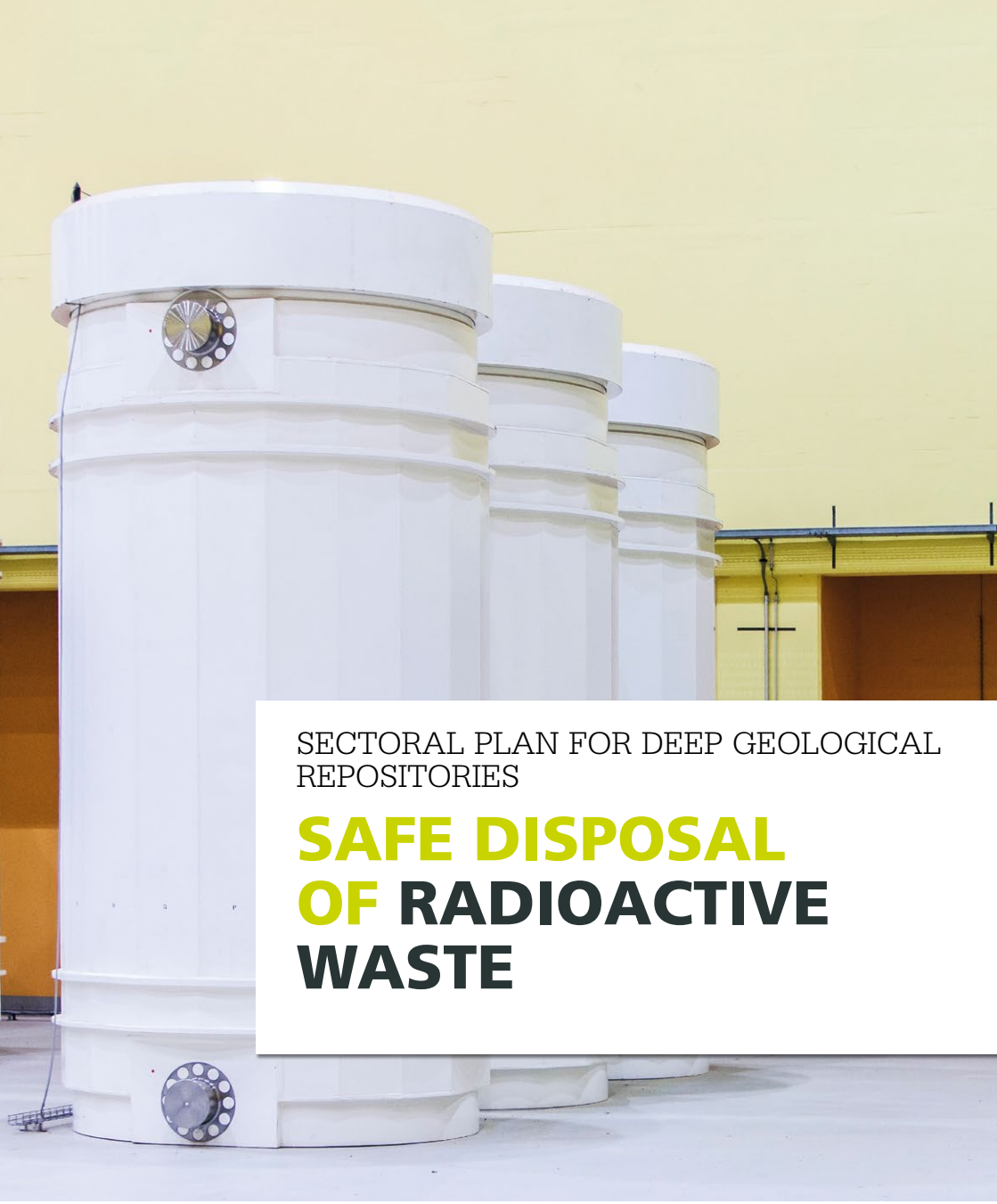


SECTORAL PLAN FOR DEEP GEOLOGICAL REPOSITORIES

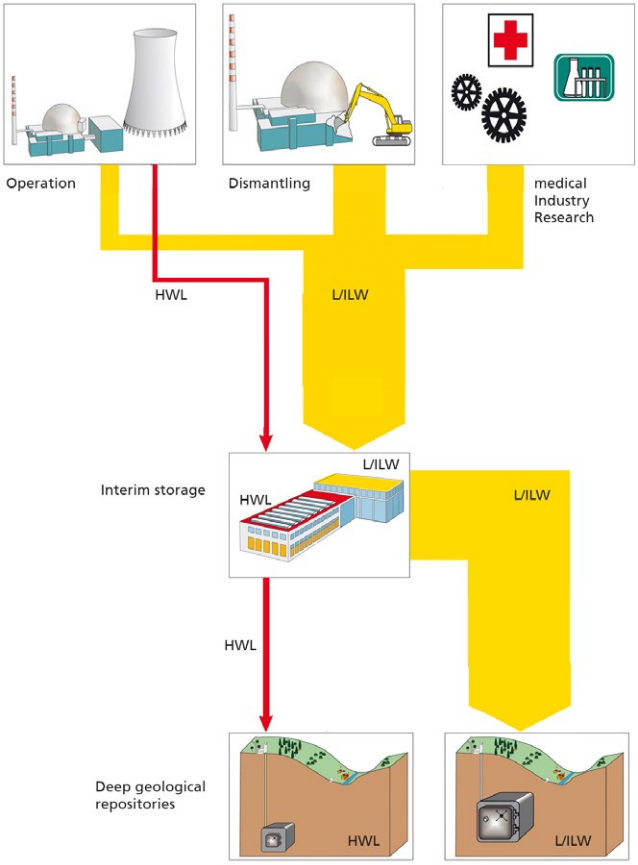
SAFE DISPOSAL OF RADIOACTIVE WASTE

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Federal Office of Energy SFOE

WHERE DO WE GO WITH RADIOACTIVE WASTE?

Switzerland has been using nuclear energy for electricity production for more than 40 years, but so far there is still no permanent and safe solution for the disposal of the resulting radioactive waste. Most of the radioactive waste in Switzerland comes from the country's five nuclear reactors, though a certain amount is also produced in the medical, industrial and research (MIR) sectors. A distinction is made between high-level and low- and intermediate-level waste. The combined total volume is around 100,000 cubic metres of material, around 90 percent of which is low- and intermediate-level waste.



From waste production to the disposal in deep geological repositories

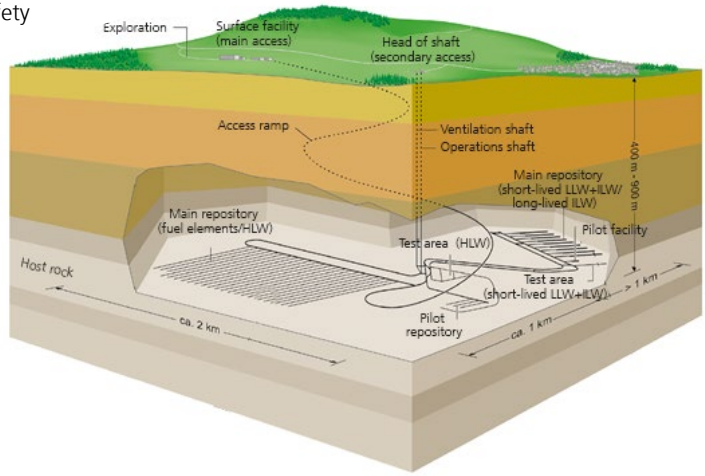
LEGAL BASIS

The handling and storage of radioactive waste is governed by the provisions of the Nuclear Energy Act and the Nuclear Energy Ordinance, both of which entered into force on 1 February 2005. The Nuclear Energy Act stipulates that radioactive waste accruing in Switzerland must be disposed of safely in Switzerland. The waste producers are responsible for the disposal of waste. These are the operators of the nuclear power plants and the federal government, which is responsible for MIR-waste.

The Federal Nuclear Energy Act also regulates the financing of the decommissioning of nuclear facilities and the disposal of the resulting radioactive waste. Waste producers have to pay into a decommissioning and disposal fund. The Act also specifies the safety-specific requirements relating to the disposal of radioactive waste in deep geological repositories. In addition to being safe to operate, a deep geological repository long-term safety must be guaranteed. A general licence, and later construction and operating licences, can only be granted if it can be demonstrated that the legally specified safety objectives can be fully complied with. The Swiss Federal Nuclear Safety Inspectorate (FNSI) is responsible for specifying the safety guidelines and monitoring the safety of deep geological repositories.

TEMPORARY SOLUTION: INTERIM STORAGE SITES

Radioactive waste is currently stored in secure, above-ground buildings located at Würenlingen (Canton Aargau) and on the premises of the nuclear power plants. However, this form of storage cannot guarantee safety over lengthy periods. Therefore, a long-term solution is needed: a deep geological repository.



