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Sectoral Plan for Deep Geological Repositories

Conceptual Part

In 2011 minor revisions to the Conceptual Part were made. The revised document of 2011 is available in German, French and Italian only. This document is the version of 2008.

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Principal
Swiss Federal Office of Energy SFOE, 3003 Bern

Agent
SFOE Legal Services and Safety Division

Project Leader
Michael Aebersold

Contributing agencies
Swiss Federal Office of Energy SFOE
Federal Office for Spatial Development ARE
Swiss Federal Nuclear Safety Inspectorate HSK
Commission for Radioactive Waste Disposal CRW
Federal Nuclear Safety Commission NSC

Advisory Board
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Andreas Bürgi, Emch + Berger (Administration)

Graphics
unikum, Bern

Swiss Federal Office of Energy SFOE
Mühlestrasse 4, CH-3063 Ittigen · Postal address: CH-3003 Bern
Phone +41 31 322 56 11, Fax +41 31 323 25 00 · contact@bfe.admin.ch · www.bfe.admin.ch

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Summary

The conceptual part of the sectoral plan for deep geological repositories defines the goals of the federal government in this area and the procedures and criteria to be applied in selecting sites for deep geological repositories for all categories of waste in Switzerland. The focus of the site selection process is on safety-based criteria, with land use and socio-economic aspects playing a secondary role. The conceptual part of the plan also specifies a three-stage site selection process and regulates the collaboration between the federal government and the cantons and neighbouring countries, among the responsible federal offices and concerned organisations and persons under public and private law, in so far as they are entrusted with performing public tasks. It also outlines how spatial planning activities are coordinated with one another and how development can be supported in siting regions that are influenced by the repository projects.

Content of the conceptual part

Of paramount importance in the disposal of radioactive waste is the long-term protection of man and the environment. It is recognised worldwide that for high-level and long-lived intermediate-level waste, only disposal in suitable, geologically stable formations can ensure safety over the long timescales involved. The sectoral plan

– defines the criteria relating to safety and technical feasibility that are applied in the selection of geological siting areas and the fundamental procedure to be followed for evaluating spatial planning and socio-economic factors;

– regulates the procedure leading from selection of geological siting areas to concrete sites for geological repositories;

– specifies, after each stage, the planning perimeters of the regions (binding on the authorities) and, finally, the sites for geological repositories.

The sectoral plan approach ensures that sites for geological repositories are evaluated and identified as part of a fair, transparent and participatory process. This should create the boundary conditions for disposing of radioactive waste in Switzerland within reasonable timescales.

Site selection in three stages

The conceptual part of the sectoral plan defines three stages which, based on investigations performed to date and current understanding of the geological conditions in Switzerland, will lead to identification of sites for the required geological repositories. Where necessary, current understanding will be improved in a stepwise process. Different requirements apply to the engineered and natural barriers for disposal of the different categories of waste. The current concept foresees two repositories, one for high-level waste (HLW) and one for low- and intermediate-level waste (L/ILW). If a single site were to fulfil the requirements for both HLW and L/ILW, the outcome of the site selection process could be one site for disposal of all radioactive waste.

In stage 1, the waste producers propose geologically suitable siting areas based on safety criteria and justify this selection in a report addressed to the federal government. This is followed by an assessment of the spatial planning situation and a safety review before the siting areas are integrated into the sectoral plan. At the same time, a cantonal commission is established and the groundwork prepared for regional participation.

Together with the siting cantons, a spatial planning assessment of the siting areas proposed in stage 1 is undertaken in stage 2 and, working together with the siting regions, socio-economic studies are prepared. With input from the siting regions, the waste producers also draw up proposals for the configuration and design of the surface infrastructure, decide on the layout of the underground components of the repository and select at least one site for each siting area. This involves carrying out provisional quantitative safety analyses and a safety-based comparison before identifying at least two sites each for HLW and L/ILW.

In stage 3, the remaining sites are investigated in depth with a view to site selection and submission of an application for a general licence. If necessary, the site-specific geological information required for these steps can be supplemented by performing geological investigations. The repository projects are concretised together with the siting regions and socio-economic implications are analysed in greater depth. The siting regions propose projects for regional development and prepare the background information for deciding on any compensation measures and for monitoring of socio-economic and environmental impacts. Compensation measures will be negotiated and made transparent in stage 3. The waste producers finally submit applications for a general licence (one each for HLW and L/ILW or one for a combined repository).

At the end of each stage, a review is conducted by the responsible federal authorities; this is followed by a three-month consultation phase before the Federal Council makes its decision. The general licence granted in stage 3 has to be approved by parliament and is subject to an optional national referendum.

Tasks and responsibilities

The lead in the sectoral plan process lies with the Swiss Federal Office of Energy. The safety authorities and commissions are responsible for reviewing and assessing all aspects relating to safety. The Technical Forum on Safety set up by the federal government discusses and answers questions on safety and geology received from the public, the communes, siting regions, organisations, cantons and public entities in neighbouring countries. On matters of spatial planning and environmental protection, the Swiss Federal Office of Energy is supported by the Federal Office for Spatial Development and the Federal Office for the Environment.

The siting cantons play an important role. They work together with the federal government, provide support in implementing the site selection process and coordinate the procedures implementing the necessary modifications to the cantonal structure plans and for collaboration with the communes. A cantonal commission is established to ensure cooperation among the government representatives of the siting cantons and the concerned neighbouring cantons and countries. The commission also supports the federal government in the implementation of the site selection process and makes recommendations to the Federal Government. An independent group of experts set up by the cantons themselves has the task of supporting and advising the cantons in evaluating safety-related materials.

The communes in the siting regions can address spatial planning and socio-economic issues as part of regionally organised participation and represent regional interests in the selection process. The interested public and organisations, political parties, associations, etc. can participate at every stage and express their opinions on proposals, expert opinions and conclusions.

The fundamental responsibility of the waste producers is to propose siting regions and, finally, sites in a three-stage process and to justify their proposals to the responsible authorities.

Time horizon and costs

The time when the geological repositories start operating is determined mainly by technical and financial considerations. A HLW repository should be available from 2040 and a L/ILW repository from 2030. The multistage selection process leading up to granting of a general licence by the Federal Council will extend over around 10 years. Taking into account the time required for the subsequent steps (construction of a rock laboratory, construction and operating licence for geological repositories), it will be possible to reach these target dates.

The implementation of the conceptual part of the sectoral plan has implications in terms of financing and manpower for the federal government, the affected cantons and communes and the waste producers. Based on an Ordinance of 22 November 2006, the Swiss Federal Office of Energy can charge fees for the implementation, review and monitoring of work associated with the site selection process. The majority of the costs will be borne by the waste producers in accordance with the user-pays principle.

1 Starting-point

1.1 Introduction

Radioactive wastes arise mainly from electricity production in the five Swiss nuclear power plants and, to a lesser extent, from the use of radioactive materials in the areas of medicine, industry and research (MIR waste). A few 100 m^3 of waste arise every year. Added to this are wastes arising after the end of operation from the dismantling and decommissioning of the power plants and research facilities. Assuming a 50-year operating lifetime for the existing power plants, the total waste volume for disposal will be around 87,100 m^3 packaged in disposal containers (77,000 m^3 L/ILW, 2600 m^3 alpha-toxic waste and 7500 m^3 HLW and spent fuel elements).[1]

The user-pays principle applies to the disposal of radioactive waste. The operators of the nuclear power plants are responsible for disposing of spent fuel and radioactive waste arising from the operation, later decommissioning and dismantling of the plants. The federal government is responsible for managing waste that does not arise from the production of nuclear electricity (i.e. MIR waste). Nagra was set up by the nuclear power plant operators and the federal government in 1972 and entrusted with the task of waste management.

The waste producers are under a legal obligation to dispose of the waste at their own cost. The waste management costs arising during operation (e.g. for reprocessing of spent fuel, Nagra's investigations, construction of interim storage facilities) are met on an ongoing basis. Decommissioning costs and waste management costs arising after the shutdown of the plants are secured by payments made by the waste producers into two funds – the decommissioning fund and the waste management fund.

The issues of nuclear energy and waste management have long been the subject of heated debate. In the latter half of the sixties, some sectors of the population began to oppose the construction of nuclear power plants, with activities reaching a high-point with the occupation of the site of the planned Kaiseraugst power plant in 1975. In 1988, the members of the Federal Assembly voted to abandon the Kaiseraugst project. In the last 30 years, there have been more than half a dozen popular initiatives calling for phasing-out of nuclear energy and all of these have been rejected, with the exception of a 10-year moratorium on the construction of new power plants that was accepted in 1990. The most recent votes on the subject of nuclear energy were on 18 May 2003. An initiative on «nuclear-free energy» (change in energy policy and gradual closure of the power plants) was rejected by 66.3 % of the voters and an initiative «moratorium plus» (extension of the existing 10-year moratorium) by 58.4 %. The people and their elected representatives thus confirmed the position of the Federal Council on nuclear energy, namely that the option should remain open and that existing plants can remain in operation as long as they are safe. This position was strengthened with the Nuclear Energy Act of 21 March 2003, which entered into force on 1 February 2005.

The paramount objective of radioactive waste disposal is to ensure the long-term protection of man and the environment from the effects of ionising radiation. It is recognised worldwide that, for high-level and long-lived intermediate-level waste, this protection can only be assured over the long timescales involved by disposal in suitable, geologically stable formations. This principle is anchored in the Nuclear Energy Act and also applies in Switzerland to disposal of low- and intermediate-level waste. The legislation thus calls for deep geological disposal of all categories of waste arising in Switzerland. These facilities, typically at a depth of several hundred metres, will be closed when the long-term protection of man and the environment by a system of passive barriers is assured.

The Nuclear Energy Act also states that waste produced in Switzerland should, in principle, be disposed of in Switzerland. In the past, the possibility of a multinational disposal solution has been raised by a

[1] Based on information from Nagra, as of September 2006.

wide range of political interest groups. However, such solutions have never been considered as a realistic possibility by the Federal Council and continue to be contentious. Multinational solutions regularly come up for discussion in technical groups of international organisations (e.g. the International Atomic Energy Agency), but the reality is that, particularly in European countries that already have repositories in operation or whose disposal programmes are far advanced, the importing of radioactive waste for disposal is prohibited by law. At present, there is no acceptable multinational solution in sight for Switzerland and, for political reasons, a multinational disposal facility located in Switzerland also does not come into question. Adopting a «wait and see» approach and failing to bring national projects forward is considered irresponsible. Independent of the further use of nuclear energy, it is the responsibility and the task of the current generation to solve the waste disposal issue without delay If, at some point in the future, a multinational project that is acceptable to Switzerland were to be developed, the waste producers could still participate at this stage.

Past experience has shown that selecting sites for geological repositories is a politically controversial process. The purpose of the sectoral plan approach is to provide a fair and transparent selection process which, once the conceptual part has been approved, will lead in a single procedure to identification of one site each for construction of a repository for high-level waste (HLW) and low- and intermediate-level waste (L/ILW). If one sites fulfils the requirements for both HLW and L/ILW, the outcome of the selection procedure could be a single site for all categories of waste. A repository for HLW will be required from 2040 and one for L/ILW from 2030. In contrast with HLW that produces heat and has to be stored until such time as it can be disposed of, L/ILW is ready for emplacement in a repository today.

1.2 Legal framework

1.2.1 Nuclear energy legislation

The Nuclear Energy Act of 21 March 2003 and the Nuclear Energy Ordinance of 10 December 2004 provide comprehensive regulation of all aspects of radioactive waste management. They entered into force on 1 February 2005, replacing the Atomic Act of 23 December 1959. Whoever operates or decommissions a nuclear installation is responsible, at his own cost, for the safe disposal of radioactive waste arising from the installation (Art. 31 NEA). This duty of disposal is fulfilled according to Art. 31, para. 2 when the waste has been emplaced in a geological repository and the financial means are secured for a monitoring phase and subsequent closure of the facility, or when the waste has been emplaced in a foreign disposal facility.

The waste producers are also required to prepare a waste management programme. This is reviewed by the federal authorities and approved by the Federal Council. The waste producers have to provide information on the radioactive waste for disposal, the required geological repositories and their design concepts, the allocation of waste to the repositories, the time plan for implementing the repositories and the financing of waste management activities.

The Nuclear Energy Act also regulates the licensing procedure. Licences for geological investigations in potential siting regions, a general licence, and licences for construction, operation and closure of the repositories are required.

The Nuclear Energy Act does not specify the procedure to be followed for selecting sites for geological repositories. According to Art. 5 of the Ordinance, the federal government has to specify the objectives and requirements applying to disposal of waste in geological repositories in a sectoral plan. This includes, in particular, the site selection process for repositories for all waste categories. The site selection process represents an important basis for the waste management programme; the programme depends to a large extent on the configuration of the selection process as specified in the sectoral plan and, according to the Act, has to be modified periodically to meet changing conditions.

The Ordinance also sets out the fundamental requirements applying to a site for a geological repository. With a view to fulfilling the requirement of assuring long-term safety, Art. 11 provides that the site must have the following properties:

a. sufficient extent of suitable host rock;

b. favourable hydrogeological conditions;

c. long-term geological stability.

A repository also has to be designed in such a way that:

a. the principles applying to the design of nuclear power plants according to Art. 10, para. 1 of the Ordinance, which apply analogously to repositories, are fulfilled;

b. long-term safety is assured by a system of multiple, passive safety barriers;

c. measures for facilitating the monitoring and repair of the repository or for retrieving the waste do not compromise the functioning of the passive safety barriers following closure of the repository;

d. it can be closed within a few years.

The requirements applying to deep geological disposal are defined in HSK Guideline R-21 «Protection Objectives for the Disposal of Radioactive Waste»[2]. The objective of deep geological disposal is to isolate radioactive waste in such a way that man and the environment are protected on the long term from the ionising radiation emitted by the waste. R-21 defines concrete protection objectives and principles for disposal:

Principle 1: *The additional radiation dose to the population resulting from radioactive waste disposal shall be low.*

Principle 2: *When disposing of radioactive waste, environmental protection shall be assured in such a way that the variety of living species (biodiversity) is not endangered and the use of mineral resources is not unnecessarily restricted.*

Principle 3: *The risk to man and the environment arising from radioactive waste disposal in Switzerland shall not, at any time in the future or in any other country, exceed the levels that are permissible in Switzerland today.*

Principle 4: *The long-term safety of a repository shall be assured by a system of multiple passive safety barriers.*

Principle 5: *Any measures that would facilitate monitoring and repair of a repository or retrieval of the waste shall not impair the functioning of the passive safety barriers.*

Principle 6: *The provision of measures for disposal of radioactive waste is the responsibility of the present society that benefits from the waste-producing activities and may not be passed on to future generations.*

The principles have been translated into concrete safety requirements. Two Protection Objectives have been derived from Principles 1, 2 and 3, which apply to the long-term safety of a repository. Protection

[2] The Guideline is based on the old nuclear energy legislation and still uses old terminology. The Nuclear Energy Act defines new terminology (e.g. deep geological repository) and HSK is currently bringing the Guideline into line with the new provisions.

Objective 1 relates to the presumed evolution of the repository under the influence of processes and events that can realistically be assumed to occur. As a complement to this, Objective 2 relates to processes and events that have a lower likelihood of occurrence. Finally, Objective 3 embodies the implementation of Principles 4, 5 and 6, which forbid passing on undue burdens to future generations.

Protection Objective 1: *The release of radionuclides from a sealed repository as a result of processes and events reasonably expected to happen shall at no time give rise to individual doses exceeding 0.1 mSv per year.*

Protection Objective 2: *The individual radiological risk of fatality from a sealed repository as a result of unlikely processes and events not taken into consideration under Objective 1 shall at no time exceed one in a million per year.*

Protection Objective 3: *After a repository has been sealed, no further measures shall be necessary to ensure safety. The repository must be designed in such a way that it can be sealed within a few y*ears.

An annual dose of 0.1 mSv corresponds to one tenth of the limit specified in Art. 37 of the current Radiation Protection Ordinance (of 22 June 1994) for persons not exposed during the course of their employment. It amounts to a few per cent of the average natural radiation exposure and is small compared to fluctuations in natural exposure depending on location. It is in line with Art. 7 of the Radiation Protection Ordinance, which specifies that the licensing authority shall decide on the specification of a source-related dose limit. This limit is low compared with international standards (the ICRP[3] recommends a maximum of 0.3 mSv/year). Radiation exposure that would result in a personal dose of 0.1 mSv per year also represents no hazard for animal and plant species.

The main aspects of financing the decommissioning of nuclear installations and the disposal of radioactive waste and spent fuel are regulated in the Nuclear Energy Act, with the details being contained in the Ordinance of 7 December 2007 on the waste management fund and decommissioning fund for nuclear installations. These two independent funds are fed by annual contributions from the facility operators. The decommissioning fund was established in 1984 and, at the end of 2006, the accumulated fund capital was around CHF 1.3 billion. The waste management fund was established in 2001 and had an accumulated capital of around CHF 3 billion at the end of 2006.

Implementation of the conceptual part of the sectoral plan has implications in terms of financing and manpower for the federal government and the waste producers. The Swiss Federal Office of Energy (SFOE) has the overall lead role in the sectoral plan process and is responsible for centralised operational and administrative activities. This includes, for example, cooperation with the concerned cantons and communes and preparation of key background materials for decision-making. Based on an Ordinance of 22 November 2006, the SFOE can charge fees for the implementation, review and monitoring of work associated with the site selection process and the waste management programme of the waste producers. The majority of the costs will be charged to the waste producers in accordance with the user-pays principle.

1.2.2 Spatial planning legislation

Sectoral strategies and sectoral plans are concerned with the activities of the federal government that have a spatial impact in particular areas that have a significant impact on land use and the environment. They deal with the situation where there is a functional link between these activities and where there is a particular need for coordination with other activities. Article 13 of the Spatial Planning Act of 22 June 1979 requires the federal government to prepare the necessary basis to allow it to fulfil its land use planning obligations; in this connection, it has to draw up the necessary sectoral strategies and sectoral plans

[3] International Commission on Radiological Protection (1998): Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste. ICRP Publication 81. Elsevier.

and integrate them with one another. The federal government has to work closely together with the cantons in this respect. In its sectoral strategies and sectoral plans, the federal government sets out:

1. what its goals are and how these are reconciled with regional planning policy objectives;

2. what general guidelines apply for fulfilling its tasks, in particular what interests have to be taken into consideration, what priorities it sets in realizing its goals and what means are used for this.

If the federal government has the necessary competence, as is the case for management of radioactive waste, it also issues:

3. concrete instructions to the responsible federal and cantonal authorities regarding the site for planned installations or measures, requirements for implementation, organisation of work or the work programme.

In the application for granting of the general licence, the applicant has to show in a report how the project has been reconciled with the spatial planning situation. The Spatial Planning Ordinance of 28 June 2000 implements the provisions of the Spatial Planning Act and, in particular, regulates cooperation of the responsible federal authorities, the cantons and neighbouring countries, consultation of the cantons and communes and information and participation of the public.

1.2.3 Environmental protection legislation

Radioactive materials and ionising radiation are covered by the legislation on radiation protection and nuclear energy. Article 10a of the Environmental Protection Act of 7 October 1983 also provides that an environmental impact assessment (EIA) requires to be carried out for projects that may have a significant impact on the environment. As part of this EIA, the applicant has to prepare a report documenting the original conditions before starting the project work, the details of the project, including measures foreseen for protection of the environment, and the expected remaining impact on the environment.

According to the Ordinance on the EIA, geological repositories for radioactive waste require to undergo a two-stage EIA. The first stage forms part of the general licence procedure (Art. 12 ff. of the Nuclear Energy Act) and the second stage is part of the construction licence procedure (Art. 15 ff. of the Nuclear Energy Act).

It has to be shown in stage 1 that the project can be implemented in an environmentally acceptable manner in the sense of the applicable legislation (including environmental protection, water protection and nature and heritage protection). The synthesis report prepared in this first stage performs the function of a preliminary investigation for the stage 2 EIA and sets out the specifications for the main investigation in stage 2. Stage 2 of the EIA relates to the construction licence project.

1.2.4 Strategy of the Federal Council for sustainable development (2002)

The preamble to the Federal Constitution of 1999 requires the Swiss people and the cantons to bear responsibility for future generations. According to Article 73 (sustainability), and by way of a binding mission on state organs of all levels, the federal government and the cantons are required to strive for a long-term balance between nature and its power of renewal on the one hand and the burdens placed on it by man on the other. Against the backdrop of the World Summit on Sustainable Development in Johannesburg, the federal government renewed its strategy for sustainable development in spring 2002. It is based on the provisions of the Federal Constitution and seeks to integrate the principles of sustainable development into as many areas of politics as possible. The strategy sets out the conditions relating to the content and procedures of the sustainable development policy to be followed by the Federal Council in the coming years. In addition to conceptual guidelines, it contains a total of 22 impact-oriented measures in 10 different fields of activity.

Radioactive waste management is not explicitly mentioned in the strategy. However, the aim of a sustainable waste management policy must include preparation for and implementation of safe, long-term disposal of waste arising from the operation of the nuclear power plants and from medicine, industry and research by the generations enjoying the benefits of these activities. Based on the applicable legislation, the federal government has assumed its role in the planning and implementation of waste management measures and ensures that the necessary financial means are available.

The conceptual part of the sectoral plan defines the selection process for sites for geological repositories and opens the way to discussing key aspects of sustainable regional development, identifying conflicting goals and ways to balance these and implementing a solution to the waste disposal issue.

1.3 Waste categories

With a view to disposal, radioactive waste in Switzerland is divided into the following categories (Art. 51 Nuclear Energy Ordinance):

a. high-level waste:

   1. spent fuel not destined for further use;

   2. vitrified fission product solutions from reprocessing of spent fuel;

b. alpha-toxic waste, with a content of alpha emitters that exceeds 20,000 Becquerels/g[4] of conditioned waste;

c. low- and intermediate-level waste: all other radioactive waste.

The current Swiss concept envisages two deep geological repositories: one for low- and intermediate-level waste (L/ILW) and one for high-level waste (HLW). The question of allocation of the waste to the two facilities will have to be described in broad terms at the start of the selection process for geological siting areas as the requirements applicable to a disposal site will also depend on the planned content of the repository. The waste to be placed in a repository (radiotoxicity, half-lives, material composition) has a bearing on requirements in terms of containment (functioning of the engineered and natural barriers), the necessary duration of the barrier function and the safety-related requirements of the site.

On the basis of a concept with two repositories, alpha-toxic waste can be divided and disposed of partly with HLW and partly with L/ILW. If alpha-toxic waste is allocated to the L/ILW repository, the geological siting area will have to fulfil stricter safety requirements than that at which only L/ILW is disposed of. Some L/ILW may also be allocated to the HLW repository. The possibility also exists of constructing a repository for all waste categories at the same site. The first step of stage 1 would be for waste producers to allocate the waste to the two repository types. The definitive allocation would be specified in the general licence (Art. 14 para. 2b of the Nuclear Energy Act).

1.4 Disposal concept

A first concept for nuclear waste management in Switzerland was presented in February 1978. It was based on deep geological disposal and assumed that radioactive waste would be disposed of in suitable geological formations. Top priority was assigned to long-term safety following final closure of the repository.

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[4] Becquerel (Bq): unit for the activity of a radionuclide; 1 Bq = 1 decay per second.

In 1999, the Federal Department of the Environment, Transport, Energy and Communications (DETEC) set up an expert group on disposal concepts for radioactive waste (EKRA). The task assigned to this group was to prepare a basis upon which compare the waste management concepts under discussion. In its report, EKRA came to the conclusion that only deep geological disposal could provide the required long-term protection of man and the environment. The group developed the concept of monitored long-term geological disposal, which combines the features of final disposal with the possibility of retrieving the waste, and thus with reversibility. Prior to closure, the concept foresees an extended monitoring phase with operation of a pilot facility, during which the waste can be retrieved without significant effort. Monitoring, control and maintenance can be foreseen for several generations. The EKRA concept was integrated into the Nuclear Energy Act in the form of deep geological repositories.

The repository has to be passively safe in the long term; this is ensured by a system of engineered and natural safety barriers. A deep repository is brought into operation in stages. Part of the repository – the so-called pilot facility – is to be used for long-term monitoring. Comprehensive checks and controls ensure that any potentially unfavourable developments can be recognised at an early stage and the necessary measures taken. Once emplacement operations are complete, the law requires an extended monitoring phase during which the waste can be retrieved without significant effort. After this, the parts of the repository that are still open can be backfilled and sealed. Following proper closure, the Federal Council can call for a further monitoring phase or for environmental monitoring. The requirements are contained in the Nuclear Energy Act and Ordinance. Responsibility for the closed facility ultimately passes to the State. Based on current planning, this will only occur several decades after the end of operations, towards 2100 at the earliest.

