IM	**2.3.2**	The overall objectives of the workshop were to: – foster discussions among participants (e.g. regulators, operators, policymakers, waste producers, decommissioning entities) from different backgrounds to promote a holistic development and optimisation of predisposal RWM programmes; – understand the overall RW path from generation to disposal of waste (acknowledging the inclusion of regulatory and licensing processes as well as safe operation); – promote the understanding of the impact of various factors (legal, technical, economic, societal, etc) on the fuel cycle system for optimisation of RWM, – identify topics for continuing and extending RWMC predisposal work, identify potential collaborations with relevant STCs, and potential areas for joint projects and collaboration with other international organisations (the IAEA and the EC, among others).	https://www.oecd-nea.org/upload/docs/application/pdf/2021-06/rwm_r_2020_3_approved.pdf

2021	**NEA, The Forum on Stakeholder Confidence Report on Dialogue in the Long-Term Management of Radioactive Waste**	ITD	**1.1.3**	In 2010, the FSC examined partnership arrangements and their history in 13 national programmes in the report *Partnering for Long-Term Management of Radioactive Waste*. It showed the shift from the traditional "decide, announce and defend" model to the "engage, interact and co-operate" model. According to the report, this shift fostered the emergence of partnerships between proponents of the RWM facility and the potential host community. Working in collaboration with potential host communities enables pertinent issues and concerns to be raised and addressed. Such collaboration also created an opportunity for developing a relationship of mutual understanding and learning, as well as for developing solutions that will involve an added value to the host community or communities and region. The report documented the implementation of these elements in RWM strategies in most OECD countries.	https://www.oecd-nea.org/jcms/pl_56330/the-forum-on-stakeholder-confidence-report-on-dialogue-in-the-long-term-management-of-radioactive-waste?details=true
2022	**Stakeholder Confidence in Radioactive Waste Management** **An Annotated Glossary of Key Terms, 2022 Update**	ITD	**1.1.3**	In 2018, the FSC membership decided to update the Glossary and include a new entry on added value. The concept of added value was first discussed in the report Fostering a Durable Relationship between a Waste Management Facility and its Host Community: Adding Value through Design and Process (NEA, 2015). It was recognised that although	https://www.oecd.org/publications/stakeholder-confidence-in-radioactive-waste-management-293d3ad6-en.htm

				the concept has many facets and continues to evolve, a shared understanding of this concept was necessary. It is to be expected that within the coming years and through continuing dialogue, the understanding of certain concepts will evolve further and other terms will come to the fore. The FSC will continue to discuss and update its glossary to maintain it as a living document.	
	Published before 2000				
1995	**The Environmental and Ethical Basis of Geological Disposal** **Collective Opinion of the NEA Radioactive Waste Management Committee**	ITD	**1.1.1** **1.5.2**	This report presents such a consensus position in the form of a Collective Opinion of the RWMC of the OECD NEA. It addresses the strategy for the final disposal of long-lived RWs seen from an environmental and ethical perspective, including considerations of equity and fairness within and between generations. This Collective Opinion, by professionals having responsibilities at a national level in the field of RWM, is intended to contribute to an informed and constructive debate on this subject.	https://www.oecd-nea.org/jcms/pl_34631/the-environmental-and-ethical-basis-of-geological-disposal-of-long-lived-radioactive-wastes?details=true
1999	**Confidence in the Long-Term Safety of Deep Geological Repositories -** **Its Development and Communication**	ITD	**1.1.3** **1.5.2**	This report is aimed at practitioners of SA and at technical specialists wishing to become versed in the subject. In its current form, it is intended to improve communication among these specialists by clarifying the concepts related to the development of confidence, and by	https://cybercemetery.unt.edu/archive/brc/20120621083615/http://brc.gov/sites/default/files/documents/nea_confidence_1999.pdf

				placing the various measures that are employed to evaluate, enhance and communicate confidence in the technical aspects of safety in a clear, logical framework. These measures are increasingly embodied in actual procedures applied in today's SAs, and can be incorporated in a common framework, despite differences in approaches, practices and constraints both within and between repository projects.	

2.1.6 EC, EURAD

Date	Title	Type of doc	EURAD roadmap ID	Short description	Web link
2011	**EUROPEAN COMMISSION. Council Directive 2011/70/Euratom, 19 July 2011. Establishing a Community Framework for the Responsible and Safe Management of Spent Fuel and Radioactive Waste.**	IR	**1.1.1**	This Directive establishes a Community framework for ensuring responsible and safe management of SF and RW to avoid imposing undue burdens on future generations. It ensures that MSs provide for appropriate national arrangements for a high level of safety in SF and RW management to protect workers and the	https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011L0070&from=EN

				general public against the dangers arising from ionising radiation. It ensures the provision of necessary public information and participation in relation to SF and RW management while having due regard to security and proprietary information issues. 4. Without prejudice to Directive 96/29/Euratom, this Directive supplements the basic standards referred to in Article 30 of the Euratom Treaty as regards the safety of SF and RW.	
2018	**STRATEGIC RESEARCH AGENDA** **Scientific and technical domains and sub-domains and knowledge management needs of common interest between EURAD participants**		**1.1**	The Strategic Research Agenda (SRA) of the European Joint Programme on RWM (EURAD) describes the scientific and technical domains and sub-domains and knowledge management needs of common interest between EURAD participant organisations. The SRA scope is structured by seven Scientific. These themes are also used in the roadmap. Although all technical in nature, Theme 1 is an overarching theme, Themes 2-5 are predominantly focussed on fundamental science, engineering, and technology, and Themes 6 and 7 include aspects more of an applied science and integration focus.	https://www.ejp-eurad.eu/sites/default/files/2020-01/2._eurad_sra.pdf
2018	**EURAD ROADMAP** **A generic framework to organise typical scientific and technical domains/subdomains in a logical manner**		**1.1**	A Roadmap, with clear objectives, linking EURAD activities (as listed in the SRA) to milestones typical of different phases of a radioactive waste management (RWM)	https://www.ejp-eurad.eu/publications/eurad-roadmap

	against different phases of a RWM programme			programme has been developed (focussed on those planning for disposal). The Roadmap relates to Joint Programme Founding Documents (and was not addressed by the preparatory work carried out in the EC JOPRAD project).	
2021	**EURAD Roadmap THEME 1 Overview, Programme Management**		**Theme 1**		https://www.ejp-eurad.eu/sites/default/files/2021-05/1_Programme_Management_Theme_Overview.pdf
2021	**EURAD Roadmap THEME 2 Overview, Predisposal**		**Theme 2**		https://www.ejp-eurad.eu/sites/default/files/2021-09/2_Predisposal_Theme_Overview.pdf
2021	**EURAD Roadmap THEME 3 Overview, Engineered Barrier System**		**Theme 3**		https://www.ejp-eurad.eu/publications
2021	**EURAD Roadmap THEME 4 Overview, Geoscience**		**Theme 4**		https://ejp-eurad.eu/sites/default/files/2021-05/4_Geoscience_Theme_Overview_0.pdf
2021	**EURAD Roadmap THEME 5 Overview, disposal facility design and optimization**		**Theme 5**		https://www.ejp-eurad.eu/sites/default/files/2021-08/5_Disposal_facility_design_and_optimisation_Theme_Overview.pdf

2021	**EURAD Roadmap THEME 6 Overview, Siting and licensing**		**Theme 6**		eurad.eu/sites/default/files/2021-11/6_Siting%20and%20Licensing_Theme_Overview.pdf
2021	**EURAD Roadmap THEME 7 Overview, Safety case**		**Theme 7**		https://www.ejp-eurad.eu/sites/default/files/2021-05/7_Safety_Case_Theme_Overview.pdf

2.1.7 Other

Date	Title	Type of doc	EURAD roadmap ID	Short description	Web link
2014	Report Radioactive Waste Disposal Facilities Safety Reference Levels WENRA	IG	**Theme 1.**	This document contains the results of the work of WGWD in the area of the safety of disposal facilities for RW. The objective of this report is to provide safety reference levels for these facilities, which were based on the RHWG report, other WGWD reports and ad hoc IAEA documents (requirements, guidance, etc.). Although the IAEA safety standards establish an essential basis for safety of all nuclear installations covering also RW disposals, the WENRA safety	https://www.wenra.eu/sites/default/files/workinggroups/wgwd/srl_disposal_final_version_2014_12_22.pdf

				reference levels incorporate more facility specific requirements.	
2014	**MANAGEMENT OF SPENT NUCLEAR FUEL AND ITS WASTE. EUR 26234. Luxembourg: Publications Office of the European Union;** **JRC84826.**	ITD	**1.1.2**	A report aims to inform policy makers on important issues to take into consideration in developing national programmes for the future management of SF and the RW generated by fuel treatment. The report describes the options for spent fuel management, their present state of development, and the consequences of choices between them, as well as important issues for national programmes to take into consideration in order to implement Directive 2011/70/EURATOM. The report discusses in a synthetic way: - the need for a national policy; - the fuel cycles to consider; - the decision factors in fuel cycle choice; - experience with the involvement of SHs in decision-making; and - the key decisions to be taken and their consequences. To inform preparation of the report, a seminar was held in February 2013 to get the views of an international group of experts on the challenges associated with different strategies to manage SF, in respect of both open cycles and various steps towards closing the nuclear fuel cycle.	https://publications.jrc.ec.europa.eu/repository/handle/JRC84826

2018	**Guidance on Openness and Transparency for European Nuclear Safety Regulators** **ENSREG**	IG	**1.1.3**	The document entitled 'Guidance for National Regulatory Organisations, Principles for Openness and Transparency' was endorsed by ENSREG in 2011. In 2014, a decision to update the document with a view to reflect new legislation, developments and needs, was made. The update of the document was introduced as dedicated task in the ENSREG Work Programme. To this end, a survey on the implementation of the principles for openness and transparency has been conducted among Member States in 2018. The findings from this survey have been reflected in the revised guidance.	https://www.ensreg.eu/sites/default/files/attachments/guidance_for_regulators_on_openness_and_transparency.pdf
2013	**Technical Safety Assessment Guide** **Human and Organisational Factors in Nuclear Facilities Design and Modification Processes** **ETSON**	IG	**7.3**	This document addresses the review and assessment to be done by regulatory bodies regarding human and organisational factors (HOF) during design and modifications of nuclear facilities. Its primary goal is to provide some **guidance** for reviewers/assessors, with at least basic knowledge about HOF. This guidance relies as far as possible on practical experience considering safety assessment in the HOF field.	https://www.irsn.fr/EN/newsroom/News/Documents/ETSON_Technical-Safety-Assessment-Guide-Human-Organizational-Factors_01-2013.pdf
2019	**Safety assessment guide: Harmonized general review principles** **ETSON**	IG	**7.3**	Safety reviews are the core activity performed by TSOs in supporting regulatory bodies: asked by a regulatory body, a TSO provides technical positions and recommendations on safety demonstrations to the regulatory body in order to contribute to its decisions. This	https://www.etson.eu/sites/default/files/publications/ETSON-SAG-4.pdf

				guide presents further views and good practices related to the activity of safety reviews, based on the experience gained by ETSON organizations. It provides general principles to be followed when performing safety reviews, agreed among ETSON organizations and recommendations for building TSOs scientific and technical capabilities to support the safety assessments. This guide is intended to serve as a reference for European TSOs and in particular for newcomers.	

2.2 National guides and guide-like technical documents

2.2.1 Belgium

Year	Title		EURAD roadmap ID	Short description	Web link
	"**Analyse de la sûreté post-fermeture des établissements de stockage définitif de déchets radioactifs"**	NG	**7.3**		

	(Technical Guide "Post-closure safety analysis"). **FANC-SAR**				
	Guide on the radiological protection during the operational period of a facility for the disposal of radioactive waste, **(Technical Guide "Operational Radiation Protection").** **FANC-MP1-03a; Memo 008-007 EN, rev. 5**	NG	*		
	Guide on the radiological protection during the operational period of a facility for the disposal of radioactive waste, FANC-MP1-03a; Memo 008-007 EN, rev. 5 **(Technical Guide "Operational Radiation Protection").** **FANC_RPC-OP**	NG	*		
2011	**Technical guide "Radiation Protection Criteria for Post-Operational Safety Assessment for Radioactive Waste Disposal",** **FANC External Note 2011-06-28-CAD-5-4-3-EN of 2011/08/23.** **FANC_RPC-POP**	NG	*		
	FANC_RPC-LT, Technical Guide "Post-closure Radiation Protection"	NG	*		
	FANC Technical Guide "Geological Disposal"	NG	**Theme 1.**		

	Regulatory guidance for the geologic disposal of radioactive waste: « A minima requirements on argillaceous sedimentary formations » (Bel V) **PSIN-GEN**	NG	**Theme 4**		

2.2.2 Canada

Year	Title		EURAD roadmap ID	Short description	Web link
2005	**Regulatory guidance for the geologic disposal of radioactive waste: « A minima requirements on argillaceous sedimentary formations »,** **AVN report N°KOLIBRI-29152- v1** **AVN-GEO-ARG**	NG	**Theme 1.**		
2006	**Regulatory Guide G-320: Assessing the Long-term Safety of Radioactive Waste Management** **CNSC**	NG	**Theme 7.**	The purpose of this regulatory guide is to assist applicants for new licenses and for license renewals in assessing the long-term safety of RWM. This document describes approaches for assessing the potential long-term impact that RW storage and disposal methods may have on the environment	http://www.cnsc.gc.ca/pubs_catalogue/uploads/G-320_Final_e.pdf

				and on the health and safety of people. This guide addresses: 1. Long term care and maintenance considerations; 2. Setting post-decommissioning objectives; 3. Establishing assessment criteria; 4. Assessment strategies and level of detail; 5. Selecting time frames and defining assessment scenarios; 6. Identifying receptors and critical groups; and 7. Interpretation of assessment results	
2012	**Management system requirements for nuclear facilities** **CSA N286-12**	NR	**1.2.4**	This Standard identifies management system requirements for nuclear facilities. It integrates the requirements from management system standards for health, safety, environment, security, economics, and quality. The CSA N-Series of Standards provides an interlinked set of requirements for the management of nuclear facilities. CSA N286 provides overall direction to management to develop and implement sound management practices and controls, while the other CSA nuclear Standards provide technical requirements and guidance that support the management system.	https://www.techstreet.com/standards/csa-n286-12-r2017?product_id=1836900

2014	**CSA Group. CSA N292.0-14, General principles for the management of radioactive waste and irradiated fuel**	NG	: **Theme 1.**		http://www.nuclearsafety.gc.ca/eng/acts-and-regulations/regulatory-documents/published/html/regdoc1-2-1/index.cfm
	Guidance on Deep Geological Repository Site Characterization **REGDOC-1.2.1** **CNSC**	NG	: **Theme 4.**	It sets out guidance on site characterization for a DGR facility for RW. Information gathered for site characterization may be used in subsequent license applications. This document is complemented by the requirements and **guidance** in REGDCOC-2.11.1, Waste Management, Volume I: Management of Radioactive Waste and REGDOC-2.11.1. Waste Management, Volume III: Safety Case for the Disposal of Radioactive Waste, Version 2 Footnote2. Together, these regulatory documents provide requirements and **guidance** for site characterisation.	http://www.nuclearsafety.gc.ca/eng/acts-and-regulations/regulatory-documents/published/html/regdoc1-2-1/index.cfm http://www.nuclearsafety.gc.ca/
2017	**REGDOC-3.5.1, Licensing Process for Class I Nuclear Facilities and Uranium Mines and Mills** **CNSC**	NG	**1.2.1** **1.2.2**		http://www.nuclearsafety.gc.ca/eng/acts-and-regulations/regulatory-documents/published/html/regdoc1-2-1/index.cfm
2018	**Public and Aboriginal Engagement** **Public Information and Disclosure** **REGDOC-3.2.1** **CNSC**	NG	**1.1.3**	It sets out requirements and guidance for public information and disclosure for licensees and applicants.	http://www.nuclearsafety.gc.ca/

2018	**REGDOC-2.11, Framework for Radioactive Waste Management and Decommissioning in Canada** **CNSC**	NG	**Theme 1**		http://www.nuclearsafety.gc.ca/eng/acts-and-regulations/regulatory-documents/published/html/regdoc1-2-1/index.cfm
2018	**Group. CSA N292.6, Long-Term Management of Radioactive Waste and Irradiated Fuel** **CSA**	NG	**Theme 1**		http://www.nuclearsafety.gc.ca/eng/acts-and-regulations/regulatory-documents/published/html/regdoc1-2-1/index.cfm
2018	**REGDOC-3.2.1, Public Information and Disclosure** **CNSC**	NG	**1.1.3**		http://www.nuclearsafety.gc.ca/eng/acts-and-regulations/regulatory-documents/published/html/regdoc1-2-1/index.cfm
2019	**REGDOC 2.1.1, Management System** **CNSC**	NG	**1.2.4**		http://www.nuclearsafety.gc.ca/eng/acts-and-regulations/regulatory-documents/published/html/regdoc1-2-1/index.cfm
2021	**Licence Application Guide: Class II Nuclear Facilities and Prescribed Equipment** **REGDOC-1.4.1** **CNSC**	NG	**1.2.1** **1.2.2**	It sets out requirements and guidance for applying for any Class II facility and/or prescribed equipment license. While the use of the application form associated with this guide is not a specific requirement for licensing, it is intended to assist applicants in submitting complete and structured information to the Commission so that the request can be processed as quickly as possible.	http://www.nuclearsafety.gc.ca/eng/acts-and-regulations/regulatory-documents/published/html/regdoc1-4-1/index.cfm http://www.nuclearsafety.gc.ca/

2021	**REGDOC-2.11.1, Waste Management, Volume I: Management of Radioactive Waste** **CNSC**	NG	**Theme 1**	This document provides requirements and **guidance**, applicable as part of the licensing basis, for licensees managing radioactive wastes. Specifically, it addresses: – the management of RW – RW storage and disposal facilities	http://www.nuclearsafety.gc.ca/eng/acts-and-regulations/regulatory-documents/published/html/regdoc1-2-1/index.cfm
2021	**Waste Management, Volume III:** **Safety Case for the Disposal of** **Radioactive Waste** **REGDOC-2.11.1, Waste Management, Volume III, Version 2** CNSC	NG	**Theme 7.**	The purpose of this document is to provide requirements and **guidance** to licensees and applicants for developing a safety case and supporting safety assessment activities pertaining to the disposal of all classes of RW.	https://www.nuclearsafety.gc.ca/pubs_catalogue/uploads/REGDOC-2-11-1-volume-III-safety-case-for-the-disposal-of-radioactive-waste-version-2.pdf

2.2.3 Czech Republic

Year	Title		EURAD roadmap ID	Short description	Web link
2004	**National Regulation documents and Guides – Czech Republic**	NG	**Theme 7**.		

	CZ_SÚJB-2004 2004 Procedure for preparation of a safety report for issue of a licence for siting radioactive waste repositories (§ 4.3). Abridged and adapted translation of Czech regulatory body (SÚJB) guide				
2014	**Guidance on the preliminary safety report procedure to permit the construction of radioactive waste disposal repository, SUJB guidance series, 2004**	NG	**Theme 7**.	The **guidance** is prepared for the processing of a preliminary safety report, which is part of the documentation at the construction management level for the permission to build a RW repository. The aim of this material is to provide more detailed instructions for its development.	https://www.sujb.cz/vyhledavani/?tx_kesearch_pi1%5Bpage%5D=1&tx_kesearch_pi1%5BresetFilters%5D=1&tx_kesearch_pi1%5Bsword%5D=MP_umisteni&no_cache=1
2014	**Safety guide, BN-JB-1.14, SÚJB, An interpretation of the criteria for siting of nuclear facilities.**	NG	**Theme 7**.	The aim of this **guide** is to support an interpretation of the criteria established for siting of nuclear facilities, including GDR.	https://www.sujb.cz/vyhledavani/?tx_kesearch_pi1%5Bpage%5D=1&tx_kesearch_pi1%5BresetFilters%5D=1&tx_kesearch_pi1%5Bsword%5D=umistovani+JZ&no_cache=1

2.2.4 Finland

Year	Title		EURAD roadmap ID	Short description	Web link
2002	**Operational safety of a disposal facility for spent nuclear fuel**	NG	**5.4.2**	The **guide** specifies the requirements given in Finnish Government	

	GUIDE YVL 8.5			Resolution (478/1999) on the safety of disposal of SNF and concentrates on operational safety issues important during the design phase of the facility. It also includes references to other YVL Guides applicable to the disposal facility. The requirements concerning the long-term safety of SNF disposal are given in STUK Guide YVL 8.4.	
2012	**Assessment of buffer performance and related uncertainties in TURVA-2012**	NTD	**Theme 7.**	Contents – TURVA-2012 safety case portfolio – Performance requirements – Performance assessment – Early evolution of the buffer and backfill – Long-term evolution – Uncertainties identified in Performance Assessment – Treatment of uncertainties – Impact of flow conditions around buffer – Impact of chemical erosion of buffer – Summary of results – Statement of confidence	https://www.mkg.se/uploads/Karnavfallsradet_13_Posiva_Safety_Case_TURVA-2012snellman.pdf
2012	**Safety case for the disposal of spent nuclear fuel at Olkiluoto - Synthesis**	NTD	**7.2.1**	TURVA-2012 is Posiva's safety case in support of the Preliminary Safety Analysis Report (PSAR 2012) and application for a construction licence for a spent nuclear fuel repository. Consistent with the Government Decisions-in- Principle, this foresees a repository developed in bedrock at the Olkiluoto site according to the KBS-3 method, designed to accept SNF from	https://www.osti.gov/etdeweb/biblio/22134705#:~:text=TURVA-2012%20is%20Posiva%27s%20safety%20case%20in%20support%20of,construction%20licence%20for%20a%20spent%20nuclear%20fuel%20repository.

				the lifetime operations of the Olkiluoto and Loviisa reactors. Synthesis 2012 presents a synthesis of Posiva Oy's Safety Case 'TURVA-2012' portfolio. It summarizes the design basis for the repository at the Olkiluoto site, the assessment methodology and key results of performance and SAs. It brings together all the lines of argument for safety, evaluation of compliance with the regulatory requirements, and statement of confidence in long-term safety and Posiva's safety analyses. The TURVA-2012 safety case demonstrates that the proposed repository design provides a safe solution for the disposal of SNF, and that the performance and SAs are fully consistent with all the legal and regulatory requirements related to long-term safety as set out in Government Decree 736/2008 and in guidance from the nuclear regulator - the STUK. Moreover, Posiva considers that the level of confidence in the demonstration of safety is appropriate and sufficient to submit the construction licence application to the authorities. The assessment of long-term safety includes uncertainties, but these do not affect the basic conclusions on the long-term safety of the repository	
2012	**TURVA-2012 is Posiva's safety case in support of the Preliminary Safety Analysis Report (PSAR) and application for a construction licence for a repository**	NTD	**Theme 7.**	Contents – TURVA-2012 safety case portfolio – Performance requirements – Performance assessment	

	for disposal of spent nuclear fuel at the Olkiluoto site in south-western Finland.			– Early evolution of the buffer and backfill – Long-term evolution – Uncertainties identified in Performance Assessment – Treatment of uncertainties – Impact of flow conditions around buffer – Impact of chemical erosion of buffer – Summary of results – Statement of confidence	
2012	**Safety Case for the Disposal of Spent Nuclear Fuel at Olkiluoto - Design Basis** **Posiva-2012**	NTD	**7.2.1**		
2012	**Safety case for the disposal of Spent Nuclear fuel at Olkiluoto – Performance assessment. Posiva 2012-04**	NTD	**7.2.1**		
2012	**Safety case for the disposal of Spent Nuclear fuel at Olkiluoto – Features, events and processes 2012. Posiva 2012-07**	NTD	**7.2.1**		
2012	**Safety case for the disposal of Spent Nuclear fuel at Olkiluoto, Synthesis report**	NTD	**7.2.1**		
2012	**Safety case for the disposal of spent nuclear fuel at Olkiluoto – Assessment of radionuclide release scenarios for the repository system** **Posiva 2012-09**	NTD	**7.2.1**	The main emphasis in this report is on the evidence and understanding that can be gained from observations at the site, including its regional geological environment, and from natural and anthropogenic analogues for the repository, its components and the processes that affect safety. In	https://www.osti.gov/etdeweb/servlets/purl/22134703

				particular, the report addresses diverse and less quantifiable types of evidence and arguments that are enclosed to enhance confidence in the outcome of the SA. These complementary considerations have been described as evaluations, evidence and qualitative supporting arguments that lie outside the scope of the other reports of the quantitative SA.	
2013	**Safety case for the disposal of spent nuclear fuel at Olkiluoto – Models and data for the repository system 2012. Posiva 2013-01**	NTD	**7.2.1**	TURVA-2012 is Posiva Oy's SC in support of the Preliminary Safety Analysis Report (PSAR 2012) and application for a construction license for a KBS-3V SF repository. The present report is a key element of the TURVA-2012 report portfolio and has the objective of documenting the models, data, assumptions and treatment of uncertainties in the context of SC. This report is the main link between the SC and the engineered barrier design and their development as well as between the SC and the Olkiluoto site investigations. This report focuses on the models and data used in Performance Assessment and in Assessment of Radionuclide Release Scenarios for the Repository System, which are key reports of TURVA-2012. Models and data for the surface environment are discussed in dedicated biosphere modelling and data reports. This report describes the methodology for the identification of key models and data as well as the	https://www.osti.gov/etdeweb/biblio/22266520

				modelling chain with input and output data connections. Models and data are presented for all components of the repository system: SF, canister, buffer, backfill, closure, underground openings and geosphere. The report is structured so that the modelling of external processes is discussed first, followed.	
2013	**"Disposal of Nuclear Waste: Guide YVL D.5", Radiation and Nuclear Safety Authority (STUK), Helsinki, Finland**	NG	**Theme 5.** **Theme 6.** **Theme 7.**	This **Guide** addresses the large-scale disposal of nuclear waste in repositories constructed inside the bedrock. The types of nuclear waste within the scope of the present Guide include SF, RW arising from the operation of a nuclear facility, RW arising from the dismantling of a nuclear facility, and other RW to be disposed of in repositories designed for nuclear waste. The Guide covers the whole life cycle of a disposal facility (site investigations, design, construction, operation and closure), and it addresses both the operational safety of disposal facilities and the demonstration of the long-term safety of disposal.	https://ohjeisto.stuk.fi/YVLold/YVLD.5en_2013-11-15.pdf
2014	**Safety Case for the Disposal of Spent Nuclear Fuel at Olkiluoto** **Radionuclide Migration Parameters for the Geosphere**	NTD	**7.2.1**	This report presents an updated radionuclide sorption database for the far-field of the Olkiluoto nuclear waste disposal site. The geochemical environments are based on site investigations of the present conditions and on modelled evolution of the geosphere. Sorption was estimated to four rock types and on	file:///C:/Users/ormaip/Downloads/SafetyCaseforthe DisposalofSpentNuclearFuelatOlkiluotoRadionuclideMigrationParametersfortheGeosphere_HakanenErvannePuukko_2012-41.pdf

