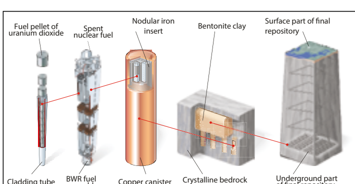
Radioactive Waste Management and Decommissioning
2019

Preservation of Records, Knowledge and Memory (RK&M) Across Generations

Developing a Key Information File for a Radioactive Waste Repository



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Radioactive Waste Management and Decommissioning

Preservation of Records, Knowledge and Memory (RK&M) Across Generations:

Developing a Key Information File for a Radioactive Waste Repository

NEA No. 7377

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Cover photo: The KBS-3 method (SKB); The Manche repository (Andra).

Dedication

This report is dedicated to our friend and colleague, Dr Abraham (Abe) van Luik, who was a key member of the RK&M team and an enthusiastic proponent of the key information file (KIF) concept. Abe was the lead author of the example KIF for the Waste Isolation Pilot Plant (WIPP), but passed away in July 2016, prior to the report being completed. He is sorely missed.

Acknowledgements

The NEA would like to thank the many who contributed to the RK&M Initiative (2011-2018), by direct participation as a member, by participating in particular project meetings, workshops or conferences, by responding to project questionnaires or by contributing to project documentation. The main part of this KIF concept report was drafted by Simon Wisbey (RWM-NDA), the Annexes A.1, A.2 and A.3 were drafted by Abe Van Luik (US Department of Energy), Sofie Tunbrant (Swedish Nuclear Fuel and Waste Management Company) and Jean-Noël Dumont (Andra), respectively.

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List of abbreviations and acronyms

BWR	Boiling water reactors
CEA	Alternative Energies and Atomic Energy Commission (France)
CRA	Compliance recertification application
DOE	Department of Energy (United States)
EPA	Environmental Protection Agency
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
KIF	Key information file
KM	Knowledge management
NEA	Nuclear Energy Agency
PWR	Pressurised water reactors
RK&M	Records, knowledge and memory
RWMC	Radioactive Waste Management Committee (NEA)
SER	Set of essential records
TRU	Transuranic waste
UNESCO	United Nations Educational, Scientific and Cultural Organisation
WIPP	Waste Isolation Pilot Plant (United States)

Chapter 1. **Introduction**

Waste is a material with no inherent "value", which has hence led to the prevailing human philosophy that its disposal must be at the lowest possible cost. Historically, approaches to the handling of waste have often simply been to dump them, based on the belief that the environment has an infinite capacity to absorb, degrade and disperse the waste. Industrialisation has led to a massive increase in the scale and toxicity of waste, and the environmental movement has played a significant role in focusing attention on proper waste management.

Since its discovery in the late 19th century, many countries have exploited the sub-atomic processes that define radioactivity. Rapid scientific development and technological application in the industrial, medical and military fields have resulted in the production of different forms of radioactive waste. These range, for example, from the large volumes of mining waste associated with uranium extraction, through the waste produced by nuclear power plants, to the discrete sources used in medical therapies or in industrial processes.

Humans and the environment need to be protected from the radioactive emissions of higher activity waste, for periods extending up to many thousands of years. The international consensus today is that waste items should be managed through a policy of "concentration and containment". Disposal facilities will consist of engineered barriers, working in combination with natural barriers, to isolate and contain the waste so that its radioactive nature cannot cause harm to life forms and the environment.

These facilities will be implemented and operated over several decades. Once closed, they are to remain safe for millennia. Radioactive waste disposal repositories are designed to be intrinsically safe, such that safety does not depend on human presence and intervention. There is nonetheless no intention to forgo, at any time, the records, knowledge and memory (RK&M) of the repository and the waste it contains.

The NEA Radioactive Waste Management Committee (RWMC) has created an international initiative to address the challenge of preservation of Records, Knowledge and Memory (RK&M) across generations. Experience indicates that RK&M need to be actively managed from the start of waste management programmes. RWMC member organisations are committed to work together and support national programmes to move forward in this area.

The international RK&M Initiative consists of a work programme supported by experts from 14 countries and 2 international organisations. The following guiding principles were established early in the initiative:

- maintain RK&M for a radioactive waste repository after its closure in order to allow future members of society to make informed decisions regarding the repository and its contents, and to help prevent inadvertent human intrusion;
- enable future members of society to make informed decisions as part of a responsible, ethically sound and sustainable radioactive waste management strategy;
- acknowledge that preparing for RK&M preservation is best addressed while waste management plans are being designed and implemented in;
- create systems that are flexible and adaptable over time for preserving RK&M;
- engage a "systemic" approach whereby the various components of the RK&M scheme complement each other, provide for redundancy of message communication and maximise the survivability of a recognisable message.

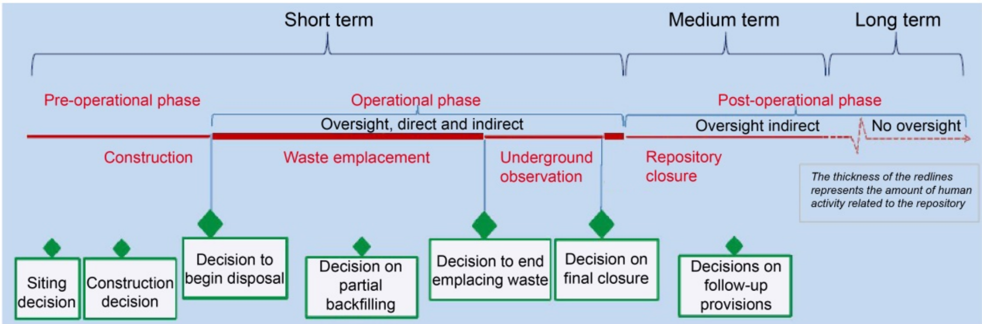
In accordance with the recommendations of the International Commission on Radiological Protection (ICRP), as related to the geological disposal of long-lived, solid radioactive waste, the development of a coherent RK&M system is thus being undertaken. The concept of oversight or "watchful care", which was developed in ICRP-122, has been specifically identified as the crucial factor that influences the application of the protection system over the different phases in the lifetime of a disposal facility. Three main time frames have been 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, special administrative bodies or the society in general;
- time of no oversight, when oversight is no longer exercised and the memory of the disposal facility is lost.

These reference time frames correspond to the "short term", "medium term" and "long term" in the RK&M Initiative.

This report forms an integral part of the formal output of the NEA RK&M Initiative, which has issued a series of reports during its activities under the NEA RWMC auspices. 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.

Figure 1. **Relationship between project phases (according to ICRP-122) and RK&M time frames**



Chapter 2 of this report outlines the RK&M system proposed by the NEA RK&M initiative, with Chapter 3 setting out the purpose of the KIF. Chapter 4 then describes the approach to the implementation of a KIF for any national disposal programme. Chapter 5 provides a summary of possible approaches for the transmission and retention of a KIF, and Chapter 6 describes how responsibilities for the development of a KIF might be assigned. The report ends with conclusions in Chapter 7. The annex provides examples of draft KIFs being developed in France, Sweden and the United States.

Chapter 2. **A preservation strategy for RK&M**

The overarching vision for the RK&M Initiative is the development and publication of a "menu" of tools and techniques to preserve information about radioactive waste disposal facilities. National disposal programmes can then select components from this menu, taking account of legal requirements, to create a varied system that maximises the likelihood of RK&M transfer and survivability over various timescales. The combination of mechanisms would be chosen on the basis that they provide robustness through reinforcement, cross-referencing, diversity and redundancy.

The menu contains a range of "approaches":

- memory institutions;
- culture, education and art;
- international mechanisms;
- markers;
- time capsules;
- oversight provisions;
- regulatory framework;
- knowledge management;
- dedicated record sets and summary files.

Each of these approaches is composed from sub-components or "mechanisms", for which unique descriptions have been developed within the RK&M initiative, based on a standard template.

A possible preservation strategy for RK&M would, for example, combine formal archives and physical marker programmes, supported by the creation of incentives for the local retention of memory.

Information retention and transmission

The RK&M initiative thus promotes an RK&M preservation strategy based on simultaneous, redundant and independent pathways. It is labelled "dual-track" where it takes advantage of mediated and non-mediated transmission into the future.

In the case of *mediated transmission*, information is passed on from one generation to another. Each generation may review the information and undertake the necessary steps to ensure the continuity of readability (legibility and language), and understandability (comprehension and context).

Non-mediated transmission places no reliance on the presence of intermediaries and the information is delivered directly (e.g. in its original format) from the present time to the future receiver. It is recognised that the two tracks may address different target audiences and consider different levels of detail and different technical means to achieve survivability.

RK&M preservation approaches

Memory institutions

Archives are defined through their long-term mission, to preserve collections of records for future generations, with no time limit. They are therefore a key institutional component of the RK&M preservation process. Depending on their respective aims and scope, different types of archives (e.g. national, regional, cultural and nuclear), may play a different role in preserving and granting access to relevant records. Libraries and museums are other types of memory institutions that may, through their mission, contribute to keeping alive the awareness and memory of the repository.

Culture, education and art

This approach refers to a series of cultural, educational and artistic mechanisms for dealing with the legacy of a group or society that is inherited from past generations, maintained in the present and bestowed for the benefit of future generations. It includes tangible elements (such as buildings, man-made landscapes, books and works of visual art), intangible elements (such as folklore, traditions and teaching) and can also include elements from the natural world (such as culturally significant landscapes).

RK&M mechanisms within the fields of culture, education and art are often mediated and participatory. It is acknowledged that what may become part of culture, education and art is not easily predefined or controlled. Topics of interest in these fields change over time and are subject to continuous reinterpretation. Nevertheless, they can be powerful frameworks for RK&M preservation.

International mechanisms

There is potential for international mechanisms to foster the preservation of RK&M over the scale of a few hundred years, corresponding to the periods of “direct” and “indirect” oversight of a repository. They can be governmental (for example the agencies of the United Nations, or formal conventions between nations), or non-governmental (for example private initiatives). Analysis shows that international mechanisms can contribute significantly to the preservation of RK&M. To this end, a few promising mechanisms have been identified, for example the UNESCO Memory of the World Programme or the International Atomic Energy Agency (IAEA) International Nuclear Information System (INIS) database.

Markers

Markers are long-lasting objects, placed strategically at or near the site for immediate recognition, or for discovery at a later time. These objects would be designed to inform future generations in the medium to long term. Any marker should be conceived to be immobile, robust and provide messages that are likely to be understandable across generations. A marking system can range from a simple stone to a contrived and monumental multi-component system. Depending on their material, structural design and intended time scope, the information that markers are intended to carry can range from “this is man-made” to much more elaborate technical content. A wealth of ideas, technologies and materials has been proposed for markers, both on the surface and underground, including berms, magnets, radar reflectors, small ceramic tokens, tracers, acoustic signals and coloured backfill materials.

Time capsules

A time capsule is a purpose-built, sealed enclosure containing a historic cache of records to be used as a means to inform future generations at a specified time or upon inadvertent discovery. Some time capsule projects involve the periodical opening and reclosing of the capsule. Time capsules could be seen as a distinctive category of historical record preservation, which supports and complements archives and site markers. It has been suggested that surface marker systems might incorporate time capsules, and that small time capsules could be placed at depth, at or near the repository horizon. Placed strategically underground, these markers could act as awareness triggers in case of inadvertent excavation at the repository site.

