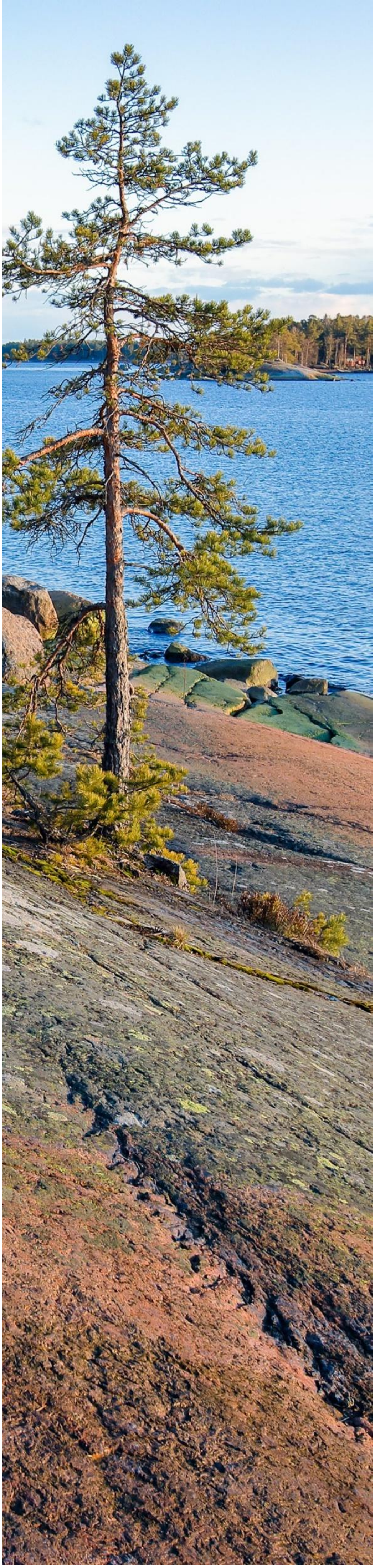

Technical Note

Requirements Table Description Note

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PREFACE

This technical note is part of the contract that Norwegian Nuclear Decommissioning (NND) has with the Finnish AINS Group together with subconsultants VTT Technical Research Centre of Finland and BGE Technology GmbH of Germany. The group assists NND with the concept development and technical design for their disposal solution for radioactive waste in Norway.

The note has been written by Annika Hagros, Taina Karvonen and Timo Saanio from AINS Group, and they have also participated in the compilation of the Excel table including the requirements. In addition, Paula Keto, Timothy Schatz and Ville Ranta-Hiiro (VTT) as well as Toivo Wanne and Michael Jobmann (BGE TEC) have participated in the compilation of the requirements table. Michael Jobmann (BGE TEC) has also reviewed the draft report. AFRY/Advansia has provided comments to the requirements table.

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1 Project objective and key input

The objective of this project is to develop a systematic approach to a generic requirements-management system for the Norwegian National Facility (as described in the Ikonen et al. (2020) and Fischer et al. (2020) reports). This work is intended to guide the further development of the disposal concepts and to support the development of a safety case for either a specific or a generic site.

The main outcome of the work is an Excel table that lists safety and technical requirements for the different repository types in the National Facility. The work relies on information available in Norwegian regulations (provided by NND) and the following international documents as defined in the contract:

- IAEA Safety Standards (including Fundamental Safety Principles, Safety Requirements and Safety Guides, especially those in categories GSR, SSR, GSG and SSG[1]),
- Relevant standards from ICRP and OECD-NEA.

As to OECD-NEA publications, emphasis is given to general NEA reports and statements over country-specific overviews, detailed handbooks and conference proceedings, although the latter are occasionally included as further references.

A few IAEA documents from series other than those listed above are included because they are referenced in the listed documents and contain important information supporting the requirements. The list of all included regulations and documents is given at the end of this note. The list does not contain regulations or documents that were checked but not quoted or referenced in the table. Such documents were not used because no applicable requirements were found or because the document has been superseded by a newer document.

The level of detail and applicability vary a lot between different documents. For example, IAEA document SSR-5 applies to all repository types, whereas additional guides, SSG-1, SSG-14 and SSG-29, repeat the SSR-5 requirements and discuss them from the point of view of a certain repository type. In the Excel table, the requirements are not repeated on more than one row, but the repository-specific discussions are extensively quoted. Guide SSG-1 on borehole disposal focuses on depths beyond a few tens of metres and up to a few hundred metres and does not consider the disposal of spent nuclear fuel/high level waste directly, but it is included in the table as its requirements are considered a necessary, while not a sufficient, basis for borehole disposal of HLW.

It should be noted that the waste currently planned to be disposed of in the landfill repository is classified as non-radioactive, but the landfill repository is designed so that it could be capable of accepting very low-level waste, in case there is a need for this in the future. The Norwegian regulatory requirements on hazardous waste and the IAEA guidelines for near surface disposal of radioactive waste are, therefore, considered to apply to the landfill repository.

The requirement table is intended as a preliminary catalogue of requirements and a tool to present the connection between the regulatory requirements and the design solutions. To best serve its intended purpose, outdated references in the requirements included in the table have been replaced with documents that have superseded the obsolete documents. The official regulatory requirements, in their proper context and with their original wordings, can be found in the actual regulatory documents.

[1] GSR = General Safety Requirements, SSR = Specific Safety Requirements, GSG = General Safety Guides and SSG = Specific Safety Guides.

2 Structure of requirements table

The Excel table (sheet “Table”) includes requirements that may have a direct effect on the design of the Norwegian National Facility and the four different repository types that may be a part of the facility. The table includes the following columns:

- Document reference,
- Document title (with a web address),
- Section/paragraph number of the requirement in question (in case several numbers are given, the requirement is usually included in the first one, and the other sections/paragraphs give further information about the issue),
- Requirement in Norwegian (in case this is the original language),
- Requirement in English (for the Norwegian requirements, here an unofficial translation is given),
- Relevant repository types (whether the requirement applies to the Landfill Repository, Intermediate Depth Repository, Deep Geological Repository (abbreviated as DGR in the Excel table) or Deep Borehole Repository),
- Repository-specific columns to facilitate the filtering of requirements according to a certain type of repository,
- Design solution fulfilling the requirement (if available),
- Further references with a similar requirement (or with more information about the topic).

The purpose of the final column (“Further references with a similar requirement”) is to document the other occurrences of the (essentially same) requirement as the one presented on the row in question, so that very similar requirements do not need to be repeated on several rows, unless some new information is provided. In this column, also full documents giving more information about the requirement subject may be referred to. The intention of this column has not been to refer to requirements that are presented elsewhere in the table but to ensure that no information is lost even though a similar requirement is not repeated several times on different table rows.

Note that some entries in the requirements column are not formulated as requirements, but they are included as they can be used for justification of requirements formulated later by NND. For example, in IAEA documents the actual requirements are often rather general, but useful details are given in the text paragraphs discussing the requirements.

In the table, the requirements from the Norwegian regulations are given first, and the requirements from international standards and other documents come next.

Another sheet (“References”) lists all the documents mentioned in the requirements table. All regulatory documents are also amended with an Internet link.

3 Scope of requirements table

The scope of the work has been to cover regulatory requirements related to the long-term safety of radioactive waste disposal and requirements regarding radiation protection, safeguards and other safety requirements specific to nuclear facilities. Normal construction aspects and all operations outside the National Facility gates/fences prior to disposal (e.g. packaging of the waste, transport) are out of the scope. Underground construction aspects are considered insofar as they apply to nuclear facilities specifically. It should be noted that there are many important regulations that will have to be taken into account in the National Facility project, even though they do not discuss nuclear issues specifically and thus are not quoted as explicit requirements in the Excel file. For example, LOV-2008-06-27-71 (Lov om planlegging og byggesaksbehandling, i.e. Act on Planning and Building Case Processing) is relevant because it regulates zoning. All nuclear facilities must be within the appropriate industrial zone. The Act on Planning and Building Case Processing is, therefore, an essential part of the regulatory framework affecting this project, but as it applies to construction projects other than nuclear projects as well, its requirements are not listed in the Excel (it is, however, mentioned as a further reference for more detailed, nuclear-specific requirements given in FOR-2017-06-21-854, Regulation on impact assessments).

The focus is on requirements that are expected to guide the design of the disposal facility, its components and operations. The work applies to the National Facility, so all general nuclear requirements that may apply also to disposal are included but not those that only apply to power plants, ship’s reactors, laser pointers or medical use of radiation sources, etc.

More specifically, it has been decided with NND to **include** requirements related to:

- nuclear waste disposal facilities specifically and nuclear facilities generally (when disposal facilities may be assumed to be included),
- disposal specifically and nuclear waste management generally (when disposal may be assumed to be included), including waste acceptance and retrievability,
- management of hazardous waste, as this applies to the landfill repository,
- safety principles of disposal (containment, isolation, etc.),
- design and construction of disposal facilities and host rock suitability,
- design and installation of engineered barriers,
- safety functions and performance targets of natural and engineered barriers,
- other structures, systems, components and procedures, including monitoring, maintenance and configuration management (in disposal facilities),
- commissioning and decommissioning/closure (of disposal facilities),
- handling of radiation sources/radioactive waste,
- institutional measures after closure,
- responsibilities of the operator (“enterprises”, “agencies”, “applicant”, “holder”, “owner”, “proprietor”), when the requirements may apply to the operator of a disposal facility,
- site selection, site investigations, land use restrictions, land ownership, real estate, socio-economic factors, infrastructure (however, only general requirements or if directly discussing suitable site characteristics),

- emergency preparedness plan, prevention of accidents, rescue work, risk assessment (only high-level requirements and only if directly related to nuclear facilities, including disposal facilities),
- dosimetry or other surveillance of doses, dose register or dose reporting (only a general requirement to have dosimetry, not the detailed requirements),
- facility design related requirements regarding situations where dose limits are exceeded and high-level requirements on required actions,
- personnel/employment/human resources and their management/training/safety culture, organisational structure (only high-level requirements),
- operational/occupational safety issues (only if directly related to design and high-level requirements),
- safety analyses, safety reviews, reports and other documentation that the operator must provide related to long-term safety (only high-level requirements),
- storage of radioactive waste (only if applies to temporary storage within the National Facility site),
- transfer of radioactive waste, i.e. transport (moving) of radioactive waste within the National Facility site.

Storage is discussed in more detail in Section 4.2 and retrievability in Section 4.4.

For the issues above where only high-level requirements are intended to be included, the detailed requirements are not included in the table, although references to more detailed requirements may be given in the last column. In addition, it has been decided with NND to **exclude** requirements related to:

- nuclear facilities that are not disposal facilities (e.g. power plants),
- “use of radiation” (the requirements relevant for this work are covered by other, more specific requirements),
- construction (also underground), when not related specifically to nuclear facilities,
- tasks defined for the King, the Norwegian Radiation Protection Authority, “government”, “Ministry”, “inspectors”, “municipality” or other regulators/authorities (note that many IAEA regulations formally apply to states, but relevant requirements are included regardless, if there are not yet any corresponding requirements in Norwegian legislation for operators),
- the process of licensing/authorisation/registration/permission/approval or complaint/appeal, insofar as licensing is a separate activity from the design of the facility, and Environmental Impact Assessment process,
- storage/treatment etc. of radioactive waste that is not subject to disposal,
- radioactive waste at a time before entering the National Facility (e.g. requirements related to packaging, encapsulation, marking or transport to the disposal site from outside),
- generation of waste, as it is assumed that the National Facility does not generate significant amounts of new radioactive waste (it may generate radioactive “pollution”, however),
- returning radiation sources to other countries, export/import of radioactive wastes or their dumping in the sea,

- open radioactive radiation sources,
- non-ionising radiation,
- notifications, certificates, registers, declaring or reporting that the operator needs to accomplish or information it needs to submit (e.g. on materials), or about otherwise contacting the Norwegian Radiation Protection Authority, police or other authorities, or the public,
- detailed investigations or other actions that should be carried out by the operator in case dose limits are exceeded or in accident situations (if it does not affect facility design),
- obligation to preserve secrecy (confidentiality),
- compensation and insurance (nuclear liability),
- penalties, sanctions, fines, fees, dues, compensation or other payments or confiscation,
- companies' general quality systems, management systems, information systems, cryptosecurity (management systems directly related to disposal facilities are, however, considered),
- who is allowed to do work related to radiation (e.g. a requirement that pregnant women are not), about appointing persons to certain tasks or about which employee is responsible for which task,
- supplier clearance, costs and finances/financial security,
- appendices (or annexes) of regulations (tables of radionuclides, specific activities, etc.), except if key requirements are given in appendices.

Generation, packaging and transport of radioactive waste is discussed in Section 4.1.

Regarding confidentiality, it should be noted that some details of disposal facilities are not public information, but in the regulations this issue was not discussed in detail.

4 Specific issues related to the National Facility development

4.1 Generation, packaging and transport of waste

Above, it is proposed that the packaging and generation of radioactive waste is excluded from the requirements presented in the Excel table. It is planned that low and intermediate level waste will be packaged in an on-site packaging facility, but the Concept Description report (Ikonen et al., 2020) did not include a design for the plant (only an area reservation; Ikonen et al., 2020, Section 5.7), as that was out of the scope of work. The report also concluded that although there might be some minor amounts of radioactive waste produced in this on-site packaging plant, these were not considered to be significant at the concept description stage (Ikonen et al., 2020, Section 2.2.5). Requirements for packaging are included in the table insofar as the waste packages are considered to contribute to the long-term safety of disposal, but no detailed requirements for packaging plants are included.

In case encapsulation (emplacement of e.g. spent fuel in a canister) will be changed to occur at the National Facility site, requirements related to packaging, encapsulation and marking should be included in considerations. The same applies to generation of waste, as there is bound to be at least hot-cell-derived, polluted materials to dismantle after operations. However, at this design phase, these issues were excluded and encapsulation assumed to occur elsewhere.

As for “transport to the disposal site from outside” mentioned to have been excluded, the exclusion applies to transport of nuclear waste, not topics concerned with admitting the waste at the site. However, requirements directly concerned with accepting and receiving the waste at the site were not identified during work. From design perspective, such requirements relate to being able to identify the canisters’ identification markings. Document inspections are not related to the scope of this work, which is on the design of the National Facility.

4.2 Storage of nuclear waste

As for storage of radioactive waste, there will most probably be a short-term storage phase before disposal at the site. This is assumed to be limited from a few hours to several months, depending on the disposal methodology. The disposal operations can be designed for a stepwise process, in which a certain amount of waste is gathered first on site and disposal is carried out as campaigns. Another option is that the waste can be transferred to disposal right after admitting it on site, which limits the holding time at the site as short as possible. The design of operational phase processes will define the exact need for storage. When storage is discussed in requirements, it usually refers to situations such as interim storage for spent fuel, where storage duration is substantially longer (years/tens of years). Requirements related only to those kinds of storages are excluded from the table, but any relating to short holding at the site are included. It is to be noted that safeguards are a strong regulating body that confine the storage phases.

4.3 Safeguards

Any programme needs to consider nuclear material safeguards. A recent IAEA publication was developed to assist facility designers and operators in considering at an early stage the safeguards activities relevant to particular nuclear fuel cycle facility types (IAEA, 2018). Safeguards should be considered early in the design process to minimise the risk of impacts on scope, schedule or budget, and to facilitate better integration with other design considerations such as those relating to operations including retrievability actions as well as safety and security. An international status of safeguards approaches is compiled in Mongiello et al. (2013). From Norwegian regulations, it is a requirement that the licence holder must provide appropriate arrangements for material accounting.

4.4 Reversibility and retrievability

Regarding retrievability, there is no general requirement from the IAEA that the waste should be retrievable, but it is acknowledged that in some cases this may be required or at least discussed. Including the option for reversing the disposal or retrieving the waste after facility closure is not, however, allowed to jeopardise the long-term safety of disposal (cf. SSR-5 (IAEA 2011), paragraph 1.25). By definition, disposal is meant to be final.

Even though there is currently no requirement for retrievability in Norway, it is possible that such a requirement is formulated at some later date. In Finland, retrievability was originally not required and not a design goal, and it became only later necessary to investigate the possibilities to retrieve the spent nuclear fuel (Saanio & Raiko, 1999). On the basis of the plans produced, retrieval of the spent fuel canisters from the repository to ground level was concluded to be possible at every stage of the project. The plan for the repository facilities contained features that made it easier to subsequently retrieve the canisters. The spent fuel is encapsulated in massive copper-iron canisters that are mechanically strong and very long-lasting. The repository facilities will be constructed by excavation into rock, which, according to experience, makes them very long-lasting, and the subsequent opening of the facilities is technically possible (Saanio & Raiko, 1999; Saanio et al., 2013, Section 5.4). These conclusions apply to the KBS-3V concept with short, vertical deposition holes for the canisters.

Reversibility and retrievability was studied considering three different phases: (1) before the closure of the deposition hole, (2) after closure of the deposition tunnel and (3) after closure of all facilities. If required, it is technically possible to retrieve the canisters to the ground level even after the underground disposal facility has been closed. For more detailed plans for this, see Saanio & Raiko (1999) and Saanio et al. (2013, Section 5.4).

In Finland, the Government's decision-in-principle of 21 December 2000 applying to Posiva's disposal project requires, in accordance with the Government's decision 478/1999, that *"…disposal must be designed so that ensuring long-term safety does not require monitoring of the repository site and that the repository can be opened if made appropriate by developing technology."* In accordance with the decision-in-principle, opening the repository means that the retrievability of the canisters from the repository facilities must be technically possible with reasonable resources for so long enough, however, that long-term safety is not compromised (Posiva, 2010, p. 274).

In the construction licence granted to Posiva Oy, there is a licence term stating that Posiva shall deliver an account of the retrievability of the spent nuclear fuel, updated in the context of the operating licence application (Finnish Government 2015). Finnish Radiation and Nuclear Safety Authority (STUK) has stated that facilitation of retrievability may not impair the long-term safety, in their evaluation on Posiva's pre-construction licence application and Posiva's nuclear waste programme 2009 (Posiva, 2010), in a statement to TEM issued on 5th October, 2010. *Reversibility*, i.e. possibility to return the waste to ground surface before the facilities have been closed, is, however, specifically mentioned in STUK's guide YVL D.5, which states that:

- Facilitation of reversibility of waste packages from the emplacement rooms for safety reasons shall be provided for the operating stage of the disposal facility.

- The disposal shall be designed so that the facilitation of reversibility does not compromise long-term safety.

- Reversibility shall not compromise operational safety or long-term safety of other waste disposed of (STUK, 2018, Section 5.5).

5 Conclusions

5.1 Overall conclusions

The Norwegian regulations applying to disposal facilities are currently at a very general level, and there are no specific requirements for the design of disposal facilities or the desired properties of disposal sites. The general requirements for nuclear installations apply, however, also to disposal facilities. Whenever there is an applicable requirement in the Norwegian legislations, it is prioritised in the table over the international requirements. For example, dose limits are mentioned in Norwegian regulations and, therefore, no dose limits or dose constraints given in international documents are listed in the table, although they are referenced in the last column in the context of the equivalent Norwegian regulations.

Organising the requirements in a rough order of priority, i.e. starting with Norwegian regulations, is only one possible way to present the requirements. The requirements could also be shown according to repository type. This can easily be done by using the Filter function. In the future, it may be useful to separate the requirements applying to the different repositories to individual files or sheets, after which it is also possible to re-arrange the requirements based on topic. In this way, similar requirements would be grouped, and repetition would be easier to reduce.

At some point, it is recommended that NND would establish a requirements management system. A requirements management system would help at various licensing stages to show how the regulatory requirements are fulfilled. The requirements in the Excel file would then be directly usable as the highest level of requirements, under which it is possible to formulate lower levels of requirements by NND. A hierarchical requirements management system would allow the long-term safety issues to be followed from the highest-level regulatory requirements all the way to the design solutions.

A requirements management system (for example, see Posiva, 2012a) is also a useful tool in post-closure safety assessment. Long-term safety can be evaluated by studying the fulfilment of safety requirements defined for repository barriers (cf. Posiva, 2013). The initial state of the disposal system would be defined based on lower-level design requirements (cf. Posiva, 2012b) and would form a starting point for the modelling of the repository evolution (Posiva, 2013).

Regulatory requirements are often updated and changed, and new documents replace earlier documents, whereby some requirements in the table become obsolete. It is important to keep the table up to date also in the future.

5.2 The most relevant requirements for the current phase

There are more than 600 requirements in the table, and not all of them are necessary to consider explicitly at the current phase of NND’s National Facility project. Many of them apply to the procedures and features of the disposal facility that have been considered in the current conceptual design at a general level and can be designed in detail at a later stage. Thereby, these requirements will not have a direct effect on the current design phase. Also, many requirements apply to safety assessments and safety cases, which will be carried out at a later stage. In the generic safety assessment started in 2021, the general requirements for safety assessments will be considered.

On the other hand, many high-level, general requirements have already been taken into account in the definition of the overall waste management strategy, for example, the selection of geological disposal for high-level radioactive waste and the decision to dispose of all the waste within Norway. What is, however, not yet done and what is, therefore, considered the most important issues for the current phase are planning of a site investigation strategy, setting up of a Quality Management System and related procedures and plans, as well as further development work (e.g. of the design basis).

The requirements that are considered to be the most relevant for *the current phase* of the National Facility project are proposed in Table 5-1. Note that site selection related requirements are not included in the table, as there are about 50 requirements in the Excel file related to the site and since these are already indicated by the word “site” in column F of the Excel table. These site-related requirements should be taken into account in developing the site investigation strategy and the related detailed plans.

Table 5-1. Requirements considered to be the most relevant for the current phase of the National Facility project, excluding site selection related requirements. All regulations, including the quoted ones, are listed at the end of this note.

Document Section/ paragraph	Requirement	Comments
Strålevernforskriften/Regulation on Radiation Protection and Use of Radiation (FOR-2016-12-16-1659)		
Section 30	The undertaking shall classify the workplace as a controlled area if a) employees may be exposed to effective doses above 6 mSv per year, b) equivalent dose to the skin and extremities may exceed 150 mSv per year, or c) equivalent dose to the lens of the eye may exceed 15 mSv per year.	The general design of controlled and supervised areas is assumed relevant at this stage (detailed requirements not included here).
Section 30	The undertaking shall classify the workplace as a supervised area if employees may be exposed to effective doses in excess of 1 mSv per year, or equivalent dose to the skin and extremities may exceed 50 mSv per year.	See above.
Section 30	The undertaking shall ensure that exposed employees outside controlled and supervised area cannot be exposed to radiation doses exceeding 1 mSv per year.	See above.
Section 30	The controlled area shall be physically delimited. If physical delimitation is not possible, it shall be clearly marked by other means.	See above,
Regulation on physical protection of nuclear material and nuclear installations (FOR-1984-11-02-1809)		
Section 14	Class I nuclear material can only be used or stored within a vital area.	Needs to be clarified in terms of the National Facility.
Section 14	Class II nuclear material may be used or stored within a vital or protected area.	See above.
Section 14	Class III nuclear material may be used or stored within a vital, protected or controlled area.	See above.
StrålevernHefte 2018:33/General terms for assessment of applications on license after nuclear energy act		
13.1	The holder shall have and update a waste management programme that documents handling, waste minimization, processing, transport, storage and safeguards of radioactive waste, nuclear waste and used nuclear fuel, including spent nuclear fuel and nuclear waste mixed with other dangerous substances.	Considered relevant in the near future, even though the requirement applies, strictly speaking, to a licence holder.
Avfallsforskriften/Regulation on recycling and treatment of waste (FOR-2004-06-01-930)		
Section 9-6	Only hazardous waste and waste that meets the pollution authority's criteria for disposal of hazardous waste are allowed to be deposited at hazardous waste landfills.	
Section 16-4	Radioactive waste should not be mixed with other waste and various types of radioactive waste should not be mixed if this can lead to a risk of contamination or cause problems for the further handling of the waste.	
Section 17-7	The operations manager shall prepare a waste management plan for minimizing, processing, recycling and disposal of mineral waste based on the principle of sustainable development. The purpose of the plan is to prevent or reduce waste production and its negative environmental consequences, to promote the use of mineral waste if this makes environmental sense and to ensure the safe disposal of mineral waste in the short and long term.	Assuming this refers to the waste to be disposed of in the National Facility (not waste produced during the National

Document Section/ paragraph	Requirement	Comments
		Facility operations).
Section 17-7	The waste management plan shall provide sufficient information so that it is possible for the pollution authority to assess the ability of the operations manager to achieve the objectives of the waste management plan and the obligations in accordance with this chapter. In particular, the plan will explain how the chosen method used for mineral extraction and treatment reduces waste production and its environmental consequences.	See above.
Section 17-7	The waste management plan shall contain at least the following: a) a characterization of the mineral waste in accordance with Annex II to this chapter b) a description of how the environment and human health can be harmed by the disposal of mineral waste c) proposed measures to minimize environmental impact, including measures to prevent water quality deterioration and to prevent or minimize air pollution d) suggestions for monitoring and control procedures e) proposed plan for termination, including rehabilitation f) relevant, proposed plan for post-operation and proposed procedures for monitoring and control after termination.	See above.
INFCIRC/546 (24 December 1997): Joint Convention on the Safety of Spent Fuel Management and Safety of Radioactive Waste Management		
Article 11(i)	Each Contracting Party shall take the appropriate steps to: (i) ensure that criticality and removal of residual heat generated during radioactive waste management are adequately addressed.	
Article 14(iii)	Each Contracting Party shall take the appropriate steps to ensure that: (iii) at the design stage, technical provisions for the closure of a disposal facility are prepared.	
Article 14(iv)	Each Contracting Party shall take the appropriate steps to ensure that: (iv) the technologies incorporated in the design and construction of a radioactive waste management facility are supported by experience, testing or analysis.	Additional analysis needed for the deep borehole concept before it can be selected.
SF-1 (IAEA 2006): Fundamental Safety Principles		
3.12	Effective leadership and management for safety must be established and sustained in organizations concerned with, and facilities and activities that give rise to, radiation risks.	
SSR-5 (IAEA 2011): Disposal of Radioactive Waste		
Requirement 25	Management systems to provide for the assurance of quality shall be applied to all safety related activities, systems and components throughout all the steps of the development and operation of a disposal facility. The level of assurance for each element shall be commensurate with its importance to safety.	
SSG-1 (IAEA 2009): Borehole Disposal Facilities for Radioactive Waste		
4.18	The operator should be responsible for conducting or commissioning the research and development needed to support the feasibility and safety of the facility design. This should include site investigations. The operator also has the responsibility for carrying out or commissioning all the investigations of sites and materials necessary to assess their suitability and to provide data for safety assessments. In the case of borehole disposal facilities, it is envisaged that the designs will rely almost entirely on tried and tested materials and working practices. This will largely confine research to desk studies and will shift the emphasis of the work towards demonstrations of the operability of the design and the suitability of the site.	A similar requirement applying to all repository types is in SSR-5 (IAEA 2011), paragraph 3.13.