				clays, kaolinite and illite, that are common on fracture surfaces in the Olkiluoto site. The possible intrusion of shallow oxidising waters to bedrock was taken into account by estimation of sorption of the redox-sensitive radionuclides in addition to the present anaerobic conditions in oxic modifications of the glacial, fresh and saline waters. The best estimate and the lower limit values were derived to radionuclides that are considered in the SC of the disposal of spent UO_2 fuel.	
2015	**STUK's review on the construction license stage post closure safety case of the spent nuclear fuel disposal in Olkiluoto** **STUK-B 197 / NOVEMBER 2015**	NTD	**7.2.1**	This report is based on a review of the SC presented in Posiva's construction license application and the related documents submitted to STUK. This report consists of the decision and the presentation memorandum of the SC and appended review report of the SC. which presents background information and details concerning the requirements in the decision as well as a great deal of inspection observations.	https://www.julkari.fi/bitstream/handle/10024/127160/stuk-b197.pdf
2015	**Review of safety assessment in Posiva's construction license application for a repository at Olkiluoto** **STUK-TR 19 / AUGUST 2015**	NTD	**Theme 7.**	In December 2012, Posiva Oy submitted a construction licence application (CLA) to the Finnish Government proposing construction of encapsulation and disposal facilities for spent nuclear fuel at Olkiluoto. An important part of the CLA is a safety case that includes a demonstration of the operational safety for about 100 years of operational period and long-term safety for up to 1,000,000 years	ttps://www.julkari.fi/bitstream/handle/10024/126757/stuk-tr19.pdf?sequence=1&isAllowed=y

				after repository closure. STUK are evaluating the CLA. This report is a compilation of the review comments from and findings of STUK's consultants in the area of SA. In its safety case, Posiva demonstrates that the proposed repository for SF will comply with the safety standards set in GD 736/2008 and in YVL D.5 with comfortable safety margins.	
2015	**Safety assessment by the Radiation and Nuclear Safety Authority of Posiva's construction license application** **STUK**	NTD	**Theme 7.**	On 28 Dec. 2012, Posiva Oy (Posiva) submitted an application to the Government for the construction of a spent nuclear fuel encapsulation plant and disposal facility at Olkiluoto in Eurajoki. The Ministry of Employment and the Economy has requested a statement from the Radiation and Nuclear Safety Authority (STUK) regarding the construction license application for a nuclear facility by Posiva (TEM/2955/08.05.01/2012, 15 February 2013). This SA presents the grounds for STUK's statement. The SA is based on the review of Posiva's construction license application and the related documents delivered to STUK. It covers the project's nuclear safety and radiation safety, security arrangements, the planning of emergency response arrangements and nuclear safeguards. The conclusions of this SA are based on the maximum volume of waste requiring disposal proposed by Posiva, but they	https://www.stuk.fi/documents/88234/963503/stuk_safety_assessment_of_posiva_construction_application.pdf/b01e5c91-2944-4d8a-a5dd-0d9b48a2b509?t=1444844110542

				are also valid for volumes of waste smaller than that.	
2017	**Safety Case Plan for the Operating License Application, report** **Posiva 2017-02, June 2017**	NTD	**7.2.1**		
2017	**Safety functions, performance targets and technical design requirements for a KBS-3V repository - Conclusions and** **recommendations from a joint SKB and Posiva working group**	NTD	**5.1.** **5.1.1**	This report presents the joint bases for the technical design requirements, performance targets and safety functions of a KBS-3V repository. In the report the iterative design and assessment process required to develop the safety functions, performance targets and technical design requirements is described. The features and characteristics of the SF that contribute to or impact the radiation safety of a KBS-3 repository are stated. The conceptual designs, safety functions and their performance targets as well as the technical design requirements are also presented for the engineered barriers, the underground openings and the rock. The safety functions with their performance targets and the technical design requirements are compiled in tables directly under sub-titles stating the safety function or, for the technical design requirements, the characteristic to be designed. Each safety function, performance target and technical design requirement is justified, and the conditions to be considered when assessing them as well as the implications for design and	https://www.skb.com/publication/2485568/Posiva+SKB+Report+01.pdf

				verification are outlined. After each presented requirement, a reference to the requirement databases is given as "Requirement" followed by the id-code of the requirement.	
2018	**Disposal of nuclear waste** **STUK GUIDE YVL D.5**	NG	**Theme 5.** **Theme 6.** **Theme 7.**	This Guide addresses the extensive disposal of nuclear waste in repositories constructed inside the bedrock. This Guide covers the whole life cycle of a disposal facility (site investigations, design, construction, operation and closure), and it addresses both the operational safety of disposal facilities and the demonstration of the long-term safety of disposal.	https://www.finlex.fi/data/normit/41417/YVL_D.5e.pdf
2018	**"Safety Evaluation for a KBS-3H Spent Nuclear Fuel Repository at Olkiluoto** **– Performance Assessment"**	NTD	**7.3**		

2.2.5 France

year	Title		EURAD roadmap ID	Short description	Web link
2008	**Safety Guide on Radioactive Waste Disposal in a Deep Geological Formation,**	NG	**Theme 1.**		http://www.asn.fr/Media/Files/guide_RFSIII_2_fV1_2_

	« Guide de sûreté relative au stockage définitif des déchets radioactifs en formation géologique profonde » **ASN guide N°1, RFSIII-2-fv1-2**				

2.2.6 Germany

Year	Title		EURAD roadmap ID	Short description	Web link
2008	**Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) mbH, Safety and Performance Indicators for Repositories in Salt and Clay Formation** **GRS-240**	NG	**7.1.2**		
2010	**Safety Requirements Governing the Final Disposal of Heat-Generation Radioactive Waste, BMU**	NR	**7.1.1**	This **guideline** applies to deep geological repositories. It specifies the applicable protection objective and protection criteria and the requirements applying to a deep geological repository. It also sets out the details of the procedure to be followed for demonstrating the safety of a DGR. It defines key terms in the area of GD as far as these are not addressed in the Nuclear Energy Act. Requirements are stipulated for the operation of facilities, in so far as these are specific to	http://www.bmub.bund.de/fileadmin/bmu-import/files/english/pdf/application/pdf/sicherheitsanforderungen_endlagerung_en_bf.pdf

				geological repositories and their closure.	
2010	**National Regulation documents and Guides** **DE_BMU-2010 2010 Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste**	NG	**Theme 1.**		
2019	**Safety concept, FEP catalogue and scenario development as fundamentals of a long-term safety demonstration for high-level waste repositories in German clay formations** **A. LOMMERZHEIM, M. JOBMANN A. MELESHYN, S. MRUGALLA, A. RÜBEL & L. STARK**,	NTD	**7.3.3**	A safety concept and a safety demonstration concept for the disposal of HLW in German clay formations have been developed. As a basis for system analysis, generic geological reference models, disposal concepts and repository designs have been developed for northern and southern Germany. All data relevant for future system evolution were compiled in two FEP (features, events and processes) catalogues. They provide information on FEP characteristics, their probabilities of occurrence, their interactions and identify 'initial FEP' that impair the safety functions of relevant barriers. A probable reference scenario has been deduced systematically from the probable 'initial FEP', and from probable processes relevant for radionuclide mobilization and transport. Four different starting points to develop alternative scenarios (i.e. less probable evolutions) were identified. The scenario development methodology is applicable to different kinds of host rock and therefore may be a basis for the preliminary safety	https://www.bge-technology.de/fileadmin/user_upload/MEDIATHEK/veroeffentlichung/2018-09-21_FEP_Catalogue_and_Senario_development.pdf

				analyses necessary in the future site selection process in Germany.	

2.2.7 Japan

Year	Title		EURAD roadmap ID	Short description	Web link
2000	**H12: Project to Establish the Scientific and Technical Basis for HLW Disposal in Japan** **Geological Isolation Research and Development** **Supplementary Report** **Background of Geological Disposal**	NTD	**1.2.5**		https://jopss.jaea.go.jp/pdfdata/JNC-TN1410-2000-005.pdf
2000	**H12 report** **Supporting Report 2** **Repository Design and Engineering Technology**	NTD	**5.1**		https://www.jaea.go.jp/04/tisou/english/report/H12_sr2.html
2000	**Geological Isolation Research and Development** **H12 report** **Supporting Report 3**	NTD	**1.2.5**		https://www.jaea.go.jp/04/tisou/english/report/H12_sr3.html

	Safety Assessment of the Geological Disposal System				
2004	**Development of Repository Concepts for Volunteer Siting Environments. NUMO-TR-04-03.**	NTD	**1.5.2**		
2011	**RMS 2010 Requirements Management Systems (RMS): Status and Recent Developments – Information Exchange Meeting Report – NUMO-TR-10-07**	IM	**7.1.1**	A discussion with - and receiving feedback from - other implementing organizations, that are also in the process of developing RMS, was deemed extremely valuable. As part of the NUMO-Nagra collaboration, an international information exchange meeting was organized on 26 January 2010 in Tokyo. Objectives were to introduce the RMS as considered by the different organizations in terms of: – Objectives and expectations, – Status of developments and progress, – Practical experience with the application, – Identification of the key common features, differences, if any, and reason, – Identification future common needs.	https://www.numo.or.jp/en/reports/pdf/TR-10-07.pdf

2.2.8 Sweden

Year	Title		EURAD roadmap	Short description	Web link

			ID		
1996	**Information, conservation and retrieval** **SKB Technical Report 96-18**	NTD	**7.2.2**	The study deals with different aspects of information, conservation and retrieval of information on final repositories for nuclear waste. First 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. In the second part 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 analyze the chains of political, economical, social and cultural events that has 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 WM would benefit from an early identification of documents to be part of an archive for RW 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 in	http://www.skb.se/upload/publications/pdf/TR-96-18webb.pdf

				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.	
2000	**Geoscientific programme for investigation and evaluation of sites for the deep repository SKB Technical Report TR-00-20**	NTD	**Theme 4.**	This report presents SKB's programme for investigation and evaluation of sites for the deep repository. The emphasis is on methodology and technology for investigating and evaluating the rock, but surface ecosystems and other conditions at the surface are also discussed. The purpose of the report is to satisfy the requirements on "a well-defined site investigation programme" in accordance with the Government's decision of 24 January 2000 on RD&D-Programme 98. The programme that is presented is general. It comprises a basis for planning corresponding activities at a later stage, tailored to the specific conditions in the municipalities and on the sites selected.	https://www.skb.com/publication/18003/TR-00-20.pdf
2001	**Site investigations Investigation methods and general execution programme SKB**	NTD	**6.2**	The report is a broadening of the general programme and describes the execution of the investigations in so-called discipline-specific programmes for the disciplines geology, rock mechanics, thermal properties, hydrogeology, hydrogeochemistry, transport properties of the rock and surface ecosystems. It also describes various technical aspects of drilling, which comprises a significant portion of the investigations. The programmes	https://skb.se/upload/publications/pdf/TR-01-29.pdf

				are generic, i.e. not tailored to the specific conditions that will exist on a particular site. Based on this possible programme, site-specific programmes will then be prepared and adapted to the site-specific questions and conditions on the specific candidate area. When the contents and scope of the sub-steps of the various stages have been tailored to the different sites, it may be found that certain investigation steps must be added, while others described here are unnecessary and can therefore be omitted. The sequence of the different investigation steps may also need to be modified. What is essential is that the site-specific information is collected when it is needed and that it is ultimately sufficient for the site-descriptive account after completed site investigation.	
2002	**Review of data types for the SKB site investigation programme** **SSI Report**	NTD	**6.2**	The aims of this project are: • to provide the Swedish regulators (SSI) with a compilation of relevant site-specific and generic biosphere data types, including data for the geosphere-biosphere interface, that will be needed to develop an understanding of biosphere processes relevant for evaluation of long-term safety and radiological protection; • to summarise the main types of analyses and site-specific models that are needed for the safety evaluation;	https://www.stralsakerhetsmyndigheten.se/contentassets/7c9ec6fc99204921b416f7033bb67fb9/200222-review-of-data-types-for-the-skb-site-investigation-programme

				• to assess how well SKB ís programme meets the above needs, to identify any major gaps in SKB ís programme in relation to SSI is regulations or international experience, to assess whether the timing of various measurements is appropriate; and • to provide a base document for SSI is future work on biosphere characterisation, i.e. for review of SKBís site investigation programme and for the planning of further SSI R&D work.	
2002	**Site Investigations Strategy for Rock Mechanics, Site Descriptive Model** **Technical Report TR-02-01**	NTD	**6.2**	As a part of the planning work for the Site Investigations, SKB has developed a Rock Mechanics Site Descriptive Modelling Strategy. Similar strategies are being developed for other disciplines. The objective of the strategy is that it should guide the practical implementation of evaluating site specific data during the Site Investigations. It is also understood that further development may be needed. This methodology enables the crystalline rock mass to be characterised in terms of the quality at different sites, for considering rock engineering constructability, and for providing the input to numericalmodels and performance assessment calculations. The model describes the initial stresses and the distribution of deformation and strength properties of the intact rock, of fractures and fracture zones, and of the rock mass. The rock	https://skb.se/upload/publications/pdf/TR-02-01.pdf

				mass mechanical properties are estimated by empirical relations and by numerical simulations.	
2004	**RD&D-Programme 2004** **SKB Technical Report TR-04-21**	NTD	**1.2.5**	Programme for research, development and demonstration of methods for the management and disposal of nuclear waste, including social science research.	https://skb.se/publication/408101/TR-04-21.pdf
2010	**RD&D Programme 2010: Programme for Research Development and Demonstration of Methods for the Management and Disposal of Nuclear Waste** **Technical Report TR-10-63**	NTD	**1.2.5**	Programme for Research Development and Demonstration of Methods for the Management and Disposal of Nuclear Waste.	
2011	**"Environmental Impact Statement (Interim Storage, encapsulation and final disposal of spent nuclear fuel)"** **SKB**	NTD	**Theme 7.**		
2011	**"Application for Licence under the Nuclear Activities Act", SKB**	NTD	**6.3.2**		
2019	**"RD&D Programme 2019" (Programme for research, development and demonstration of methods for the management and disposal of nuclear waste), TR-19-24, SKB**	NTD	**1.2.5**		

2.2.9 Switzerland

Year	Title		EURAD roadmap ID	Short description	Web link
2009	**Specific design principles for deep geological repositories and requirements for the safety case** **SGT, Sectoral Plan for Deep Geological Repositories ("Conceptual part" is available in English)** **Guideline for Swiss Nuclear Installations** **ENSI-G03/e**	NG	**5.1**	This guideline applies to DGRs as defined in Article 3 of the Nuclear Energy Act of 21 March 2003 (SR 732.1). It specifies the applicable protection objective and protection criteria and the requirements applying to a DGR. It also sets out the details of the procedure to be followed for demonstrating the safety of a GR. It defines key terms in the area of GD (Appendix 1) as far as these are not addressed in the Nuclear Energy Act. Requirements are stipulated for the operation of facilities, in so far as these are specific to GRs and their closure. Where relevant, the provisions contained in other guidelines of the regulatory authority also apply to repository construction and operation. This guideline regulates the radiological safety of DGRs. Requirements relating to the release of chemo-toxic substances from a GD are dealt with in the relevant environmental protection legislation.	https://www.ensi.ch/en/2009/11/11/g03-specific-design-principles-for-deep-geological-repositories-and-requirements-for-the-safety-case/

				Requirements applying to the security and control of fissile materials are regulated in the Ordinance of the Federal Department of the Environment, Transport, Energy and Communications) on hazard assumptions and security measures for nuclear installations and nuclear materials of 16 April 2008 and are included here only if relevant for operational and long-term safety.	

2.2.10 UK

Year	Title		EURAD roadmap ID	Short description	Web link
2001	**Managing Radioactive Waste Safely: Proposals for Developing a Policy for Managing Solid Radioactive Waste in the UK**	NTD	**1.1.1**		http://bit.ly/15Rum8m
2004	**A Review of the Deep Borehole Disposal Concept for Radioactive Waste** **Nirex Report N/108**	NTD	**1.5.2**	This report reviews the development of the DBDconcept for the disposal of RW, from its initial development in the 1970s to the present day, and provides comparisons between this concept and more commonly discussed disposal concepts, such as mined repositories. The review of the development of the deep borehole disposal concept is	https://www.mkg.se/uploads/Nirex_Report_N_108_-_A_Review_of_the_Deep_Borehole_Disposal_Concept_for_Radioactive_Waste_June_2004.pdf

				divided into two parts – early versions of the concept, which were mainly developed during the 1970s and early 1980s, and later versions that have been considered up to the present day. A substantial part of the report is based on the work which has been carried out by SKB over many years, starting from a review of the geological, hydrogeological and hydrochemical conditions at great depth to an examination of the methods that could be used to emplace the waste canisters. This review also includes the comparisons that were carried out by SKB between the DBD concept and other disposal concepts. The use of the DBD for the disposal of excess weapons grade Pu is reviewed. The majority of this work was carried out in the USA, however much of it was essentially based on the work that had been carried out by SKB. The report ends with an extensive discussion of the issues identified by the review, the key elements of the concept, important questions regarding the disposal zone, a comparison of different concepts and the R&D requirements in order to take this concept further.	
2006	**Managing our Radioactive Waste Safely – CoRWM's Recommendation to Government**	NTD	**1.1.1**	The CoRWM was asked by Government to make recommendations for the long-term management of the UK's higher activity wastes that would both protect the public and the environment, and inspire	https://www.gov.uk/government/publications/managing-our-radioactive-waste-safely-corwm-doc-700

				public confidence. To do this, a technical assessment of options with ethical considerations, examination of overseas experience and a wide-ranging programme of engagement both with the public and with interested parties (SHs) were combined. This integrated package of recommendations deals centrally with specific management options for RWs but they are also framed more broadly.	
2008	**Geological Disposal Options for High-Level Waste and Spent Fuel. Contractor** **Baldwin, T., Chapman, N. A. and Neall, F.,** **Report for the Nuclear Decommissioning Authority**	NTD	**1.5.** **1.5.2**	This report describes work carried out for the NDA. The objective of the report is to provide information on a range of HLW and SF GD concepts, in order to illustrate how GD of HLW and SF might be implemented in the UK. The work is intended to form an information source for the NDA and other SHs in the early stages of a future repository siting and options evaluation programme.	
2008	**A Framework for Implementing Geological Disposal** **Defra, BERR** **A White Paper by Defra, BERR and the devolved administrations for Wales and Northern Ireland**	NTD	**Theme 1.**	This White Paper sets out the UK Government's framework for managing higher activity RW in the long-term through GD, coupled with safe and secure interim storage and ongoing research and development to support its optimised implementation. It also invites communities to express an interest in opening up without commitment discussions with Government on the possibility of	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/68927/7386.pdf

				hosting a GD facility at some point in the future.	
2009	**Geological Disposal: Introduction to the RWM Waste Package Specification and Guidance Documentation, WPS/100/03** **NDA**	NG	**3.2**	The primary document which defines the packaging standards and specifications for ILW, and certain LLW not suitable for disposal in other LLW facilities is the Generic Waste Package Specification (GWPS). The GWPS is supported by the Waste Package Specification and Guidance Documentation (WPSGD) which comprises a suite of documentation primarily aimed at waste packagers, its intention being to present the generic packaging standards and specifications at the user level. The WPSGD also includes explanatory material and guidance that users will find helpful when it comes to application of the specification to practical packaging projects.	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/876855/WPS-915-Guidance-on-the-use-of-grout-caps-in-waste-packages-2009.pdf
2009	**Geological Disposal Facilities on Land for Solid Radioactive Wastes: Guidance on Requirements for Authorisation** **ENVIRONMENT AGENCY and NIEA**	NG	**1.2.1** **1.2.2** **1.2.3**	This guidance is aimed principally at the developers of proposed GD facilities for RW. It explains the requirements that the regulator expect a developer or operator to fulfil when applying to us for an authorisation to develop or operate such a facility. The guidance sets out our radiological protection requirements and explains the regulatory process that leads to a decision on whether to authorise RW disposal. It also describes the environmental safety case the regulator would expect from the	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/296504/geho0209bpjm-e-e.pdf

				developer/operator of a disposal facility. The guidance sets out the framework within which the regulator regulate GD facilities, and the intended regulatory approach. It is directing it mainly at the developers and operators of such facilities. The guidance is also for the regulator own staff, to help ensure systematic and consistent regulation.	
2009	**Technical issues associated with deep repositories for radioactive waste in different geological environments** **Science report: SC060054/SR1** **Environment Agency**	NTD	**3.4** **3.4.1**	This report reviews technical issues related to the development of a deep geological repository for higher activity RWs in England and Wales. The study focuses on the post-closure phase and only considers construction and operational issues which could affect the ability to achieve satisfactory post-closure safety. This project aimed to: • select a set of geological environments to represent the range of plausible repository host environments in England and Wales and highlight a range of technical issues; • identify the environment-specific broad technical issues that would need to be considered when evaluating the safety of each environment.	

2010	**Geological Disposal Feasibility studies exploring options for storage, transport and disposal of spent fuel from potential new nuclear power stations** **NDA/RWMD/060**	NTD	**1.5.**	The scope covers four key SF management work strands: a) Centralised storage facilities for SF. A centralised storage facility would enable SF to be removed from power station sites after an initial on-site cooling period; b) Centralised packaging plant for SF. The current assumption is that a SF packaging plant would be provided on each new nuclear power station site; c) Alternative SF cask types i.e. dual-purpose and multi-purpose cask systems. d) Alternative disposal concept options which are optimised for SF from new NPPs. A range of conceptual designs for a GDF have been examined by RWMD based upon knowledge of legacy SF.	
2010	**Geological Disposal: Steps towards implementation** **NDA Report no. NDA/RWMD/013**	NTD	**Theme 1.**	The report describes: • the radioactive wastes and materials that may require GD; • geological settings that are potentially suitable to host a GD facility; • the development of a range of GD concepts that would be appropriate for the disposal of the different types of RWs and materials in the various types of rock considered suitable;	http://davidsmythe.org/nuclear/NDA%20Geological-Disposal-Steps%20NDA-RWMD-013%20March-2010.pdf

				• the use of a reference case as a basis for planning assumptions and as a benchmark for provision of information; • the phases of work comprising our overall GD programme; • how we identify and aim to meet the relevant regulatory requirements; • the main organisations that we will work with to deliver GD and the nature of our relationships with those organisations; • how we communicate and engage with the public and stakeholders, and how we aim to develop this part of our programme; and • the costs of GD. Section 5 of the report describes how we are using a subset of the range of GD concepts that we are investigating to provide the basis for assessments of the safety of a GD facility during its construction and operation and in the long-term, after its closure. We use the same subset of concepts as the basis for assessments of the potential environmental, social and economic impacts of developing a facility and for assessments of the costs of its development, construction, operation and closure.	