Oversight provisions

Oversight is a general term for “watchful care” and refers to society “keeping an eye” on the technical system and the actual implementation of plans and decisions. The concept provides a useful framework to view technical monitoring activities and societal engagement as parts of a unified whole. Society cannot undertake this effectively without information relating to the disposal site, so the preservation of RK&M is an essential part of future societal oversight of the repository. Planning for oversight should start when the siting procedure begins. In order to design an optimal approach to oversight, it is important to harmonise social and technical demands and mechanisms. Involving local and regional stakeholders as part of a well-designed oversight process from the beginning of the disposal project, will encourage strong links between the local and regional populations and the repository.

Regulatory framework

A comprehensive regulatory framework is regarded as a key factor in preventing the loss of RK&M in the short and medium term. The national regulatory framework (i.e. laws and ordinances, supplemented by requirements and guidelines) drives the national disposal strategy and needs explicitly to address the requirements and main responsibilities for national RK&M preservation. The regulatory framework can also include provisions for land-use control. Land-use control can prevent potentially harmful inadvertent human action, and add value to RK&M by preserving records and memory concerning the former use of the land.

International safeguards arrangements, designed to prevent unauthorised access to and use of nuclear materials, constitute another mechanism of the regulatory framework approach. Safeguards are currently co-ordinated through the IAEA, which advocates the importance of measures to ensure a continuity of knowledge of the nuclear material inventories in the disposal facility.

Knowledge management

Knowledge management (KM) is a general term that encompasses the process of creating, sharing, using and retaining knowledge and information held by individuals and organisations. Although knowledge is also considered to be held corporately, most approaches to KM involve people. In such cases it is, by definition, a mediated form of transfer, requiring co-operation and commitment. The required timescales for the effective application of KM can vary widely, from transient commercial projects to intergenerational mechanisms that span hundreds or thousands of years. Corporate use of KM techniques on the shorter timescales is now relatively common, and there is significant potential for this experience to be applied to the preservation of RK&M.

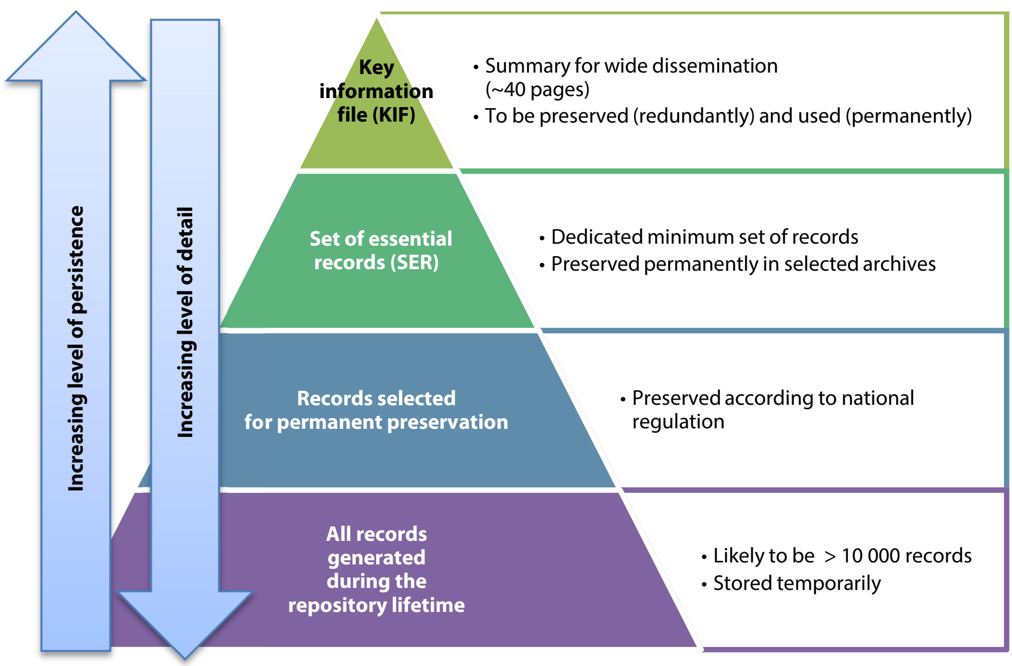
Dedicated record sets and summary files

The volume of records generated for and by a national radioactive waste facility is likely to be very large and may be difficult to manage. Primary records will be diverse, since they are produced over many decades, against a background of evolving management systems, laws and regulations. Also, the large amounts of data and information are challenging and, for RK&M retention purposes, careful selection and accessible formats thus are key. In order to address these concerns, the RK&M initiative has defined the concepts of a reduced set of essential records (SER) and a key information file (KIF).

The SER would be compiled with a technically knowledgeable audience in mind. The content of any particular SER is expected to vary according to national regulations and legal requirements. Similarly, different stakeholders could identify various sets of records as essential. Rather than using guesswork to decide what a possible future society may want to know, the recommended contents for an SER are being developed in the light of current societal information requirements. The SER will likely consist of multiple documents under the control of existing national laws and regulations.

In contrast, the KIF would provide a standardised summary of the existence, location and content of an engineered facility for the permanent disposal of radioactive waste, set in a particular social, technical and environmental context. It should be written for a broad audience and tell the story of the waste facility. In order to allow diffusion of this report to a large audience, its size would be limited.

Figure 2. **Pyramid of repository records**



Chapter 3. **Purpose of the key information file (KIF)**

The concept of producing a key information file (KIF) emerged when it was recognised that, depending on national laws and regulations, the set of essential records (SER) would likely consist of multiple documents running to hundreds of pages with a rather technical content. The intent of the KIF, on the other hand, is to tell the story of the waste facility in a widely understandable manner (i.e. for an educated but non-specialist readership). It is designed to provide a summary of the existence, location and content of an engineered facility for the permanent disposal of radioactive wastes. It should be a separate, short document, produced to a standard format across national programmes. On this basis, the KIF can contribute to safety, by providing information that should reduce the likelihood of unnecessary human intrusion. Apart from telling the story of the waste facility, it should also point to detailed national records and to the location of other repositories across the globe.

The RK&M initiative used the developing Andra "Synthesis" report for Centre de la Manche as the basis for the definition of the KIF purpose, functional requirements and key principles for the content and development process.

Key principles

The following key principles have been established for the development of the KIF:

1. The KIF should provide relevant information to future generations, to help protect the passive performance of the disposal site and to enable any necessary decision making.
2. The KIF should identify the hazard presented by the waste, describe the reduction in hazard with time, and set out the engineered and natural barriers that prevent human contact with the radioactive wastes.
3. The KIF should be written, as much as possible, in a succinct and non-technical manner. Where necessary, technical context should be provided to prevent ambiguous interpretations of the information.
4. The KIF should be produced in an internationally standardised format, be distributed widely and be available in the local language plus any other official language of the country. Parts of it may also be provided in multiple languages, typically the international "official" languages used by the United Nations (currently Arabic, Chinese, English, French, Russian and Spanish).

5. The KIF should be preserved as a publicly available document, with copies preserved in formats and locations that are easily located and accessed, so that it is readily available to all potentially interested parties.

6. The KIF should point to the planned preservation of more detailed information about the disposal facility, its content and associated safety case.

7. The KIF should be managed using available and suitable records management system techniques as appropriate. Noting that the peculiarities of the KIF concept pose unique challenges to its proper management, a dedicated "KIF management system" may need to be formulated and installed.

8. Since the KIF should tell the story of the disposal facility and aims to be widely available and comprehensible, a multidisciplinary and participatory process is recommended for its development, testing and dissemination. The process of developing and disseminating the KIF should receive as much attention as its content.

Proposed structure

Working from the "Andra Synthesis" report, key items were identified and expanded to produce the following list:

- context – origin and purpose, nature of radioactivity and radioactive wastes;
- location – natural setting, radiation baseline;
- design – repository design, key engineered structures and features, package types;
- inventory – key hazards and time profile, non-radioactive toxic components;
- safety – potential impacts and barriers, waste isolation and containment, human intrusion;
- summary – updating schedule, distribution;
- details – how to access a more detailed record.

This developed list was used to construct a proposed structure for drafting a KIF, which is presented below, with typical contents. Early testing of this structure is reported in the annex of this report – insights from those tests indicate that this should not be seen as a rigid structure. Specific repository projects are likely to organise and emphasise information in different ways, leading to slight variations of the structure set out below.

Table 1. **Key information file: Proposed structure (prior to testing)**

Section	Title and typical contents
0.	Purpose and contents of this document (to be provided in several languages).
1.	Disposal context: • nature of radioactivity/radioactive waste; • how this waste was produced; • expected lifetime of the facility; • key dates; • regulatory provisions in force.
2.	Facility location: • repository co-ordinates (latitude/longitude/depth); • geological setting; • baseline "hydro-geo-chemical" parameters at time of closure; • provisions for site monitoring (scope and timescale).
3.	Container and facility design: • container types used; • engineered features; • access and closure.
4.	Disposal inventory: • radionuclides and waste properties; • toxic components; • hazard evolution profile; • calculation of disposal inventory from residual isotopes.
5.	Safety case: • safety principles (isolation and containment); • anticipated radiological impacts (natural evolution); • impact of human disturbance.
6.	Disposal records: • updating schedule for the KIF; • distribution of the KIF; • location and distribution of detailed records.
7.	List of similar repositories in the world (to be provided in several languages): • co-ordinates of disposal facilities; • co-ordinates of records retention.

Chapter 4. **Implementation**

This chapter provides context and guidance on the developed table of contents set out in Table 1 (Chapter 3), to indicate the expected level of information.

Section 0. Preliminaries

Purpose and intent

This section of the key information file (KIF) has a simple aim, namely to provide a general introduction to the document, describing its overall role as part of a comprehensive RK&M system.

Guidance on content

This introductory material should set out the purpose of the KIF, which is primarily to inform generations that live after the closure of the disposal facility about its existence, its location, its contents and its rationale. It should provide a standard overview of the contents of the whole KIF, in the form of an annotated contents list, and record the date of issue. Ideally, this section should be provided in several languages, but it is recognised that this may be impractical for working drafts, in which case it should be provided in the official language(s) of the host nation, and the current lingua franca (in the early 21st century this is English).

Section 1. Disposal context

Purpose and intent

This section of the KIF is intended to provide an overview of the disposal facility, setting out the waste inventory "challenge" and the need for its isolation from the biosphere.

Guidance on content

The authors may wish to provide a condensed summary of the nature of radioactivity, its discovery and industrial applications, leading to the production of radioactive waste. This may include a simplified description of how the wastes were produced, the amounts that accumulated and the intensities of their radioactive emissions. The concept of half-life and the range of timescales involved would lead to a conclusion with respect to the time frame on which the facility was designed to operate.

The time period over which the wastes were produced, stored and eventually disposed of would provide valuable context and could be related to more than one date convention. The fact that the protection of humans and the environment is the subject of regulation should be recognised here, as it provides a key item of context for the existence of a repository.

Section 2. Facility location

Purpose and intent

This section is intended to provide an unambiguous description of the geographical location and geological setting of the facility, so that discovery of the KIF will confirm, restore or renew that knowledge for the reader.

Guidance on content

This section should report the detailed co-ordinates of the facility (latitude/longitude/depth), using the global system(s) in force. If possible, these should include non-arbitrary reference points. The geological setting should, in general terms, describe the spatial distribution of rock types and geological structures in the repository area. Information should be included to describe the baseline hydrological and geochemical characteristics of the disposal system, as they were determined at the time of development and closure. If for the period of indirect oversight continued monitoring activities are foreseen, the nature and extent of these should be described.

Section 3. Container and facility design

Purpose and intent

This section should provide an outline description of the engineered facility, including its barrier features and the means used for access to the disposal areas during its operation, and for their final closure. It should also describe the containers used for the wastes. Together this information should enable the reader to understand the design intent of the facility, and to make sense of evidence or records (possibly fragmentary), which have been obtained from other sources.