The underground disposal zone of a deep repository is accessed by shafts or tunnels. The surface facilities include administration and operations buildings at the entrance to the underground areas, other structures at shaft heads and the necessary road and rail links (see Figure 1). The area required for the surface facilities is around 80,000 m^2 (200 m x 400 m), which corresponds roughly to the space occupied by a medium-sized industrial operation. Infrastructure installations at any shaft heads will require around 10,000 m^3 and the road and rail links will depend on the existing local situation. While the configuration of the underground installations is dictated by safety requirements, there is some flexibility with regard to the surface facilities. This situation should be used to work together with the siting cantons and regions on arranging the surface facilities in a spatially and environmentally acceptable way, taking the wishes of the siting region into account.

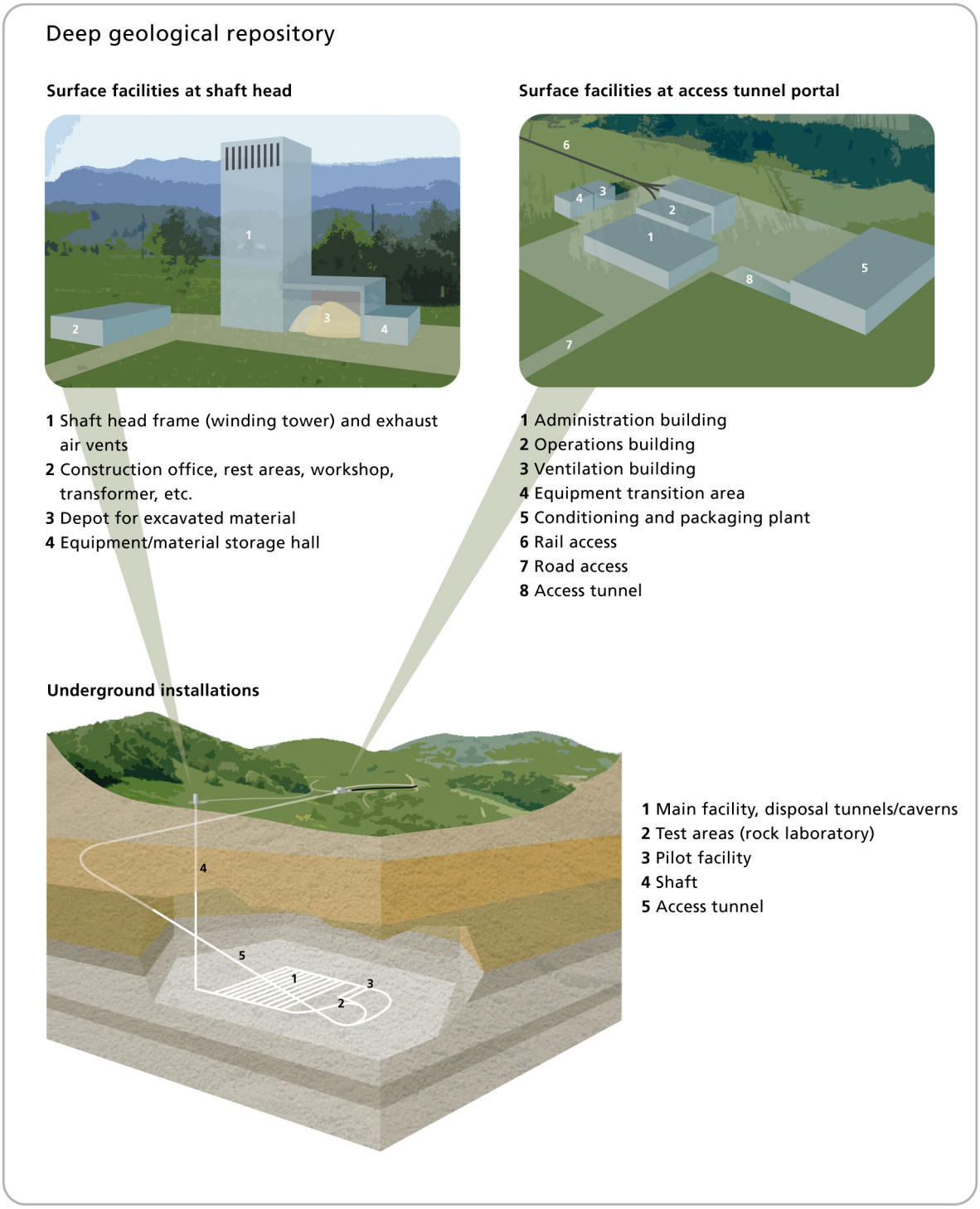

Figure 1: Conceptual model of a deep geological repository for radioactive waste

Until such time as repositories become available, the waste has to be treated (conditioned and packaged) and held in interim storage. Interim storage is already in practice today at the nuclear power plant sites and in the centralised storage facility ZWILAG in Würenlingen (canton Aargau). Waste from medicine, industry and research is held in the federal government's interim storage facility at PSI in Würenlingen.

1.5 Investigations to date and the level of geological understanding

The geology of Switzerland has been the subject of intensive research for more than 200 years and this has resulted in a high level of understanding of large-scale and regional geological conditions. The main contributors to this body of knowledge have been comprehensive large- and small-scale geological mapping exercises, university research, findings from various geotechnical investigation programmes[5] and seismic and borehole investigations, particularly in connection with oil and gas prospecting. Today, a wealth of information exists on the composition, spatial distribution and geological evolution of rock formations in various regions, providing a detailed picture of geological conditions throughout Switzerland. A large component of the information has been compiled as part of dissertation and thesis work carried out at Swiss universities and is therefore well documented.

In the last 30 years or so, Nagra has carried out a wide range of geoscientific investigations, including seismic surveys and deep boreholes, regional studies, geological syntheses and investigations in two rock laboratories. This work has made a significant contribution to the understanding of the geology of Switzerland. Exploratory boreholes using state-of-the-art methods in particular have provided valuable new information that is relevant for deep geological disposal.

Figure 2 shows the investigations that have been carried out in Switzerland in recent decades that are particularly relevant for the geological disposal of radioactive waste. The information available today forms a sound basis for carrying out repository site selection in accordance with the procedure defined in the sectoral plan, and should be applied in the search for sites. If necessary, additional field investigations (e.g. boreholes) will be carried out to investigate local conditions in more detail. The type and extent of these additional investigations will vary depending on host rock and the scope of investigations already performed.

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[5] Road and railway tunnels, hydropower plants, tunnel systems, defence installations, foundations, slope stabilisation, etc.

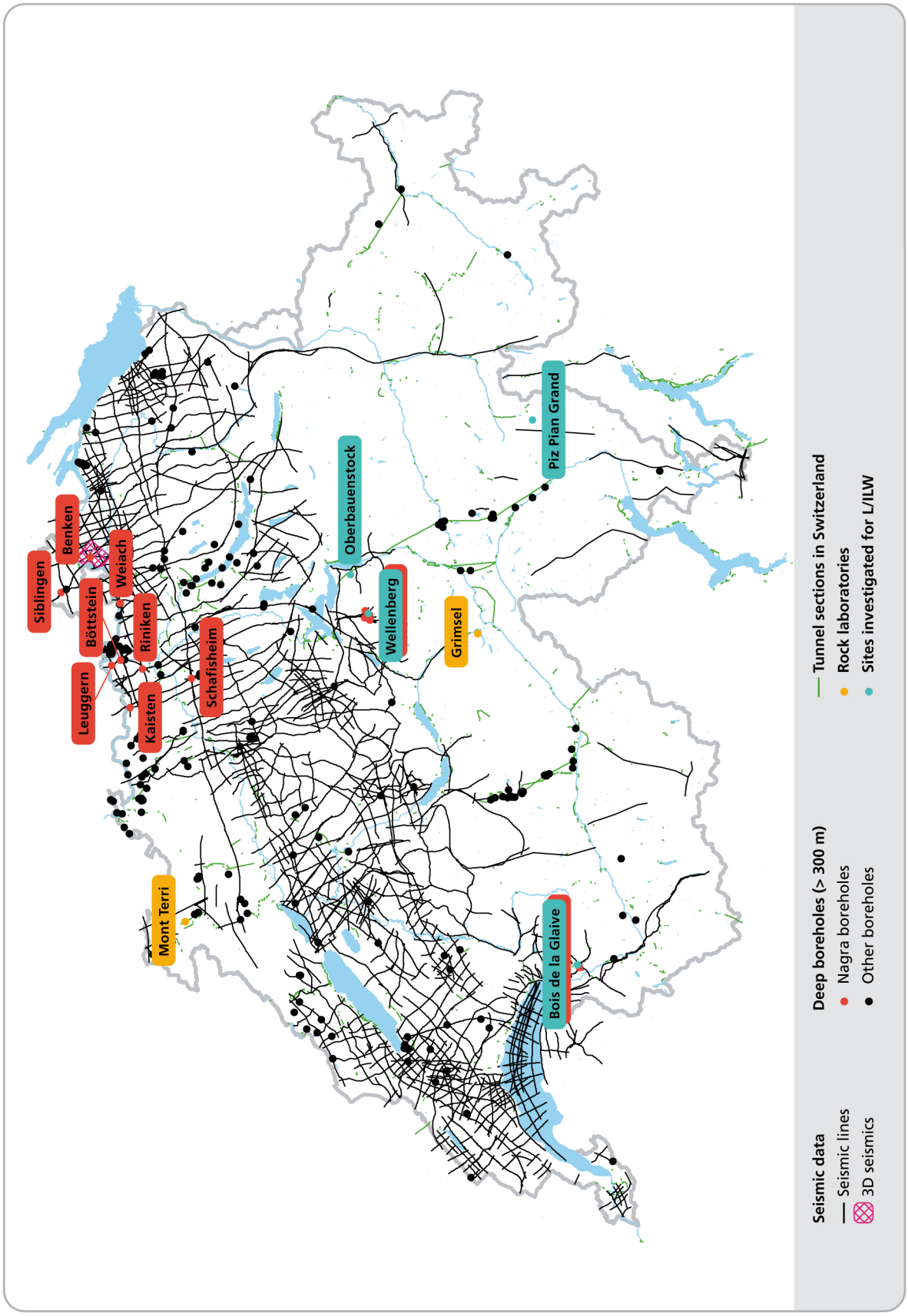

Figure 2: Geological investigations in Switzerland (reproduced with permission of swisstopo (BA068299))

With the start of commercial use of nuclear energy in Switzerland at the beginning of the 1970s, the issue of safe disposal of the resulting waste increasingly became the focus of public and political debate. This prompted the electricity utilities and Nagra to present a concept for disposal of all waste categories in February 1978. The report produced documents concepts and basic principles and outlines the general procedures to be followed, as well as the fundamental geological requirements applying to disposal of waste in geological formations. Based on the information available at the time, it was assumed that host rocks exist in Switzerland that would be suitable for the construction of repositories for all waste types.

1.5.1 Low- and intermediate-level waste (L/ILW)

In 1981, Nagra evaluated and discussed a range of geological barrier systems in terms of their suitability for hosting a L/ILW repository; the evaluations were based on safety-related requirements. These deliberations led to the identification of five potential host rock types: anhydrite, alpine marls/claystones, Opalinus Clay, crystalline basement and shielded formations, i.e. formations that are protected from water infiltration by a «roof» of impermeable rock layers. The disposal concept at the time assumed horizontal access to the underground disposal zone and, based on the information available, a total of 100 potential siting areas[6] were identified. Following a systematic evaluation[7] of these 100 areas, between two and five potential siting areas for each of the five host rock types were selected for in-depth investigation. This led to the number of potential siting areas being narrowed down to 20. In a further step, three types of host rock which had been evaluated as being suitable were selected, from which a promising site could be identified: anhydrite (Bois de la Glaive), crystalline (Piz Pian Grand), alpine marls/claystones (Oberbauenstock). In 1986, the Wellenberg site (marl) was added to the list due to its comparatively better potential for exploration. This meant that there were four potential sites for comparison.[8] Nagra submitted the feasibility study (known as 'Project Guarantee') in 1985 and, in June 1988, the federal government found that the feasibility of disposing of L/ILW had been successfully demonstrated based on a repository constructed in the marl at Oberbauenstock. Following a comparative assessment of the four sites, and once the federal authorities and the affected cantons had been given the opportunity to express their opinions, Nagra selected the Wellenberg site in canton Nidwalden for further investigation in 1993.

The plan was to construct a repository at this site after more in-depth exploration. To this end, the power plant operators set up the operating company GNW in 1994 and an application for a general licence was submitted on 29 June of the same year. In June 1995, the voters of canton Nidwalden refused to grant the concession[9] for use of underground space required under cantonal law and rejected the recommendation of the cantonal government to grant the general licence. The licence procedure was then put on hold.

The blocked project was then changed to a staged process, with the first step consisting of construction of an exploratory drift for investigating the suitability of the site. If the outcome of these investigations were positive, the second step would have been to submit an application to construct the repository. The disposal concept was also modified. GNW submitted an application for a concession for the exploratory drift in January 2001 and this was approved by the cantonal government in September 2001. One year later, in September 2002, the cantonal voters rejected the application. GNW then withdrew its general licence application and the company was dissolved the following year.

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6 23 with anhydrite, 15 with alpine schists and marls, 25 with Opalinus Clay, 23 with shielded formations and 14 with crystalline basement.

7 The following evaluation criteria were derived from the safety requirements:
1. Geometric features of the host rock such as extent, thickness and depth below surface;
2. Barrier properties such as low permeability, sorption properties, chemical milieu;
3. Predictability of geometry, geology and hydrogeology and future changes in these parameters;
4. Existing information on the site.

8 Names highlighted in turquoise on the map in Figure 2.

9 According to the Nuclear Energy Act, cantonal licences and plans are no longer necessary.

1.5.2 High-level waste (HLW)

For high-level waste disposal, Nagra initially pursued the option of the crystalline basement as a first priority and, in 1979, an application was submitted for a licence to construct a rock laboratory in the crystalline formations of the Grimsel region[10] (canton Bern). The following considerations favoured the selection of crystalline as a host rock:

– knowledge available from foreign projects (particularly Sweden);

– good rock mechanical properties (e.g. strength) that would facilitate the construction and operation of a repository;

– based on available knowledge, it was assumed that large-scale undisturbed blocks of rock with low water movement existed in the crystalline basement of northern Switzerland;

– no conflict with natural resources.

The selection of the crystalline basement as a host rock served as the basis for identifying the investigation area for potential sites: the area to be investigated had to be tectonically quiet and stable on the long term. The Alps and the areas of north and north-west Switzerland influenced by the Rhine valley rift did not meet these requirements and were therefore excluded. Because of the risk of erosion, the repository also had to be located at least 500 m below the earth's surface, yet for reasons of engineering feasibility and temperature, no deeper than 1200 m below the surface. As crystalline formations satisfying these criteria could be found only in northern Switzerland, the investigation area was limited to a relatively small area covering the cantons of Solothurn, Aargau, Zurich and Schaffhausen. In June 1980, Nagra submitted applications to perform reflection seismic measurements[11] and twelve deep boreholes in the crystalline basement of northern Switzerland.[12] Between October 1982 and February 1985, Nagra drilled exploratory boreholes at Böttstein, Weiach, Riniken, Schafisheim, Kaisten and Leuggern under the supervision of the responsible authorities. The seventh borehole, in Siblingen, was drilled between September 1988 and April 1989.[13] The investigations delivered some surprising results: it was found that the crystalline basement of northern Switzerland is intersected by a large sedimentary trough (the so-called Permo-Carboniferous Trough[14]). The notion that there was a large body of non-fractured crystalline rock in northern Switzerland therefore had to be abandoned. Based on these new findings, Nagra decided not to drill the remaining boreholes.

Project Guarantee, which was submitted to the authorities by Nagra in 1985 was based on the crystalline option for HLW disposal. Following a review by the responsible authorities, the Federal Council decided in June 1988 that it was feasible to construct a repository in crystalline rock with the required level of long-term safety. However, it found that there was insufficient proof that the site was satisfactory i.e. that sufficiently extensive bodies of rock with the required properties could be found, and called for the waste producers to expand their investigations to include sedimentary rocks.

The phase of regional investigations in the crystalline basement of northern Switzerland was concluded by Nagra in 1995 with the «Kristallin-I» safety analysis. Following a review of this project, HSK came to the conclusion in 2004 that the safety of a geological repository for vitrified HLW could be assured if a sufficiently large body of rock with the properties described in Kristallin-I could be found. In HSK's opin-

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10 Coloured orange on the map in Figure 2.

11 Reflection seismics: measurement and interpretation of seismic waves that are reflected by underground rock layers. This provides information on the location and distribution of geological formations underground.

12 Nagra submitted applications for boreholes in Hägendorf (SO), Niedergösgen (SO), Kaisten (AG), Hornussen (AG), Leuggern (AG), Böttstein (AG), Riniken (AG), Birrhard (AG), Schafisheim (AG), Weiach (ZH), Bachs/Steinmauer (ZH) and Siblingen (SH).

13 Red points in Figure 2.

14 The Permo-Carboniferous Trough is filled with very old sediments: Permian (300-250 million years old) and Carboniferous (360-300 million years old).

ion, however, the prospects of finding such a body of rock and demonstrating conclusively that it had the required properties had not improved since Project Guarantee.

For sediments, Nagra initially presented a selection of seven potential host rocks.[15] Based on existing information on safety-relevant properties and the distribution of these rock formations in Switzerland, Nagra then selected two options (Lower Freshwater Molasse (LFM) and Opalinus Clay) for further investigation. The next steps were to carry out field investigations in the Opalinus Clay, evaluate existing data on the Lower Freshwater Molasse and to participate in investigations of the LFM being carried out in various boreholes and tunnels. In 1996, an international research project was initiated in the Opalinus Clay of the Mont Terri Rock Laboratory[16] (canton Jura); Nagra and the federal government are still involved in this project today. As is the case for the Grimsel Test Site, the Laboratory is purely for research purposes.

The results of the sediment investigations have shown that, at least for a HLW repository, the Opalinus Clay had clear advantages in terms of safety over the Lower Freshwater Molasse.[17] As a result, and as part of the work to demonstrate the feasibility of disposal, Nagra proposed exploring the Opalinus Clay option with spatially restricted site investigations and keeping the LFM as a reserve option. The responsible federal authorities (ENSI, CRW, NSC) agreed to this proposal in 1995.

Defining the investigation region for Opalinus Clay was based on safety-oriented criteria[18] and led finally to extensive geological investigations[19] being carried out in the Weinland region of canton Zurich. Nagra submitted an application for a borehole at Benken, which was granted by the Federal Council in 1996. The results from the borehole and the 3D seismic campaign were analysed and documented in several reports. They confirmed the tectonically undisturbed bedding of the Opalinus Clay in the Benken-Trüllikon-Oerlingen-Marthalen area and the long-term isolation capacity of the rock formation.

Based on these results, Nagra submitted the report to demonstrate the feasibility of disposal for HLW to the federal government at the end of 2002. In a so-called options report, Nagra showed the large-scale areas would come into consideration for a HLW repository from a geological viewpoint, the host rocks are found in these areas and the potential siting areas. Following a comprehensive review and a positive evaluation of the project by the federal authorities and international experts, the Federal Council approved the report demonstrating the feasibility of disposal on 28 June 2006. This does not represent a siting decision, but is purely a demonstration of the feasibility, in principle, of constructing a geological repository in Switzerland as required by the Nuclear Energy Act.

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15 Rotliegendes (Permian), Anhydrite Group (Triassic), Gipskeuper (Triassic), Opalinus Clay (Jurassic), Effingen Beds (Jurassic), Lower Freshwater Molasse (Tertiary), Upper Freshwater Molasse (Tertiary).

16 Yellow dot in Figure 2.

17 Disadvantages of LFM compared to Opalinus Clay: heterogeneous structure (particularly marls penetrated by sandstone channels), costly and difficult to explore (unreliable information on detailed structure of the LFM).

18 Depth (of Opalinus Clay) between 400 m and 1000 m; thickness at least 100 m; tectonically undisturbed bedding; no indication of neotectonic activity.

19 Including a 3D seismic campaign and a borehole.

2 The Sectoral Plan for Deep Geological Repositories

2.1 Conceptual part

2.1.1 Preparing the conceptual part

The *conceptual part* of the sectoral plan for deep geological repositories sets out the sectoral goals of the federal government and the procedures and criteria applying to the site selection procedure for geological repositories for all categories of waste in Switzerland. The focus of the site selection procedure is on safety criteria, with land use planning and socio-economic criteria playing a secondary role. The conceptual part also defines procedural steps in three stages, regulates cooperation between the federal government and the cantons and neighbouring countries, among the different federal offices involved and with concerned organisations and public and private persons in so far as they are entrusted with public tasks. It also shows how activities that impact on spatial planning can be reconciled with one another and how the development of siting regions can be supported in so far as they are affected by a geological repository project.

The cooperation with the cantonal authorities began in March 2006. The cantonal offices responsible for spatial planning received a first, incomplete draft of the conceptual part of the sectoral plan for comment. The revised, complete second draft became available in June 2006 and served as the basis for discussions with cantonal experts and German and Austrian authorities in July and August 2006. From 22 June to 31 August 2006, the SFOE conducted a broad, written consultation involving the federal authorities, the cantons, neighbouring countries, organisations and political parties. In June and November 2006, the SFOE also organised consultative workshops for organisations and political parties. The public was brought into the process in the form of representative focus groups which met in June and August 2006 in Rapperswil (St. Gallen), Bern, Lausanne, Neuchâtel and Olten. The discussions and key results from the workshops and focus groups were documented in openly published reports. Together with the written responses from the official consultation process, these formed the basis for revising the draft sectoral plan to produce the version of 11 January 2007.

The hearing and participation phase for this draft version began on 15 January 2007, followed immediately by public information events in Bern, Lausanne, Zürich and Germany. Information events were also held for German and Austrian authorities in Berlin and Vienna in February 2007. At the end of this phase on 20 April 2007, around 180 responses had been received from Swiss, Austrian and German authorities and from cantons and interested organisations (149 from Switzerland, 26 from Germany and 4 from Austria). With the exception of four cantons, all the cantonal governments made use of the opportunity to express their opinions. Around 11,300 responses (mainly joint responses) were submitted by individual persons. A final hearing of the cantons took place from 8 November to 21 December 2007. The present version of the conceptual part of the plan takes into account a large proportion of the opinions expressed.

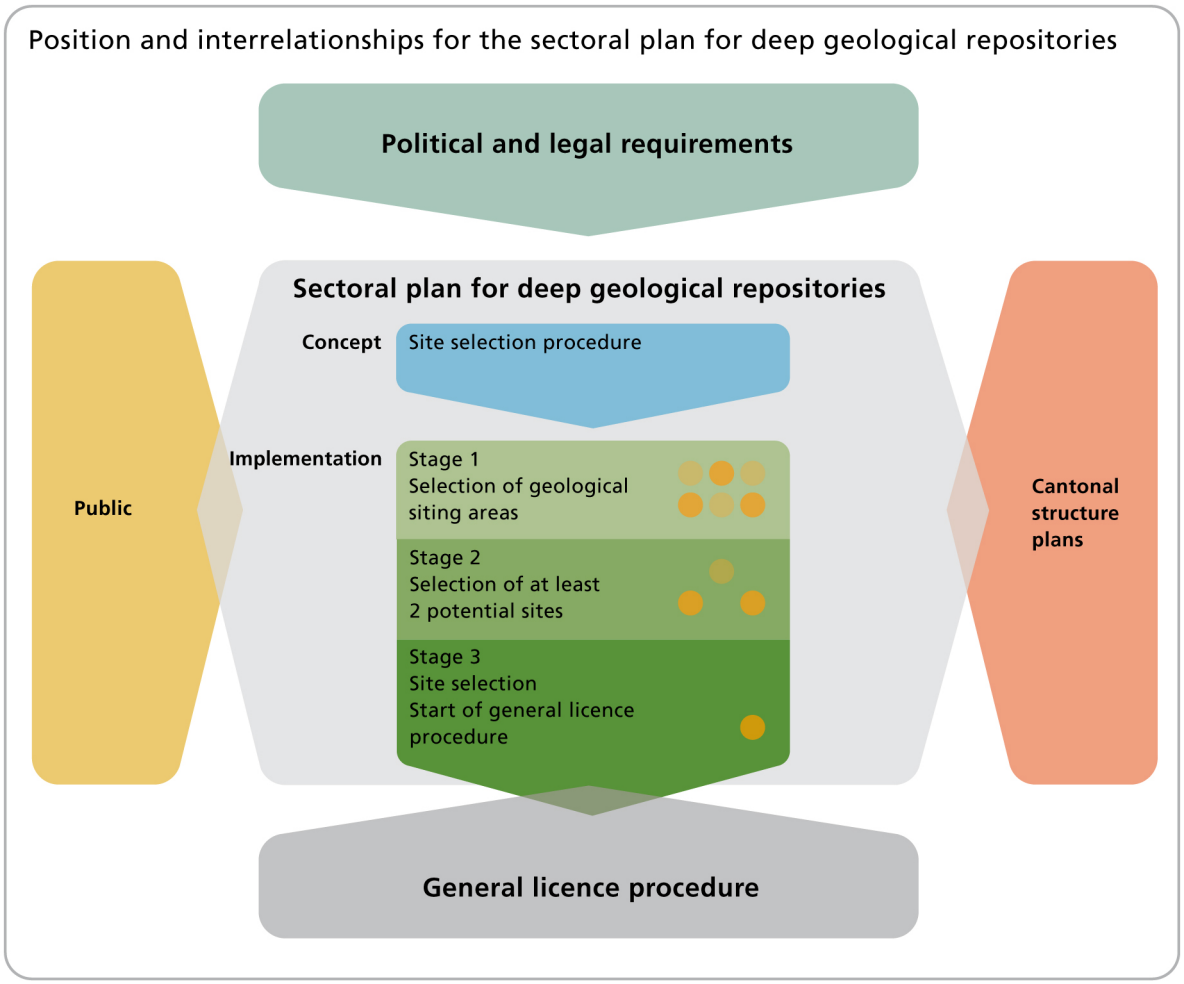

Figure 3: Position and interrelationships for the sectoral plan for deep geological repositories

2.1.2 Sectoral goals of the Federal Government

According to Article 5 of the Nuclear Energy Ordinance, the federal government specifies, in a sectoral plan, the objectives and criteria applying to the disposal of radioactive waste in deep geological repositories; these are then legally binding for the relevant authorities. The sectoral plan is an instrument of the federal government foreseen in the Spatial Planning Act for coordinating infrastructure projects that have nationwide significance. The sectoral plan for deep geological repositories will provide the framework for disposing of waste arising in Switzerland within national boundaries.