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**	NTD	**7.2.2**		http://www.hse.gov.uk/nuclear/wastemanage/rwm-part3d.pdf
2010	**Guidance on the preparation of submissions for the disposability assessment of waste packages by use of a Standard Waste Package Description, WPS/921/01, NDA**	NG	**3.2.2**	This document forms part of a suite of documents, the Waste Package Specification and Guidance Documentation (WPSGD), prepared and issued by the Radioactive Waste Management Directorate (RWMD) of the Nuclear Decommissioning Authority (NDA). The WPSGD provide specifications for waste packages which meet the transport and disposability requirements of GD in the UK. They are based on, and are compatible with, the Generic Waste Package Specification (GWPS). The WPSGD are intended to provide a 'user-level' interpretation of the GWPS to assist Site Licence Companies (SLCs) in the early development of plans and strategies for the management of RWs.	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/873107/GD-Guidance-on-the-preparation-of-submissions-for-the-disposability-assessment-of-waste-packages-WPS921.pdf
2011	**Geological Disposal: RWMD Approach to Issues Management, NDA Report No. NDA/RWMD/081**	NTD	**1.1** **1.2**	As implementer for GD in the UK and in preparation for future phases of the GD programme (e.g. surface-based investigations and beyond), RWMD are developing a process for managing	http://www.nuclearwasteadvisory.co.uk/wp-content/uploads/2013/02/Geological-Disposal-RWMD-approach-to-issues-management-March-2012.pdf

				issues, focussing on those raised by regulators and stakeholders. The process has also been developed to make RWMD approach to managing issues more open and transparent, and to provide an opportunity for all who take an interest in geological disposal to provide input on our approach and influence RWMD work programmes. The term 'issue' means any challenge, or concern that is raised internally or externally that could affect the implementation of a geological disposal system.	
2011	**Geological Disposal: R&D Programme Overview: Research and Development Needs in the Preparatory Studies Phase** **NDA**	NTD	**1.2.5**		
2012	**R&D Programme overview: Research and development needs in the preparatory studies phase 2012 Revision (with Changes), NDA/RWMD/073 Version 2**	NTD	**1.2.5**	This document identifies and prioritises the NDA's Radioactive Waste Management Directorate's research and development (R&D) needs to support GD of the UK's higher activity RWs. The R&D programme is needs-driven and has the specific objective of supporting GD in the UK. Development of the implementation programme is at an early stage and it will be some time before a site is selected. Therefore, in this document, we focus on R&D that is needed in the preparatory studies phase and to prepare us for the work we will need to do in future phases of the programme. This document sets	https://webarchive.nationalarchives.gov.uk/ukgwa/20211004152537/https://rwm.nda.gov.uk/publication/geological-disposal-rd-programme-overview-research-and-development-needs-in-the-preparatory-studies-phase-2012-revision/

				the context for our needs-driven R&D programme, explaining the high-level drivers for the programme. It explains how the programme is structured into topics and identify the R&D needs in each area within the topics. It also explains how the R&D is prioritised, using a series of structured questions to consider, for each area, what is needed to know by when, the impact, what knowledge gap is, what is needed to do to fill the knowledge gap and the urgency. It is then described how these questions help identify and prioritise the R&D needs for each topic. This document complements our R&D strategy, which describes how we will develop, manage and evaluate the R&D programme.	
2013	**Guidance: Geological disposal of radioactive waste: a guide for communities**	NG	**1.1.3**	A **guide** for communities on how the UK plans to deal with its radioactive waste on a long-term basis and the process for identifying a site for a geological disposal facility.	https://www.gov.uk/guidance/managing-radioactive-waste-safely-a-guide-for-communities
2014	**Implementing GD, A Framework for the long-term management of higher activity radioactive waste** **UK Government**	NTD	**1.1**	This White Paper sets out the UK Government's framework for managing higher activity RW in the long term through GD. It sets out a number of initial actions that will be undertaken by the UK Government and by the developer (RWM Limited) to help implement GD. It also sets out a number of key principles and commitments that will shape the subsequent process of working with	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/332890/GDF_White_Paper_FINAL.pdf

				communities to identify and assess potential sites.	
2015	**Geological Disposal: WPSGD no. WPS/850/03** **Waste Package Data and Information Recording, Requirements: Explanatory Material and Guidance** **RWM**	NG	**3.2**	This document forms part of the Waste Package Specification and Guidance Documentation (WPSGD), a suite of documents prepared and issued by RWM Ltd. The WPSGD is intended to provide a 'user-level' interpretation of the RWM packaging specifications, and other aspects of GD, to assist UK waste packagers in the development of plans for the packaging of higher activity waste in a manner suitable for GD. Key documents in the WPSGD are the WPS which define the requirements for the transport and geological disposal of waste packages manufactured using standardised designs of waste container. The WPS are based on the high level requirements for all waste packages as defined by the Generic WPS and are derived from the bounding requirements for waste packages containing a specific category of waste, as defined by the relevant Generic Specification. This document provides **guidance** to waste packagers on the data and information recording requirements to cover the history of the packaged waste from the time of waste arising, through initial waste characterisation, waste package development, to package. production, storage, transport and disposal in a GDF.	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/877682/NDA_WPS_850_03_-_GD_-_Waste_Package_Data_and_Information_Recording_Guidance.pdf

2015	**The management of higher activity radioactive waste on nuclear licensed sites** **Joint guidance from the Office of Nuclear Regulation, the Environment Agency, the Scottish Environment Protection** **Agency and Natural Resources Wales to nuclear licensees**	NG	**Theme 1.**	Licensees who follow this **guidance** will normally be doing enough to comply with the relevant law as interpreted by the regulators at the time of writing, and the regulators may refer to this guidance as illustrating relevant good practice. However, licensees are not required to follow this guidance and compliance with it does not automatically mean that we will approve an application for a nuclear site licence, a consent or agreement under the licence or an authorisation. The guidance provides information to other parties who may be stakeholders in how RW is managed on a nuclear licensed site.	tps://www.sepa.org.uk/media/153704/management-of-higher-activity-radioactive-joint-guidance.pdf
2016	**Geological Disposal: Generic Disposal System Specification, Part A: High Level Requirements** **NDA Report no. DSSC/401/01**	NR	**Theme 1.**	Radioactive Waste Management Limited (RWM), a wholly owned subsidiary of the Nuclear Decommissioning Authority (NDA), is responsible for implementing the UK Government's policy on geological disposal of higher activity waste. RWM is being developed into a Site Licence Company responsible for the construction and operation of a GDF. RWM has developed a generic DSS to describe the requirements on the disposal system which form the basis of RWM's design and assessment work. The DSS comprises two documents: • Disposal System Specification Part A: High Level Requirements	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/901002/DSSC_-_401_-_01_-_Geological_Disposal_-_Disposal_System_Specification_-_Part_A_-_High_Level_Requirements_a.pdf

				• Disposal System Specification Part B: Technical Specification This document is the DSS Part A whose purpose is to document the high level requirements on the disposal system which derive from: • inventory of waste for disposal •legislative and regulatory requirements • stakeholder requirements.	
2016	**Geological Disposal Part B: Technical Specification, NDA Report no. DSSC/402/01** **Generic Disposal System Specification**	NR	**Theme 1.**	RWM has developed a generic Disposal System Specification (DSS) to describe the requirements on the disposal system and is core to RWM's design and assessments work. The DSS comprises two documents: • The Disposal System Specification Part A – High Level Requirements. The purpose of the Part A is to document the high-level external requirements on the disposal system, including the activities required to transport, receive and emplace waste packages in the GDF. • The DSS Part B – Technical Specification. The purpose of the Part B is to capture the technical requirements defined by RWM to frame the development of a disposal solution to meet the requirements of Part A. The primary objective of the DSS is to provide the designers of the disposal system with the requirements that must	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/901005/DSSC_-_402_-_01_-_Geological_Disposal_-_Disposal_System_Specification_-_Part_B_-_Technical_Specification.pdf

				be satisfied and therefore defines the scope and bounds of the engineering design work. DSS Part A documents the overarching requirements from legislation, regulation, and the inventory for disposal. DSS Part B is written for a technical audience and is published to enable the work programme to develop in line with the functional needs of the GDF.	
2016	**Guidance on the Preparation of Submissions for the Disposability Assessment of Waste Packages, WPS/908/04** **NDA**	NG	**3.2.2**	This document provides **guidance** on the preparation of submissions to RWM for the disposability assessment of proposals to package waste in a form suitable for disposal in a geological disposal facility. The guidance is intended to provide a 'user-level' interpretation of the RWM packaging specifications, and other aspects of geological disposal, to assist UK waste packagers in the development of plans for the packaging of higher activity waste in a manner suitable for geological disposal.	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/876824/NDA_WPS_908_05_-_GD_-_Guidance_on_the_preparation_of_submissions_for_the_disposability_assessment_of_waste_packaging_proposals.pdf
2016	**Geological Disposal, Science and Technology Programme** **RWM**	NTD	**Theme 1.**	Part A: provided an introduction, including high-level context, together with some information on the processes used to develop RWM's work programme. It explained how the work programme is structured, and summarised the alignment of key deliverables from packages of technical work, termed "Major Products", with RWM's mission.	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/526331/NDA_Report_no_NDA_RWM_112_-_GD_-_Science_and_Technology_Programme.pdf

				• Part B presented detailed descriptions of the Major Products, along with the frameworks, strategies and tools for delivering these products, called "Delivery Mechanisms". Each Major Product and Delivery Mechanism description followed a systematic structure. • Part C was a detailed description of the prioritised programme for R&D activities required to support the delivery of a GDF.	
2016	**Geological Disposal: Generic Transport Safety Case - Main Report** **NDA Report no. DSSC/201/01**	NTD	**Theme 7.**	The generic Disposal System Safety Case (DSSC) plays a key role in the iterative development of a geological disposal system and is a demonstration that a GDF can be implemented safely. The generic DSSC also forms a benchmark against which RWM provides advice to waste producers on the packaging of wastes for disposal. One part of the generic DSSC is the generic Transport Safety Case (TSC). The generic TSC comprises three documents that together aim to provide confidence in the radiological safety of the transport of radioactive waste to a GDF, without being specific to any potential GDF location.	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/634885/NDA_Report_no_DSSC-201-01_-_Geological_Disposal_-_Generic_Transport_Safety_Case_-_Main_Report.pdf
2016	**Geological Disposal: Overview of the generic Disposal System Safety Case** **NDA Report no. DSSC/101/01**	NTD	**Theme 7.**	This document provides an overview of the generic Disposal System Safety Case (DSSC): the suite of documents that considers the safety and environmental	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/634857/NDA_Report_no_DSSC-101-01_-_Geological_Disposal_-

				implications of the geological disposal of RW. The Overview provides context and a summary of the conclusions and key safety arguments. It provides a way into the suite of documents, the interfaces between them and pointers to where information can be found. It is intended primarily for a regulatory audience.	_Overview_of_the_generic_Disposal_System_Safety_Case.pdf
2018	**Guidance: Regulating the geological disposal of radioactive waste: environmental protection**	NG	**1.2**	The Environment Agency's role in the development and regulation of a geological disposal facility for radioactive waste.	https://www.gov.uk/guidance/regulating-the-geological-disposal-of-radioactive-waste-environmental-protection#full-publication-update-history
2018	**Implementing GD – working with communities** **An updated framework for the long-term management of higher activity radioactive waste** **UK Government**	NTD	**1.1.3**	This document sets out the UK Government's framework for managing higher activity RW through GD, including how the delivery body, RWM Ltd, work in partnership with communities to identify a suitable location to host a GDF. RWM can draw on more than 30 years of experience and expertise in GD. It collaborates with scientists around the world sharing knowledge, expertise and the latest scientific developments.	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/766643/Implementing_Geological_Disposal_-_Working_with_Communities.pdf
2018	**Consultation on geological disposal of radioactive waste: Working with potential host communities** **Number: WG33010** **Welsh Government**	NTD	**1.1.3**	This consultation paper seeks views on the arrangements for engaging with communities in Wales who may be considering entering discussions about potentially hosting a GDF. The report is seeking responses on how:	https://beta.gov.wales/sites/default/files/consultations/2018-02/180125-consultation-document-en.pdf

				– communities should be identified and what might constitute a "community"; – communities should be represented and supported during discussions; – people in the community more widely should be involved; – the right of withdrawal and the test of public support, which are the important safeguards for communities, should be delivered; and, – the disbursement of community investment assessment of funding applications, and the ability of communities to influence investment within their geographic areas should be delivered.	
2018	**Pre-application advice and scrutiny of Radioactive Waste Management Limited: Joint regulators' assessment of the 2016 generic Disposal System Safety Case Environment Agency**	NTD	**1.2.1**	The Environment Agency and the Office for Nuclear Regulation have assessed the 2016 generic DSSC at the request of RWM, to provide scrutiny and advice on parts of its work ahead of any permit or license application. A generic DSSC is not a regulatory requirement. The assessment provides advice and comment to RWM on matters within our respective regulatory remits to help ensure that any future applications supporting a GDF take full account of our permitting and licensing requirements; it does not form the basis of any regulatory decision.	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/907995/Joint_regulators__assessment_of_the_2016_generic_Disposal_System_Safety_Case.pdf
2018	**Consultation: National Policy Statement for geological disposal infrastructure. Implementing geological disposal,**	NTD	**1.1.3**	This consultation is seeking views on how communities should be engaged and represented in a siting process for	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/676391/WWC_consultation.pdf

	Department for Business, Energy, and Industrial Strategy			a GDF for higher activity RW. The proposals build on commitments set out in the 2014 White Paper 'Implementing Geological Disposal', in which the UK Government and Northern Ireland Executive jointly set out an approach based on working with communities in England and Northern Ireland that are willing to participate in the siting process for a GDF. They relate to how communities should be represented, how early community investment could be provided to communities that participate in the siting process, how a right of withdrawal could operate throughout the siting process and how a test of public support could be carried out before construction and operation of a GDF.	
2019	**National Policy Statement for Geological Disposal Infrastructure, A framework document for planning decisions on nationally significant infrastructure, Department for Business, Energy, and Industrial Strategy**	NG	**1.1.1**	This National Policy Statement significant infrastructure projects (NSIPs) related to the geological disposal of higher activity radioactive waste in England and the government's approach to deliver them. It also provides **planning guidance** for developers of NSIPs on geological disposal infrastructure.	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/814491/national-policy-statement-geological-disposal-infrastructure.pdf
2021	**Inventory for geological disposal** **RWM**	NTD	**1.4** **1.4.1**	This report presents the 2019 inventory for geological disposal (IGD). The IGD is based on Government policy, industry plans and publicly available information. Data are presented on the quantity, activity, and material composition of the waste according to	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/997521/RWM_REPORT_DSSC_403_03_Inventory_for_Geological_Disposal_MAIN_REPORT.pdf

				its classification, which in its simplest form is high and low heat-generating reflecting the relevant disposal concepts. To support the assessment of non-radiological substances, the inventory for GD includes an estimate of the construction materials associated with a GDF.	
2021	**The management of higher activity radioactive waste on nuclear licensed sites** **Joint guidance from the Office for Nuclear Regulation, the Environment Agency, the Scottish Environment Protection** **Agency and Natural Resources Wales to nuclear licensees**	NG	**Theme 1.**	This document provides **guidance** covering the management of higher activity radioactive wastes (HAW) on nuclear licensed sites. The main aims of the guidance are to: • provide a comprehensive source of information that can be used by nuclear site licensees and the regulators' staff, and referred to by other stakeholders; and • advise licensees on how to obtain regulatory acceptance of their proposals for RWM.	ttps://www.sepa.org.uk/media/594000/joint-guidance-on-management-of-higher-activity-waste-v-21-july-2021.pdf

2.2.11 USA

Year	Title		EURAD roadmap ID	Short description	Web link
	40 CFR Part 191 - Environmental radiation protection standards for management and disposal of spent	NR	**1.2.2**	Subpart A - Environmental Standards for Management and Storage (§§ 191.01 - 191.05)	https://www.law.cornell.edu/cfr/text/40/part-191

	nuclear fuel, high-level and transuranic radioactive wastes			Subpart B - Environmental Standards for Disposal (§§ 191.11 - 191.17) Subpart C - Environmental Standards for Ground-Water Protection (§§ 191.21 - 191.27) SUBPART (§§ -) Appendix A to Part 191 - Table for Subpart B Appendix B to Part 191 - Calculation of Annual Committed Effective Dose Appendix C to Part 191 - Guidance for Implementation of Subpart B	
	10 CFR Part 60 - Disposal of high-level radioactive wastes in geologic repositories	NR	**1.2**	This part prescribes rules governing the licensing (including issuance of a construction authorization) of the U.S. DoE to receive and possess source, special nuclear, and byproduct material at a geologic repository operations area sited, constructed, or operated in accordance with the Nuclear Waste Policy Act of 1982, as amended.	https://www.ecfr.gov/current/title-10/part-60
2008	**Yucca Mountain Repository License Application. DOE/RW-0573, Update No. 1.** **Washington, DC: U.S. Department of Energy, Office of Civilian Radioactive Waste Management**	NTD	**1.2**	Chapter 1, "Repository Safety Before Permanent Closure" Chapter 2, "Repository Safety After Permanent Closure" Chapter 3, "Research and Development Program to Resolve Safety Questions" Chapter 4, "Performance Confirmation Program"	https://www.nrc.gov/waste/hlw-disposal/yucca-lic-app/yucca-lic-app-safety-report.html

				Chapter 5, "Management Systems"	
2012	**Waste Acceptance Product Specifications for Vitrified High-Level Waste Forms. DOE/EM-0093, Rev. 3. Washington, DC: U.S. Department of Energy, Office of Environmental Management.**	NG	**5.1.1**	The Nuclear Waste Policy Act of 1982 mandated that all HLW be sent to a federal geologic repository for permanent disposal. DOE published the Environmental Assessment in 1982 which identified borosilicate glass as the chosen HLW form in 1985 the DoE instituted a Waste Acceptance Process to assure that DWPF glass waste forms would be acceptable to such a repository. This assurance was important since production of waste forms will precede repository construction and licensing. As part of this Waste Acceptance Process, the DOE Office of Civilian RWM formed the Waste Acceptance Committee (WAC). The WAC included representatives from the candidate repository sites, the waste producing sites and DOE. The WAC was responsible for developing the Waste Acceptance Preliminary Specifications which defined the requirements the waste forms must meet to be compatible with the candidate repository geologies.	https://www.osti.gov/biblio/10161671
2013	**Deep Borehole Disposal Research: Demonstration Site Selection Guidelines, Borehole Seals Design, and RD&D Needs,** **SAND2013-9490P, SANDIA**	NG	**1.2.5** **5.1** **Theme 7.**		https://www.energy.gov/ne/downloads/deep-borehole-disposal-research-demonstration-site-selection-guidelines-borehole-seals

2014	**Evaluation of Options for Permanent Geologic Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste in Support of a Comprehensive National Nuclear Fuel Cycle Strategy Volume I** **Prepared for U.S. Department of Energy Used Fuel Disposition Campaign by Sandia National Laboratories**	NTD	**Theme 1.**	This study provides a technical basis for informing policy decisions regarding strategies for the management and permanent disposal of SNF and HLW in the United States requiring geologic isolation. Relevant policy questions this study can help inform include the following: Is a "one-size-fits–all" repository a good strategic option for disposal? Do different waste types and forms perform differently enough in different disposal concepts that they warrant different treatment? Do some disposal concepts perform significantly better with or without specific waste types or forms? The study provides this basis by evaluating potential impacts of waste forms on the feasibility and performance of representative generic concepts for geologic disposal.	https://www.energy.gov/sites/default/files/2014/04/f15/DOE%20DispOptions%20R1%20Volume1%20Apr15.pdf
2014	**Evaluation of Options for Permanent Geologic Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste in Support of a Comprehensive National Nuclear Fuel Cycle Strategy** **Volume II: Appendices** **Prepared for U.S. Department of Energy Used Fuel Disposition Campaign by Sandia National Laboratories**	NTD	**Theme 1.**	Waste Types and Waste Forms: – Spent Nuclear Fuel – High Level Wastes – Waste Categorization by risk – Orphan Wastes TRU Waste and WIPP Disposal Safeguards and Security	https://www.energy.gov/sites/default/files/2014/04/f15/DOEDispOptionsR1Volume2Appendices%20Apr15_0.pdf

2.2.12 Other

year	Title		EURAD roadmap ID	Short description	Web link
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** **Jensen, M.**	NTD	**7.2.2**	In 1990, the working group of the NKS project KAN-1.3 was formed and given the task to establish a basis for a common Nordic view of the need for information conservation for nuclear waste repositories, by investigating what type of information should be conserved. In what form the information should be kept. The quality of the information, as regards both type and form. The problems of future retrieval of information, including retrieval after very long periods of time.	
2003	**RWMC TECHNICAL REPORT Record Management and Long-term Preservation and Retrieval of Information regarding Radioactive Waste** **RWMC-TRE-03002**	NTD	**7.2.2**	RWMC has been aiming at providing information for the government and related bodies to utilize in formulating programs as a component of the institutional control concerning GD. In this study, it is considered “Who, How long, For whom, What kind of records should be preserved. And How?” Furthermore, in order to show the technical possibility of long-term record preservation, we developed the new record preservation method called	http://www.rwmc.or.jp/library/file/RWMC-TRE-03001.pdf

				LASER-GLYPH using sintered silicon carbide thin plates and engraving their surface by the laser marking system.	
2006	**Radioactive waste information: meeting our obligations to future generations with regard to the safety of waste disposal facilities** **INTERN. COUNCIL ON ARCHIVES**	NTD	**7.2.2**	The objective of this safety report is to examine the critical importance of the preservation and transfer of information in ensuring the safety of RW disposal facilities for future generations. The report: – Provide an overview of RWM and the implications these operations have for both record creation and long-term record keeping; – Identify information preservation and transfer issues that are central to the requirement that future generations have access to the knowledge necessary for the ongoing safety of RW disposal facilities; – Identify the core issues surrounding current practice that indicate that these practices are not sufficient to meet long-term requirements; – Propose new strategies that will stimulate further discussion and help the industry adapt its information preservation and transfer practices to meet its long-term obligations.	https://www.ica.org/sites/default/files/ICA_Study-18-Radioactive-waste_EN.pdf

3. ANALYSIS OF THE GUIDANCE LITERATURE

3.1 International regulation documents and guidance

Each country develops its own regulations taking account of guidance published by ICRP and IAEA, but that guidance is advisory, not obligatory. Considering the IAEA Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management the signatories are obliged to meet its requirements for reporting etc.

3.1.1 International Commission on Radiological Protection (ICRP)

The main strength of ICRP is its set up of a unified radioprotection system applicable to all types of exposure situations. However, in the case of radioactive waste disposal, the long timescale to deal with has led ICRP to publish dedicated recommendations (ICRP 81, published in 1999) in order to take such a challenge into account while still using the classical tools of ICRP system of radiological protection.

Since then, ICRP has issued new general recommendations, in 2007 (Publication 103), which formally replaced the previous recommendations of 1991 (Publication 60) on which ICRP 81 was based.

ICRP Publication 122 provides the most recent explanation of how the ICRP system of radiological protection can be applied in the context of the geological disposal of long-lived solid radioactive waste.

3.1.2 Western European Nuclear Regulators' Association (WENRA)

WENRA is an international body made up of the Heads and senior staff members of Nuclear Regulatory Authorities of European countries with nuclear power plants. The main objectives of WENRA is to develop a common approach to nuclear safety, to provide an independent capability to examine nuclear safety and to be a network of chief nuclear safety regulators in Europe exchanging experience and discussing significant safety issues. To accomplish the tasks associated with radioactive waste a working group within the WENRA have been established - Working Group on Waste and Decommissioning (WGWD).

Although the IAEA safety standards establish an essential basis for safety of all nuclear installations covering also radioactive waste disposals, the WENRA safety reference levels incorporate more facility specific requirements.

3.1.3 International Atomic Energy Agency (IAEA)

The IAEA Safety Standards encompasses safety fundamentals, safety requirements and safety guides.

These include geological repositories within their remit. They serve as a global reference for protecting people and the environment and contribute to a harmonised high level of safety worldwide.

IAEA Safety Guides provide recommendations and guidance on how to comply with the safety requirements, indicating an international consensus that it is necessary to take the measures recommended (or equivalent alternative measures). The Safety Guides present international good practices, and increasingly they reflect best practices, to help users striving to achieve high levels of safety.

The IAEA Nuclear Energy Series (NES) documents also offer very useful information – among other subjects – on radioactive waste disposal. NES is structured into four levels:

(1) The Nuclear Energy Basic Principles publication describes the rationale and vision for the peaceful uses of nuclear energy.

(2) Nuclear Energy Series Objectives publications describe what needs to be considered and the specific goals to be achieved in the subject areas at different stages of implementation.

(3) Nuclear Energy Series **Guides and Methodologies** provide high level guidance or methods on how to achieve the objectives related to the various topics and areas involving the peaceful uses of nuclear energy.

(4) Nuclear Energy Series Technical Reports provide additional, more detailed information on activities relating to topics explored in the IAEA NES.

The IAEA facilitates international co-operation through a wide range of projects including, for example, projects relating to geological RW disposal:

- Human Intrusion in the Context of Disposal of Radioactive Waste (HIDRA)
- Demonstration of the Operational and Long-Term Safety of Geological Disposal Facilities for Radioactive Waste (GEOSAF)
- Modelling and Data for Radiological Impact Assessments (MODARIA II)

3.1.4 Current IAEA activities in the context of geological disposal

There are ongoing IAEA activities focusing on the geological disposal of radioactive waste such as Underground Research Facilities Network for Geological Disposal (URF Network) and GEOSAF Part III. These projects are to provide useful information on the subject creating further useful inputs for potential new guidance documents.
The URF Network establishes a community of practice and learning for geological disposal. It provides its members with a platform to assess and share best practices in developing, evaluating and implementing geological disposal solutions for intermediate level waste, high level waste and spent nuclear fuel. Emphasis is placed on the role and use of URFs to support successful disposal program development and implementation.
According to the TOR of GEOSAF Part III. the initial deliverables shall include a compilation of all specific topics and sub-topics in a skeleton document as the basis for the headings. This document will identify provisions and/or references to other sources of information. The document will also contain an Annex compiling the generic topics with their related IAEA references. In parallel to this work a proposal for the final structure of the **guidance document** will be developed, that will rearrange the topics into general themes with commentary. This document will have the structure of a Specific Safety Guide (SSG) document.
Furthermore, identification of relevant references and sources of information related to uncertainties, monitoring and handling of deviations available is to be compiled.

Final deliverable from GEOSAF III aims at **developing guidance** on how safety cases are used and reassessed/updated with respect to the specific topics identified for GEOSAF III.

An IAEA activity is in progress on drafting a Guide to Knowledge Management Strategies and Approaches in Nuclear Organisations.

3.1.5 Organisation for Economic Co-operation and Development Nuclear Energy Agency (OECD/NEA)

Specific areas of competence of the NEA include safety and regulation of nuclear activities, radioactive waste management, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information.
NEA Radioactive Waste Management Committee (RWMC) facilitates and co-ordinates collaboration within member countries on a range of topics, include in support of safe implementation of geological repositories. Its work contributes to advancing scientific knowledge and defining international best practices for safe geological repository implementation.
Initiatives within the NEA that are relevant to geological disposal are as follows:

- The “Salt Club” and “Clay Club”, together with a new “Crystalline Club”, provide fora for collaboration and research relating to the associated host rock types for geological repositories;

- The Integration Group for the Safety Case (IGSC) includes studies of engineered barrier systems, cementitious materials and sorption projects;
- The Expert Group on Operational Safety assesses operational safety issues in the pre-closure phase, along with longer-term monitoring;
- The "Preservation of Records, Knowledge and Memory across generations" (RK&M) initiative develops international guidance on technical, administrative and societal mechanisms to address preservation and transfer of the relevant information on various timescales;
- The Repository Metadata Management project (RepMet) co-ordinates collaboration and guidance pertaining to the management and retention of repository data;
- The Forum on Stakeholder Confidence (FSC) serves as a platform for understanding stakeholder dialogue and discussing methods to develop shared confidence, informed consent and approval of radioactive waste management solutions.

3.1.6 Current NEA activities in the context of geological disposal

3.1.6.1 Crystalline Club

The Crystalline Club continues to conduct an R&D status review on the characterization and safety assessment of crystalline rocks for the disposal of radioactive waste. The group held its first Crystalline Club workshop on Research Methods and Modern Measuring Equipment Used for Site and Rock Characterisation, over three online sessions in March 2021. This expert group issued its annual summary paper in November 2021.

3.1.6.2 Clay Club

The Clay Club Working Group reviewed the status of the CLAYWAT Project, which was started in 2016 to examine the binding state and mobility of water in clay-rich media. The draft project report is to be provided to the Club in the course of 2022. This group also endorsed the modalities to publish an updated version of the Clay Club Catalogue of Characteristics of Argillaceous Rocks, which builds upon the 2005 Catalogue and annexes data of 11 argillaceous formations in six NEA member countries. The report was completed in December 2021.

3.1.6.3 Salt Club

The Salt Club expert group developed the FEP Database and Salt Knowledge Archive, which is available for registration and internal use. Furthermore, the group continued its scientific work on the assessment of actinide geochemistry and on the thermodynamic database to optimise the safety of nuclear waste repositories. The group decided to integrate as new research activity on the lessons learnt from failure events/processes of conventional salt mines.