Guidance on content

It will be necessary to avoid providing too much detail in this section. Full engineering specifications will not be required, as general arrangement drawings would provide the reader with adequate information. This section should reassure the reader that the facility was well planned and executed. The various engineered barriers need to be set out in sufficient detail that their intent and mode of operation (even if passive), is clear and unambiguous.

The design of the primary containers, including the materials of their construction and expected performance parameters, should be included. This would logically lead to a description of the engineered features and barriers that constitute the disposal facility. The method of access during facility operations and of closure of the filled facility would provide valuable information to support a future interpretation of "evidence" for the facility.

Section 4. Disposal inventory

Purpose and intent

The contents of this section should provide the reader with enough information about the disposal inventory to provide understanding of the hazard and its evolution with time.

Guidance on content

Both radioactive and non-radioactive (toxic) materials will be present and both should be described, including a summary of their chemical and physical properties, in order to give a complete picture. The hazards represented by these materials should be identified by provision of information on their decay modes and half-lives as appropriate. Reference date(s) should be given for the radioactive components, so that time-based calculations can be conducted if required.

Section 5. Safety case

Purpose and intent

This section is designed to set out the basis of the safety case for the disposal facility, as approved by relevant regulator(s), to inform the readers about the estimated radiological impacts from passive performance of the facility. It should also show that significant disturbance to the natural barriers could affect these estimates and alter the expected performance.

Guidance on content

It will be important to avoid too much detail in this section. It should be sufficient to briefly describe the expected evolution of the repository system and how the important aspects of isolation and containment are ensured by the technical and natural barriers. Reference can be made to detailed numerical modelling, which may include probabilistic calculations, to provide confidence that the performance of the facility was analysed using appropriate techniques at the time of closure.

As disposal facilities rely on passive evolution, it will be important to emphasise the potential disbenefits of disturbing the natural and technical barriers. This is likely to constitute a warning not to intrude into the facility by excavation or drilling.

For near-surface disposals, land-use controls would be particularly valuable to prevent the direct consequences of disturbance before the end of the planned surveillance. Reference should be made to monitoring for safeguards purposes during the operational phase and early post-closure period, which should also help to prevent inadvertent intrusions.

Section 6. Disposal records

Purpose and intent

This section of the KIF will be somewhat self-referential, providing a summary of how it was developed, updated, reviewed by regulator(s), distributed and stored. This is designed to build confidence that the process of development and completion for the KIF was conducted carefully, professionally and in a participatory manner, so that the end product can be seen as a reliable summary of the disposal system.

Guidance on content

The schedule for production of the KIF, from its initiation to final updating, should be set out. This should identify any changes to the inventory, the safety case or the regulatory regime in force during the operation and closure of the facility. The intended distribution and retention of copies of the KIF should be listed, so that other copies can be located if required. The intended location and distribution of more detailed records, including the set of essential records (SER) and the full repository disposal record, should also be identified.

Section 7. List of similar repositories in the world (to be provided in several languages)

Purpose and intent

This section is designed to provide for cross-referencing between disposal facilities across the world. The more that they identify each other, the more likely it is that some record of them will remain available to future society.

Guidance on content

The text should recognise that the global use of nuclear power and radioactive materials will inevitably lead to multiple disposal facilities around the world. If each of these produces a KIF that refers to similar facilities, then it is likely that multiple references to each facility will be available around the globe. Each KIF should refer to the unique location co-ordinates of the other facilities and to any formalised collection of records, such as nuclear archives. Ideally this section should be provided in several languages, but it is recognised that this may be impractical for working drafts, in which case it should be provided in the official language(s) of the host nation and the current lingua franca (in the early 21st century this is English).

Additional observations on implementation

The relevant information required to populate the KIF will need to be provided as soon as it becomes available, be it during construction, operation or after closure of the disposal facility. Delays in compiling this information, or in developing and issuing the KIF, should be avoided as these will inevitably lead to loss of information and expertise. Other key risks to the quality of the KIF are likely to include loss of context, lack of attention to the non-technical style and to understandability by the targeted audience, failure to update and/or finalise some technical sections, and failure to share and distribute copies and updates.

The main concerns over technical accuracy can stem from the absence of an appropriate reference date(s) for the disposal inventory and the potential to confuse design intent information with "as built" data. If either of these issues comes to light in the future, it is likely to reduce confidence in the implementation of the disposal facility and have the potential to raise questions about the safety of the passive operation of the facility. Therefore, it is essential that design intent information is unambiguously marked as such and replaced by "as built" data as soon as practicable.

Finally, it is important to note that the KIF is designed as a summary document. It must point to the existing and planned preservation of more detailed information about the disposal facility, its content and associated safety cases. Thus the KIF should identify the SER and full archive records.

Care should be taken to ensure that the KIF does not become a long document. This will require skilful drafting and careful editing. It is recommended that the final KIF should be in the order of 40 printed pages.

Chapter 5. **Transmission and retention**

The key information file (KIF) should be preserved as a publicly available document – there would be no intention to control access to it from a security or confidentiality perspective. The KIF would therefore need to be preserved in formats and locations that are easily located and accessed, making it readily available to all potentially interested parties.

Methods of transmission

The KIF may be subject to both mediated and non-mediated transmission. Taking non-mediated transmission first, the longevity of a KIF would be based on the use of quality, degradation-resistant materials, and a wide distribution of a significant number of copies. The intention would be that despite the inevitable loss of copies, one or more examples would survive for an extended period of time.

Turning to mediated transmission, the KIF could be reissued on a defined timescale, thus reminding the relevant population of the facility and replacing ageing versions with new ones. This would also provide an opportunity to review the wording and understandability of the text, and to choose new materials to improve longevity. The timing of such updates would ideally be pre-planned, potentially in synchrony with updates of the set of essential records (SER) and detailed records, and may be chosen to coincide with other cyclic events, which may include those with connections to cultural heritage or monitoring.

Use of archives

In the context of the RK&M initiative, archives are defined through their long-term mission to preserve collections of records for future generations, with no time limit. They are therefore a key institutional component of the RK&M preservation process and should be considered as a key location for distribution and preservation of a KIF. Depending on their respective aims and scope, different types of archives (e.g. national, regional, cultural and nuclear), may play a different role in preserving and granting access.

Although similar to archives, libraries tend to operate under a different regime, allowing free access to their material. While this is in line with the need for easy access to the KIF, the potential for record loss is quite significant. The most promising aspect of libraries with respect to the task of preservation might be to ensure that copies are also lodged in academic research institutions, which are less vulnerable to changing stock and funding crises.

Use of time capsules

A time capsule is a purpose-built, sealed enclosure containing a historic cache of records to be used as a means to inform future generations at a specified time or upon inadvertent discovery. Large time capsules at or near the land surface provide a very visible indication of the facility and may contain copies of the original KIF, alongside other records. Small time capsules, possibly made of the same material as the waste containers, could preserve actual records, such as a KIF, possibly miniaturised on long-lasting support materials. The discovery of such materials could trigger a new campaign of oversight. Embedding time capsules in important cultural settings, coupled with their public opening at certain specific times, also suggests that time capsules can become part of cultural heritage.

Additional observations on transmission

It should be recognised that there is potential for confusion, particularly in the case of mediated transmission, over the existence of draft or interim copies of a KIF, which may contain incomplete material. All issues of the KIF should be dated, and the formal updating or re-issue of a KIF would ideally be accompanied by withdrawal of a previous version. Clearly complete withdrawal of a previous copy may be difficult to achieve with any degree of confidence. This suggests that a system for identifying the latest version might need to be considered, for example the definition of a fixed publication plan, and the identification of any distributed version against that plan.

Despite this, it is recommended that implementation of the KIF should not wait until closure of the facility. Instead, a common understanding that there is only one “valid” KIF for any repository at any one time would be helpful. On this basis, the issuance of the first valid KIF would be a fundamental non-technical milestone in the lifetime of a disposal facility.

Once implemented, the KIF should be “used”, for example in schools, information centres, administration, etc., with these uses forming part of an ongoing participatory process. Proving to be useful in the present provides some confidence in the usefulness of the KIF in the future, and is key to a robust mediated transmission of the KIF into the future.

Chapter 6. **Responsibilities**

The implementation of a key information file (KIF), including ensuring successful transmission across generations, requires the co-operation of a range of key actors. The anticipated range of responsibility for each of these groups is set out in this section.

Government

The national government would normally retain overall responsibility for the disposal facility and the associated administrative and records framework, including the production and issuance of a KIF. The government may essentially “delegate” the practical oversight of this work to designated organisations, including radiological protection and health monitoring bodies, at a national, regional and/or local level. In these cases, the responsibility should be clearly stated in any “client specification”. The implementation of land-use controls would also normally fall to government, although in many cases this would be applied at a local level.

Facility developers

The disposal facility will be managed and operated by a “development body”. Such a body would typically have full operational control of the development and implementation, including closure, of the disposal facility. As noted above, the development of a KIF should normally be produced during the operational and closure phases of a disposal facility, and the “developer” thus has a key role in providing information for the KIF. Depending on national legislation, it is the responsibility of the “developer” to compile, publish and distribute a functional KIF, potentially employing external bodies with an appropriate range of skills and experience to complete the detailed design and implementation of a KIF.

Contractors

The facility developer may wish to employ specialist commercial firms from the supply chain, with an appropriate range of skills and experience, to complete the detailed design and implementation of a KIF. These bodies would typically operate on a profit-making business model, which would require careful oversight and audit by the customer. The production of draft versions, and the update at regular intervals, would normally need to be checked and confirmed by the facility developer, prior to formal publication.

Experts from various disciplines

This broad group of actors includes those who will help to develop, maintain, copy, store and bring attention back to the KIF. Some of these will recognise their role as a professional responsibility, whereas others may act informally, or out of public duty. In this context this may include technical specialists, communication specialists, linguists, archivists and community involvement experts.

Local communities

Although local communities may not have a formal responsibility with regard to the KIF, their participation in the development and implementation of the KIF is highly relevant from the point of view of RK&M preservation.

Additional observations on responsibilities

Establishing and maintaining the chain of command is important, to ensure that any decision that could affect the KIF "system" is referred to an authority at the appropriate level. In this context it may be appropriate to establish a "KIF commission", based on a consortium of relevant bodies (formal or informal), including representatives of the host community.

Similarly, the value of maintaining links with other national programmes that have developed a KIF should be recognised. Such links have the potential for positive re-enforcement of the KIF mission and provide opportunities to learn from experience.

Chapter 7. **Conclusions**

The concept of a key information file (KIF) emerged in response to the challenge presented by the expected large amounts of records and knowledge that national disposal programmes are likely to generate. The KIF is intended to be a single, short document, produced to a standard format across national programmes. Widely distributed and openly available, it is intended to contain some sections in several languages.

The KIF is designed to provide a fully integrated summary record covering all of the aspects of RK&M. In particular it is designed to:

- provide a summary “record”, directing the reader to further detail;
- support “knowledge” through the provision of enough context for an educated reader to draw appropriate conclusions;
- contribute to “memory” by ensuring that successive generations do not forget the location of the repositories.

Because of the long time frames involved in the geological disposal of radioactive waste, many uncertainties exist, and a solution for “perfect knowledge preservation” is unrealistic. It will therefore be key to allow redundancy and to plan for periodic review so as to ensure the transfer of relevant information.

As of 2018, the KIF concept is being tested with encouraging results via the preparation of draft documents for the Waste Isolation Pilot Plant at Carlsbad in the United States (deep geological disposal), the planned repository for spent nuclear fuel at Forsmark in Sweden (deep geological disposal) and the closed Centre de la Manche facility in France (surface disposal) (see annex for further details on these tests).