Document Section/ paragraph	Requirement	Comments
ICRP Publication 81 (1998): Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste		
67(b)	A comprehensive system of quality assurance should ensure that the repository system is constructed as planned and designed.	
ICRP Publication 122 (2013): Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste		
68	The design basis considers a range of incidents, accidents, and natural events, and attempts to ensure that these events are prevented if possible and/or consequences are mitigated.	Design basis work has been partially started in the current project.
87	The general implementation of the Commission's recommendations on the disposal of radioactive waste requires that organisational and managerial structures and processes are put into place, and that technical principles are applied. Organisational structures and processes can differ between countries, but should be based on the principles laid down by the International Atomic Energy Agency in its fundamental safety principles and safety standards on management systems [SF-1 (IAEA 2006), GS-G-3.4 (IAEA 2008)].	
88, 89	The Commission recommends that management principles and requirements should be applied to the disposal system development and implementation process to enhance confidence that the protection of humans and the environment will be ensured for as long as needed. This requires the implementation of a management system that integrates safety, health, environmental, security, quality, and economic elements, with safety being the fundamental principle upon which the management system is based [NEA No. 6182 (OECD/NEA 2007), NEA/RWM/RF(2009)1 (OECD/NEA 2010)].	

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7 List of regulations and other documents used in the table

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Strålevernforskriften (FOR-2016-12-16-1659)	Forskrift om strålevern og bruk av stråling / Regulation on Radiation Protection and Use of Radiation (Radiation Protection Regulations) https://lovdata.no/dokument/SF/forskrift/2016-12-16-1659 [Unauthorised translation as of 20 August 2017:] https://www2.dsa.no/publikasjon/radiation-protection-regulations.pdf
FOR-2010-11-01-1394	Forskrift om forurensningslovens anvendelse på radioaktiv forurensning og radioaktivt avfall / Regulation on the application of the Pollution Control Act to radioactive pollution and radioactive waste https://lovdata.no/dokument/SF/forskrift/2010-11-01-1394 English: https://www2.dsa.no/dav/2cdd099f28.pdf
Atomenergiloven (LOV-1972-05-12-28)	Lov om atomenergivirksomhet / Act concerning Nuclear Energy Activities [Revised 28 August 1995] https://lovdata.no/dokument/NL/lov/1972-05-12-28 English: https://app.uio.no/ub/ujur/oversatte-lover/data/lov-19720512-028-eng.pdf
FOR-1984-11-02-1809	Forskrift om fysisk beskyttelse av nukleært materiale og nukleære anlegg / Regulation on physical protection of nuclear material and nuclear installations https://lovdata.no/dokument/SF/forskrift/1984-11-02-1809
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The Nature and Purpose of the Post-Closure Safety Cases for Geological Repositories
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ISBN 92-64-18498-8 / EUR 19964 EN (OECD/NEA 2003)	Engineered Barrier Systems and the Safety of Deep Geological Repositories: State-of-the-art Report https://www.oecd-nea.org/jcms/pl_13634/engineered-barrier-systems-and-the-safety-of-deep-geological-repositories
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OECD/NEA 1995	The Environmental and Ethical Basis of Geological Disposal: A Collective Opinion of the Radioactive Waste Management Committee of the OECD Nuclear Energy Agency https://www.oecd-nea.org/upload/docs/application/pdf/2020-07/geological-disposal.pdf

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Document reference	Document title (with link)	Section/ paragraph number	Requirement in Norwegian	Requirement in English	Relevant repository types	Intermed	DGR	Borehole	Landfill	Design solution fulfilling the requirement	Further references with a similar requirement
Strålevernloven (LOV-2000-05-12-36)	Lov om strålevern og bruk av stråling / Act on Radiation Protection and Use of Radiation (https://lovdata.no/dokument/NL/lov/2000-05-12-36/KAPITTEL_2#%C2%A79) (English: https://app.uio.no/ub/ujur/oversatte-lover/data/lov-20000512-036-eng.pdf)	Section 5, 8	Enhver tilvirkning, import, eksport, transport, overdragelse, besittelse, installasjon, bruk, håndtering og avfallsdisponering av strålekilder skal være forsvarlig, slik at det ikke oppstår risiko for dem som utøver virksomheten, andre personer eller miljøet.	All manufacture, import, export, transport, transfer, possession, installation, use, handling and waste disposal of radiation sources shall be performed properly to ensure that risks to those performing any such activity, to other persons or to the environment do not arise.	All	I	D	B	L	The design as a whole	FOR-2004-06-01-930, Section 16-1, 16-4 INFCIRC/546 (24 December 1997), Article 6(ii), 13(ii) SF-1 (IAEA 2006), 2, 3.27
Strålevernloven (LOV-2000-05-12-36)	Lov om strålevern og bruk av stråling / Act on Radiation Protection and Use of Radiation (https://lovdata.no/dokument/NL/lov/2000-05-12-36/KAPITTEL_2#%C2%A79) (English: https://app.uio.no/ub/ujur/oversatte-lover/data/lov-20000512-036-eng.pdf)	Section 7	I virksomhet som omfattes av loven, skal de ansatte og andre tilknyttede personer i nødvendig utstrekning ha utdanning eller opplæring, som sikrer at de har tilstrekkelige kvalifikasjoner eller kunnskap innen strålevern og sikker bruk av stråling.	In enterprises encompassed by this Act, the employees and other associated persons shall have such instruction or training as is necessary to ensure that they have sufficient qualifications or knowledge in the field of radiation protection and safe use of radiation.	All	I	D	B	L	General requirement, not directly related to facility design	Strålevernforskriften, Section 16, 18 StrålevernHefte 2018:33, 11.1 GSG-7 (IAEA 2018), 3.141–3.156 NEA/RWM/R(2013)9 (OECD/NEA 2014), p. 139–140 DGR, Intermediate Depth: SSG-14 (IAEA 2011), 6.84 Deep Borehole: SSG-1 (IAEA 2009), 4.19, 5.42 Landfill: SSG-29 (IAEA 2014), 6.51, 6.52
Strålevernforskriften (FOR-2016-12-16-1659)	Forskrift om strålevern og bruk av stråling / Regulation on Radiation Protection and Use of Radiation (Radiation Protection Regulations) (https://lovdata.no/dokument/SF/forskrift/2016-12-16-1659) [Unauthorised translation as of 20 August 2017:] (https://www2.dsa.no/publikasjon/radiation-protection-regulations.pdf)	Section 6	Effektiv dose til allmennhet og ikke-yrkeseksponerte arbeidstakere skal ikke overstige 1 mSv/år for ioniserende stråling. Ekvivalent dose til øyelinse skal ikke overstige 15 mSv/år. Ekvivalent dose til hud skal ikke overstige 50 mSv/år, målt eller beregnet over et vilkårlig hudareal på 1 cm².	The effective dose to the public and non-occupationally exposed workers shall not exceed 1 mSv/year for ionising radiation. Equivalent dose to the lens of the eye shall not exceed 15 mSv/year. Equivalent dose to the skin shall not exceed 50 mSv/year, measured or calculated over any skin area of 1 cm².	All	I	D	B	L	The design as a whole	SSR-5 (IAEA 2011), 2.15(a) GSG-7 (IAEA 2018), 2.12–2.14 GSG-8 (IAEA 2018), 2.30–2.32, 3.49–3.54 ICRP Publication 26 (1977), 103, 119, 120, 130 ICRP Publication 46 (1985), 42 ICRP Publication 77 (1997), Section 5.2, 5.3, 6.1, 6.2 ICRP Publication 103 (2007), Section 5.10, 6.1 DGR, Deep Borehole, Intermediate Depth: ICRP Publication 122 (2013), 44, 49
Strålevernforskriften (FOR-2016-12-16-1659)	Forskrift om strålevern og bruk av stråling / Regulation on Radiation Protection and Use of Radiation (Radiation Protection Regulations) (https://lovdata.no/dokument/SF/forskrift/2016-12-16-1659) [Unauthorised translation as of 20 August 2017:] (https://www2.dsa.no/publikasjon/radiation-protection-regulations.pdf)	Section 6	Virksomheten skal planlegge strålingen og skjermingstiltakene slik at ikke-yrkeseksponerte arbeidstakere og allmennhet ikke eksponeres for en effektiv dose som overstiger 0,25 mSv/år.	The undertaking shall plan the use of radiation and protective measures to ensure that exposure of the non-occupationally exposed workers and the public, shall not be exposed to an effective dose exceeding 0.25 mSv/year.	All	I	D	B	L	The design as a whole. Exposure of operating personnel, limiting the radiation exposure of personnel (Ikonen et al. 2020, Section 2.2.1). Radiation protection (Ikonen et al. 2020, Sections 6.2.5, 7.1.1, 7.2.5, 8.2.4, 9.2.5). Operational safety during handling and storage of the waste and waste packages. Sufficient ventilation, use of protective eyewear, clothing and respirators, etc.	cf. SSR-5 (IAEA 2011), 2.15(b) GSG-7 (IAEA 2018), 3.28–3.48 ICRP Publication 26 (1977), 103 ICRP Publication 81 (1998), 55, 63, 64 ICRP Publication 103 (2007), Section 5.10, 6.1
Strålevernforskriften (FOR-2016-12-16-1659)	Forskrift om strålevern og bruk av stråling / Regulation on Radiation Protection and Use of Radiation (Radiation Protection Regulations) (https://lovdata.no/dokument/SF/forskrift/2016-12-16-1659) [Unauthorised translation as of 20 August 2017:] (https://www2.dsa.no/publikasjon/radiation-protection-regulations.pdf)	Section 7, 30, 33	Redningsarbeid i nødssituasjoner skal så langt som mulig utføres innenfor dosegrensene i § 32 første ledd bokstavene a) til c). Arbeid som kan medføre effektive doser som overstiger 50 mSv, skal bare utføres av frivillige som er tilstrekkelig informert om aktuell strålerisiko og de faremomenter dette innebærer. Gravide kvinner skal ikke delta. Overskridelse av grensen kan bare aksepteres for å redde liv, unngå alvorlig helseskade eller forhindre en omfattende oppskalering av ulykken. Effektive doser over 500 mSv skal så langt som mulig unngås. Bestemmelsene i § 30 og § 33 gjelder tilsvarende.	Rescue work in emergency situations shall as far as possible be carried out within the dose limits mentioned in section 32, subsection one, paragraph a) to c). Work that may result in effective doses exceeding of 50 mSv, shall be carried out by volunteers only being adequately informed about the actual risks and dangers involved. Exceeding this limit will only be acceptable to save lives, avoid serious damage to health or prevent a dramatic escalation of the accident. Effective doses above 500 mSv shall as far as possible be avoided. The provisions of Section 30 and § 33 apply accordingly.	All	I	D	B	L	General requirement, not directly related to facility design. Operational safety issue.	GSR Part 3 (IAEA 2014), Req. 45 GSG-7 (IAEA 2018), 4.1–4.32, 7.228–7.243 GSG-8 (IAEA 2018), 3.55–3.76 ICRP Publication 26 (1977), 113, 114 ICRP Publication 103 (2007), Section 6.2 DGR, Deep Borehole, Intermediate Depth: ICRP Publication 122 (2013), 60
Strålevernforskriften (FOR-2016-12-16-1659)	Forskrift om strålevern og bruk av stråling / Regulation on Radiation Protection and Use of Radiation (Radiation Protection Regulations) (https://lovdata.no/dokument/SF/forskrift/2016-12-16-1659) [Unauthorised translation as of 20 August 2017:] (https://www2.dsa.no/publikasjon/radiation-protection-regulations.pdf)	Section 14	Radioaktive strålekilder som er kasserte og som ikke kan returneres til opprinnelseslandet, skal deponeres i Norge og håndteres i henhold til forskrift 1. juni 2004 nr. 930 om gjenvinning og behandling av avfall kapittel 16.	Disused radioactive sources not returned to the country of origin shall be disposed of in Norway and handled according to regulation of 1 June 2004 no 930, regarding recycling and treatment of waste, chapter 16.	All	I	D	B	L	General requirement, not directly related to facility design	
Strålevernforskriften (FOR-2016-12-16-1659)	Forskrift om strålevern og bruk av stråling / Regulation on Radiation Protection and Use of Radiation (Radiation Protection Regulations) (https://lovdata.no/dokument/SF/forskrift/2016-12-16-1659) [Unauthorised translation as of 20 August 2017:] (https://www2.dsa.no/publikasjon/radiation-protection-regulations.pdf)	Section 15, 21	Virksomheten skal til enhver tid ha kontroll over strålekildene.	At all time, the undertaking shall have control of the radiation sources.	All	I	D	B	L	General requirement, not directly related to facility design	
Strålevernforskriften (FOR-2016-12-16-1659)	Forskrift om strålevern og bruk av stråling / Regulation on Radiation Protection and Use of Radiation (Radiation Protection Regulations) (https://lovdata.no/dokument/SF/forskrift/2016-12-16-1659) [Unauthorised translation as of 20 August 2017:] (https://www2.dsa.no/publikasjon/radiation-protection-regulations.pdf)	Section 16	Virksomheten skal utarbeide skriftlige instrukser og arbeidsprosedyrer som sørger for et forsvarlig strålevern. Disse skal bidra til å forhindre at personer eksponeres for nivåer som overskrider dosegrenser eller grenseverdier etter forskriften, gjeldende standarder eller internasjonale retningslinjer.	The undertaking shall prepare instructions and work procedures in writing that ensures proper radiation protection. These shall contribute to prevent exposure of persons to levels that exceed dose limits or limit values pursuant to these regulations, applicable standards or international guidelines.	All	I	D	B	L	General requirement, not directly related to facility design. Radiation protection (Ikonen et al. 2020, Sections 6.2.5, 7.1.1, 7.2.5, 8.2.4, 9.2.5). Adequate instructions shall be in place for the operation, maintenance, periodic inspections and tests of the plans (Ikonen et al. 2020, Section 2.2.1).	

Strålevernforskriften (FOR-2016-12-16-1659)	Forskrift om strålevern og bruk av stråling / Regulation on Radiation Protection and Use of Radiation (Radiation Protection Regulations) (https://lovdata.no/dokument/SF/forskrift/2016-12-16-1659) [Unauthorised translation as of 20 August 2017:] (https://www2.dsa.no/publikasjon/radiation-protection-regulations.pdf)	Section 17	Virksomheter som er underlagt godkjenningsplikt etter § 9 eller § 10 eller meldeplikt etter § 13, skal ha et system som ivaretar strålevern.	Undertakings, subject to authorization under section 9 or 10 or registration under section 13, shall have a radiation protection system.	All	I	D	B	L	General requirement, not directly related to facility design. Radiation protection (Ikonen et al. 2020, Sections 6.2.5, 7.1.1, 7.2.5, 8.2.4, 9.2.5).	
Strålevernforskriften (FOR-2016-12-16-1659)	Forskrift om strålevern og bruk av stråling / Regulation on Radiation Protection and Use of Radiation (Radiation Protection Regulations) (https://lovdata.no/dokument/SF/forskrift/2016-12-16-1659) [Unauthorised translation as of 20 August 2017:] (https://www2.dsa.no/publikasjon/radiation-protection-regulations.pdf)	Section 18	Virksomheter som planlegger å bruke eller håndtere strålekilder, skal utarbeide en skriftlig risikovurdering knyttet til strålebruken. Nye aktiviteter med strålekilder skal ikke settes i gang før risikovurderingen er gjennomført og nødvendige forebyggende tiltak er iverksatt.	Undertakings, planning to use or handle radiation sources, shall prepare a written risk assessment related to the use of radiation. New activities involving radiation sources shall not start before the risk assessment is completed and necessary preventive measures implemented.	All	I	D	B	L	General requirement, not directly related to facility design. Operational safety issue.	
Strålevernforskriften (FOR-2016-12-16-1659)	Forskrift om strålevern og bruk av stråling / Regulation on Radiation Protection and Use of Radiation (Radiation Protection Regulations) (https://lovdata.no/dokument/SF/forskrift/2016-12-16-1659) [Unauthorised translation as of 20 August 2017:] (https://www2.dsa.no/publikasjon/radiation-protection-regulations.pdf)	Section 19	Virksomheten skal, på grunnlag av en risikovurdering, utarbeide en beredskapsplan og gjennomføre tiltak for å opprettholde evnen til å håndtere ulykker og unormale hendelser.	Based on a risk assessment, the undertaking shall prepare an emergency preparedness plan and implement measures that maintain the ability to handle accidents and abnormal events.	All	I	D	B	L	General requirement, not directly related to facility design (emergency-related systems are, however, included in the conceptual design, e.g. Ikonen et al. 2020, Section 6.1.2, 6.2.6). Impacts caused by probable natural phenomena and other events external to the facility shall be considered in the design of the repository (Ikonen et al. 2020, Section 2.2.1).	Strålevernloven (LOV-2000-05-12-36), Section 16 LOV-1981-03-13-6, Section 40 INFCIRC/546 (24 December 1997), Article 25 SF-1 (IAEA 2006), 3.34–3.38 GSR Part 3 (IAEA 2014), 3.43 GSR Part 7 (IAEA 2015) DGR, Deep Borehole (spent fuel storage): SSG-15 (Rev. 1) (IAEA 2020), 6.73–6.74
Strålevernforskriften (FOR-2016-12-16-1659)	Forskrift om strålevern og bruk av stråling / Regulation on Radiation Protection and Use of Radiation (Radiation Protection Regulations) (https://lovdata.no/dokument/SF/forskrift/2016-12-16-1659) [Unauthorised translation as of 20 August 2017:] (https://www2.dsa.no/publikasjon/radiation-protection-regulations.pdf)	Section 25	Virksomheten er ansvarlig for at radioaktive strålekilder oppbevares forsvarlig. Dette innebærer blant annet at a) oppbevaring av åpne radioaktive strålekilder skal begrenses til et minimum, b) det på oppbevaringsplassen skal foreligge en oversikt over strålekildene, c) oppbevaringsplassen skal være sikret mot adgang fra uvedkommende, d) oppbevaringsplassen skal være merket med fareskilt som advarer mot risiko og fare for ioniserende stråling i henhold til forskrift 6. desember 2011 nr. 1356 om utforming og innretning av arbeidsplasser og arbeidslokaler, e) doseraten utenfor oppbevaringsplassen ikke skal overstige 7,5 µSv/t, og f) radioaktive strålekilder ikke skal oppbevares sammen med eksplosiver, sterkt brennbare stoffer eller i korrosivt miljø.	The undertaking is responsible for safe and proper storage of radioactive sources. This entails inter alia that a) storage of open radioactive radiation sources shall be limited to a minimum, b) at the storage site, an available inventory outline of the radiation sources, c) the storage site shall be secured against access by unauthorised persons, d) the storage site shall be marked with an ionising radiation warning sign in compliance with regulations of 6 December 2011 no. 1356 relating to the workplace, e) the dose rate outside the storage site shall not exceed 7.5 µSv/h, and f) radioactive sources shall not be stored together with explosives, highly flammable substances or in a corrosive environment.	All (storage at National Facility site before disposal)	I	D	B	L	Storage (Ikonen et al. 2020, Section 5.7, Ch. 3, Figure 5-5). Intermediate Depth, DGR: Storage, waste reception building (Ikonen et al. 2020, Section 5.7, Ch. 3, Figures 5-4, 5-5); Storage of canisters (DGR) (Ikonen et al. 2020, Section 7.1.1, Figures 7-1, 7-2). Deep Borehole: Storage location for waste (Fischer et al. 2020, Section 4.2.4). Landfill: Container laydown area option (Ikonen et al. 2020, Figure 5-5, Section 5.7), temporary storage area for waste packages (Ikonen et al. 2020, Table 9-5).	
Strålevernforskriften (FOR-2016-12-16-1659)	Forskrift om strålevern og bruk av stråling / Regulation on Radiation Protection and Use of Radiation (Radiation Protection Regulations) (https://lovdata.no/dokument/SF/forskrift/2016-12-16-1659) [Unauthorised translation as of 20 August 2017:] (https://www2.dsa.no/publikasjon/radiation-protection-regulations.pdf)	Section 26	Virksomheten skal sørge for at strålesikring og annet sikkerhetsutstyr, som personlig verneutstyr og tekniske sikkerhetssystemer, finnes der det er påkrevd eller anses som nødvendig.	The undertaking shall ensure that radiation shielding and other safety equipment, such as personal protective equipment and technical safety systems, is available where necessary.	All	I	D	B	L	Structures, systems and equipment containing significant amounts of radioactive substances shall be placed in separate rooms or shielded effectively. Adequate safety margins shall be incorporated in the design of radiation shielding (Ikonen et al. 2020, Section 2.2.1). DGR: During transfer, the canister is covered with a radiation shield (Ikonen et al. 2020, Section 7.1.2). Deep Borehole: Remote handling techniques are used, as during the disposal procedure the canisters are unshielded (Ikonen et al. 2020, Section 8.2.7).	
Strålevernforskriften (FOR-2016-12-16-1659)	Forskrift om strålevern og bruk av stråling / Regulation on Radiation Protection and Use of Radiation (Radiation Protection Regulations) (https://lovdata.no/dokument/SF/forskrift/2016-12-16-1659) [Unauthorised translation as of 20 August 2017:] (https://www2.dsa.no/publikasjon/radiation-protection-regulations.pdf)	Section 30	Virksomheten skal klassifisere arbeidsplassen som kontrollert område, dersom a) arbeidstakere kan utsettes for effektiv dose som overstiger 6 mSv per år, b) ekvivalent dose til huden og ekstremitetene kan overstige 150 mSv per år, eller c) ekvivalent dose til øyelinsen kan overstige 15 mSv per år.	The undertaking shall classify the workplace as a controlled area if a) employees may be exposed to effective doses above 6 mSv per year, b) equivalent dose to the skin and extremities may exceed 150 mSv per year, or c) equivalent dose to the lens of the eye may exceed 15 mSv per year.	All	I	D	B	L	Controlled and uncontrolled areas and phases (Ikonen et al. 2020, Section 6.2.4, 7.2.4, 9.2.4; Fischer et al. 2020, Section 5.3)	GSG-7 (IAEA 2018), 3.75–3.82 ICRP Publication 103 (2007), 184, 185
Strålevernforskriften (FOR-2016-12-16-1659)	Forskrift om strålevern og bruk av stråling / Regulation on Radiation Protection and Use of Radiation (Radiation Protection Regulations) (https://lovdata.no/dokument/SF/forskrift/2016-12-16-1659) [Unauthorised translation as of 20 August 2017:] (https://www2.dsa.no/publikasjon/radiation-protection-regulations.pdf)	Section 30	Virksomheten skal klassifisere arbeidsplassen som overvåket område, dersom a) arbeidstakere kan utsettes for effektiv dose som overstiger 1 mSv per år, eller b) ekvivalent dose til huden og ekstremitetene kan overstige 50 mSv per år.	The undertaking shall classify the workplace as a supervised area if employees may be exposed to effective doses in excess of 1mSv per year, or equivalent dose to the skin and extremities may exceed 50 mSv per year.	All	I	D	B	L	Controlled and uncontrolled areas and phases (Ikonen et al. 2020, Section 6.2.4, 7.2.4, 9.2.4; Fischer et al. 2020, Section 5.3)	GSG-7 (IAEA 2018), 3.75, 3.83–3.86 ICRP Publication 103 (2007), 184
Strålevernforskriften (FOR-2016-12-16-1659)	Forskrift om strålevern og bruk av stråling / Regulation on Radiation Protection and Use of Radiation (Radiation Protection Regulations) (https://lovdata.no/dokument/SF/forskrift/2016-12-16-1659) [Unauthorised translation as of 20 August 2017:] (https://www2.dsa.no/publikasjon/radiation-protection-regulations.pdf)	Section 30	Virksomheten skal sørge for at arbeidstakere utenfor kontrollert og overvåket område ikke kan utsettes for effektiv dose som overstiger 1 mSv per år.	The undertaking shall ensure that exposed employees outside controlled and supervised area cannot be exposed to radiation doses exceeding 1 mSv per year.	All	I	D	B	L	Controlled and uncontrolled areas and phases (Ikonen et al. 2020, Section 6.2.4, 7.2.4, 9.2.4; Fischer et al. 2020, Section 5.3). Radiation protection (Ikonen et al. 2020, Sections 6.2.5, 7.1.1, 7.2.5, 8.2.4, 9.2.5).	
Strålevernforskriften (FOR-2016-12-16-1659)	Forskrift om strålevern og bruk av stråling / Regulation on Radiation Protection and Use of Radiation (Radiation Protection Regulations) (https://lovdata.no/dokument/SF/forskrift/2016-12-16-1659) [Unauthorised translation as of 20 August 2017:] (https://www2.dsa.no/publikasjon/radiation-protection-regulations.pdf)	Section 30	Kontrollert område skal være fysisk avgrenset, eller tydelig merket der hvor fysisk avgrensning ikke er mulig.	The controlled area shall be physically delimited. If physical delimitation is not possible, it shall be clearly marked by other means.	All	I	D	B	L	Controlled and uncontrolled areas and phases (Ikonen et al. 2020, Section 6.2.4, 7.2.4, 9.2.4; Fischer et al. 2020, Section 5.3)	GSG-7 (IAEA 2018), 3.81