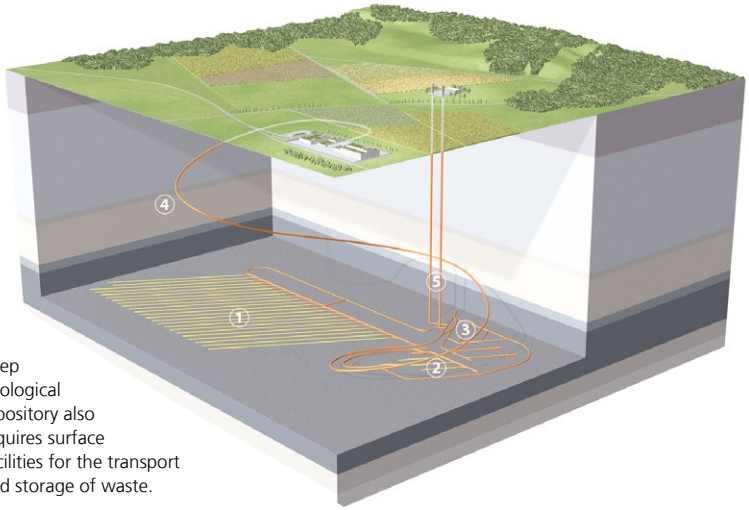
Block diagram of a deep geological repository, in this case a combined HLW repository

LONG-TERM SOLUTION: DEEP GEOLOGICAL REPOSITORIES

Radioactive waste is dangerous because of the radiation it emits. It has to be disposed of in such a manner as to ensure that as little radiation and radioactive materials as possible are released into the environment. Throughout the world, scientists agree that storing radioactive waste in deep geological repositories is the safest solution. High-level and low- and intermediate-level waste has to be stored for periods lasting from several tens of thousands of years up to hundreds of thousands of years until the process of radioactive decay has reduced the level of radiation enough so that it no longer poses a threat for human beings and the environment. Safe containment of high-level waste is pursued in deep geological repositories with a combination of technical and natural barriers.

INFRASTRUCTURE AND EFFECTS ON THE SURFACE

A deep geological repository comprises various facilities on the surface, depending on its stage of development (see below). The largest and most important of these is the surface facility to which the radioactive waste is delivered and where it is prepared for storage. The appropriate transport infrastructure to the repository has to be provided. The surface facility also includes the 'gateway' via which the filled end-storage containers are transported to the underground storage area. In addition to this 'gateway', at least two other access shafts or tunnels (auxiliary access facilities) to the storage area are required: one for the supply of fresh air and another for construction and operational purposes. The latter is used for moving excavated material out and construction materials in, transporting personnel and supplying the deep geological repository with power and water.



A deep geological repository also requires surface facilities for the transport and storage of waste.

1. Main facility (spent fuel/HLW)
2. ILW repository (long-lived LILW)
3. Test zone
4. Access tunnel
5. Ventilation shaft and construction shaft

TWO
REPOSITORIES

Both high-level and low- and intermediate-level wastes are produced in Switzerland. Based on the Sectoral Plan for Deep Geological Repositories, the two types of waste have to be stored either in separate repositories or in a 'co mbined repository'. This means the repositories may be constructed at a single site or at two different sites.

↗ Search for sites for low- and intermediate-level waste

The largest quantity of low- and intermediate-level waste results from the dismantling of nuclear power plants and from nuclear research facilities. The National Cooperative for the Disposal of Radioactive Waste (Nagra) conducted numerous studies to identify the safest location for the storage of low- and intermediate-level waste and ultimately selected the marl rock near Wellenberg (in the canton of Nidwalden) as the most suitable site. In 1993, Nagra submitted an application for a general licence for a repository for low- and intermediate-level waste, but the local population voted against the proposed project. For the site selection procedure, the FNSI specified criteria for assessing the host rock properties. Based on these criteria and depending on the type and location of the repository, the most suitable host rock formations for low- and intermediate-level waste were determined to be 'Brauner Dogger', 'Effinger Member', Helvetic marls and Opalinus clay. This marked the end of stage 1 in the process. At the end of stage 2, the siting regions were reduced to those with host rock formations consisting of Opalinus clay and 'Brauner Dogger'.

↗ Search for sites for high-level waste

High-level waste includes spent fuel elements from nuclear power plants and vitrified fission products resulting from reprocessing. Due to their geological instability, the Alps and the Folded Jura cannot be considered as potential sites for deep geological repositories. Nagra's studies therefore focused on the central plateau and northern Switzerland. After conducting comprehensive studies, Opalinus clay was identified as the most suitable host rock for the storage of high-level waste. This demonstration of feasibility was accepted by the Federal Council in June 2006.