The concept of a KIF has the full support of the RK&M initiative, which is overseen by the NEA Radioactive Waste Management Committee (RWMC). It is strongly recommended that disposal projects include a KIF in their RK&M planning.

Annex: **Examples of key information files**

This annex consists of extracts from, or summaries of, example KIFs for deep geological disposal (WIPP and Forsmark), and surface disposal (Centre de la Manche). At this early stage, the principles of the KIF, as set out in this concept report, have been applied with some flexibility. This has allowed each organisation to address the issues within their specific national constraints. As a result, comparisons between the three tests presented here may show some discrepancies. Testing of the KIF concept will continue, with a view to developing it to achieve a greater degree of convergence.

These summaries remain under development by RK&M initiative members, who are part of the implementing bodies of the respective countries. They will be finalised in future in a multidisciplinary, participatory manner.

A.1. Overview of the KIF for the Waste Isolation Pilot Plant in New Mexico, United States
(developed by the US Department of Energy)

This synopsis is part of the key information file (KIF) and can also be used as a stand-alone document to inform and support land-use management agencies and jurisdictions.

Section 0. Synopsis

This KIF is dated 2016. This KIF is to be updated with each five-yearly update of the Waste Isolation Pilot Plant (WIPP) Compliance Recertification Application (CRA) to the US Environmental Protection Agency (EPA), until the repository has been sealed and closed.

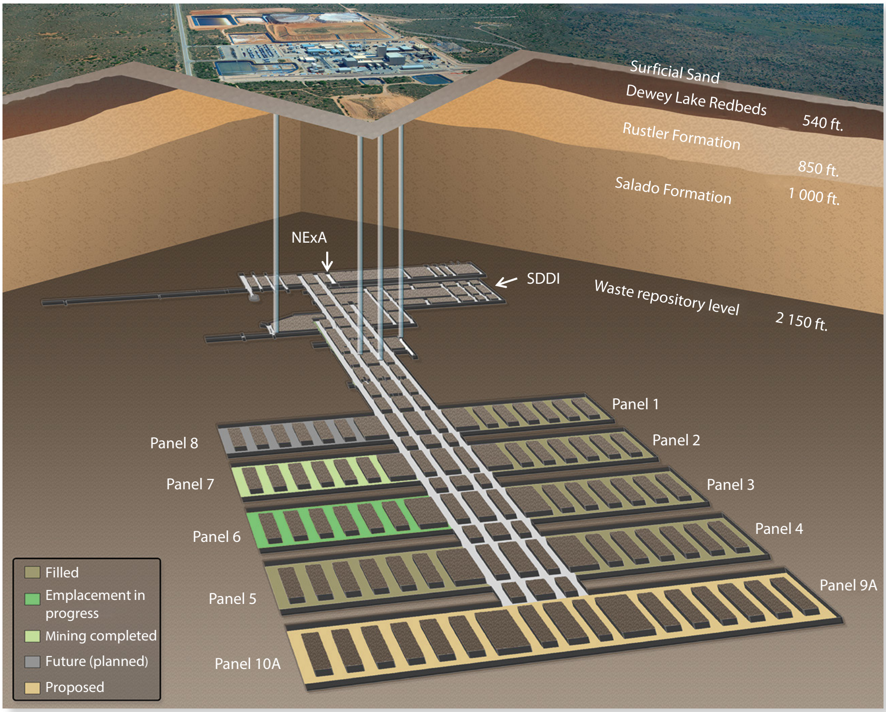
The WIPP is a deep geological repository for the permanent isolation of transuranic (TRU) waste and TRU-mixed wastes from US defence programmes. It is located in the Chihuahuan Desert about 26 miles south-east of Carlsbad, New Mexico. The location co-ordinates are: 32°22′11″N 103°47′30″W.

Figure 0.1 shows a schematic view of the repository layout in 2016, at a depth of 2 150 feet (655 metres) below the ground surface in a thick sequence of bedded salt formations.

TRU waste by definition contains alpha particle emitting radionuclides with a half-life greater than 20 years in concentrations greater than 100 nanocuries (3.7 kilo Becquerel) per gram of waste. The TRU and TRU-mixed waste is classified as either contact handled (CH) or remote handled (RH) based on the contact dose rate at the surface of the waste container. If the contact dose rate is less than 200 millirem per hour (2 milliSievert per hour), the waste is defined as CH-TRU. If the contact dose rate is greater than or equal to 200 millirem per hour (2 milliSievert per hour), the waste and its container are defined as RH-TRU.

A US law, the Land Withdrawal Act (LWA), limits WIPP disposal to 6.2 million ft^3 (175 564 m^3) of TRU waste. The LWA also specifies that only RH-TRU waste less than or equal to 1 000 rem per hour (10 Sievert per hour) is eligible for disposal at the WIPP, and that the emplaced RH-TRU waste is not to exceed a total activity of 5.1 million Ci (~188 700 TeraBecquerel) or a total activity concentration of 23 Ci (851 GigaBecquerel) per litre maximum activity level (averaged over the volume of the canister). No more than five per cent of the emplaced RH-TRU waste may exhibit a dose rate in excess of 100 rem per hour (1 Sievert per hour).

Figure 0.1. Schematic view of WIPP repository layout in 2016

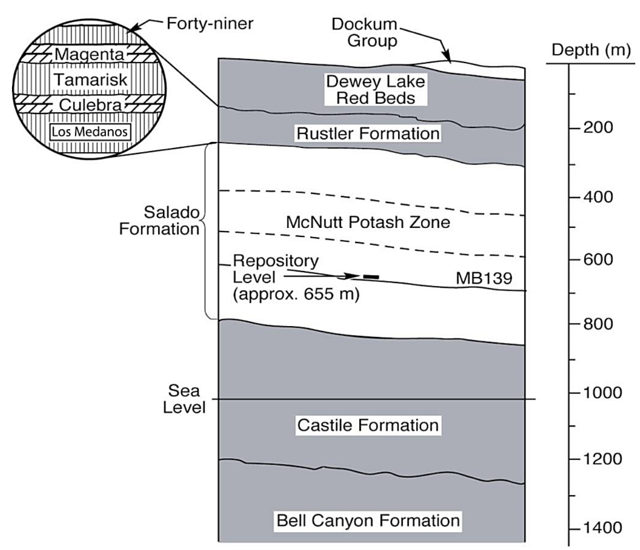


Source: US Department of Energy.

Geologically, the WIPP repository is located in the Delaware Basin of south-eastern New Mexico and consists of a labyrinth of tunnels and rooms excavated in a bedded salt formation of Permian age about 2 150 feet (655 metres) below the land surface. Overlaying the repository horizon are bedded salts, anhydrite layers, siltstones and shales of various thickness and permeability along with two saline persistent water bearing zones labelled the Magenta and the Culebra (Figure 0.2).

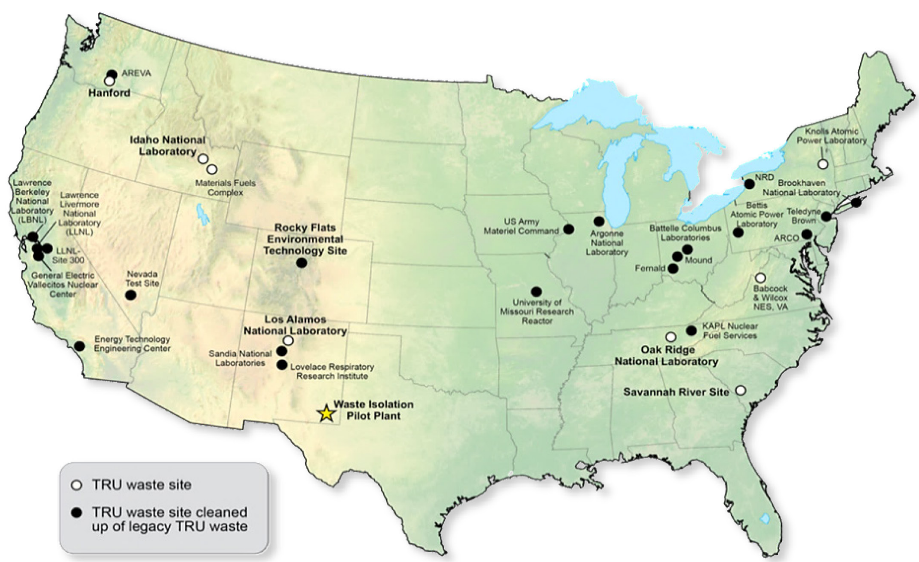
The Department of Energy/Carlsbad Field Office (DOE/CBFO) manages the disposal of transuranic (TRU) and TRU-mixed waste at the WIPP. As shown in Figure 0.3, the WIPP mission is a nationwide mission, with (in 2016) 22 sites that formerly stored legacy defence-related TRU waste now unencumbered by the cost and risk associated with managing this material. Legacy waste from other major sites associated with the nuclear weapons complex, as well as newly generated waste from ongoing missions, will continue to require disposal at WIPP for decades to come. In future, additional missions for waste disposal may be assigned to WIPP by law.

Figure 0.2. Schematic of vertical geologic profile showing repository level in the Salado formation



Source: US Department of Energy.

Figure 0.3. The WIPP transuranic waste isolation mission is a nationwide mission (showing site clean-up status in 2016)



Source: US Department of Energy.

Disposal operations are expected to continue past 2050. Site sealing and closure will be followed by a period of monitoring. Active institutional controls will be maintained for a considerable duration, and passive institutional controls (markers and other means of preserving knowledge, including this KIF) are to be put in place and disseminated to provide a degree of assurance of continuing land-use control.

Below the WIPP and in surrounding areas, oil and gas reserves exist and have been drilled/extracted extensively from deep formations. Drilling is not presently permitted on the land withdrawal area, and ideally in the future, deep excavation or drilling would not be allowed at the WIPP location. However, if future societies feel they are capable of dealing with any waste brought to the surface and will monitor for such an event, some drilling may be allowed to take place by that society; we have no way to control future human actions. However, such a purposeful intrusion would be advertent rather than inadvertent, and the future society engaged in such a purposeful intrusion accepts the inherent risk.