Strålevernforskriften (FOR-2016-12-16-1659)	Forskrift om strålevern og bruk av stråling / Regulation on Radiation Protection and Use of Radiation (Radiation Protection Regulations) (https://lovdata.no/dokument/SF/forskrift/2016-12-16-1659) [Unauthorised translation as of 20 August 2017:] (https://www2.dsa.no/publikasjon/radiation-protection-regulations.pdf)	Section 30	Kontrollert og overvåket område skal merkes med skilt som opplyser om at dette er et kontrollert eller overvåket område. For øvrig skal arbeidsplassen være merket med fareskilt som advarer mot risiko og fare for ioniserende stråling i henhold til forskrift 6. desember 2011 nr. 1356 om utforming og innretning av arbeidsplasser og arbeidslokaler.	Controlled and supervised area shall be marked with a sign showing that it is a controlled or supervised area. Additionally, the workplace shall be marked with a warning sign against risk of danger for ionising radiation according to regulations of 6 December 2011 no. 1356 relating to the layout and arrangements in the workplace and work premises.	All	I	D	B	L	Controlled and uncontrolled areas and phases (Ikonen et al. 2020, Section 6.2.4, 7.2.4, 9.2.4; Fischer et al. 2020, Section 5.3)	GSG-7 (IAEA 2018), 3.80, 3.86
Strålevernforskriften (FOR-2016-12-16-1659)	Forskrift om strålevern og bruk av stråling / Regulation on Radiation Protection and Use of Radiation (Radiation Protection Regulations) (https://lovdata.no/dokument/SF/forskrift/2016-12-16-1659) [Unauthorised translation as of 20 August 2017:] (https://www2.dsa.no/publikasjon/radiation-protection-regulations.pdf)	Section 31	Virksomheten skal sørge for at yrkeseksponerte arbeidstakere inndeles i to kategorier: a) Kategori A: yrkeseksponerte arbeidstakere som kan utsettes for - en effektiv dose over 6 mSv per år, - en ekvivalent dose over 150 mSv per år til huden og ekstremitetene, eller - en ekvivalent dose over 15 mSv per år til øyelinsen. b) Kategori B: yrkeseksponerte arbeidstakere som ikke klassifiseres i kategori A. Virksomheten skal inndele den enkelte arbeidstaker i kategori A eller B før arbeid som kan medføre eksponering starter. Ved inndelingen skal det tas hensyn til potensiell eksponering.	The undertaking shall ensure classification of exposed workers in two categories: a. Category A: exposed worker who might be exposed to: – an effective dose above 6 mSv/year – an equivalent dose above 150 mSv/year to the skin and extremities, or – an equivalent dose above 15 mSv/year to the lens of the eye b. Category B: exposed workers not classified as category A. The undertaking shall classify each worker in category A or B before work involving exposure starts. In the categorisation, potential exposure shall be taken into account.	All	I	D	B	L	General requirement, not directly related to facility design. Operational safety issue.	
Strålevernforskriften (FOR-2016-12-16-1659)	Forskrift om strålevern og bruk av stråling / Regulation on Radiation Protection and Use of Radiation (Radiation Protection Regulations) (https://lovdata.no/dokument/SF/forskrift/2016-12-16-1659) [Unauthorised translation as of 20 August 2017:] (https://www2.dsa.no/publikasjon/radiation-protection-regulations.pdf)	Section 32	Virksomheten skal sørge for at all stråleeksponering holdes så lav som praktisk mulig, og at følgende dosegrenser ikke overskrides: a) Effektiv dose for yrkeseksponerte arbeidstakere, lærlinger og studenter over 18 år skal ikke overstige 20 mSv per år. Direktoratet for strålevern og atomsikkerhet kan gi dispensasjon for enkeltpersoner, der det av hensyn til arbeidets art ikke er praktisk mulig å fastsette en årlig grense på 20 mSv. Det kan i slike tilfeller gis tillatelse til å praktisere en grense på 100 mSv over en sammenhengende periode på fem år, under forutsetning av at dosen ikke overstiger 50 mSv i noe enkelt år. b) Ekvivalent dose til øyelinsen for yrkeseksponerte arbeidstakere, lærlinger og studenter over 18 år skal ikke overstige 20 mSv per år, eller 100 mSv for en sammenhengende periode på fem år så lenge dosen i et enkelt år ikke overstiger 50 mSv. c) Ekvivalent dose til huden for yrkeseksponerte arbeidstakere, lærlinger og studenter over 18 år skal ikke overstige 500 mSv per år. Dosegrensen gjelder for middelverdien av dosen målt eller beregnet over et vilkårlig hudareal på 1 cm². Ekvivalent dose for ekstremitetene skal ikke overstige 500 mSv per år. d) Ekvivalent dose til fosteret for gravide yrkeseksponerte arbeidstakere, lærlinger og studenter skal ikke overstige 1 mSv for den resterende delen av svangerskapet, dvs. etter at graviditet er kjent.	The undertaking shall ensure that all radiation exposure is as low as practically achievable and the following dose limits applies: a) The effective dose for exposed workers, apprentices and students over the age of 18 shall not exceed 20 mSv per year. The Norwegian Radiation Protection Authority may grant dispensation for individuals, where in consideration of the nature of the work, it is not practically possible to establish an annual limit of 20 mSv. In such cases, a permit to practise a limit of 100 mSv over a consecutive five-year period may be granted, if the dose do not exceed 50 mSv in any single year. b) The equivalent dose to the lens of the eye for exposed workers, apprentices and students over the age of 18 years, to the lens of the eye, shall not exceed 20 mSv per year, or 100 mSv over a consecutive five-year period, provided that the dose do not exceed 50 mSv in any single year. c) The equivalent dose to the skin for exposed workers, apprentices and students shall not exceed 500 mSv per year. The dose limit applies to the mean value of measured dose or calculated over any 1cm² skin area. Equivalent dose for extremities shall not exceed 500 mSv/year. d) Equivalent dose to the foetus for pregnant exposed workers, apprentices and students shall not exceed 1 mSv for the remainder of the pregnancy, i.e. after the pregnancy is known.	All	I	D	B	L	Exposure of operating personnel, limiting the radiation exposure of personnel (Ikonen et al. 2020, Section 2.2.1). Radiation protection (Ikonen et al. 2020, Sections 6.2.5, 7.1.1, 7.2.5, 8.2.4, 9.2.5).	
Strålevernforskriften (FOR-2016-12-16-1659)	Forskrift om strålevern og bruk av stråling / Regulation on Radiation Protection and Use of Radiation (Radiation Protection Regulations) (https://lovdata.no/dokument/SF/forskrift/2016-12-16-1659) [Unauthorised translation as of 20 August 2017:] (https://www2.dsa.no/publikasjon/radiation-protection-regulations.pdf)	Section 33	Virksomheten skal systematisk overvåke yrkeseksponerte i kategori A. Overvåkingen av effektiv dose skal være basert på individuelle målinger som utføres av en persondosimetritjeneste. Der dette ikke er praktisk mulig, skal individuell overvåking baseres på doseberegninger. I tilfeller hvor arbeidstakere kan bli eksponert for en vesentlig intern bestråling eller en vesentlig bestråling av øyelinsen eller ekstremitetene, skal det innføres et egnet overvåkingssystem.	The undertaking shall perform a systematic surveillance of exposed workers in category A. The surveillance of effective dose shall, be based on individual measurements from a personal dosimetry service. In cases, where individual measurements is practically impossible, individual surveillance shall, be based on dose calculations. In cases where workers can have a significant exposure via internal irradiation, or to the lens of the eye or extremities, a suitable surveillance system shall be established.	All	I	D	B	L	Surveillance and monitoring (Ikonen et al. 2020, Sections 5.2, 5-6, 5-7, Figures 5-4, 5-5). The purpose of radiation monitoring is to measure and monitor the activity of disposal facility air and the radiation doses received by personnel (Ikonen et al. 2020, Section 6.2.5).	GSG-7 (IAEA 2018), Chapter 7
FOR-2010-11-01-1394	Forskrift om forurensningslovens anvendelse på radioaktiv forurensning og radioaktivt avfall / Regulation on the application of the Pollution Control Act to radioactive pollution and radioactive waste (https://lovdata.no/dokument/SF/forskrift/2010-11-01-1394) (English: https://www2.dsa.no/dav/2cdd099f28.pdf)	Section 2(c)	(Definisjon:) radioaktivt avfall: løsøregjenstander eller stoffer som regnes som avfall etter forurensingsloven § 27 første ledd, og inneholder eller er forurenset med radioaktive stoffer med spesifikk aktivitet som er større eller lik verdiene angitt i vedlegg I bokstav a.	(Definition:) radioactive waste means objects of personal property or substances that are considered to be waste under the Pollution Control Act section 27 first paragraph and contain or are contaminated with radioactive substances with specific activity that exceeds or are equal to values listed in annex I letter a.	All	I	D	B	L	Definition, not a requirement (affects waste classification)	
FOR-2010-11-01-1394	Forskrift om forurensningslovens anvendelse på radioaktiv forurensning og radioaktivt avfall / Regulation on the application of the Pollution Control Act to radioactive pollution and radioactive waste (https://lovdata.no/dokument/SF/forskrift/2010-11-01-1394) (English: https://www2.dsa.no/dav/2cdd099f28.pdf)	Section 2(d)	(Definisjon:) deponeringspliktig radioaktivt avfall: radioaktivt avfall med større eller lik verdier for total aktivitet og spesifikk aktivitet enn angitt i vedlegg I bokstav b.	(Definition:) radioactive waste subject to a disposal requirement means radioactive waste with values that exceed or are equal to values for total activity and specific activity listed in annex I letter b.	DGR, Deep Borehole, Intermediate Depth	I	D	B		Definition, not a requirement (affects waste classification)	
Atomenergiloven (LOV-1972-05-12-28)	Lov om atomenergivirksomhet / Act concerning Nuclear Energy Activities [Revised 28 August 1995] (https://lovdata.no/dokument/NL/lov/1972-05-12-28) (English: https://app.uio.no/ub/ujur/oversatte-lover/data/lov-19720512-028-eng.pdf)	Section 4, 5, 7	Uten konsesjon av Kongen kan ingen oppføre, eie eller drive atomanlegg.	It shall be unlawful to construct, own or operate a nuclear installation without a licence granted by the King.	All	I	D	B	L	General requirement, not directly related to facility design	SF-1 (IAEA 2006), 3.4–3.7
Atomenergiloven (LOV-1972-05-12-28)	Lov om atomenergivirksomhet / Act concerning Nuclear Energy Activities [Revised 28 August 1995] (https://lovdata.no/dokument/NL/lov/1972-05-12-28) (English: https://app.uio.no/ub/ujur/oversatte-lover/data/lov-19720512-028-eng.pdf)	Section 11(2)	Før et atomanlegg settes i drift, skal innehaveren ha godkjenning til dette av Direktoratet for strålevern og atomsikkerhet.	Before a nuclear installation is put into operation, the operator must have obtained authorization for this from the Nuclear Energy Safety Authority.	All	I	D	B	L	General requirement, not directly related to facility design	
Atomenergiloven (LOV-1972-05-12-28)	Lov om atomenergivirksomhet / Act concerning Nuclear Energy Activities [Revised 28 August 1995] (https://lovdata.no/dokument/NL/lov/1972-05-12-28) (English: https://app.uio.no/ub/ujur/oversatte-lover/data/lov-19720512-028-eng.pdf)	Section 11(3)	I god tid før atomanlegget settes i drift, skal innehaveren legge frem for Direktoratet for strålevern og atomsikkerhet en fullstendig sikkerhetsrapport for anlegget.	In good time before the nuclear installation is put into operation the operator shall submit to the Nuclear Energy Safety Authority a complete safety report on the installation concerned.	All	I	D	B	L	General requirement, not directly related to facility design	

Atomenergiloven (LOV-1972-05-12-28)	Lov om atomenergivirksomhet / Act concerning Nuclear Energy Activities [Revised 28 August 1995] (https://lovdata.no/dokument/NL/lov/1972-05-12-28) (English: https://app.uio.no/ub/ujur/oversatte-lover/data/lov-19720512-028-eng.pdf)	Section 12	Dersom en innehaver akter å gjennomføre en endring i anleggets konstruksjon, drift eller ledelse som avviker fra det som lå til grunn for godkjenning etter § 11 punkt 2 og som kan ha betydning for sikkerheten, plikter han før endringen settes i verk å legge saken frem for Direktoratet for strålevern og atomsikkerhet til godkjenning.	If an operator proposes to make an alteration in the construction, operation or management of the installation which constitutes a departure from the conditions on the basis of which authorization was granted under Section 11, subsection 2 and which may affect safety, he must submit the matter to the Nuclear Energy Safety Authority for authorization before the alteration is put into effect.	All	I	D	B	L	General requirement, not directly related to facility design	
Atomenergiloven (LOV-1972-05-12-28)	Lov om atomenergivirksomhet / Act concerning Nuclear Energy Activities [Revised 28 August 1995] (https://lovdata.no/dokument/NL/lov/1972-05-12-28) (English: https://app.uio.no/ub/ujur/oversatte-lover/data/lov-19720512-028-eng.pdf)	Section 15(1)	Innehaveren av et atomanlegg plikter å holde anlegg og utstyr i forskriftsmessig og forsvarlig stand og å treffe alle nødvendige tiltak for å sikre at det ikke blir voldt skade som følge av radioaktivitet eller andre farlige egenskaper ved atombrensel eller radioaktivt produkt som finnes på anleggets område, eller som fjernes eller slippes ut derfra, eller som er under transport for innehaveren.	It shall be the duty of the operator of a nuclear installation to maintain the installation and equipment in sound and proper order and to take all necessary measures to ensure that no damage will be caused as a result of radioactivity or other hazardous features of such nuclear fuel or radioactive products which are to be found on the installation site, or which are removed or discharged therefrom, or which are undergoing transportation on the operator's behalf.	All	I	D	B	L	Intermediate Depth, DGR: The purpose of condition monitoring is to monitor the condition of the disposal facility and systems during the operating phase. Instrumentation systems are used for gathering and processing information on the condition of the facility and ensuring that working safety is good in the facility. The monitoring and control data are collected in the control room in the operational building (Ikonen et al. 2020, Sections 6.1.2, 7.1.2). Transport within the site: Intermediate Depth (Ikonen et al. 2020, Sections 6.1.1, 6.1.2, 6.2.2, Figure 6-4); DGR (Ikonen et al. 2020, Sections 7.1.1, 7.1.2, 7.2.2, Figures 7-5, 7-6); Deep Borehole (Fischer et al. 2020, Ch. 3, Section 4.1); Landfill (Ikonen et al. 2020, Table 9-5, Section 9.2.2). Installation: Intermediate Depth (Ikonen et al. 2020, Section 6.2.2); DGR (Ikonen et al. 2020, Section 7.2.2, Figures 7-6, 7-7); Deep Borehole (Ikonen et al. 2020, Sections 8.2.1, 8.2.2); Landfill (Ikonen et al. 2020, Sections 9.1.7, 9.2.2).	
Atomenergiloven (LOV-1972-05-12-28)	Lov om atomenergivirksomhet / Act concerning Nuclear Energy Activities [Revised 28 August 1995] (https://lovdata.no/dokument/NL/lov/1972-05-12-28) (English: https://app.uio.no/ub/ujur/oversatte-lover/data/lov-19720512-028-eng.pdf)	Section 15(2)	Likeså plikter innehaveren å treffe nødvendige tiltak for å sikre at anlegget etter nedlegging ikke blir til fare for den allmenne sikkerhet.	Similarly, it shall be the duty of the operator to take the necessary measures to ensure that the installation does not become a danger to public safety after operations have been discontinued.	All	I	D	B	L	The design as a whole. Decommissioning and closure: Intermediate Depth (Ikonen et al. 2020, Section 6.3); DGR (Ikonen et al. 2020, Section 7.3); Deep Borehole (Ikonen et al. 2020, Section 8.3); Landfill (Ikonen et al. 2020, Section 9.3).	
Atomenergiloven (LOV-1972-05-12-28)	Lov om atomenergivirksomhet / Act concerning Nuclear Energy Activities [Revised 28 August 1995] (https://lovdata.no/dokument/NL/lov/1972-05-12-28) (English: https://app.uio.no/ub/ujur/oversatte-lover/data/lov-19720512-028-eng.pdf)	Section 15(4)	Innehaveren og andre som får befatning med atombrensel eller radioaktivt produkt, plikter å treffe alle nødvendige tiltak for å sikre at det ikke blir voldt skade som følge av radioaktivitet eller andre farlige egenskaper ved stoffet.	It shall be the duty of the operator and all other persons concerned with nuclear fuel or radioactive products to take all necessary measures to ensure that no damage is caused as a result of radioactivity or other hazardous properties of the material.	All	I	D	B	L	The design as a whole	
FOR-1984-11-02-1809	Forskrift om fysisk beskyttelse av nukleært materiale og nukleære anlegg / Regulation on physical protection of nuclear material and nuclear installations (https://lovdata.no/dokument/SF/forskrift/1984-11-02-1809)	Section 12	Anleggsinnehaveren skal, på grunnlag av en trusselvurdering utarbeidet av Politiets sikkerhetstjeneste, utarbeide en designbasistrussel.	The asset owner shall, on the basis of a threat assessment prepared by the Police Security Service, prepare a design base threat.	All	I	D	B	L	To be decided	
FOR-1984-11-02-1809	Forskrift om fysisk beskyttelse av nukleært materiale og nukleære anlegg / Regulation on physical protection of nuclear material and nuclear installations (https://lovdata.no/dokument/SF/forskrift/1984-11-02-1809)	Section 12	Anleggsinnehaveren skal utarbeide en sikkerhetsrapport vedrørende den fysiske beskyttelse. Denne rapporten skal graderes etter sitt innhold, men minimum begrenset i henhold til lov 20. mars 1998 nr. 10 om forebyggende sikkerhetstjeneste § 11.	The asset owner shall prepare a safety report regarding the physical protection. This report shall be graded according to its contents, but at least limited in accordance with law 20 March 1998 no. 10 on the Preventive Safety Service section 11.	All	I	D	B	L	General requirement, not directly related to facility design	
FOR-1984-11-02-1809	Forskrift om fysisk beskyttelse av nukleært materiale og nukleære anlegg / Regulation on physical protection of nuclear material and nuclear installations (https://lovdata.no/dokument/SF/forskrift/1984-11-02-1809)	Section 12	Anleggsinnehaveren skal jevnlig kontrollere at systemet for fysisk beskyttelse virker.	The asset holder should regularly check that the physical protection system is working.	All	I	D	B	L	The reliable operation of systems and components shall be ensured through maintenance and regular periodic inspections and tests (Ikonen et al. 2020, Section 2.2.1).	
FOR-1984-11-02-1809	Forskrift om fysisk beskyttelse av nukleært materiale og nukleære anlegg / Regulation on physical protection of nuclear material and nuclear installations (https://lovdata.no/dokument/SF/forskrift/1984-11-02-1809)	Section 13	En beredskapsplan skal utarbeides i samråd med politiet og den skal være i samsvar med de reelle myndighetsforhold mellom de involverte instanser. Nødvendig verne-/ måleutstyr som anleggsinnehaveren kan stille til politiets disposisjon, skal tas med i planen, og den skal også omfatte nødvendige øvelsesaktiviteter.	A contingency plan shall be drawn up in consultation with the police and it shall be in accordance with the real authority relations between the agencies involved. The necessary protective/measuring equipment that the facility owner can provide to the police's disposal shall be included in the plan, and it shall also include necessary practice activities.	All	I	D	B	L	To be decided	StrålevernHefte 2018:33, 14.1
FOR-1984-11-02-1809	Forskrift om fysisk beskyttelse av nukleært materiale og nukleære anlegg / Regulation on physical protection of nuclear material and nuclear installations (https://lovdata.no/dokument/SF/forskrift/1984-11-02-1809)	Section 14	Nukleært materiale i klasse I kan bare anvendes eller lagres innenfor et vitalt område.	Class I nuclear material can only be used or stored within a vital area.	To be confirmed later	I	D	B		It needs to be established wheher Class I nuclear material is to be disposed of in the various repositories of the National Facility.	FOR-1984-11-02-1809, Appendix 1
FOR-1984-11-02-1809	Forskrift om fysisk beskyttelse av nukleært materiale og nukleære anlegg / Regulation on physical protection of nuclear material and nuclear installations (https://lovdata.no/dokument/SF/forskrift/1984-11-02-1809)	Section 14	Nukleært materiale i klasse II kan anvendes eller lagres innenfor vitalt eller beskyttet område.	Class II nuclear material may be used or stored within a vital or protected area.	To be confirmed later	I	D	B	L	It needs to be established wheher Class II nuclear material is to be disposed of in the various repositories of the National Facility.	FOR-1984-11-02-1809, Appendix 1
FOR-1984-11-02-1809	Forskrift om fysisk beskyttelse av nukleært materiale og nukleære anlegg / Regulation on physical protection of nuclear material and nuclear installations (https://lovdata.no/dokument/SF/forskrift/1984-11-02-1809)	Section 14	Nukleært materiale i klasse III kan anvendes eller lagres innenfor vitalt, beskyttet eller kontrollert område.	Class III nuclear material may be used or stored within a vital, protected or controlled area.	To be confirmed later	I	D	B	L	It needs to be established wheher Class III nuclear material is to be disposed of in the various repositories of the National Facility. Storage (Ikonen et al. 2020, Section 5.7, Ch. 3, Figure 5-5). Intermediate Depth, DGR: Storage, waste reception building (Ikonen et al. 2020, Section 5.7, Ch. 3, Figures 5-4, 5-5); Storage of canisters (DGR) (Ikonen et al. 2020, Section 7.1.1, Figures 7-1, 7-2). Landfill: Container laydown area option (Ikonen et al. 2020, Figure 5-5, Section 5.7), temporary storage area for waste packages (Ikonen et al. 2020, Table 9-5).	FOR-1984-11-02-1809, Appendix 1
FOR-1984-11-02-1809	Forskrift om fysisk beskyttelse av nukleært materiale og nukleære anlegg / Regulation on physical protection of nuclear material and nuclear installations (https://lovdata.no/dokument/SF/forskrift/1984-11-02-1809)	Section 15	Personellsikkerhet: Anleggsinnehaver skal vurdere personers pålitelighet før de autoriseres for adgang til beskyttet eller vitalt område. Det kreves ikke ordinær sikkerhetsklarering eller politiattest som basis for en slik vurdering. Personer som skal ha tilgang til gradert informasjon, skal sikkerhetsklareres i henhold til bestemmelsene i lov 20. mars 1998 nr. 10 om forebyggende sikkerhetstjeneste med forskrifter.	Personnel safety: The facility owner shall assess the reliability of persons before authorizing them for access to protected or vital areas. No ordinary security clearance or police certificate is required as the basis for such an assessment. Persons who shall have access to classified information shall be trusted in accordance with the provisions of The Act 20 March 1998 no. 10 on preventive security services with regulations.	All	I	D	B	L	General requirement, not directly related to facility design	