3.1.6.4 Operational safety

The Expert Group on Operational Safety (EGOS) expert group has developed internal reports on fire risk management and on-site transportation of radioactive waste, and has made progress on an operational hazard database.

3.1.6.5 Information, Data and Knowledge Management

The NEA's RWMC established the Working Party on Information, Data and Knowledge Management (WP-IDKM) to examine the management of information, data and knowledge. Subjects for the working party include safety issues, knowledge management, archiving and preservation of data and information. Through these activities, the WP-IDKM strives to propose standardised approaches for managing information and data of radioactive waste and repositories. The working party also tries to identify solutions to minimise the risk of losing implicit knowledge in the pioneer generation. The working party aims to ensure the adoption of good practices in RWMC member countries, towards the realisation of their final radioactive waste repositories.

NEA Radioactive Waste Management Committee (RWMC) established a new initiative to address a comprehensive scope of information, data and knowledge management issues in the domain of radioactive waste management. Expert Groups were established:

- on a Data and Information Management Strategy for the Safety Case (EGSSC).
- on Knowledge Management for Radioactive Waste Management Programmes and Decommissioning (EGKM)
- on Archiving for Radioactive Waste Management Activities (EGAR)
- on Awareness Preservation after Repository Closure (EGAP)

3.1.6.6 Fostering dialogue between regulators and implementers

Building constructive dialogue between regulators and implementers in the development of disposal solutions for radioactive waste has been a concern of the RWMC since 2016. As the mandate of the Expert Group on Building Constructive Dialogues Between Regulators and Implementers in Developing Disposal Solutions for Radioactive Waste (RIDD) expired at the end of 2020, the group has seen its mandate extended for 2021-2022, following the approval of the RWMC in March 2021. Since then, the Expert Group has conducted a survey to further complete the preliminary results gained from the initial 2018 Survey of RWMC members. A questionnaire was submitted to the RWMC members with the aim of obtaining a unified national answer to enlighten the Expert Group on the national dialogue between the regulator and the implementer. From the collected answers, the RIDD report was drafted and further presented to the RWMC Bureau. The RIDD will continue its work in order to deliver a report providing an overview of the practices established in NEA member countries as well as sharing the lessons learnt in this area.

3.1.7 International Association for Environmentally Safe Disposal of Radioactive Materials (EDRAM)

The EDRAM is a collaborative forum to promote exchange of knowledge, experience and information among senior executives from national agencies worldwide. The forum includes discussion of strategic issues among implementers. Drawing on international expertise, experience and collaboration is of great value and leads to better solutions for the safe implementation of radioactive waste disposal.

Association for Multinational Radioactive Waste Solutions (ERDO)

The objective of ERDO is to carry out the necessary work to address the common challenges of safely disposing of the long-lived radioactive wastes in its Member Countries by the sharing of knowledge, technologies and facilities.

ERDO WG identify and select higher priority topics that can be developed in more detail. The suggestions and guidance are aimed primarily, but not exclusively, at organisations from national radioactive waste programmes with small inventories or early stage disposal programmes.

European Commission and Euratom

Three of the EC's Directorate-Generals (DGs) have significant programmes relating to geological repository programmes: DG for Development and Co-operation, DG for Energy and DG for Research and Development. The EC facilitates and provides funding for research and training under the Euratom programme. Since 1975, a large number of collaborative projects have been initiated. Historic EC project resulted in valuable reports and guides, among others, on geological disposal.

EURATOM Projects (FP 1 to 7) related to RW disposal are listed in Appendix 2.
Two EURATOM projects worth particularly mentioning as they provided valuable technical support on geological repositories for radioactive waste.

3.1.9.1 Implementing Geological Disposal of radioactive waste Technology Platform (IGD-TP)

Through collaboration, IGD-TP aims to help to contribute towards a sound, shared and transparent scientific and technological basis for geological disposal. Activities such as conferences and handbooks have been arranged to transfer knowledge towards less-advanced disposal programme.
The IGD-TP is dedicated to initiating and carrying out European strategic initiatives to facilitate the stepwise implementation of safe, deep geological disposal of spent fuel, high-level waste and other long-lived radioactive waste. It aims to address the remaining scientific, technological and social challenges, and support European waste management programmes.

3.1.9.2 Sustainable network for Independent Technical EXpertise of radioactive waste disposal (SITEX)

The objective of the FP7 program SITEX project was to set up a network capable of harmonizing European approaches to technical expertise in geological repositories for radioactive waste.
SITEX intended to help establishing the conditions required for developing a sustainable network of technical safety experts who have their own skills and analytical tools, independently of the operators, and who are capable of conducting their own research programs in coordination with research activities performed by operators. It is expected that this network will able to provide technical support for regulators within corresponding decision making and licensing processes. Stakeholders involved in these processes could be another target group for expertise independent from the implementer of geological repositories.

3.2 Overview of Existing Technical Guides and Further Development

Technical guidance may be needed to ensure that regulatory expectations are clearly interpreted and communicated by the experts fulfilling an expertise function within or for the regulatory body.

These aspects were covered within the work package WP2.1 of SITEX: “Overview of Existing Technical Guides and Further Development” and presented in this deliverable D2-1. WP2.1 04/2014 is to be situated in a larger context of WP2, which consists in the setting up of the conditions for allowing mutual understanding between the Regulatory Body (RB) and the Waste Management Organisations (WMOs).

The main objective of WP2.1 was to identify areas where development and harmonization of technical guidance is needed in priority and topics for which it is felt that dialogue is needed. The priorities were established by taking into consideration the importance for safety and the IGD-TP vision statement that “by 2025, the first geological disposal facilities for spent fuel, high-level waste, and other long-lived radioactive waste will be operating safely in Europe”.

The scope WP2.1 encompasses all the aspects associated with the safety of geological disposal under development. An overview of existing and available technical guides addressing the main “safety topics” to consider in the development of a geological disposal and submission of safety case.

Common points and differences between the guides are presented and the needs for further development are identified according to the main “safety topics”.

The objective of the other task WP4 EC SITEX was to establish the conditions for developing common technical review methodologies so as to seek for harmonisation of the review methods and make as far as possible the expertise function consistent through the member states. In a first step a framework for the development of harmonised methods for reviewing the safety cases has been established and is developed in this report (ref: Available technical review guidance and further needs, D 4.1, EC SITEX, 2014).

EURAD

The guidance, technical and scientific reports contribute to Knowledge Base and primarily focus on domain and sub-domain levels.

The EURAD roadmap has been developed from the experiences of the more advanced EU programmes that have already been involved in many of the activities described, have made advanced plans for DGR

implementation and have already taken some of the early steps in these plans. Because these programmes have developed over more than 40 years and have adopted different technical and strategic approaches to DGR development, the roadmap has been structured to capture largely generic best practice in its presentation of Themes and programme phasing.

The Roadmap Matrix of Phases vs. Themes > Sub-themes > Domains is used to create a suite of roadmap documentation to codify important knowledge. For each of the seven roadmap themes, a Theme Overview is available. This describes broadly the typical RWM activities and capability that is required to successfully achieve each of the roadmap goals, including how activities and programme capability evolves through different RWM phases.

At the next level down, the roadmap is populated by short context documents called Domain Insights. Each will link existing and available knowledge to generic safety and implementation goals and provide a broad but not detailed overview of each domain relative to knowledge maturity, areas of uncertainty, and signpost to existing resources such as guidance, training and mobility, or more detailed knowledge via networks or documents, including historic EC project reports.

Theme overviews (TO)

Documents that describe broadly the typical RWM activities and capability that is required to successfully achieve each of the roadmap goals, including how activities and programme capability evolve through different RWM phases.

• Typical programme activities in each theme as a function of time (by Phases)

• Capability needed at each phase of implementation (including what is typically developed and maintained by the National Programme and that which can be accessed).

Domain insights (DI)

Context documents that provide direct links for each knowledge domain to safety and implementation goals related to DGR requirements by orientating users to:

- the role of domains (whether object-oriented or methodological-oriented) for safety (provide/ undermine safety in relation to safety-functions) and expectations
- measures to be taken during implementation to ensure that expectations on domains are met
- scientific-technological basis to support feasibility, reliability and maturity of the technologies

The DI content respect three guidelines:

• Focus on contextualising and orientation of the domain

• Give a broad, but not detailed overview

• Sign-posting to available high-level knowledge documents

State-of-Knowledge (SoK)

Experts' view of the most relevant knowledge and associated uncertainties in a specific domain applied in the Level of detail context of a radioactive waste management programme Work Package 12 (Guidance WP) of EURAD has a role to develop guides for the end-users of EURAD and the RWM community. These guides have to be needs driven, meaning, that a wide range of end-users consider the newly developed guides useful for radioactive waste management (RWM) programme implementation. The guides are self-standing documents but integrated in the EURAD roadmap. To this end the Guidance WP has initiated a preliminary screening process to have a first list of prioritized topics for guidance documents. The aim was to select a first topic for a pilot guide, for which a simplified selection process was applied in comparison to the future selection process outlined in this deliverable. In the development of the pilot guide the earlier delivered quality management procedure (Deliverable 12.2) will be tested.

5. The most relevant guides and guide-like docs on geological disposal arranged by EURAD roadmap WBS are listed in Appendix 1. CONCLUSION

There are numerous guidance and guidance-like documents on geological disposal of SNF, HLW and long-lived waste available that cover all of the EURAD Roadmap themes, to varying extents.

The table below summarizes the result of the literature screening.

	Theme 1	Theme 2	Theme 3	Theme 4	Theme 5	Theme 6	Theme 7	TOTAL
IAEA guides	**11**	**-**	**-**	**-**	**1**	**1**	**3**	**16**
IAEA guide-like documents	**18**	**1**	**1**	**-**	**8**	**3**	**19**	**50**
OECD/NEA guide-like documents	**19**	**1**	**3**	**1**	**1**	**-**	**31**	**56**
Other int. guide	**3**	**-**	**-**	**-**	**-**	**-**	**2**	**5**
National guides	**17**	**-**	**3**	**2**	**6**	**2**	**9**	**39**
National guide-like documents	**34**	**-**	**3**	**-**	**2**	**4**	**28**	**71**
TOTAL	**102**	**2**	**10**	**3**	**18**	**10**	**92**	**237**

It can be concluded that Theme 1 (National programme management) and Theme 7 (Safety case) are much more covered by guidance and other instruction type documents then the other themes.

It was noted that the level of detail with which some topics are covered may be too low and that further development of these topics may be warranted. Furthermore, the information on some topics is currently scattered over a number of documents.

In general, most of the existing guidance need to be revised and – if needed – supplement from time to time in the light of progressed legislative change or other developments.

In one of the theme overviews (ref: 1. Programme management; theme overview Implementing a National RWM Programme leading to Geological Disposal) a general conclusion was drawn:

“At present, there is no shortage of advice, experience or management expertise at a European level, although newer radioactive waste management programmes are likely to find gaps at a national level as they improve and integrate their pre-disposal activities and begin to implement disposal solutions. Mechanisms for such programmes to make best use of the available knowledge do, however, need to be developed or improved quite urgently.”

A previous study (ref: SITEX Available technical review guidance and further needs) concluded that:

"A list of minimum competences needed could be described in a guide. Even if there is no difference of view between the organisations on the required qualities of experts, these qualities could be better detailed in international guidance, as well as the way to ensure it. Harmonisation could be useful, as well as a European (or larger) experts' network for performing training and tutoring.

Based on the current literature survey it can be concluded that although the available technical documents and guidance are abundant, early-stage programmes or small inventory programmes could face a challenge of information overload and deciphering which sources of information are most accurate and most recent. If one supplements with 'examples' then there are hundreds of documents that could be added to every EURAD Roadmap category. Thus, the guidelines should aim at providing concise references to orient the reader.

One of the key challenges for the early-stage disposal programmes is planning and implementing their site investigation programme. To provide information on the State-of-the-Art regarding the various data acquisition technologies and interpretation techniques that are potentially available to support site investigations, including detailed information about the constraints and added benefits associated with particular methods is crucial. Such a compilation in the context of radioactive waste disposal does not currently exist in the international literature. This gap, however, hopefully will cease soon when the IAEA publish the guidance, currently in the form of an advanced draft.

With the aim of drafting a set of new guidance documents, on the basis of the literature screening and other previous analyses for selection of guidance, a short list of topic proposals will be prepared. The list is to be evaluated against pre-defined selection criteria based on the expert judgement of the WP12 team in a qualitative and semi-quantitative way.

How a selection of future guidance topics might proceed is discussed in WP12 Deliverable D12.5.

It is recognised that collection of end-user feedback on topic selection will be given high priority. The short list will be sent to the end-user-group for comment and to request them to prioritise and select topics.

Further guidance can be developed using material that can be found in existing publications as a starting point.

In order to achieve acceptance within the EURAD community, the selected theme and the ranking of the selected topics for the further guidance will be proposed by the WP to the PMO (and validated by Bureau/General Assembly).

The result of the guidance selection process will be summarized in the WP12 Deliverable D12.5 titled "Selecting of topics for further guidance documents on geological disposal of radioactive waste".

Appendix 1. The most relevant guides and guide-like docs on geological disposal grouped based on the EURAD Roadmap themes

	Guides or guide-like docs
THEME 1. NATIONAL PROGRAMME MGT.	– Establishing the Infrastructure for Radiation Safety, IAEA, SSG-44, 2018 – Technical Guide "Geological Disposal", FANC, Belgium – Regulatory guidance for the geologic disposal of radioactive waste: « A minima requirements on argillaceous sedimentary formations », AVN report N°KOLIBRI-29152- v1, AVN-GEO-ARG, Canada, 2005 – General principles for the management of radioactive waste and irradiated fuel, CSA Group. CSA N292.0-14, Canada, 2014 – Group. CSA N292.6, Long-Term Management of Radioactive Waste and Irradiated Fuel CSA, Canada, 2018 – Safety Guide on Radioactive Waste Disposal in a Deep Geological Formation, « Guide de sûreté relative au stockage définitif des déchets radioactifs en formation géologique profonde », ASN guide N°1, RFSIII-2-fv1-2, France, 2008 – National Regulation documents and Guides, DE_BMU-2010, Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste, Germany, 2010 – EURAD Roadmap THEME 1 Overview, Programme Management, 2021
1.1. Programme Planning	– Use of External Experts by the Regulatory body, IAEA, GSG-4, 2013
1.1.1 National RWM policy	– Policies and Strategies for Radioactive Waste Management, IAEA, No. NW-G-1.1, 2009 – National Inventories and Management Strategies for Spent Nuclear Fuel and Radioactive Waste, Methodology for Common Presentation of Data, OECD NEA No. 7323, 2016 – National Inventories and Management Strategies for Spent Nuclear Fuel and Radioactive Waste, Final Methodology, OECD 2020, NEA No. 7424

	– Options for Management of Spent Fuel and Radioactive Waste for Countries Developing New Nuclear Power Programmes, IAEA, No. NW-T-1-24 (Rev. 1), 2018
1.1.2 Timetable for decision making	– Stepwise Approach to Decision Making for Long-term Radioactive Waste Management: Experience, Issues and Guiding Principles, OECD 2004, NEA No. 4429 – Options for Management of Spent Fuel and Radioactive Waste for Countries Developing New Nuclear Power Programmes, IAEA Nuclear Energy Series, 2013
1.1.3 Public information and participation	– Guidance for NRO, Principles for Openness and Transparency, ENSREG, 2013 – Guidance on Openness and Transparency for European Nuclear Safety Regulators, ENSREG, 2018 – The Forum on Stakeholder Confidence Report on Dialogue in the Long-Term Management of Radioactive Waste, NEA/RWM/R(2020)1, OECD NEA, 2021 – Communication and Consultation with Interested Parties by the Regulatory Body, General Safety Guides, IAEA, No. GSG-6, 2017 – Stakeholder engagement in nuclear programmes, IAEA, No. NG-G-5.1, 2021 – Communication and stakeholder Involvement in radioactive Waste disposal, IAEA, No. NW-T-1.16, 2022 – Public and Aboriginal Engagement, Public Information and Disclosure, REGDOC-3.2.1, CNSC, Canada, 2018 – REGDOC-3.2.1, Public Information and Disclosure, CNSC, Canada, 2018 – Guidance: Geological disposal of radioactive waste: a guide for communities, UK, 2013
***1.1.4** Development and optimization of the plan*	– Optimization of GD of Radioactive Waste, National and International Guidance and Questions for Further Discussion, 2010
1.2. Programme Organisation	– Functions and processes of the regulatory body for safety, IAEA, GSG-13, 2018 – Organization, Management and Staffing of the Regulatory Body for Safety, IAEA, GSG-12, 2018 – Leadership, Management and Culture for Safety in Radioactive Waste Management, IAEA, No. GSG-16, 2022 – Guidance: Regulating the geological disposal of radioactive waste: environmental protection, UK, 2018

1.2.1 Licensing framework	– Documentation relating to the regulatory process, IAEA, GS-G-1.4, 2002 – Licensing Process for Nuclear Installations, IAEA, SSG-12, 2010 – Regulation and Guidance for the Geological Disposal of Radioactive Waste, A Review of the Literature and Initiatives of the Past Decade, OECD NEA N°6405, 2010 – REGDOC-3.5.1, Licensing Process for Class I Nuclear Facilities and Uranium Mines and Mills, CNSC, Canada, 2017 – License Application Guide: Class II Nuclear Facilities and Prescribed Equipment, REGDOC-1.4.1, CNSC, Canada, 2021 – Geological Disposal Facilities on Land for Solid Radioactive Wastes: Guidance on Requirements for Authorisation, ENVIRONMENT AGENCY and NIEA, UK, 2009
1.2.2 Licensing criteria	– REGDOC-3.5.1, Licensing Process for Class I Nuclear Facilities and Uranium Mines and Mills, CNSC, Canada, 2017 – License Application Guide: Class II Nuclear Facilities and Prescribed Equipment, REGDOC-1.4.1, CNSC, Canada, 2021 – Geological Disposal Facilities on Land for Solid Radioactive Wastes: Guidance on Requirements for Authorisation, ENVIRONMENT AGENCY and NIEA, UK, 2009
1.2.3 Allocate responsibilities	– Geological Disposal Facilities on Land for Solid Radioactive Wastes: Guidance on Requirements for Authorisation, ENVIRONMENT AGENCY and NIEA, UK, 2009
1.2.4 Waste Management System	– Application of the Management System for Facilities and Activities, IAEA, GS-G-3.1, 2006 – Management System for Disposal of Radioactive Waste, IAEA, GS-G-3.4, 2008 – Knowledge loss risk management in nuclear organizations, No. NG-T-6.11, 2017 – REGDOC 2.1.1, Management System, CNSC, Canada, 2019
1.*2.5 RD&D Strategy*	– Research and development basis for the safety of geological repositories (draft report), 2011 – R&D Programme overview: Research and development needs in the preparatory studies phase 2012 Revision (with Changes), NDA/RWMD/073 Version 2, UK, 2012
1.3. Programme Resources	– Functions and Processes of the regulatory Body for Safety, IAEA, No. GSG-13, 2018
1.3.1 Financing Schemes	– Nuclear Energy Series: No. NW-T-1.25. Costing Methods and Funding Schemes for Radioactive Waste Disposal Programmes – EURAD pilot guide: Guidance on Cost Assessment and Financing Schemes of Radioactive Waste Management Programmes, 2021

1.3.2 Skills and Competence Management	– Organization, Management and Staffing of the Regulatory Body for Safety, IAEA, GSG-12, 2018 – Use of External Experts by the Regulatory body, IAEA, GSG-4, 2013
1.4. National inventory *1.4.1 National RW inventory*	– Options for Management of Spent Fuel and Radioactive Waste for Countries Developing New Nuclear Power Programmes, IAEA, No. NW-T-1-24 (Rev. 1), 2018 – National Inventories and Management Strategies for Spent Nuclear Fuel and Radioactive Waste, Methodology for Common Presentation of Data, NEA No. 7323, 2016 – National Inventories and Management Strategies for Spent Nuclear Fuel and Radioactive Waste, Extended Methodology for the Common Presentation of Data, NEA No. 7371, 2017 – National Inventories and Management Strategies for Spent Nuclear Fuel and Radioactive Waste, Final Methodology NEA No. 7424, 2020
1.5. Management Solutions	
1.5.1 Integrated waste management routes and strategic options	– Developing Multinational Radioactive Waste Repositories: Infrastructural Framework and Scenarios of Cooperation, IAEA-TECDOC-1413, IAEA, Vienna 2004 – Framework and Challenges for Initiating Multinational Cooperation for the Development of Radioactive Waste Repositories, IAEA Nuclear Energy Series report, 2016 – Options for Management of Spent Fuel and Radioactive Waste for Countries Developing New Nuclear Power Programs, IAEA Nuclear Energy Series NW-T-1.24, 2013 – Viability of Sharing Facilities for the Disposal of Spent Fuel and Nuclear Waste, IAEA-TECDOC-1658, IAEA, Vienna, 2011
1.5.2 Options and concept selection	– Options for Management of Spent Fuel and Radioactive Waste for Countries Developing New Nuclear Power Programmes, IAEA, No. NW-T-1-24 (Rev. 1), 2018
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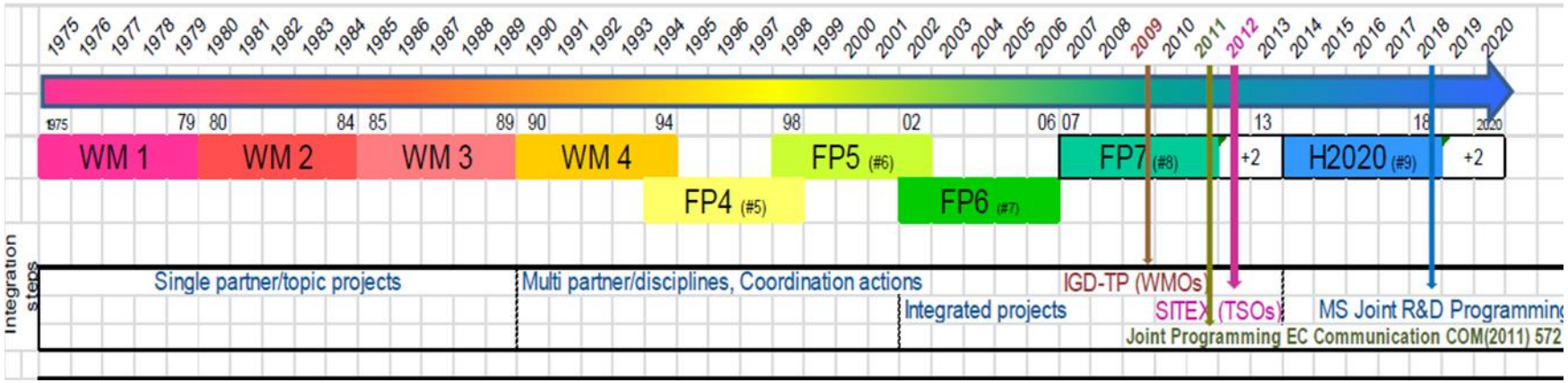
Appendix 2. EURATOM projects on radioactive waste disposal



Project acronym	
	FP1
	The HAW project: demonstration facility for high-level radioactive waste disposal in the Asse salt mine https://cordis.europa.eu/project/rcn/14040_en.html The main aims of the research were: the determination of the temperature, stress and time ranges over which a steady state creep law could be reliably applied; the determination of the steady state creep parameters of the rock salt in the Asse mine and the variation of these creep parameters in space.
	Comparison of waste management aspects of direct disposal of spent fuel and reprocessing

	https://cordis.europa.eu/project/rcn/13981_en.html The overall aim of the whole joint project is to compare, on the basis of the costs and radiological impact of the management and disposal of all the associated wastes, reprocessing of PWR fuel with its direct disposal by emplacement in a deep geological formation on land. For the reprocessing case, the wastes to be considered include gaseous and liquid effluents discharged routinely during reprocessing, solid low and intermediate level wastes arising at the reprocessing plant, and vitrified high level waste. The latter will also be assumed to be disposed of by emplacement in a deep geological formation. The study will include an analysis of the sensitivity of the results to variations in key assumptions, such as the time for which spent fuel is stored prior to reprocessing**.**
	Application of EC-test procedure: repository system simulation test https://cordis.europa.eu/project/rcn/13986_en.html The EC test procedure provides: - a test method which may be used by various laboratories interested in evaluating waste form performance in different host rock materials, including granite, clay and salt; - a versatile test apparatus which may be used in a flow test or as a closed system under extremely different experimental conditions including pressures up to several hundred bars, temperatures up to 200 C degrees, corrosive solutions, etc... And where the waste form can be tested in the presence of one or several additional materials, e g canister, backfill, overpack and host rock materials; - experimental evidence for the appropriate functioning and operation experience with the test apparatus prior to its inclusion in this document; - specified experimental conditions in the document which may be used as a reference in a round robin type interlaboratory test.
	Study of the coupled thermo-hydro-mechanical effects on a HLW repository in a granite geological formation https://cordis.europa.eu/project/rcn/13967_en.html For the evaluation of the performance of radioactive waste geological storage, the description of hydraulic, thermal, chemical and mechanical phenomena is necessary in the near field and in the far field. The difficulty of this description rests, on one hand in the definition of behaviour laws in accordance with time and space that we consider, on the other hand in the connecting of phenomena. The studies already achieved on this subject in the different countries are concerned with either thermo-mechanical effects or thermo-hydraulic effects. The main purpose of this study is to consider together the thermo-hydro-mechanical effects due to a HLW repository in a granite site. In order to do so two models available now are coupled: CASTEM (thermo-mechanical model) and TRIO (thermo-hydraulic and migration model). Studies of radionuclides migration in the granite rock are conducted with the coupled model and the hydraulic model in order to evaluate the influence of the different phenomena.
	Corrosion of carbon steel overpacks for the geological disposal of radioactive waste

	https://cordis.europa.eu/project/rcn/11781_en.html The main objectives have been to complete the assessment of the long term corrosion of carbon steel overpacks in granite or clay-like formations and to finalise the mathematical model for localised corrosion. The validity of the previously developed general corrosion model and the improved localised corrosion model will be tested by the results from the experimental programme. The overall programme will yield generic models for general and localised corrosion which may be applied to evaluate overpack life, or the metal thickness needed to achieve a specific life, in granite or argillaceous disposal sites.
	Application of EC-test procedure: repository system simulation test. https://cordis.europa.eu/project/rcn/13989_en.html A test method which may be used by various laboratories in evaluating waste form performance in different host rock materials, including granite, clay and salt; - a versatile test apparatus which may be used in a flow test or as closed system under extremely different experimental conditions including pressures up to several hundred bars, temperatures up to 200 C degrees, corrosive solutions, etc... And where the waste form can be tested in the presence of one or several additional materials, e.g. canister, backfill, overpack and host rock materials; - experimental evidence for the appropriate functioning and operation experience with the test apparatus prior to its inclusion in this document;
	A thermo-mechanical behaviour of boom clay. https://cordis.europa.eu/project/rcn/13969_en.html The understanding of thermal effects due to decay heat like pore pressure rise, change in mechanical properties and in the hydraulic field under high lithostatic pressures is fundamental in the evaluation of safety and in the design of nuclear waste repositories in clay. For this purpose, a thermo-hydro-mechanical model has been developed in ISMES. Its suitability in reproducing the thermo-mechanical response of the samples tested under different loading conditions has been tri-axial cell operating in ISMES laboratories on various types of stiff clays, either remoulded and undisturbed. Furthermore, the interpretation procedures of thermal tests showed that for some of the clay tested the Campanella and Mitchell procedure can lead to inconsistent results.
	Study of the migration of U, Thu, and REE in a intragranitic uranium deposit https://cordis.europa.eu/project/rcn/13968_en.html **T**he intra-granitic uranium deposit of the Jalerys (granite de Grury-Morvan-France) is considered in this study as a natural analogue of a high level radioactive waste repository realized in a similar geological formation. The physico-chemical processes of transport for some trace elements of interest are being investigated mainly in the near field.
	In-situ study of radionuclide diffusion in clays by means of the autolab probe.