The sectoral plan

– defines the criteria relating to safety and engineering feasibility that apply for the selection of geological siting areas and the basic procedure for evaluating spatial planning and socio-economic factors;

– regulates the procedure leading from the selection of geological siting areas to concrete sites for deep geological repositories;

– sets the planning perimeters of the regions after each stage and, finally, the sites for geological repositories in a manner binding on the authorities.

The sectoral plan process ensures that sites for geological repositories are evaluated and identified as part of a fair, transparent, participatory process. This will provide the boundary conditions for disposing of waste in Switzerland on a reasonable timescale. In particular, the aims are

– to inform the public about the objectives, principles and procedures of the federal government in the area of nuclear waste management;

– to collaborate with the concerned cantons, communes and neighbouring countries;

– to create a stable and secure planning framework for the waste producers in their search for sites and implementation of geological repositories;

– to ensure that the rules for site selection and the responsibilities and competences of the different actors are clearly understood from the beginning;

– to define the criteria for selecting sites for deep geological repositories;

– to ensure that different, partly conflicting, interests are discussed, that conflicts and potential solutions are identified and that the site selection process is thus transparent;

– to ensure that the population in the siting regions can participate in an appropriate way and that their concerns are taken into account as far as possible;

– to ensure that, where appropriate, compensation measures are drawn up and implemented in view of expected developments and impacts associated with the repository projects in affected communes and that such compensation measures are negotiated transparently;

– to ensure coordination with other land uses and of the procedures and requirements set out in the Nuclear Energy Act, the Spatial Planning Act and the Environmental Protection Act;

– to ensure that the general licence procedure according to the Nuclear Energy Act is freed from conflicts that can be solved in advance and is thus streamlined.

2.2 Implementation

2.2.1 Results report and object sheets

With the implementation of the conceptual part, the sectoral plan develops a concrete impact in terms of content and spatial implications. The results of the individual stages are documented in a results report and object sheets; these form a central component of the sectoral plan. After each stage, the object sheets and the findings in the results reports are approved by the Federal Council and thus become part of the sectoral plan.

The results report and object sheets represent the outcome of the respective coordination processes. They consist of maps and text and show the extent of the geological siting area, the planning perimeter and, in stages 2 and 3, the sites. They also contain the results of the assessment of safety and feasibility and the evaluation of spatial and environmental aspects. They provide guidelines for implementation in the subsequent stage and for the approval of the general licence.

To provide an overview of all siting regions, the site-specific object sheets are supplemented with single object sheets showing all siting areas for high-level and for low- and intermediate-level waste respectively.

2.2.2 Geological siting area, planning perimeter and siting region

According to the requirements in the conceptual part of the plan, in stage 1 the waste producers put forward proposals for geological siting areas. The selection is based exclusively on criteria relating to safety and engineering feasibility. The geological siting areas are defined by bodies of rock that are suitable for the disposal of radioactive waste. Communes within whose boundary a geological siting area is located, either partly or fully, qualify as siting communes.

In stage 1, a planning perimeter is defined for each geological siting area and – if the evaluation by the authorities is positive – an object sheet is prepared. The planning perimeter designates the geographic region that is defined by the extent of the geological siting area, taking into account possible configurations of the facilities required at the surface.

The siting region is made up of the siting communes and communes that lie wholly or partly within the planning perimeter. In justified cases, other communes can also be included in the siting region.

Figure 4 shows the link between geological siting area, planning perimeter and siting region.

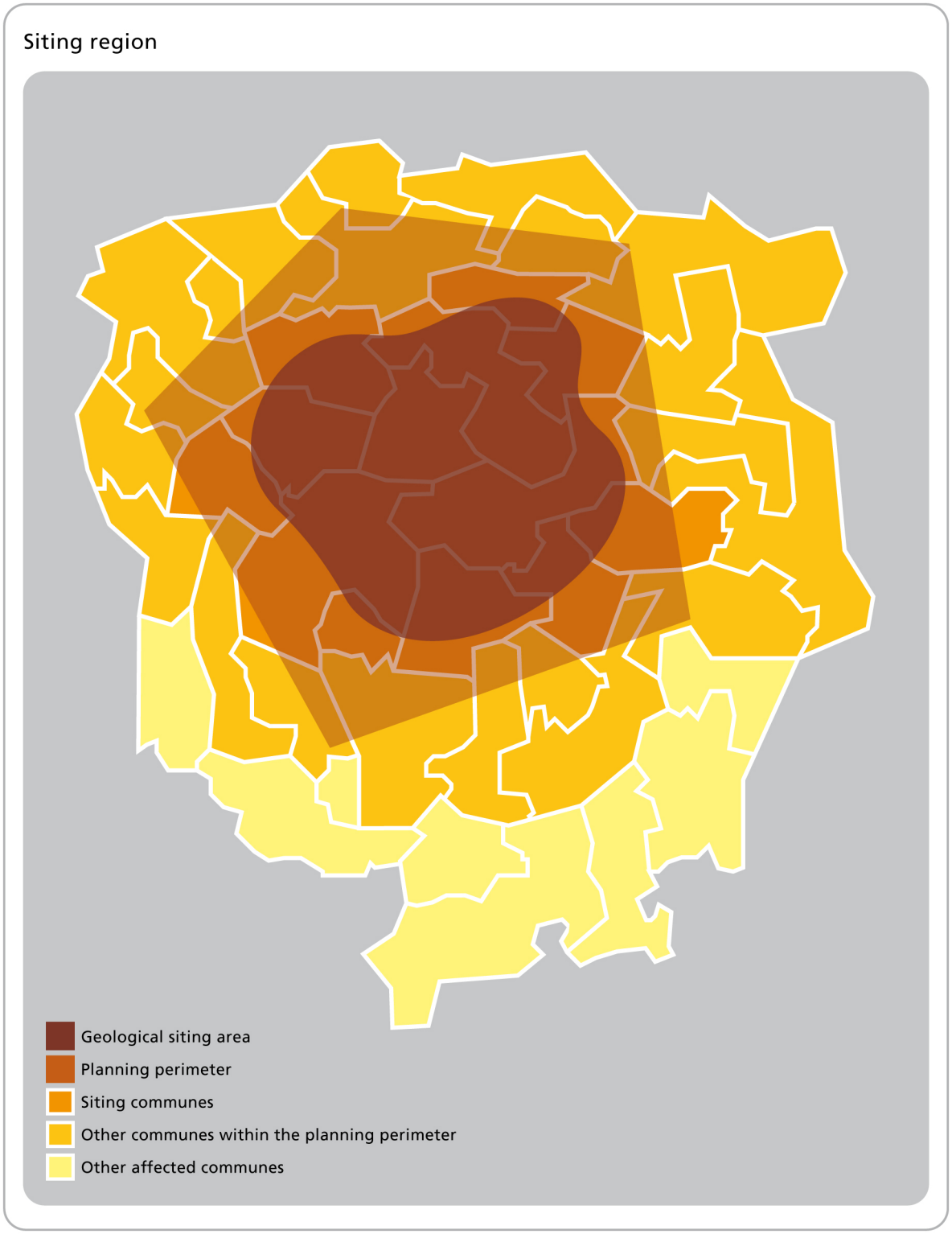

Figure 4: Schematic representation of a siting region

2.2.3 Project organisation

The Federal Department of the Environment, Transport, Energy and Communications (DETEC) steers and monitors the site selection process. In this role, it is supported by the Federal Nuclear Safety Commission (NSC)[20], a Waste Management Advisory Council and an internal departmental steering committee. The Advisory Council is set up by DETEC and, given its independence and its situation on a national level, is expected to bring an outside viewpoint into the process. The steering committee monitors the site selection process in terms of top-level coordination between the federal government and the cantons and ensures that the time schedule is observed.

The lead in the sectoral plan procedure lies with the Swiss Federal Office of Energy (SFOE), which is responsible for project organisation and planning. In its project management role, it appoints working groups (e.g. on safety, spatial planning and law and procedures) and thus ensures that its activities are coordinated with those of the cantons and the waste producers. The SFOE also coordinates the involvement of the relevant authorities of the affected cantons and neighbouring countries in the process and ensures that the public in the siting regions can participate in the decision-making process. The SFOE leads and coordinates the review by the authorities and prepares and updates the results reports and object sheets that are submitted to the Federal Council for approval following a participatory and consultation phase.

In the areas of spatial planning and environmental protection, the SFOE is supported by the Federal Office of Spatial Development (ARE) and the Federal Office for the Environment (FOEN). HSK[21] works together with its advisory body CRW on safety-related questions and evaluates safety aspects. Various experts inside and outside the federal administration are brought in to address individual aspects of the project. For example, the Federal Office of Public Health (FOPH) looks at health aspects within the general licence procedure, swisstopo supports HSK on geological questions and experts from various institutes of the ETH are represented in various technical groups. PSI also plays a central role in research on waste management in Switzerland.

An important role is played by the cantons. They work closely with the involved federal offices and are responsible for the formal implementation of the public participation process. The SFOE supports the cantons in the areas of information and participation of the public by providing relevant materials and setting up a Technical Forum on Safety. Under the lead of ENSI, the Forum receives, discusses and answers technical questions relating to the sectoral plan procedures from the public and other stakeholders. The Forum is made up of technical experts from the authorities (HSK, swisstopo), commissions (NSC, CRW) and the waste producers. In agreement with the SFOE, and on the request of actors involved in the sectoral plan process, further technical experts may be included in the Forum. The cantons and neighbouring countries have numerous opportunities to express their opinions and to participate when they are affected by the process. The communes can become involved in the formal hearing phase, and communes of the siting regions can also take part in the regional participation phase.

The main task of the waste producers[22] is to propose, in three stages, geological siting areas and then sites and to justify these proposals in reports addressed to the responsible authorities.

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[20] The Federal Nuclear Safety Commission replaced the Federal Commission for the Safety of Nuclear Installations (NSC) on 1.1.2008

[21] As of 1.1.2009, HSK will become independent and be replaced by the Federal Nuclear Safety Inspectorate (ENSI). The responsibilities of ENSI within the context of the sectoral plan remain unchanged.

[22] The responsibilities of the waste producers are performed by Nagra. In the present document, only the term «waste producers» is used, meaning all producers of radioactive waste according to the Nuclear Energy Act. According to Art. 33 of the Act, the federal government is responsible for MIR waste and is thus a member of the Nagra Cooperative. The Federal Office of Public Health in the Federal Department of Home Affairs exercises the responsibilities of the government in this respect.

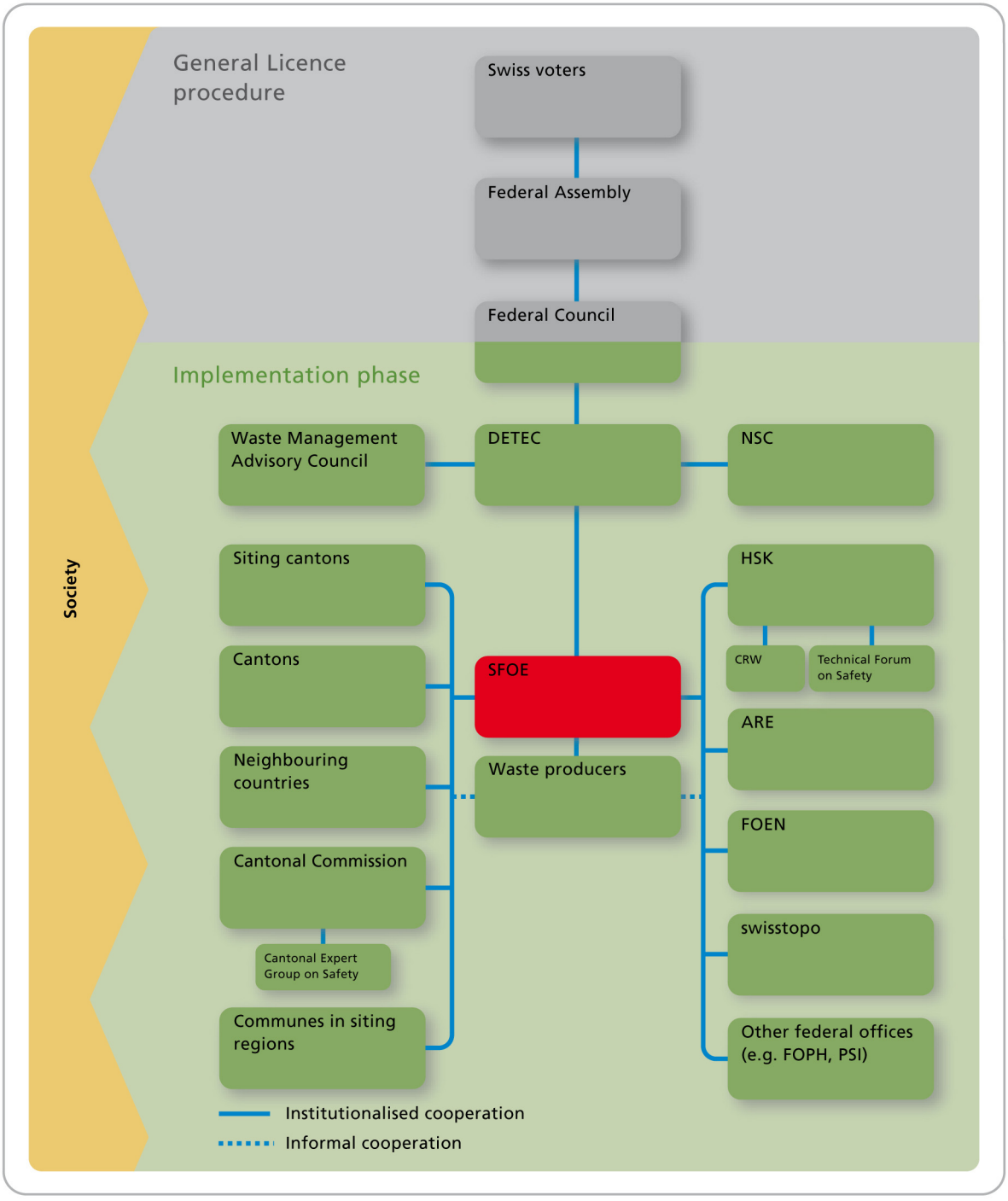

Figure 5: Organisation of the implementation phase[23]

[23] The internal federal project organisation (steering committee, organisation SFOE) is not part of the sectoral plan and is not included in the figure.

Summarised under the term «society», the interested population and organisations, political parties, associations, etc. can participate at every stage and express their views on the drafts of the results reports and object sheets as part of the official consultation phase.[24] The voting public also has the opportunity to express its views in the event of an optional national referendum on the site for a geological repository.

The main activities of the involved federal offices, waste producers and other actors in the site selection process (Waste Management Advisory Council, siting cantons, other cantons, Cantonal Commission and cantonal expert group on safety, communes in the siting regions) are explained briefly in the following and described in more detail in Appendix V.

Swiss voters	May call for an optional national referendum and thus decide on the general licence for geological repositories
Federal Assembly	Approves the general licence
Federal Council	At the end of the three stages, approves the results reports and object sheets and grants the general licence
DETEC	Monitors and guides work on the sectoral plan
NSC	Advises ENSI, DETEC and the Federal Council on fundamental aspects of safety and prepares opinions on the evaluations made by HSK in the three stages
Waste Management Advisory Council	Advises DETEC on implementing the site selection process for geological repositories
SFOE	Lead authority for implementing the sectoral plan process. Prepares and updates results reports and object sheets
HSK	Reviews and evaluates the siting proposals of the waste producers from a safety viewpoint and advises the SFOE on safety issues
Technical Forum on safety	Discusses and answers technical and scientific questions on safety and geology within the framework of the sectoral plan process
CRW	Advises HSK on geological aspects
swisstopo	Supports HSK on geological questions
ARE	Reviews and evaluates spatial planning aspects
FOEN	Reviews and evaluates environmental aspects
Other federal offices (e.g. FOPH, PSI)	Support the SFOE in specific technical areas
Waste producers	In accordance with the requirements specified in the conceptual part of the plan, search for geological siting areas and finally sites for disposal of HLW and L/ILW, evaluate these sites and propose that they be integrated into the plan. They are responsible for preparing and submitting the general licence application together with the necessary supporting documentation

[24] The inclusion of society is also called for with the participation of the siting regions.

Siting cantons	Work together with the Federal Government and support it in carrying out the site selection process; coordinate the procedure for modifying the cantonal structure plans and ensure cooperation with the communes in the siting region
Cantons	As part of the official hearing process, express opinions on drafts of the results reports and object sheets and participate in the process as specified in the Nuclear Energy Act and Spatial Planning Act
Cantonal commission	Ensures cooperation between government representatives of the siting cantons and affected neighbouring cantons and countries and supports the Federal Government in implementing the selection procedure
Cantonal expert group on Safety	Supports and advises the cantons in evaluating safety-related documentation
Communes in the siting regions	Work together with the SFOE in organising and implementing regional participation and represent regional interests
Neighbouring countries	Express opinions on the results reports and object sheets as part of the hearing process and participate in accordance with Appendix VI

2.3 Information, collaboration and hearings

The participation of citizens, the affected public, organisations and parties in Switzerland is made possible by the instruments of direct democracy (polls, referendums, initiatives, elections) and/or by legal procedures (hearings, consultations, right of objection and complaint). These have the disadvantage that they come into play only at the end of a procedure and the possibilities for participating in and influencing the issues under debate are thus restricted. Long-term, complex and controversial projects need a range of interests to be represented at an early stage, as well as a balancing of freedom to negotiate and alternatives. Experience to date with such projects has shown that approaches without direct involvement of the groups affected often fail to obtain the necessary acceptance.

Geological repositories are projects with an uneven cost-benefit distribution. The benefit – the safe disposal of radioactive waste and, before this, the use of nuclear energy that produces this waste – accrues to society as a whole. Any disadvantages that a repository may bring with it are experienced mainly by the siting region. As is the case for other large-scale projects (e.g. waste incineration plants, waste dumps), repository projects can thus be controversial. People tend to perceive the risks associated with such facilities unevenly and evaluate them subjectively. These and other factors make it essential to involve them in the process.

The requirements for involving the different actors can be found in nuclear energy and spatial planning legislation. Spatial planning law, in particular, calls for cooperation and participation in the sectoral plan procedure already at the stage of basic definition of objectives, problem definition and structuring of the procedure. The cooperation and hearing processes defined in spatial planning legislation are suitable tools and methods for allowing those affected by projects to bring their interests and values into the decision-making process. The implementation of the site selection procedure defined in the conceptual part of the sectoral plan is carried out in accordance with spatial planning law, in close cooperation with the cantons and neighbouring countries and involving the public and interested organisations.

2.3.1 Information

In the sectoral plan process, importance is attached to information and communication – an acknowledgement that providing open and transparent information is essential for successful implementation of the site selection process. The work that will be carried out in the three stages and the decisions made, together with justification of these decisions, have to be traceable and transparent. Each stage has to be fully documented by the waste producers and the authorities. Together with the cantons, the federal government will use various information channels (e.g. question and discussion events, presentations, brochures, internet) to inform the public in an understandable way.

The federal government also regularly provides information to:

– affected authorities of the federal administration, the cantons and neighbouring countries

– concerned organisations and the public in Switzerland

Informing organisations and the public in other countries is the responsibility of the foreign authorities.

2.3.2 Cooperation

Before the formal hearing process in accordance with the Spatial Planning Act, there is close cooperation between the federal government and the affected cantons on both a technical and political level. Neighbouring countries that are affected receive the relevant documentation and can present their position under existing state treaty regulations. The sectoral plan also regulates the flexibility in the spatial planning legislation in terms of cooperation as follows:

In stage 1, a cantonal commission will be established; this ensures early coordination among government representatives of the affected cantons and supports collaboration between the cantons and the federal government. If neighbouring countries are affected by the proposed siting areas, they have a right to a place on the commission.

In stage 1, participatory processes are established in all siting regions to ensure that their interests, needs and values can be taken into account in stage 2. Decisive for the right to be involved in regional participation is whether a commune is affected. Siting communes and communes that lie completely or partly within the planning perimeter are considered as being affected. In addition, in justified cases other communes can be considered to fall within the siting region and can then be part of the regional participation. Building up regional participation is done under the lead of the SFOE together with the siting canton and siting communes in question.

2.3.3 Hearing

Each of the three stages of the site selection process ends with a three-month formal hearing or consultation phase prior to the decision of the Federal Council on the drafts of the results reports and the object sheets. The proposals of the waste producers, the results of the reviews by the authorities, the opinions and reports of the cantonal commission and the siting regions and the drafts of the results reports and the object sheets to be approved by the Federal Council are opened to the public. Cantons, neighbouring countries, neighbouring federal states (Germany, Austria) and regions (France, Italy), organisations and political parties can submit their opinion to DETEC. The cantonal offices responsible for spatial planning hold hearings with the cantonal, regional and local offices and ensure that the population is involved in an appropriate manner.

2.4 Relationship between the sectoral plan and the cantonal structure plans

With the sectoral plan, the federal government shows how it deals with its responsibilities as defined by legislation and the constitution. The sectoral plan for deep geological repositories does not create any new powers for the federal government. Sectoral strategies and sectoral plans of the government, the structure plans of the cantons and regional development concepts are taken into consideration in preparing the sectoral plan for geological repositories (in analogy with Art. 6 of the Spatial Planning Act).

The cantons are responsible for their own spatial planning to ensure optimum use and ordered settlement of their region. In cantonal structure plans, which are binding on the authorities, they define the basic principles according to which their region should develop spatially, taking into account the sectoral strategies and plans of the federal government and the structure plans of neighbouring cantons. They take account of the powers of the federal government and its spatial planning tasks and responsibilities.

The duty to cooperate applies to all planning authorities. If conflicts between the sectoral plan and cantonal structure planning cannot be resolved, the siting cantons, neighbouring cantons and federal authorities have the right to call at any time for a settlement procedure from the responsible department (Art. 7 para. 2 and 12 of the Spatial Planning Act, Art. 13 para. 1 of the Spatial Planning Ordinance). If this is unsuccessful, the department will ask the Federal Council to decide (Art. 12 para. 2 of the Spatial Planning Act).

The siting decisions for a geological repository resulting from collaboration between the federal government and the cantons are made within the sectoral plan process and are binding on the authorities at all levels. The cantonal structure plans can specify requirements relating to the arrangement of the surface facilities and how they are accessed. It is also a matter for the cantons, in the sense of Article 6 para. 4 and 8 of the Spatial Planning Act, to define in their structure plans how the other activities of the cantons and communes that impact on spatial planning are to be reconciled with the provisions of the sectoral plan.

The directives in the sectoral plan and the cantonal structure plans complement each other. With a view to defining the planning perimeter, the existing spatial planning situation is recorded in stage 1. This is done by the Federal Office of Spatial Development (ARE), with support from the siting cantons and the waste producers. Based on the existing structure and land use plans, the waste producers prepare the necessary documentation. The geological siting areas that have been evaluated in terms of safety and the defined planning perimeters are included in the sectoral plan in the form of object sheets by way of a preliminary orientation after a three-month consultation phase. Modification of the cantonal structure plans does not appear to be necessary in stage 1.