FOR-1984-11-02-1809	Forskrift om fysisk beskyttelse av nukleært materiale og nukleære anlegg / Regulation on physical protection of nuclear material and nuclear installations (https://lovdata.no/dokument/SF/forskrift/1984-11-02-1809)	Section 6, 15	Kontrollert område: Adgang skal skje gjennom en resepsjon/vaktsentral som skal være bemannet dag og natt. Utenom normal arbeidstid skal inngangsdører være låst.	Controlled area: Access should be made through a reception/call centre which should be staffed day and night. Outside normal working hours, front doors should be locked.	All	I	D	B	L	Controlled and uncontrolled areas and phases (Ikonen et al. 2020, Section 6.2.4, 7.2.4, 9.2.4; Fischer et al. 2020, Section 5.3)
FOR-1984-11-02-1809	Forskrift om fysisk beskyttelse av nukleært materiale og nukleære anlegg / Regulation on physical protection of nuclear material and nuclear installations (https://lovdata.no/dokument/SF/forskrift/1984-11-02-1809)	Section 6, 15	Kontrollert område: Private kjøretøyer kan ikke parkeres inne på området uten spesiell tillatelse. Anleggsinnehaver skal da forsikre seg om at det ikke bringes inn uønskede personer eller utstyr som kan representere en fare for anlegget.	Controlled area: Private vehicles cannot be parked inside the area without special permission. The facility owner shall then ensure that no unwanted persons or equipment may represent a danger to the facility.	All	I	D	B	L	Controlled and uncontrolled areas and phases (Ikonen et al. 2020, Section 6.2.4, 7.2.4, 9.2.4; Fischer et al. 2020, Section 5.3)
FOR-1984-11-02-1809	Forskrift om fysisk beskyttelse av nukleært materiale og nukleære anlegg / Regulation on physical protection of nuclear material and nuclear installations (https://lovdata.no/dokument/SF/forskrift/1984-11-02-1809)	Section 7, 15	Beskyttet område: Adgang skal begrenses til autoriserte personer og til personer som ledsages av disse.	Protected area: Access shall be limited to authorized persons and to persons accompanied thereof.	All	I	D	B	L	Controlled and uncontrolled areas and phases (Ikonen et al. 2020, Section 6.2.4, 7.2.4, 9.2.4; Fischer et al. 2020, Section 5.3)
FOR-1984-11-02-1809	Forskrift om fysisk beskyttelse av nukleært materiale og nukleære anlegg / Regulation on physical protection of nuclear material and nuclear installations (https://lovdata.no/dokument/SF/forskrift/1984-11-02-1809)	Section 7, 15	Beskyttet område: Adgangskontrollen skal skje etter et system for personidentifikasjon eller nøkkelkort.	Protected area: The access control shall take place according to a system for personal identification or key cards.	All	I	D	B	L	Controlled and uncontrolled areas and phases (Ikonen et al. 2020, Section 6.2.4, 7.2.4, 9.2.4; Fischer et al. 2020, Section 5.3)
FOR-1984-11-02-1809	Forskrift om fysisk beskyttelse av nukleært materiale og nukleære anlegg / Regulation on physical protection of nuclear material and nuclear installations (https://lovdata.no/dokument/SF/forskrift/1984-11-02-1809)	Section 7, 15	Beskyttet område: Anleggsinnehaveren skal føre et register over personer som har eller gis adgang til området.	Protected area: The facility owner shall keep a register of persons who have or are granted access to the area.	All	I	D	B	L	Controlled and uncontrolled areas and phases (Ikonen et al. 2020, Section 6.2.4, 7.2.4, 9.2.4; Fischer et al. 2020, Section 5.3)
FOR-1984-11-02-1809	Forskrift om fysisk beskyttelse av nukleært materiale og nukleære anlegg / Regulation on physical protection of nuclear material and nuclear installations (https://lovdata.no/dokument/SF/forskrift/1984-11-02-1809)	Section 7, 15	Beskyttet område: Kjøretøy og alt som bringes inn i området, skal kontrolleres for å sikre at det ikke bringes inn uønskede personer eller utstyr som kan representere fare for anlegget.	Protected area: Vehicles and everything brought into the area should be checked to ensure that unwanted persons or equipment may not be brought into the facility.	All	I	D	B	L	Controlled and uncontrolled areas and phases (Ikonen et al. 2020, Section 6.2.4, 7.2.4, 9.2.4; Fischer et al. 2020, Section 5.3)
FOR-1984-11-02-1809	Forskrift om fysisk beskyttelse av nukleært materiale og nukleære anlegg / Regulation on physical protection of nuclear material and nuclear installations (https://lovdata.no/dokument/SF/forskrift/1984-11-02-1809)	Section 8, 15	Vitalt område: I tillegg til kravene under beskyttet område gjelder: Ved inn- og utpassering skal personer og pakker kontrolleres med spesielle detektorer supplert med manuell kontroll.	Vital area: In addition to the requirements under protected area, the requirements apply: In case of entry and egress, persons and packages must be checked with special detectors supplemented by manual control.	To be confirmed later	I	D	B		Controlled and uncontrolled areas and phases (Ikonen et al. 2020, Section 6.2.4, 7.2.4, 9.2.4; Fischer et al. 2020, Section 5.3)
FOR-1984-11-02-1809	Forskrift om fysisk beskyttelse av nukleært materiale og nukleære anlegg / Regulation on physical protection of nuclear material and nuclear installations (https://lovdata.no/dokument/SF/forskrift/1984-11-02-1809)	Section 8, 15	Vitalt område: Adgang forutsetter at det alltid er to eller flere personer tilstede i området, eller at det er etablert særlig overvåking.	Vital area: Access assumes that there are always two or more persons present in the area, or that special monitoring has been established.	To be confirmed later	I	D	B		Controlled and uncontrolled areas and phases (Ikonen et al. 2020, Section 6.2.4, 7.2.4, 9.2.4; Fischer et al. 2020, Section 5.3). Monitoring radiation safety (Ikonen et al. 2020, Section 2.2.1). Intermediate depth, DGR: Disposal facility monitoring and control systems (Ikonen et al. 2020, Sections 6.1.2, 7.1.2). Landfill repository monitoring (Ikonen et al. 2020, Section 9.2.8).
FOR-1984-11-02-1809	Forskrift om fysisk beskyttelse av nukleært materiale og nukleære anlegg / Regulation on physical protection of nuclear material and nuclear installations (https://lovdata.no/dokument/SF/forskrift/1984-11-02-1809)	Section 16	For sikring mot innbrudd og sabotasje skal det etableres et alarmsystem med tilhørende forbindelse til anleggsinnehaverens vaktsentral med helkontinuerlig vakt. Vaktsentralen skal ha direkte forbindelse til politi. Vaktsentralen skal utformes slik at den kan opprettholde sin funksjon også i nærvær av designbasistrussel.	For protection against burglary and sabotage, an alarm system shall be established with an associated connection to the facility owner's duty centre with a continuous guard. The call centre shall have a direct connection to the police. The call centre should be designed so that it can maintain its function even in the presence of design base threat.	All	I	D	B	L	The facilities will be protected by an automatic fire alarm system (Ikonen et al. 2020, Section 6.1.4). The security guards work in three shifts (Ikonen et al. 2020, Section 5.6).
FOR-1984-11-02-1809	Forskrift om fysisk beskyttelse av nukleært materiale og nukleære anlegg / Regulation on physical protection of nuclear material and nuclear installations (https://lovdata.no/dokument/SF/forskrift/1984-11-02-1809)	Section 16	Låsesystemer og andre systemer for adgangskontroll som er vesentlige ledd i systemet for fysisk beskyttelse, skal løpende kontrolleres og forandres dersom det antas at uvedkommende har fått kjennskap til systemene.	Locking systems and other access control systems that are essential parts of the system for physical protection shall be continuously checked and changed if it is assumed that unauthorized persons have been informed of the systems.	All	I	D	B	L	Operations/maintenance. The ventilation channels will be fitted with fire insulation and safety locks will be installed in places where the channels cross from one fire compartment to another (Ikonen et al. 2020, Sections 6.1.2, 7.1.2). Checking of the locking systems and other access control systems: to be decided.
FOR-1984-11-02-1809	Forskrift om fysisk beskyttelse av nukleært materiale og nukleære anlegg / Regulation on physical protection of nuclear material and nuclear installations (https://lovdata.no/dokument/SF/forskrift/1984-11-02-1809)	Section 16	De kommunikasjonssystemer som inngår som en vesentlig del av systemet for fysisk beskyttelse, inklusive forbindelse til politi, skal være dublert og skal testes regelmessig.	The communication systems that are part of the system of physical protection, including connection to law enforcement, shall be duplicated and should be tested regularly.	All	I	D	B	L	The reliable operation of systems and components shall be ensured through maintenance and regular periodic inspections and tests (Ikonen et al. 2020, Section 2.2.1).
FOR-1984-11-02-1809	Forskrift om fysisk beskyttelse av nukleært materiale og nukleære anlegg / Regulation on physical protection of nuclear material and nuclear installations (https://lovdata.no/dokument/SF/forskrift/1984-11-02-1809)	Section 16	Uavhengige og dublerte overføringslinjer, inklusive uavhengig kraftforsyning, skal opprettes mellom vaktsentral og overvåkingsutstyr.	Independent and duplicate transmission lines, including independent power supply, shall be created between the call centre and monitoring equipment.	All	I	D	B	L	To be decided. Affects design and cost estimation.
FOR-1984-11-02-1809	Forskrift om fysisk beskyttelse av nukleært materiale og nukleære anlegg / Regulation on physical protection of nuclear material and nuclear installations (https://lovdata.no/dokument/SF/forskrift/1984-11-02-1809)	Section 16	Beskrivelsen av disse systemene skal graderes etter sitt innhold, men minimum begrenset i henhold til lov 20. mars 1998 nr. 10 om forebyggende sikkerhetstjeneste § 11.	The description of these systems shall be graded according to their contents, but at least limited in accordance with law 20 March 1998 no. 10 of the Preventive Safety Service § 11.	All	I	D	B	L	To be decided
FOR-1984-11-02-1809	Forskrift om fysisk beskyttelse av nukleært materiale og nukleære anlegg / Regulation on physical protection of nuclear material and nuclear installations (https://lovdata.no/dokument/SF/forskrift/1984-11-02-1809)	Section 16	Kontrollert område: Bygninger innenfor et slikt område som inneholder nukleært materiale, skal være avlåst utenom arbeidstid. Rom som inneholder nukleært materiale, skal være forsvarlig avlåst når autorisert personell ikke oppholder seg der. Vinduer i rom som inneholder slikt materiale, skal være forsynt med alarm og være fysisk sikret mot inntrengning.	Controlled area: Buildings within such an area containing nuclear material shall be locked off outside working hours. Rooms containing nuclear material must be securely locked down when authorized personnel are not present. Windows in rooms containing such material shall be provided with alarm and be physically secured against intrusion.	DGR, Intermediate Depth	I	D			Controlled and uncontrolled areas and phases (Ikonen et al. 2020, Section 6.2.4, 7.2.4). Locking and alarms: to be decided.
FOR-1984-11-02-1809	Forskrift om fysisk beskyttelse av nukleært materiale og nukleære anlegg / Regulation on physical protection of nuclear material and nuclear installations (https://lovdata.no/dokument/SF/forskrift/1984-11-02-1809)	Section 16	Beskyttet område: I tillegg til kravene under kontrollert område gjelder: Den ytre grense for området skal være ryddet, opplyst og forsynt med tilstrekkelig TV-overvåking.	Protected area: In addition to the requirements under the controlled area apply: the outer boundary of the area shall be cleared, illuminated and provided with adequate TV monitoring.	All	I	D	B	L	CCTV surveillance: Intermediate Depth, DGR (Ikonen et al. 2020, Sections 6.1.2, 7.1.2)
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	1.1	Innehaveren skal ha kontroll med alle eiendomstransaksjoner som påvirker atomanlegget, for å sikre at innehaveren har til enhver tid har full kontroll over anleggsområdet.	The holder shall have control over all real estate transactions that affect the nuclear facility, to ensure that the holder has full control over it at all times the construction area.	The National Facility as a whole (site)	I	D	B	L	General requirement, not directly related to facility design

StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	1.2	Innehaveren skal markere grensen til det godkjente anlegget med perimeter/gjerder eller andre egnede midler og skal sørge for at grensene er vedlikeholdt.	The holder must mark the boundary of the approved facility with perimeter / fences or other suitable means and shall ensure that the boundaries are maintained.	The National Facility as a whole	I	D	B	L	The National Facility site will be fenced. The office building and visitor centre will be outside the facility fence (Ikonen et al. 2020, Figure 5-4).	
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	1.3	Innehaveren skal utarbeide og iverksette nødvendige tiltak for å forhindre at uautoriserte personer kommer seg inn i atomanlegget.	The holder shall prepare and implement the necessary measures to prevent that unauthorized persons enter the nuclear facility.	All	I	D	B	L	The National Facility site will be fenced (Ikonen et al. 2020, Figure 5-4). Security and emergency arrangements (Ikonen et al. 2020, Section 2.2.1). Security patrols and surveillance of the disposal facility are centralised in the operation building. This control post is manned at all times, so it is the logical point for controlling access (Ikonen et al. 2020, Section 5.7). The security guards work in three shifts. At night, surveillance of the operation building takes place from the security guard centre (Ikonen et al. 2020, Section 5.6).	
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	4.1	Innehaveren skal sørge for at all atomsubstans (inkludert atomsubstans som er definert som radioaktivt avfall) som blir bragt inn på atomanlegget skjer i samsvar med gjeldende regelverk, konsesjon/tillatelser og prosedyrer.	The holder must ensure that all atomic substance (including atomic substance that is defined as radioactive waste) that is brought into the nuclear facility takes place in accordance with current regulations, licenses / permits and procedures.	All	I	D	B	L	General requirement, not directly related to facility design	
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	5.1, 5.2	Innehaveren skal til enhver tid sørge for nødvendige økonomiske og menneskelige ressurser for sikker drift av atomanlegget.	The holder must at all times provide for necessary financial and human resources for safe operation of the nuclear facility.	All	I	D	B	L	General requirement, not directly related to facility design	
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	5.3	Endringer i organisasjonsstruktur eller ressurser skal være beskrevet i henhold til deres sikkerhetsmessige betydning.	Changes in organizational structure or resources shall be described in accordance with their safety significance.	All	I	D	B	L	General requirement, not directly related to facility design	SSR-5 (IAEA 2011), 5.23 ICRP Publication 122 (2013), 87
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	5.4	Innehaveren skal til enhver tid ha nok personell med tilstrekkelig kompetanse på alle nivåer i organisasjonen.	The holder must at all times have sufficient personnel with sufficient competence all levels of the organization.	All	I	D	B	L	General requirement, not directly related to facility design	
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	5.5	Innehaverens ledelse skal til enhver tid legge til rette for og oppfordre til en sunn sikkerhetskultur.	The owner's management shall at all times facilitate and encourage a sound safety culture.	All	I	D	B	L	General requirement, not directly related to facility design. Safety culture (Ikonen et al. 2020, Sections 2.2.1, 2.2.7).	INSAG Series No. 12 (IAEA 1999) SSG-15 (Rev. 1) (IAEA 2020), 2.6, 3.16 ICRP Publication 81 (1998)
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	6.1	Innehaveren skal til enhver tid ha oppdatert sikkerhetsanalyse/sikkerhetsrapport, og skal jevnlig foreta systematiske gjennomganger av sikkerhetsanalysen på en måte som er tilpasset anleggets eller prosessens kompleksitet (graded approach).	The holder must at all times have an updated safety analysis / safety report and shall regularly carry out systematic reviews of the safety analysis in a manner that is adapted to the complexity of the facility or process (graded approach).	All	I	D	B	L	General requirement, not directly related to facility design	SSG-23 (IAEA 2012), 6.23–6.28

StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	6.2	Sikkerhetsanalyser og endringer i den skal godkjennes av Statens strålevern i henhold til atomenergiloven §§ 11 og 12.	Safety analyses and changes to them must be approved by the Norwegian Radiation Protection Authority in according to sections 11 and 12 of the Atomic Energy Act.	All	I	D	B	L	General requirement, not directly related to facility design	
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	8.1	Innehaveren skal til enhver tid ha et HMS-program for anlegget som oppdateres jevnlig.	The holder must at all times have an HSE (Health, Environment, and Safety) programme for the facility that is updated regularly.	All	I	D	B	L	General requirement, not directly related to facility design	
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	9.1	Innehaveren skal ha dekommisjoneringsplaner for alle faser i atomanleggets levetid, og gjennomgå og revidere planen etter krav fra Statens strålevern, og senest innen 5 år fra forrige gjennomgang.	The holder shall have decommissioning plans for all phases of the nuclear facility lifetime, and review and revise the plan as required by the Norwegian Radiation Protection Authority, and no later than 5 years from the previous review.	All	I	D	B	L	Decommissioning: Intermediate Depth (Ikonen et al. 2020, Section 6.3); DGR (Ikonen et al. 2020, Section 7.3); Deep Borehole (Ikonen et al. 2020, Section 9.3); Landfill (Ikonen et al. 2020, Section 9.3)	
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	10.1	Innehaveren skal ha en sikkerhetskomité med et fast mandat og prosedyrer som skal godkjennes av Statens strålevern.	The holder shall have a security committee with a permanent mandate and procedures such as shall be approved by the Norwegian Radiation Protection Authority.	All	I	D	B	L	General requirement, not directly related to facility design	
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	12.1	Innehaveren skal ha og oppdatere sine internkontrollrutiner, for å sikre at alle relevante krav og vilkår til strålevern er oppfylt på anlegget.	The holder shall have and update his internal control routines, to ensure that all relevant requirements and conditions for radiation protection are met at the facility.	All	I	D	B	L	Radiation protection (Ikonen et al. 2020, Sections 6.2.5, 7.1.1, 7.2.5, 8.2.4, 9.2.5). Control and maintenance rooms (Ikonen et al. 2020, Figure 6-1, Section 6.1.1, 6.1.4).	FOR-1996-12-06-1127, Section 4, 5, 6
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	13.1	Innehaveren skal ha og oppdatere et avfallshåndteringsprogram som dokumenterer håndtering, avfallsminimering, bearbeiding, transport, lagring og sikkerhetskontroll (safeguards) av radioaktivt avfall, atomavfall og brukt atombrensel, inkludert brukt atombrensel og atomavfall som er blandet med andre farlige stoffer.	The holder shall have and update a waste management programme that documents handling, waste minimization, processing, transport, storage and safeguards of radioactive waste, nuclear waste and used nuclear fuel, including spent nuclear fuel and nuclear waste mixed with other dangerous substances.	All	I	D	B	L	Safeguards, nuclear material accounting (Ikonen et al. 2020, Sections 2.2.8, 7.2.7, 7.1.2, 7.2.3, 8.2.6). Storage (Ikonen et al. 2020, Section 5.7, Ch. 3, Figure 5-5). Transport within the site: Intermediate Depth (Ikonen et al. 2020, Sections 6.1.1, 6.1.2, 6.2.2, Figure 6-4); DGR (Ikonen et al. 2020, Sections 7.1.1, 7.1.2, 7.2.2, Figures 7-5, 7-6); Deep Borehole (Fischer et al. 2020, Ch. 3, Section 4.1). Installation: Intermediate Depth (Ikonen et al. 2020, Section 6.2.2); DGR (Ikonen et al. 2020, Section 7.2.2, Figures 7-6, 7-7); Deep Borehole (Ikonen et al. 2020, Sections 8.2.1, 8.2.2). Landfill: Transport and installation (Ikonen et al. 2020, Section 9.2.2, Table 9-5), container laydown area option (Ikonen et al. 2020, Figure 5-5, Section 5.7), temporary storage area for waste packages (Ikonen et al. 2020, Table 9-5).	Nuclear Energy Series No. NF-T-3 (IAEA 2018)
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	16.1	Dersom innehaveren foreslår å bygge eller installere en ny konstruksjon eller innretning på området som inngår i definisjonen av atomanlegg i atomenergiloven §1 e) kreves det godkjenning fra Statens strålevern.	If the holder proposes to build or install a new structure or facility in the area that is included in the definition of nuclear facilities in the Atomic Energy Act §1 e), approval from the Norwegian Radiation Protection Authority is required.	All	I	D	B	L	Safety case and licensing (Ikonen et al. 2020, Section 2.2.1).	
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	17.1	Innehaveren skal for ethvert tiltak som kan påvirke sikkerheten utvikle en sikkerhetsanalyse som beskriver sikkerhetsmessige driftsbetingelser og vilkår (OLC, Operational Limits and Conditions).	The holder shall, for any measure that may affect safety, develop one safety analysis describing safety operating conditions and conditions (OLC, Operational Limits and Conditions).	All	I	D	B	L	The design as a whole	INFCIRC/546 (24 December 1997), Article 9(ii), 16(ii)

StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	17.2	Innehaveren skal gjennomføre ethvert tiltak på en slik måte at de sikkerhetsmessige driftsbetingelsene med tilhørende vilkår er oppfylt.	The holder shall implement any measures in such a way that the safety operating conditions and associated conditions are met.	All	I	D	B	L	General requirement, not directly related to facility design	
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	17.3	Driftsprosedyrer skal vurderes jevnlig og oppdateres i henhold til forhåndsbestemte prosesser og være kjent for driftspersonell. Særskilte driftsprosedyrer skal utvikles, vurderes, og godkjennes før starten av nye aktiviteter.	Operating procedures shall be reviewed regularly and updated according to predetermined processes and be familiar to operating personnel. Separate operating procedures must be developed, assessed, and approved before the start of new activities.	All	I	D	B	L	General requirement, not directly related to facility design	GSR Part 2 (IAEA 2016), Req. 10
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	17.5	Innehaveren skal sørge for at alle operasjoner og tiltak som kan påvirke sikkerheten, utføres under kontroll og tilsyn av kvalifisert og erfarent personell utpekt av innehaveren.	The holder must ensure that all operations and measures that may affect safety are performed under the control and supervision of qualified and experienced personnel designated by the holder.	All	I	D	B	L	General requirement, not directly related to facility design	
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	18.1	Innehaveren skal identifisere alle konstruksjoner, systemer og komponenter som er viktige for sikkerheten og klassifisere dem på grunnlag av deres sikkerhetsfunksjon og sikkerhetsbetydning.	The holder shall identify all structures, systems and components as are important for safety and classify them on the basis of their safety function and safety significance.	All	I	D	B	L	Classficiation of components and their safety functions remains to be done. It is a subject for detailed design, in the coming development phases. Safety classification: Intermediate Depth (Ikonen et al. 2020, Section 6.1.3); DGR (Ikonen et al. 2020, Sections 6.1.3, 7.1.3); Deep Borehole (Ikonen et al. 2020, Section 8.1.6); Landfill (Ikonen et al. 2020, Section 9.1.3)	
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	18.2	Innehaveren skal sørge for at utstyr ved anlegget ikke driftes, inspiseres, vedlikeholdes eller testes med mindre hensiktsmessige og tilstrekkelige sikkerhetsmekanismer, -innretninger og -kretser er riktig tilkoblet og i god stand.	The holder must ensure that equipment at the facility is not operated, inspected, maintained or tested unless appropriate and sufficient safety mechanisms, devices, and circuits are properly connected and in good condition.	All	I	D	B	L	The reliable operation of systems and components shall be ensured through maintenance and regular periodic inspections and tests (Ikonen et al. 2020, Section 2.2.1).	
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	18.3	Innehaveren skal sørge for at alle konstruksjoner, systemer og komponenter som er viktige for sikkerheten skal utformes for å kunne kalibreres, testes, vedlikeholdes, repareres eller erstattes, inspiseres og overvåkes etter behov, for å sikre deres funksjon og opprettholde opprinnelige spesifikasjoner eller tilstand.	The holder shall ensure that all structures, systems and components such as are important for safety are designed to be calibrated, tested, maintained, repaired or replaced, inspected and monitored as necessary, to ensure their function and maintain original specifications or condition.	All	I	D	B	L	Monitoring radiation safety (Ikonen et al. 2020, Section 2.2.1). Intermediate depth, DGR: The purpose of condition monitoring is to monitor the condition of the disposal facility and systems during the operating phase. Instrumentation systems are used for gathering and processing information on the condition of the facility and ensuring that working safety is good in the facility. The monitoring and control data are collected in the control room in the operational building (Ikonen et al. 2020, Sections 6.1.2, 7.1.2). The reliable operation of systems and components shall be ensured through maintenance and regular periodic inspections and tests (Ikonen et al. 2020, Section 2.2.1). Deep Borehole: Monitoring (Ikonen et al. 2020, Section 8.2.7). Landfill: Monitoring (Ikonen et al. 2020, Section 9.2.8).	
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	18.4	Innehaveren skal gjennomføre prinsippet om en «enkeltfeil-tilnærming» («single failure criteria approach»), slik at ingen enkeltfeilet komponent skal kunne føre til at et system mister evnen til å utføre sin sikkerhetsfunksjon.	The holder shall implement the principle of a "single-fault approach" ("single failure criteria approach"), so that no single failure component can lead to that a system loses the ability to perform its safety function.	All	I	D	B	L	The handling systems for spent fuel disposal canisters or other waste packages shall be designed so that a single equipment failure cannot cause a drop accident or another kind of accident where significant amounts of radioactive substances could be released from a package or canister (Ikonen et al. 2020, Section 2.2.1).	
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	18.5	Innehaveren skal sørge for at alle sikkerhetssystemene er utformet slik at de automatisk avslutter operasjoner (drift) på en sikker måte, ved alle forhåndsdefinerte utløsende uønskede hendelser.	The holder must ensure that all safety systems are designed so that they automatically terminate operations (operation) in a safe manner, by all predefined triggering unwanted events.	All	I	D	B	L	Incidents and accidents (Ikonen et al. 2020, Section 2.2.1): Intermediate Depth (Ikonen et al. 2020, Section 6.2.6); DGR (Ikonen et al. 2020, Section 7.2.6); Deep Borehole (Ikonen et al. 2020, Section 8.2.5); Landfill (Ikonen et al. 2020, Section 9.2.6). Impacts caused by probable natural phenomena and other events external to the facility shall be considered in the design of the repository (Ikonen et al. 2020, Section 2.2.1).	

StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	18.6	Innehaveren skal sørge for at alle konstruksjoner, systemer og komponenter opererer innenfor angitte sikkerhetsgrenser og sikkerhetsmarginer under alle driftsforhold.	The holder must ensure that all structures, systems and components operate within specified safety limits and safety margins below all operating conditions.	All	I	D	B	L	Disposal facility monitoring and control systems (Ikonen et al. 2020, Sections 6.1.2, 7.1.2, 8.2.7, 9.2.8). Monitoring radiation safety (Ikonen et al. 2020, Section 2.2.1). The purpose of condition monitoring is to monitor the condition of the disposal facility and systems during the operating phase. Instrumentation systems are used for gathering and processing information on the condition of the facility and ensuring that working safety is good in the facility. The monitoring and control data are collected in the control room in the operational building. The following measurements can be carried out in the disposal facility: measurements of air, bedrock and water temperature; air humidity; drainage water level; air activity; CO-, CO2-, NOx- and radon content; air dust content; as well as smoke detection (Ikonen et al. 2020, Sections 6.1.2, 7.1.2).
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	19.1	Innehaveren skal ha nødvendige prosedyrer for regelmessig og systematisk undersøke, inspisere, vedlikeholde og teste alt utstyr ved anlegget som kan påvirke sikkerheten. Det skal foreligge en vedlikeholdsplan for anlegget for hver relevant konstruksjon, system og komponent.	The holder shall have the necessary procedures to regularly and systematically examine, inspect, maintain and test all equipment at the facility that can affect safety. There must be a maintenance plan for the facility for each relevant construction, system and component.	All	I	D	B	L	The reliable operation of systems and components shall be ensured through maintenance and regular periodic inspections and tests (Ikonen et al. 2020, Section 2.2.1). Control and maintenance rooms (Ikonen et al. 2020, Figure 6-1, Section 6.1.1, 6.1.4).
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	19.2	Innehaveren skal av sikkerhetshensyn sørge for at enhver undersøkelse, inspeksjon, vedlikehold og test av ethvert utstyr ved anlegget, eller deler av dette, utføres: a. av tilstrekkelig kvalifisert og erfarent personell; b. i samsvar med skriftlige planer og prosedyrer; c. innenfor de tidsintervaller som er angitt i vedlikeholdsplanen for anlegget; og d. under kontroll og tilsyn av tilstrekkelig kvalifisert og erfarent personell utpekt av innehaveren for dette formål.	The holder shall, for safety reasons, ensure that any examination, inspection, maintenance and testing of any equipment at the facility, or parts thereof, are performed: a. by adequately qualified and experienced personnel; b. in accordance with written plans and procedures; c. within the time intervals specified in the maintenance schedule for the facility; and d. under the control and supervision of adequately qualified and experienced personnel designated by the holder for this purpose.	All	I	D	B	L	General requirement, not directly related to facility design
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	19.4	Det forebyggende vedlikeholdsprogrammet skal dekke alle konstruksjoner, systemer og komponenter som er viktige for sikkerheten ved anlegget.	The preventive maintenance programme shall cover all constructions, systems and components that are important for the safety of the facility.	All	I	D	B	L	General requirement, not directly related to facility design. Control and maintenance rooms (Ikonen et al. 2020, Figure 6-1, Section 6.1.1, 6.1.4).
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	19.6	Innehaveren skal sørge for at alt måle- og testutstyr som er brukt til dette formålet, er riktig kalibrert, underlagt kontrollert bruk og merket/fjernet når det ikke lenger fungerer som forutsatt.	The holder must ensure that all measuring and test equipment used for this purpose is properly calibrated, subject to controlled use and marked / removed when it no longer works as intended.	All	I	D	B	L	Operational requirement. To be decided.
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	19.8	Innehaveren skal også når det kreves av Statens strålevern, etter konsultasjon med innehaveren, utføre særskilt vedlikehold, tester, inspeksjoner og undersøkelser i forbindelse med ethvert utstyr ved anlegget.	The holder shall also, when required by the Norwegian Radiation Protection Authority, after consultation with the holder, perform special maintenance, tests, inspections and investigations in connection with any equipment at the facility.	All	I	D	B	L	The reliable operation of systems and components shall be ensured through maintenance and regular periodic inspections and tests (Ikonen et al. 2020, Section 2.2.1).
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	20.1	Innehaveren skal ha prosedyrer og gjennomføre nødvendige tiltak for å kontrollere alle endringer, midlertidige endringer eller eksperimenter som utføres på enhver del av atomanlegget eller prosesser, som kan påvirke sikkerheten.	The holder shall have procedures and implement the necessary measures to check for any changes, temporary changes, or experiments performed on any part of the nuclear facility or processes, which may affect safety.	All	I	D	B	L	Facility adaptation for different waste volumes: Intermediate Depth (Ikonen et al. 2020, Section 6.1.5); DGR (Ikonen et al. 2020, Section 7.1.5); Deep Borehole (Ikonen et al. 2020, Section 8.1.8); Landfill (Ikonen et al. 2020, Section 9.1.5)
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	20.2	Disse tiltakene skal sørge for klassifisering av endringer, midlertidige endringer eller eksperimenter i henhold til deres sikkerhetsmessige betydning. Tiltakene skal, der det er hensiktsmessig, dele opp endringen, den midlertidige endringen eller eksperimentet i faser. Der Statens strålevern bestemmer, skal innehaveren ikke påbegynne eller fortsette fra en fase trinn til den neste, uten etter samtykke fra Statens strålevern.	These measures shall provide for the classification of changes, temporary changes or experiments according to their safety significance. The measures shall, where appropriate, divide the change, the temporary change or the experiment in phases. Where the Norwegian Radiation Protection Authority decides, the holder shall not begin or continue from one phase step to the next, without consent from the Norwegian Radiation Protection Authority.	All	I	D	B	L	Safety classification: Intermediate Depth (Ikonen et al. 2020, Section 6.1.3); DGR (Ikonen et al. 2020, Sections 6.1.3, 7.1.3); Deep Borehole (Ikonen et al. 2020, Section 8.1.6); Landfill (Ikonen et al. 2020, Section 9.1.3)

StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	21.1	Når det er nødvendig for å muliggjøre en undersøkelse, inspeksjon, vedlikehold eller testing av utstyr ved anlegget skal innehaveren sørge for at utstyr ved anlegget skal nedstenges i samsvar med kravene i vedlikeholdsplanen for anlegget, med mindre Statens strålevern på forhånd har samtykket til forlengelse av anleggets driftsperiode.	When it is necessary to enable an investigation, inspection, maintenance or testing of equipment at the facility, the owner shall ensure that equipment at the facility is shut down in accordance with the requirements in the maintenance plan for the facility, unless the Norwegian Radiation Protection Authority has agreed in advance to extend the facility's operating period.	All	I	D	B	L	To be considered in the design (components) enabling a shutdown for inspections and maintenance that causes the least risk for the operation of the facility	
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	21.2	Dersom Statens strålevern ber om det, skal innehaver sørge for at utstyr ved anlegget eller operasjon eller prosess som har blitt nedstengt i samsvar med ovennevnte vilkår, ikke startes opp igjen uten Statens stråleverns samtykke.	If the Norwegian Radiation Protection Authority so requests, the holder shall ensure that equipment at the facility or operation or process that has been shut down in accordance with the above conditions is not restarted without the Norwegian Radiation Protection Authority's consent.	All	I	D	B	L	To be considered in the design (components) enabling a shutdown for inspections and maintenance that causes the least risk for the operation of the facility	
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	21.3	Innehaveren skal, dersom Statens strålevern krever det, stanse driften av ethvert utstyr, operasjon eller prosess på atomanlegget innen en viss frist fastsatt av Statens strålevern, og skal da ikke starte opp igjen uten Statens stråleverns samtykke.	The holder shall, if required by the Norwegian Radiation Protection Authority, stop the operation of any equipment, operation or process on the nuclear facility within a certain period set by the Norwegian Radiation Protection Authority, and shall not start up again without the consent of the Norwegian Radiation Protection Authority.	All	I	D	B	L	To be considered in the design (components) enabling a shutdown for inspections and maintenance that causes the least risk for the operation of the facility	
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	22.1	Innehaveren skal, etter behov eller med de tidsintervaller som er spesifisert av Statens strålevern, utføre en sikkerhetsgjennomgang av om anleggets drift er i tråd med vilkår for drift og at operativ ytelse er overholdt for å kunne avklare om atomanlegget fortsatt er egnet til videre drift.	The holder shall, as required or at the time intervals specified by the Norwegian Radiation Protection Authority, carry out a safety review of whether the facility's operation is in line with conditions for operation and that operational performance is complied with in order to clarify whether the nuclear facility is still suitable for further operation.	All	I	D	B	L	General requirement, not directly related to facility design	
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	23.1	Innehaveren skal sørge for hensiktsmessige ordninger for materialregnskap og sikkerhetskontroll (Safeguards).	The holder must provide appropriate arrangements for material accounting and security control (Safeguards).	All	I	D	B	L	Safeguards, nuclear material accounting (Ikonen et al. 2020, Sections 2.2.8, 7.2.7, 7.1.2, 7.2.3, 8.2.6), nuclear material control (Ikonen et al. 2020, Section 7.1.1)	DGR, Deep Borehole (spent fuel storage): SSG-15 (Rev. 1) (IAEA 2020), 3.31 Nuclear Energy Series No. NF-T-3 (IAEA 2018)
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	24.1	Innehaveren skal iverksette hensiktsmessige tiltak for å sikre atomsubstans, radioaktivt materiale og radioaktivt avfall på det konsesjonsbelagte området og sikre anlegget mot sabotasje i henhold til krav i lover og forskrifter jf. vilkår 1.	The holder shall implement appropriate measures to secure nuclear material, radioactive material and radioactive waste in the licensed area and secure the facility against sabotage in accordance with requirements in laws and regulations, cf. condition 1.	All	I	D	B	L	Security and emergency arrangements (Ikonen et al. 2020, Section 2.2.1). Safeguards, nuclear material accounting (Ikonen et al. 2020, Sections 2.2.8, 7.2.7, 7.1.2, 7.2.3, 8.2.6), nuclear material control (Ikonen et al. 2020, Section 7.1.1).	DGR, Deep Borehole (spent fuel storage): SSG-15 (Rev. 1) (IAEA 2020), 3.31A, 3.31B FOR-1984-11-02-1809
StrålevernHefte 2018:33	Generelle vilkår for vurdering av søknader om konsesjon etter atomenergiloven / General terms for assessment of applications on license after nuclear energy act (https://dsa.no/publikasjoner/stralevernhefte-33-generelle-vilkar-for-vurdering-av-soknader-om-konsesjon-etter-atomenergiloven/Str%C3%A5levernHefte_33_Generelle%20vilk%C3%A5r%20for%20vurdering%20av%20s%C3%B8knader%20om%20konsesjon%20etter%20atomenergiloven.pdf)	25.1	Innehaveren skal utarbeide og iverksette hensiktsmessige ordninger for idriftsettelse av anlegg eller prosesser som kan påvirke sikkerheten.	The holder shall prepare and implement appropriate arrangements for the commissioning of facilities or processes that may affect safety.	All	I	D	B	L	To be considered in the design (components/sectioning) enabling a commissioning that causes the least risk for the operation of the facility	
Forurensningsloven (LOV-1981-03-13-6)	Lov om vern mot forurensninger og om avfall / Act on protection against pollution and waste (Pollution Control Act) (https://lovdata.no/dokument/NL/lov/1981-03-13-6?q=forurensningsloven)	Section 2(1), 7	Det skal arbeides for å hindre at forurensning oppstår eller øker, og for å begrense forurensning som finner sted. Loven skal nyttes for å oppnå en miljøkvalitet som er tilfredsstillende ut fra en samlet vurdering av helse, velferd, naturmiljøet, kostnader forbundet med tiltakene og økonomiske forhold.	Efforts must be taken to prevent pollution from occurring or increasing, and to limit pollution that takes place. The act shall be used to achieve an environmental quality that is satisfactory based on an overall assessment of health, welfare, the natural environment, costs associated with the measures and economic conditions.	All	I	D	B	L	The design as a whole. Environmental impact factors (Ikonen et al. 2020, Section 2.2.11). Monitoring of the environmental impacts (Ikonen et al. 2020, Sections 2.2.1, 6.2.8, 7.2.8, 8.2.7, 9.2.8, Table 9-3). There may be some minor amounts of radioactive waste produced in the on-site packaging plant for low and intermediate level waste, but these are not considered to be significant at this concept description stage (Ikonen et al. 2020, Section 2.2.5).	
Forurensningsloven (LOV-1981-03-13-6)	Lov om vern mot forurensninger og om avfall / Act on protection against pollution and waste (Pollution Control Act) (https://lovdata.no/dokument/NL/lov/1981-03-13-6?q=forurensningsloven)	Section 2(3)	For å unngå og begrense forurensning og avfallsproblemer skal det tas utgangspunkt i den teknologi som ut fra en samlet vurdering av nåværende og fremtidig bruk av miljøet og av økonomiske forhold, gir de beste resultater.	In order to avoid and limit pollution and waste problems, the technology shall be used that, based on an overall assessment of the current and future use of the environment and of economic conditions, produces the best results.	All	I	D	B	L	The design as a whole. Use of best available, proven technology (Ikonen et al. 2020, Section 2.2.7). Landfill: Ikonen et al. (2020), Ch. 9, Table 9-3.	
Forurensningsloven (LOV-1981-03-13-6)	Lov om vern mot forurensninger og om avfall / Act on protection against pollution and waste (Pollution Control Act) (https://lovdata.no/dokument/NL/lov/1981-03-13-6?q=forurensningsloven)	Section 2(4)	Avfall skal tas hånd om slik at det blir minst mulig til skade og ulempe.	Waste should be taken care of so that the damage and inconvenience are as small as possible.	All	I	D	B	L	The design as a whole	

Forurensningsloven (LOV-1981-03-13-6)	Lov om vern mot forurensninger og om avfall / Act on protection against pollution and waste (Pollution Control Act) (https://lovdata.no/dokument/NL/lov/1981-03-13-6?q=forurensningsloven)	Section 2(6)	Forurensning og avfallsproblemer som skyldes virksomhet på norsk område skal motvirkes i samme utstrekning hva enten skadene eller ulempene inntrer i eller utenfor Norge.	Pollution and waste problems caused by activities in Norwegian territory shall be counteracted to the same extent as either the damage or disadvantages occur in or outside Norway.	All	I	D	B	L	General requirement, not directly related to facility design
Forurensningsloven (LOV-1981-03-13-6)	Lov om vern mot forurensninger og om avfall / Act on protection against pollution and waste (Pollution Control Act) (https://lovdata.no/dokument/NL/lov/1981-03-13-6?q=forurensningsloven)	Section 20	Hvis et anlegg blir nedlagt eller en virksomhet stanser, skal eieren eller brukeren gjøre det som til enhver tid er nødvendig for å motvirke forurensninger.	If a facility is shut down or a business stops, the owner or user shall do what is necessary at all times to prevent contaminants.	All	I	D	B	L	Will be part of a monitoring programme that shall be included in the licence application
Avfallsforskriften (FOR-2004-06-01-930)	Forskrift om gjenvinning og behandling av avfall / Regulation on recycling and treatment of waste (https://lovdata.no/dokument/SF/forskrift/2004-06-01-930?q=avfallsforskriften)	Section 9-6	Bare farlig avfall og avfall som oppfyller forurensningsmyndighetens kriterier for deponering av farlig avfall, tillates deponert på deponier for farlig avfall.	Only hazardous waste and waste that meets the pollution authority's criteria for disposal of hazardous waste are allowed to be deposited at hazardous waste landfills.	Landfill				L	Design is compatible with the Norwegian requirements for hazardous waste landfills. Ikonen et al. (2020), Ch. 9, Table 9-3. Placement of inert decommissioning waste (concrete, soil) and hazardous waste in the same unit is not possible based on this requirement, even though the design would be the same for both.
Avfallsforskriften (FOR-2004-06-01-930)	Forskrift om gjenvinning og behandling av avfall / Regulation on recycling and treatment of waste (https://lovdata.no/dokument/SF/forskrift/2004-06-01-930?q=avfallsforskriften)	Section 16-4	Radioaktivt avfall skal ikke blandes sammen med annet avfall og ulike typer radioaktivt avfall skal ikke sammenblandes dersom dette kan medføre fare for forurensning eller skape problemer for den videre håndteringen av avfallet.	Radioactive waste should not be mixed with other waste and various types of radioactive waste should not be mixed if this can lead to a risk of contamination or cause problems for the further handling of the waste.	All	I	D	B	L	Different waste types as disposed in different repositories (DGR/Deep Borehole, Intermediate Depth, Landfill). Landfill: Design is compatible with the Norwegian requirements for hazardous waste landfills. Ikonen et al. (2020), Ch. 9, Table 9-3. Waste is under the clearance levels and not considered as radioactive waste.
Avfallsforskriften (FOR-2004-06-01-930)	Forskrift om gjenvinning og behandling av avfall / Regulation on recycling and treatment of waste (https://lovdata.no/dokument/SF/forskrift/2004-06-01-930?q=avfallsforskriften)	Section 16-4	Det ikke er tillatt å fortynne radioaktivt avfall med den hensikt å komme under grensene for radioaktivt avfall i vedlegg I til forskrift 1. november 2010 nr. 1394 om forurensningslovens anvendelse på radioaktiv forurensning og radioaktivt avfall.	It is not permitted to dilute radioactive waste with the intention of coming under the limits of radioactive waste in Annex I to Regulation 1 November 2010 no. 1394 on the application of the Pollution Control Act to radioactive pollution and radioactive waste.	All	I	D	B	L	Dilution of radioactive waste will not be done. Landfill: Waste is under the clearance levels and not considered as radioactive waste.
Avfallsforskriften (FOR-2004-06-01-930)	Forskrift om gjenvinning og behandling av avfall / Regulation on recycling and treatment of waste (https://lovdata.no/dokument/SF/forskrift/2004-06-01-930?q=avfallsforskriften)	Section 17-7	Den driftsansvarlige skal utarbeide en avfallshåndteringsplan for minimering, behandling, gjenvinning og disponering av mineralavfall ut i fra prinsippet om bærekraftig utvikling. Formålet med planen er å hindre eller redusere avfallsproduksjonen og de negative miljøkonsekvensene av den, å fremme nyttiggjøring av mineralavfall dersom dette er miljømessig fornuftig og å sikre sikker disponering av mineralavfall på kort og lang sikt.	The operations manager shall prepare a waste management plan for minimizing, processing, recycling and disposal of mineral waste based on the principle of sustainable development. The purpose of the plan is to prevent or reduce waste production and its negative environmental consequences, to promote the use of mineral waste if this makes environmental sense and to ensure the safe disposal of mineral waste in the short and long term.	Landfill, Intermediate Depth	I			L	General requirement, not directly related to facility design
Avfallsforskriften (FOR-2004-06-01-930)	Forskrift om gjenvinning og behandling av avfall / Regulation on recycling and treatment of waste (https://lovdata.no/dokument/SF/forskrift/2004-06-01-930?q=avfallsforskriften)	Section 17-7	Avfallshåndteringsplanen skal gi tilstrekkelige opplysninger slik at det er mulig for forurensningsmyndigheten å vurdere den driftsansvarliges evne til å nå målene med avfallshåndteringsplanen og forpliktelsene i henhold til dette kapitlet. Planen skal særlig forklare hvordan valgt metode som benyttes til mineralutvinning og -behandling reduserer avfallsproduksjonen og miljøkonsekvensene av den.	The waste management plan shall provide sufficient information so that it is possible for the pollution authority to assess the ability of the operations manager to achieve the objectives of the waste management plan and the obligations in accordance with this chapter. In particular, the plan will explain how the chosen method used for mineral extraction and treatment reduces waste production and its environmental consequences.	Landfill, Intermediate Depth	I			L	Intermediate Depth: Monitoring of the environmental impacts of the project (Ikonen et al. 2020, Section 6.2.8). Landfill: Landfill Design presented in Ikonen et al. (2020), Ch. 9, assumed disposal of (non-radioactive) mineral waste. Re-use or recycling of non-radioactive inert was discussed as an alternative (Ikonen et al. 2020, Table 2-3). Ikonen et al. (2020), Section 2.1.4. See also Table 2-3 for concrete pre-treating and re-use/recycle options. Landfill repository monitoring (Ikonen et al. 2020, Section 9.2.8).
Avfallsforskriften (FOR-2004-06-01-930)	Forskrift om gjenvinning og behandling av avfall / Regulation on recycling and treatment of waste (https://lovdata.no/dokument/SF/forskrift/2004-06-01-930?q=avfallsforskriften)	Section 17-7	Avfallshåndteringsplanen skal minst inneholde følgende: a) en karakterisering av mineralavfallet i samsvar med vedlegg II til dette kapitlet b) en beskrivelse av hvordan miljøet og menneskers helse kan bli skadet av deponeringen av mineralavfallet c) forslag til tiltak for å minimere miljøvirkningen, herunder tiltak for å forebygge forringelse av vannkvaliteten og å hindre eller minimere luftforurensning d) forslag til framgangsmåter for overvåking og kontroll e) forslag til plan for avslutning, herunder rehabilitering f) om relevant, forslag til plan for etterdrift og forslag til framgangsmåter for overvåking og kontroll etter avslutning.	The waste management plan shall contain at least the following: a) a characterization of the mineral waste in accordance with Annex II to this chapter b) a description of how the environment and human health can be harmed by the disposal of mineral waste c) proposed measures to minimize environmental impact, including measures to prevent water quality deterioration and to prevent or minimize air pollution d) suggestions for monitoring and control procedures e) proposed plan for termination, including rehabilitation f) relevant, proposed plan for post-operation and proposed procedures for monitoring and control after termination.	Landfill, Intermediate Depth	I			L	Monitoring radiation safety (Ikonen et al. 2020, Section 2.2.1). Environmental impact factors (Ikonen et al. 2020, Section 2.2.11). Intermediate depth: Disposal facility monitoring and control systems (Ikonen et al. 2020, Section 6.1.2). Landfill design presented in Ikonen et al. (2020), Ch. 9, assumed disposal of (non-radioactive) mineral waste. Re-use or recycling of non-radioactive inert was discussed as an alternative (Ikonen et al. 2020, Table 2-3). Ikonen et al. (2020), Section 2.1.4. See also Table 2-3 for concrete pre-treating and re-use/recycle options. Landfill repository monitoring (Ikonen et al. 2020, Section 9.2.8).
Avfallsforskriften (FOR-2004-06-01-930)	Forskrift om gjenvinning og behandling av avfall / Regulation on recycling and treatment of waste (https://lovdata.no/dokument/SF/forskrift/2004-06-01-930?q=avfallsforskriften)	Section 17-9	Ved oppføring av et nytt avfallsanlegg eller endring av et eksisterende avfallsanlegg skal den driftsansvarlige sikre at: a) avfallsanlegget har en egnet beliggenhet b) avfallsanlegget utformes, forvaltes og vedlikeholdes på en slik måte at det sikres at det er fysisk stabilt c) avfallsanlegget utformes, forvaltes og vedlikeholdes på en slik måte at forurensning av jord, luft, overflatevann og grunnvann reduseres i størst mulig grad, jf. § 17-12 d) erosjon som følge av vann eller vind reduseres i den grad det er teknisk mulig og økonomisk gjennomførbart e) skader på landskapet begrenses i størst mulig grad f) det foreligger egnede fremgangsmåter for regelmessig overvåking og kontroll av avfallsanlegget.	When building a new waste facility or modifying an existing waste facility, the operations manager shall ensure that: a) waste system has a suitable location b) the waste system is designed, managed and maintained in such a way that it is ensured that it is physically stable c) the waste system is designed, managed and maintained in such a way that pollution of soil, air, surface water and groundwater is reduced to the greatest extent possible, cf. § 17-12 d) erosion due to water or wind is reduced to the extent that it is technically possible and economically feasible e) damage to the landscape is limited to the greatest extent possible f) appropriate procedures for regular monitoring and control of the waste disposal facility.	Landfill, Intermediate Depth	I			L	The reliable operation of systems and components shall be ensured through maintenance and regular periodic inspections and tests (Ikonen et al. 2020, Section 2.2.1). Monitoring radiation safety (Ikonen et al. 2020, Section 2.2.1). Intermediate depth: Disposal facility monitoring and control systems (Ikonen et al. 2020, Section 6.1.2). Environmental impact factors (e.g. landscape) (Ikonen et al. 2020, Section 2.2.11). Landfill: Design is compatible with the Norwegian requirements for hazardous waste landfills (Ikonen et al. 2020, Ch. 9, Table 9-3). Landfill repository monitoring (Ikonen et al. 2020, Section 9.2.8).