+ HOW DOES A DEEP GEOLOGICAL REPOSITORY FUNCTION? FROM CONSTRUCTION TO CLOSURE

CONSTRUCTION

The first step is to set up a rock laboratory where the safety-related and structural properties of the host rock can be studied on site. If the expectations are confirmed, a licence for the construction of the deep geological repository can be issued and the construction of the repository can then commence.

OPERATION

A deep geological repository is put into operation in a series of steps. The facility encompasses test areas, a pilot facility and a main repository. The purpose of the test areas is to gain a deeper understanding about the host rock and to test emplacement and closure technology. In the pilot facility, the behaviour of the waste and the barrier system is monitored in order to detect any unfavourable developments at an early stage and take the necessary remedial measures. The radioactive waste will be stored in the main repository.

MONITORING PERIOD

After the waste has been deposited in the repository, the legislation calls for a lengthy monitoring period during which it must be possible to retrieve the waste if necessary without undue effort.

CLOSURE

If, at the end of the monitoring period, it is ascertained that no further measures are required in order to guarantee long-term safety, the sections of the facility that are still open can be filled and sealed so that the entire deep geological repository can be permanently closed. The remaining surface facilities are then dismantled. At that point, the permanent protection of human beings and the environment is secured solely through passive barriers requiring no human intervention. In principle, it would still be possible to retrieve the radioactive waste from the repository, at least as long as the storage containers remain intact. However, this would entail high financial and operational cost.

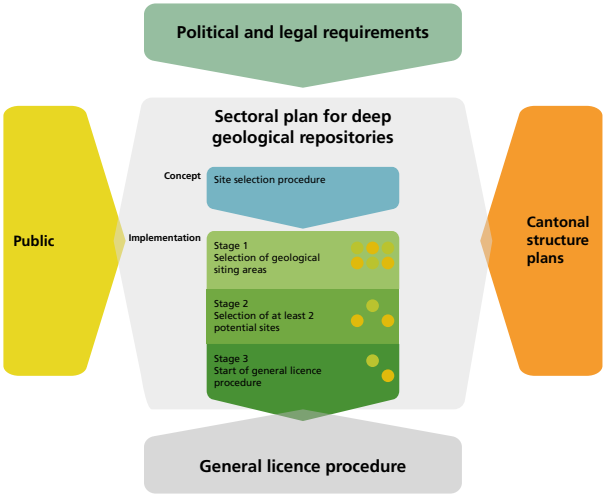
SEARCH FOR SITES FOR DEEP GEOLOGICAL REPOSITORIES

SECTORAL PLAN FOR DEEP GEOLOGICAL REPOSITORIES

The Federal Council adopted the Conceptual Part of the Sectoral Plan for Deep Geological Repositories in 2008. This plan specifies the objectives, procedures and criteria for the selection of sites for deep geological repositories. The top priority is to ensure the long-term protection of human beings and the environment.

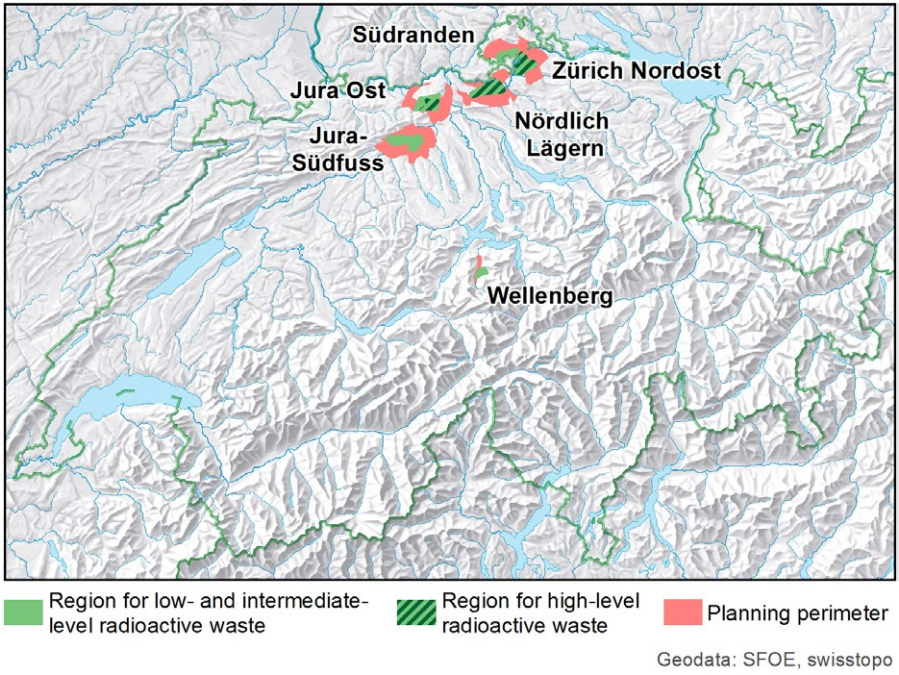
The procedure comprises three stages, in each of which comprehensive studies are carried out to obtain further geological information. At the end of each stage, the Federal Council can thus decide on the steps to be taken next based on the latest scientific and technical findings.