The end-result of stage 2 is the identification of at least two potential sites each for HLW and L/ILW. If a valid cantonal structure plan were to have the effect of preventing the objectives of the sectoral plan from being achieved or would make it unnecessarily difficult, the canton in question and the SFOE, together with the ARE, coordinate the procedure for the required modification of the structure plan and preparation of the sectoral plan (Art. 18 para. 2 of the Spatial Planning Ordinance).

It is foreseen in stage 3 that, if necessary, the Federal Council can invite the siting canton to modify its structure plan in order to allow a decision to be made simultaneously on the general licence application, the specification of the site in the sectoral plan and the modification of the cantonal structure plan.

2.5 Waste volumes

The question arises as to whether, in selecting a site, it is expected to accommodate the waste volumes that can be foreseen today or whether it has to have capacity for waste arising from any new nuclear power plants. Waste volumes vary depending on the number of power plants and their operating life-

time. Given the small scale of the Swiss nuclear energy programme, the question of waste volume should not be decisive for the technical feasibility of a repository – HLW amounts to just a few thousand m^3.

The continued use of nuclear energy in Switzerland is possible and the Federal Council considers it necessary to replace the existing power plants or to construct new ones. A new NPP would require a general licence, which is subject to an optional national referendum, meaning that the Swiss voters have the last word on whether or not a new plant should be constructed. It therefore remains open at present whether or when new power plants will be constructed in the future.

The site selection process defined in the conceptual part of the sectoral plan should therefore lead to geological repositories that can accommodate the waste from the existing and any possible new NPPs, from their decommissioning and dismantling and from medicine, industry and research (including decommissioning and dismantling of research installations). The maximum disposal capacities will be specified bindingly in the general licences for the repositories. For reasons of transparency, it has to be addressed in stage 1 whether and what reserves are available in the geological siting areas being considered. Highest priority is assigned to the safety of the repository, which may not be compromised by larger volumes of waste.

2.6 Timeframe

Experience in recent decades, both in Switzerland and abroad, has shown that it is possible, although challenging, to set key milestones for the management of radioactive waste and to keep to these. This was one of the main reasons why the Nuclear Energy Act and Ordinance called for a waste management programme to be prepared by the waste producers, reviewed by the SFOE and HSK and approved by the Federal Council. One important component of the programme is a timeframe for the construction of geological repositories.

Up to the time of granting the general licence, the sectoral plan provides key input for preparing the waste management programme. The following figure shows the key steps and deadlines from approval of the conceptual part of the plan to the start of operation of repositories for L/ILW and HLW. It is based on the licensing procedure set out in the Nuclear Energy Act, the site selection procedure outlined in the sectoral plan and the assumption that the Federal Council will decide on the conceptual part of the plan at the beginning of 2008.

The timeframe in Figure 6 does not take into consideration delays resulting from objections and settlement procedures under the Nuclear Energy Act, Spatial Planning Act or other applicable legislation, which could have a significant influence on timing. The dates in the timeframe are not binding, but are instead intended as a guide based on what is known today. Deadlines could move in either direction.

Timeframe

		Date	
Sectoral plan for deep geological repositories Preparation of conceptual part	Approval by Federal Council	2008	
Sectoral plan for deep geological repositories Implementation	**Procedure according to Spatial Planning Act and Ordinance**		**Procedure according to Nuclear Energy Act**
Stage 1: Selection of geological siting areas (2.5 years)	• Cooperation • Hearings and participation • Settlement • Decision on object sheets		
Stage 2: Selection of at least two sites (2.5 years)	• Cooperation • Hearings and participation • Settlement • Decision on object sheets		
Stage 3: Site selection and general licence procedure (2.5-4.5 years)	• Cooperation • Hearings and participation • Settlement		• Preparation and submission of general licence application • Review and approval procedure
Decision of Federal Council (1.5 years)	Approval of object sheets	By 2016/18[1]	Granting of general licence
		By 2017/19	Approval of general licence by Parliament (1 year) • Possible national referendum
		By 2019/23	Approval of geological investigations, construction licence for rock lab at site (2-4 years) • Licence can be opposed before Federal Administrative Court and Federal Supreme Court
		L/ILW by 2025/31 HLW by 2035/41	Supplementary investigations, construction of access tunnel including underground exploration, construction and operation of rock lab at site and construction licence procedure for repository (L/ILW 6-8 years, HLW 16-18 years) • Construction licence can be opposed before Federal Administrative Court and Federal Supreme Court
		L/ILW by 2030/38 HLW by 2040/48	Construction of disposal tunnels/caverns and operating licence (5-7 years) • The operating licence is prepared and granted during the construction phase; licence can be opposed before Federal Administrative Court and Federal Supreme Court
		L/ILW from 2030 HLW from 2040	Earliest start of operation • Additional criteria are taken into account for the start of emplacement, particularly the temperature of the fuel elements to be emplaced in the HLW repository

Figure 6: Timeframe 2008-2038/48

[1] *The time period largely depends e.g. on whether additional exploratory boreholes have to be drilled.*

3 Overview of the site selection procedure

3.1 Site selection in three stages

According to international recommendations, the main features of a repository site selection procedure should be a broadly based search for sites, stepwise narrowing-down of potentially suitable areas and application of safety-based criteria. The conceptual part of the sectoral plan therefore defines three stages which, based on investigations conducted to date and the current status of geological understanding, will lead to the identification of sites for the required geological repositories. Where necessary, this knowledge can be expanded in a stepwise manner. Different requirements apply to the engineered and natural barriers depending on the waste categories for disposal. The current waste management concept foresees two repositories, one for high-level waste (HLW) and one for low- and intermediate-level waste (L/ILW). Alpha-toxic waste (ATW) could be assigned to one or other of the repositories or divided between them. Some of the L/ILW could also be allocated to the HLW repository. If one site fulfils the requirements for both a HLW and a L/ILW repository, the selection procedure could end in a single site for all types of waste. When selecting geological siting areas, however, it has to be clear from the beginning, at least along general lines, which waste categories and sub-categories are foreseen for disposal at a particular site. The site selection procedures for the two repositories are conducted simultaneously.

Based on the user-pays principle, the waste producers are responsible for constructing geological repositories and for all the associated preparatory work. According to the sectoral plan, they are required, in stage 1, to submit proposals to the authorities for geological siting areas and then for concrete sites in the subsequent phases. Based on the overriding principles and objectives of waste disposal and the associated legal framework, the following hierarchy applies to site selection:

– Safety has highest priority: the long-term protection of man and the environment has to be assured. This means that radioactive substances have to be safely isolated from the biosphere until such time as their radiotoxicity has decayed to acceptable levels.

– After safety come aspects of spatial planning, ecology and economic and societal considerations.

The three stages of the site selection procedure are discussed briefly in the following.

The binding requirements for the three stages can be found highlighted in grey in chapters 4 to 6.

3.1.1 Stage 1: Selection of geological siting areas for L/ILW and HLW

Following the definition of the waste inventory and the specification of requirements based on this information in accordance with Appendix I, stage 1 leads to the identification of several geological siting areas for L/ILW and HLW. The waste producers propose these potential siting areas based on the criteria relating to safety and technical feasibility listed in Appendix I and justify the selection in a report to the SFOE.

The siting cantons and communes are then informed by the SFOE before the proposals are made public. A cantonal commission in which the siting cantons and affected neighbouring cantons are represented is then set up. Affected neighbouring countries are also entitled to be represented on this commission.

Based on the sectoral plans and inventories of the federal government, the cantonal structure plans and the land use plans of the communes, the existing spatial planning situation within a 5 km radius of the proposed geological siting area is surveyed. Together with the siting cantons and the ARE, the SFOE defines a provisional planning perimeter and initiates the establishment of regional participation.

In stage 1, the decisive spatial planning indicators and the method for their evaluation in stage 2 are also defined. The lead role for this task falls to the ARE, working together with the siting cantons and the waste producers.

After the safety evaluation and appraisal of the spatial planning situation by the federal authorities, a report on the findings and object sheets are prepared by the SFOE; following a three-month consultation phase under the Spatial Planning Act and approval by the Federal Council, these are then integrated into the sectoral plan as a preliminary orientation. It is possible to resort to any of the designated geological siting areas until such time as the repository general licence is issued. Consequently, they remain part of the sectoral plan up until this point.

3.1.2 Stage 2: Selection of at least two sites each for L/ILW and HLW

The aim of stage 2 is to select at least two sites each for HLW and L/ILW disposal. Safety criteria continue to have the highest priority.

Preparation of background information on socio-economic aspects and the evaluation of the land use situation are led by the SFOE and ARE respectively, working together with the siting cantons and siting regions. Based on the recording of the spatial planning situation in stage 1, a plan is drawn up of existing and planned land uses and contracts are granted for socio-economic studies.

As part of regional participation, the geological repository scenario is considered in all its dimensions with a view to making recommendations to the local communes of the siting regions. For example, questions on safety for man and the environment or potential socio-economic or environmental impacts are discussed with those involved in the process. The siting regions also have the following specific tasks:

– Preparing a background socio-economic study for each siting region under the lead of the SFOE.

– Preparing scenarios for sustainable regional development, proposals for supporting measures aimed at minimising potential negative socio-economic or environmental impacts and the basis for monitoring these impacts.

– Preparing proposals for the layout, location and accessing of the surface infrastructure together with the waste producers.

If a siting region fails to take up the opportunity for cooperation, the waste producers prepare the project proposals together with the authorities of the siting canton.

Together with the siting regions, and focusing on engineering feasibility, the waste producers prepare proposals for the configuration of the required surface infrastructure, design the layout of the underground components of the repository and propose at least one site for each geological siting area. They then carry out quantitative provisional safety analyses for the proposed sites (Appendices I and III).

Based on the evaluation of the sites, including in particular the results of the provisional safety analyses, the waste producers propose at least two sites for each repository. Sites that would come into question for disposal of all waste types should be designated as such.

Following a review of the results of stage 2 by the federal authorities, the results report and object sheets are prepared and updated and, following a three-month consultation phase and with the approval of the Federal Council, the sites identified are incorporated into the sectoral plan as an interim result. The rest of the sites are designated as reserve options and remain in the sectoral plan until the general licence has been granted.

3.1.3 Stage 3: Site selection and general license procedure for L/ILW and HLW

In the final stage, the remaining sites are investigated in greater detail and geological knowledge of the specific sites is brought to such a level – if necessary by means of further investigations (boreholes, seismic surveys) – that the sites can be compared from a safety perspective with a view to preparing the general licence application. The project is developed further with the involvement of the siting region, and socio-economic aspects are investigated in greater depth. The siting region proposes projects for regional development and prepares the background for possible compensation payments and the monitoring of socio-economic and environmental impacts. If compensation is foreseen, this has to be negotiated in stage 3 and made transparent. The waste producers then propose the site where the repository will be constructed (one each for HLW and L/ILW or one for all waste categories).

For the selected site, there must be sufficient information to allow an application for a general licence to be submitted (Appendix IV). Stage 3 leads to the general licence procedure and to the first stage of the environmental impact assessment and ends with the specification of the site in the sectoral plan and the granting of the general licence by the Federal Council.

The decision of the Federal Council is followed by approval by parliament and – if the opportunity is taken up – a national referendum. Sites that were deferred in stage 3 continue to be reserve options and are retained as an interim result in the sectoral plan until such time as the operating licence has been granted.

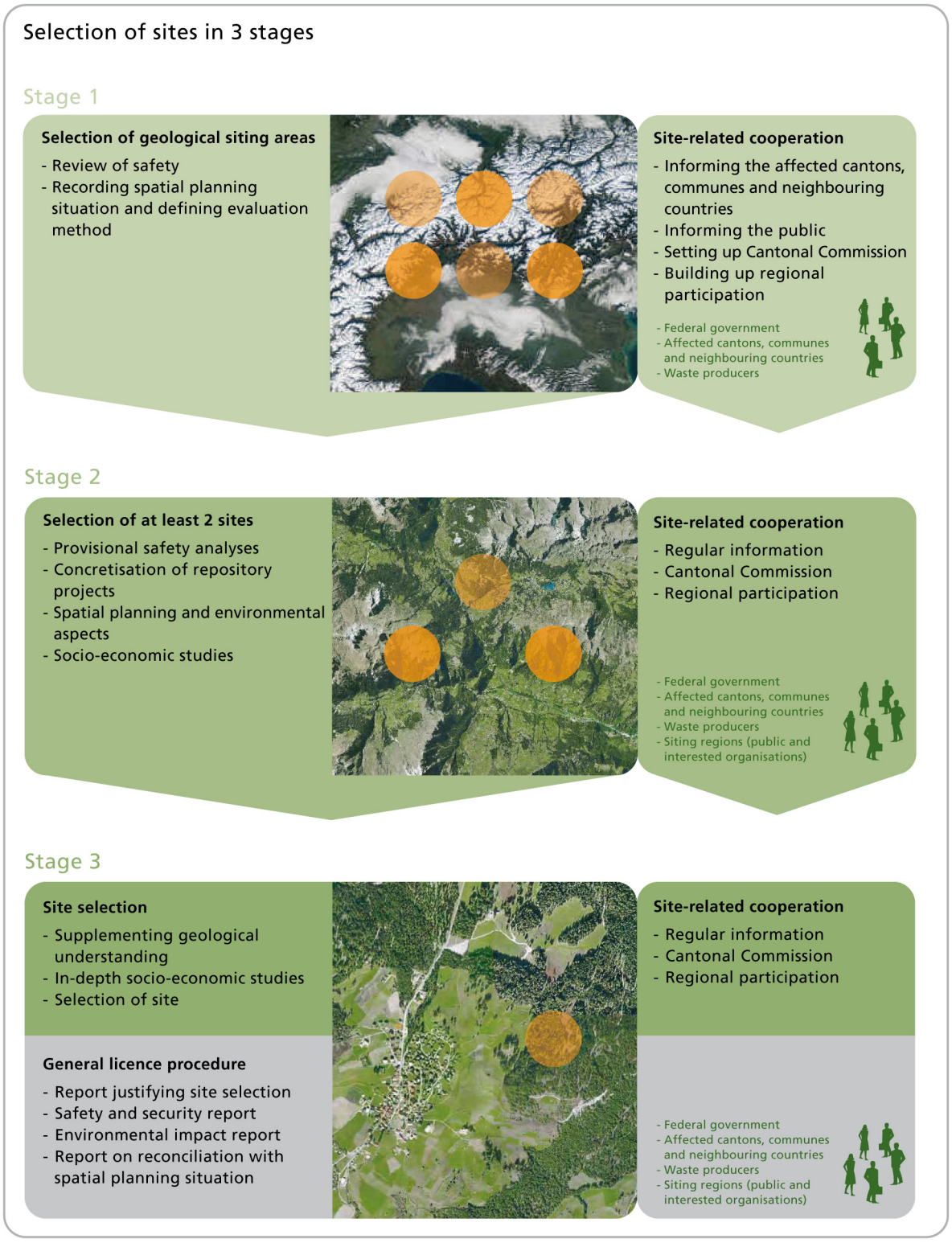

Figure 7: The site selection process and site-related cooperation

3.2 Criteria relating to safety and technical feasibility

In order to identify suitable geological siting areas and subsequently the specific sites, various criteria have to be taken into consideration during the site selection procedure. The initial focus is on wide area criteria essential for long-term safety, after which localised criteria have to be included. The site selection procedure has to investigate the following (Appendix I):

– How are the wastes allocated to the two repository types?

– Taking into account the allocated waste inventory and the associated safety and barrier concept, what requirements apply to the site-specific geological conditions?

– Where are sufficiently large geological-tectonic areas to be found that fulfil the safety requirements?

– In these areas, what rock types are potentially suitable as host rocks or effective containment zones?

– Where can potential host rocks be found in suitable configurations (composition, configuration, depth, thickness, access to underground structures)?

The criteria relating to safety and technical feasibility are initially considered qualitatively. A quantitative evaluation is made in the course of the multi-stage procedure based on the requirements contained in Guideline HSK R-21 «Protection Objectives for the Disposal of Radioactive Waste». The selection of potential geological siting areas and sites is made on the basis of the properties of the underground environment and the overall geological situation that can be expected based on the available knowledge and investigations. The procedure should take account of the fact that a suitable site will not be identified as such on the basis of one individual characteristic. The criteria and the aspects to be evaluated are generally interdependent in their safety-related impact and dependent on the waste inventory and the design of the engineered barriers. In the narrowing-down process, the situation whereby a suitable site would be eliminated due to unnecessarily high requirements in terms of one single characteristic (for example, when applying quantitative individual criteria) should be avoided. The criteria for ruling out a possible disposal area for not fulfilling the stated requirements are defined in the general licence (Art. 14 para. 1f of the Nuclear Energy Act). The potential of a site for expansion, i.e. the possibility of expanding the repository at a later date to accommodate radioactive waste from new power plants, does not play a direct role in the safety assessment of geological siting areas and sites for site selection. Any spatial reserves and their significance for the safety assessment should, however, be considered.

3.3 Spatial planning and socio-economic aspects

When selecting sites, top priority is assigned to the long-term protection of man and the environment. The site selection process, investigation of geological siting areas and construction, operation and closure of geological repositories all have to be oriented towards achieving this goal. While decisions relating to safety are relevant for very long time periods, socio-economic and spatial planning aspects have a short- to medium-term impact, i.e. they are important mainly for the planning, construction and operational phase and for the post-operational phase up to repository closure. Spatial planning and socio-economic aspects should be taken into account in site selection when the sites for selection are equivalent in terms of safety. They are, in any case, relevant for the economic development of a siting region and the optimum arrangement of the surface facilities and the accessing of the repository.

Analyses of the spatial planning situation and socio-economic impacts thus provide additional bases for decision making which can vary significantly from region to region and which are subject to shifts and changes given the long timescales under discussion. Examples include changing borders, political and economic developments and technical developments that cannot be foreseen today. Spatial planning

aspects are investigated under the lead of the Federal Office for Spatial Development (ARE) together with the siting cantons.

In stage 1, the existing spatial planning situation is recorded and decisive indicators and methods for evaluating this situation are clarified and defined in stage 2.

Based on the existing situation, a land use plan is drawn up together with the siting cantons in stage 2. This contains information on existing and planned projects. The sites are evaluated according to spatial planning criteria together with the cantons, following the procedure outlined in stage 1. Socio-economic studies are prepared together with the siting regions and the social, demographic, environmental and economic impacts of a geological repository are evaluated.

In stage 3, land use and planning aspects are important for regional and local integration of the surface installations, the access links to the site, the dumps for excavated material and for general optimisation of the project. The economic implications are investigated in more depth and the background prepared for monitoring socio-economic and environmental impacts.

3.4 Settlement of disputes

The collaboration between the federal government, the waste producers, the cantons and neighbouring countries and the siting regions is aimed at minimising potential conflicts by making reasonable proposals and providing appropriate compensation measures for any conflicts that remain. The legal basis for involving the cantons, neighbouring countries and the public and for dealing with disputes is contained in the nuclear energy, spatial planning and environmental protection legislation, as well as in bilateral agreements and international conventions. In addition to this, the siting cantons and affected neighbouring cantons and countries can represent their interests on the cantonal commission. The communes of the siting regions can bring their interests to bear as part of regional participation.

If the federal government and the cantons, who also represent the interests of the communes in the case of dispute, cannot reach an agreement on how to reconcile their respective activities that impact on spatial planning (Art. 7 of the Spatial Planning Act), or if the results report or object sheets contain contradictions with the cantonal structure plans that cannot be resolved (Art. 20 of the Spatial Planning Ordinance), then a settlement procedure can be initiated. Such a procedure can be called for at any time by the affected cantons, neighbouring cantons or federal authorities (Art. 13 of the Spatial Planning Ordinance). After hearing the submissions of the parties involved, the Federal Council orders a reconciliation procedure. If this is unsuccessful, the Federal Council takes the decision (Art. 12 of the Spatial Planning Act).

Bilateral agreements exist with the neighbouring countries Germany, France, Italy and Austria; these regulate exchange of information and form the basis for establishing bilateral commissions that can deal with questions relating to near-border repositories and site selection procedures. Switzerland has also signed and ratified the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. The Convention contains provisions relating to the selection of planned facilities and regulates the settlement of differences of opinion between the contracting parties. Together with all its neighbours, Switzerland has also ratified the UNECE Convention on Environmental Impact Assessment in a Transboundary Context (the Espoo Convention). This also contains provisions regulating the settlement of disputes between parties.

In the case of differences of opinion with neighbouring states, Switzerland makes every effort to reach an amicable settlement, in accordance with the principles of transparency and traceability followed in the sectoral plan process. Additional instruments for settling disputes are not necessary and cannot be established within the framework of the sectoral plan process.

3.5 Knowledge management and quality control

Knowledge management and quality control are important components of the site selection process. They include comprehensive documentation of the process and how to deal with uncertainties. During the course of the site selection process, uncertainties will arise and these will have to be reduced by additional investigations and research in subsequent stages and in the licensing procedures (general licence, construction and operating licence). At the end of each stage, the waste producers have to identify uncertainties and show how these will be addressed in subsequent stages.

Under certain circumstances, the site selection process may lead to sites which, based on new findings, do not (or not completely) fulfil the previously formulated requirements. In such cases, earlier decisions are reviewed and may be revised. During and between stages, the possibility exists to revert back to geological siting areas or sites that have been put in reserve as part of the narrowing-down process.

The SFOE is responsible for data management of materials that are relevant for decision-making and for quality control in implementing the site selection process according to the sectoral plan.

4 Stage 1: Selection of geological siting areas for L/ILW and HLW

4.1 Cooperation

4.1.1 Proposing geological siting areas

The waste producers identify geological siting areas based on the criteria relating to safety and technical feasibility. They document, evaluate and justify their proposals in a report and inform the SFOE of the selection that has been made.

The evaluation in terms of safety and technical feasibility is made in accordance with the criteria defined in Table 1, taking into account the foreseen waste inventory and the provisional design of the engineered barriers. In particular, the waste producers also have to indicate which geological siting areas come into question for disposal of all waste categories (combined repository). The procedure is described in Appendix I.

As soon as the public has been informed, the waste producers prepare the background for recording the spatial planning situation within a 5-km radius of the proposed geological siting areas. The basis for this is provided by the sectoral plans and inventories of the federal government, the structure plans of the siting cantons and the land use plans of the siting communes.

Criteria for site evaluation from the viewpoint of safety and technical feasibility

Criteria group	Criteria
1. Properties of the host rock and the effective containment zone	1.1 Spatial extent 1.2 Hydraulic barrier effect 1.3 Geochemical conditions 1.4 Release pathways
2. Long-term stability	2.1 Stability of the site and rock properties 2.2 Erosion 2.3 Repository-induced influences 2.4 Conflicts of use
3. Reliability of geological findings	3.1 Ease of characterisation of the rock 3.2 Explorability of spatial conditions 3.3 Predictability of long-term changes
4. Engineering suitability	4.1 Rock mechanical properties and conditions 4.2 Underground access and drainage

Table 1: Criteria for site evaluation from the viewpoint of safety and technical feasibility

Table 1 sets out the most important factors for site evaluation in the form of 13 individual criteria. The criteria in group 1 address the barrier effect of the host rock and the effective containment zone. The criteria in group 2 ensure that the barrier effect is maintained for the required time period. The criteria in group 3 assess the reliability of the geological findings in terms of the ability to characterise, explore and predict geological conditions. Group 4 relates exclusively to the suitability of the host rock in terms of engineering requirements and the possibility for underground access.

4.1.2 Information and establishment of the cantonal commission

After submission of the documentation by the waste producers, DETEC and the SFOE first contact the siting cantons and communes. After this, neighbouring cantons and countries and the public are informed.

After consulting the siting cantons, DETEC and the SFOE set up a cantonal commission, consisting of representatives of the siting cantons, affected neighbouring cantons and countries. This commission ensures cooperation between government representatives of the siting cantons and of the affected neighbouring cantons and countries, it supports the federal government in implementing the site selection process and makes recommendations to the government. It supports the government in identifying potential conflicts with long-term cantonal and supraregional spatial and development planning at an early stage and indicates possibilities for resolving these conflicts. Its recommendations are taken into account in the overall evaluation.

The commission remains in existence until the granting of the general licence; its composition will be modified in later stages to take account of the cantons remaining in the process.

4.1.3 Establishing regional participation

The SFOE informs the affected cantons and communes of the arrangements for regional participation and initiates this participation with the involvement of the siting canton in question and the siting communes. The siting communes are supported from the time of first contact by the SFOE, with the latter providing a point of contact for the communes.

In preparation for stage 2, it has to be clarified which communes, in addition to the siting communes, make up the siting region and are therefore to be included in the participatory process. The starting-point for this is the planning perimeter. The planning perimeter delineates the geographic area that is defined by the extent of the geological siting area, taking into account the possible configuration of the installations required at the surface. Communes that lie within the planning perimeter are considered to be affected and form part of the siting region. The siting region is thus made up of the siting communes and communes that lie fully or partly within the planning perimeter.