	https://cordis.europa.eu/project/rcn/13972_en.html The storage of nuclear wastes in a deep geological formation calls for that a dependable knowledge of the site safety is gained. Significant data on the radionuclide diffusion throughout argillaceous materials should be acquired by in-situ observations and measurements in a drill-hole, provided that the conditions of the receptor environment are safeguarded.
	FAR - field modelling of radionuclide migration https://cordis.europa.eu/project/rcn/14008_en.html The project aims to improve the capability, efficiency and realism of the NAMMU code, which simulates groundwater flow and solute transport through a porous medium. The detailed objectives are to discover and exploit superior methods for solving significantly non-linear problems; to introduce into the code a capability for modelling chemical reactions; to identify and test improved techniques for simulating the progress of sharp fronts in solute concentration; and to identify better-founded representations of solute dispersion. The last two topics will be covered by sub-contracts placed at universities in the UK.
	Simulation of radionuclide exchange between aqueous and mineral organic phases. https://cordis.europa.eu/project/rcn/11715_en.html The goals of the project: - measurements of humic acids molecular weight by means of ultracentrifugation and liquid chromatography (inter-calibration exercise); - fractionation and isolation of humic and fulvic species; - measurements of the competition between the different species in the sorption of ^{156}Eu, ^{99}Tc, ^{241}Am, ^{238}Pu by means of a specially-built dialysis display.
	EC repository systems simulation test-round robin test/granite system https://cordis.europa.eu/project/rcn/13991_en.html The repository system simulation test (RSST) has been laid out to accommodate a wide range of experimental conditions and materials in a multi-purpose leaching container. Among the possible options are: active tests, temperatures up to 200 C, choice of static or dynamic tests. In order to verify, that the test procedure is workable and that representative and reproducible results can be obtained, the commission will organize an inter-laboratory test campaign (round robin) for a single set of conditions, but with a choice of 3 geologic host materials: salt, clay and granite. The RSST determines concentrations of matrix constituents and radionuclides released from nuclear waste forms under simulated geological repository conditions. The results should provide the information to establish and validate near-field models for risks analysis.
	Natural analogues of radionuclide migration in granitic rocks through the study of palaeo-hydrothermal alteration

	https://cordis.europa.eu/project/rcn/14009_en.html
FP2 Projects	
	Study of a communication strategy aimed at achieving a possible better understanding of the consequence of radioactive waste management in a well defined group of public https://cordis.europa.eu/project/rcn/3108_en.htm
	Study concerning the evaluation of toxic elements present in nuclear wastes https://cordis.europa.eu/project/rcn/3019_en.html The aim of the study is to make an evaluation of those chemical elements and of their quantity in the different waste streams. This involves the selection of toxic elements, in particular heavy metals, in function of the actual local, national and European legal context, and an evaluation of the presence of these toxic elements in the nuclear wastes. The different waste streams will be identified systematically (per producer and per category), making a segregation between them based on the production process (operational, technological, dismantling, packaging, conditioning, etc.). The chemical properties of the identified waste streams will be included in a general databank covering the identification and quantification, the physico-chemical properties, and the radiological characterization of the nuclear wastes. This involved defining both the toxic limits acceptable for the admission of waste on a shallow land burial, referring to the operational criteria for conventional landfilling of industrial waste, and the evaluation methods or measurements needed to identify and quantify the toxic elements in nuclear waste.
	Inventory and Characterization of Important Radionuclides for Safety of Storage and Disposal. Correlation with Key Nuclides that are Easy to Measure in Typical Waste Streams https://cordis.europa.eu/project/rcn/3106_en.ht ml This programme has three main objectives: - checking and standardisation of operational analytical methods for application to real samples of the main waste streams, - developing some alternative analytical methods for long-lived radionuclides, - computing correlation factors for critical radionuclides to easily measurable key nuclides, through the analysis of the main waste streams of the contractors. This contribution to the characterization of the radionuclide inventory of isotopes of critical importance to the safety of storage and disposal comprises a study of the main radioactive waste streams produced in each of the participating countries.

DEBORA	Development of Borehole Seals for High-Level Radioactive Waste https://cordis.europa.eu/project/rcn/3020_en.html The objective of the DEBORA-project is the "Development of Borehole Seals for High-Level Radioactive Waste". The DEBORA-project consists of two phases. During the first phase (1991-1994) a test plan for a subsequent in situ verification test will be developed in form of a desk study. This study will include an evaluation of literature, a performance of model calculations, and discussions of experts to identify the requirements for and the tasks of HAW-borehole seals under normal repository conditions. Altered repository conditions will be considered at a later stage of the project.
BACCHUS	Demonstration of the In-situ Application of an Industrial Clay-Based Backfill. (BACkfilling Control Experiment for High level wastes in Underground Storage) https://cordis.europa.eu/project/rcn/4511_en.html The BACCHUS 2 project includes the characterisation of the granular backfill and the retrieval and the expertise of the BACCHUS 1 test mock up. Compacted expansive clays are proposed as engineered barriers in reference concepts for the disposal of heat-emitting nuclear waste in granite and clay. The backfill material of the BACCHUS 2 test consists of a mixture of high density pellets and powder. This granular backfill material was characterized. The hydraulic conductivity and swelling pressure was measured as a function of the dry density. X-ray tomography has been applied successfully to measure the evolution of the density distribution during hydration.
	Performance Assessment of the Geological Disposal of Spent Fuel in a clay layer https://cordis.europa.eu/project/rcn/3090_en.html The main objective of the study is the evaluation of the radiological consequences of the geological disposal of spent fuel in a hypothetical repository located in the Boom clay layer at the Mol site. Hitherto the performance assessments of geological disposal in clay layers considered essentially waste forms resulting from the reprocessing of the spent fuels. The low price of fresh uranium and the use of mixed oxides (MOX) fuel mean that the direct disposal of spent fuel is becoming a realistic option for the nuclear fuel cycle.
	Aqueous Corrosion of Nuclear Glasses: Influence of Disposal Conditions https://cordis.europa.eu/project/rcn/3091_en.html Three major avenues of research are investigated in a programme combining an experimental approach and modelling of relational processes to characterize and quantify the potential reaction mechanisms of glass matrix corrosion and the degree of radionuclide containment: < basic research on aqueous corrosion of nuclear glass; > the effect of the host rock on R7T7 glass alteration; and finally the development of models describing glass behaviour in repository conditions. Geological disposal of vitrified HLW packages will expose the containment glass to multiple complex chemical reactions (involving the host rock, the engineered barrier materials and the nuclear glass) due to the presence of the water vector in the repository environment. The presence of environmental or local site

	materials affects (increases or decreases) the glass matrix corrosion rates and the degree of radionuclide containment. It is therefore essential to characterize and quantify the potential reaction mechanisms in a geological disposal complex. The investigation begins at laboratory scale; the experimental approach also allows the development of a nuclear glass dissolution model applicable to actual repository conditions.
	Corrosion of Selected Packaging Materials for Disposal of Heat Generating Radioactive Waste https://cordis.europa.eu/project/rcn/3119_en.html The programme has two main objectives: - Investigation of the influence of essential parameters on the corrosion behaviour of the materials in disposal relevant salt brines. These parameters are: temperature, gamma radiation and selected characteristics of packaging manufacturing (KfK). - Investigation of the resistance of carbon steels to stress corrosion cracking in an MgCl2-rich brine at various temperatures and strain rates by means of the slow strain rate technique (ENRESA).
	The evolution and implementation of a public information strategy on radioactive waste management … https://cordis.europa.eu/project/rcn/3646_en.html The programme to be developed should aim in: - providing a firm basis for the evolution of Community policy on the public information aspects of radioactive waste disposal, - enabling the communications lessons learned by individual Member Country authorities to be shared across the Community, - providing a resource base of independent and authoritative communications materials to be used in the communications programmes of Member countries.
	OKLO Natural Analogue for Transport Processes in a Geological Repository https://cordis.europa.eu/project/rcn/3787_en.html This programme involves several different tasks: 1. In situ sampling, in close collaboration with the mining company (C.O.M.U.F. COmpagnie des Mines d'Uranium de Franceville, Mounana, Gabon). To this part of the programme can be added the collecting of new data on the general setting of the Oklo mining area and deposits. 2. Study and characterization of the source term. 3 Studies on the geochemical systems ruling the migrations can in turn be divided into studies on the ancient migrations, contemporaneous to the rock diagenesis, to the nuclear reactions and to the general geological history of the basin, and on the recent to present migrations.

	3. A The studies of the ancient migrations will encompass several subjects: the petrography and elemental chemistry of the deposits. the retention properties of the clays towards radionuclides; the thermal history of the deposits in and around the reactor zones; reconstructing the chemical characteristics of the hydrothermal fluids which left their chemical imprint in tracer mineral when they were circulated through the deposits. 3.B The study of the recent migrations will encompass the two following subjects: the understanding of the hydrogeological conditions. 4. Modelling: 1st stage models and final integrated models.
	Organic matter and uraninite from the Oklo natural fission reactors - Natural analogous of radioactive waste-containing bitumen and UO2 irradiated fuel https://cordis.europa.eu/project/rcn/3089_en.html This programme is specially aimed at investigating the relationship between radiation effects, due to various particles emitted by alpha decay of uranium and during fission reactions, and changes in the structure of organic matter (OM) with which it is in contact. In the Oklo s.l. U-ore, it is intended to characterize the different types of (U + OM) phases, ranging from "invisible" U-rich OM to millimetric uraninites inclusions within the OM, in order to estimate the specific consequences of radiation damages.
	The Corrosion of Nuclear Waste Glasses in a Clay Environment: Mechanisms and Modelling https://cordis.europa.eu/project/rcn/3094_en.html The objective of the present project is to enlarge the already existing database on the performance of various simulated HLW-glasses in one of the reference repository environments, the Boom clay, with the aim to elucidate corrosion mechanisms in clay media and to propose a source term for the radionuclide release into the near field by the use of corrosion accelerating conditions (accelerated tests) and more complex media (integrated tests) and to model the long term interaction between glass and clay environment, which is the final goal of the project. This programme studies the performance of various simulated high level radioactive waste (HLW) glasses in one of the reference repository environments, the Belgian Boom clay, with the aim to elucidate corrosion mechanisms in clay media and to propose a source term for the radionuclide release into the nearfield. The objective of the present project is to enlarge the already existing database by the use of corrosion accelerating conditions (accelerated tests) and more complex media (integrated tests) and to model the long term interaction between glass and clay environment, which is the final goal of the project. In the accelerated tests, surface area to solution volume and temperature are used as the corrosion accelerating parameters. To obtain a high surface area to solution volume the glass is powdered. In the integrated tests glass corrosion is studied in the presence of canister and overpack corrosion products and backfill.
DECOVALEX	Development of coupled models and their validation against experiments in nuclear waste isolation: Modelling of THM Behaviour for Granitic Rocks

	https://cordis.europa.eu/project/rcn/4415_en.html DECOVALEX is dealing with the study of coupled hydro-thermo-mechanical modelling processes in fractured rock and associated computer codes. A computer program has been designed to simulate the processes in a large rock mass with a repository located at depth of about 500 m. The model is two dimensional, measures 3000 m x 1000 m and contains two sets of intersecting fractures. Three fracture spacings are defined or 25 m, 50 m, 100 m. A non-uniform hydraulic head acts at the ground surface and zero flux is imposed on the bottom and lateral boundaries. The heat flux from the repository is assumed to decay exponentially with time.
	Study of the Coupling Between "Fractured Medium" and "Porous Medium" Flow Models https://cordis.europa.eu/project/rcn/3638_en.html The objective of the present study is to investigate the use of the coupled model from a methodological point of view. Modelling of fractured medium in the framework of the safety analysis of a deep geological disposal for radioactive waste generally relies on two families of models: - the Equivalent Porous Medium model relies on the assumption that properties of the fracture's medium (hydraulic conductivities, porosity, ...) can be averaged in a meaningful manner on rock volumes which can be regarded as small on the regional scale of interest; - the Discrete Fracture Model seeks to represent each fracture of the medium, or at least a statistically equivalent set of fractures, and to describe more accurately the flow in the fractures.
	Radionuclide Transport through the Geosphere into the Biosphere. Review Study of the Project MIRAGE https://cordis.europa.eu/project/rcn/23964_en.html The objectives of this review study was to come to a critical evaluation of the state-of-the-art in the different research areas of the EC coordinated project MIRAGE (MIgration of RAdionuclides through the GEosphere) which was launched by the Commission in 1983. The study focused on the research work covered under the umbrella MIRAGE such as geochemical behaviour of radionuclides in natural aquifer systems including colloids and organic materials, natural migration systems including Natural Analogue Studies, modelling of radionuclide migration including model verification and validation and finally migration and retardation experiments performed by laboratory and in-situ tests.
	The Performance of Cementitious Barriers in Repositories https://cordis.europa.eu/project/rcn/3084_en.html The mechanisms of crack healing within cementitious materials under repository conditions are being investigated. The critical characteristics of cement type, groundwater chemistry, crack geometry and hydraulic head which lead to healing will be identified. The material involved in the closure of cracks will be characterized. An existing model of the crack healing process by carbonate precipitation will be notified. Similar models for crack healing by the precipitation of silicate minerals will be developed. A modified version of a repository source term model which takes account of the development of inhomogeneities will be supplied.

	In-situ research on compaction of and gas release in saliferous backfill (TSS experiment) https://cordis.europa.eu/project/rcn/22612_en.html The main objectives of the test are the study of the thermomechanical interactions of the heated casks, backfill and surrounding rock salt for the validation of thermal and thermomechanical computer models as well as the investigation of moisture and gas release due to heating and corrosion processes.
	Inventory and characterisation of important radionuclides in reactor and reprocessing waste https://cordis.europa.eu/project/rcn/4455_en.html No info
	The effect of Microbial Activity on the Near and Far Fields of a Deep Repository https://cordis.europa.eu/project/rcn/27217_en.html The objective of the present work is to determine the global effect of microbial presence on the mobility of radionuclides supposedly immobilized in the near field (clay or cement). Micro-organisms can produce organic or mineral acids that can promote corrosion and complexing agents that can modify the characteristics of the repository. So, radionuclides that have been immobilized by cement or bitumen embedding matrix can be leached either as soluble ions or soluble complexes (effects of the corrosion of the matrix). This leads to an increase of their mobility. On the other hand, micro-organisms can decrease the mobility of initially soluble species by sorption on the cell membrane or on polymers (especially polysaccharides) produced by cells, and also by bioaccumulation in the cell.
	Effect of Humic Substances on the Migration of Radionuclides: Complexation of Actinides with Humic Substances in Natural Aquatic Systems https://cordis.europa.eu/project/rcn/3640_en.html The aim of the present research programme is to study the complexation behaviour of actinide ions with humic substances in natural aquifer systems and hence to quantify the commonly found in all groundwaters in different concentrations have a strong tendency towards complexation with actinide ions. This in one of the major geochemical reactions but hitherto least quantified. Therefore, the effect of humic substances on the actinide migration is poorly understood. In the present research programme the complexation of actinide ions with humic substances will be described thermodynamically. This description will be based on a model being as simple as possible to allow an easy introduction of the resulting reaction constants into geochemical modelling of the actinide migration.
EURATOM FP 3 Projects	

EURATOM FP 4 Projects	
	Understanding & improvement of ultra high performance cementitious materials resistance to long term water aggression https://cordis.europa.eu/project/rcn/38989_en.html The main deliverables of the project are: to measure and understand microstructural and transfer properties of 7 HPC/UHPC mixes before and after long-term; degradation by water leaching (representative of natural conditions), to understand thermodynamical and kinetical processes at stake in the course of the long term water aggression and to trace back their origin into the mix design, to perform numerical simulation of degradation and lifetime modelling of the HPC/UHPC mixes, to provide data for the introduction of HPC/UHPC into codes, to lay ground for perennial HPC/UHPC industrial solutions in the field of industrial or nuclear waste management.
SUSRAD	Highly versatile but sustainable processes for the removal of radionuclides from radioactive waste https://cordis.europa.eu/project/rcn/46371_en.html
	EURATOM FP 5 Projects
SFS	Spent fuel stability under repository conditions https://cordis.europa.eu/project/rcn/58448_en.html This project aims to develop and validate a reliable and robust model to predict the radionuclides (RN) release rate as a function of time for the spent nuclear fuel (RN source term), which can thereafter be used in the performance assessment exercises for repository systems.
FEBEX II	Full-scale engineered barriers experiment in crystalline host rock phase II https://cordis.europa.eu/project/rcn/58656_en.html FEBEX II consists in the extension of the operational phase of the FEBEX (I) in-situ test until the year 2001, prior to proceeding to its dismantling. It is also planned the extension, until quite-saturation, of the heating phase of the mock-up test; design and construction of a geochemical mock-up, and some complementary laboratory tests, as well as modelling works. The good performance of the whole system, justifies the prolongation of the FEBEX tests two additional years in the case of the in situ and for as long as needed to get close to saturation in the case of the mock-up, while the heating and monitoring systems remain operative. It is planned dismantle only one of the heaters of the in situ test during FEBEXII, leaving the second to continue the heating and buffer saturation.
CROP	For technical/economical optimisation of concepts of future European repositories for rad waste it would be of great help if assessment is made of the experience from the various large-scale underground laboratories for testing techniques and which specifically aims at comparing methods and data obtained from the laboratories for evaluating present concepts and developing improved ones. Several of these underground projects, which deal with disposal in crystalline rock, salt and clay formations, have been supported by the EC.

	The proposal implies constitution of a forum -a cluster- for the intended evaluation and assessment, focusing on construction, instrumentation and correlation of theoretical models with field data, especially concerning EBS.
NET.EXCEL	Network of excellence in nuclear waste management and disposal https://cordis.europa.eu/project/rcn/65039_en.html A future efficient use of European resources in research and development of safe methods for final disposal of high-level radioactive waste calls for close interaction between European end users in planning of national programmes as well as in development of international projects. The proposal concerns the forming of a network of end users for the intended analysis of present status and future requirements in RTD for the three different rock media: salt, clay sediments and crystalline rock. The expected results are common and systematic basis for priorities and co-ordination of future European RTD work for radioactive waste management, and suggested areas and priorities for joint RTD projects. The objective is develop a common and systematic basis for priorities and co-ordination of future European RTD work for Radioactive Waste Management and suggest areas and priorities for joint RTD projects. This will be accomplished by forming a Network of Excellence with the main European organisations given the national responsibilities to develop systems for safe handling and disposal of long-lived radioactive waster and by jointly working out a document that can serve as an aid for the planning and execution of future coordinated RTD activities between European implementors.
GASNET	A thematic network on gas issues in safety assessment of deep repositories for nuclear waste https://cordis.europa.eu/project/rcn/58150_en.html Repositories for nuclear waste are expected to produce gases as a result of a variety of chemical, microbiological and radioactive decay processes. Assessment of the impact of the generation and migration of gas is recognised to be an important element of any safety case for the disposal of such wastes. A recent report, based on the proceedings of a joint NEA/EC workshop, provides a foundation for improving the treatment of gas issues in safety assessments. This thematic network will build on the existing approaches for producing safety cases for deep geological disposal, utilising the expertise of the European nuclear industry, academia, regulators and other specialists, in order to: (a) summarise the present treatment of gas in safety assessments and (b) evaluate these approaches and provide guidance for future safety assessments. To evaluate the present treatment of gas issues in safety assessments of deep geological repositories for nuclear waste, and to improve the translation of scientific information on these issues into safety arguments for such repositories. Utilising the expertise of the nuclear industry, academia, regulators and other specialists in achieving this evaluation, to produce a project report that documents the current approaches used in dealing with gas issues in safety assessments and the strengths and limitations of these approaches.
RESEAL II	A large scale in situ demonstration test for repository sealing in an argillaceous host rock - phase II

	https://cordis.europa.eu/project/rcn/52868_en.html The main objective of RESEAL II is to demonstrate on a representative scale that the sealing of a shaft i.e. the "experimental" shaft of the HADES underground laboratory, with a low permeability powder/pellets mixture of bentonite avoids preferential migration of water, gas or radionuclides either through the seal of through the excavation disturbed zone around it. The mechanical stability of the seal under accidental overpressure conditions will be also tested. A tracer diffusion in the host clay formation around the seal will allow to study, by modelling, the migration parameters of the excavation disturb ed zone. Hydro-mechanical models will be applied for the interpretation of the test results and consequently to demonstrate our understanding of the seal behaviour.
RISCOM II	Enhancing transparency and public participation in nuclear waste management https://cordis.europa.eu/project/rcn/53141_en.html The project represents a major effort in five countries to promote the development of a "European approach" to public participation and trustworthy decision processes in the area of nuclear waste management. It will use a methodology for integrating scientific, procedural and organisational aspects within a consistent framework for improved transparency. The project provides a "map" of values in performance assessment, a review of dialogue processes and hearing formats, a diagnosis of organisational structures and an understanding of the organisational impact on transparency. Possibilities and limitations of the Internet as a means for communication about social issues in the context of large industrial projects will also be highlighted.
TRANCOM II	Migration case study: transport of radionuclides in a reducing clay sediment https://cordis.europa.eu/project/rcn/52867_en.html For deep geological disposal of radioactive waste in clay, it is essential to consider the mobility of radionuclides. This proposal addresses the migration behaviour of radionuclides (U, Pu, Se and Am), identified as critical by Performance Assessment, in a reducing clay environment, with special emphasis on the role of the organic matter. Considerable attention is devoted to developing and demonstrating concepts describing radionuclide migration and the acquisition of the model parameters. An equal amount of effort is devoted to batch experiments, aimed at understanding the mechanisms behind the migration.
BENIPA	Bentonite barriers in integrated performance assessment https://cordis.europa.eu/project/rcn/52851_en.html Bentonite barriers are a fundamental component of repositories in granite and clay host rocks. The project will analyse and integrate the numerous developments achieved in the study of these barriers in order to improve their treatment in Integrated Performance Assessment. Current repository concepts will be reviewed and referent cases common to all the participants will be selected for the project. Available information on FEPs will be assessed and processed in order to evaluate the bases for decisions in IPA. Assessment codes at process and integrated level will be analysed and upgraded where necessary. New more advanced calculations at process and integrated level will be carried out, in order to verify model performance and to evaluate the sufficiency of available assessment methods. Sensitivity and optimisation analyses will be performed.