Avfallsforskriften (FOR-2004-06-01-930)	Forskrift om gjenvinning og behandling av avfall / Regulation on recycling and treatment of waste (https://lovdata.no/dokument/SF/forskrift/2004-06-01-930?q=avfallsforskriften)	Section 17-12	Den driftsansvarlige skal treffe alle nødvendige tiltak for å forebygge eller i størst mulig grad redusere eventuelle skadevirkninger på miljøet og menneskers helse som følge av håndtering av mineralavfall. Tiltakene skal blant annet bygge på de beste tilgjengelige teknikker, jf. forskrift 1. juni 2004 nr. 931 om begrensning av forurensning (forurensningsforskriften) kapittel 36 vedlegg II. Den driftsansvarlige skal blant annet: a) evaluere potensialet for sigevannproduksjon, herunder innholdet av forurensende stoff i sigevannet, i det deponerte avfallet under drift og etter avslutning av avfallsanlegget, og bestemme avfallsanleggets vannbalanse b) forebygge eller minimere sigevannproduksjonen og forurensning av overflatevann, herunder kystvann, og grunnvann fra avfallet. Ved deponering av mineralavfall i vann gjelder reglene i forskrift 15. desember 2006 nr. 1446 om rammer for vannforvaltningen c) treffe nødvendige tiltak for å samle opp og behandle forurenset vann og sigevann for å oppnå påkrevd utslippskvalitet d) treffe tilstrekkelige tiltak for å hindre eller redusere utslipp av støv og gass.	The operations manager shall take all necessary measures to prevent or to the greatest extent possible reduce any adverse effects on the environment and human health as a result of the handling of mineral waste. The measures shall, among other things, build on the best available techniques, cf. Regulation 1 June 2004 no. 931 on limiting pollution (pollution regulations) Chapter 36 Annex II. Among other things, the operations manager shall: a) evaluate the potential for sickening water production, including the content of pollutants in the sickle water, in the deposited waste during operation and after the closure of the waste facility, and determine the waste facility's water balance b) prevent or minimize water production and contamination of surface water, including coastal water, and groundwater from the waste. When depositing mineral waste in water, the rules in regulations 15 December 2006 no. 1446 apply to water management frameworks c) take necessary measures to collect and treat contaminated water and sickle water to achieve the required emission quality d) take adequate measures to prevent or reduce the release of dust and gas.	Landfill, Intermediate Depth	I			L	Environmental impact factors (Ikonen et al. 2020, Section 2.2.11). Intermediate Depth: Monitoring of the environmental impacts of the project (Ikonen et al. 2020, Section 6.2.8). Use of best available, proven technology (Ikonen et al. 2020, Section 2.2.7). Landfill: Design is compatible with the Norwegian requirements for hazardous waste landfills (Ikonen et al. 2020, Ch. 9, Table 9-3). Landfill: Design is compatible with the Norwegian requirements for hazardous waste landfills (Ikonen et al. 2020, Ch. 9, Table 9-3). Landfill repository monitoring (Ikonen et al. 2020, Section 9.2.8).	
Avfallsforskriften (FOR-2004-06-01-930)	Forskrift om gjenvinning og behandling av avfall / Regulation on recycling and treatment of waste (https://lovdata.no/dokument/SF/forskrift/2004-06-01-930?q=avfallsforskriften)	Section 17-15	Den driftsansvarlige for avfallsanlegg som forurensningsmyndighetene har klassifisert som et risikoanlegg i henhold til bestemmelsene i vedlegg III til dette kapitlet, unntatt anlegg som faller inn under virkeområdet til forskrift 17. juni 2005 nr. 672 om tiltak for å forebygge og begrense konsekvensene av storulykker i virksomheter der farlige kjemikalier forekommer (storulykkeforskriften), skal før driften tar til: a) utarbeide en plan for forebygging av større ulykker ved håndtering av mineralavfall og iverksette et sikkerhetsstyringssystem som gjennomfører den, i samsvar med bestemmelsene i pkt. 1 i vedlegg I til dette kapitlet. Som en del av denne planen skal den driftsansvarlige utpeke en sikkerhetsansvarlig med ansvar for gjennomføring og regelmessig tilsyn med planen for forebygging av større ulykker b) iverksette en beredskapsplan som fastslår hvilke tiltak som skal treffes i tilfelle en ulykke, i samsvar med bestemmelsene i pkt. 2 i vedlegg I til dette kapitlet.	The operations manager for waste facilities that the pollution authorities have classified as a risk facility in accordance with the provisions of Annex III to this chapter, except for facilities that fall under the scope of regulations 17 June 2005 no. 672 on measures to prevent and limit the consequences of major accidents in enterprises where hazardous chemicals occur (major accident regulations), shall before operation take into account: a) develop a plan for the prevention of major accidents when handling mineral waste and implement a safety management system that implements it, in accordance with the provisions of Section 1 of Annex I of this chapter. As part of this plan, the operations manager shall appoint a safety officer responsible for implementation and regular supervision of the plan for the prevention of major accidents b) implement a contingency plan that determines what measures should be taken in the event of an accident, in accordance with the provisions of Section 2 of Annex I of this chapter.	Landfill, Intermediate Depth	I			L	Incidents and accidents (Ikonen et al. 2020, Sections 2.2.1, 6.2.6, 9.2.6). Landfill: Design is compatible with the Norwegian requirements for hazardous waste landfills (Ikonen et al. 2020, Ch. 9, Table 9-3). The specific plans mentioned in the requirement: to be decided.	
FOR-2017-06-21-854	Forskrift om konsekvensutredninger / Regulation on impact assessments (https://lovdata.no/dokument/LTI/forskrift/2017-06-21-854)	APPENDIX I, Item 3	a) Anlegg for opparbeiding av bestrålt kjernebrensel b) Anlegg beregnet: i) på produksjon eller anrikning av kjernebrensel ii) på bearbeiding av bestrålt kjernebrensel eller avfall med høy radioaktivitet iii) på disponering av bestrålt kjernebrensel iv) utelukkende på disponering av radioaktivt avfall v) utelukkende på lagring (planlagt å vare mer enn 10 år) av bestrålt kjernebrensel eller radioaktivt avfall på annet sted enn produksjonsstedet.	a) Facilities for the preparation of irradiated nuclear fuel b) Facilities calculated: i) on the production or enrichment of nuclear fuel ii) on the processing of irradiated nuclear fuel or waste with high radioactivity iii) on disposal of irradiated nuclear fuel iv) solely on the disposal of radioactive waste v) solely on storage (planned to last more than 10 years) of irradiated nuclear fuel or radioactive waste at a location other than the production site.	All	I	D	B	L	General requirement, not directly related to facility design. The requirement is that facilities for disposal of radioactive waste must be subject to a concequence assessment and part of a programme for zoning and planning (according to Planning and Building Act).	Plan- og bygningsloven (LOV-2008-06-27-71)
FOR-2017-06-21-854	Forskrift om konsekvensutredninger / Regulation on impact assessments (https://lovdata.no/dokument/LTI/forskrift/2017-06-21-854)	APPENDIX II, Item 2d	Dypboring, særlig: i. Geotermisk boring ii. Boring for atomavfall iii. Boring med sikte på vannforsyning med unntak av boring som utføres for å studere jordbunnens fasthet.	Deep drilling, in particular: i. Geothermal drilling ii. Drilling for nuclear waste iii. Drilling with a view to water supply with the exception of drilling carried out to study the firmness of the soil.	All	I	D	B	L	General requirement, not directly related to facility design. The requirement is that drilling for nuclear waste is pursuant to the Planning and Building Act.	Plan- og bygningsloven (LOV-2008-06-27-71)
INFCIRC/546 (24 December 1997)	Joint Convention on the Safety of Spent Fuel Management and Safety of Radioactive Waste Management (https://www.iaea.org/sites/default/files/infcirc546.pdf)	Article 11(i)		Each Contracting Party shall take the appropriate steps to: (i) ensure that criticality and removal of residual heat generated during radioactive waste management are adequately addressed.	DGR, Deep Borehole, (Intermediate Depth)	I	D	B		DGR, Deep Borehole: Spent fuel configuration and canister design (Ikonen et al. 2020, Section 2.2.2), thermal dimensioning (Ikonen et al. 2020, Sections 2.2.6, 7.1.1). Intermediate Depth: ILW package design. The formation of such spent fuel configurations that would cause an uncontrolled chain reaction of fission shall be prevented by means of the structural design of systems and components. The waste canisters containing spent fuel shall be designed so that no critical fuel configurations may be formed in any operational situations, including any anticipated incident or postulated accident. The emplaced canisters shall retain their subcriticality also over the long term when the canisters' internal structures may be corroded and partly filled with groundwater (Ikonen et al. 2020, Section 2.2.1).	SSG-27 (IAEA 2014)
INFCIRC/546 (24 December 1997)	Joint Convention on the Safety of Spent Fuel Management and Safety of Radioactive Waste Management (https://www.iaea.org/sites/default/files/infcirc546.pdf)	Article 13(i)		Each Contracting Party shall take the appropriate steps to ensure that procedures are established and implemented for a proposed radioactive waste management facility: (i) to evaluate all relevant site-related factors likely to affect the safety of such a facility during its operating lifetime as well as that of a disposal facility after closure.	All (site)	I	D	B	L	Site selection (Ikonen et al. 2020, Ch. 4). Landfill design is also compatible with IAEA guidelines given for near surface disposal, although the waste is under clearance levels and not considered as radioactive waste.	GSR Part 3 (IAEA 2014), 3.52

INFCIRC/546 (24 December 1997)	Joint Convention on the Safety of Spent Fuel Management and Safety of Radioactive Waste Management (https://www.iaea.org/sites/default/files/infcirc546.pdf)	Article 14(i)	Each Contracting Party shall take the appropriate steps to ensure that: (i) the design and construction of a radioactive waste management facility provide for suitable measures to limit possible radiological impacts on individuals, society and the environment, including those from discharges or uncontrolled releases.	All	I	D	B	L	The design as a whole. Facility construction: Intermediate Depth (Ikonen et al. 2020, Section 6.1.7); DGR (Ikonen et al. 2020, Section 7.1.7, Figure 7-8); Deep Borehole (Ikonen et al. 2020, Sections 8.1.9, 8.2.1); Landfill (Ikonen et al. 2020, Sections 9.1.6, 9.1.7). Landfill design is also compatible with IAEA guidelines given for near surface disposal, although the waste is under clearance levels.	
INFCIRC/546 (24 December 1997)	Joint Convention on the Safety of Spent Fuel Management and Safety of Radioactive Waste Management (https://www.iaea.org/sites/default/files/infcirc546.pdf)	Article 14(iii)	Each Contracting Party shall take the appropriate steps to ensure that: (iii) at the design stage, technical provisions for the closure of a disposal facility are prepared.	All	I	D	B	L	Closure design: Intermediate Depth (Ikonen et al. 2020, Figure 6-8, Section 6.3); DGR (Ikonen et al. 2020, Sections 2.1.2, 7.3); Deep Borehole (Ikonen et al. 2020, Section 8.3); Landfill (Ikonen et al. 2020, Section 9.3)	
INFCIRC/546 (24 December 1997)	Joint Convention on the Safety of Spent Fuel Management and Safety of Radioactive Waste Management (https://www.iaea.org/sites/default/files/infcirc546.pdf)	Article 14(iv)	Each Contracting Party shall take the appropriate steps to ensure that: (iv) the technologies incorporated in the design and construction of a radioactive waste management facility are supported by experience, testing or analysis.	All	I	D	B	L	Facility construction: Intermediate Depth (Ikonen et al. 2020, Section 6.1.7); DGR (Ikonen et al. 2020, Section 7.1.7, Figure 7-8); Deep Borehole (Ikonen et al. 2020, Sections 8.1.9, 8.2.1); Landfill (Ikonen et al. 2020, Sections 9.1.6, 9.1.7). The reliable operation of systems and components shall be ensured through maintenance and regular periodic inspections and tests (Ikonen et al. 2020, Section 2.2.1).	
INFCIRC/546 (24 December 1997)	Joint Convention on the Safety of Spent Fuel Management and Safety of Radioactive Waste Management (https://www.iaea.org/sites/default/files/infcirc546.pdf)	Article 15(i)	Each Contracting Party shall take the appropriate steps to ensure that: (i) before construction of a radioactive waste management facility, a systematic safety assessment and an environmental assessment appropriate to the hazard presented by the facility and covering its operating lifetime shall be carried out.	All	I	D	B	L	General requirement, not directly related to facility design. Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7).	GSR Part 3 (IAEA 2014), Req. 13
INFCIRC/546 (24 December 1997)	Joint Convention on the Safety of Spent Fuel Management and Safety of Radioactive Waste Management (https://www.iaea.org/sites/default/files/infcirc546.pdf)	Article 15(ii)	Each Contracting Party shall take the appropriate steps to ensure that: (ii) in addition, before construction of a disposal facility, a systematic safety assessment and an environmental assessment for the period following closure shall be carried out and the results evaluated against the criteria established by the regulatory body.	All	I	D	B	L	General requirement, not directly related to facility design. Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7).	GSR Part 3 (IAEA 2014), Req. 13
INFCIRC/546 (24 December 1997)	Joint Convention on the Safety of Spent Fuel Management and Safety of Radioactive Waste Management (https://www.iaea.org/sites/default/files/infcirc546.pdf)	Article 15(iii)	Each Contracting Party shall take the appropriate steps to ensure that: (iii) before the operation of a radioactive waste management facility, updated and detailed versions of the safety assessment and of the environmental assessment shall be prepared when deemed necessary to complement the assessments referred to in paragraph (i).	All	I	D	B	L	General requirement, not directly related to facility design. Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7).	GSR Part 3 (IAEA 2014), 3.35 LOV-2008-06-27-71, Ch. 14 FOR-2017-06-21-854
INFCIRC/546 (24 December 1997)	Joint Convention on the Safety of Spent Fuel Management and Safety of Radioactive Waste Management (https://www.iaea.org/sites/default/files/infcirc546.pdf)	Article 16(iii)	Each Contracting Party shall take the appropriate steps to ensure that: (iii) operation, maintenance, monitoring, inspection and testing of a radioactive waste management facility are conducted in accordance with established procedures. For a disposal facility the results thus obtained shall be used to verify and to review the validity of assumptions made and to update the assessments as specified in Article 15 for the period after closure.	All	I	D	B	L	The reliable operation of systems and components shall be ensured through maintenance and regular periodic inspections and tests (Ikonen et al. 2020, Section 2.2.1). Monitoring radiation safety (Ikonen et al. 2020, Section 2.2.1). Intermediate depth, DGR: Disposal facility monitoring and control systems (Ikonen et al. 2020, Sections 6.1.2, 7.1.2). Control and maintenance rooms (Ikonen et al. 2020, Figure 6-1, Section 6.1.1, 6.1.4), maintenance washing (Ikonen et al. 2020, Sections 6.1.2, 7.1.2). Deep Borehole: Monitoring (Ikonen et al. 2020, Section 8.2.7). Landfill: Monitoring (Ikonen et al. 2020, Section 9.2.8).	
INFCIRC/546 (24 December 1997)	Joint Convention on the Safety of Spent Fuel Management and Safety of Radioactive Waste Management (https://www.iaea.org/sites/default/files/infcirc546.pdf)	Article 16(iv)	Each Contracting Party shall take the appropriate steps to ensure that: (iv) engineering and technical support in all safety-related fields are available throughout the operating lifetime of a radioactive waste management facility.	All	I	D	B	L	The support point of personnel handling nuclear fuel is in the operation building where the access control point for the controlled underground area is located (Ikonen et al. 2020, Section 5.6).	
INFCIRC/546 (24 December 1997)	Joint Convention on the Safety of Spent Fuel Management and Safety of Radioactive Waste Management (https://www.iaea.org/sites/default/files/infcirc546.pdf)	Article 16(v)	Each Contracting Party shall take the appropriate steps to ensure that: (v) procedures for characterization and segregation of radioactive waste are applied.	All	I	D	B	L	Predisposal management issue. To be decided.	
INFCIRC/546 (24 December 1997)	Joint Convention on the Safety of Spent Fuel Management and Safety of Radioactive Waste Management (https://www.iaea.org/sites/default/files/infcirc546.pdf)	Article 16(ix)	Each Contracting Party shall take the appropriate steps to ensure that: (ix) plans for the closure of a disposal facility are prepared and updated, as necessary, using information obtained during the operating lifetime of that facility and are reviewed by the regulatory body.	All	I	D	B	L	Closure design: Intermediate Depth (Ikonen et al. 2020, Figure 6-8, Section 6.3); DGR (Ikonen et al. 2020, Sections 2.1.2, 7.3); Deep Borehole (Ikonen et al. 2020, Section 8.3); Landfill (Ikonen et al. 2020, Section 9.3)	
SF-1 (IAEA 2006)	Fundamental Safety Principles (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1273_web.pdf)	3.12	Effective leadership and management for safety must be established and sustained in organizations concerned with, and facilities and activities that give rise to, radiation risks.	All	I	D	B	L	General requirement, not directly related to facility design	
SF-1 (IAEA 2006)	Fundamental Safety Principles (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1273_web.pdf)	3.25	Measures for controlling radiation risks must ensure that no individual bears an unacceptable risk of harm.	All	I	D	B	L	The design as a whole. Radiation protection (Ikonen et al. 2020, Sections 6.2.5, 7.1.1, 7.2.5, 8.2.4, 9.2.5).	
SF-1 (IAEA 2006)	Fundamental Safety Principles (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1273_web.pdf)	3.28	The present system of radiation protection generally provides appropriate protection of ecosystems in the human environment against harmful effects of radiation exposure. The general intent of the measures taken for the purposes of environmental protection has been to protect ecosystems against radiation exposure that would have adverse consequences for populations of a species (as distinct from individual organisms).	All	I	D	B	L	Radiation protection (Ikonen et al. 2020, Sections 6.2.5, 7.1.1, 7.2.5, 8.2.4, 9.2.5). The fulfilment of requirements concerning radiation safety during the operation of the disposal facility shall be ensured through continuous or regular measurements. The potential release routes and the environment of the facility shall in particular be subjected to monitoring. In order to monitor the potential release routes of radioactive substances, systems shall be designed for measuring and recording data on the quantities of radioactive substances released into the environment. It shall be possible to also monitor the emissions during an anticipated operational transient or a postulated accident (Ikonen et al. 2020, Section 2.2.1). Environmental impact factors (Ikonen et al. 2020, Section 2.2.11).	GSG-8 (IAEA 2018), Chapter 4

GSR Part 1 (Rev. 1) (IAEA 2016)	Governmental, Legal and Regulatory Framework for Safety (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1713web-70795870.pdf)	Requirement 24	The applicant shall be required to submit an adequate demonstration of safety in support of an application for the authorization of a facility or an activity.	All	I	D	B	L	General requirement, not directly related to facility design. Safety case and licensing (Ikonen et al. 2020, Section 2.2.1).	
GSR Part 2 (IAEA 2016)	Leadership and Management for Safety (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1750web.pdf)	Requirement 1	The registrant or licensee — starting with the senior management — shall ensure that the fundamental safety objective of protecting people and the environment from harmful effects of ionizing radiation is achieved.	All	I	D	B	L	The design as a whole	SF-1 (IAEA 2006), 3.3 GSR Part 1 (Rev. 1) (IAEA 2016), Req. 6 GSR Part 3 (IAEA 2014), Req. 4, 9
GSR Part 3 (IAEA 2014)	Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1578_web-57265295.pdf)	Requirement 14, 32	Registrants and licensees and employers shall conduct monitoring to verify compliance with the requirements for protection and safety.	All	I	D	B	L	Monitoring radiation safety (Ikonen et al. 2020, Section 2.2.1). Surveillance and monitoring (Ikonen et al. 2020, Sections 5.2, 5-6, 5-7, Figures 5-4, 5-5). Intermediate depth, DGR: The purpose of condition monitoring is to monitor the condition of the disposal facility and systems during the operating phase. Instrumentation systems are used for gathering and processing information on the condition of the facility and ensuring that working safety is good in the facility. The monitoring and control data are collected in the control room in the operational building. The following measurements can be carried out in the disposal facility: measurements of air, bedrock and water temperature; air humidity; drainage water level; air activity; CO-, CO2-, NOx- and radon content; air dust content; as well as smoke detection (Ikonen et al. 2020, Sections 6.1.2, 7.1.2; see also 6.2.8, 7.2.8). DGR: Measurements related to nuclear material (high level waste) safeguards are also included (Ikonen et al. 2020, Section 7.1.2). Deep Borehole: Monitoring (Ikonen et al. 2020, Section 8.2.7). Landfill: Monitoring (Ikonen et al. 2020, Section 9.2.8).	GSG-7 (IAEA 2018), 3.97–3.140, Chapter 7 SSG-31 (IAEA 2014), Ch. 5
GSR Part 3 (IAEA 2014)	Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1578_web-57265295.pdf)	Requirement 15	Registrants and licensees shall apply good engineering practice and shall take all practicable measures to prevent accidents and to mitigate the consequences of those accidents that do occur.	All	I	D	B	L	Incidents and accidents: Intermediate Depth (Ikonen et al. 2020, Section 6.2.6); DGR (Ikonen et al. 2020, Section 7.2.6); Deep Borehole (Ikonen et al. 2020, Sections 8.2.5); Landfill (Ikonen et al. 2020, Section 9.2.6)	SF-1 (IAEA 2006), 3.30 ICRP Publication 103 (2007), 317
GSR Part 5 (IAEA 2009)	Predisposal Management of Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1368_web.pdf)	Requirement 11	Waste shall be stored in such a manner that it can be inspected, monitored, retrieved and preserved in a condition suitable for its subsequent management. Due account shall be taken of the expected period of storage, and, to the extent possible, passive safety features shall be applied.	All (storage at National Facility site before disposal)	I	D	B	L	Storage (Ikonen et al. 2020, Section 5.7, Ch. 3, Figure 5-5). Intermediate Depth, DGR: Storage, waste reception building (Ikonen et al. 2020, Section 5.7, Ch. 3, Figures 5-4, 5-5); Storage of canisters (DGR) (Ikonen et al. 2020, Section 7.1.1, Figures 7-1, 7-2). Deep Borehole: Storage location for waste (Fischer et al. 2020, Section 4.2.4). The reliable operation of systems and components shall be ensured through maintenance and regular periodic inspections and tests (Ikonen et al. 2020, Section 2.2.1). Monitoring radiation safety (Ikonen et al. 2020, Section 2.2.1). Intermediate depth, DGR: Disposal facility monitoring and control systems (Ikonen et al. 2020, Sections 6.1.2, 7.1.2). Deep Borehole: Monitoring (Ikonen et al. 2020, Section 8.2.7). Landfill: Container laydown area option (Ikonen et al. 2020, Figure 5-5, Section 5.7), temporary storage area for waste packages (Ikonen et al. 2020, Table 9-5), monitoring (Ikonen et al. 2020, Section 9.2.8).	WS-G-6.1 (IAEA 2006) DGR, Deep Borehole (spent fuel storage): SSG-15 (Rev. 1) (IAEA 2020), Chapter 6
GSR Part 5 (IAEA 2009)	Predisposal Management of Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1368_web.pdf)	4.22	Provision has to be made for the regular monitoring, inspection and maintenance of the waste and of the storage facility to ensure their continued integrity. The adequacy of the storage capacity has to be periodically reviewed, with account taken of the predicted waste arisings, both from normal operation and from possible incidents, of the expected lifetime of the storage facility and of the availability of disposal options.	All (storage at National Facility site before disposal)	I	D	B	L	Storage (Ikonen et al. 2020, Section 5.7, Ch. 3, Figure 5-5). The reliable operation of systems and components shall be ensured through maintenance and regular periodic inspections and tests (Ikonen et al. 2020, Section 2.2.1). Monitoring radiation safety (Ikonen et al. 2020, Section 2.2.1). Surveillance and monitoring (Ikonen et al. 2020, Sections 5.2, 5-6, 5-7, 6.2.8, 7.2.8, Figures 5-4, 5-5). Intermediate depth, DGR: Disposal facility monitoring and control systems (Ikonen et al. 2020, Sections 6.1.2, 7.1.2). Control and maintenance rooms (Ikonen et al. 2020, Figure 6-1, Section 6.1.1, 6.1.4). Deep Borehole: Monitoring (Ikonen et al. 2020, Section 8.2.7), storage (Fischer et al. 2020, Section 4.2.4). Landfill: Container laydown area option (Ikonen et al. 2020, Figure 5-5, Section 5.7), temporary storage area for waste packages (Ikonen et al. 2020, Table 9-5), monitoring (Ikonen et al. 2020, Section 9.2.8).	WS-G-6.1 (IAEA 2006)
GSR Part 5 (IAEA 2009)	Predisposal Management of Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1368_web.pdf)	Requirement 12	Waste packages and unpackaged waste that are accepted for processing, storage and/or disposal shall conform to criteria that are consistent with the safety case.	All	I	D	B	L	Packaging (Ikonen et al. 2020, Section 2.2.2). ILW packages (Ikonen et al. 2020, Figure 2-8); LILW packages (Ikonen et al. 2020, Figure 2-9). Deep Borehole: Waste packages (Ikonen et al. 2020, Section 8.2.3). Packaging plant (Ikonen et al. 2020, Sections 2.2.5, 5.7, Figure 5-5).	SSR-6 (Rev. 1) (IAEA 2018), Section VI