Communes outside the planning perimeter can also be part of the siting region if they are affected in a particular way. In justified cases, additional communes can thus form part of the siting region if they directly border communes within the planning perimeter and

- are affected by the local construction site traffic, local delivery traffic and other infrastructure such an unloading stations, etc., or
- they belong to the immediate region from the perspective of naturally occurring boundaries such as ranges of hills or bodies of water, or
- they are strongly linked in terms of regional economy with the siting communes through e.g. labelled products, key tourist attractions, etc.

During the build-up phase, a process moderator nominated by the SFOE together with the siting communes supports the siting regions in organising regional participation. In establishing this participation, it has to be ensured that there is a balanced representation of the different interests and involvement of the affected communes and the public. The siting regions are supported by experts they select themselves, by the SFOE and by the siting cantons. If required, representatives of the federal government, the siting canton and the waste producers can take part in meetings and events held as part of regional participation. The costs of administrative and technical support of the siting regions are borne by the waste producers, with the approval of the SFOE.

4.1.4 Review by the authorities

Review of safety

When reviewing the safety of the proposed geological siting areas, the authorities have to consider the following questions:

- Are the requirements on the host rock and the effective containment zone and the site derived by the waste producers transparent and sufficient?
- Have the waste producers taken all relevant available geological information into account and is this sufficient for the purposes of the preliminary orientation?
- Have the waste producers taken the pre-determined criteria for preparing proposals for geological siting areas into account adequately and at the correct level?
- Is the procedure followed by the waste producers in proposing potential geological siting areas transparent and reproducible?
- Can the authorities approve the proposals from the point of view of safety and feasibility?

The results of the reviews are documented in an expert opinion prepared by the responsible federal office (HSK) and in the form of opinions by CRW and NSC.

Spatial planning situation and determining the assessment methodology

For the spatial planning considerations relating to a deep repository, it is assumed that construction, operation and the surface facilities will have a relatively small spatial impact on the region. Spatial planning aspects do not have an exclusionary character, but should lead to optimum spatial integration of the repository into the siting region.

When planning a geological repository, the development prospects of the siting cantons and siting regions have to be taken into consideration. This should allow fundamental conflicts to be recognised at an early stage and the need for coordination assessed. In stage 1, the ARE works together with the siting cantons based on preparations made by the waste producers to record the current situation based on existing cantonal structure plans and the land use plans of the communes taking into consideration the areas listed in Appendix II. Together with the ARE and the siting cantons, the SFOE defines a provisional planning perimeter.

In stage 1, the decisive spatial planning indicators and methods for their evaluation in stage 2 are identified and defined. The lead in this is taken by the ARE working together with the siting cantons and the waste producers.

4.2 Hearing, settlement and decision of the Federal Council

The SFOE evaluates the result of the safety assessment and the recording of the spatial planning situation, undertakes an overall evaluation of the proposed selection taking into account the views of the cantonal commission and prepares a results report and object sheets.

The hearing phase according to the Spatial Planning Ordinance is planned by the SFOE in cooperation with the cantons. Integration of the geological siting areas and the defined planning perimeters into the sectoral plan in the form of object sheets as a preliminary orientation is preceded by a three-month hearing phase. The SFOE makes the drafts of the results report and the object sheets and other relevant documentation available to the cantons, affected federal offices and neighbouring states, as well as interested national organisations for comment. The cantons and the responsible cantonal offices invite regional and communal authorities and the public to participate.

Following the hearing phase, the results report and object sheets are updated and submitted to the cantons for final comment. The cantons can call for a settlement procedure before the results report and object sheets of stage 1 are submitted to the Federal Council for approval. The decision of the Federal Council cannot be challenged in a court of law.

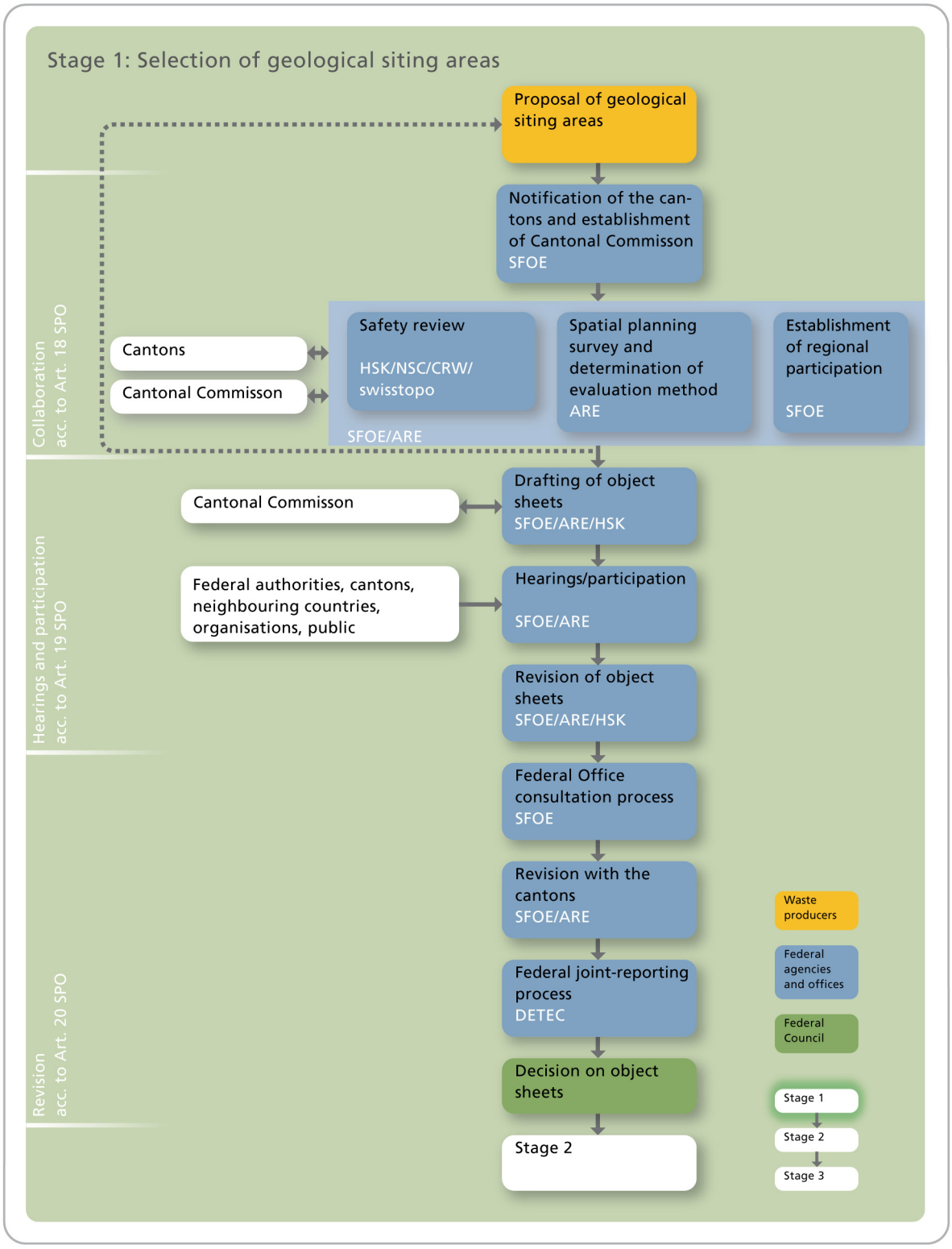

Figure 8: Schematic summary of Stage 1

5 Stage 2: Selection of at least two sites each for L/ILW and HLW

5.1 Collaboration

5.1.1 Investigation of geological siting areas and specification of the repository projects

Regional participation

In stage 2 at the latest, the communes of the siting region take over the organisation and implementation of regional participation. Within the framework of this participation, they work together with the federal authorities and the waste producers and represent regional interests.

Specification of the repository projects

With the involvement of the siting regions and taking into account engineering feasibility, the waste producers prepare proposals for the design and layout of the required surface infrastructure and configure the underground components of the repository.

The siting regions discuss these proposals and express their views on the design, placing and accessing of the surface infrastructure. Working together with the siting regions, the waste producers then identify at least one site per planning perimeter.

Provisional safety analyses

The waste producers carry out provisional safety analyses for the sites identified together with the siting regions (Appendix III). These relate to long-term safety following repository closure and take into account the allocated waste inventory. They indicate the retention capacity of the geological repository for the emplaced radionuclides and the contribution of the geological barrier to long-term safety. The information available on the sites must be sufficient to allow such safety analyses to be carried out; if necessary it can be supplemented by additional investigations. The waste producers have to discuss the need for further investigations with HSK at an early stage. The geological data used must adequately reflect the current situation at the site and take account of existing uncertainties.

Spatial planning and environmental aspects

Based on the planning perimeters defined in the first stage, the waste producers prepare the necessary materials for the spatial planning evaluation of the selected sites in stage 2. The FOSD then carries out the spatial planning evaluation together with the siting cantons.

The starting-point for the evaluation is to record spatial aspects by presenting the subject areas in a land use planning register. This should ensure that the evaluation is as comprehensive as possible and will allow potential conflicts in terms of spatial requirements, land use, development of population centres and use of resources to be identified, as well as coordination with existing sectoral plans, cantonal structure plans and land use plans. The evaluation is carried out using the method specified in stage 1.

With a view to the first stage of the environmental impact assessment that will be conducted in stage 3, the waste producers clarify in preliminary investigations according to Art. 8 of the Environmental Impact Assessment (EIA) Ordinance which impacts of a geological repository at the proposed sites could place a burden on the environment.

Socio-economic studies

To allow the siting regions to make a comprehensive assessment of the socio-economic impacts of a repository, they prepare a strategy, measures and projects for the sustainable development of their region or update existing strategies, measures and projects. The investigations cover the impact of planning, constructing, operating and closing a repository on the siting region. Socio-economic studies commissioned by the SFOE together with the siting regions form the basis for drawing up the regional development strategy.

5.1.2 Proposing at least two sites

Based on the investigations carried out and the collaboration with the siting cantons and siting regions, the waste producers propose at least two sites each for HLW and L/ILW.

They document and justify their proposals in a report addressed to the SFOE. They also submit a technical report on the methodology and results of the provisional safety analyses.

5.1.3 Review by the authorities

Supported by CRW, HSK reviews and evaluates the selection made by the waste producers from a safety perspective. The results of the provisional safety analyses are evaluated using the safety requirements in the HSK R-21 Guideline and Appendices I and III. For each site, HSK also checks whether the available information and any uncertainties are such that they would allow a provisional safety analysis to be performed. The geological data used (e.g. extent of host rock, hydraulic conductivity, expected hydraulic gradients, geochemistry) must adequately represent the situation at the site and take account of existing uncertainties. HSK records the results of its review in an expert opinion. KNS also prepares an opinion on HSK's review.

The FOSD evaluates spatial planning aspects and the Federal Office for the Environment (FOEN) environmental aspects.

5.2 Hearing, settlement and Federal Council decision

Based on the review by the authorities and the opinions of the cantonal commission and the siting regions, the SFOE makes an overall evaluation of the proposals and updates the object sheets.

Before the selected sites that have been reviewed by the authorities are included in the sectoral plan as an interim result, there is a three-month hearing phase in accordance with the Spatial Planning Act.

Conducting the hearing phase is planned and coordinated by the SFOE together with the cantons. The SFOE makes the draft results report and object sheets and any other relevant materials available to the cantons, affected federal offices, neighbouring countries and interested national organisations for their consideration. The cantons and responsible cantonal offices invite regional and communal authorities and the public to participate.

After the hearing phase, the results report and the object sheets are updated and submitted to the cantons for final comment. The cantons can call for a settlement procedure before the results report and object sheets of stage 2 are submitted to the Federal Council for approval. The decision of the Federal Council cannot be challenged in a court of law.

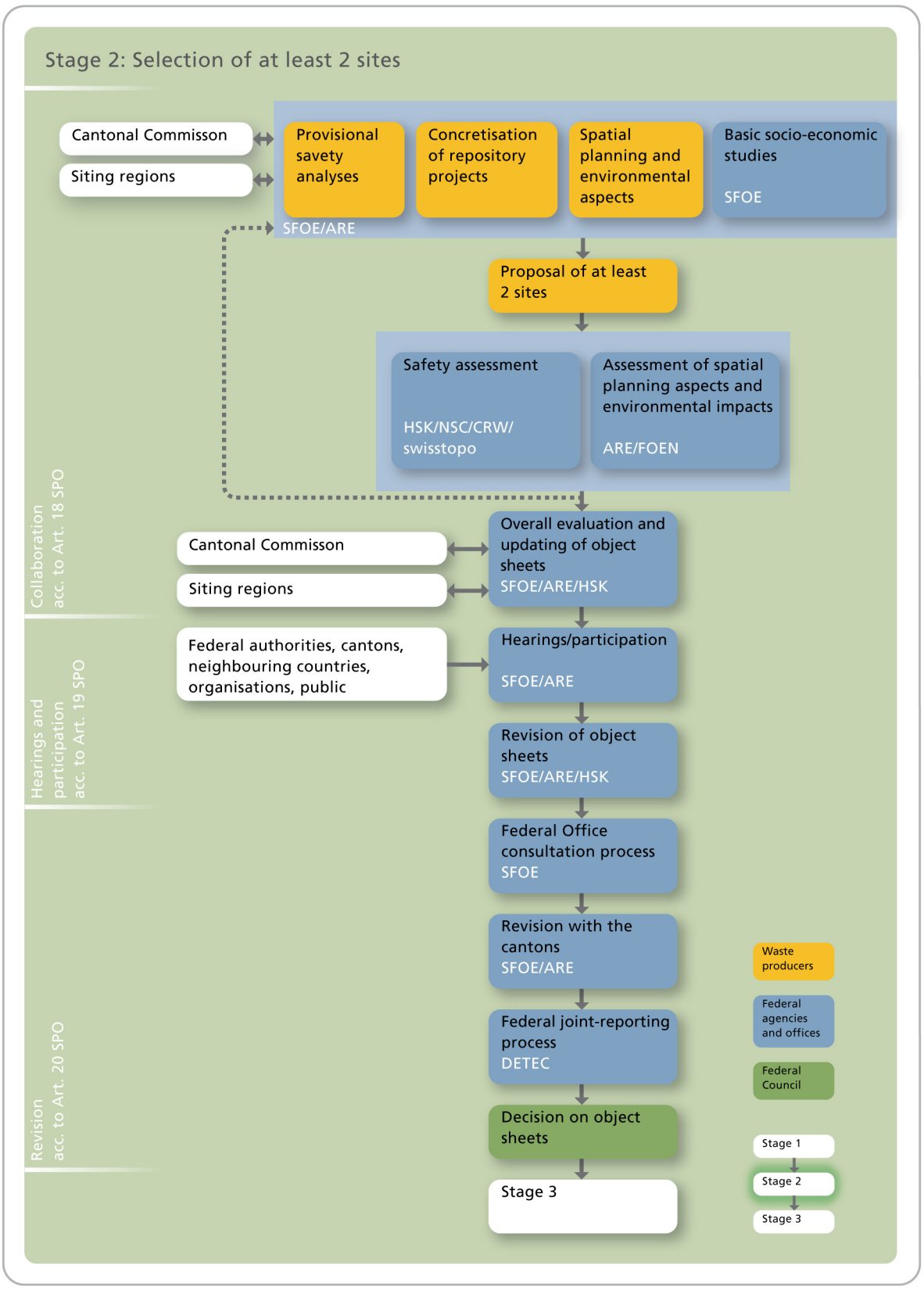

Figure 9: Schematic summary of Stage 2

6 Stage 3: Site selection and general licence procedure for L/ILW and HLW

6.1 Collaboration

6.1.1 In-depth investigation of sites

Supplementing geological information

Before a site is selected for the submission of a general licence application[25], the geological information on the sites selected at the end of stage 2 has to be brought by the waste producers to a level that allows a comparison of the sites to be made from a safety perspective based on verified site-specific data (Appendix IV).

Detailed economic investigations

Together with the siting region, the SFOE prepares in-depth economic studies. A public opinion poll will be conducted and the data, information and decision basis improved to allow monitoring of socio-economic and environmental impacts to be introduced with a view to realising a repository.

The siting region proposes measures and projects for implementing the regional development strategy and draws up the basis for any compensation measures. Other tasks of the siting region relate to issues of preserving knowledge and exchanging information with the public.

Any compensation is regulated in stage 3 by the siting canton and siting region together with the waste producers.

6.1.2 Site selection and preparation of the general licence application

The documentation required for the general licence application is listed in Articles 23 and 62 of the Nuclear Energy Ordinance. It includes in particular a safety and security report, an environmental impact report, a report on compliance with spatial planning and a report justifying the site selection.

The general licence specifies the licence-holder, the site, the purpose of the facility, the basic features of the project and the maximum permissible radiation exposure to persons in the vicinity of the facility.

The basic outline of the project has to include the approximate size and location of the most important structures (surface and underground), the categories of waste for disposal and the maximum disposal capacity. The general licence also defines a preliminary protection zone and the criteria, non-fulfilment of which would lead to a planned disposal zone being ruled out due to lack of suitability. As part of the general licence application, the waste producers have to prepare a stage 1 report on the impact of the facility on the environment and the coordination with spatial planning.

The waste producers submit the general licence application to the SFOE and request the stipulation of the selected site in the sectoral plan.

[25] In the following, the terms siting region, general licence application and object sheet will be used in the singular. This is the case when one repository is foreseen for all waste categories (combined repository). Otherwise, a general licence application is submitted for each repository (HLW and L/ILW).

6.1.3 Review by the authorities

The general licence application and the request for stipulation of the selected site in the sectoral plan is reviewed by the responsible federal offices and authorities. It is determined in particular whether the design principles according to Article 11 para. 2 of the Nuclear Energy Ordinance and the requirements in Articles 64 to 69 of the Ordinance have been complied with. The criteria used to evaluate the long-term safety of a geological repository are defined in HSK Guideline R-21 «Protection Objectives for the Disposal of Radioactive Waste» and explained in Appendix I.

6.2 Hearing, settlement procedure and decision by the Federal Council

Based on the review by the authorities and the opinions of the cantonal commission and the siting regions, the SFOE makes an overall evaluation of the proposals and updates the object sheet. The ARE coordinates any necessary modifications to the structure plan with the siting canton.

The hearing phase according to the Spatial Planning Act and the general licence procedure according to the Nuclear Energy Act are planned and coordinated by the SFOE together with the cantons.

The SFOE submits the documentation for the general licence application, the drafts of the results report and the updated object sheet and other relevant materials to the cantons, relevant federal offices and neighbouring countries and interested national organisations for comment. The cantons and responsible cantonal offices invite regional and communal authorities and the public to participate.

After the hearing phase, the results report and the object sheet are updated and submitted to the cantons for final comment. The cantons can call for a settlement procedure before the results report and object sheet are submitted to the Federal Council for approval.

The procedure for granting the general licence, particularly the participation of the siting canton and neighbouring cantons and countries in the immediate vicinity, and the lodging of objections is carried out according to Articles 42 to 48 of the Nuclear Energy Act.

The general licence application, results report and updated object sheet for stage 3 are submitted to the Federal Council for approval at the same time. The decision of the Federal Council cannot be challenged in a court of law. The general licence has to be approved by the Federal Assembly and this decision is subject to an optional national referendum.

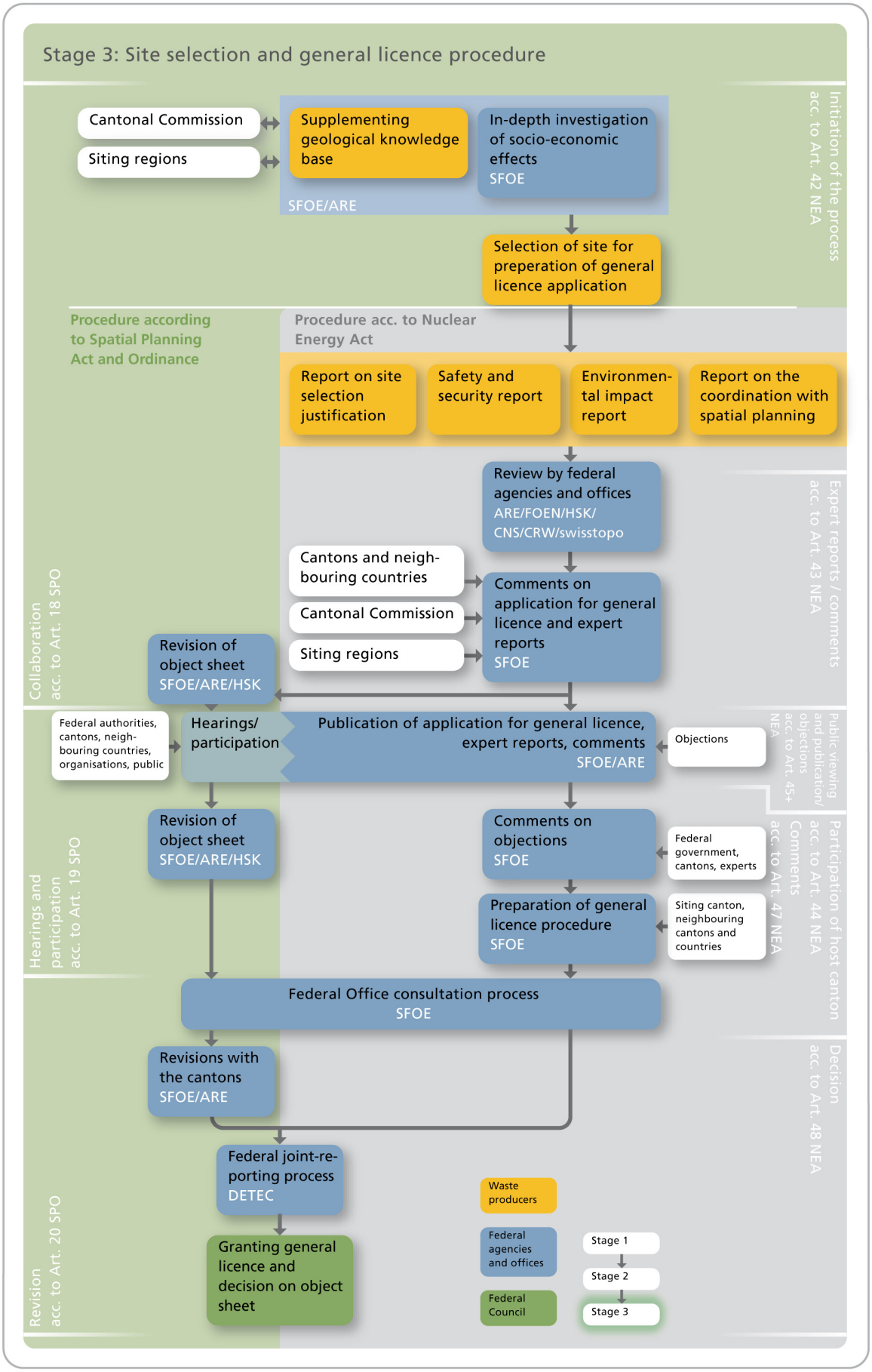

Figure 10: Schematic summary of Stage 3

Appendix I: Description and application of criteria relating to safety and technical feasibility

In the following, the criteria presented in Table 1 of the sectoral plan are described in more detail, the aspects to be evaluated are presented and their relevance for safety explained. When applying the criteria for evaluating the siting possibilities, the requirements resulting from the type of waste (nuclide inventory, waste volumes, chemical-physical properties, etc.) and the design of the engineered barriers have to be taken into consideration. The assessments carried out by the waste producers with a view to making proposals for siting regions and sites have to be in line with these requirements.

Table A1-1

Criteria group	**1 Properties of the host rock and the effective containment zone**
Criterion	**1.1 Spatial extent**
Aspects to be evaluated	The spatial potential (thickness, lateral extent) and depth of the host rock and the effective containment zone (ECZ) are evaluated, taking into account regional geotectonic conditions (e.g. regional fault zones, glacially deepened valleys, inclusions of foreign rock). The space required by the repository (including reserves) and the flexibility in arranging the underground caverns and tunnels also have to be considered in the evaluation.
Relevance for safety	Favourable conditions are considered to be those in which the composition and extent of the host rock and the ECZ are such that radionuclides will be largely retained in the host rock and the ECZ.

Table A1-2

Criteria group	**1 Properties of the host rock and the effective containment zone**
Criterion	**1.2 Hydraulic barrier effect**
Aspects to be evaluated	The properties of the host rock and the ECZ are evaluated in terms of water flow and transport of dissolved substances, as well as the regional hydrogeological situation. To ensure long-term isolation and containment of radioactive waste, rocks with low groundwater movement are sought. This parameter depends on the properties of the rock, including the hydraulic conductivity and hydraulic gradient, and gives an indication of the dominant transport processes (advection, diffusion) and the functioning as a hydraulic barrier. When evaluating the hydrogeological conditions, indirect indicators are considered, e.g. general hydrochemical classification and boundaries between the different groundwater levels, expected isotope signatures and residence times of deep groundwater.
Relevance for safety	A low hydraulic conductivity leads to low water flow, which is favourable for the functioning and protection of the engineered barriers. In a later phase, it also ensures that radionuclide transport in the host rock and ECZ is extremely slow (barrier effect).