Although the storage of radioactive waste in deep geological repositories is widely regarded as the safest solution, the choice of location for these facilities is a subject of contention. It is, therefore, essential to determine sites on the basis of a transparent, broadly accepted site selection procedure. The Sectoral Plan for Deep Geological Repositories provides a comprehensible, step-by-step selection procedure which is being implemented under the leadership of the Swiss Federal Office of Energy (SFOE).



Establishment of the Sectoral Plan for Deep Geological Repositories

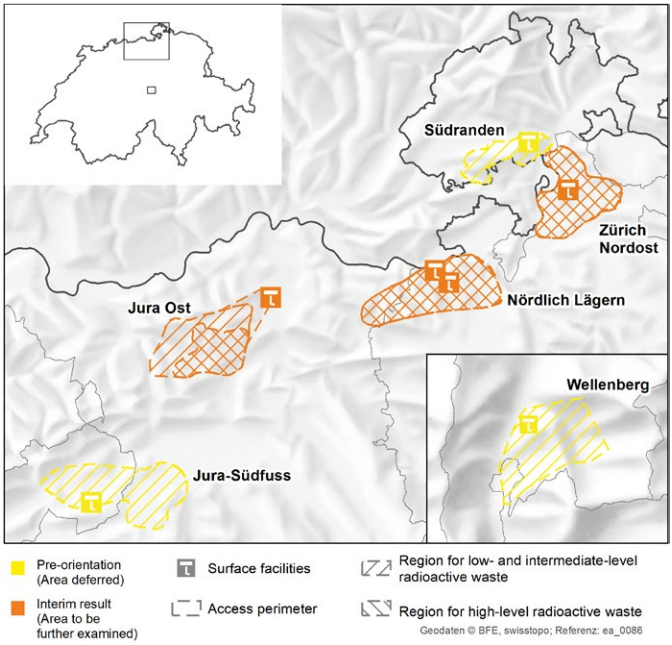
Stage 1 (2008–2011):
In stage 1, the main focus was on identifying suitable geological siting areas based on safety-related and geological criteria. Nagra proposed six geological siting areas based on the current status of geological knowledge. As a result of the findings of stage 1, Jura Ost, Jura-Südfuss, Nördlich Lägern, Südranden, Wellenberg and Zürich Nordost were to be examined in greater detail. The Federal Council confirmed this proposal. Regional participation was also established during this stage, enabling communes, organised interest groups and the local population of all six proposed siting regions to address regional issues and concerns.



Based on the decision of the Federal Council on stage 1, the six siting areas of Jura Ost, Jura-Südfuss, Nördlich Lägern, Südranden, Wellenberg and Zürich Nordost were designated for further study in stage 2.

Stage 2 (2011–2018):
At the beginning of 2015, Nagra proposed that two geological siting areas (Jura Ost and Zürich Nordost) be examined in greater detail in stage 2 and backed up its proposal with comprehensive reports. The FNSI studied these reports and, at the end of 2016, came to the conclusion that Nördlich Lägern should be further examined in stage 3 as well, stating that the existing data did not suffice to identify any clear disadvantages.

In stage 2, in addition to focusing the selection of potential geological siting areas, Nagra worked closely together with the proposed siting regions to identify possible locations for the placement of the surface facilities. At the end of 2018, the Federal Council decided that the siting areas Jura Ost, Nördlich Lägern, and Zürich Nordost should be further examined in stage 3.



According to the Federal Council, Jura Ost, Nördlich Lägern, and Zürich Nordost have to be studied further in stage 3.

In-depth geological studies will be made of the remaining siting areas in stage 3.