	The inventarisation of the product design requirements was carried out by means of a questionnaire. On this basis the requirements in the field of marketing, standards, functionality, mass production demands, lifetime and reliability were gathered. Research was carried out in the field of the inverter concept. The optimal topology was chosen, in direct relation with the control concept. The design of the power electronic circuit was finished and has brought a robust design, focused on reliability and cost reduction. This was accomplished by the integration of control and power conversion functions and the thermal, electric and mechanical optimisation of the design for large-scale production. A first version of a prototype was built and successfully tested.
BIOMOSA	Biosphere models for Safety Assessment of radioactive waste disposal based on the application of the Reference Biosphere Methodology https://cordis.europa.eu/project/rcn/59925_en.html he proposal aims at the improvement of the scientific basis for the application of biosphere models in the framework of long-term safety studies of nuclear waste disposals. The results will especially reduce the uncertainty of the dose assessment to population groups far in the future and it will increase the transparency of biosphere modelling in long-term safety studies. The project will therefore help to maintain and enhance public confidence in the results of the assessment of potential radiological impact to members of future hypothetical groups. Furthermore, the outcome of the project will be to provide implementations and regulatory bodies with guidelines for performance assessments of repository systems. The BioMoSA study has provided valuable input for the performance assessment studies of nuclear waste disposals in Europe. The conclusions can be drawn for the development of site-specific assessment tools that are going to be applied in long-term safety studies
BENCHPAR	Benchmark tests and guidance on coupled processes for performance assessment of nuclear repositories https://cordis.europa.eu/project/rcn/58655_en.html The purpose of the proposed work is to improve the ability to incorporate thermo-hydro-mechanical (THM) coupled processes into Performance Assessment modelling, This will be achieved by three benchmark modelling tests for: the near-field, upscaling, and the far-field. Key THM processes will be included in the models. The first test will be on the re-saturation of the buffer and interaction with the rock mass. The second test will determine how the upscaling process impacts on performance assessment measures. The third test will model the long-term evolution of a fractured rock mass in which a repository undergoes a glaciation- deglaciation cycle. A technical auditing capability will produce a transparent and traceable audit trail for the benchmark tests. The final deliverable will be a Guidance Document giving advice to EU Member States on how to incorporate THM processes into Performance Assessment.
MODEX-REP	Elaboration of hydromechanical coupled models by interpretation of the dist... https://cordis.europa.eu/project/rcn/52458_en.html An instrument array will record the rock mass response during shaft sinking for an underground research laboratory in Eastern France in a deep argillite formation. This kind of geological formation is considered as a potential host rock for a radioactive waste repository. The proposed MODEX-REP project consists in: development of the constitutive models by analysing surface laboratory tests results; prediction of the rock mass response to shaft excavation; analysis of the results of in-situ measurements; comparison of the prediction

	with the measured rock mass response; and validation of the models. The relevance of the constitutive models for predicting rock mass hydromechanical behaviour will be evaluated through the comparison. The models validated by in-situ testing at natural scale will enhance public confidence in prediction capacity. Shaft excavation is not included financially in the proposed project.
SOMOS	Safety and operational monitoring of nuclear waste repositories with optic sensing systems. https://cordis.europa.eu/project/rcn/59927_en.html To guarantee operational safety during the operational phase of a final repository, monitoring systems are indispensable. At the same time, long-term safety analysis performed prior to the construction and operation, can be verified by the measurements obtained during the operational phase. With respect to the specific aspects of monitoring nuclear waste repositories, optical fibre sensors offer unique advantages: small size, remote distributed measurements along a single optical fibre and for some types the potential of renewable sensors if emplaced in small tubes. The renewable aspect inherently covers some of the long-term aspects. Within the scope of this project, three types of sensors will be developed and/or qualified: renewable distributed temperature sensing, renewable distributed dosimetry and hydrogen sensing.
PROTOTYPE REPOSITORY	Prototype repository - full scale testing of the KBS-3 concept for high-level radioactive waste https://cordis.europa.eu/project/rcn/52873_en.html SKB's reference concept for deep disposal of spent nuclear fuel, the KBS-3 system, has several features in common with other European concepts and full-scale testing is therefore of great value. Components of this system have been thoroughly investigated but the Prototype Repository is the first full scale application. The Prototype Repository will be conducted at the AEspoe Hard Rock Laboratory (AEHRL) as an integrated test focusing on EBS performance but comprising also canister deposition, backfilling and plug construction. It offers a number of possibilities to compare test results with models and assumptions and also to develop engineering standards and quality assurance methods. The co-operative work aims at accomplishing confidence building as to the capability of constructing safe repositories and predicting EBS performance also for somewhat different conditions than those in the AEHRL. Project´s actual: - Completion of a test set-up with up to six canisters with heaters in deposition holes; - Preparation of an operating monitoring system covering THM processes in buffer, backfill and rock, and gas and water sampling; - Results of predictive modelling for: - THM processes in bentonite buffer and bentonite-based backfill during saturation; - heat distribution in the buffer and surrounding rock; - development of stresses in the rock mass; - development of piezometric heads in the rock mass;

	- movement of canisters (heaters) in the buffer; - chemical changes in the buffer (salt enrichment, precipitations), (THC); - microbial effects (migration, attack on minerals), (THMB). Tentative comparison between the readings from the first two years after commissioning and the results from predictive modelling.
CONTAINER CORROSION	Long-term performance of candidate materials for HLW / spent fuel... https://cordis.europa.eu/project/rcn/52916_en.html The proposal addresses the qualification of corrosion resistant materials for long- lived HLW/Spent Fuel disposal containers. Such containers as a component of the multi-barrier system will improve the safety in the disposal in geological formations. Based on the findings and recommendations of the previous EU-project the corrosion studies will be concentrated on the most promising container materials such as carbon steel, stainless steels, Ti99.8-Pd Hastelloy and Cu-Ni alloys. The project includes corrosion studies in rock salt, granite and clay environments. The work will consist of: (i) long-term immersion tests to determine the final corrosion rate of the materials and their susceptibility to local corrosion; (ii) electrochemical studies to examine the corrosion mechanisms and the influence of various parameters on corrosion; (iii) slow strain rate tests to examine the stability of the materials to stress corrosion cracking**.**
CLUSTER URL 2	Club of Underground Storage, Testing and Research Facilities for Radioactive Waste Disposal - CLUSTER URL 2 https://cordis.europa.eu/project/rcn/58145_en.html The seminar planned in Mol from 27.09 to 28.09.2001 will address the R&D and demonstration projects running or planned in European URL's to stimulate further networking activities. Deep geological disposal is currently the most studied option for isolation high-level radioactive waste from man and his environment. URL's have been constructed with the aim to further characterise in situ candidate or potential host rocks (clay, salt, granite) and to test and/or demonstrate the technical feasibility of the repository concepts. They offer important opportunities for participation of research institutes from all Member States of the European Union. Beside a general overview of current and planned activities some projects will be described more in detail. A special session will address the approaches, capabilities and limitations of the models used in the respective projects for the EBS and their application in Performance Assessment.
TN ON MONITORING	Thematic network on the role of monitoring in a phased approach to disposal https://cordis.europa.eu/project/rcn/58152_en.html The scope of work will cover potential monitoring requirements during all stages of disposal system development. It will consider a broad range of potential monitoring requirements including, but not limited to, monitoring for the following reasons:

	(i) Establishment of baseline conditions. (ii) System of performance at the time of monitoring. (iii) Provision of data to be used in evaluations/assessments of repository performance. (iv) Monitoring in the broad sense e.g. developments in relevant areas of science. It is proposed that the project is divided into four work packages. The first work package would be information gathering and improving the definition of work to be carried out in subsequent work packages. The second work package would be to describe what parameters might require monitoring and the reasons for that monitoring. The third work package would address techniques and strategies for monitoring. The fourth work package would be to compile a final report of the project.
ACTINET	Network to review natural analogue studies and their applications to repository safety assessment and public communication https://cordis.europa.eu/project/rcn/65144_en.html The network is envisaged to facilitate the coordination and utilization of "pooled" facilities for the research on actinide sciences but also consolidate and exploit the training and education possibilities in Europe. The structure of the network will consist of the core-institutions and associated laboratories. Radiochemistry laboratories of universities and national laboratories can be associated members to join the individual subject areas of actinide research.
NANET	Establishment of a Network of Excellence for Actinide Science https://cordis.europa.eu/project/rcn/67692_en.html The aim of this project is to promote a more considered use of natural analogues in safety assessment and public communication. This will be achieved by a critical review of traditional analogue studies, such as investigations of radionuclide transport around uranium ore bodies and analogues of processes such as glass degradation. Scoping consideration will also be given to other types of natural system studies, which adopt a similar philosophy to analogues, such as studies of the geosphere-biosphere interface. Previous uses of analogues in performance assessment will also be critically assessed in light of present-day requirements for safety cases supported by multiple lines of reasoning. This review of the state-of-the-art will lead to the construction of a coherent set of recommendations for future analogue applications presented in a series of concise project reports, supported by a searchable database of analogue information. The aim of this project is to promote a more considered use and understanding of natural analogues in safety assessment and public communication.
GLAMOR	A critical evaluation of the dissolution mechanisms of high level nuclear waste glasses in conditions of relevance for geological disposal

	https://cordis.europa.eu/project/rcn/58309_en.html The objectives of the proposal are to achieve a common understanding on this interpretation, and to quantify the uncertainty of the calculations done in models that are nowadays applied to the glass dissolution. This will be achieved by applying a selection of analytical models on a limited amount of experimental data, both models and data referring to the differing interpretations, and evaluating the output. The partners in this proposal involve laboratories that are dealing with these studies.
COMPAS	Comparison of alternative waste management strategies for long-lived radioactive wastes https://cordis.europa.eu/project/rcn/58636_en.html This proposal aims to set-up a thematic network for the evaluation and comparison of the alternative long-term strategies for the management of long-lived radioactive waste that have been considered in the EU member states and applicant countries. The focus would be strategies for the management of spent fuel intended for direct disposal, long-lived ILW and HLW generated from reprocessing and transmutation. Additional nuclear materials, e.g. U or Pu stocks, not currently classified as waste, would also be considered. National differences influencing strategy selection and the key drivers in the formulation of national policies would be reviewed, with the aim of reaching a common understanding of the differences in current strategies.
HUPA	Humic substances in performance assessment of nuclear waste disposal: actinide and iodine migration in the far-field https://cordis.europa.eu/project/rcn/58446_en.html The impact of humic substances on the lengthen safety of nuclear waste disposal is quantified. Results are tailored for implementation in PA. Natural humic colloids have been shown to migrate like ideal tracers over long distances and time-spans. It has also been unarobiguously shown that there is a large potential impact by humic colloid mediated radionuclide migration. However, due to discrepancies between the behaviour of radionuclides from laboratory studies and natural chemical analogues, presently no final conclusion is possible on this issue. This can only be resolved by development of adequate process understanding. The project takes a necessary broad approach, including development of model humic substances, generation of missing data and development of models and transport codes. The impact on PA is visualized by migration case studies. The long-term safety relevant actinide ions and iodine are studied.
HE	Heater experiment: rock and bentonite thermo-hydromechanical (THM) processes in the near field https://cordis.europa.eu/project/rcn/58447_en.html The aim is to identify the coupled thermo-hydro-mechanical (THM) processes in both the bentonite buffer and the host rock clay formation after a medium-term heating phase at 100 C under saturated conditions. A heating tube with a diameter of 10 cm was installed in a 7 m deep borehole with a diameter of 30 cm. The gap between the heater and the clay host rock was backfilled with compacted bentonite blocks. A constant temperature of 100 C will be maintained at the surface of the heater in contact with the artificially saturated bentonite buffer for about 18 months. The THM response in both the buffer

	and the rock will be monitored in-situ. During this time-period modelling and supporting laboratory work will be performed. Thereafter the buffer and part of the surrounding host rock will be excavated for characterisation at the laboratory.
RETROCK	Treatment of geosphere retention phenomena in safety assessments https://cordis.europa.eu/project/rcn/58527_en.html The overall objective of the project is to develop a common basis for incorporating geosphere retention phenomena in safety assessments for deep geological repositories. The main focus will be in examining whether simplifications frequently adopted in safety assessments can be defended with more complex process models, experiments and other sources. The project concentrates on saturated fractured hard rocks, such as e.g. crystalline bedrock.
BAMBUS II	Backfill and material behaviour in underground salt repositories, phase II https://cordis.europa.eu/project/rcn/58654_en.html The proposal addresses the safe disposal of radioactive waste in geological salt formations. Based on the findings and recommendations of the BAMBUS-I project, the work will consist of: (1) in situ investigations in the Asse salt mine in which the complex behaviour of backfill and rock salt will be studied during and after dismantling of the large-scale TSDE experiment; (2) laboratory tests to measure specific parameter values needed in models to predict repository performance; (3) modelling studies to increase the predictive capability of the models and to improve their capacity for, e.g. 3D calculations; and (4) a desk study to investigate the retrievability of heat generating waste and to evaluate viability and boundary conditions for retrieval operations.
ECOCLAY II	Effects of Cement on CLAY barrier performance - phase II https://cordis.europa.eu/project/rcn/52388_en.html Cements will be used intensively in radioactive waste repositories. During their degradation in time, in contact with geological pore water, they will release hyper-alkaline fluids rich in calcium and alkaline cations. This will induce geochemical transformations that will modify the containment properties of the different barriers (geological media and EBS, i.e. clay-based engineered barriers). ECOCLAY I identified major geochemical reactions between bentonite and cement. ECOCLAY II proposes to investigate aspects such as radionuclides sorption, kinetics of the geochemical reactions, coupled geochemistry / transport processes, conceptual and numerical modelling and performance assessment. The whole hyper-alkaline plume (EBS, clay and granite host rock) will be studied within the project. To do so, ECOCLAY II brings together the efforts of 8 European countries on this subject with an aim of supplementing studies.
IN CAN PROCESSES	Rates and mechanisms of radioactive release and retention inside a waste disposal canister

	https://cordis.europa.eu/project/rcn/52870_en.html This project will use an innovative method based on isotope dilution measurements to determine the actual dissolution rate of uranium dioxide and spent nuclear fuel as a function of radiation dose and redox conditions. The results will remove the present uncertainties in source term estimates due to precipitation of secondary phases during experiments. Other studies will measure the rate of reduction of oxidized forms of U and Np when they encounter solutions that contain actively corroding iron, which represents the interior of a waste disposal canister. Theoretical calculations concerning expected solution concentrations and rates of reduction reactions will support and elucidate the experimental results. These calculations will also be used to evaluate the data base information used in repository performance assessments.
BIOCLIM	Modelling sequential biosphere systems under climate change for radioactive waste disposal https://cordis.europa.eu/project/rcn/52457_en.html The project will provide a scientific basis to assess the safety of radioactive waste repositories in deep formations, with regard to the possible long-term impacts. Two complementary strategies will provide representation of future climate changes using respectively analysis of extreme situations and a continuous simulation over the next 1,000,000 years. Climate and vegetation models of different spatio-temporal scales will therefore be used to simulate the time series of climate and vegetation in various European areas. These results will be used to derive the nature of the human environments (i.e. the biosphere systems) through which radionuclides, coming from the repository, may transfer to Man. Finally these exposure and migration pathways will be described for three selected biosphere systems using two different approaches: a discrete one commonly used and a more innovative transitional one.
	Clay as a potential humic colloid source - implications for nuclear waste disposal https://cordis.europa.eu/project/rcn/64043_en.html The objective is to investigate the potential for conversion of clay organic matter into dissolved humic alike substances under conditions relevant for nuclear waste disposal in the presence of cement. The project is based on preliminary investigations under aerobic conditions with clay rich inorganic matter that has not been consolidated under elevated temperatures. In the present project, investigations will be extended to anoxic conditions and clays with high temperature consolidated clay organic matter. Two different clays are contacted with alkaline solution up to around 550 days. The alkaline solution reflects conditions resulting from cement dissolution. The generation of humic substances is monitored and important properties for radio nuclide complexation and mobility are determined. This includes determination of functional group content (proton exchange capacity), actinide complexation studies. molecular mass and size distribution. Simultaneously, the morphology of clay during the alkaline treatment is studied as well as the generation of new phases. Generation and characterization of clay mineral colloids is also studied. Results are interpreted in view of the potential: impact on actinide mobility in the near field of disposed radioactive waste.
	FP6 Projects
TIMODAZ	Thermal Impact on the Damaged Zone Around a Radioactive Waste Disposal in Clay Host Rocks

	https://cordis.europa.eu/project/rcn/80054_en.html In all nuclear power generating countries, spent nuclear fuel and long lived radioactive-waste management is an important environmental issue today. Disposal in deep clay geological formations is one of the promising options to dispose of these wastes. An important item for the long-term safety of underground disposal is the proper evaluation of the Damaged Zone (DZ) in the clay host rock. The DZ is first initiated during the repository construction. Its behaviour is a dynamic problem, dependent on changing conditions that vary from open-drift period, to initial closure period, to the entire heating-cooling cycle of the decaying waste. Other factors concern the even longer-term issues of chemical reactions and biological activities. The TIMODAZ project will focus on the study of the combined effect of the EDZ (Excavation Damaged Zone) and the thermal impact. The influence of the temperature increases on the EDZ evolution as well as the possible additional damage created by the thermal load will be studied. Three types of clay will be investigated: the Boom Clay, the Opalinus Clay and the Callovo-Oxfordian argilite. To assess the impact of the different repository evolution stages on the host rock, numerical tools will be developed allowing a good prognosis of the THMC host rock behaviour at the time and spatial scale of a repository. These developments will build on an experimental programme including laboratory and in-situ tests. The knowledge gained within the project will allow an assessment of the significance of the TDZ (Thermal Damaged Zone) in the safety case for disposal in clay host rock and to provide direct feedback to repository design teams. In order to ensure appropriate and continuous linkage between the end-users' needs and the priorities of the project, an end-users' group that will be active throughout the duration of the project has been constituted. The end-user group will consist of mainly national agencies for management of radioactive waste.
THERESA	Coupled thermal-hydrological-mechanical-chemical processes for application in repository safety assessment https://cordis.europa.eu/project/rcn/85596_en.html This proposal aims to develop a scientific methodology for evaluating the capabilities of mathematical models and computer codes used in Performance Assessment and applied to the design, construction, operation, performance and safety assessment, and post-closure monitoring of geological nuclear waste repositories, based on the scientific principles governing coupled thermo-hydro-mechanical and chemical (THMC) processes in geological systems and geo-materials.
CIP	New Governance approaches to radioactive waste management in Europe: Cowam in practice https://cordis.europa.eu/project/rcn/90946_en.html The objectives of CIP are: - to tribute to enabling European societies to make actual progress in the governance of radioactive waste management (RWM) while contributing to increasing societal awareness of and accountability for radioactive waste management (RWM) in Europe in order to reach practicable, accountable and sustainable decisions. - to follow up and analyse five innovative national processes on RWM on the basis of COWAM 2 results with a view to support stakeholders, particularly local communities, directly in their engagement with their particular RWM programme(s) - and to capture the learning from that experience. - to develop best practices and guidance for the application (implementation and improvement) of new inclusive governance of RWM approaches in the EU25, including benchmarking on practical and sustainable decision making processes recognised as fair and equitable by the stakeholders on the short, medium and long term.

SAPIERR	Strategy Action Plan for Implementation of European Regional Repository - Stage 2 https://cordis.europa.eu/project/rcn/107817_en.html The objective of this proposed project is to develop the feasibility studies of SAPIERR (2003-5) into a practical implementation strategy and organisational structures that will enable a formalised, structured organisation to be established in 2008 for working on shared EU radioactive waste storage and disposal activities. Principal goals: 1)Development of an organisational framework and project plan to facilitate debate on the establishment of a modestly sized, self-sufficient European Development Organisation (EDO) that can work in parallel with national waste agencies; 2) Further studies of key issues related to economics, design, public and political attitudes and the safety and security of shared storage and disposal facilities. Main Tasks within the Project: 1) Preparation of a management study on the legal and business options for establishing an EDO; 2)A study on the legal liability issues of international waste transfer within Europe; 3) A study of the potential economic implications of European regional repositories; 4) First considerations of the safety and security impacts of implementing regional repositories; 5) A survey of public and political attitudes towards regional repositories and of approaches to involving communities in decision making; 6) Development of a Strategy and a Project Plan for the work of the organisation, EDO. The immediate tasks are agreeing a progressive, slow, staged strategy that would lead to the definition of potential host countries and eventually, to potential repository sites and definition of a parallel science and technology programme that could be addressed by the EDO after its initiation.
PAMINA	Performance assessment methodologies in application to guide the development of the safety case https://cordis.europa.eu/project/rcn/92084_en.html The main objective of IP PAMINA is to improve and harmonise integrated performance assessment (PA) methodologies and tools for various disposal concepts of long-lived radioactive waste and spent nuclear fuel in different deep geological environments. The IP PAMINA aims at providing a sound methodological and scientific basis for demonstrating the safety of deep geological disposal of such wastes, that will be of value to all national radioactive waste management programmes, regardless of waste type, repository design, and stage, that has been reached in PA and safety case development.
MICADO	Model uncertainty for the mechanism of dissolution of spent fuel in a nuclear waste repository https://cordis.europa.eu/project/rcn/80043_en.html

	The proposed coordinated action attempts to assess the uncertainties in models describing the dissolution mechanism of spent nuclear fuel in a repository for geological time periods. Most worldwide leading experts in the field from research and waste management and organisations are present in the project, representing different approaches to the prediction on the performance of disposed spent fuel for very long times: based on either electrochemical, geochemical and/or radiolytical viewpoint. Simplified operational models are used by waste management and regulating organisations for the predictions in more complex systems.
FUNMIG	Fundamental processes of radionuclide migration https://cordis.europa.eu/project/rcn/74124_en.htm Main objectives are the fundamental understanding of radio nuclide migration processes in the geosphere, the application to performance assessment and communication of the results. The project tackles one of the main challenges for a sustainable European energy mix, namely scientific and social credibility of geological HLNW disposal. Fundamental processes are studied in two RTDCs, covering key radionuclide transport and retardation processes at the molecular level. This molecular level understanding is moved forward into studies on the host rocks being considered in Europe (clay, granite, salt). In three host-rock specific RTDCs, migration processes are studied at scales of interest for the performance assessment (PA). Spatial scales reach from nanometres to kilometres and time-scales from laboratory to geological systems. Integration and abstraction to PA are key issues. The scientific and technological knowledge gained in the project will improve the state of the art of PA abstraction and visualisation methodologies. The knowledge acquired throughout the project is brought forward to the general scientific community and broader stakeholder communities by active training, knowledge transfer and dissemination.
CARD	Co-ordination of research, development and demonstration (RD and D) priorities and strategies for geological disposal https://cordis.europa.eu/project/rcn/80060_en.html The proposal is aimed at assessing the feasibility of a Technology Platform that would provide a European framework for networking and cooperation in the field of RD and D for geological disposal of radioactive waste in the EU. The study will seek inputs from partners in the project, which are radioactive waste management organisations (disposal implementers) and key stakeholders.
ESDRED	Engineering Studies and Demonstrations of Repository Designs https://cordis.europa.eu/project/rcn/74120_en.htm he Integrated Project ESDRED, a joint research effort by major national radioactive waste management agencies (or subsidiaries of agencies) and by research organizations, representing nine European countries, is a major step to establish a sound technical basis for demonstrating the safety of disposing spent fuel and long-lived radioactive wastes in deep geological formations and to underpin the development of a common European view on the main issues related to the management and disposal of waste. The overall objective of the Integrated Project ESDRED over 5 years is to demonstrate the technical feasibility at an industrial scale for activities carried out to construct, operate and close a deep geological repository, and at the same time comply with requirements on long-term safely, operational salty, irretrievability and monitoring.

COWAM 2	Community Waste Management 2 : Improving the Governance of Nuclear Waste Management and Disposal in Europe (COWAM-2) https://cordis.europa.eu/project/rcn/74123_en.html The objective of COWAM 2 is to contribute to the actual improvement of the governance of Radioactive Waste Management (RWM) in order to address the issue of geological waste disposal in Europe, by: - Better addressing and understanding societal expectations, needs and concerns as regards radioactive waste decision making processes, notably at local and regional levels, taking advantage of the past and ongoing successful and unsuccessful experiences of RWM in the concerned European countries- Increasing societal awareness of and accountability for RWM at local, national and European levels, creating the conditions for an improved dialogue among representatives of civil society and the traditional public and private actors of RWM- Developing guidance on innovative democratic governance of RWM, integrating local, national and European levels of decision as well the key non-technical and technical dimensions involved, - Developing best practices and benchmarking on practical and sustainable decision making processes recognised as fair and equitable by the stakeholders involved at the local, national and European levels as well as consistent on the short, medium and long term of RWM- Contributing to enable European societies to make actual progress in the governance of RWM, in order to reach practicable, accountable and sustainable decisions.
SAPIERR	Support action: pilot initiative for European regional repositories https://cordis.europa.eu/project/rcn/74103_en.html Some small nuclear power programmes in the expanded EU may not have the resources or the full range of expertise to build their own geological repositories. Even for countries that could potentially implement national projects, there are environmental and economic advantages in co-operation. The prospect that countries could work together to explore regional solutions is raised in the EC radioactive waste Directive. Such solutions raise new trans-national issues of safety and governance, nuclear security, national & European public acceptability, trans-boundary transport and national & European economics and law. SAPIERR is a pilot initiative to help the EC to begin to establish the boundaries of the issue, collating and integrating information in sufficient depth to allow potential regional options to be identified and the new RTD needs to be scoped. Possible future programme components and structures will be suggested.
NF	Understanding and Physical and Numerical Modelling of the Key Processes in the Near-Field and their Coupling for Different Host Rocks and Repository Strategies (NF-PRO) https://cordis.europa.eu/project/rcn/74118_en.htm The principal objective of the Integrated Project NF-PRO is to establish the scientific and technical basis for evaluating the safety function "containment and minimisation of release" of the near-field of a geological repository for HLW and SF. To this end, NF-PRO will investigate dominant processes and process couplings affecting the isolation of nuclear waste within the near-field and apply and develop conceptual and mathematical models for predicting the source-term release of radio nuclides from the near-field to the far-field. Results and conclusions of experimental and modelling work will be integrated in performance assessment. To understand the performance of the overall near-field system, an adequate insight in both the performance of the individual near-field sub-systems and

	their interactions is essential. Accordingly, NF-PRO has been structured in five Research and Technology Development Components each representing a major near-field sub-system. In particular, RTD Components 1 to 4 address key processes controlling dissolution of and release from the waste matrix, chemical processes taking place in the Engineered Barrier System (EBS), the thermo-hydromechanical (THM) evolution of the EBS and the characteristics and the evolution of the excavation disturbed zone (EDZ), respectively. Process couplings and integration in performance assessment are dealt within RTD Component 5.
CATT	Co-operation and Technology Transfer on long-term radioactive waste management for Member States with small nuclear programmes https://cordis.europa.eu/project/rcn/78635_en.html This project investigates the feasibility of Member States with small nuclear programmes (Recipient Member States, RMS) implementing long-term radioactive waste management solutions within their national borders, through collaboration with Member States with advanced disposal concepts (Donor Member States, DMS). The study will explore the viability of implementing technology transfer between the DMSs and those RMSs, which may not be able to develop their own solutions due to insufficient financial, technical or human resources, or those with a geology, which may dictate expensive engineering solutions.
	FP7 Projects
BELBAR	Bentonite Erosion: effects on the long-term performance of the engineered Barrier and radionuclide transport https://cordis.europa.eu/project/rcn/101412_en.html Recent safety assessments nuclear waste repositories have shown that the formation and stability of colloids may have a direct impact on the overall performance of the repository. The main aim of the BELBaR project is increase the knowledge of the processes that controls clay colloid stability, generation and ability to transport radionuclides. The overall purpose of the project will be to suggest a treatment of the issues in long-term safety assessment.
CARBOWASTE	Treatment and disposal of irradiated graphite and other carbonaceous waste https://cordis.europa.eu/project/rcn/88385_en.html Gas-Cooled Reactors (GCR), RBMK and some Material Test Reactors (MTR) make use of graphite as moderator of the fuel, structures of the core and/or thermal columns. During operation, the graphite and other carbonaceous materials like carbon brick, pyro-carbon and silicon carbide coatings are contaminated by fission products and neutron activation. These irradiated carbonaceous wastes are problematic due to their content of long-lived radioisotopes (e.g. Carbon14, Chlorine 36) and due to their large volumes. About 250 000 t of i-carbon are existing, worldwide. Acceptable solutions have not yet been established to handle this kind of waste. This fact also represents a significant drawback for the market introduction of graphite-moderated reactors like Very/High-Temperature Reactors (V/HTR) as a promising Generation IV system candidate. Graphite moderated reactors represent the very first generation of nuclear reactors and therefore need to be decommissioned ahead of other reactor types which evolved later. Presently, accelerated decommissioning of GCR and RBMK and subsequent disposal of i-graphite is the preferred option for not leaving this waste as a legacy for future generations. The CARBOWASTE project aims at an integrated waste management approach for this kind of radioactive

	wastes which are mainly characterized as Intermediate Level Waste (ILW), due to the varying content of long-lived radioisotopes. Methodologies and databases will be developed for assessing different technology options like direct disposal in adopted waste containers, treatment & purification before disposal or even recycling i-carbonaceous material for reuse in the nuclear field.
CATCLAY	Processes of Cation Migration in Clay rocks https://cordis.europa.eu/project/rcn/94448_en.html The overall objective of CatClay is to provide a scientifically well grounded answer to the following question: Can the migration of actinides and other strongly sorbing radionuclides in clay rock be predicted by coupling models of (i) their sorption equilibria on representative clay minerals and (ii) the diffusion-driven mass transport of radionuclide sorbed and dissolved species in compacted masses of these clay minerals? The answer is of prime importance for Safety Cases for clay rock formation-based radioactive waste disposal concepts. The project takes as its starting point experimental observations showing that certain cations known to form highly stable surface complexes with sites on mineral surfaces, migrated more deeply into clay rock than expected.
CROCK	Crystalline rock retention processes https://cordis.europa.eu/project/rcn/97424_en.html The EURATOM FP7 Collaborative Project “Crystalline Rock Retention Processes” (CP CROCK) is established with the overall objective to develop a methodology for decreasing the uncertainty in the long-term prediction of the radionuclide migration in the crystalline rock far-field. The project is launched in response to the need identified in conjunction with selection of retention data for the forthcoming crystalline host-rock HLW disposal Safety Case. The process of selecting a set of data for this purpose showed that the spread in data is broad and that this spread in data cannot presently be related to material properties or processes. Consequently, very conservative numbers need to be used in order to be defendable within the Safety Case. This does not lead to unacceptable dose predictions, but remains highly unsatisfactorily.
DOPAS	Full Scale Demonstration of Plugs and Seals https://cordis.europa.eu/project/rcn/106583_en.html https://www.posiva.fi/dopas/ DOPAS aims to improve the adequacy and consistency regarding industrial feasibility of plugs and seals, the measurement of their characteristics, the control of their behavior over time in repository conditions and also their hydraulic performance acceptable with respect to the safety objectives. This DOPAS project addresses the design basis, reference designs and strategies to demonstrate the compliance of the reference designs to the design basis, for plugs and seals in geological disposal facilities. The project focuses on shaft seals for salt rock (German repository concept), tunnel plugs for clay rock (French and Swiss repository concepts), and tunnel plugs for crystalline rock (Czech, Finnish and Swedish repository concepts). Five different demonstration experiments are part of the project and will take place in Sweden, France, Finland, Czech Republic and Germany. They are in different state-of-development.