Table A1-3

Criteria group	**1 Properties of the host rock and the effective containment zone**
Criterion	**1.3 Geochemical conditions**
Aspects to be evaluated	The geochemical conditions in the host rock and ECZ (mineralogy, water chemistry, pH, redox conditions, salinity, water-rock interactions, microbial processes) are evaluated in terms of retention and retardation of radionuclides (limited solubility, sorption capacity) and long-term behaviour of the engineered barriers.
Relevance for safety	A favourable situation is when the geochemical conditions and rock composition result in good radionuclide retention in the host rock and the ECZ. Geochemical conditions that lead to radionuclide retention in the engineered barriers and to long-term stability of the engineered barrier properties are also favourable.

Table A1-4

Criteria group	**1 Properties of the host rock and the effective containment zone**
Criterion	**1.4 Release pathways**
Aspects to be evaluated	Preferential radionuclide release pathways in the host rock and in the ECZ are evaluated. Various properties of the transport pathways influence radionuclide migration, such as the nature and distribution of pathways in the rock (porous or fractured medium), the nature of the pore space (channelling = flow channels) and the pathway length and transmissivity. In the case of migration along fissures and fractures in the rock, the self-sealing capacity has to be considered; this depends to a large extent on the clay content of the rock.
Relevance for safety	Transport pathways that lead to a significant retardation of radionuclide release from the host rock and the ECZ are favourable. There should be a homogeneous distribution of the flowpaths in the host rock, in contrast to a concentration of flow in a few fractures, veins other inhomogeneities. The longer the duration of nuclide transport in the rock, the greater the proportion of nuclides that decay in the rock and thus do not reach the biosphere.

Table A1-5

Criteria group	**2 Long-term stability**
Criterion	**2.1 Stability of site and rock properties**
Aspects to be evaluated	The long-term geological stability of the site and the rock properties are evaluated, in particular any degradation or alteration of the isolation capacity of the host rock and the ECZ due to geological processes such as perturbation of rock units as a result of differential movements (shearing, reactivation of fractures and faults, formation of new water and gas flowpaths) caused by neotectonic activity (e.g. seismicity), geochemical processes (dissolution, karst formation, water-rock interactions) or rare geological events such as fracture formation associated with strong earthquakes or volcanism.
Relevance for safety	Areas and rock formations that can ensure the required barrier function over the time period considered for the safety assessment are seen as favourable. Rocks should have a low tendency to form new water flowpaths and an ability to self-seal fissures, fractures and faults formed due to deformation. Differential movements within the disposal zone should be unlikely.

Table A1-6

Criteria group	**2 Long-term stability**
Criterion	**2.2 Erosion**
Aspects to be evaluated	The influence of erosion, i.e. the factors and processes (depth of the repository, uplift rate, erosion rate and glacial gully erosion) that could compromise the barrier effect of the host rock and the ECZ (reduction of rock overburden, relaxation of the host rock structure and increasing hydraulic conductivity) or could lead to exposure of the repository within the time period under consideration are evaluated.
Relevance for safety	The situation is favourable (low erosion and/or considerable depth) if the barrier function of the host rock cannot be compromised, or where this occurs at as late a stage as possible.

Table A1-7

Criteria group	**2 Long-term stability**
Criterion	**2.3 Repository-induced influences**
Aspects to be evaluated	The effects of the repository on the host rock (gas production from the waste and gas transport, heat output and sensitivity to thermal effects, thermal-hydraulic-mechanical coupled processes, chemical interactions, formation of an excavation damaged zone around underground structures, reversibility of changes, self-sealing capacity) are evaluated. The planned disposal concept (e.g. layout, engineered barrier materials) and the inventory for disposal have to be considered.
Relevance for safety	Host rocks are considered to be favourable when repository-induced processes do not lead to a significant reduction of their barrier function. Rocks that have the ability to self-seal fissures and fractures and are not sensitive to temperature effects in terms of affecting their hydraulic and rock mechanical properties are favourable.

Table A1-8

Criteria group	**2 Long-term stability**
Criterion	**2.4 Conflicts of use**
Aspects to be evaluated	The evaluation considers the presence of workable raw materials and any conflicts of use that may arise. Particular attention is paid to whether, in or beneath the host rock and the ECZ, there are raw materials deposits that are workable from a present-day viewpoint (e.g. salt, hydrocarbons, geothermal, mineral water or thermal springs). It has to be considered whether accessing and using the resources would affect the barrier function of the host rock or could directly impact on the repository.
Relevance for safety	A favourable situation is that where there are no significant deposits of natural resources within the siting region that could lead to a significant reduction in the barrier effect of the host rock.

Table A1-9

Criteria group	**3 Reliability of geological information**
Criterion	**3.1 Ease of rock characterisation**
Aspects to be evaluated	The possibilities for characterising the host rock and ECZ properties and determining their safety-relevant properties (homogeneity/heterogeneity of rock composition, existence and nature of architectural elements, variability of safety-relevant properties) are evaluated. It has to be determined whether the necessary data can be obtained with sufficient reliability.
Relevance for safety	Host rock properties should be as homogeneous as possible and they should be measurable without resorting to overly destructive investigations (which might adversely affect the barrier function of the rock). For the evaluation, it is advantageous if relevant experience and knowledge of the host rock or similar rock types are already available either nationally and internationally.

Table A1-10

Criteria group	**3 Reliability of geological information**
Criterion	**3.2 Explorability of spatial conditions**
Aspects to be evaluated	The geotectonic complexity and explorability of the spatial geological conditions (bedding conditions, extent and continuity of strata, spatial continuity of lithological features, host rock boundaries, location of fault zones, small-scale faults, etc.) are evaluated. Accessibility from the surface for the purpose of performing investigations (Quaternary cover, topography, population density, forests, etc.) is also important.
Relevance for safety	The situation is favourable when the bedding conditions and the geometry of the host rock and the ECZ are simple and easy to explore from the earth's surface (e.g. using reflection seismics), and when the observation and investigation of safety-relevant properties can be interpolated and extrapolated spatially. There should also be no factors at the surface that make exploration difficult (e.g. thick Quaternary deposits, difficult topography, dense forests and population centres).

Table A1-11

Criteria group	**3 Reliability of geological information**
Criterion	**3.3 Predictability of long-term changes**
Aspects to be evaluated	The predictability of possible long-term geological changes (e.g. using models of climate evolution and geodynamics, indications of recent movements, seismicity) which, over the time period being considered, could have an effect on the containment capacity of the host rock and the ECZ is evaluated. Independent evidence of long-term containment (e.g. old porewaters, natural tracers and their distribution) is also evaluated.
Relevance for safety	The safety-relevant properties and geometry of the host rock and the ECZ should be predictable with sufficient reliability over the necessary time periods. Also favourable are host rocks with independent evidence of long-term isolation (e.g. containment of old porewaters) or the presence/distribution of natural tracers, which indicate low water circulation.

Table A1-12

Criteria group	**4 Engineering suitability**
Criterion	**4.1 Rock mechanical properties and conditions**
Aspects to be evaluated	The rock mechanical properties and conditions for the construction, operation, monitoring and closure of a geological repository are evaluated (e.g. rock strength, deformation behaviour, depth, rock stresses, stability of voids, natural gas transport).
Relevance for feasibility	Conditions that are easy to manage from an engineering point of view are favourable and depth should not place any extreme requirements on the construction, operation, monitoring (including possible retrieval) or closure of the repository. The repository components should be able to be closed without technical problems using the required sealing structures.

Table A1-13

Criteria group	**4 Engineering suitability**
Criterion	**4.2 Underground access and water drainage**
Aspects to be evaluated	The conditions for accessing the disposal tunnels and caverns are evaluated, particularly the engineering and hydrogeological conditions for constructing, operating and maintaining the access tunnels/shafts to the disposal tunnels and caverns (including natural gas transport).
Relevance for feasibility	A favourable situation is one in which no significant hydrogeological or engineering problems are expected above the disposal level.

1 Applying the criteria relating to safety and technical feasibility in site evaluation

1.1 Stage 1: Selection of potential siting regions

When preparing proposals for suitable siting regions for geological repositories, the waste producers have to answer the following logical sequence of questions:

– How are the wastes allocated to the L/ILW and HLW repositories?

– What requirements apply to the site-specific geological conditions, taking into account the allocated waste inventory and the applicable safety and barrier concepts?

– Where are there suitable large-scale geotectonic units that would fulfil the safety requirements?

– What rocks in these units are potentially suitable as host rocks or effective containment zones (ECZ)?

– Where can potential host rocks be found in suitable configurations (composition, arrangement, depth, thickness, access to underground structures)?

For proposing potential siting regions, the following five-step procedure results:

1.1.1 Step 1: Allocating the waste to the L/ILW and HLW repositories

The concept of the waste producers foresees two repositories, one for high-level waste (HLW) and one for low- and intermediate-level waste (L/ILW). There are various possibilities for allocating the waste categories as defined in the Nuclear Energy Ordinance (HLW, ATW, L/ILW) to the two repositories. The waste producers have to propose suitable solutions that are subject to review by the authorities.

The first step in stage 1 is to allocate the wastes to the two repositories. The following waste properties are decisive in this respect:

– radionuclide inventory and half-lives

– selection of safety-relevant nuclides (evaluation of radiotoxicity)

– waste volumes

– material properties (waste matrix, containers) and their possible impact on the host rock

– heat production

– content of potentially gas-producing components (metals, organics)

– content of complexants

1.1.2 Step 2: Defining the safety concept and quantitative and qualitative requirements

Based on the allocated waste inventory, the waste producers have to describe the safety concept for the two repository types, present the quantitative and qualitative requirements and objectives for the geological barrier using generic safety considerations (see Appendix III) and, as far as possible, quantify the safety criteria according to Table 1. They have to define and explain the following for each repository:

– Barrier and safety concept for the repository

– Expected contributions of the different elements of the barrier system to the safety of the repository as a whole

– Quantitative requirements on the host rock and the geosphere in terms of the time period being considered and size and space requirements of the repository

– Quantitative targets in terms of depth, thickness, lateral extent and hydraulic conductivity of the host rock and the ECZ

– Qualitative evaluation scales (e.g. very favourable/favourable/less favourable) for the application of other criteria relating to safety and engineering feasibility (see Table 1 of the sectoral plan). The evaluation scale is based on the results of generic safety considerations and on empirical values for the property in question. Besides the qualitative evaluation scale, the procedure for the overall evaluation of siting regions has to be described. This overall evaluation is presented on a qualitative evaluation scale of suitability (i.e. very suitable/suitable/limited suitability/less suitable).

1.1.3 Step 3: Identification of suitable large-scale geotectonic units

The identification of large-scale units that are suitable from a geotectonic viewpoint and fulfil the safety requirements has to take into account (and evaluate) the following:

– Large-scale erosion (criterion 2.2)

– Long-term stability: differential movements, neotectonic activity and seismicity (criterion 2.1)

– Predictability of potential long-term changes (criterion 3.3)

– Large-scale geotectonic complexity and explorability of the spatial conditions (criterion 3.2)

1.1.4 Step 4: Identification of potentially suitable host rocks and effective containment zones

To identify host rocks and ECZs within large-scale units that would be suitable for hosting a repository, the following aspects and criteria have to be evaluated:

– Spatial potential of the host rock: thickness, lateral extent and distribution at a suitable depth (criterion 1.1)

– Properties, relating to water flow and material transport: hydraulic barrier effect (criterion 1.2)

– Geochemical conditions and retention properties (criterion 1.3)

– Preferential release pathways and their properties (criterion 1.4)

– Long-term host rock behaviour: stability of site and rock properties (criterion 2.1)

– Behaviour with respect to repository-induced effects (criterion 2.3)

– Rock mechanical conditions and properties: rock strength, deformation characteristics (criterion 4.1)

– Geotectonic complexity: ease of characterisation of host rock properties and explorability of spatial conditions (criteria 3.1 and 3.2)

1.1.5 Step 5: Identification of suitable configurations

To identify host rocks and ECZs with suitable configurations, the following criteria have to be evaluated:

– Depth, thickness and lateral extent, taking into account regional geotectonic features (criterion 1.1)

– Potentially usable disposal volume in relation to requirements, based on the known maximum disposal capacity foreseen for the site: space requirement/space availability (criterion 1.1)

– Hydrogeological conditions and properties relevant for water flow: hydraulic barrier effect (criterion 1.2)

– Preferential transport pathways and their properties (criterion 1.4)

– Influence of erosion: depth of repository, uplift, large-scale erosion, glacial scouring (criterion 2.2)

– Exploitable natural resources and conflicts of use (criterion 2.4)

– Rock mechanical properties and conditions for construction of the repository (criterion 4.1)

– Geotechnical and hydrogeological conditions above the disposal zone, underground access and water drainage (criterion 4.2)

– Long-term stability: neotectonically potentially active elements (differential movements) on a regional scale, geological history and predictability of potential long-term climatic and geological changes (criteria 2.1 and 3.3)

– Geotectonic complexity, ease of characterisation of host rock properties and explorability of spatial conditions (criteria 3.1 and 3.2)

Table A1-14: Overview of steps 1 to 5 in stage 1: waste allocation (step 1), determining requirements for the narrowing-down process (step 2) and aspects to be evaluated, allocated criteria and relevant indicators for implementation (steps 3 to 5).

Step	Requirements for narrowing-down process	Relevant parameters / properties
1. Waste allocation to the two repositories (L/ILW and HLW)	Waste allocation to the two repositories (L/ILW and HLW)	Waste volumes, nuclide inventory, toxicity, chemical and physical properties

Step	Requirements for narrowing-down process	Relevant parameters / properties
2. Defining the safety concept and quantitative and qualitative requirements for site evaluation	– Defining the barrier and safety concept – Expected contributions of the different barrier system elements to safety – Quantitative requirements and objectives for the host rock and geosphere – Qualitative evaluation scale for further criteria related to safety and technical feasibility	Design of engineered barriers, layout of disposal tunnels/ caverns Results of generic safety assessments Quantification of: – timescale for assessment – size and space requirement of repository – depth, thickness, lateral extent and hydraulic conductivity of host rock and effective containment zone

Step	Aspects to be evaluated	Allocated criteria according to Table 1	Relevant indicators for implementation
3. Identification of suitable large-scale geotectonic units	Influence of erosion	2.2 Erosion	Large-scale erosion over the time period considered
	Long-term stability: differential movements, neotectonic activity and seismicity; predictability of potential long-term geological changes	2.1 Stability of site and rock properties 3.3 Predictability of long-term changes	Measured data and model concepts for geodynamics, neotectonics (inc. seismicity), geochemical processes or rare geological events
	Geotectonic complexity and explorability	3.2 Explorability of spatial conditions	Regional fault pattern, bedding conditions and continuity of rock strata of interest
4. Identification of potentially suitable host rocks and effective containment zones	Spatial potential	1.1 Spatial extent	Thickness, lateral extent and distribution at suitable depth

Step	Aspects to be evaluated	Allocated criteria according to Table 1	Relevant indicators for implementation
	Water flow and material transport	1.2 Hydraulic barrier effect	Hydraulic conductivity, (taking into account expected hydraulic gradient), dominant transport processes (advection, diffusion), residence times of deep groundwaters (e.g. isotope signatures)
	Geochemistry	1.3 Geochemical conditions	Mineralogy, pH, redox conditions, salinity, sorption properties, microbial processes
	Preferential transport pathways and their properties	1.4 Release pathways	Type of transport pathway (fracture network vs. porous medium), nature of pore space, transmissivity of preferential release pathways, clay content, self-sealing capacity of fractures/faults
	Long-term rock behaviour	2.1 Stability of site and rock properties	Long-term changes, potential for formation of new water flowpaths, karstification, self-sealing capacity
	Repository-induced influences	2.3 Repository-induced influences	Excavation damaged zone adjacent to underground structures, gas production/transport, chemical interactions, heat production and conductivity, self-sealing of new fractures
	Rock mechanical properties and conditions	4.1 Rock mechanical properties and conditions	Depth and expected rock stresses, rock strength, deformation behaviour
	Ease of characterisation and explorability	3.1 Ease of rock characterisation 3.2 Explorability of spatial conditions	Homogeneity of rock properties (inc. architectural elements), experience Geotectonic situation, complexity, exploration conditions

Step	Aspects to be evaluated	Allocated criteria according to Table 1	Relevant indicators for implementation
5. Identification of suitable rock configurations	Depth, thickness and lateral extent, space requirement/availability	1.1 Spatial extent	Depth, thickness and lateral extent taking into account geotectonic conditions (regional fault zones, glacial scouring of valleys, foreign rock inclusions), space available, flexibility/reserves
	Water flow, hydrogeological conditions	1.2 Hydraulic barrier effect	Hydraulic conductivity and expected hydraulic gradients, transport processes (advection/diffusion), groundwater levels
	Preferential transport pathways and their properties	1.4 Release pathways	Nature of transport pathways (fracture network vs. porous medium), nature of pore space, length and transmissivity of preferential release pathways
	Influence of erosion	2.2 Erosion	Depth, uplift rate, erosion rate, overdeepened valley with Quaternary deposits (glacial erosion)
	Natural resources and conflicts of use	2.4 Conflicts of use	Raw materials deposits, geothermal resources, mineral springs, hot springs
	Rock mechanical properties and conditions	4.1 Rock mechanical properties and conditions	Depth and expected rock stresses, rock strength, deformation properties
	Conditions for accessing disposal caverns and tunnels	4.2 Underground access and drainage	Accessibility of underground structures, geotechnical and hydrogeological conditions (inc. aquifers, karst, natural gas flow)

Step	Aspects to be evaluated	Allocated criteria according to Table 1	Relevant indicators for implementation
	Long-term stability, differential movements and neotectonics	2.1 Stability of site and rock properties	Model concepts for climate evolution and geodynamics, indications of differential movements (geomorphology, seismicity), distance to potentially active faults or faults capable of reactivation
		3.3 Predictability of long-term changes	Long-term changes, potential for formation of new water flowpaths, karstification potential, self-sealing capacity Independent evidence of long.-term isolation
	Ease of characterisation and explorability	3.1 Ease of rock characterisation 3.2 Explorability of spatial conditions	Geotectonic situation, small-scale faults, homogeneity/heterogeneity of rock composition and variability of rock properties (inc. architectural elements, frequency of fractures/ faults), possibilities for 3D seismics, boreholes

Once the five selection steps have been carried out, the waste producers have to present an overall evaluation of the siting regions. The results for the individual criteria are brought together using a matrix to provide an overall picture of the suitability of the siting regions. The results are presented on a qualitative value scale (i.e. very suitable/suitable/limited suitability/less suitable). The procedure followed and the results are documented in a report that will be presented by the waste producers at the time of submitting the proposals for potential siting regions. To come into question as a potential siting region, an area must have a score of at least «limited suitability».

1.1.6 Reviewing safety and engineering feasibility

When evaluating the proposed siting regions, the authorities have to consider the following questions:

– Is the allocation of the waste to the two repository types transparent and traceable (step 1)?

– Are the quantitative and qualitative requirements applying to the geotectonic situation, the host rock and ECZ and the site (step 2), as derived by the waste producers, transparent and sufficient?

– Have the waste producers taken into account all relevant geological information and is this sufficient for the purposes of the preliminary orientation?

– Have the waste producers taken the pre-defined criteria for preparing proposals for potential siting regions into account adequately and suited to the stage in question?

– Is the procedure followed by the waste producers in preparing proposals for potential siting regions transparent and reproducible?

– Can the authorities approve the proposals from the viewpoint of safety and feasibility?

The result of the review are prepared in the form of expert reviews (HSK) and opinions (CRW, NSC).

1.2 Stage 2: Selection of at least two sites

Within the siting regions proposed and approved in stage 1, the waste producers identify potential sites in stage 2, taking into account safety and engineering feasibility as well as spatial planning and socio-economic aspects; at least two sites each are proposed for HLW and L/ILW for inclusion in the sectoral plan as an interim result. The proposals are made in two steps:

1.2.1 Step 1: Identification of sites in the selected siting regions

The waste producers first identify potential sites within the selected siting regions. In cooperation with the affected cantons and regions, proposals are prepared for the location and layout of surface facilities and for the underground disposal zones.

1.2.2 Step 2: Comparative evaluation and proposal of at least two sites

For the sites identified in step 1, the waste producers then carry out quantitative provisional safety analyses (cf. Appendix III). Based on the planned waste inventory and the properties of the engineered barriers and the host rock, these safety analyses have to provide information on

– the retention properties of the system as a whole (engineered and geological barriers and their interaction) and the maximum dose from realistically expected releases

– the contribution of the geological barrier to long-term safety and

– the long-term behaviour of the barrier system.

Together with the results of a qualitative assessment of other safety criteria and aspects according to the conceptual part of the sectoral plan (Table 1), the results of the provisional safety analyses lead through an overall evaluation to proposal of at least two sites each for HLW and L/ILW. When preparing the proposals, the waste producers have to consider the following:

– The site has to fulfil the HSK R-21 dose protection objective of 0.1 mSv/year.

– No site can be proposed as an interim result if, based on a provisional safety analysis, it has been assessed as being clearly less suitable than the others. The evaluation and comparison of sites has to follow a standardised procedure (see Appendix III).

– Socio-economic aspects can only be decisive for the selection where sites are comparable from the viewpoint of safety (safety has top priority).

The waste producers are required to document the procedure and results for stage 2 in a report and to justify their selection of at least two sites.

1.2.3 Reviewing safety and engineering feasibility

The sites proposed by the waste producers are reviewed and assessed by the responsible authorities (HSK) and technical commissions (NSC, CRW). They have to decide whether the selection is justified from a safety perspective.

The review must address the following questions:

– Have the waste producers taken the criteria relating to safety and technical feasibility (Table 1) into account adequately and appropriately for the stage in question in preparing proposals for potential sites?

– Is the procedure followed by the waste producers in preparing proposals for potential sites transparent and reproducible?

– Have the waste producers taken into account all available relevant geological information and is this sufficient for the purposes of a provisional safety analysis with a view to reaching the interim result?

– Can the authorities reproduce the results of the provisional safety analyses?

– Can the authorities reproduce the results of the deliberations based on qualitative safety criteria and endorse the result of the overall evaluation?

– Can the authorities approve the siting proposals from the viewpoint of safety and feasibility?

The results of the review are prepared in the form of an expert review (HSK) and opinions (CRW, NSC).

1.3 Stage 3: Site selection and general licence procedure

In this stage, the waste producers select the site at which the geological repository will be constructed and prepare a general licence application for this site.

1.3.1 Selection of the site

The waste producers select the site for repository construction from the sites that have been integrated into the sectoral plan as an interim result. To be able to make and justify this selection, the level of knowledge for the different sites has to sufficient to allow a comparison to be carried out; if necessary, additional geological investigations will have to be carried out. The results – together with the evaluation of further aspects in accordance with the conceptual part of the sectoral plan – lead to an overall evaluation for site selection by the waste producers.

1.3.2 Preparing and submitting a general licence application

For the selected site, the waste producers have to prepare the necessary data and reports for the general licence application. The suitability of the site has to be confirmed by geological investigations. For this purpose, additional investigations will be necessary, in so far as they have not already been carried out when selecting the site.

According to Art. 62 of the Nuclear Energy Ordinance, the applicant must also submit a report containing the following information, in addition to the documentation supporting the licence application (Art. 23):

– A comparison of the options open for selection from the viewpoint of the safety of the planned repository.

– An evaluation of the properties that were decisive in leading to selection of the site.

– The amount of the costs.

The supporting documentation required for the general licence application is listed in Art. 23 of the Nuclear Energy Ordinance. Besides a safety and security report, it has to include an environmental impact report (stage 1), a report on the situation with respect to spatial planning and the concept for the monitoring phase and repository closure. It has to be shown that the requirements for granting a general licence in terms of Art. 13 of the Nuclear Energy Act have been fulfilled. A key aspect is demonstrating the long-term safety of the repository after closure.

1.3.3 Content of the general licence

The general licence specifies the licence-holder, the site, the purpose of the facility, the main features of the project and the maximum permissible radiation doses to persons in the vicinity of the facility. It also has to specify the criteria, non-fulfilment of which would exclude a planned disposal zone on the grounds of lack of suitability, as well as a provisional protection zone (Nuclear Energy Act Art. 14). The main features of the project include the approximate size and location of the key components of the facility (surface and underground), the categories of waste for emplacement and the maximum disposal capacity.