- Stage 3 (2018–2029):
  In the remaining geological siting areas, the site-specific geological conditions will be supplemented by further geological studies. The repository projects will be finalised in cooperation with the proposed siting regions and the socio-economic and ecological impacts of the repositories will be examined in greater detail. Approximately in 2024, Nagra will submit general licence applications for the construction of the deep geological repositories. These applications will have to be reviewed by the relevant authorities. Towards the end of the 2020s, the Federal Council will decide on the applications for general licences, and its decision will have to be approved by Parliament. The parliamentary resolution is subject to an optional national referendum. If a referendum should be initiated, the Swiss electorate will decide on the award of the general licence, most likely in the early 2030s. Only once this process is concluded will the sites for the deep geological repositories be definitive.

Rules governing the site selection procedure

In the search for sites for deep geological repositories, the protection of human beings and the environment is the top priority. Potential sites must therefore meet the high requirements placed on safety. Spatial planning and socio-economic and ecological aspects must be taken into account in the site selection procedure as well. These include transport infrastructure, protection of nature and landscapes, and the economic development of the region. For this purpose, astudy of the socio-economic and ecological impacts for all six siting regions proposed in stage 1 was conducted in stage 2.

TIMETABLE

A repository for low- and intermediate-level waste will be available by 2050 at the earliest and one for high-level waste by 2060 at the latest. Here are the key milestones on the way to the repositories:

Search for sites for deep geological repositories (Sectoral plan and general licensing procedures)	Duration
Development of the Conceptual Part of the Sectoral Plan for Deep Geological Repositories with broad participation	December 2004 to April 2008
Stage 1 (proposal and official review of six potential geological siting areas, establishment of regional participation)	April 2008 to December 2011
Stage 2 (location of surface facilities, involvement of regional conferences, narrow focus to three geological siting areas)	December 2011 to the end of 2018
Stage 3 (deep boreholes, preparation of application for general licence, specification of sites, issue of general licence)	End of 2018 to the end of 2029
Adoption by Parliament of the Federal Council's decision concerning the general licence, possibly followed by referendum	Beginning 2030 to the end of 2031

Construction of deep geological repositories (in accordance with 2016 Waste Management Programme [NTB 16-01])	Repository for low- and intermediate-level waste	Repository for high-level waste
Geological studies ('rock laboratory') Construction permit for deep geological repository	2032–2044	2032–2048
Construction of deep geological repository, operating licence	2045–2049	2049–2059
Operation, storage operation	**2050**–2064	**2060**–2074
Monitoring period	2065–2114	2075–2124
Closure of complete repository	2115–2118	2125–2126
Long-term monitoring	from 2118	from ab 2126

COOPERATION

REGIONAL PARTICIPATION

Close cooperation with the communes and the population in the proposed siting regions is necessary. For this purpose, regional participation was established at the end of stage 1. The objectives of this process are the integration of a deep geological repository project into the region, drafting of proposals for the layout of the surface facilities and the development of measures and projects aimed at mitigating any potential negative socio-economic or ecological impacts. Regional conferences were set up in each of the six siting regions proposed in stage 1.

Lectures and discussion sessions are used to inform members of regional conferences about the content of the Sectoral Plan for Deep Geological Repositories

TRANSPARENCY

In order for this cooperation to function smoothly, the information of the involved stakeholders and the population is an important aspect of the site selection procedure. The key steps in the process and the decisions taken have to be communicated in a clear, transparent and comprehensible way. In cooperation with the cantons, information and communication activities are carried out via various channels (including special events, forums, newsletters etc.).

INTEGRATION OF NEIGHBOURING COUNTRIES

To assure the cooperation with the cantons, the Commission of Cantons was established. The Commission secures the collaboration between official representatives of siting cantons, neighbouring cantons and neighbouring countries, and it supports the federal government with the implementation of the site selection procedure and submits recommendations to the federal government.

Who is taking which decision?

The division of duties between Nagra and the federal government is clearly defined. The **SFOE** bears overall responsibility for the site selection procedure. Its duty is to manage and coordinate the procedure. It conducts the public consultation and organises the regional participation. It is also responsible for providing the public with information about the site selection procedure and its current status. **Nagra** is responsible for providing the geological fundamentals in the search for suitable sites and for proposing potential solutions. The **siting cantons** support the SFOE in its organisation of the regional participation process and provide their expertise. They are also responsible for making necessary adjustments to cantonal structure plans. The relevant **federal authorities** are responsible for reviewing every stage of the site selection procedure. The **Federal Council** decides on each stage of the procedure. Upon completion of the site selection procedure, it is also responsible for awarding the general licence for deep geological repositories. The Federal Council's decision regarding the general licence has to be submitted to **Parliament** for approval. The **electorate** has the final say in a national referendum.