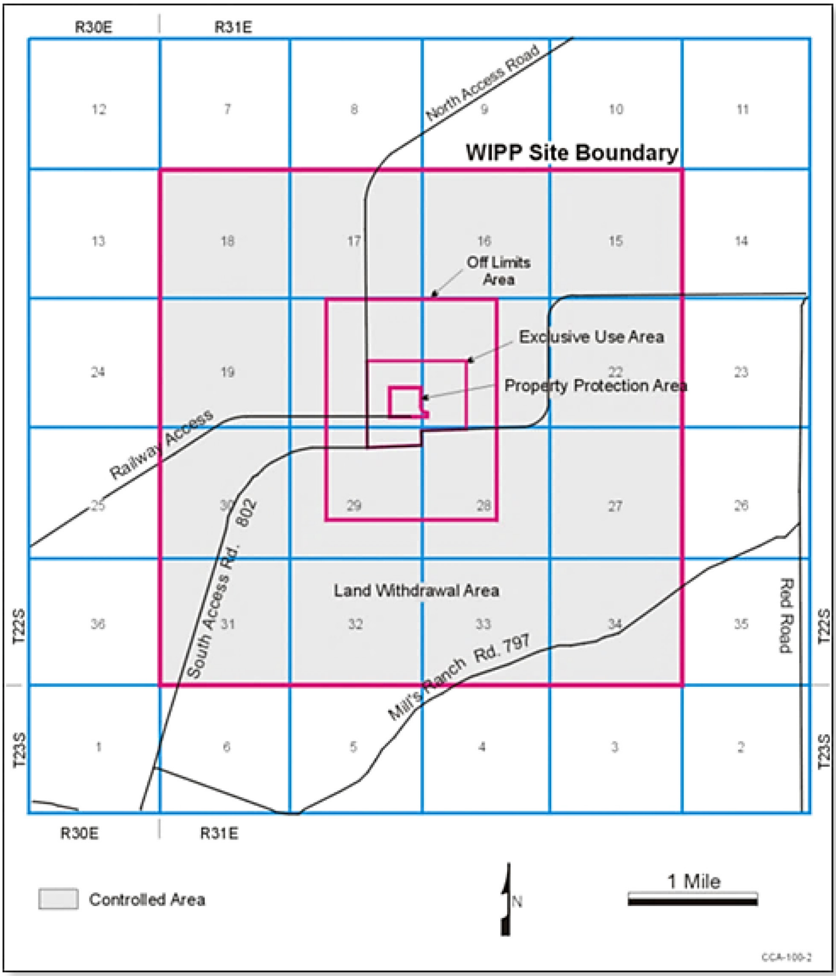
At the present time (2016) the facility has been divided into four areas designated for protection of human health and the environment (see Figure 0.4):

1. The property protection area, which is surrounded by a chain-link security fence that encloses approximately 13.7 hectares (34 acres) and provides security and protection for all major surface structures.
2. The exclusive use area, which is approximately 112 hectares (277 acres) restricted exclusively for the use of the DOE, its contractors, and subcontractors in support of the project and posted against trespass and use by the general public.
3. The off-limits area, which consists of approximately 5.9 km^2 (1 454 acres) posted and managed as off-limits by the DOE.
4. The WIPP land withdrawal area, the 16 mi^2 (41.4-km^2) federal land area under jurisdiction of the DOE and bounded by the WIPP site boundary.

The underground waste disposal area of the repository lies within the bounds of the "off-limits area," which is the area to which long-term land-use controls need to be applied to prevent inadvertent intrusion. Its map co-ordinates can be determined from Figure 0.4. Greater detail on the location of the WIPP facility can be found in Table 0.1.

Long-term safety evaluations of the WIPP repository, updated in the five-yearly CRAs, suggest that no releases will occur from this repository unless there is human intrusion. The natural system, once it is closed around the waste and the room/panel and shaft seals, is impermeable, and if not disturbed will contain the waste essentially forever.

Figure 0.4. The "off-limits area"



Source: US Department of Energy.

The "off-limits area" is the area to which land-use controls need to be applied and maintained to ensure no deep excavation or drilling unless risks have been investigated and mitigation responsibilities are assumed by the intending intruder (the purpose of the land-use controls is to prevent inadvertent intrusion into the repository).

Table 0.1. Detailed description of the WIPP site location

Item	Description
Facility name	Waste Isolation Pilot Plant (WIPP)
EPA identification number	NM 4890139088
Location	41.84 km (26 miles) east of Carlsbad, New Mexico
Latitude	32°22'11"N
Longitude	103°47'30"W
County	Eddy
Section	15-22 and 27-34
Township	22S
Range	31E
Land withdrawal area	41.4 km^2 (16 mi^2)
Property protection area	13.7 hectares (34 acres)
Depth to repository horizon	655 metres (2 150 feet) below grade level

A.2. Overview of the KIF for a deep geological repository in Forsmark, Sweden

(developed by SKB)

A draft key information file (KIF) is under development for the planned spent nuclear repository in Forsmark, Sweden. It provides a brief description of the existence, location and content of the facility, based on information and the safety case submitted to the Land and Environmental Court and to the Radiation Safety Authority in the ongoing licensing process (June 2017).

The Swedish example of a KIF is an attempt to write directly to a future generation (100-200 years) without planned updates or modifications. Below are some examples of the content in the different chapters of the KIF document for spent nuclear repository and reflections from writing it. Sections that would be further developed in a complete KIF are indicated with an ellipsis (…).

Section 0. Purpose and contents of this document

From 1954 to 20xx nuclear power plants are used to generate electricity in Sweden. This resulted in spent nuclear fuel or radioactive waste, which is hazardous. In the year 2085, a final repository for the long-term radioactive waste was sealed in Forsmark, Sweden. The purpose of the repository is the keep the waste isolated for 100 000 years. Given the long time-perspective, preservation of information regarding this facility was considered. This document is part of that work and its purpose is to provide basic information about why the repository was created, what it contains, how it is contained and the possible consequences of disturbing the repository. It also gives some historic context about how society looked at the time this document was written and why electricity was needed. This document is of the lowest level of detail but gives directions to where more extensive information can be found.

Section 1. Disposal context

1.0 Socio-economic background

The global part of this section should, as far as possible, be jointly written with other KIFs that are developed in the same time period. The regional/national part has to be exclusive for each repository or nation, if there are several repositories in a country.

1.1 Nature of radioactivity/radioactive waste

As the spent nuclear waste is radioactive, it is important to understand the concept of radioactivity in order the grasp the hazard that it presents. The text should, in a simplified manner, describe what radioactivity is and what effects it might have on both humans and nature. This section should, as far as possible, be jointly written with other KIFs that are written in the same time period.

- Radioactive decay

Radioactivity occurs in unstable atoms. An unstable atom does not have a balance between the amount of protons and neutrons in its nucleus, the dense central region of an atom. This causes the atom to decay, losing energy from its nucleus. A nuclide in which the decay occurs is called a radionuclide. Radioactive decay comes in three main types: alpha, beta and gamma …

- Effects on human health

Radiation's effects on human health can be divided into deterministic and stochastic effects. Deterministic effects can with certainty be attributed to radiation exposure and occur after a certain dose threshold has been absorbed. The damage of deterministic effects is dependent on the size of the absorbed dose, the rate at which it is delivered and what parts of the body are exposed …

How to protect yourselves …

1.2 How this waste was produced

- Exclusive text for each repository

In Sweden, there were two types of nuclear reactor in use: pressurised water reactors (PWR) and boiling water reactors (BWR). Both make use of fission, a process in which atomic nuclei are split by bombarding them with neutrons …

1.3 Why the waste needed geological disposal

"Why the waste needed geological disposal" might be deleted, as this information should be evident from the "Nature of radioactivity/radioactive waste".

1.4 Electricity generation and usage in Sweden

Nuclear power plants are one of several different ways that society produces electricity. In Sweden, hydroelectric power plants are the biggest source of electricity, closely followed by nuclear power plants. Together, the two make up about 84% of Sweden's electricity generation. The rest of the electricity generation comes mostly from thermal power plants, which often run on some kind of fossil fuel, and wind turbines, while a small portion comes from solar power.

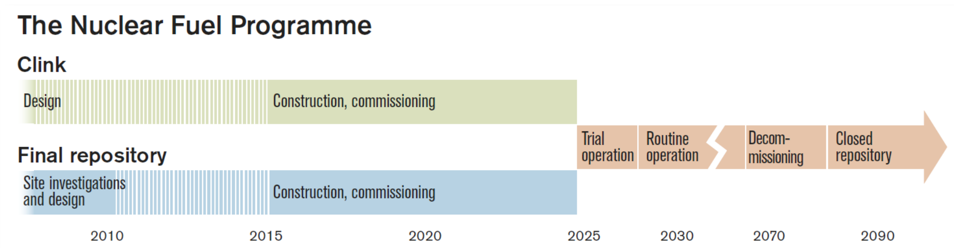
Electricity is needed in all areas of Swedish society. The biggest consumer is the manufacturing sector, which is responsible for about 37% of Sweden's total electricity usage …

1.5 Key dates

The applications, according to the Environmental code and the nuclear activities act, were submitted in March 2011 …

In 2019, construction and commissioning of the final repository began. Ten years later, trial operations began and continued for five years until routine operations took over. In 2090, the repository was sealed.

Figure 1.1. Timetable for construction, operation and decommissioning of the interim radioactive waste repository (i.e. Clab), encapsulation plant and final repository



Source: SKB.

1.6 *Regulatory provisions in force*

"Regulatory provisions in force" is not relevant for the Swedish example of a KIF, since the document is aimed directly at a far future generation and regulatory provisions would become immaterial information for anyone looking at the file in 500 years.

Section 2. Facility location

Exclusive text for each repository.

2.1 *Repository co-ordinates (latitude/longitude/depth)*

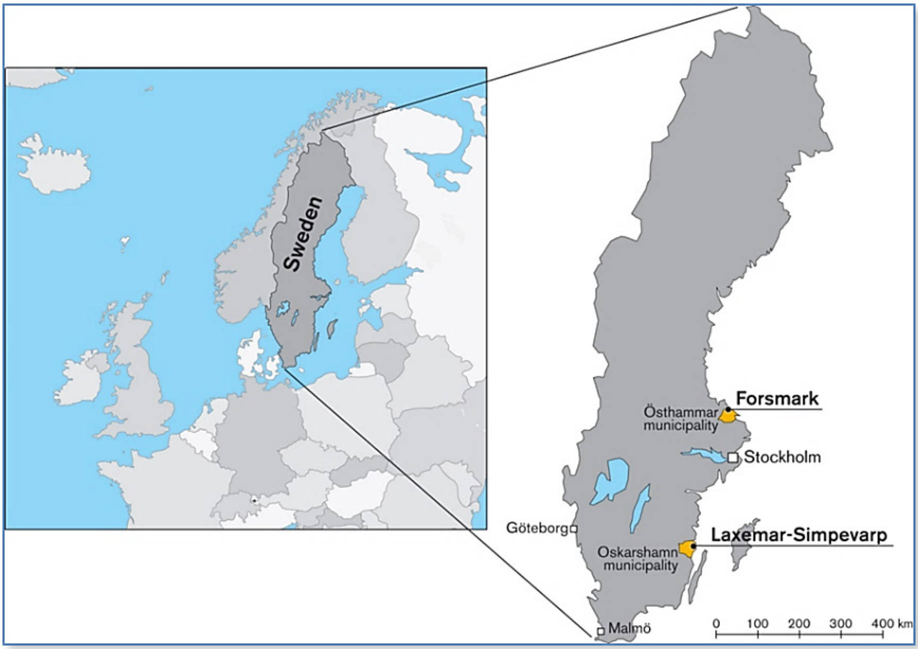
The location co-ordinates are 60°24'1.67"N, 18°11'1.58"E in SWEREF 99 (WGS 84) or X = 6700425 and Y = 1631103 in RT90 ("Rikets koordinatsystem"). The repository is located at a depth of about 500 m.

2.2 *Surface*

The landscape in Forsmark is a relatively flat peneplain that dates back to about 540 million years ago. This peneplain dips gently towards the east. The most elevated areas in the south-western part are located at about 25 m above current sea level. The upper surface of the bedrock ripples over small distances implying large variations in the thickness of the Quaternary cover (the cover of the bedrock, formed under the Quaternary period which span from 2.58 million years ago to the present) …

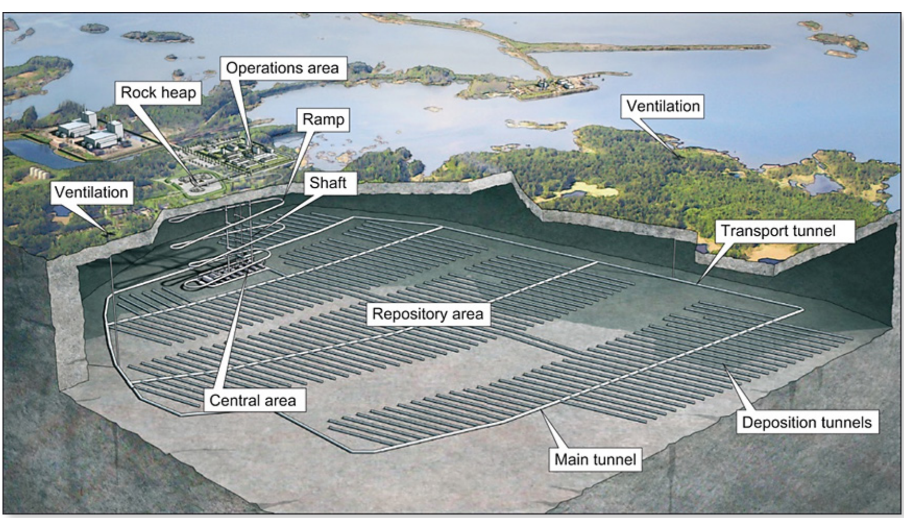
Quaternary deposits, vegetation, lakes …

Figure 2.1. SFK is located nearby the Forsmark NPPs in the Östhammar municipality about 150 km north of Stockholm



Source: SKB.