1.3.4 Reviewing safety and engineering feasibility

The general license application is reviewed by the responsible federal authorities, particularly with respect to whether the design principles according to Art. 11 para. 2 of the Nuclear Energy Ordinance and the requirements in Art. 64 to 69 of the Nuclear Energy Ordinance have been fulfilled.

The most important question to be answered is whether the long-term protection of man and the environment can be assured. In this respect, the geological features of the site play a key role, but the required level safety has to be provided by the system as a whole, consisting of the waste, the engineered barriers and the surrounding natural barrier. The criteria used to evaluate long-term safety are specified in HSK Regulatory Guideline R-21.

The result of the review is documented in an expert review (HSK) and opinions (CRW, NSC). This includes an evaluation of the suitability and exclusion criteria proposed by the applicant according to Art. 63 of the Nuclear Energy Ordinance.

1.3.5 Granting the general licence and further investigations

The Federal Council decides on the granting of the general licence (Nuclear Energy Act Art. 48), based on the reviews and opinions that have been submitted. The decision is presented to the Federal Assembly for ratification. The decision of the latter is subject to an optional national referendum. The licence specifies the site (Nuclear Energy Act Art. 14) and, at the same time, the site is specified in the sectoral plan according to spatial planning law.

After the general licence has been granted, in-depth geological investigations have to be performed with a view to constructing the facility; this will include an exploratory drift or shaft and a rock laboratory at the planned disposal level. The investigations have to be performed in such a way that it can be determined whether the suitability criteria specified in the general licence have been fulfilled. The characterisation of the site and the host rock must proceed underground up to the stage where the site properties can be confirmed and an application for a construction licence can be submitted.

Appendix II: Spatial planning aspects: planning areas and indicators

Planning areas		Indicators	
1. SOCIETY			
1.1	**Development of population centres**	1.1.1	Existing population centres
		1.1.2	Existing available building zones
		1.1.3	Areas planned for development
1.2	**Local recreation areas**	1.2.1	Existing local recreation areas
1.3	**Access infrastructure**	1.3.1	Newly sealed surfaces
		1.3.2	Conflict or synergy potential with other projects
1.4	**Transport routes**	1.4.1	Rail and road network
1.5	**National, cantonal and communal borders**	1.5.1	Affected regional authorities
2. ECONOMY			
2.1	**Economic efficiency**	2.1.1	Investment costs
		2.1.2	Costs of formal/material expropriation
2.2	**Attractiveness of location in terms of economics and living conditions**	2.2.1	Chances and risks for improving added value
		2.2.2	Chances and risks of regional population influx/outflux
		2.2.3	Property and construction land market
		2.2.4	Population structure
		2.2.5	Job market and regional economy
2.3	**Tourism / leisure**	2.3.1	Affected tourist areas and routes, thermal baths
2.4	**Agriculture / ground sealing**	2.4.1	Crop rotation areas
		2.4.2	Affected special products with indication of origin
2.5	**Use of underground space**	2.5.1	Mineral and thermal springs
		2.5.2	Affected raw materials deposits, geothermal resources
		2.5.3	Soil-covered supply and disposal infrastructures

Planning areas	Indicators
3. ECOLOGY	
3.1 Nature and landscape protection	3.1.1 Conflicts with area-specific protection programs
	– federal inventory of landscapes and natural monuments of national significance
	– inventory of protected places of interest
	– moors and wetlands
	– alluvial zones
	– game protection areas
	– cantonal protection areas (nature/landscape)
	– other federal inventories and protected areas • historical traffic routes • meadows • bird reserves • hunting areas • amphibian habitats
3.2 Forests	3.2.1 Affected areas divided according to forestry functions
3.3 Water protection	3.3.1 Affected groundwater protection zones
	3.3.2 Affected water protection areas
	3.3.3 Affected surface waters
	3.3.4 Affected water use concessions
3.4 Contaminated sites	3.4.1 Register of contaminated sites
3.5 Disturbances	3.5.1 Hazard potential for operations, transport routes
3.6 Air and noise pollution	3.6.1 Persons affected at place of residence (day and night)
	3.6.2 Persons affected at place of work (day)
3.7 Natural hazards	3.7.1 Areas with flooding risk
	3.7.2 Areas with erosion risk
3.8 Excavated material	3.8.1 Dump sites/recycling/transport

Appendix III: Stepwise consolidation of safety considerations from stage 1 to stage 3

1 Introduction

According to international recommendations, a site selection procedure is characterised by a broadly based search for sites, a stepwise narrowing-down of the areas that come into question and the application of safety-based criteria. The conceptual part of the sectoral plan therefore defines three stages which, based on investigations to date and the current status of geological understanding, lead to identification of sites for geological repositories.

Demonstrating the safety of HLW and L/ILW repositories places partly different demands on the host rock and its long-term containment function because the waste to be emplaced differs in the two cases in terms of its physico-chemical properties, decay characteristics, toxicity and hazard potential. For this reason, quantitative requirements can only be placed on the geological barrier once the waste inventory (waste volumes, nuclide inventory, chemico-physical composition of waste packages, etc.) has been defined for planning purposes. As a first step, the waste producers therefore define the allocation of the waste to the two repositories and, based on this, derive, for each repository type, minimum quantitative requirements on the geological barriers. These serve as targets for the site selection process defined in the sectoral plan, which foresees a stepwise narrowing-down of potential sites and host rocks and stepwise consolidation of safety considerations from stage 1 to stage 3.

13 individual criteria were identified as the most important factors for the site evaluation; these apply to the containment function of the rock, the long-term stability of the barrier effect, the reliability of geological information and engineering properties (Table 1). The criteria, and the aspects to be evaluated, are generally linked with respect to their safety function. Only in the case of extremely unfavourable values can a single criterion be used to decide that a geological siting region or site has to be excluded as being unsuitable. Generally, it is all the criteria taken together that allow a decision to be made on suitability or safety. This requires an integrated safety assessment.

The requirements applying to the safety of deep geological disposal of radioactive waste are contained in HSK Guideline R-21[26]. R-21 defines the principles and requirements applying to deep geological repositories, as well as concrete protection objectives to be met by waste disposal in a repository. The quantitative requirements (dose and risk objectives) are derived from the radiation protection legislation[27] and from international recommendations (ICRP[28], IAEA). According to R-21, the release of radionuclides from a sealed repository may not lead to an annual individual dose exceeding 0.1 mSv per year. The dose limit is low compared with international standards (ICRP recommends a maximum of 0.3 mSv/a) and forms the yardstick for measuring radiological safety.

In order to carry through a selection procedure that is oriented to safety and allows comparison of potential geological siting regions and sites, safety considerations are necessary at all stages of the procedure. The generic safety assessment required at the beginning of stage 1 is used to derive quantitative requirements for the geological barrier, taking into account the defined waste inventory. The provisional safety analysis in stage 2 includes a quantitative analysis of the containment and retention capacity of the host rock and the behaviour of the system as a whole and is used to compare sites from a safety

[26] This Guideline was prepared before the new nuclear energy legislation and uses old terminology. According to Art. 11 of the NEO, HSK regulates design principles for repositories in guidelines. A new guideline – G03 – is presently being prepared and will replace R-21. The dose protection objective of 0.1 mSv/a will remain the same.

[27] Radiation Protection Act of 22 March 1991 and Radiation Protection Ordinance of 22 June 1994

[28] International Commission on Radiological Protection (1998): Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste. ICRP Publication 81. Elsevier.

perspective. The safety analysis in stage 3 is carried out with a view to the general licence procedure and is more detailed and comprehensive. It is based on in situ data and demonstrates the long-term safety of the planned repository, as required in the nuclear energy legislation. The stepwise consolidation of the safety assessments is considered in more detail in the following.

2 Generic safety consideration (stage 1)

Objective: Based on a defined waste inventory, the generic safety assessment is intended to derive quantitative requirements and objectives for the geological barrier and to quantify the site-relevant criteria according to Table 1 as far as possible. It is not a safety case for a geological repository.

Content: The generic safety assessment is a first quantitative analysis of the containment and retention capacity of the overall system or parts thereof. It takes into account the defined waste inventory and the planned engineered barriers and one or more model geological situations. In the case of the waste inventory and the engineered barriers, the analysis is based as far as possible on specific data and, if these are not available, on generic (general, typical) material parameters. For the geological barrier, generic properties that can be demonstrated by existing knowledge and experience are used.

The assessment confirms the expected contributions of the different elements of the barrier system and the quantitative requirements placed on the properties of the geological barrier. The scale used for evaluation is explained in relation to the results of the generic safety considerations and based on empirical values for the property in question. To derive the quantitative requirements on the geological barrier (depth, thickness, lateral extent, hydraulic conductivity), the waste producers apply the dose protection objective in HSK R-21 of 0.1 mSv/a.

3 Provisional safety analysis (stage 2)

Objective: The provisional safety analysis aims to provide information on the functioning and behaviour of the individual barriers and to show that the calculated doses lie below the protection objective of HSK R-21. Numerical calculations form part of the provisional safety analysis for the site in question. The results allow sites to be compared in terms of safety and give indications of the investigations that will be required in stage 3 to achieve the level of data certainty required for a general licence application.

Content: Based on the disposal concept and taking the defined waste inventory and available technical and scientific data into account, the provisional safety analyses required in stage 2 must provide information on:

– the retention capacity of the overall system (engineered and geological barriers and their interactions) and the maximum dose from realistically conceivable releases (reference scenario)

– the contribution of the geological barrier to long-term safety

– the long-term evolution of the barriers.

The potential release of radionuclides (migration from the repository to the biosphere) is determined quantitatively in the provisional safety analysis. The analysis is based on a defined waste inventory and founded assumptions and empirical values for the properties of the engineered and geological barriers. The dose to an individual person is calculated taking into account water flowpaths in the biosphere and possible uptake of radionuclides via drinking-water and foodstuffs,. The measure for safety is the value of 0.1 mSv/a in the HSK R-21 Guideline.

Additional aspects of system behaviour and robustness are to be taken into account in the analysis. This is understood to include the following:

– Variability and uncertainties in the parameters used in the modelling and their influence on dose calculations

– Sensitivity of the calculated dose to system behaviour that deviates from expectations.

– Reliability of spatial and temporal predictions (explorability, predictability, reliability of data).

4 Comparison of sites (stage 2)

As an interim result in stage 2, no site can be proposed that, based on the provisional safety analysis and other safety aspects, would be evaluated as clearly less suitable than the others. At the same time, sites may not be ruled out because of differences in dose arising only from uncertainties in the underlying data.

For the safety-based comparison of potential sites, a standardized procedure is required that takes into account the quantitative results of the provisional safety analyses as well as the qualitative aspects of the safety considerations. The comparison consists of the following elements:

1. Presentation of the quantitative results of the release calculations for the realistically expected evolution of the repository (reference scenario, personal dose curve with time).

2. Discussion of the robustness of the repository system with respect to internal and external perturbations and identification of uncertainties/variabilities in the parameters used in the modelling and the influence of these on the dose curve.

3. Evaluation of other (qualitative) criteria relating to safety and technical feasibility (e.g. reliability of geological information, possible degradation due to erosion). Other qualitative safety indicators (e.g. residence or containment times of natural tracers in the porewater of the host rock) are to be taken into consideration where available.

The comparison of the sites in terms of safety is done first using the method described below, which also includes a comparison of numerical calculations. The expected evolution of the whole system (repository, near-field, geosphere) and its robustness and the uncertainties and variability in the quantitative parameters are taken into account. Sites that emerge from this comparison as being clearly less suitable than the others or do not fulfil the dose protection objective are ruled out.

The remaining sites are then evaluated using the qualitative safety criteria (under point 3). A site can be excluded if clear disadvantages compared to the other are identified at this stage.

4.1 Method for comparing the numerical calculations

For the comparison of sites, the results of the numerical calculations are included and evaluated using two radiological criteria. The first criterion is the objective of 0.1 mSv/a defined in HSK R-21 and the second is the value of 0.01 mSv/a derived from the Radiation Protection Ordinance, below which all sites are considered to be equivalent in terms of safety, irrespective of the calculated dose maxima. The definition of a lower threshold value for potential annual individual dose is permissible in terms of the Swiss radiation protection legislation. According to the Radiation Protection Ordinance, there is no further optimisation in terms of radiation protection if persons accumulate an effective dose of less than 0.01 mSv/a.

The comparison between potential sites is thus carried out as follows:

– For each site, a reference scenario is used to calculate the time profile of realistically expected doses (reference case). The reference scenario describes the likely evolution of the whole system (repository, near-field, geosphere and nuclide transport to the biosphere). The assumptions and parameter values used in the modelling for the reference case are justified by the waste producers. They reflect a realistic situation based on the current status of science and technology,. The calculation shows the evolution with time of dose, the maximum of which gives the maximum value for individual dose in the reference case (green point in Fig. A3-1).

– To assess robustness and the influence of uncertainties and variability for the reference scenario, the performance of the repository is calculated for alternative evolution scenarios (e.g. increased water flow, earlier failure of the HLW container, more pessimistic values for sorption). The regulatory authority defines a standardised parameter variation procedure within the reference scenario for this purpose. This procedure is used to determine the maximum individual dose for the parameter variations (red point in Fig. A3-1).

– For each site, a characteristic dose interval results as a measure of suitability in terms of safety. The dose interval extends from the maximum dose calculated for the reference case to the maximum dose determined using the parameter variations (blue interval in Fig. A3-1).

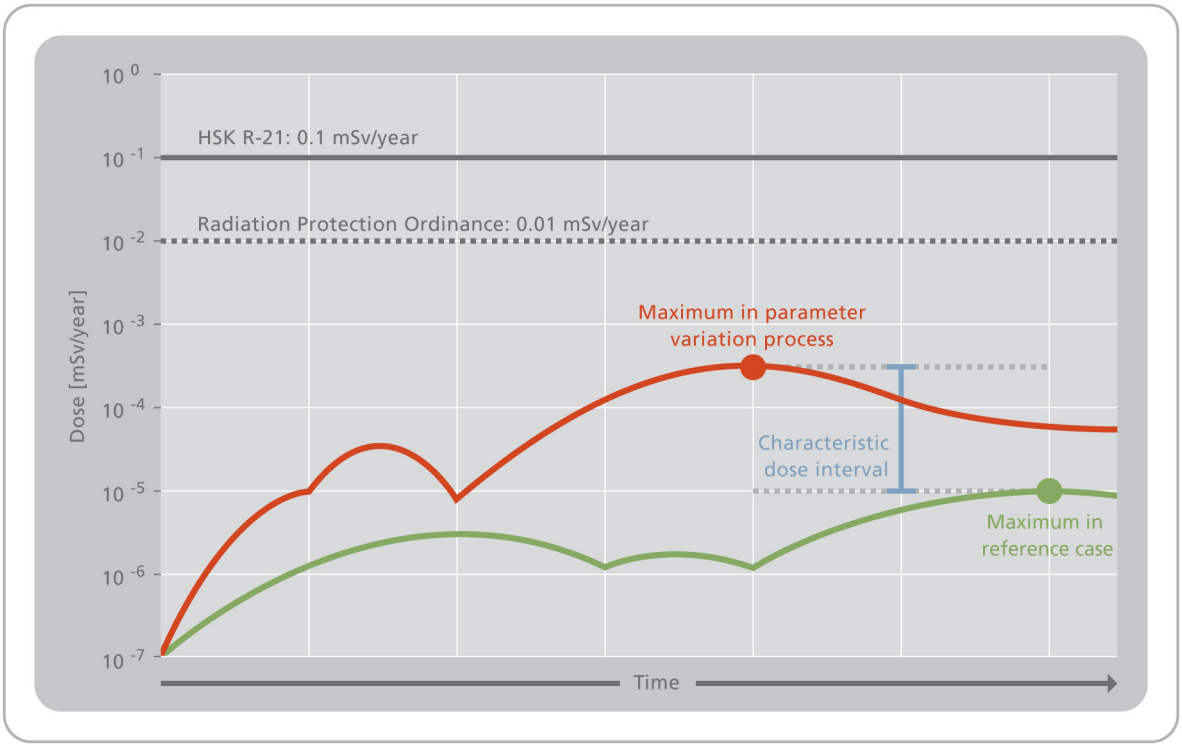

Figure Appendix A3-1: Determining the characteristic dose interval for a deep repository used in the comparative approach: the evolution with time of the calculated doses is calculated for the reference case (green) and for the cases defined using the parameter variations (red). The dose maxima in each case that define the dose interval are shown (filled circles). Note: The dose curves shown are hypothetical examples.

– Only sites with a dose interval below the protection objective of 0.1 mSv/a defined in HSK R-21 are taken into consideration. These sites are classified as suitable in terms of safety and the other sites are excluded.

– No distinction in terms of safety is made among sites if their dose interval is below 0.01 mSv/a. They are considered to be equivalent in terms of safety.

– A site for which part of the dose interval lies between 0.01 and 0.1 mSv/a remains in the selection if its dose interval overlaps with the dose interval for the site with the smallest dose maximum in the reference case (site 1 in Fig. A3-2). This criterion of dose interval is used to prevent a potentially suitable site from being excluded too early on the basis of a possibly incomplete database.

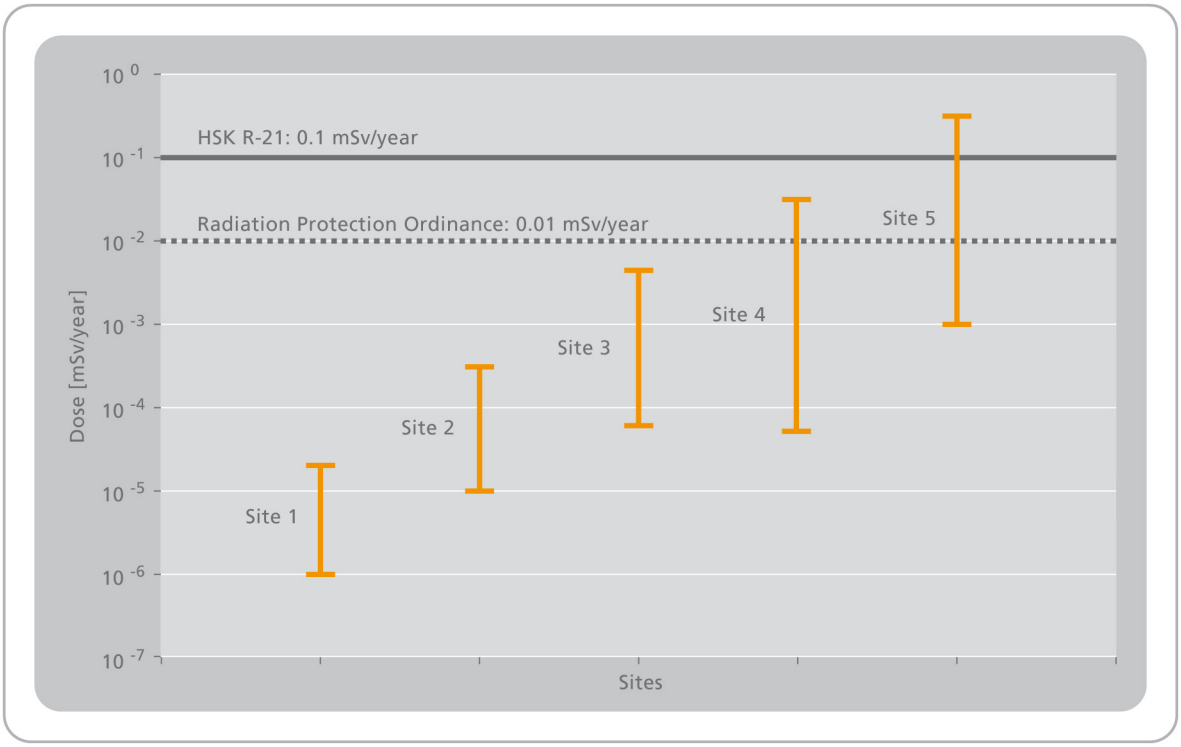

Figure Appendix A3-2: Dose intervals from the provisional safety analyses for five hypothetical sites (that could be in different host rocks). Each site is compared with the radiologically best site (site with the lowest dose in the reference case, in this example site 1). In this example, site 5 is excluded since the upper value of the interval of dose maxima is above the HSK R-21 protection objective of 0.1 mSv/a. Sites 1, 2, 3 and 4are suitable from the viewpoint of safety as their dose intervals lie below 0.1 mSv/a. Sites 1, 2 and 3 are also considered to be equivalent in terms of safety as their dose intervals lie below the threshold value of 0.01 mSv/a. Site 4 is excluded from further consideration as its dose interval does not overlap with that of the best site (site 1) and goes beyond 0.01 mSv/a.

5 Safety analysis with a view to the general licence procedure (stage 3)

Objective: The objective of the safety analysis is to make the safety case at the stage of the general licence application in accordance with the Nuclear Energy Act (Art. 12-14) and Ordinance (Art. 22-23, 62).

Content: The safety analysis is to be conducted in accordance with the requirements of the Nuclear Energy Act and Ordinance and the provisions in HSK R-21. The provisional safety analysis of the site is consolidated and supplemented with a comprehensive scenario and risk analysis.

Appendix IV: General licence application

In order to prepare a general licence application, investigations that require a permit according to nuclear energy legislation have to be carried out (Nuclear Energy Act Art. 35). Investigations that have only a minimum negative impact are excepted from this, but cantonal permits and permits under other federal legislation may still be required. According to Art. 61 of the Nuclear Energy Act, these are:

– seismic and other geophysical measurements such as gravimetric, geoelectric and electromagnetic measurements

– geological measurements at the surface and in existing underground structures, including collection of rock samples

– collection of groundwater and spring water samples, measurement of springs, shallow piezometric measurements and tracer tests

– soil gas measurements

The investigations have to show that the requirements for granting a general licence under Art. 13 of the Nuclear Energy Act have been fulfilled. A key aspect is demonstrating the long-term safety of the repository following closure.

According to Art. 62 of the Nuclear Energy Ordinance, the applicant has to submit a report containing the following, in addition to the documentation required by Art. 23 of the Nuclear Energy Ordinance:

– a comparison of the options available for selection in terms of the safety of the planned repository

– an evaluation of the properties that were decisive for the selection of the site

– the amount of costs

The general licence also defines the criteria which, if not fulfilled, will lead to a planned disposal zone being ruled out due to lack of suitability. These criteria relate to (Art. 63 of the Nuclear Energy Ordinance):

– the extent of the suitable host rock areas

– the hydrogeological conditions at the site

– the residence time of deep groundwaters.

Appendix V: Task descriptions

This Appendix defines the responsibilities of the actors directly involved in the implementation of the sectoral plan. The most important tasks, powers and responsibilities are included.[29]

1 Nuclear Safety Commission (NSC)

Main function: Advises HSK, the Federal Council and DETEC on fundamental safety issues and prepares opinions on the findings of HSK in the three stages

1.1 Prepares opinions on the expert reviews of HSK

1.2 Prepares an opinion on the general licence application

1.3 Participates in the Technical Forum on Safety

1.4 Makes its expert knowledge available to the federal authorities, cantonal and communal authorities, the Cantonal Commission, the siting regions and the public

2 Waste Management Advisory Council

Main function: Advises DETEC on implementation of the site selection process for deep geological repositories

2.1 Monitors the selection procedure with the aim of early identification of conflicts and risks and proposing solutions

2.2 Evaluates positions, opinions and reviews from a national perspective and prepares recommendations for DETEC

2.3 Brings an independent viewpoint to the site selection process and advises DETEC accordingly

2.4 Encourages dialogue among the actors in the process and supports the public relations activities of the federal government

3 Swiss Federal Office of Energy (SFOE)

Main function: The lead federal office in the sectoral plan and general licence procedures.

3.1 Bears overall responsibility for the implementation of the sectoral plan and general licence procedures

3.2 Submits the internal federal project organisation to DETEC for approval

3.3 Prepares and updates the project plan and is responsible for monitoring and time plans and deadlines

[29] The order in which actors are presented generally follows the three levels of state (national, cantonal, local). Within the individual levels, the order is according to their organisational and hierarchical affiliation.