+ SELECTED QUESTIONS AND ANSWERS

The concept of deep geological repositories raises numerous questions, several of which are addressed below. You will find more questions on our website under the heading, 'Questions & Answers'.

Does radioactive waste have to be disposed of now? Would it not be better to wait until the problem of disposal can be solved with the aid of new technologies (e.g. transmutation)?

Those who utilise nuclear energy also have to accept responsibility for the safe disposal of radioactive waste. It is our duty towards future generations to tackle the problem of waste disposal without delay. In 2000, the 'Expert group for disposal concepts for radioactive waste', which was established by the Federal Department of the Environment, Transport, Energy and Communications (DETEC), came to the conclusion that the storage of radioactive waste in deep geological repositories is the only disposal solution that meets the requirements for long-term safety (safety ensured for at least 100,000 years). The expert group therefore developed the concept of 'controlled long-term geological storage', which combines end-storage with the option of recovery of the waste, and thus reversibility. Site selection, construction, operation, monitoring and closure of a deep geological repository are a step-by-step process that requires several decades. During this time, knowledge is constantly being acquired and new findings can be incorporated into the process. The decision for a definite closure of the facility after a lengthy observation period is deliberately left to future generations.

Is it possible for radioactivity to escape from a deep geological repository and reach the surface?

The long-term protection of human beings and the environment from the effects of radiation is the top priority. Radioactive waste must be disposed of in such a manner as to ensure that little or no radioactivity can be released into the environment. To this end, radioactive waste is to be stored deep underground in sealed repositories that meet extremely stringent safety criteria. For example, the annual additional radiation exposure must not exceed 0.1 millisieverts. This level is well below that of the natural radiation to which the population of Switzerland is exposed, namely an average of 5.5 millisieverts per annum.

What impacts would a deep geological repository have on a region?

Safety is the highest priority in the search for sites for deep geological repositories. It takes precedence over considerations regarding land use and socio-economic implications. A study carried out on behalf of the SFOE examined how a deep geological repository could affect the quality of life and prosperity of a region. A team of experts compared the effects of five storage projects in Switzerland and abroad, ranging from the interim storage facility in Würenlingen to an end storage project for high-level waste in Finland. The study found that the economic effects of a storage facility were positive rather than negative, with the construction industry benefiting the most. At the locations concerned, neither land nor real estate prices showed a negative trend nor were there any negative impacts on population growth. However, industries such as tourism and organic farming could suffer from a negative image. A study on radioactive waste disposal in Switzerland, including an analysis of the socio-economic impacts of storage facilities, is available on the Internet at **www.radioaktiveabfaelle.ch**.

What options do residents have for participating in the site selection procedure?

Implementing a deep geological repository will only be possible if there is sufficiently broad acceptance of it, and for this reason the involvement of the cantons and communes is an essential factor in all three stages of the site selection procedure. In the initial stage, the federal government formed a 'Commission of Cantons' comprising the cantons concerned and German authorities. In stages 2 and 3, the communes in the siting regions are responsible for regional participation, in which local residents can become involved. In all three stages, citizens also have the option to express their views and concerns during the public consultation. At the end of stage 3, a national referendum against the parliamentary decision concerning the award of a general licence can be launched.

GLOSSARY

Auxiliary access facility
Auxiliary access facilities for ventilation and operational access.

FNSI
Swiss Federal Nuclear Safety Inspectorate

Geological siting area
A geological siting area is determined by the rock mass underground that is suitable for the storage of radioactive waste.

High-level waste
Spent fuel elements that can no longer be used are classified as high-level waste. This category also includes vitrified fission products resulting from reprocessing. High-level waste exclusively results from the operation of nuclear power plants.

Jura Ost
Geological siting area which will be further explored in stage 3 according to the decision of the Federal Council of November 2018.

Jura-Südfuss
After the Federal Council's decision of November 2018 this geological siting area will not be further explored in stage 3.

Low- and intermediate-level waste
This category of waste primarily contains short-lived material with a shorter half-life. This waste results from the operation and later dismantling of nuclear power plants, and from the medical, industrial and research sectors.

MIR waste
The medical, industrial and research (MIR) sectors mainly produce low- and intermediate-level radioactive waste. The federal government is responsible for the disposal of this waste category.

Nagra
The operators of the five nuclear power plants are responsible for the disposal of the radioactive waste they produce. In 1972, they established the National Cooperative for the Disposal of Radioactive Waste (Nagra), the responsibilities of which include the planning of deep geological repositories for both categories of radioactive waste and the preparation of proposals for suitable sites for deep geological repositories based on geological studies.