FIRST-Nuclides	Fast / Instant Release of Safety Relevant Radionuclides from Spent Nuclear Fuel https://cordis.europa.eu/project/rcn/100941_en.html The EURATOM FP7 Collaborative Project “Fast / Instant Release of Safety Relevant Radionuclides from Spent Nuclear Fuel (CP FIRST-Nuclides)” is established with the overall objective to provide for improved understanding of the fast / instantly released radionuclides from disposed high burn-up UO2 spent nuclear fuel. This issue is given a high priority in the SRA of the IGD-TP. The outcome of the project is relevant for all types of host rocks in Europe. European experimental facilities with specialised equipment for work with highly radioactive materials collaborate for improving the knowledge relevant for the period after loss of the disposed canister integrity. The project provides for experiments combined with modelling studies on integration of the different results as well as for up-scaling from experimental conditions to entire LWR fuel rods. Spent fuel materials are selected and characterized that have known initial enrichment, burn-up and irradiation histories.
FORGE	Fate of Repository Gases https://cordis.europa.eu/project/rcn/89382_en.html Understanding gas generation and migration is vital in the quantitative assessment of repositories and is the focus of the research in this proposal for an integrated, multi-disciplinary project. The FORGE proposal is for a pan-European project with links to international radioactive waste management organisations, regulators and academia, specifically designed to tackle the key research issues associated with the generation and movement of repository gasses. Of particular importance are the long-term performance of bentonite buffers, plastic clays, indurated mudrocks and crystalline formations. Further experimental data are required to reduce uncertainty relating to the quantitative treatment of gas in performance assessment. FORGE address these issues through a series of laboratory and field-scale experiments, including the development of new methods for up-scaling allowing the optimisation of concepts through detailed scenario analysis. The FORGE partners are committed to training and CPD through a broad portfolio of training opportunities and initiatives which form a significant part of the project.
INSOTEC	(International) Socio-Technical Challenges for implementing geological disposal https://cordis.europa.eu/project/rcn/97435_en.html InSOTEC aims at identifying the main socio-political challenges for implementing geological disposal and their interplay with technical challenges. It will furthermore provide the IGD-TP with concrete suggestions on how to address these entangled socio-technical challenges. The biggest challenge today lies in adapting the generic concept of geological disposal to the real world environment (both natural and social) in which it needs to be implemented and with which the whole of the waste management system will need to build and maintain a long-term sustainable relationship. Addressing this challenge will imply searching for a strong and lasting connection between the technical and social aspects of managing radioactive waste.

IPPA	Implementing Public Participation Approaches in Radioactive Waste Disposal https://cordis.europa.eu/project/rcn/97430_en.html The focus of IPPA is on the establishment of arenas where different stakeholders can move forward together to increase their understanding of the issues involved in radioactive waste disposal and of their respective views. The focus is on implementation in some central and eastern European countries. The overall structure is in one end to take stock of existing research results and other experiences for implementation, and in the other end to evaluate to provide feedback to knowledge and research. The framework of the "Implementing Geological Disposal of Radioactive Waste Technology Platform" (IGD-TP) can be a suitable forum in which to investigate these issues further, therefore emphasis is given to linking IPPA results to the development of the platform.
LUCOEX	Large underground concept experiments https://cordis.europa.eu/project/rcn/97392_en.html The included experiments provide a check on the suitability of the different emplacement concepts and a possibility to understand and compare important parameters for the implementation and the long-term safety of the concepts. Important experience is expected to be obtained regarding testing and improving of methods, equipment, technologies, processes or operability related to the construction, operation and closure of a repository system. The key technical areas to address will be gallery construction, manufacturing and emplacement of buffer around waste canisters, emplacement of waste packages, and backfilling and sealing of galleries.
MODERN	Monitoring Developments for safe Repository operation and staged closure https://cordis.europa.eu/project/rcn/93569_en.html The MoDeRn project aims at providing a reference framework for the development and possible implementation of monitoring activities and associated stakeholder engagement during relevant phases of the radioactive waste disposal process, i.e. during site characterisation, construction, operation and staged closure, as well as a post-closure institutional control phase. Monitoring provides operators and other stakeholders with in-situ data on repository evolutions, to contribute to operational safety, to help manage construction, operation and/or closure activities, and may allow for a comparison with prior safety assessments. It thus provides information to inform necessary decisions. If, in addition, monitoring activities respond to stakeholder needs and provide them with understandable results, they will contribute to transparency and possibly to stakeholder confidence in the disposal process.
PEBS	Long-term performance of Engineered Barrier Systems (EBS) https://cordis.europa.eu/project/rcn/96796_en.html The main aim of the project PEBS (Long-term Performance of the Engineered Barrier System) is to evaluate the sealing and barrier performance of the EBS with time, through development of a comprehensive approach involving experiments, model development and consideration of the potential impacts on long-term safety functions. The experiments and models cover the full range of conditions from initial emplacement of wastes (high heat generation and EBS re-saturation) through to later stage establishment of near steady-state conditions, i.e. full re-saturation and thermal equilibrium with the host rock. These aspects will be integrated in a manner that will

	lead to a more convincing connection between the initial transient state of the EBS and its long-term state that provides the required isolation of the wastes
PETRUS II	Towards European training market and professional qualification in Geological Disposal https://cordis.europa.eu/project/rcn/93518_en.htm The aim of this proposal is to enable present and future professionals on radioactive waste management in Europe, whatever their initial disciplinary background, to follow a training programme on geological disposal which would be widely recognized across Europe. This ambitious aim will only be achieved over a close collaboration between all stakeholders and through an effective and flexible use of academic and non-academic resources and competences. In addressing the needs of the end-users that will be identified through updating the CETRAD outcomes, access to a combination of education (formal), continuous learning and professional development (non-formal), and in-job learning (informal) will be offered and developed within the project.
PETRUS III	Implementing sustainable E&T programmes in the field of Radioactive Waste Disposal https://cordis.europa.eu/project/rcn/109649_en.html PETRUS3 project aims at continuation of the European Cooperation in this area including: • Practical implementation of PETRUS training programme following ECVET principles: Starting from the outcomes of the previous project, we will experiment the elaboration and the implementation of training modules defined in term of learning outcomes in a "Competency-Based Curriculum". The objective is to set up accredited and recognised qualification in geological disposal that can be achieved in parallel both through formal and PD training programmes. • Elaboration of multidisciplinary training and research framework for PhD student: The objectives are i) to fast-track the research activities in geological disposal by proposing customised training programmes, ii) to organize periodic PhD workshops and iii) to enhance the emergence of multidisciplinary research. • Development of strategies and frameworks for maintaining PETRUS initiative over the long-term.
RECOSY	Redox phenomena controlling systems https://cordis.europa.eu/project/rcn/88406_en.html Main objectives of ReCosy are the sound understanding of redox phenomena controlling the long-term release/retention of radionuclides in nuclear waste disposal and providing tools to apply the results to Performance Assessment/Safety Case. Although redox is not a new geochemical problem, different questions are still not resolved and thus raised by implementers and scientists. From a top-down approach, the reliability of redox measurements for site characterization, redox disturbances by the near-field materials, changes induced by glaciation scenarios or the redox buffer capacity of host-rocks and the kinetics of response to redox perturbations are addressed.

REDUPP	Reducing Uncertainty in Performance Prediction https://cordis.europa.eu/project/rcn/97434_en.html At the core of the safety case for long-term geologic disposal for spent nuclear fuel lie the issues regarding spent fuel dissolution. We have today significant knowledge regarding dissolution of uranium oxide in the laboratory. However, uncertainties remain regarding spent fuel dissolution under realistic conditions. The objectives of the work proposed here are to reduce the uncertainty in the dissolution rate to be used in the safety case and thereby increase the confidence that can be placed in our ability to demonstrate that the geologic repository will function as designed. A second objective of this work is to provide for the training of young research workers who can continue to support the research needed in the future concerning radioactive waste disposal.
SECIGD	Secretariat of the Implementing Geological Disposal Technology Platform https://cordis.europa.eu/project/rcn/94433_en.html The IGD-TP needs administrative support to be of European value-added. A secretariat is a necessary contribution to the daily management of the IGD-TP and for acting as an open information centre on the platform activities, and for stakeholder participation. The Secretariat supports the preparation of the Strategic research agenda (SRA) and contributes in an efficient manner to operations of the platform (the agreed vision, the SRA, and its deployment plan). It maintains a public website where e.g. progress reports and announcements for future events are published in support of exchange among the members and other stakeholders, and fosters consultation and cooperation on projects. The dissemination of the work results of IGD-TP to all stakeholders is needed. The secretariat acts closely with the Executive Group of the IGD-TP, WMOs, centres of competence in RD&D and other stakeholders participating in its operations, since there is a joint awareness of the need of cooperation on challenges related to geological disposal."
SECIGD2	Secretariat of the Implementing Geological Disposal of Radioactive Waste - Technology Platform - Phase 2 2 https://cordis.europa.eu/project/rcn/106449_en.html The Secretariat promote the scientific and technical quality of the Research, Development and Demonstration (RD&D) by fostering interactions between national programmes. In this dissemination function, it maintains a website where e.g. progress reports and announcements for future events are published.
SITEX	Sustainable network of Independent Technical expertise for radioactive waste disposal https://cordis.europa.eu/project/rcn/101495_en.html SITEX aims at identifying the efficient means that should be developed through the establishment of a sustainable expertise function network within a European framework with the view to: - allowing mutual understanding between regulatory bodies, TSOs and waste management organisations (WMOs) on (i) the regulatory expectations at decision hold-points and (ii) how the scientific and technical elements carried out by the WMOs comply with these expectations. In that perspective, the needs in clarification of existing regulatory guidance or in developing new guidance will be

	addressed. Exchanges with IGD-TP on that issues is favoured. In complement, role of expertise function and the needs for improving it will be discussed; - in coordination with or in complement to WMO's research program, defining TSO's R&D program that would ensure independent capabilities development for reviewing the Safety Case and assessing the scientific arguments provided by WMOs. TSO's R&D program and priorities will be addressed by favouring close interaction with IGD-TP and seeking for joined research activities with the WMOs in order to foster common understanding of technical key points for safety and avoiding undue duplication; - ensuring competence building of experts in charge of technical review and transfer of knowledge on waste safety and radiation protection; the needs in guidance development for harmonising the technical review activity and in dedicated training and tutoring for spreading the expertise culture and practices will be addressed; - sharing, where needed, expertise approach with various stakeholders, in a manner more integrated than when only communication or dissemination are envisaged.
SKIN	Slow processes in close-to-equilibrium conditions for radionuclides in water/solid systems of relevance to nuclear waste management https://cordis.europa.eu/project/rcn/97427_en.html The project intends to assess the effect of surface properties on apparent solubility as well as the kinetics of incorporation of radionuclides in the structure of a solid phase, and the associated reaction mechanisms for various solids in a systematic manner, using isotope exchange under close-to-equilibrium conditions.
	Euratom Projects
ANNETTE	Advanced Networking for Nuclear Education and Training and Transfer of Expertise https://cordis.europa.eu/project/id/661910 The main objectives of the proposal are: 1. Survey and coordination of networking in E&T and vet in the nuclear areas 2. Design and implementation of coordinated E&T and vet efforts (master and summer courses for continuous professional development) 3. Generational transfer of expertise (sustainable production of educational material) 4. Cross border transfer of expertise (implementation of ECVET based exchanges among industrial bodies) 5. Reinforcing ETI actions for sharing and enhancing nuclear safety culture competence 6. Facilitating the nuclear transition in fusion: coordinating the E&T actions

BEACON	Bentonite Mechanical Evolution Beacon https://cordis.europa.eu/project/rcn/210819_en.html The overall objective of the project is to develop and test the tools necessary for the assessment of the hydro-mechanical evolution of an installed bentonite barrier and its resulting performance. This will be achieved by cooperation between design and engineering, science and performance assessment. The evolution from an installed engineered system to a fully functioning barrier will be assessed. One of the challenges is to take into account initial heterogeneities introduced in the system by conception with a combination of block and pellets or due to the size of the bentonite component (several 100 m^3). It will require a more detailed understanding of material properties, of the fundamental processes that lead to homogenisation, of the role of scale effects and improved capabilities for numerical modelling. The goal is to verify the performance of current designs for buffers, backfills, seals and plugs. The overall driver for the project is the assessment cases that will be defined at the onset of the project (WP1). The quantitative models currently available are not fully able to represent all the complexities of the evolution of an installed bentonite.
CEBAMA	Cement-based materials, properties, evolution, barrier functions https://cordis.europa.eu/project/rcn/196920_en.html Specific objectives of CEBAMA are: (i) experimental studies of interface processes between cement based materials and host rocks or bentonite, and assessing the specific impact on transport properties, (ii) quantifying radionuclide retention under high pH cement conditions, and (iii) developing comprehensive modeling approaches. Modeling will support interpretation of results and prediction of the long-term evolution of key transport characteristics such as porosity, permeability and diffusion parameters especially in the interface between cement based materials and the engineered and natural barriers. Further objectives cover dissemination of results to scientific and non-scientific stakeholders as well as training and education of young professionals for carrying over the expertise into future implementation programs.
CHANCE	Characterization of conditioned nuclear waste for its safe disposal in Europe https://cordis.europa.eu/project/rcn/210835_en.html Successful interim storage and final disposal of radioactive waste (RW) requires effective characterization and quality control of the waste. CHANCE aims to address the as yet unsolved and specific issue of the characterization of conditioned radioactive waste (CRW). CHANCE will establish a comprehensive understanding of current characterization methods and quality control schemes for conditioned radioactive waste in Europe. Furthermore, CHANCE will develop, test and validate already-identified and novel new techniques that will undoubtedly improve the characterization of CRW. Input from “end users” (mainly WMOs and waste producers) on methods of CRW characterization is critical to the success of CHANCE. Therefore, a dedicated End-Users Group will be established within CHANCE in order to represent and promote the interests and requirements of end-users.

	One of the project's key tasks will be dedicated to the identification of links and overlaps between waste acceptance criteria and actual waste characterization technologies available, in order to identify specific, as yet unsolved, methodology issues and technology gaps. CHANCE's R&D programme consists of the testing and evaluation of the performance of 3 innovative characterization techniques that are complementary and supplementary to current techniques for the non-destructive assay of RW, specifically: • Calorimetry as an innovative non-destructive technique to reduce uncertainties on the inventory of radionuclides (RN), namely from hidden RN-compounds with a weak gamma signal. • Muon Tomography to address the specific issue of the non-destructive interrogation of the content of large volume RW. • Cavity Ring-Down Spectroscopy as an innovative technique to characterize outgassing of RW at a very low detection level.
DISCO	Modern Spent Fuel dissolution and chemistry in failed container conditions https://cordis.europa.eu/project/rcn/210837_en.html While the scientific understanding of the dissolution of standard spent uranium oxide fuel has reached a certain mature state, new types of fuels with additives ("doped fuels") have been developed. These fuels are already in use in some reactors, and their use is foreseen to be expanded. Dissolution data is now required to confirm that the dissolution behaviour of such fuels in a geological repository environment is similar to that of standard fuel. Similarly, there is a dearth of dissolution data from MOX fuels, which are also currently in use in several reactors. This project is therefore targeting oxide fuels containing additives, including Cr, Gd and Pu, in order to ensure that relevant characteristics are understood to a level commensurate with standard fuels. This project aims to expand the database on spent fuel dissolution with results from dissolution studies performed in truly reducing conditions, with hydrogen present. The effects of dopants will be investigated through experiments using both spent nuclear fuel and synthetic materials specifically designed for the project. In addition, chemical modelling will be employed to improve the understanding and description of the dissolution process relevant to the expected chemical conditions inside a failed waste container in a deep geological repository environment.
EURAD	European Joint Programme on Radioactive Waste Management https://cordis.europa.eu/project/rcn/223662_en.html The European Joint Programme on Radioactive Waste Management (EURAD) is a project that will help the EU member states implement Directive 2011/70/Euratom (Waste Directive) by working with their national programmes. It will also coordinate action on joint targets among all related organisations involved at European level, whether in research or technical support. Building on the EC JOPRAD project, the EURAD project will help member states obtain the know-how required to implement safe and long-term management of radioactive waste. EURAD will also provide management knowledge to operate disposal facilities, and help transfer that knowledge between countries and organisations.
JOPRAD	Towards a Joint Programming on Radioactive Waste Disposal https://cordis.europa.eu/project/rcn/196893_en.html

	The goal of this project is to prepare the setting up of a "Joint Programming on Radioactive Waste Disposal" that would be established to coordinate at the European level, national research programmes and the associated research and development (R&D) activities on geological disposal for high activity long lived radioactive waste. This action includes reviewing of all strategic aspects linked to a stepwise move towards a Joint Programming in this field. This project involves organisations that are active in the safety, management and disposal of radioactive waste and research entities.
MIND	Development of the safety case knowledge base about the influence of microbial processes on geological disposal of radioactive wastes https://cordis.europa.eu/project/rcn/196908_en.html The multidisciplinary project addresses key technical issues that must be tackled to support the implementation of planned geological disposal projects for higher-level radioactive wastes across the EU. Our current understanding of the impact of microbial metabolism on the safety of geological repositories remains tenuous, even though microorganisms may have controlling influences on waste form evolution in situ, multibarrier integrity and ultimately radionuclide migration from the repository. This proposal targets a number of "high urgency" and "high importance" topics identified in the most recent IGD-TP Strategic Research Agenda, focusing specifically on the influence of microbial processes on waste forms and their behavior, and the technical feasibility and long-term performance of repository components. The project will bring together, for the first time, 15 European groups working on the impact of microbial processes on safety cases for geological repositories across the EU, focusing on key questions posed by waste management organisations. The emphasis will be on quantifying specific measureable impacts of microbial activity on safety cases under repository-relevant conditions, thus altering the current view of microbes in repositories and leading to significant refinements of safety case models currently being implemented to evaluate the long-term evolution of radwaste repositories.
Modern2020	Development and Demonstration of monitoring strategies and technologies for geological disposal https://cordis.europa.eu/project/rcn/196921_en.html The Modern2020 project aims at providing the means for developing and implementing an effective and efficient repository operational monitoring programme, taking into account the requirements of specific national programmes. The work allows advanced national radioactive waste disposal programmes to design monitoring systems suitable for deployment when repositories start operating in the next decade and supports less developed programmes and other stakeholders by illustrating how the national context can be taken into account in designing dedicated monitoring programmes tailored to their national needs. The work is established to understand what should be monitored within the frame of the wider safety cases and to provide methodology on how monitoring information can be used to support decision making and to plan for responding to monitoring results. Research and development work aims to improve and develop innovative repository monitoring techniques from the proof of feasibility stage to the technology development and demonstration phase. Innovative technical solutions facilitate the integration and flexibility of required monitoring components to ease the final implementation and adaptation of the monitoring system. Full-scale in-situ demonstrations of innovative monitoring techniques will further enhance the knowledge on the operational implementation of specific disposal monitoring and will demonstrate the performance of the state-of-the-art, the innovative techniques and their comparison with conventional ones.
SITEX II	Sustainable network for Independent Technical Expertise of Radioactive Waste Disposal - Interactions and Implementation

	https://cordis.europa.eu/project/rcn/196925_en.html The coordination action SITEX-II aims at implementing in practice the activities along with the interaction modes issued by the FP7 program SITEX project (2012-2013), in view of developing an Expertise function network. This network is expected to ensure a sustainable capability of developing and coordinating joint and harmonized activities related to the independent technical expertise in the field of safety of deep geological disposal of radioactive waste. SITEX-II tasks include: – the definition of the Strategic Research Agenda (SRA) based on the common R&D orientations defined by SITEX (2012-2013), the definition of the Term-of-Reference (ToR) for the implementation of specific topics from the SRA, and the interaction with IGD-TP and other external entities mandated to implement research on radioactive waste disposal regarding the potential setting up of an European Joint Programming on radioactive waste disposal; – the production of a guidance on the technical review of the safety case at its different phases of development, fostering a common understanding on the interpretation and proper implementation of safety requirements for developing, operating and closing a geological repository and on the verification of compliance with these requirements; – the development of a training module for generalist experts involved in the safety case review process, including the implementation a pilot training session; – the commitment of CS in the definition of the SRA mentioned above, considering the expectations and technical questions to be considered when developing R&D for the purpose of Expertise function. Close interactions between experts conducting the review work will allow enhancing the safety culture of CS and more globally, proposing governance patterns with CS in the framework of geological disposal; – the preparation of the “administrative” framework for a sustainable network, by addressing the legal, organisational and management aspects.