3.4 Specifies the administrative requirements and responsibilities of the offices and institutions involved in the sectoral plan procedure in so far as these are not defined in the sectoral plan, ensures their involvement in the procedure and coordinates all activities

3.5 Prepares the results reports and updates the object sheets together with HSK and the ARE

3.6 Leads the hearing and participation procedures

3.7 Prepares a communication concept, informs the public and coordinates media information and public relations activities with the involved federal offices

3.8 Is responsible for data management for decision-relevant documentation and for overall quality control of the implementation of the site selection process

3.9 Prepares the budget for arising costs and charges this to the waste producers (e.g. costs of the cantonal expert group on safety, for administrative and technical support of regional participation, socio-economic studies, other studies and personnel costs of the federal government)

3.10 Keeps DETEC informed and is responsible for internal departmental coordination

3.11 Is the contact partner for the cantons and ensures involvement of affected neighbouring countries in the procedure

3.12 After consultation of the siting cantons, establishes the Cantonal Commission in stage 1

3.13 Supports the Cantonal Commission and participates in its meetings

3.14 Defines the planning perimeter together with the siting cantons and the ARE

3.15 Is responsible for building up regional participation involving the siting cantons and communes and supports them in the ongoing process

3.16 Prepares socio-economic studies together with the siting regions in stage 2 and a more detailed evaluation of socio-economic impacts in stage 3

3.17 Ensures that the activities and results of the regional participation in the different siting regions are comparable and of a similar level of detail

3.18 Establishes the Technical Forum on Safety

3.19 Leads the procedure for licensing geological investigations and prepares the decision of DETEC

4 Swiss Federal Nuclear Safety Inspectorate (HSK)[30]

Main function: Reviews and assesses safety aspects

4.1 Bears overall responsibility for the safety assessment of geological siting regions and sites

4.2 Leads the Technical Forum on Safety, coordinates its work and heads the secretariat

[30] On 1.1.2009 HSK will become legally independent under the title the Federal Nuclear Safety Inspectorate (ENSI). The tasks of ENSI within the sectoral plan procedure will remain the same.

4.3 Evaluates the selection of geological siting regions in stage 1 from a safety viewpoint and prepares an expert opinion

4.4 Evaluates the selection of sites in stage 2 from a safety perspective, reviews the provisional safety analyses and prepares an expert opinion

4.5 Reviews the applications for geological investigations and prepares an expert opinion

4.6 Monitors and supports the geological investigations and leads the associated coordination bodies

4.7 Evaluates the general licence application from a safety viewpoint and prepares an expert opinion

4.8 Reviews the narrowing down criteria proposed by the waste producers according to Art. 14 para. 1 f(1) of the Nuclear Energy Act and Art. 63 of the Nuclear Energy Ordinance.

4.9 Makes its expert knowledge available to the federal authorities, cantonal and communal authorities, the Cantonal Commission, the siting regions and the public

4.10 Supports the SFOE in preparing and updating the results reports and the object sheets

4.11 In agreement with the SFOE, informs the media and the public about safety aspects and the activities of the Technical Forum on Safety

5 Commission for Radioactive Waste Disposal (CRW)

Main function: Advises HSK on geological issues

5.1 Supports HSK in its work on safety assessments as part of the sectoral plan and general licence procedures

5.2 Prepares opinions for HSK for the geological evaluation of geological siting regions and sites and on the engineering feasibility of repository construction

5.3 Prepares opinions on behalf of HSK on applications for geological investigations

5.4 Participates in the Technical Forum on Safety

6 swisstopo

Main function: Supports HSK on geological issues

6.1 Supports and advises HSK on geological questions arising in the sectoral plan and general licence procedures

6.2 Participates in the Technical Forum on Safety

7 Federal Office for Spatial Development (ARE)

Main function: Reviews and assesses spatial planning aspects and supports the SFOE

7.1 Bears overall responsibility for spatial planning issues in the site selection process

7.2 Supports the SFOE in evaluating submitted project documentation, in defining the planning perimeter and in the preparation and updating spatial planning issues in the results reports and object sheets

7.3 Supports the SFOE in project organisation and planning

7.4 Together with the SFOE and the cantons, clarifies the need for modification of the cantonal structure plans and coordinates the structure plan and sectoral plan procedures

7.5 Together with the siting cantons and the waste producers, defines the decisive spatial planning indicators and the method for evaluating these in stage 1; responsible for recording the spatial planning situation

7.6 Evaluates spatial planning aspects in phase 2, together with the siting cantons

7.7 Supports the cantons on questions of spatial planning

7.8 Makes its expert knowledge available to the siting regions

7.9 Supports DETEC on spatial planning aspects involved in solving conflicts with the cantons and third parties

8 Federal Office for the Environment (FOEN)

Main function: Reviews and evaluates environmental aspects and supports the SFOE

8.1 Bears overall responsibility for evaluating environmental aspects

8.2 Supports the ARE in the spatial planning assessment in stages 2 and 3 in terms of impacts on the environment

8.3 In stage 2, prepares an opinion on the requirements for the environmental impact report

8.4 Reviews the stage 1 environmental impact assessment report as part of the general licence procedure

8.5 Advises the SFOE on issues of environmental protection

9 Waste producers

Main function: In accordance with the requirements specified in the conceptual part of the sectoral plan, propose geological siting regions and sites and submit an application for a general licence

9.1 Prepare repository concepts and all the necessary geological materials and data for the geological siting regions and sites

9.2 In accordance with the requirements of the sectoral plan and the relevant legal provisions, evaluate the proposed geological siting regions and sites, particularly with respect to
– safety (safety assessment, safety analysis)
– aspects of spatial planning and environmental protection
and document their findings in reports addressed to the federal authorities

9.3 In each stage, identify the uncertainties and show how these will be taken into account in the future procedure

9.4 On request, make their expert knowledge available to the actors listed in Appendix V and participate in the Technical Forum on Safety

9.5 Prepare regular reports for the SFOE on the progress and status of work and on deadlines

9.6 Based on criteria relating to safety and technical feasibility, simultaneously propose geological siting regions for HLW and L/ILW in stage 1

9.7 Participate in stage 1 in the preparation of spatial planning indicators and the method for their evaluation together with the ARE

9.8 In stage 1, prepare the necessary background for recording the spatial planning situation in the proposed geological siting regions. Particular account has to be taken of cantonal planning. If specific information is required from cantons or communes, this is requested via the ARE

9.9 In stage 2, concretise the repository projects together with the siting regions and identify at least one site for each planning perimeter

9.10 In stage 2, concretise the underground layout of the repository and carry out provisional safety analyses

9.11 In stage 2, perform preliminary investigations in accordance with Art. 8 of the Environmental Impact Assessment Ordinance EIAO and prepare a specification

9.12 With the involvement of the siting regions, prepare and concretise the repository projects (layout and design of surface facilities, infrastructure) in stages 2 and 3

9.13 In stage 2, prepare the background for evaluating spatial planning aspects

9.14 In stage 2, propose at least two sites each for the HLW and L/ILW repository

9.15 Submit applications for the necessary geological investigations and perform these

9.16 Support the SFOE and the siting regions in preparing socio-economic background information in stages 2 and 3

9.17 In stage 3, bring the geological understanding of the selected sites to a level that allows a comparison to be made from a safety perspective

9.18 In stage 3, select the site for which the general licence application will be prepared

9.19 In stage 3, regulate the question of compensation measures with the siting canton and the siting region

9.20 Perform the investigations necessary for the general licence application and prepare the necessary supporting reports

9.21 Submit the general licence application

9.22 Based on the relevant ordinance on fees of the Swiss Federal Office of Energy of 22 November 2006, pay the costs arising (in particular the costs of the cantonal expert group on safety, administrative and technical support for regional participation, studies on socio-economic impacts, other studies and personnel costs of the federal government)

10 Siting cantons

Main function: Work together with the federal government, provide support in implementing the site selection process and coordinate the procedure for any necessary modifications to the cantonal structure plans and the cooperation with the communes

10.1 Work together with the ARE and the waste producers and make available the necessary spatial planning information and background

10.2 In stage 1, delegate their representation to the Cantonal Commission

10.3 Support the SFOE in implementing the site selection process and delegate their representation to project-related bodies and working groups

10.4 Support the SFOE in building up and implementing regional participation and coordinating collaboration with the communes

10.5 Support the SFOE in stage 1 is defining the provisional planning perimeter

10.6 Support the ARE in stage 1 in recording the spatial planning situation and in preparing the decisive spatial planning indicators and the methods for their evaluation in stage 2

10.7 Support the SFOE in defining the planning perimeter in stage 1

10.8 Support the ARE in evaluating the spatial planning aspects in stages 2 and 3

10.9 Support the siting regions in building up regional participation and coordinate cooperation with the SFOE

10.10 Represent the communes of the siting region if they are not involved in the participatory process

10.11 Together with the siting regions and the waste producers, regulate the question of compensation in stage 3

10.12 Support the siting regions in preparing compensation measures

10.13 Conduct, in their own canton, the hearing and participation procedures on the drafts of the results reports and object sheets

10.14 Coordinate their cantonal planning procedures with the sectoral plan procedure of the federal government and revise the cantonal structure plans if necessary

10.15 Request a settlement procedure if they cannot agree with the federal government on spatial planning issues

10.16 Evaluate the dossier for the general licence application and make it open to the public

10.17 Participate in preparing the decision on the general licence application according to Art. 44 of the Nuclear Energy Act

11 Cantons

Main function: Express opinions on the drafts of the results reports and the object sheets as part of the hearing phase and participation according to the Nuclear Energy Act and Spatial Planning Act

11.1 Work together with the ARE and the waste producers and make available the necessary spatial planning information and background

11.2 As a neighbouring canton in the immediate vicinity of a geological repository, delegate a representative to Cantonal Commission

11.3 Implement the hearing and participation procedures on the draft results reports and object sheets in their own canton

11.4 Coordinate their cantonal planning procedure with the sectoral plan procedure of the federal government and revise the cantonal structure plans if necessary

11.5 Request a settlement procedure if they cannot agree with the federal government on spatial planning issues

11.6 Evaluate the dossier for the general licence application and make it open to the public

11.7 Participate as a neighbouring canton in the immediate vicinity of a geological repository in preparing the decision on the general licence application according to Art. 44 of the Nuclear Energy Act

12 Cantonal Commission

Main function: Ensures cooperation between government representatives of the siting cantons and affected neighbouring cantons and countries, supports the federal government in carrying out the site selection process and makes recommendations to the federal government

12.1 Coordinates the activities of the affected cantons in the siting regions

12.2 Advises and supports the SFOE with the aim of making the activities and results from the different cantons and siting regions comparable and bringing them to the same level of detail

12.3 Supports the SFOE in early recognition of potential conflicts with long-term cantonal and supra-regional spatial and development planning and proposes solutions

12.4 Keeps informed on activities of the siting regions

12.5 Reports regularly to the SFOE on its activities and points out possible improvements in the implementation of the sectoral plan procedure

12.6 With a view to the hearings in stages 1 to 3, prepares, on behalf of the cantons, opinions on the proposals made by the waste producers, on the reports of the siting regions and other materials that are relevant for the site selection process

12.7 Channels questions relating to safety from the cantons to the cantonal expert group on safety or the Technical Forum on Safety

12.8 Sets up the cantonal expert group on safety in stage 1 and appoints the members

12.9 Prepares a budget for the work of the cantonal expert group on safety and requests the funding from the SFOE

12.10 In stage 1, provides an opinion on the decisive spatial planning indicators and the method for their evaluation in stage 2 and on the definition of the planning perimeter

12.11 Provides an opinion on the spatial planning evaluation in stage 2

12.12 In stage 3, provides an opinion on the planned regional development projects and any compensation measures

13 Cantonal expert group on safety

Main function: Supports and advises the cantons in evaluating safety documentation

13.1 On behalf of the Cantonal Commission, evaluates the safety-related documentation prepared by the waste producers

13.2 Addresses further safety-related questions on behalf of the Cantonal Commission

13.3 With a view to the hearings in stages 1, 2 and 3, prepares background information for the opinions of the cantons

14 Communes in the siting regions

Main function: Work together with the SFOE in organising and implementing regional participation and represent regional interests

14.1 Ensure that the interests, needs and other values of the siting region are taken into account in the sectoral plan procedure and that the regional population is informed

14.2 Support the SFOE in stage 1 in building up regional participation

14.3 Nominate their representation in regional participation and bring the viewpoints of the communes into the process

14.4 Contribute to continuous, understandable information and communication with the public

14.5 Ensure that citizens have access to all relevant information and documentation for regional participation

14.6 Work together with other communes of the siting region and siting canton

14.7 Estimate the resources required for implementing regional participation (including administrative support, infrastructure, involvement of external experts), make applications for the necessary funding from the SFOE and manage the budget

14.8 Can request expert knowledge from the federal authorities and the waste producers and direct safety-related questions to the Technical Forum on Safety

14.9 Can delegate one representative per siting region to the Technical Forum on Safety

14.10 Identify and analyse existing and potential future conflicts

14.11 In stage 2, take over responsibility, together with the SFOE, for regional participation

14.12 Support the SFOE in stage 2 in preparing the socio-economic studies and drawing up a strategy, measures and projects for sustainable development of their siting region or updating existing strategies, measures and projects

14.13 In stages 2 and 3, prepare or concretise proposals for the design, location and accessing of the surface installations within the planning perimeter together with the waste producers

14.14 Support the SFOE in stage 3 in carrying out in-depth socio-economic investigations and propose measures and projects for implementing the regional development strategy

14.15 In stage 3, prepare the background for monitoring socio-economic and environmental impacts and for possible compensation measures

14.16 Regulate the question of compensation payments together with the siting cantons and the waste producers in stage 3

14.17 In stage 3, make proposals for the financing required for implementing the sustainable development strategy of the siting region

14.18 With a view to the participation of the communes of the siting region during the hearing phase in stages 2 and 3, prepare reports on the topics discussed as part of regional participation as well as the supporting information for their opinions

15 Technical Forum on Safety

Main function: Discusses and answers technical and scientific questions on safety and geology from the public, the communes, the siting regions, organisations, cantons and public bodies of affected neighbouring countries

15.1 Collects and structures incoming questions

15.2 Defines the procedure for processing and answering questions and brings in external experts if necessary

15.3 Ensures that the answers to questions are documented traceably, publishes answers and provides regular information on the processing stage of questions

15.4 Can itself raise and answer technical and scientific questions

Appendix VI: Possibilities for participation of neighbouring countries

This Appendix discusses only the participation of neighbouring countries. Affected bodies of neighbouring countries will be represented in the Cantonal Commission (affected federal states and regions) and in the siting regions (affected communes) and will participate in the sectoral plan procedure as specified in Appendix V.

1 Stage 1: Selection of potential siting regions

Affected neighbouring countries are informed by the SFOE on the proposal of geological siting regions. The neighbouring countries have a right to express their opinion on the draft of the results reports and object sheets. This implements the terms of the following Swiss regulations and bilateral and multilateral agreements:

– Article 18 of the Spatial Planning Ordinance

– Article 6 of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

– Bilateral agreements with neighbouring countries in the nuclear field

– The recommendations of Art. 2 para. 7 of the UNECE Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention)

The decision of the Federal Council cannot be challenged in a court of law.

2 Stage 2: Selection of at least two sites

As part of the official hearing, neighbouring countries have the opportunity to express an opinion on the draft of the results reports and object sheets. They are also invited to give an opinion on the report on the preliminary investigation and specification for preparation of the report on the impact of the facility on the environment (EIA stage 1). This implements the terms of the following Swiss regulations and bilateral and multilateral agreements:

– Article 18 of the Spatial Planning Ordinance

– Article 6 of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

– Bilateral agreements with neighbouring countries in the nuclear field

– The UNECE Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention), including the recommendation in Art. 2 para. 7.

The decision of the Federal Council cannot be challenged in a court of law.

3 Stage 3: Site selection and general licence procedure

Neighbouring countries are informed by the SFOE of the siting proposal of the waste producers. They can express an opinion on the general licence application and on the submitted expert opinions (Art. 23 and 62 of the Nuclear Energy Ordinance). The documentation supporting the application includes in

particular a security and safety report, a report on reconciliation with spatial planning, a report on the impact of the facility on the environment (EIA stage 1) and a specification for the report for stage 2 of the EIA. The latter is conducted as part of the construction licence procedure. Neighbouring countries also have the opportunity to express an opinion on the drafts of the results reports and revised object sheets of the sectoral plan. This implements the terms of the following Swiss regulations and bilateral and multilateral agreements:

– Article 18 of the Spatial Planning Ordinance

– Article 6 of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

– Bilateral agreements with neighbouring countries in the nuclear field

– The UNECE Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention)

According to Article 44 of the Nuclear Energy Act, the Department involves the neighbouring countries in the immediate vicinity of the planned site in the preparation of the decision on the general licence. The decision of the Federal Council cannot be challenged in a court of law. The Federal Council submits its decision to the Federal Assembly for approval and the decision of the latter is subject to an optional national referendum. Swiss voters decide on whether or not a referendum will take place.

4 Construction and operating licence

With the new Nuclear Energy Act, there are now only federal licences in the nuclear field, i.e. a general licence followed by a construction licence and an operating licence. These cover all non-nuclear licences required previously. Cantonal licences or permits are no longer required.

The applications for the construction and operating licence are opened to the public. Affected neighbouring countries are informed and consulted according to the requirements in:

– The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

– Bilateral agreements with neighbouring countries in the nuclear field

– The UNECE Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention)

Neighbouring countries, foreign authorities and individuals living abroad can obtain party status in the licensing procedure. A party is whoever is affected in the sense of Swiss administrative procedural legislation, i.e. in the practice of the Swiss courts whoever has sufficient proximity to the project. An affected person can lodge objections independent of their domicile (Switzerland or abroad). A public administrative unit can only lodge an objection if it is affected in the same way as a private person. In concrete terms this means a compromising of its property rights.

Abbreviations and glossary

ARE	Federal Office for Spatial Development
ATW	Alpha-toxic waste: radioactive waste with a high concentration of alpha-emitters.
Backfilling	Filling of disposal caverns and tunnels after emplacement of waste packages (Art. 67 NEO)
Barriers	Barriers form the passive safety system of the repository which protects man and the environment. They consist of engineered and natural (geological) containment and retention systems which, based on the multibarrier concept, isolate the radioactive waste from the biosphere.
Closure	Backfilling and sealing of all underground components and the accesses to a geological repository after the end of the monitoring phase (Art. 69 NEO)
Collaboration/ cooperation	In order to recognise and solve potential conflicts in the area of planning at an early stage, the affected federal authorities, the cantons and neighbouring countries, as well as affected organisations and persons under private and public law who are charged with public tasks are included in the process at an early stage (Art. 18 SPO).
Compensation	There is no legal basis for compensation. Based on experience within Switzerland and abroad, it can be assumed that a siting region will receive compensation. The conceptual part of the sectoral plan specifies that decisions on compensation should be transparent and not detached from the sectoral plan process. Compensation will be negotiated in stage 3 and paid by the waste producers only when a valid general licence exists. A siting region is thus compensated for a service it performs to solve a national issue. The siting region prepares proposals for the distribution and application of the compensation and submits these to the affected cantons and communes of the siting region.
Compensation measures	Compensation measures are applied when the planning, construction or operation of a deep geological repository are found to have negative consequences for a region. The compensation measures are developed in co-operation with the siting region and canton, are approved by the SFOE and financed by the waste producers.
CRW	Commission for Radioactive Waste Disposal
Deep geological repository	Facility in the underground geological environment that can be closed provided the long-term protection of man and the environment is assured by a passive safety barrier system.
DETEC	Federal Department of the Environment, Transport, Energy and Communications
Effective containment zone	Part of the geological barrier which, given normal evolution of the geological disposal system over the isolation period considered, ensures containment of the waste, together with the engineered and geological barriers.
EIA	Environmental Impact Assessment

EKRA	Expert Group on Disposal Concepts for Radioactive Waste
Entsorgungsnachweis	The «Entsorgungsnachweis» is a demonstration of the feasibility in principle of disposing of radioactive waste in a specific geological formation. It shows that a sufficient large body of rock with the required properties exists in Switzerland. The demonstration has been carried out successfully for HLW and L/ILW.
EPA	Environmental Protection Act of 7 October 1983
FDHA	Federal Department of Home Affairs
FE	Fuel element: an arrangement of fuel rods in which nuclear fuel is placed in a reactor. The fuel element for a pressurised water reactor contains around 530 kg of uranium and that for a boiling water reactor around 190 kg.
FOEN	Federal Office for the Environment
FOPH	Federal Office of Public Health
Geological siting region	The geological siting region is defined by geological body of rock underground that is suitable for disposal of radioactive waste.
Hearing	At the end of each stage, the results report and the object sheets are submitted to the affected cantons and opened to the public for a minimum of 20 days. The hearing phase generally lasts 3 months (Art. 19 Spatial Planning Ordinance).
HLW	High-level waste: This includes spent fuel and vitrified fission products from reprocessing. Radioactive decay produces high heat levels.
Host rock	The rock formation in which the repository is located. It indicates that part of the geosphere that is decisive for the protection of the engineered barriers, restricting water flow to the repository and for radionuclide retention.
HSK	Swiss Federal Nuclear Safety Inspectorate
ICRP	International Commission on Radiological Protection
L/ILW	Low- and intermediate-level waste: This consists mainly of short-lived radioactive substances with short half-lives. They originate from the operation and later dismantling of nuclear power plants and from medicine, industry and research.
LFM	Lower Freshwater Molasse
MIR waste	Waste from medicine, industry and research
mSv	Millisievert: Sievert is a measure for biological damage caused by absorption of ionising radiation (in living cells) and is usually given in thousandths of a Sievert (mSv).
Nagra	National Cooperative for the Disposal of Radioactive Waste. With a view to implementing the permanent, safe disposal of radioactive waste, the operators of the five Swiss nuclear power plants and the Swiss Confederation set up Nagra in 1972.

NEA	Nuclear Energy Act of 21st March 2003. It regulates the peaceful use of nuclear energy and defines the procedure for management of radioactive waste.
NEO	Nuclear Energy Ordinance of 10 December 2004
NPP	Nuclear power plant
NSC	Swiss Federal Nuclear Safety Commission
Object sheet	The core of the Federal Government sectoral plan is formed by object sheets describing the individual projects. They consist of a map and a text part and are built up following a consistent pattern: a. Title with number of sheet b. Overview with brief description c. Status of preparation with information on sectoral plan category d. List of involved parties e. Starting-point, description of problem f. Aims for integrating the facility in the large-scale area; facility components, access, landscape g. Compensation measures outside the facility for regional development h. Final part: Reconciliation and coordination instructions i. Further procedure j. Documentation
Opalinus Clay	Some 175 million years ago during the Jurassic period, fine clay particles were deposited on the floor of a shallow sea. These formed Opalinus Clay. The argillaceous sediment is evenly deposited over parts of northern Switzerland.
Participatory process	The participatory process gives affected citizens and organisations the opportunity to participate and bring their wishes forward wherever other persons are able to decide or influence their living conditions and interests. Participatory processes include activities undertaken freely by affected citizens with the aim of influencing decisions on different levels of the political system.
Planning perimeter	The planning perimeter designates the geographical area defined by the extent of the geological siting region, taking into account possible arrangements of the facilities required at the surface.
PSI	Paul Scherrer Institute
Reflection seismics	Measurement and interpretation of energy and travel-times of seismic waves reflected at discontinuities underground. This is used to derive information on the location and distribution of geological strata underground.
Retrievability	The possibility of recovering radioactive waste from an open, partly or fully closed facility with more or less financial and technical effort.

Sediments	Sediments are so-called «secondary rocks» formed from weathering materials which are transported by wind, water or ice and then deposited, or formed by chemical precipitation.
Seismic investigations	Seismic investigations involve generating oscillations at the earth's surface. These propagate in the form of waves into the deep underground and are reflected by rock layers. The reflected waves are recorded at the surface and allow a spatial image to be formed of geological structures.
SFOE	Swiss Federal Office of Energy
Siting canton	Canton with one or more communes in a siting region.
Siting commune	Commune within whose boundaries a geological siting region is partly or fully located.
Siting region	The siting region is made up of the siting communes and communes which are located partly or wholly within the planning perimeter. In justified cases, other communes can also be included in the siting region.
SPA	Spatial Planning Act of 22 June 1979
SPO	Spatial Planning Ordinance of 28 June 2000
Waste management concept	Based on current understanding, geological disposal is the only method for managing radioactive waste that meets requirements of long-term safety. Concepts that rely on continuous monitoring by human institutions do not fulfil these requirements. For this reason, Switzerland has opted for the concept of deep geological disposal. Following repository closure, the federal government assumes responsibility for the facility.
Waste management programme	The waste producers are obliged by Art. 52 of the Nuclear Energy Ordinance to provide the following information in a waste management programme: a. Origin, type and volumes of radioactive waste b. The geological repositories required, including a design concept c. The allocation of the waste to the geological repositories d. The time plan for constructing geological repositories e. The duration and required capacity of centralised and decentralised interim storage f. The financing plan for waste management activities up to the decommissioning of the nuclear installation, with information on 1. the work to be performed 2. the amount of costs 3. the nature of financing 4. the information concept

The waste producers are required to update the programme every five years. HSK and the lead federal authority are responsible for monitoring and observing the programme.

Waste producers

Whoever operates or decommissions a nuclear installation is obliged to dispose of the waste arising from the installation safely at his own cost (Art. 31 NEA). The federal government is responsible for waste delivered according to Art. 27 para. 1 of the Radiation Protection Act (Art. 33 NEA). With a view to implementing the permanent, safe disposal of radioactive waste, the operators of the five Swiss nuclear power plants and the Swiss Confederation set up Nagra in 1972.