Neighbouring countries
In the Sectoral Plan for Deep Geological Repositories, the term 'neighbouring countries' refers to Austria and Germany, which are represented in various committees.

Nördlich Lägern
Geological siting area which will be further explored in stage 3 according to the decision of the Federal Council of November 2018.

Nuclear Energy Act
The Nuclear Energy Act regulates the peaceful use of nuclear energy in Switzerland. It entered into force in 2005 and is constantly being amended, for example following the decision taken in 2011 to phase-out nuclear energy.

Nuclear Energy Ordinance
This Ordinance is based on the Federal Nuclear Energy Act (Article 101, paragraph 1).

Sectoral Plan for Deep Geological Repositories: Conceptual Part
The Federal Council adopted the Conceptual Part of the Sectoral Plan for Deep Geological Repositories on 2 April 2008. It defines the objectives of the federal government and the criteria, according to which the site selection procedure for all waste categories is to be carried out in Switzerland.

SFOE
Swiss Federal Office of Energy

Siting canton
A canton with one or more communes in a siting region. In stage 3, the siting cantons are Aargau, Schaffhausen, Thurgau and Zurich.

Siting commune
A commune beneath the boundaries of which a geological siting region lies.

Siting region
In stage 2, a siting region comprised the siting communes plus other communes located partially or entirely within the defined planning perimeter. In certain justified cases, other communes could also be included in a siting region. In stage 3, a siting region comprises the infrastructure communes and other communes included as necessary. Infrastructure communes include siting communes and other communes where an infrastructure system could be constructed on or below the surface of their territory. Other communes to be included are those communes involved in stage 2 that are not already designated as infrastructure communes and those bordering on siting regions and thus with an interest based on regional connectivity, topographic proximity to the surface infrastructure or potential socio-economic or ecological impacts.

Südranden
After the Federal Council's decision of November 2018 this geological siting area will not be further explored in stage 3.

Surface facility
The Surface facility is the main point of entry to deep geological repository.

Waste producers
Anyone who operates or decommissions a nuclear facility is obliged to dispose of all radioactive waste produced at that facility, at their own cost (Article 31, Federal Nuclear Energy Act). The federal government is responsible for the disposal of radioactive waste produced from the MIR sectors (Article 33, paragraph 1a, Federal Nuclear Energy Act). In 1972, the federal government and the operators of Switzerland's five nuclear power plants formed Nagra, a cooperative with the aim of finding a solution to the problem of permanently and safely disposing of nuclear waste.

Wellenberg
After the Federal Council's decision of November 2018 this geological siting area will not be further explored in stage 3.

Zürich Nordost
Geological siting area which will be further explored in stage 3 according to the decision of the Federal Council of November 2018.

+ WEBSITES

- Federal Department of the Environment, Transport, Energy and Communications
  www.detec.admin.ch
- Swiss Federal Office of Energy (SFOE), radioactive waste disposal
  www.radioaktiveabfaelle.ch
- Swiss Federal Office of Energy (SFOE), financing of waste disposal
  www.entsorgungsfonds.ch
  www.stilllegungsfonds.ch
- Swiss Federal Office of Energy (SFOE)
  www.sfoe.admin.ch
- Federal Office for Spatial Development
  www.are.admin.ch
- Swiss Federal Nuclear Safety Inspectorate
  www.ensi.ch
- Federal Nuclear Safety Commission
  www.kns.admin.ch
- Federal Geoinformation Centre
  www.swisstopo.admin.ch
- National Cooperative for the Disposal of Radioactive Waste (Nagra)
  www.nagra.ch

Where can I obtain more detailed information?
This brochure provides an introduction to the site selection procedure for deep geological repositories. We will be pleased to supply you with additional documentation. Please do not hesitate to call us, order other reports or visit the websites listed below.

Additional documentation that is available from the SFOE:

«Focus Tiefenlager», an SFOE newsletter dealing with the Sectoral Plan for Deep Geological Repositories, Swiss Federal Office of Energy

Sectoral Plan for Deep Geological Repositories – Conceptual Part, Swiss Federal Office of Energy

IMPRESSUM Federal Department of the Environment, Transport, Energy and Communications DETEC — **Swiss Federal Office of Energy SFOE,** Disposal of Radioactive Waste section, Mühlestrasse 4, CH-3063 Ittigen — Postal address: 3003 Bern — Phone +41 (58) 465 07 35 — Fax +41 (58) 463 25 00

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