Figure 2.2. The final repository with surface and underground parts

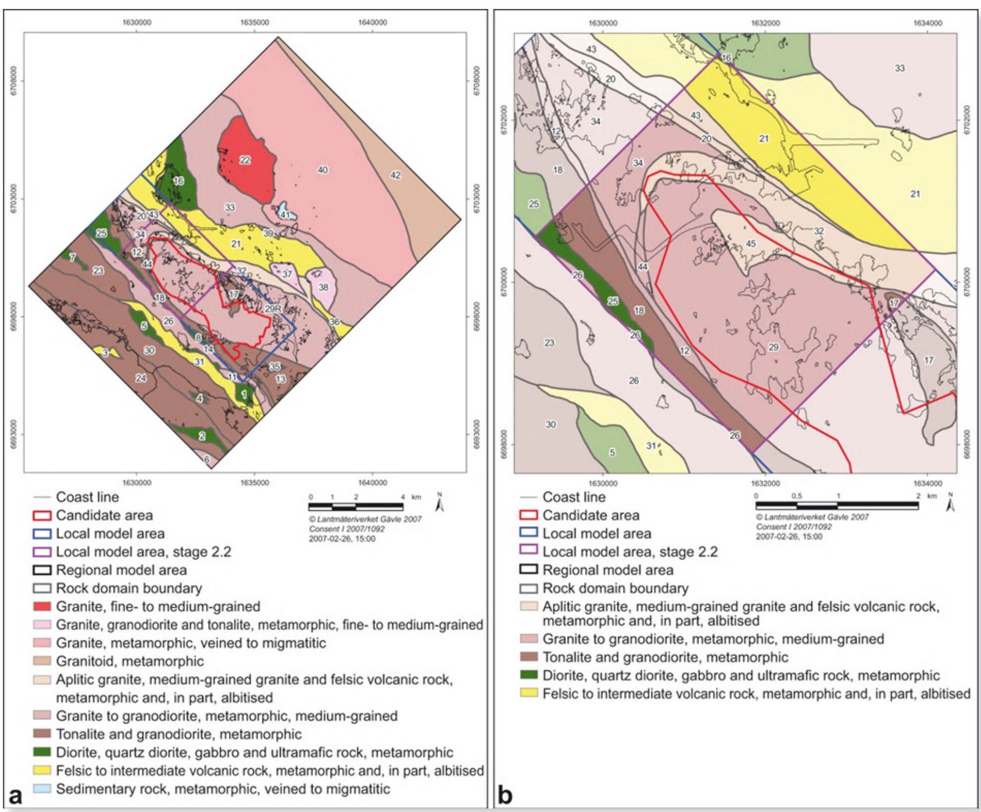


Source: SKB.

2.3 Geological setting

The area for site investigation is located along the shoreline of Öregrundsgrepen, within the north-western part of a major tectonic lens that formed between 1.87 and 1.85 billion years ago by the ongoing collision between the oceanic plates and the old continental plate in a process called the Svecokarelian Orogeny. The area is approximately 6 km long and 2 km wide. The north-western part of the candidate area lacks hydraulically conductive, gently dipping fracture zones at potential repository depth. Due to its internal homogeneity, most of the lens in the candidate area can be described in terms of two rock domains referred to as RFM029 and RFM045 (Figure 2.3). Deformation of the bedrock in Forsmark started deep down in the earth's crust about 1.9 billion years ago at high temperature …

Figure 2.3. The geological composition of the bedrock of the area



Source: SKB.

2.4 Baseline "hydro-geo-chemical" parameters at time of closure

The groundwater of the bedrock consists of different mixtures of:

1. modern or old surface water;
2. meltwater from the continental ice sheet;
3. water from the Littorina Sea (an earlier stage of the Baltic Sea that existed around 7 500-4 000 years ago);
4. extremely old and saline "deep water" from the deep bedrock.

Groundwaters in the uppermost 100 to 200 m of the bedrock display a wide range of chemical variability, with chloride concentrations in the range of 200 to 5 000 mg/L, suggesting the influence of both brackish marine water (recent Baltic or old Littorina Sea relicts) and meteoric waters (water derived from precipitation) …

In the near-surface waters (down to a depth of about 20 m) there are high pH-values (usually higher than 7) and variable but high calcium concentrations (mostly between 50 and 200 mg/L) depending on the biogenic carbon dioxide input …

2.5 Provisions for site monitoring (scope and timescale)

Moved to 3.4.

2.6 Description of markers (if any)

So far, there are no decisions about markers in Sweden.

Section 3. Container and facility design

The method for isolating the spent nuclear fuel is called the KBS-3 method. The method involves encapsulation of the spent fuel in copper canisters which are then emplaced, surrounded by a buffer of bentonite clay, in deposition holes in a tunnel system at a depth of 400-700 metres in the bedrock, illustrated in Figure 3.1. The purpose of the three barriers (canister, buffer and bedrock) is to isolate the radionuclides in the fuel from the surrounding environment …

3.1 Bedrock

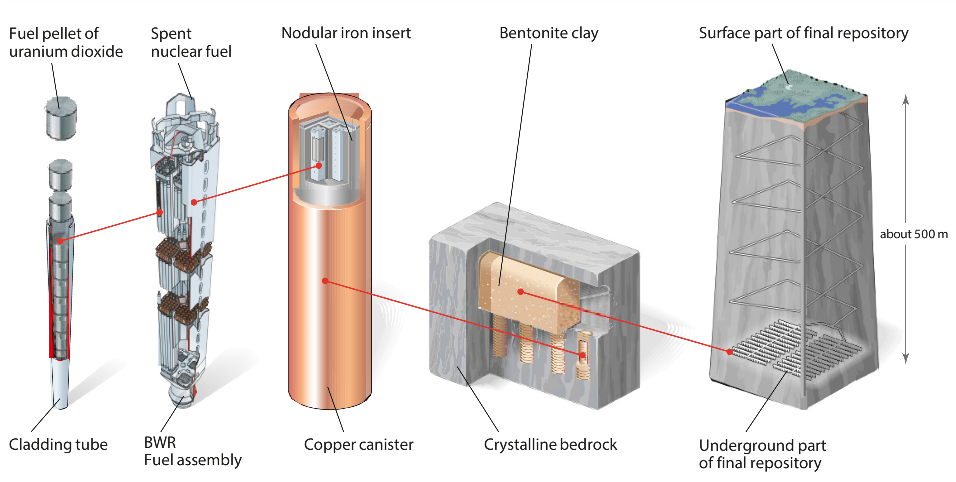
The purpose of the bedrock is to provide chemically favourable conditions, favourable hydrogeological and transport conditions, a mechanically stable environment as well as favourable thermal conditions.

3.2 Engineered features

- Canister

The spent fuel is contained within cylindrical canisters consisting of a barrier of 5 cm thick copper and a load-bearing insert of nodular cast iron …

Figure 3.1. The KBS-3 method



Source: SKB.

- Buffer

The buffer is made up of bentonite clay, which swells when it comes into contact with water. The buffer surrounds the canister and fills the space between the canister and the bedrock. The main purpose of the buffer is to restrict water flow around the canister …

- Backfill

The backfill replaces the excavated rock of the deposition tunnels. It consists of blocks of bentonite, which are stacked in the tunnels as well as pellets of the same material …

- Sealing

The sealing is the materials used to fill and seal the caverns, shafts, ramp and tunnels that are not deposition tunnels. The purpose of the sealing is to aggravate intrusion, restrict water flow and keep the backfill in place.

- The main tunnels and transport tunnels are backfilled in the same way as the deposition tunnels with blocks and pellets of compacted bentonite.
- The central area is filled with crushed rock.
- The lower part of the shafts and the ramp is backfilled with bentonite and the upper part with crushed rock.
- The upper part of shafts and the ramp is filled with compacted coarse crushed rock.
- Plugs are made out of reinforced concrete.

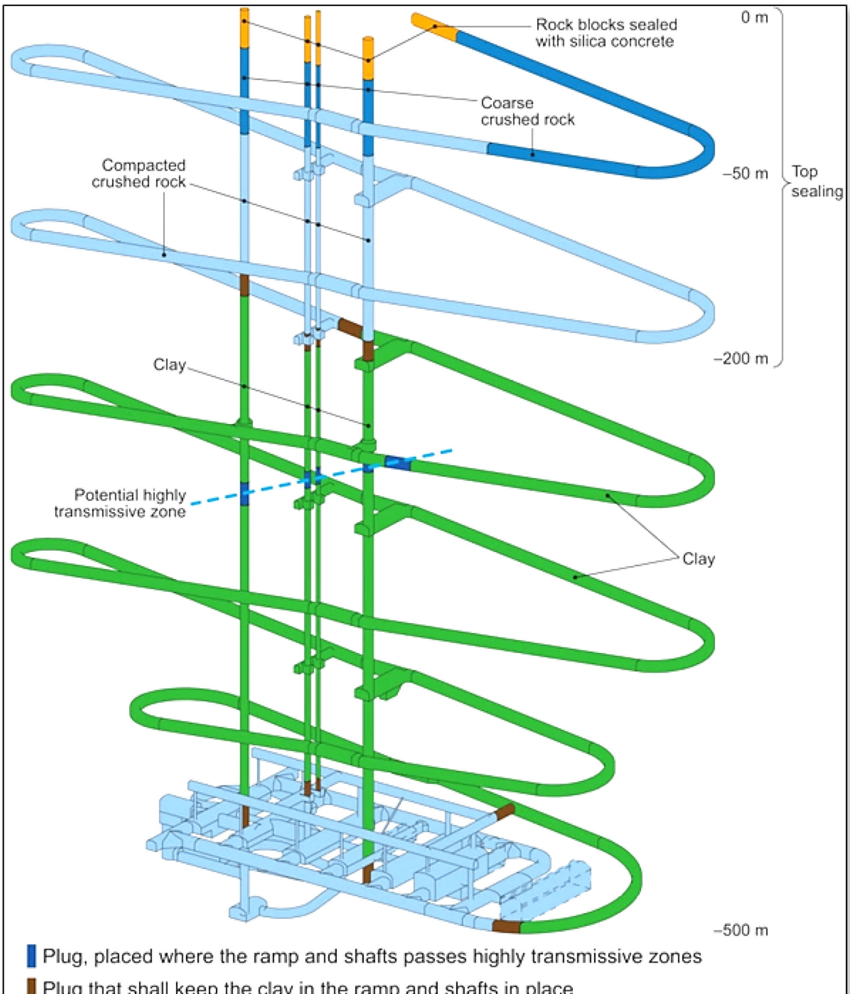
3.3 *Access after closure*

The location of shaft seals …

3.4 *Provisions for site monitoring (scope and timescale)*

Not yet decided.

Figure 3.2. Top sealing, the parts of the ramp and shafts filled with clay and the placement of plugs in ramp and shafts



Source: SKB.