Some relevant project details

2010	**ARGONA Project:** **Suggested Guidelines for Transparency and Participation in Nuclear Waste Management Programmes**	IG	1.1.3	These guidelines are recommendations that have emerged from the EU Research Project ARGONA (Arenas for Risk Governance).	https://igdtp.eu/documents/
2011	**PAMINA project:** **Performance Assessment Methodologies in Application to Guide the Development of the Safety** **Case** **D1.1.4** **D5.1**	IG	Theme 7.	The PAMINA project (Performance Assessment Methodologies in Application to Guide the Development of the Safety Case) had the aim of improving and developing a common understanding of integrated performance assessment (PA) methodologies for disposal concepts for spent fuel and other long-lived radioactive wastes in a range of geological environments. The results form what is referred to as the "European Handbook of Safety Assessment Methods for Geological Repositories".	http://www.ip-pamina.eu/downloads/pamina.summaryweb.pdf http://www.ip-pamina.eu.
2013	**MoDeRn Project:** **Monitoring During the Stages Implementation of Geological Disposal:** **MoDeRn Deliverable D6.1.**	IG	5.5	The Modern2020 project aims at providing the means for developing and implementing an effective and efficient repository operational monitoring programme, taking into account the requirements of specific national programmes. The work allows advanced national radioactive waste disposal programmes to design monitoring systems suitable for deployment when repositories start operating in the next decade and supports less developed	

				programmes and other stakeholders by illustrating how the national context can be taken into account in designing dedicated monitoring programmes tailored to their national needs. The work is established to understand what should be monitored within the frame of the wider safety cases and to provide methodology on how monitoring information can be used to support decision making and to plan for responding to monitoring results. Research and development work aims to improve and develop innovative repository monitoring techniques from the proof of feasibility stage to the technology development and demonstration phase. Innovative technical solutions facilitate the integration and flexibility of required monitoring components to ease the final implementation and adaptation of the monitoring system. Full-scale in-situ demonstrations of innovative monitoring techniques will further enhance the knowledge on the operational implementation of specific disposal monitoring and will demonstrate the performance of the state-of-the-art, the innovative techniques and their comparison with conventional ones.	
2014	**SITEX project:** **Available technical review guidance and further needs** **D 4.1**	IG	Theme 7.	The objective of this task (WP4) was to establish the conditions for developing common technical review methodologies so as to seek for harmonisation of the review methods and make as far as possible the expertise function consistent through the member states. In a first step	https://igdtp.eu/documents/

				a framework for the development of harmonised methods for reviewing the safety cases has been established and is developed in this report.	
2014	**SITEX project:** **Overview of Existing Technical Guides and Further Development** **D 2.1**	IG	Theme 7.	An overview of existing and available technical guides addressing the main "safety topics" to consider in the development of a GD and submission of safety case and which are used within the SITEX consortium is given. Common points and differences between the guides are presented and the needs for further development are identified according to the main "safety topics".	https://igdtp.eu/wp-content/uploads/2019/02/SITEX-2014-D-2.1-Existing-Technical-Guides-Overview.pdf.
2014	**SITEX project:** **A plan for competence development in expertise of radwaste disposal safety** **D 4.2**	IG	1.3.2 Theme 6 Theme 7	The objective of WP°4 is to establish the conditions necessary for developing common technical review methodologies, which will enable the harmonisation of review methods. In 2013, participants devised a plan to organise training activities related to the technical review methodology. The present report focuses on the outcome of the latter task.	https://igdtp.eu/documents/
2014	**SITEX project:** **Conditions for establishing a sustainable expertise network** **D 6.1**	IM	Theme 7 6.3	The D6.1 identifies the conditions and means to ensure the existence of a sustainable expertise function, at national level, in the countries concerned by the SITEX project. This report also presents a common understanding (shared by the SITEX participants) of the function of expertise and its missions, as well as a review of the various institutional setting of expertise functions in the different	https://igdtp.eu/documents/

				national contexts. It also considers the requirements of the other SHs (Civil Society, implementers) regarding their interactions with the national expertise function. The different needs and missions of the national expertise function along the Decision-Making Process have been identified in respect with and are related to: Safety Case Regulatory Review, Implementation of Research in Safety, Training of Experts in charge of regulatory review and Interaction with Civil Society. Regarding these different functions, the report identifies the potential areas of cooperation, exchanges or sharing of resources that could be developed by the future SITEX network.	
2015	**IGD-TP:** **PLANDIS Guide: RD&D Planning Towards Geological Disposal of Radioactive Waste; Guidance for less-advanced Programmes** **D 2.3**	IG	1.2	This Guide has been developed by the SecIGD2 project of the Implementing GD of Radioactive Waste Technology Platform (IGD-TP). It responds directly to the needs of less advanced programmes to 'set-out the research, development and demonstration (RD&D) activities that are needed in order to implement their national policies for the responsible and safe management of spent fuel and radioactive waste' The Guide comprises three main sections which are aimed at providing (i) an introduction to the broad disposal programme activities that affect how an RD&D plan is established; (ii) an illustration of the core RD&D activities that are typically prioritised during early phases of a disposal programme; (iii) instructional questions and example templates that can be used as a basis for	https://igdtp.eu/documents/

				a first attempt at developing a national RD&D planning document – specifically oriented towards GD.	
2015	**IGD-TP SecIGD2 Project:** **RD&D Planning Towards Geological Disposal of Radioactive Waste** **Guidance for less-advanced Programmes**	**IG**	1.2	This Guide considers the essential elements of RD&D planning and provides instructional questions that should be addressed to respond to Council Directive 2011/70/EURATOM 'to set-out RD&D activities that are needed in order to implement national policies for the responsible and safe management of spent fuel and radioactive waste' It considers the RD&D activities that are typically planned during early phases of disposal programme management. It also considers the management activities that need to be considered to successfully implement RD&D activities, such as competency management, civil society involvement, different contractual mechanisms for completing RD&D, and the potential benefits of technology transfer of RD&D knowledge from more advanced RW programmes. The Guide comprises three main sections which are aimed at providing (i) an introduction to the broad disposal programme activities that affect how an RD&D plan is established; (ii) an illustration of the core RD&D activities that are typically prioritised during early phases of a disposal programme; (iii) instructional questions (contained in boxed text throughout) and example templates that can be used as a basis for a first attempt at developing a national	https://igdtp.eu/documents/

				RD&D planning document – specifically oriented towards GD.	
2018	**SITEX II project:** **Technical Guide on the Review of a Safety Case**	**IG**	Theme 7.	This guide describes the role of the regulatory body in the pre-licensing and in the licensing processes, identifies the needs for an efficient management system and for developing competences. It proposes also a tool for the regulatory body to analyze the safety cases through the different phases of the development of a GD. The guide gives an example of table of content for the review report to be performed by the regulatory body.	
2019	**MODERN 2020 project:** **Monitoring in Geological disposal** **& public participation:** **A stakeholder guide**	**IG**	6.3.1	The two aims of this SH guide stem from the fact that it was informed not only by scientific work, but also by the experiences of local citizen SHs. This document is the result of an interactive and iterative process which brings together various perspectives on monitoring in the context of the GD of HLW.	http://www.modern2020.eu/fileadmin/Deliverables/Modern2020-_D5.2_FINAL_Stakeholder_Guide_EN_web-.pdf

Appendix 3. SITEX list of international and national guides and documents

List of international and national guides and documents for the “Safety Topics” on Management and on the development of a geological disposal

Source: SITEX, Overview of Existing Technical Guides and Further Development Dissemination level 2014, D-N°:2.1

Abbreviation	Management	Site selection	Design	Construction	General aspect on operation	Investigations and feedback of information on operating experience	Operational limits and conditions	Modifications	Emergency preparedness and	Maintenance, periodic testing and inspection	Occupational exposure	Public exposure	Receiving, handling and emplacement of waste	Closure & Decommissioning	Period after closure and institutional
	ST13	ST14	ST15	ST16	ST17a	ST17b	ST17c	ST17d	ST17e	ST17f	ST17g	ST17h	ST17i	ST18	ST19
IAEA GSG-2									X						
IAEA GS-G-2.1									X						
IAEA GS-G-3.1	X														
IAEA GS-G-3.4	X														
IAEA GS-G-3.5	X														
IAEA SSG-14	X	X	X	X		X	X	X			X			X	
IAEA SSG-23	X			X											X
IAEA RS-G-1.1									X		X	X			
IAEA WS-G-5.1														X	
IAEA WS-G-5.2														X	
IAEA-TECDOC-0630						X					X	X		X	
IAEA GEOSAF-OP-Comp							X	X							
EUR EPG-SC-Rev				X											X
EUR EPG-WAC	X														
NEA-6424-Timescale															X
NEA-6923-MeSA															X
NEA-78121-Post-closure															X
NEA RK&M-ProgRep	X														
BE FANC-NS															X
BE FANC-GEN															X
BE FANC-GEO		X	X												
BE AVN-GEO-ARG		X													
CA NSCA				(X)											
CA CI1 SOR2000-204			X											X	
CA CNSC-P-290														(X)	
CA CSA-N294-09-Decom														X	
CA CNSC-G-129														(X)	
CA CNSC-G-219														X	
CA CNSC-G-320															X
CA Joint-Review-Process			X												
CH NEA														X	X
CH NEO	X		X	(X)		X	X	X		X				X	
CH ENSI-G03	X		X	X											X
CH SFOE-SP-CP	X			(X)											
CZ SÚJB-132/2008	X														
CZ SÚJB-2004			X			(X)								X	X
CZ SÚJB???															
DE BMU-2010		X	X	X										X	X
FR ASN-RFIII-2		X	X	X										X	

	Safety case & safety assessment	Characterization, knowledge and system understanding					Safety assessment methodologies, approaches & tools									
Abbreviation	Objectives and scope, Graded approach, content vs regulatory decision steps	general aspects	Waste	Engineered components	Site	Use of operating experience & monitoring data	Timescales and timeframes	Assessment of the possible radiation risks	Uncertainties	Deterministic vs. probabilistic approaches	Conservative & realistic assessments	Scenarios	Models	Indicators & criteria	Operational Safety assessment	L-T Safety assessment
	ST22	ST23a	ST23b	ST23c	ST23d	ST23e	ST24	ST25	ST26	ST27	ST28	ST29	ST30	ST31	ST32	ST33
IAEA GSG-2													G			
IAEA GS-G-2.1		G	G	G	G	G						G			G	
IAEA GS-G-3.1	G		G		G		G	G	G	G	G	G	G			G
IAEA GS-G-3.4						G										
IAEA GS-G-3.5				G		G										
IAEA SSG-14														G		
IAEA SSG-23						G										
IAEA RS-G-1.1														G		
IAEA WS-G-5.1														G		
IAEA WS-G-5.2	G								G		G	G				
IAEA-TECDOC-0630														G		
IAEA_GEOSAF-OP-Comp												G				
EUR EPG-SC-Rev							G		G							
EUR EPG-WAC							(G)									
NEA-6424-Timescale							(G)		G	G		G	G			G
NEA-6923-MeSA														G		
NEA-78121-Post-closure												G				
NEA RK&M-ProgRep							G	(G)		G	G	G	G			G
BE_FANC-NS								G								
BE_FANC-GEN														G		
BE FANC-GEO													G			
BE AVN-GEO-ARG							G									
CA_NSCA	G			(G)		G	G		G	G	G	G	G	G		G
CA_CI1_SOR2000-204				G		G										
CA CNSC-P-290	G			G			G	G	G	G	G	G	G		G	G
CA_CSA-N294-09-Decom														G		
CA_CNSC-G-129								G								
CA_CNSC-G-219									G	G	G	G	G	G		G
CA CNSC-G-320					G	G	G		G	G	G	G		G		G
CA_Joint-Review-Process			G	G	G	G			(G)	G	G	G	G	G		
CH_NEA							G					G		G		G
CH_NEO							(G)									
CH ENSI-G03												G				
CH_SFOE-SP-CP													G			
CZ_SÚJB-132/2008		G	G	G	G	G						G			G	
CZ SÚJB-2004	G		G		G		G	G	G	G	G	G	G			G

	Safety case & safety assessment	Characterization, knowledge and system understanding					Safety assessment methodologies, approaches & tools									
Abbreviation	Objectives and scope, Graded approach, content vs regulatory decision steps	general aspects	Waste	Engineered components	Site	Use of operating experience & monitoring data	Timescales and timeframes	Assessment of the possible radiation risks	Uncertainties	Deterministic vs. probabilistic approaches	Conservative & realistic assessments	Scenarios	Models	Indicators & criteria	Operational Safety assessment	L-T Safety assessment
	ST22	ST23a	ST23b	ST23c	ST23d	ST23e	ST24	ST25	ST26	ST27	ST28	ST29	ST30	ST31	ST32	ST33
CZ SÚJB???						G										
DE BMU-2010				G		G										
FR ASN-RFIII-2														G		
SE SSMFS 2008:21						G										
UK EA-NIEA-GD-2009														G		

Appendix 4. EURAD Roadmap Goals Breakdown Structure (GBS)

Version: 0.6, 19 Mar 2021

A generic roadmap for implementing radioactive waste management, leading to geological disposal

1**. NATIONAL PROGRAMME MANAGEMENT**		
Theme	**Sub-theme**	**Domain**
1. Implement a national programme for the management of spent fuel and radioactive waste, covering all types of spent fuel and radioactive waste under its jurisdiction and all stages of spent fuel and radioactive waste management, from generation to disposal **(National Programme Mgt.)**	1.1 Establish the national policy and plan for radioactive waste and spent fuel management activities, from generation to disposal **(Programme Planning)**	1.1.1 Establish and maintain a national plan for radioactive waste management, including a nuclear fuel cycle strategy (e.g., open or closed cycle) for those countries with, or intending to use, nuclear power as well as management strategies for wastes which do not need deep geological disposal **(National RWM Policy).**
		1.1.2 Develop and maintain broad timescales and schedule for implementing radioactive waste management activities using a stepwise decision-making process **(Timetable for decision making)**
		1.1.3 Ensure that public information on radioactive waste and spent fuel and a process for public participation are available **(Public information and participation**)
		1.1.4 Establish a process for progressive development and optimization of the plan **(Safety, security, use of resources)**
	1.2 Establish and maintain a national regulatory and organisational framework for the timely implementation of all steps of spent fuel and	1.2.1 Establish and maintain a competent and independent regulatory body and system for licensing **(Licensing framework)**

	radioactive waste management, from generation to disposal **(Programme Organisation)**	1.2.2 Establish regulatory criteria for waste management facilities, based on international standards (**Licensing criteria)**
		1.2.3 Establish and maintain organizational structures or license holder(s) having overall clear responsibility for any activity or facility related to the management of spent fuel and radioactive waste **(Allocate responsibilities)**
		1.2.4 Implement a system of appropriate oversight, a management system, regulatory inspections, documentation and reporting obligations for radioactive waste and spent fuel management activities **(Waste Management System)**
		1.2.5 Establish and implement a research, development and demonstration strategy with activities clearly related to timeframes, concepts, plans, and milestones defined in the national programme **(RD&D strategy)**
	1.3 Ensure that adequate financial and human resources (core capability and supply chain support) are available, and can be adapted, to the changing needs of the programme over many tens of years, from generation to disposal **(Programme Resources)**	1.3.1 Specify a funding mechanism to ensure that adequate financial resources are available when needed for the implementation of the national radioactive waste programme **(Financing scheme)**
		1.3.2 Develop and maintain a technical and management skill base within the programme (core capability), meeting national regulatory competence requirements **(Skills and competence Management)**
		1.3.3 Use the knowledge, technology and experience gained internationally and co-develop RD&D where possible to improve and consolidate confidence in the scientific and technical data base, to help reduce risks to successful programme implementation and to avoid unnecessary costs **(International cooperation)**

		1.3.4 Work collaboratively with delivery and specialist organisations nationally and internationally to obtain value for money **(Procurement & Supply Chain Arrangements)**
	1.4 Establish and maintain a national inventory of radioactive wastes **(National inventory)**	1.4.1 Develop and maintain an inventory of all spent fuel and radioactive wastes from all sources and activities, together with estimates for future quantities arising, including the characteristics, location, ownership (responsible organisation) and amounts, in accordance with an appropriate classification scheme **(National radioactive waste inventory)**
	1.5 Identify and select appropriate disposal routes and concepts for the national radioactive waste inventory (**Management Solutions)**	1.5.1 Identify and evaluate potentially available concepts and technical solutions for spent fuel and radioactive waste management, taking account of national or local conditions, such as available predisposal and storage options, geological environments, national technical and economic resources and expertise etc. **(Integrated waste management routes and strategic options)**
		1.5.2 Perform iterative evaluation of options and concepts at each stage of programme development taking account of international technological advances **(Options and concept selection)**
2. PREDISPOSAL		
Theme	**Sub-theme**	**Domain**
2. In conjunction with waste producers, identify and deliver solutions to optimise the management of radioactive waste throughout the predisposal phases of the radioactive waste management programme **(Predisposal)**	2.1 Planning predisposal management of radioactive waste in close cooperation with waste producers **(Planning)**	2.1.1 Evaluate waste inventory from producers and existing storages, accounting for future waste generation and evolution **(Inventory)**
		2.1.2 Identify parameters and metrics for waste acceptance criteria through whole life cycle **(Waste Acceptance Criteria)**

		2.1.3 Assess potential technologies for implementation phase, considering cost-benefit ratio and availability **(Technology selection)**
		2.1.4 Evaluate options to apply waste hierarchy to minimise waste volumes at higher impact inventory disposal levels **(Waste hierarchy)**
	2.2 Implementing predisposal management of radioactive waste to support key risk and hazard reduction, and to help reduce costs and save space at interim storage and disposal facilities **(Implementation)**	2.2.1 Sort, characterise, classify and quantify radioactive waste in accordance with requirements established or approved by the regulatory body **(Characterisation)**
		2.2.2 Minimise the quantity and volume of radioactive waste through pre-treatment and treatment **(Treatment processing)**
		2.2.3 Stabilise waste by conditioning prior to long-term storage **(Conditioning)**
		2.2.4 Package waste accounting for future transport and deposition, and maintain safe interim storage of packages **(Storage)**
		2.2.5 Transport radioactive wastes between facilities in accordance with regulatory requirements **(Transport)**
	2.3 Enhancing predisposal operations through iteration with waste producers and repository operators, to develop and deliver safe and cost-effective solutions **(Operations)**	2.3.1 Implement quality system and management system to ensure accurate detailed records of waste and package characteristics over their lifetime, from production until deposition **(Quality & Management Systems)**
		2.3.2 Evaluate potential for improving and optimising implementation phases with new technologies, to improve costs and environmental impact while maintaining safety and accounting for potential risk scenarios **(Optimisation)**

		2.3.3 Manage secondary waste streams produced during initial processing, for holistic operations **(Secondary waste management)**
3. ENGINEERED BARRIER SYSTEM		
Theme	**Sub-theme**	**Domain**
3. Develop an engineered barrier system, tailored to the characteristics of the waste and compatible with the natural (geological) barrier, that performs its desired functions, for the long-term disposal of radioactive waste **(EBS)**	3.1 Confirm wasteform compositions, properties and behaviour under storage and disposal conditions, including impact on the disposal environment **(Wasteform)**	3.1.1 Spent nuclear fuel **(SNF)**
		3.1.2 Vitrified high-level waste **(HLW)**
		3.1.3 Cemented long-lived intermediate level waste **(Cemented LL-ILW)**
		3.1.4 Other wasteforms such as bituminized waste, ceramics, polymers, non-conditioned or non-encapsulated wastes **(Other wasteforms)**
	3.2 Identify appropriate container materials and designs for each wasteform and their properties with respect to storage and disposal conditions **(Waste packages, for disposal)**	3.2.1 HLW and SNF disposal containers **(HLW/SF disposal containers)**
		3.2.2 LL-ILW disposal containers **(LL-ILW disposal containers)**
		3.2.3 Containers using advanced materials **(Other disposal containers)**
	3.3 Identify appropriate buffer, backfill and seal/plug materials and designs, and confirm their properties, behaviour and evolution for the selected repository concept **(Buffers, backfills, plugs and seals)**	3.3.1 Buffer components under storage and disposal conditions **(Buffer)**
		3.3.2 Backfill components under storage and disposal conditions **(Backfills)**
		3.3.3 Plug and sealing components under storage and disposal conditions **(Plugs and seals)**
	3.4 Confirm integrated EBS system understanding and identify compatible EBS designs and materials for facilities containing multiple wasteforms **(EBS system integration)**	3.4.1 Confirm complete and integrated EBS system understanding, including the design of an optimized interface EBS/repository and the understanding of the interaction with the repository nearfield environment **(EBS system)**

		3.4.2 Confirm that interactions between different EBS materials in disposal areas for different waste types do not compromise the performance of the disposal system **(Co-disposal)**
4. GEOSCIENCE		
Theme	**Sub-theme**	**Domain**
4. Assemble geological information for site selection, facility design and demonstration of long-term safety **(Geoscience)**	4.1 Provide, or confirm a description of the natural barrier system and how it contributes to high level safety objectives **(Site description)**	4.1.1 Develop a model of the host rock and surrounding geological environment, including distributions of rock types, geometry and properties of structural features, geotechnical properties and the hydrogeological and hydro-chemical environment **(Site descriptive model)**
		4.1.2 Describe bedrock transport properties, including retention material properties (diffusion and sorption) of different geological materials as well as flow related properties **(Aqueous transport and retention)**
		4.1.3 Characterize or describe the expected gas generation in the disposal system, its impacts on facility evolution and gaseous transport properties from disposal areas to surface **(Gas transport)**
		4.1.4 Characterize or confirm surface ecosystem properties and their potential evolution in the future **(Biosphere model)**
	4.2 Characterise the potential impact of disposal facility construction and operation on the natural geological barrier **(Perturbations)**	4.2.1 Characterize or confirm the chemical, hydrogeological, geo-mechanical, thermal, geomicrobiological, gaseous and radiation-induced perturbations which may be caused by facility construction, operations or closure and their impacts on long-term disposal system evolution **(Perturbations).**

	4.3 Provide, or confirm a description of the expected evolution of the geosphere (including the repository) in response to natural processes and future human actions **(Long-term stability)**	4.3.1 Assess the expected geological and tectonic evolution and the potential for natural disruptive events and their impacts on the stability of the natural barrier **(Geological and tectonic evolution)**
		4.3.2 Assess the nature of future climate change and landscape evolution and its potential impacts on THMC conditions in the repository host rock (including the repository) and surrounding formations **(Climate change)**
		4.3.3. Assess the effects of future human actions **(Human intrusion by exploration activities, exploitation of natural resources within, above and below the host rock)**
	4.4 Provide a geoscientific synthesis with geoscientific key information with respect to long-term safety and repository layout and construction **(Geosynthesis)**	4.4.1 Provide commented tables with key data, key figures (conceptual models) and comments on the interrelationships of site characteristics, perturbations and long-term evolution (stability). This report should contain the so-called **Geo-Datasets** for long-term safety analyses and repository concepts (layout and construction) for each licensing phase.
5. DESIGN AND OPTIMISATION		
Theme	**Sub-theme**	**Domain**
5. Design a facility that fulfils safety and security requirements and that can be practicably constructed, operated and closed **(Disposal Facility Design and Optimisation)**	5.1 Design and develop a disposal system for the national radioactive waste inventory **(Design)**	5.1.1 Based on the concept evaluation results, establish a detailed requirements management system leading to design specifications for the preferred concept option and practical methods of design and data verification for facility barriers and components **(Design specification)**

		5.1.2 Establish design qualification procedures to confirm that structures, systems and components will perform their allocated safety function(s) in all normal operational, fault and accident conditions identified in the safety case and for the duration of their operational lives **(Design qualification)**
	5.2 Demonstrate and verify that facility components and barriers can be practically manufactured, constructed and installed in accordance with detailed design requirements and specifications **(Constructability, demonstration and verification testing)**	5.2.1 Develop, adapt and/or buy the technology and systems required to be able to construct and then commission the facility **(Pilot-scale, full-scale testing, and active commissioning)**
		5.2.2 Continuously consider how the technical solutions can be optimized and made more efficient, without any negative effect on safety **(Optimisation)**
		5.2.3 Establish reliable manufacturing routes to produce facility barriers and components, and inspections plans for how to test for defects, and overall quality assurance against specified design tolerances and industry standards **(Manufacture, inspection and testing)**
		5.2.4 Utilise available robotics and remote handling technology to optimise facility construction and operations **(Robotics)**
		5.2.5 Simulate facility operations by using remote technologies and models to predict the most important variables of the disposal system implementation processes **(Virtual Reality / Digital Twin)**
	5.3 Prevent theft of nuclear material or sabotage of nuclear facilities and protect sensitive technology, software and information **(Security and safeguards)**	5.3.1 Establish arrangements to ensure that no nuclear material leaves the system and to ensure effective nuclear materials accountancy during transport, operations and closure of the facility, and that such information is suitable for transfer to a future facility operator **(Safeguards).**

		5.3.2 Design and provide physical security measures to ensure compliance with regulatory security arrangements for transport and disposal of radioactive materials **(Security and physical protection).**
	5.4 Develop and maintain operational safety case to demonstrate that the construction, operation and closure of the disposal facility will meet safety standards and be robust against potential faults such that the associated risks are restricted to levels that are as low as reasonable practicable **(Operational safety)**	5.4.1 Identify construction hazards or risks, and implement measures to eliminate these or provide a means of preventing the outcome, protecting those affected and reducing the consequences **(Construction and Non-Radiological Safety)**
		5.4.2 Identify operational hazards or risks, and implement measures to eliminate these or provide a means of preventing the outcome, protecting those affected and reducing the consequences (**Normal operations safety**)
		5.4.3 Perform design basis accident analysis and optimise with mitigation options for risk reduction for identified faults **(Accident safety)**
		5.4.4 Demonstrate criticality safety during operations and determine the likelihood and impact of criticality in the long-term **(Criticality safety)**
	5.5 Establish and implement an overall plan for meeting with national requirements for monitoring, and if required, reversibility and/or retrievability requirements. **(Monitoring and Retrievability)**	5.5.1 Establish plans and methods for implementing baseline environmental monitoring programme ready for the start of site characterisation **(Baseline monitoring)**
		5.5.2 Establish plans and methods for implementing a monitoring program for the construction and operational phase of the repository **(Monitoring during Construction and Operations)**
		5.5.3 Establish technical feasibility of retrieving the waste after emplacement, and if required, demonstrate in full-scale representative conditions before the start of operations **(Retrievability)**

6. SITING AND LICENSING		
Theme	**Sub-theme**	**Domain**
6. Engage effectively and demonstrate to regulators (and the public) that a properly sited disposal facility will protect people and the environment at the time of disposal and in the very long term, following closure **(Siting and licensing)**	6.1 Establish and implement an overall plan for the site selection process, and identify potential geological environments using available data **(Site selection process**).	6.1.1 Identify key decision points, and develop screening guidelines to enable a facility to be located to match national performance criteria and socio-economic, political and environmental considerations **(Conceptual planning)**
		6.1.2 Identify areas that may contain suitable sites by using the developed screening guidelines **(site evaluation)**
	6.2 Investigate one of more sites to demonstrate that they would be suitable from the safety and other viewpoints **(Detailed site investigation)**	6.2.1 Initiate a site(s) investigation programme to obtain sufficient data to obtain regulatory approval that the site(s) is/are likely to be suitable and whether the final stage of site confirmation would be likely to result in a license application **(Site characterisation)**
		6.2.2 Continue detailed site(s) investigation, confirmation of the site, and preparation of an environmental impact assessment to the level required for construction and operational license application submission **(Site confirmation)**
	6.3 Obtain the necessary land use permits and nuclear licenses to construct, operate and close the disposal facility **(Licensing)**	6.3.1 Engage effectively with local government / regulators / consultative bodies / waste producers by providing open access to information, and that their concerns are appropriately weighted and that they can participate in the relevant decision-making processes **(Stakeholder involvement).**
		6.3.2 Adhere to the licensing process set by national legislation and regulatory bodies (for nuclear installations) and meet the requirements relating to facility authorization **(Regulatory licensing)**
7. SAFETY CASE		
Theme	**Sub-theme**	**Domain**

7. Iteratively quantify and demonstrate, the safety of the disposal system and inform strategic design decisions **(Safety Case)**	7.1 Establish the safety fundamentals as a basis for the safety assessment **(Safety strategy)**	7.1.1 Establish the requirements that must be met to ensure the protection of people and the environment, both now and in the future **(Safety requirements)**
		7.1.2 Establish safety indicators to complement dose and risk, defined relative to overall safety requirements **(Performance indicators)**
	7.2 Combine experimental and field data with scientific understanding and qualitative observations to construct models of the possible future behaviour of the disposal system **(Integration of safety related information)**	7.2.1 Maintain and develop a synthesis of all available information relevant to facility safety, required for regulatory compliance, and to guide forward disposal programme activities **(Safety case production)**
		7.2.2 Establish a system and adopt international good practice for information, data and knowledge management, modelling, transfer, and preservation **(Information, Data, and Knowledge management)**
	7.3 Assess radiation risks and assure adequacy and quality of all the safety related work associated with the facility or activity **(Safety Assessment and Tools)**	7.3.1 Quantify how the facility and its components behave and evolve to provide continuing safety (**Performance assessment and system models)**
		7.3.2 Characterise uncertainties and determine their implications for the outcome of the safety assessment (**Treatment of uncertainty)**
		7.3.3 Evaluate post-closure features, events and processes relevant to safety to create plausible scenarios of disposal system behaviour **(Scenario development and FEP analysis)**