Section 4. Disposal Inventory

4.1 *Radionuclides*

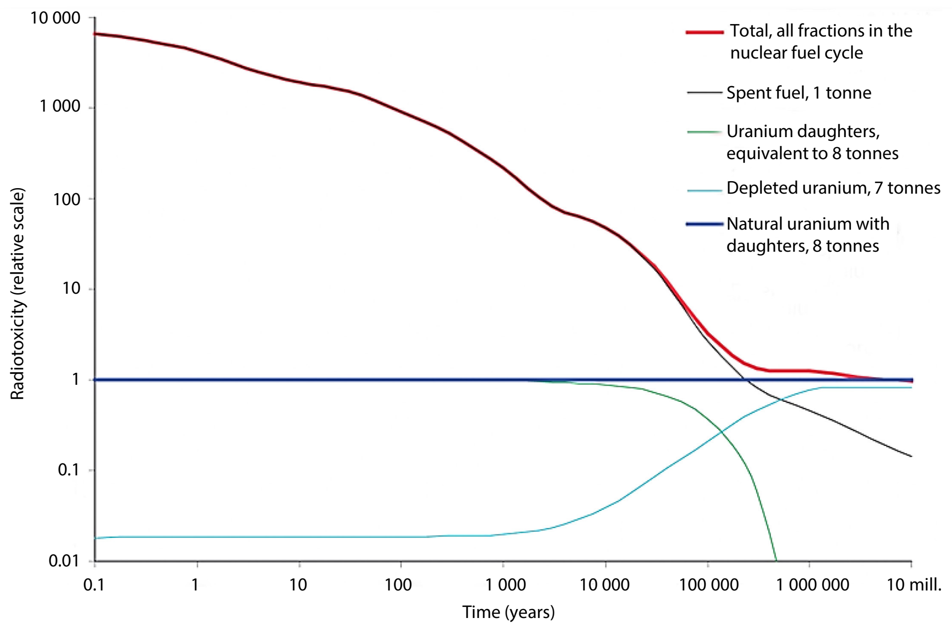
In the extended KIF there is a table showing the total inventory in BWR and PWR assemblies of 13 radionuclides (Bq) of importance for radiotoxicity and calculated long-term risk (alphabetic order). The inventories are calculated for the calendar year 2045.

4.2 *Toxic components*

To assess the potential chemical toxicity of the waste in the final repository, the elements in the fuel, the fuel elements and fuel boxes, the copper canister shell and the canister insert were compiled …

4.3 *Hazard evolution profile if undisturbed*

Figure 4.1. The change of radiotoxicity profile with time



Source: SKB.

Radiotoxicity in ingestion of uranium and daughters in ore (blue line), and of the sum of all fractions that arise when the same quantity of uranium is used in the nuclear fuel cycle (red line). The time refers to the time after reactor operation. The different fractions comprise the spent fuel (38 MWd thermal energy/kgU of type SVEA 64 BWR), the depleted uranium and the uranium daughters that are separated in the uranium mill.

Section 5. Safety Case

5.1 Future human actions

Out of all possible future human action identified, only drilling in the rock is judged to possibly lead to penetration of the copper canister and breach of waste containment, while at the same time being inadvertent, technically possible, practically feasible and plausible …

Section 6. Disposal Record

Not possible to write on the basis of the application documents in 2017.

Section 7. List of similar repositories in the world

This section should as far as possible be jointly written with other KIFs that are written in the same time period.

7.1 Co-ordinates of disposal facilities

7.2 Co-ordinates of records retention

A.3. Overview of the KIF for the Centre de Stockage de la Manche in France

(developed by Andra)

Andra is developing a preliminary KIF regarding the Manche disposal facility, "Centre de Stockage de la Manche", in the framework of the next review of the safety case, due in 2019. French regulation requires a summary memory file (SMF) to be presented by the operator prior to the closure of a repository. Andra decided to present the KIF as being part of the SMF. Regulatory requirements not met by the KIF, because it is being developed in an international context, will be addressed by complementary documents also belonging to the SMF. The SMF will replace the "summary record" that was elaborated earlier, at a preliminary stage, and displayed as such on Andra's website. The concept of KIF has already been presented to local stakeholders. They will be consulted during the elaboration process.

This KIF is being developed in French, with some parts (introduction, chapter abstracts, etc.) provided both in French and in English. Hereunder is a "storyboard" of this KIF, translated in English, with full text developed in a few sections.

Section 0. Introduction

This document has been finalised in MM YYYY. It aims to inform future generations of the existence of a radioactive waste repository near the town of Digulleville, 20 km north-west of the city of Cherbourg-en-Cotentin (France).

This repository hosts radioactive wastes that pose a threat to man and the environment. A system of isolation and surveillance has therefore been put in place to guarantee the safety of future generations. In order for it to be effective, any human intrusion must be avoided as long as the dangerousness of the disposed waste has not diminished to an acceptable level. Most of the radionuclides contained by the waste have a short period, which means that they will lose half of their radioactivity in at most 31 years. These radionuclides will have almost disappeared at the horizon of the 24th century.

Several means have been put in place to preserve the memory of the existence of the Manche repository as long as possible, avoid any involuntary intrusion and pass a detailed knowledge of the repository to future generations. This document plays a central role in this process.

To fully fulfil its role, this document must be accessible and understandable to as many people as possible. You have it in your hands today, so please do your best to ensure that future generations can have access to it and understand what is written there.

Section 1. Context

Based on a natural physical phenomenon, radioactivity is used by humans for various applications. It produces radioactive waste harmful to human health and the environment, which must be isolated according to appropriate management methods. The Manche disposal facility houses low- and intermediate-level*[1] and short-lived waste, stored in structures that contain it.

What is radioactivity?

Origin of radioactivity and definition of what it is. Including a description of the distinction between natural radioactivity and artificial radioactivity.

Where do radioactive wastes come from?

Summary of the various types of radioactive wastes.

Basic principles for radioactive waste management

Before the creation of the Manche repository in 1969, disposal at sea was considered the most appropriate management solution for radioactive waste. This practice was abandoned by France for most of the wastes in 1969, and completely abandoned in 1983. Ocean dumping was banned by international rules in 1993.

Since 1969, in France, radioactive wastes are distributed towards the most appropriate repositories according to their lifetime and their dangerousness to guarantee the adequate protection of people and the environment. Very low-level wastes, low- and intermediate- level short-lived wastes are thus disposed in surface repositories, whereas projects for long-lived wastes are conducted at various depths according to their dangerousness.

Section 2. The Manche repository

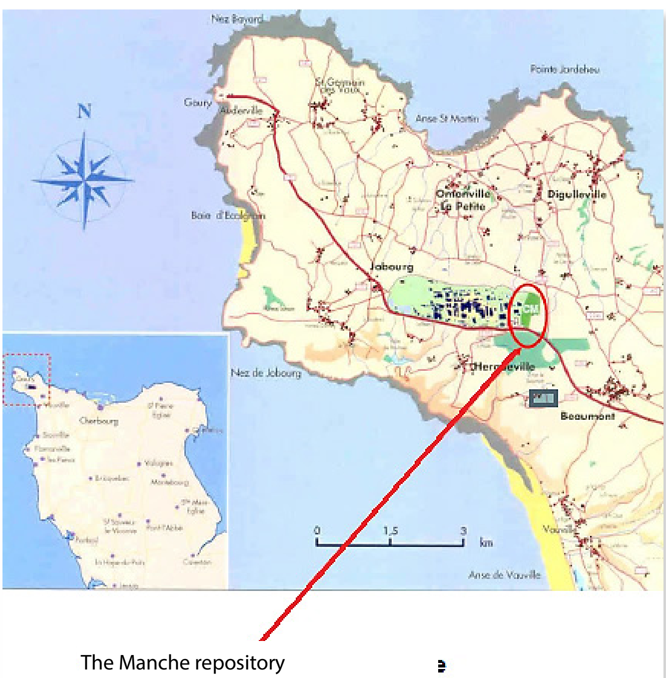
The Manche disposal facility is located in the extreme north-west of the Cotentin Peninsula, in a geographical area characterised by a marked ocean climate and an ancient and complex geological environment. Operated from 1969 to 1994, it provided feedback that led to the implementation of an effective radioactive waste management policy in France.

1. Words followed by an asterisk will be defined in a glossary.

Presentation

Source: Andra.

Established in 1969, the Manche repository is the first on-ground repository for radioactive wastes in France. It is located at the extreme north-west of the Cotentin peninsula, about 20 kilometres west of the city of Cherbourg-en-Cotentin. Its footprint is about 15 hectares (0.15 square kilometres).



Source: Andra.

Geographic co-ordinates of the Manche repository (corresponding to the red oval on the map):

Latitude: 49.6770

Longitude: -1.8630

Repository history

Year	Notable event
1967	Siting decision
1969	Creation of decree, and beginning of operation by Infratome under CEA responsibility
1979	Creation of Andra, within CEA
1991	30 December 1991 Act : Andra becomes an independent body
1991-1997	Implementation of the cover system
1994	Reception of the last waste package
1996	Conclusions of the Turpin Committee
2003	Decree authorising the modification for entering the closure phase, and Order for release authorisation
2009-2010	Transmission to the Safety Authority for investigation of the report on the suitability of a more perennial cover and of the Final Safety Report
2015	Transmission to the Safety Authority of the Progress Report on Cover Studies
2019	Transmission to the Safety Authority of the Safety Case Review File

Environment/geological setting

The Manche repository is located in a very old geological region, which has undergone several successive stages of deformation. Two types of rock are mainly present: schists and sandstones.

- Environment/climate

Bordered by the sea (Channel) on three sides, the Manche District is subject to a very marked oceanic climate: high wind speeds, significant annual mean rainfall, high humidity, temperate annual temperature, annual sunshine duration of 1 650 hours on average.

- Environment/hydrological baseline

Run-off from the Manche repository is found in three surrounding streams that flow into the sea within four kilometres: St. Helena Creek, Grand Bel Creek and Roteures Creek.

Section 3. The design of the repository system

Being the first surface repository created in France for the management of radioactive waste, the Manche disposal facility has evolved over time. Here are the main evolutions that marked its conception and its operation.

During repository operation, from 1969 to 1993:

- The waste acceptance criteria

In order to be accepted at the disposal site, a package of waste had to meet criteria, in particular radiological composition.

- Packaging

The packaging methods were regulated according to the nature of the waste and its level of radioactivity. Thus, all waste stored inside the Manche repository was disposed of as a package, with the exception of some land that was built into the base of the cover. Each package contains a bar code identification number displaying essential information: weight, dimensions, contained radioactive substances and radiological activity.

- Repository structures

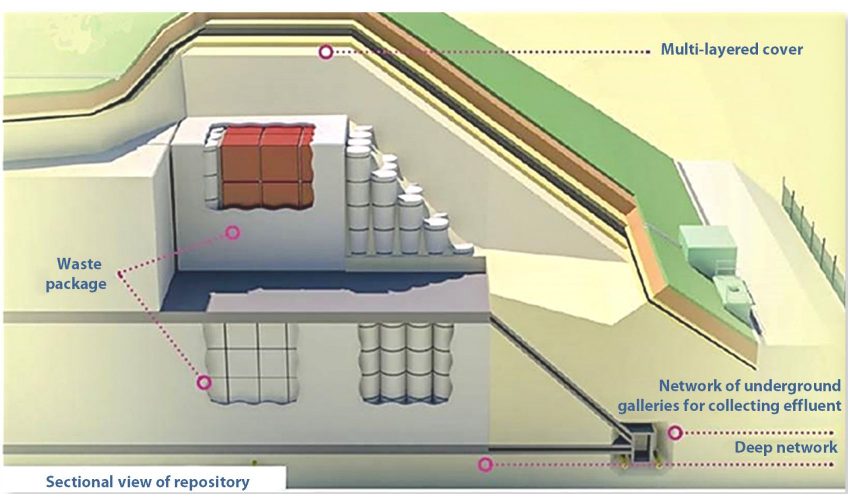
There are currently three categories of structures:

- first-generation structures (ordinary trenches and pits);
- structures dedicated to the least active waste (platforms and tumuli);
- structures dedicated to the most active waste (concrete trenches and monoliths*).

The repository in 2017:

- The facilities

The Manche repository is currently in the shape of a vast grassy mound. Waste packages and repository structures are located under a multi-layered cover, consisting of alternating drainage and impermeable layers.

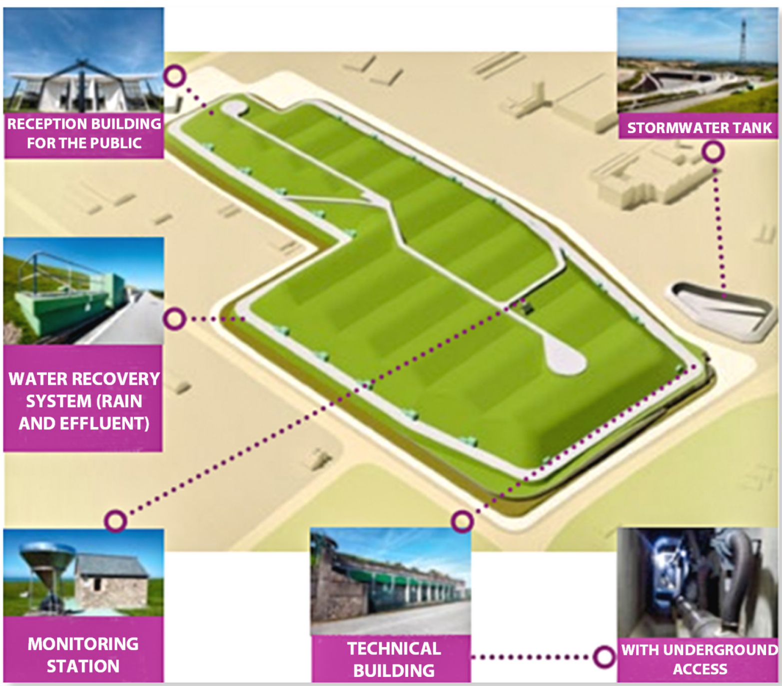


Source: Andra.

In the basement, under the repository structures, a network of underground galleries allows for the monitoring of any infiltration water coming from the repository structures and likely to have been in contact with waste packages.

To the north of the centre, the technical building includes all the outlets of the water recovery systems, troughs or tanks of retention and storage before control. Located at different levels of coverage, these networks allow for the differentiation and separate management of rainwater and effluent collected in underground installations.

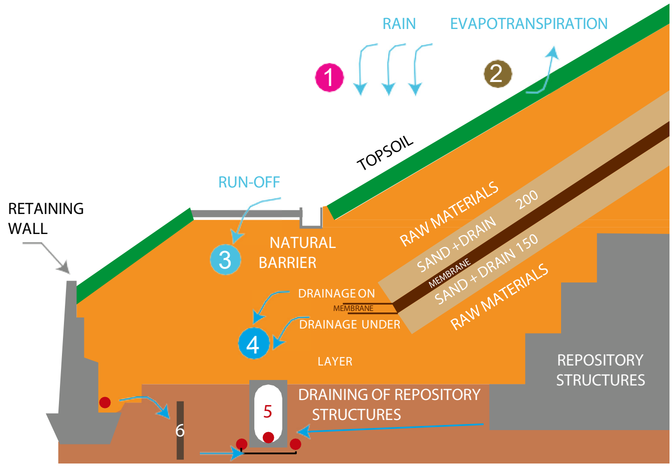
To the south, the reception building for the public includes staff offices, permanent or temporary exhibition spaces, the archive room and the security guard.



Source: Andra.

- Water management

Rainwater was separated from the drainage of the structures. The latter have been evacuated to a specific network so as not to contaminate the surrounding streams. Several water collection networks have been emplaced at the surface and at different depths, at the level of the roof, the retaining walls, the repository structures, etc. The collected water is analysed and redirected according to its potential radioactive contamination.



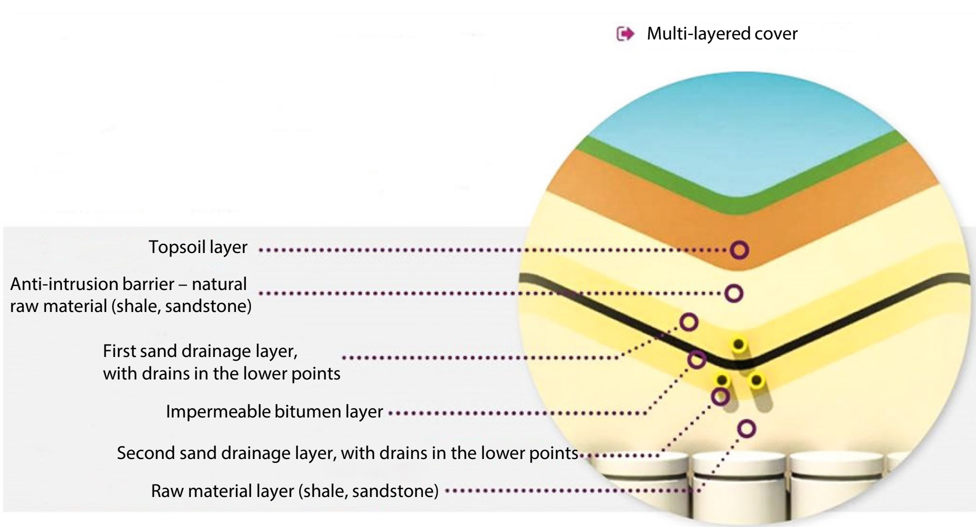
Four types of water collection networks have been set on the Manche repository:

1. a surface network collecting run-off from the cover;
2. a drainage network collecting seepage water through the cover;
3. a buried network collecting the drained water collected at the base of the structures;
4. a deep drainage network, which is not in direct contact with the waste packages.

Source: Andra.

- The covering system

Coverage of the repository must include the protection of waste from rainwater (to prevent the spread of radioactive substances in groundwater) and against erosion, climatic variations, human and animal intrusion or plants (roots), etc.



Source: Andra.

These criteria led to a "multi-layer" covering system based on the alternation of layers of various characteristics in terms of permeability. It is made of a synthetic material called geomembrane*, chosen for its elasticity and its capacity to adapt to ground movements. This material was soaked in bitumen to make it tight, then emplaced between several layers of sand and earth.

Laying a geomembrane strip. The strips are welded to each other along an axis parallel to the north-south axis.

Source: Andra.

- The planned final configuration

The configuration of the repository as of 2017 allows for close monitoring by Andra but requires maintenance. It is not the planned final configuration, where no maintenance is required.

In the final configuration:

- The network of underground galleries that collects any infiltration water will be backfilled, as will the associated technical building, in order to stabilise these works.
- The repository will be in a passive (no human intervention required) configuration; monitoring as performed at present will be stopped; effluent management will be adapted.

Section 4. The disposed waste

The waste in the Manche repository contains substances that are harmful due to their radioactivity and/or their chemical nature. An inventory of these substances is proposed in this chapter. Despite the natural decay of radioactivity over time, the disposal centre site cannot be trivialised at the end of the monitoring period, due in particular to the presence of alpha* waste.

Inventory of the main radionuclides/inventory of the main toxic chemicals

Section 5. Monitoring and evolution of the site

In 2003, the Manche repository entered a closure phase and a monitoring was put in place to verify that its chemical and radiological impact remains very low. Nevertheless, safety studies are carried out to identify the impact of different risk scenarios on humans and the environment.

- Towards passive surveillance

In 2017, the main activities on the repository are to monitor its evolution. This surveillance makes it possible to monitor the evolution of the coverage system, to verify that its behaviour is in line with expectations and that the impact of the repository on its environment remains very low. The level of surveillance will decrease progressively, as knowledge is acquired.

The latest measurements carried out on and around the Manche repository during 2016 confirm the very low impact of the repository on its environment: 0.18 microSievert per year, as well as the good behaviour of the cover, which protects the radioactive waste disposal structures. These results confirm that the evolution of the repository is in line with the safety studies carried out by Andra.

And tomorrow?

The expected evolution of the repository

Various evolution scenarios are investigated. In the expected evolution scenario, the projected radiological impact of the Manche repository is very low. It is related to the infiltration of rainwater through the repository cover. At present, these drainage waters are collected, analysed and treated before being discharged into the environment. In passive operation (date not fixed), the water collection system will no longer provide drainage because it will be refilled. A part of the stream released by the waste packages will therefore reach the groundwater and migrate slowly into the environment.

Risks

Although provisions have been made for the protection of humans and the environment against the harmfulness of wastes present at the Manche repository, it is necessary to identify risk situations that could lead to people still being exposed to effects (radioactive or chemical) resulting from the disposed waste (the main situations which could lead to risks for man and the environment will be described and associated with provisions presently implemented and provisions suggested in the future).

Section 6. The hierarchy of documents

This document is intended for wide dissemination, mainly to the local population and its representatives (elected representatives, associations, etc.). It aims to provide essential information to avoid human intrusion into the Manche repository. It is supplemented by other more or less detailed documents that also convey the memory of the Manche repository.

Did you know?	This KIF is part of the summary memory file required by French regulation, also intended for wide dissemination, which contains also a very short document and thematic sheets providing more insight on specific subjects. Detailed information on the repository is provided by the detailed memory file, which contains more than 11 000 records as of 2017. They are kept in at least two copies, one on the site of the Manche repository, the other in the National French Archives.

Section 7. Radioactive waste repositories worldwide

All countries using radioactivity, whether for energy production, medicine, research or any other industrial activity, are confronted with the problem of managing the waste generated by these activities. Radioactive waste disposal facilities of various types therefore exist all over the world, at different stages of their life cycle, projected or receiving radioactive waste, or not receiving any more but remaining monitored.

To be completed later.

Annexes to be added at a later date:

References

Glossary of terms

Table of the main radionuclides

NEA PUBLICATIONS AND INFORMATION

The full **catalogue of publications** is available online at www.oecd-nea.org/pub.

In addition to basic information on the Agency and its work programme, the NEA website offers free downloads of hundreds of technical and policy-oriented reports. The professional journal of the Agency, **NEA News** – featuring articles on the latest nuclear energy issues – is available online at www.oecd-nea.org/nea-news.

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Preservation of Records, Knowledge and Memory (RK&M) Across Generations

Radioactive waste repositories are designed to be intrinsically safe in that they are not dependent on the presence or intervention of humans. In response to this challenge, the Nuclear Energy Agency initiated the Preservation of Records, Knowledge and Memory (RK&M) Across Generations Initiative, calling on the international community to help create specific means to preserve RK&M.

The concept of a key information file (KIF) emerged in response to the challenge presented by the large volumes of RK&M material generated by national disposal programmes. This concept has been developed into an important component of a RK&M preservation strategy. The KIF is designed to be a single, short document, produced in a standard format, with the aim of allowing society to understand the nature and intent of a repository, and thus to reduce the likelihood of unnecessary human intrusion. It should be made openly available and ultimately be widely distributed.

This report describes the KIF concept in detail, in a manner that should enable those concerned with any particular repository to create their own versions. Three draft key information files, currently under development to support RK&M preservation in France, Sweden and the United States, are provided as examples.

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