GSR Part 5 (IAEA 2009)	Predisposal Management of Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1368_web.pdf)	4.24	Waste acceptance criteria have to be developed that specify the radiological, mechanical, physical, chemical and biological characteristics of waste packages and unpackaged waste that are to be processed, stored or disposed of; for example, their radionuclide content or activity limits, their heat output and the properties of the waste form and packaging.	All	I	D	B	L	Packaging (Ikonen et al. 2020, Section 2.2.2). ILW packages (Ikonen et al. 2020, Figure 2-8); LILW packages (Ikonen et al. 2020, Figure 2-9). Deep Borehole: Waste packages (Ikonen et al. 2020, Section 8.2.3). DGR: Thermal dimensioning (Ikonen et al. 2020, Sections 2.2.6, 7.1.1). Deep Borehole: Heat generation (Ikonen et al. 2020, Section 8.1.4). The concept description of the National Facility is, at this point, still flexible and able to be adjusted to different waste acceptance criteria or packaging options (Ikonen et al. 2020, Section 2.2.2). To be decided.	
GSR Part 5 (IAEA 2009)	Predisposal Management of Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1368_web.pdf)	4.25	Adherence to the waste acceptance criteria is essential for the safe handling and storage of waste packages and unpackaged waste during normal operation, for safety during possible accident conditions and for the long term safety of the subsequent disposal of the waste.	All	I	D	B	L	The concept description of the National Facility is, at this point, still flexible and able to be adjusted to different waste acceptance criteria or packaging options (Ikonen et al. 2020, Section 2.2.2). To be decided.	
GSR Part 5 (IAEA 2009)	Predisposal Management of Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1368_web.pdf)	4.26	The operators' procedures for the reception of waste have to contain provisions for safely managing waste that fails to meet the acceptance criteria; for example, by taking remedial actions or by returning the waste.	All	I	D	B	L	To be decided	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	1.14(a)	Specific landfill disposal: Disposal in a facility similar to a conventional landfill facility for industrial refuse but which may incorporate measures to cover the waste. Such a facility may be designated as a disposal facility for very low level radioactive waste (VLLW) with low concentrations or quantities of radioactive content [GSG-1]. Typical waste disposed of in a facility of this type may include soil and rubble arising from decommissioning activities.	Landfill				L	Landfill design is compatible with Norwegian regulations for hazardous waste landfills and with IAEA guidelines on near surface disposal. Design described in Ikonen et al. (2020), Ch. 9.	GSG-1 (IAEA 2009)
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	1.14(b)	Near surface disposal: Disposal in a facility consisting of engineered trenches or vaults constructed on the ground surface or up to a few tens of metres below ground level. Such a facility may be designated as a disposal facility for low level radioactive waste (LLW) [GSG-1].	Intermediate Depth (LLW only), Landfill	I			L	LLW disposal (Sections 6.1.1, 2.1.1, Figures 6-1, 6-2, Landfill: Ch. 9). LLW is disposed in the Intermediate Depth Repository, which is a geological repository rather than a near surface repository.	GSG-1 (IAEA 2009)
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	1.14(c)	Disposal of intermediate level waste: Depending on its characteristics, intermediate level radioactive waste (ILW) can be disposed of in different types of facility [GSG-1]. Disposal could be by emplacement in a facility constructed in caverns, vaults or silos at least a few tens of metres below ground level and up to a few hundred metres below ground level. It could include purpose built facilities and facilities developed in or from existing mines. It could also include facilities developed by drift mining into mountainsides or hillsides, in which case the overlying cover could be more than 100 m deep.	Intermediate Depth	I				ILW disposal (Sections 6.1.1, 2.1.1, Figures 6-1, 6-2)	GSG-1 (IAEA 2009)
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	1.14(d)	Geological disposal: Disposal in a facility constructed in tunnels, vaults or silos in a particular geological formation (e.g. in terms of its long term stability and its hydrogeological properties) at least a few hundred metres below ground level. Such a facility could be designed to receive high level radioactive waste (HLW) [GSG-1], including spent fuel if it is to be treated as waste. However, with appropriate design, a geological disposal facility could receive all types of radioactive waste.	DGR		D			Deep Geological Repository (Ikonen et al. 2020, Ch. 7)	GSG-1 (IAEA 2009) DGR, Deep Borehole, Intermediate Depth: ICRP Publication 122 (2013), 5
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	1.14(e)	Borehole disposal: Disposal in a facility consisting of an array of boreholes, or a single borehole, which may be between a few tens of metres up to a few hundreds of metres deep. Such a borehole disposal facility is designed for the disposal of only relatively small volumes of waste, in particular disused sealed radioactive sources. A design option for very deep boreholes, several kilometres deep, has been examined for the disposal of solid high level waste and spent fuel, but this option has not been adopted for a disposal facility by any State.	Deep Borehole			B		Borehole design and construction (Ikonen et al. 2020, Section 8.1.1)	GSG-1 (IAEA 2009)
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	1.24	The disposal system (i.e. the disposal facility and the environment in which it is sited) is developed in a series of steps in which the scientific understanding of the disposal system and of the design of the disposal facility is progressively advanced. Safety assessment is an important tool for guiding site selection and evaluation and for assisting with the design of the facility. It is also used for evaluating the prevailing level of understanding of the disposal system and for assessing the associated uncertainties through the various steps in the development of the facility. The extent and complexity of such an assessment will vary with the type of facility and will be related to the hazard potential of the waste.	All	I	D	B	L	Overall schedule with key steps (Ikonen et al. 2020, Section 2.2.4, 2.2.7, Ch. 3, Figure 2-13). Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7).	DGR, Intermediate Depth: SSG-14 (IAEA 2011), 2.6 Landfill: SSG-29 (IAEA 2014), 2.7
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	1.25	No relaxation of safety standards or requirements could be allowed on the grounds that waste retrieval may be possible or may be facilitated by a particular provision. It would have to be ensured that any such provision would not have an unacceptable adverse effect on safety or on the performance of the disposal system.	All	I	D	B	L	To be decided	SSG-23 (IAEA 2012), 6.74–6.78
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	1.26	The safety case (i.e. the collection of arguments and evidence to demonstrate the safety of a facility) for a disposal facility will be developed together with the development of the facility. This approach provides a basis for decisions relating to the development, operation and closure of the facility. It also allows the identification of areas of uncertainty on which attention needs to be focused to improve further the understanding of those aspects influencing the safety of the disposal system.	All	I	D	B	L	Long-term radiation safety is demonstrated through a safety case, i.e. the collection of arguments and evidence to demonstrate the safety of a disposal facility (Ikonen et al. 2020, Section 2.2.1). Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7).	NEA No. 3679 (OECD/NEA 2004) NEA No. 6319 (OECD/NEA 2008) NEA No. 6251 (OECD/NEA 2009) NEA No. 6923 (OECD/NEA 2011) NEA/RWM/R(2013)1 (OECD/NEA 2013) NEA/RWM/R(2013)9 (OECD/NEA 2014)

SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	2.15, 3.47, 5.11	The safety objective is to site, design, construct, operate and close a disposal facility so that protection after its closure is optimized, social and economic factors being taken into account. A reasonable assurance also has to be provided that doses and risks to members of the public in the long term will not exceed the dose constraints or risk constraints that were used as design criteria.	All	I	D	B	L	The design as a whole	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	3.4	Safety after closure is achieved by developing a disposal system in which the various components work together to provide and to ensure the required level of safety. This approach offers flexibility to the designer of a disposal facility to adapt the facility's layout and engineered barriers so as to take advantage of the natural characteristics of the site and the barrier potential of the host geology, if applicable.	All	I	D	B	L	Barrier system: Intermediate depth (Ikonen et al. 2020, Figure 2-1, Section 2.1.1); DGR (Ikonen et al. 2020, Figures 2-1, 2.5, Section 2.1.2); Deep Borehole (Ikonen et al. 2020, Section 2.1.3); Landfill (Ikonen et al. 2020, Table 9-3, Sections 2.1.4 9.1.1). Layout (Ikonen et al. 2020, Figure 6-5). Layout flexibility and constraints (Ikonen et al. 2020, Section 2.2.6). Adaptation of design to match the bedrock conditions/rock suitability: Intermediate Depth (Ikonen et al. 2020, Section 6.1.7, 6.2.8); DGR (Ikonen et al. 2020, Section 7.1.1, 7.1.7); Deep Borehole (Ikonen et al. 2020, Sections 8.0, 8.1.8).	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	Requirement 3	The operator of a disposal facility for radioactive waste shall be responsible for its safety. The operator shall carry out safety assessment and develop and maintain a safety case, and shall carry out all the necessary activities for site selection and evaluation, design, construction, operation, closure and, if necessary, surveillance after closure, in accordance with national strategy, in compliance with the regulatory requirements and within the legal and regulatory infrastructure.	All	I	D	B	L	The design as a whole. Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7).	NEA/RWM/R(2013)1 (OECD/NEA 2013) NEA/RWM/R(2013)9 (OECD/NEA 2014)
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	3.13	The operator has to conduct or commission the research and development work necessary to ensure that the planned technical operations can be practically and safely accomplished, and to demonstrate this. The operator likewise has to conduct or commission the research work necessary to investigate, to understand and to support the understanding of the processes on which the safety of the disposal facility depends. The operator also has to carry out all the necessary investigations of sites and of materials and has to assess their suitability and obtain all the data necessary for the purposes of safety assessment.	All (incl. site)	I	D	B	L	General requirement, not directly related to facility design. Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7). DGR: Demonstration tunnels (Ikonen et al. 2020, Section 7.1.8, Figure 7-1). Deep Borehole: Demonstrations of borehole disposal operation (Ikonen et al. 2020, Section 8.1.10).	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	3.14	The operator has to establish technical specifications that are justified by safety assessment, to ensure that the disposal facility is developed in accordance with the safety case.	All	I	D	B	L	General requirement, not directly related to facility design	DGR, Intermediate Depth: SSG-14 (IAEA 2011), 3.10 Landfill: SSG-29 (IAEA 2014), 3.13
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	Requirement 4	Throughout the process of development and operation of a disposal facility for radioactive waste, an understanding of the relevance and the implications for safety of the available options for the facility shall be developed by the operator. This is for the purpose of providing an optimized level of safety in the operational stage and after closure.	All	I	D	B	L	General requirement, not directly related to facility design	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	3.17	Disposal facilities for radioactive waste may be developed and operated over a period of several years or several decades. Key decisions, such as decisions on site selection and evaluation, and on the design, construction, operation and closure of the disposal facility, are expected to be made as the project develops. In this process, decisions are made on the basis of the information available at the time, which may be either quantitative or qualitative, and the confidence that can be placed in that information.	All	I	D	B	L	General requirement, not directly related to facility design. Continuous design process. Overall schedule with key steps (Ikonen et al. 2020, Section 2.2.4, 2.2.7, Ch. 3, Figure 2-13).	NEA No. 6433 (OECD/NEA 2008), p. 9 ICRP Publication 81 (1998), 72 DGR, Intermediate Depth: SSG-14 (IAEA 2011), 2.4, 4.3, 6.1 Landfill: SSG-29 (IAEA 2014), 6.1
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	3.18	Decisions on the development, operation and closure of the facility are constrained by external factors, which include: national policy and preferences, the capacity and capability of existing storage and disposal facilities to accommodate waste, and the availability of suitable sites and geological formations to host planned new disposal facilities. An adequate level of confidence in the safety of each disposal facility has to be developed before decisions are taken.	All	I	D	B	L	General requirement, not directly related to facility design	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	3.19	At each major decision point, the implications for the safety of the available design options and operational options for the disposal facility have to be considered and taken into account. Ensuring safety, both in the operational stage and after closure, is the overriding concern at each decision point. If more than one option is capable of providing the required level of safety, then other factors also have to be considered. These factors could include public acceptability, cost, site ownership, existing infrastructure and transport routes.	All	I	D	B	L	General requirement, not directly related to facility design	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	3.20	Consideration has to be given to locating the facility away from significant known mineral resources, geothermal water and other valuable subsurface resources. This is to reduce the risk of human intrusion into the site and to reduce the potential for use of the surrounding area to be in conflict with the facility. The safety of the facility has to be considered at every step in the decision making process to ensure that safety is optimized in the sense discussed in the Appendix.	All (site)	I	D	B	L	Affects site selection (favours sites with away from significant known mineral resources, geothermal water and other valuable subsurface resources). Site selection (Ikonen et al. 2020, Ch. 4).	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	Requirement 5	The operator shall evaluate the site and shall design, construct, operate and close the disposal facility in such a way that safety is ensured by passive means to the fullest extent possible and the need for actions to be taken after closure of the facility is minimized.	All (incl. site)	I	D	B	L	The design as a whole	

SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	3.21	In the operational stage of a disposal facility for radioactive waste, certain active control measures have to be applied. However, where passive features such as the shielding and containment provided by the packaging material can provide safety, then safety has to be ensured by such passive means.	All	I	D	B	L	Containment: Intermediate depth (Ikonen et al. 2020, Table 2-1); DGR (Ikonen et al. 2020, Section 2.1.2); Deep Borehole (Ikonen et al. 2020, Sections 2.1.3, 8.2.1); Landfill (Ikonen et al. 2020, Section 2.1.4). Structures, systems and equipment containing significant amounts of radioactive substances shall be placed in separate rooms or shielded effectively. Adequate safety margins shall be incorporated in the design of radiation shielding (Ikonen et al. 2020, Section 2.2.1). Disposal facility monitoring and control systems (Ikonen et al. 2020, Sections 6.1.2, 7.1.2). DGR: During transfer, the canister is covered with a radiation shield (Ikonen et al. 2020, Section 7.1.2).	DGR, Intermediate Depth: SSG-14 (IAEA 2011), 4.17
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	3.22	To some extent, the safety of a disposal facility can depend on some future actions such as maintenance work or surveillance. However, this dependence has to be minimized to the extent possible.	All	I	D	B	L	The disposal concept is designed so that there will be no need for monitoring or other maintenance after the closure of connections to the repositories. If desired, signs can be left on the site to indicate the presence of radioactive waste underground. Post-closure monitoring can be included, if required (Ikonen et al. 2020, Section 2.2.7).	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	3.23	For a geological disposal facility, it is possible to provide for safety after closure by means of passive features.	DGR, Intermediate Depth	I	D			Long-term safety is provided through the repository design by passive means to fulfil the requirements and shall not rely on extended monitoring or maintenance of the site (Ikonen et al. 2020, Section 2.2.1).	NEA No. 6424 (OECD/NEA 2009), Section 3.1.2
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	3.23	It is likewise possible to provide for the safety of a borehole disposal facility after closure by means of passive features, owing to the host geology.	Deep Borehole			B		Site selection (Ikonen et al. 2020, Ch. 4)	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	3.23	In the case of a near surface disposal facility, actions such as maintenance, monitoring or surveillance may be necessary for a period of time after closure to ensure safety.	Landfill				L	Post-closure period, institutional control (Ikonen et al. 2020, Sections 9.2.1, 9.3)	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	3.24	Providing for the safety of a disposal facility after closure by means of passive features will entail proper closure of the facility and ending the need for its active management. The cessation of management means that the disposal facility, with its associated radiological hazard, is no longer under active control. It is the performance of the natural and engineered barriers that provides safety after closure, together, for a near surface disposal facility, with institutional controls.	All	I	D	B	L	Closure design: Intermediate Depth (Ikonen et al. 2020, Figure 6-8, Section 6.3); DGR (Ikonen et al. 2020, Sections 2.1.2, 7.3); Deep Borehole (Ikonen et al. 2020, Section 8.3); Landfill (Ikonen et al. 2020, Section 9.3). Post-closure period (Ikonen et al. 2020, Section 2.2.7).	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	Requirement 6	The operator of a disposal facility shall develop an adequate understanding of the features of the facility and its host environment and of the factors that influence its safety after closure over suitably long time periods, so that a sufficient level of confidence in safety can be achieved.	All	I	D	B	L	General requirement, not directly related to facility design	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	3.32	A disposal facility is designed to contain the radionuclides associated with the radioactive waste and to isolate them from the accessible biosphere. The disposal facility is also designed to retard the dispersion of radionuclides in the geosphere and biosphere and to provide isolation of the waste from aggressive phenomena that could degrade the integrity of the facility. The various elements of the disposal system, including physical components and control procedures, contribute to performing safety functions in different ways over different timescales.	All	I	D	B	L	The design as a whole (as well as site properties)	NEA No. 6424 (OECD/NEA 2009), Section 3.2.1 DGR, Intermediate Depth: SSG-14 (IAEA 2011), 2.2
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	3.34	Adequate defence in depth has to be ensured by demonstrating that there are multiple safety functions, that the fulfilment of individual safety functions is robust and that the performance of the various physical components of the disposal system and the safety functions they fulfil can be relied upon, as assumed in the safety case and supporting safety assessment.	All	I	D	B	L	Safety functions: Intermediate depth (Ikonen et al. 2020, Table 2-1, Section 2.1.1); DGR (Ikonen et al. 2020, Table 2-2, Section 2.1.2); Landfill (Ikonen et al. 2020, Section 2.1.4, Table 9-3)	ICRP Publication 81 (1998), 66 NEA No. 5990 (OECD/NEA 2006), Section 5.3.3 NEA No. 6182 (OECD/NEA 2007), p. 24–25 NEA No. 6424 (OECD/NEA 2009), Section 3.1.3 NEA/RWM/R(2012)7 (OECD/NEA 2012), Section 2.3, 3.1.2 GSR Part 4 (Rev. 1) (IAEA 2016), Requirement 7, 13, para. 4.20, 4.21 SSG-23 (IAEA 2012), 6.29–6.42 DGR, Deep Borehole, Intermediate Depth: ICRP Publication 122 (2013), 90 Deep Borehole: SSG-1 (IAEA 2009), 4.50 DGR, Deep Borehole (spent fuel storage): SSG-15 (Rev. 1) (IAEA 2020), 6.13–6.15

SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	Requirement 7	The host environment shall be selected, the engineered barriers of the disposal facility shall be designed and the facility shall be operated to ensure that safety is provided by means of multiple safety functions. Containment and isolation of the waste shall be provided by means of a number of physical barriers of the disposal system. The performance of these physical barriers shall be achieved by means of diverse physical and chemical processes together with various operational controls. The capability of the individual barriers and controls together with that of the overall disposal system to perform as assumed in the safety case shall be demonstrated. The overall performance of the disposal system shall not be unduly dependent on a single safety function.	All	I	D	B	L	Barrier system: Intermediate depth (Ikonen et al. 2020, Figure 2-1, Section 2.1.1); DGR (Ikonen et al. 2020, Figures 2-1, 2.5, Section 2.1.2); Deep Borehole (Ikonen et al. 2020, Section 2.1.3); Landfill (Ikonen et al. 2020, Table 9-3, Sections 2.1.4 9.1.1). Containment: Intermediate depth (Ikonen et al. 2020, Table 2-1); DGR (Ikonen et al. 2020, Section 2.1.2); Deep Borehole (Ikonen et al. 2020, Sections 2.1.3, 8.2.1); Landfill (Ikonen et al. 2020, Section 2.1.4). Isolation: Intermediate depth (Ikonen et al. 2020, Table 2-1), DGR (Ikonen et al. 2020, Section 2.1.2); Deep Borehole (Ikonen et al. 2020, Section 2.1.3); Landfill (Ikonen et al. 2020, Section 2.1.4). DGR: Demonstration tunnels (Ikonen et al. 2020, Section 7.1.8, Figure 7-1).	NEA No. 6433 (OECD/NEA 2008), p. 7 DGR, Deep Borehole, Intermediate Depth: ICRP Publication 122 (2013), 4, 6, 7
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	3.35	The engineered and physical barriers that make up the disposal system are physical entities, such as the waste form, the packaging, the backfill, and the host environment and geological formation. A safety function may be provided by means of a physical or chemical property or process that contributes to containment and isolation, such as: impermeability to water; limited corrosion, dissolution, leach rate and solubility; retention of radionuclides; and retardation of radionuclide migration.	All	I	D	B	L	Safety functions: Intermediate depth (Ikonen et al. 2020, Table 2-1, Section 2.1.1); DGR (Ikonen et al. 2020, Table 2-2, Section 2.1.2); Landfill (Ikonen et al. 2020, Section 2.1.4, Table 9-3)	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	3.36	Active controls can also fulfil safety functions or contribute to confidence in natural and engineered barriers and safety functions. The presence of a number of physical and other elements performing safety functions gives assurance that even if any of them do not perform fully as expected (e.g. owing to an unexpected process or an unlikely event), a sufficient margin of safety will remain.	All	I	D	B	L	Safety functions: Intermediate depth (Ikonen et al. 2020, Table 2-1, Section 2.1.1); DGR (Ikonen et al. 2020, Table 2-2, Section 2.1.2); Landfill (Ikonen et al. 2020, Section 2.1.4, Table 9-3)	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	3.37	The physical elements and their safety functions can be complementary and can work in combination. The performance of a disposal system is thus dependent on different physical elements and on other elements that perform safety functions, which act over different time periods. For example, the roles of the waste package and the host geological formation for a geological disposal facility may vary in different time periods.	All	I	D	B	L	Safety functions: Intermediate depth (Ikonen et al. 2020, Table 2-1, Section 2.1.1); DGR (Ikonen et al. 2020, Table 2-2, Section 2.1.2); Landfill (Ikonen et al. 2020, Section 2.1.4, Table 9-3)	DGR, Intermediate Depth: SSG-14 (IAEA 2011), 4.16 Deep Borehole: SSG-1 (IAEA 2009), 4.51
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	3.38	The safety case has to explain and justify the functions performed by each physical element and other features. It also has to identify the time periods over which physical components and other features are expected to perform their various safety functions, and also the alternative or additional safety functions that are available if a physical element does not fully perform or another safety function is not fulfilled.	All	I	D	B	L	General requirement, not directly related to facility design. Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7).	NEA/RWM/R(2013)1 (OECD/NEA 2013) NEA/RWM/R(2013)9 (OECD/NEA 2014)
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	Requirement 8	The engineered barriers, including the waste form and packaging, shall be designed, and the host environment shall be selected, so as to provide containment of the radionuclides associated with the waste. Containment shall be provided until radioactive decay has significantly reduced the hazard posed by the waste. In addition, in the case of heat generating waste, containment shall be provided while the waste is still producing heat energy in amounts that could adversely affect the performance of the disposal system.	All	I	D	B	L	Containment: Intermediate depth (Ikonen et al. 2020, Table 2-1); DGR (Ikonen et al. 2020, Section 2.1.2); Deep Borehole (Ikonen et al. 2020, Sections 2.1.3, 8.2.1); Landfill (Ikonen et al. 2020, Section 2.1.4). Packaging (Ikonen et al. 2020, Section 2.2.2). DGR: Thermal dimensioning (Ikonen et al. 2020, Sections 2.2.6, 7.1.1). Deep Borehole: Heat generation (Ikonen et al. 2020, Section 8.1.4).	Landfill: SSG-29 (IAEA 2014), 4.18
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	3.39	The containment of radioactive waste implies designing the disposal facility to avoid or minimize the release of radionuclides. Releases of small amounts of gaseous radionuclides and of small fractions of other highly mobile species from some types of radioactive waste may be inevitable. Such releases, nevertheless, have to be demonstrated to be acceptable by means of safety assessment.	All	I	D	B	L	Containment: Intermediate depth (Ikonen et al. 2020, Table 2-1); DGR (Ikonen et al. 2020, Section 2.1.2); Deep Borehole (Ikonen et al. 2020, Sections 2.1.3, 8.2.1); Landfill (Ikonen et al. 2020, Section 2.1.4). Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7).	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	3.39	The containment may be provided by the characteristics of the waste form and the packaging and by the characteristics of other engineered components of the disposal system and the host environment and geological formation.	All	I	D	B	L	Containment: Intermediate depth (Ikonen et al. 2020, Table 2-1); DGR (Ikonen et al. 2020, Section 2.1.2); Deep Borehole (Ikonen et al. 2020, Sections 2.1.3, 8.2.1); Landfill (Ikonen et al. 2020, Section 2.1.4). Packaging (Ikonen et al. 2020, Section 2.2.2). The methods used for the construction, operation and sealing off repositories and other underground openings shall be chosen so that the bedrock will maintain its natural containment characteristics in an optimal fashion (Ikonen et al. 2020, Section 2.2.6).	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	3.40	The containment of the radionuclides in the waste form and the packaging over a defined period has to ensure that the majority of shorter lived radionuclides decay in situ. For low level waste, such periods would be of the order of several hundred years; for high level waste the period would be several thousands of years. For high level waste, it also has to be ensured that any migration of radionuclides outside the disposal system would occur only after the heat produced by radioactive decay has substantially decreased.	All	I	D	B	L	Containment: Intermediate depth (Ikonen et al. 2020, Table 2-1); DGR (Ikonen et al. 2020, Section 2.1.2); Deep Borehole (Ikonen et al. 2020, Sections 2.1.3, 8.2.1); Landfill (Ikonen et al. 2020, Section 2.1.4). Packaging (Ikonen et al. 2020, Section 2.2.2).	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	3.41, 2.15	Radioactive waste from mining and mineral processing may include radionuclides with very long half-lives. Providing assurance of the integrity of the containment features of disposal facilities for such waste over the corresponding timescales requires particular consideration. If the waste has activity levels for which the dose and/or risk criteria for human intrusion into such facilities might be exceeded, alternative disposal options will have to be considered. Possible alternative options include, for example, disposal of the waste below the surface, or separation of the radionuclide content giving rise to the higher dose, as determined by the safety case for the disposal facility.	Landfill, Intermediate Depth	I			L	WAC issue. To be decided.	

SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	3.42	Containment is most important for more highly concentrated radioactive waste, such as intermediate level waste and vitrified waste from fuel reprocessing, or for spent nuclear fuel. Attention also has to be given to the durability of the waste form. The most highly concentrated waste has to be emplaced in a containment configuration that is designed to retain its integrity for a long enough period of time to enable most of the shorter lived radionuclides to decay and for the associated generation of heat to decrease substantially. Such containment may not be practicable or necessary for low level waste. The containment capability of the waste package has to be demonstrated by means of safety assessment to be appropriate for the waste type and the overall disposal system.	DGR, Deep Borehole, Intermediate Depth	I	D	B		Containment: Intermediate depth (Ikonen et al. 2020, Table 2-1); DGR (Ikonen et al. 2020, Section 2.1.2); Deep Borehole (Ikonen et al. 2020, Sections 2.1.3, 8.2.1). Packaging (Ikonen et al. 2020, Section 2.2.2). ILW packages (Ikonen et al. 2020, Figure 2-8); LILW packages (Ikonen et al. 2020, Figure 2-9); Deep Borehole waste packages (Ikonen et al. 2020, Section 8.2.3). Packaging plant (Ikonen et al. 2020, Sections 2.2.5, 5.7, Figure 5-5). Most of the waste is assumed to be packed outside the National Facility (Ikonen et al. 2020, abstract). Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7).	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	Requirement 9	The disposal facility shall be sited, designed and operated to provide features that are aimed at isolation of the radioactive waste from people and from the accessible biosphere. The features shall aim to provide isolation for several hundreds of years for short lived waste and at least several thousand years for intermediate and high level waste. In so doing, consideration shall be given to both the natural evolution of the disposal system and events causing disturbance of the facility.	All	I	D	B	L	Isolation: Intermediate depth (Ikonen et al. 2020, Table 2-1); DGR (Ikonen et al. 2020, Section 2.1.2); Deep Borehole (Ikonen et al. 2020, Section 2.1.3); Landfill (Ikonen et al. 2020, Section 2.1.4)	Landfill: SSG-29 (IAEA 2014), 4.27
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	3.43	For near surface facilities, isolation has to be provided by the location and the design of the disposal facility and by operational and institutional controls.	Intermediate Depth (LLW only), Landfill	I			L	Isolation: Intermediate depth (Ikonen et al. 2020, Table 2-1); DGR (Ikonen et al. 2020, Section 2.1.2); Landfill (Ikonen et al. 2020, Section 2.1.4). Disposal facility monitoring and control systems (Ikonen et al. 2020, Sections 6.1.2). Post-closure period (Ikonen et al. 2020, Section 2.2.7). Landfill repository monitoring (Ikonen et al. 2020, Section 9.2.8).	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	3.43	For geological disposal of radioactive waste, isolation is provided primarily by the host geological formation as a consequence of the depth of disposal.	DGR, Deep Borehole, Intermediate Depth	I	D	B		Site selection (e.g. avoidance of sites with valuable resources) and the depth of the repositories (Intermediate Depth: design depth 100 m (Ikonen et al. 2020, Section 6.1.1); DGR: approximately 400 m (Ikonen et al. 2020, Section 7.1.1); Deep Borehole: > 1000 m). For all underground repositories, the depth will depend strongly on the site geology and for the deep borehole alternative the detailed disposal concept, especially the chosen borehole and container diameter (Ikonen et al. 2020, Ch. 1). The eventual disposal depths will be decided based on site-specific conditions.	NEA No. 6424 (OECD/NEA 2009), Section 3.2.2 DGR, Intermediate Depth: SSG-14 (IAEA 2011), 2.2
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	3.44	Isolation means design to keep the waste and its associated hazard apart from the accessible biosphere. It also means design to minimize the influence of factors that could reduce the integrity of the disposal facility. Sites and locations with higher hydraulic conductivities have to be avoided. Access to waste has to be made difficult to gain without, for example, violation of institutional controls for near surface disposal. Isolation also means providing for a very slow mobility of radionuclides to impede migration from disposal facilities.	All	I	D	B	L	Isolation: Intermediate depth (Ikonen et al. 2020, Table 2-1); DGR (Ikonen et al. 2020, Section 2.1.2); Deep Borehole (Ikonen et al. 2020, Section 2.1.3); Landfill (Ikonen et al. 2020, Section 2.1.4)	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	3.45	Location of a disposal facility in a stable geological formation provides protection of the facility from the effects of geomorphological processes, such as erosion and glaciation.	All (site)	I	D	B	L	Affects site selection (only sites in stable geological formations are allowed). Site selection (Ikonen et al. 2020, Ch. 4).	NEA No. 6424 (OECD/NEA 2009), Section 3.1.4 NEA/RWM/R(2013)9 (OECD/NEA 2014), p. 55 DGR, Deep Borehole, Intermediate Depth: ICRP Publication 122 (2013), 6
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	3.45	The disposal facility has to be located away from known areas of significant underground mineral resources or other valuable resources. This will reduce the likelihood of inadvertent disturbance of the facility and will avoid resources being made unavailable for exploitation.	All (site)	I	D	B	L	Affects site selection (favours sites located away from known areas of significant underground mineral resources or other valuable resources)	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	3.46	In some cases, it may not be possible to provide sufficient assurance of separation from the accessible biosphere, owing to phenomena such as uplift, erosion and glaciation. In such cases, and if the remaining activity in the waste is still significant at the time such phenomena occur, the possibility of human intrusion has to be evaluated in determining the degree of isolation provided.	All	I	D	B	L	General requirement, not directly related to facility design	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	Requirement 10	An appropriate level of surveillance and control shall be applied to protect and preserve the passive safety features, to the extent that this is necessary, so that they can fulfil the functions that they are assigned in the safety case for safety after closure.	All	I	D	B	L	The disposal concept is designed so that there will be no need for monitoring or other maintenance after the closure of connections to the repositories. If desired, signs can be left on the site to indicate the presence of radioactive waste underground. Post-closure monitoring can be included, if required (Ikonen et al. 2020, Section 2.2.7). Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7).	DGR, Intermediate Depth: SSG-14 (IAEA 2011), 6.65, 6.66 Landfill: SSG-29 (IAEA 2014), 4.29, 4.31, 4.44, 4.45, 4.48, 4.49, 4.50, 5.15, 6.69, 7.22
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	Requirement 11	Disposal facilities for radioactive waste shall be developed, operated and closed in a series of steps. Each of these steps shall be supported, as necessary, by iterative evaluations of the site, of the options for design, construction, operation and management, and of the performance and safety of the disposal system.	All	I	D	B	L	General requirement, not directly related to facility design. Overall schedule with key steps (Ikonen et al. 2020, Section 2.2.4, 2.2.7, Ch. 3, Figure 2-13). Facility construction in phases: Intermediate Depth (Ikonen et al. 2020, Sections 6.1.6, 6.2); DGR (Ikonen et al. 2020, Section 7.1.6); Deep Borehole (Ikonen et al. 2020, Section 8.1.9); Landfill (Ikonen et al. 2020, Section 9.1.6).	

SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	4.6, 4.7–4.11	The development of a safety case and supporting safety assessment for review by the regulatory body and interested parties is central to the development, operation and closure of a disposal facility for radioactive waste. The safety case substantiates the safety of the disposal facility and contributes to confidence in its safety. The safety case is an essential input to all important decisions concerning the disposal facility. It has to provide the basis for understanding the disposal system and how it will behave over time. It has to address site aspects and engineering aspects, providing the logic and rationale for the design, and has to be supported by safety assessment.	All	I	D	B	L	General requirement, not directly related to facility design. Safety case and licensing (Ikonen et al. 2020, Section 2.2.1).	NEA/RWM/R(2013)1 (OECD/NEA 2013) NEA/RWM/R(2013)9 (OECD/NEA 2014)
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	Requirement 12, 4.21–4.14	A safety case and supporting safety assessment shall be prepared and updated by the operator, as necessary, at each step in the development of a disposal facility, in operation and after closure. The safety case and supporting safety assessment shall be submitted to the regulatory body for approval. The safety case and supporting safety assessment shall be sufficiently detailed and comprehensive to provide the necessary technical input for informing the regulatory body and for informing the decisions necessary at each step.	All	I	D	B	L	General requirement, not directly related to facility design. Safety case and licensing (Ikonen et al. 2020, Section 2.2.1).	NEA/RWM/R(2013)1 (OECD/NEA 2013) NEA/RWM/R(2013)9 (OECD/NEA 2014) GSR Part 4 (Rev. 1) (IAEA 2016), Requirement 2
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	Requirement 13, 4.15, 4.17–4.22	The safety case for a disposal facility shall describe all safety relevant aspects of the site, the design of the facility and the managerial control measures and regulatory controls. The safety case and supporting safety assessment shall demonstrate the level of protection of people and the environment provided and shall provide assurance to the regulatory body and other interested parties that safety requirements will be met.	All	I	D	B	L	General requirement, not directly related to facility design. Safety case and licensing (Ikonen et al. 2020, Section 2.2.1).	ICRP Publication 81 (1998), 69 NEA/RWM/R(2013)1 (OECD/NEA 2013) NEA/RWM/R(2013)9 (OECD/NEA 2014)
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	4.16	Accidents of a lesser frequency, but with significant radiological consequences (i.e. possible accidents that could give rise to radiation doses over the short term in excess of annual dose limits (see Section 2)), have to be considered with regard to both their likelihood of occurrence and the magnitude of possible radiation doses. The adequacy of the design and of the operational features also has to be evaluated.	All	I	D	B	L	Incidents and accidents: Intermediate Depth (Ikonen et al. 2020, Section 6.2.6); DGR (Ikonen et al. 2020, Section 7.2.6); Deep Borehole (Ikonen et al. 2020, Section 8.2.5); Landfill (Ikonen et al. 2020, Section 9.2.6). Landfill: Cleared waste, but however the design is compatible with the IAEA guidelines for near surface disposal.	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	Requirement 15	The site for a disposal facility shall be characterized at a level of detail sufficient to support a general understanding of both the characteristics of the site and how the site will evolve over time. This shall include its present condition, its probable natural evolution and possible natural events, and also human plans and actions in the vicinity that may affect the safety of the facility over the period of interest. It shall also include a specific understanding of the impact on safety of features, events and processes associated with the site and the facility.	All (site)	I	D	B	L	May affect site selection (requirement favours sites with more predictable evolution). Site selection (Ikonen et al. 2020, Ch. 4).	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	4.26	An understanding of the site for a disposal facility has to be gained in order to present a convincing scientific description of the disposal system on which the more conceptual descriptions that are used in the safety assessment can be based. The focus has to be on features, events and processes relating to the site that could have an impact on safety and that are addressed in the safety case and supporting safety assessment. In particular, this has to demonstrate that there is adequate geological, geomorphological or topographical stability (as appropriate to the type of facility), and features and processes that contribute to safety. It also has to demonstrate that other features, events and processes do not undermine the safety case.	All (site)	I	D	B	L	Affects site selection (favours sites with geological, geomorphological or topographical stability and features and processes that contribute to safety). Site selection (Ikonen et al. 2020, Ch. 4).	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	4.27	Characterization of the geological aspects has to include activities such as the investigation of: long term stability, faulting and the extent of fracturing in the host geological formation; seismicity; volcanism; the volume of rock suitable for the construction of disposal zones; geotechnical parameters relevant to the design; groundwater flow regimes; geochemical conditions; and mineralogy. The extent of characterization necessary will depend on the types of disposal facility and the site in question.	All (site)	I	D	B	L	May affect site selection (implies important properties of the host rock). Site selection (Ikonen et al. 2020, Ch. 4). Site characterisation (Ikonen et al. 2020, Section 4.3).	DGR, Intermediate Depth: SSG-14 (IAEA 2011), 6.5, 6.6, 6.7, 6.8, 6.9 Landfill: SSG-29 (IAEA 2014), II.6 - II.33 in Appendix II
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	4.28	A graded approach has to be adopted, depending on the hazard potential of the waste and the complexity of the site and disposal facility design. Site characterization undertaken in an iterative manner has to provide input to, and has, in turn, to be guided by, the safety case. Additionally, investigation of, for example, natural background radiation and the radionuclide content in soil, groundwater and other media may contribute to a better understanding of the characteristics of the site of the disposal facility. It may also assist in the evaluation of radiological impacts on the environment by providing a reference for future comparisons.	All (site)	I	D	B	L	General requirement, not directly related to facility design	GSG-8 (IAEA 2018), 2.49–2.54 DGR, Intermediate Depth: SSG-14 (IAEA 2011), 2.5
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	4.29	Characterization of the surface environmental features has to include natural aspects, such as hydrological and meteorological aspects and flora and fauna. It also has to cover human activities in the vicinity of the site relating to normal residential settlement patterns and industrial and agricultural activities. Due regard has to be given to the probable natural evolution of the site, including effects of erosion and climate change.	All (site)	I	D	B	L	May affect site selection (implies important properties of the site). Site selection (Ikonen et al. 2020, Ch. 4).	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	Requirement 16	The disposal facility and its engineered barriers shall be designed to contain the waste with its associated hazard, to be physically and chemically compatible with the host geological formation and/or surface environment, and to provide safety features after closure that complement those features afforded by the host environment. The facility and its engineered barriers shall be designed to provide safety during the operational period.	All	I	D	B	L	Safety features: Intermediate depth (Ikonen et al. 2020, Table 2-1); Landfill (Ikonen et al. 2020, Table 9-3). Containment: DGR (Ikonen et al. 2020, Section 2.1.2); Deep Borehole (Ikonen et al. 2020, Sections 2.1.3, 8.2.1); Landfill (Ikonen et al. 2020, Section 2.1.4).	NEA No. 6424 (OECD/NEA 2009), Section 3.2.4

SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	4.30	In general, optimal use has to be made of the safety features offered by the host environment. This has to be done by designing a disposal facility that does not cause unacceptable long term disturbance of the site, is itself protected by the site and performs safety functions that complement the natural barriers.	All	I	D	B	L	Site selection (Ikonen et al. 2020, Ch. 4). The methods used for the construction, operation and sealing off repositories and other underground openings shall be chosen so that the bedrock will maintain its natural containment characteristics in an optimal fashion (Ikonen et al. 2020, Section 2.2.6).	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	4.31	The layout has to be designed so that waste is emplaced in the most suitable locations.	All	I	D	B	L	Layout (Ikonen et al. 2020, Figure 6-5). Layout flexibility and constraints (Ikonen et al. 2020, Section 2.2.6). Adaptation of design to match the bedrock conditions/rock suitability: Intermediate Depth (Ikonen et al. 2020, Sections 6.1.7, 6.2.8); DGR (Ikonen et al. 2020, Sections 7.1.1, 7.1.7); Deep Borehole (Ikonen et al. 2020, Sections 8.0, 8.1.8). A rock classification system needs to be created for defining the desired properties for host rock material and for developing the acceptance criteria regarding the suitability of any given host rock volume for disposal purposes, including the acceptance criteria for (DGR) deposition holes and tunnels (Ikonen et al. 2020, Sections 2.2.9, 7.1.7). Landfill: Ikonen et al. (2020), Table 9-3.	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	4.31	Key features, such as shafts and seals in geological disposal facilities, have to be appropriately located.	All	I	D	B	L	Locations of key features, e.g. shafts and seals	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	4.31	Materials used in the facility have to be resistant to degradation under the conditions prevailing in the facility (e.g. conditions of chemistry and temperature) and selected also to limit any undesirable impacts on the safety functions of any element of the disposal system.	All	I	D	B	L	DGR: The EBS structures are designed to be compatible with other EBS structures and the host rock and support their performance (Ikonen et al. 2020, Section 2.1.2). Many investigations and research projects have shown that copper has a good corrosion resistance in deep (reducing) groundwater (Ikonen et al. 2020, Section 2.2.2). The chemical stability of bentonite shall be ensured for a very long period of time in order to guarantee the long-term safety of the HLW disposal solution (Ikonen et al. 2020, Section 2.2.6). Use of materials: Intermediate Depth (Ikonen et al. 2020, Section 6.1.7); DGR (Ikonen et al. 2020, Section 7.1.7). Foreign materials remaining in the facility: Intermediate Depth (Ikonen et al. 2020, Section 6.3.3); DGR (Ikonen et al. 2020, Section 7.3.3). Landfill: Norwegian regulations for hazardous waste landfills also to be applied. Landfill material options (Ikonen et al. 2020, Table 9-3).	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	4.32	Disposal facilities, in particular disposal facilities for high level and intermediate level waste, are expected to perform over much longer timescales than the periods usually considered in engineering applications. Investigation of the ways in which analogous natural materials have behaved in geological formations in nature, or how ancient artefacts and structures have behaved over time, may contribute to confidence in the assessment of long term performance. Demonstration of the feasibility of fabrication of waste containers and of the construction of engineered barriers with the necessary features, for example, in underground laboratories, is important for the purpose of assessment and for contributing to confidence that an adequate level of performance can be achieved.	DGR, Deep Borehole, Intermediate Depth	I	D	B		General requirement, not directly related to facility design (although demonstrations can confirm the feasibility of the design)	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	Requirement 17	The disposal facility shall be constructed in accordance with the design as described in the approved safety case and supporting safety assessment. It shall be constructed in such a way as to preserve the safety functions of the host environment that have been shown by the safety case to be important for safety after closure. Construction activities shall be carried out in such a way as to ensure safety during the operational period.	All	I	D	B	L	The design as a whole, the construction process as a whole. Facility construction: Intermediate Depth (Ikonen et al. 2020, Section 6.1.7); DGR (Ikonen et al. 2020, Section 7.1.7, Figure 7-8); Deep Borehole (Ikonen et al. 2020, Section 8.1, 8.2.1); Landfill (Ikonen et al. 2020, Sections 9.1.6, 9.1.7). During the construction and closure of the repository, efforts are made to maintain the bedrock's original properties and to keep changes in as limited an area as possible around the tunnels and shafts. Accordingly, the rock is excavated carefully so as to keep the impact on the surrounding bedrock at an insignificant level (Ikonen et al. 2020, Section 2.2.7).	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	4.33	An adequate level of characterization has to be completed before construction is begun.	All (site)	I	D	B	L	Site characterisation activities (Ikonen et al. 2020, Section 4.3). The details of site characterisation will be decided when the site is selected.	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	4.33	Excavation and construction activities have to be carried out in such a way as to avoid unnecessary disturbance of the host environment.	All	I	D	B	L	Facility construction: Intermediate Depth (Ikonen et al. 2020, Section 6.1.7); DGR (Ikonen et al. 2020, Section 7.1.7, Figure 7-8); Deep Borehole (Ikonen et al. 2020, Section 8.1, 8.2.1); Landfill (Ikonen et al. 2020, Sections 9.1.6, 9.1.7). The methods used for the construction, operation and sealing off repositories and other underground openings shall be chosen so that the bedrock will maintain its natural containment characteristics in an optimal fashion (Ikonen et al. 2020, Section 2.2.6).	DGR, Intermediate Depth: SSG-14 (IAEA 2011), 6.44

SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	4.33	Sufficient flexibility in engineering techniques has to be adopted to allow for variations to be encountered, such as variations in rock conditions or groundwater conditions in underground facilities.	All	I	D	B	L	Layout flexibility and constraints (Ikonen et al. 2020, Section 2.2.6). Adaptation of design to match the bedrock conditions/rock suitability: Intermediate Depth (Ikonen et al. 2020, Section 6.1.7, 6.2.8); DGR (Ikonen et al. 2020, Section 7.1.1, 7.1.7); Deep Borehole (Ikonen et al. 2020, Sections 8.0, 8.1.8).	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	4.34	Excavation and construction of a disposal facility could continue after the commencement of operation of part of the facility and after the emplacement of waste packages. Such overlapping of construction and operational activities has to be planned and carried out so as to ensure safety, both in operation and after closure.	All	I	D	B	L	The phases of implementation of the disposal facility can be partly parallel. The phases shall be scheduled and implemented with due regard to long-term safety (Ikonen et al. 2020, Section 2.2.7).	DGR, Intermediate Depth: SSG-14 (IAEA 2011), 6.45, 6.51
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	Requirement 18	The disposal facility shall be operated in accordance with the conditions of the licence and the relevant regulatory requirements so as to maintain safety during the operational period and in such a manner as to preserve the safety functions assumed in the safety case that are important to safety after closure.	All	I	D	B	L	General requirement, not directly related to facility design	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	4.35, 2.13	All operations and activities important to the safety of a disposal facility have to be subjected to limitations and controls and emergency plans have to be put in place. The various procedures and plans have to be documented and the documentation has to be subject to appropriate control procedures [cf. GSR Part 2 (IAEA 2016)]. The safety case has to address and justify both the design and the operational management arrangements that are used to ensure that the safety objective and criteria set out in Section 2 are met. Additional, facility specific criteria may be established by the regulatory body or by the operator.	All	I	D	B	L	Long-term radiation safety is demonstrated through a safety case, i.e. the collection of arguments and evidence to demonstrate the safety of a disposal facility (Ikonen et al. 2020, Section 2.2.1). Emergency-related systems: Intermediate Depth (Ikonen et al. 2020, Sections 6.1.2, 6.2.6); DGR (Ikonen et al. 2020, Sections 7.1.2, 7.2.6). Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7). Disposal facility monitoring and control systems (Ikonen et al. 2020, Sections 6.1.2, 7.1.2). Deep Borehole: Monitoring (Ikonen et al. 2020, Section 8.2.7). Landfill repository monitoring (Ikonen et al. 2020, Section 9.2.8).	GSR Part 2 (IAEA 2016)
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	4.36	The safety case also has to demonstrate that hazards and other radiation risks to workers and to members of the public under conditions of normal operation and anticipated operational occurrences have been reduced as low as reasonably achievable. Active control of safety has to be maintained for as long as the disposal facility remains unsealed, and this may include an extended period after the emplacement of waste and before the final closure of the facility.	All	I	D	B	L	Disposal facility monitoring and control systems (Ikonen et al. 2020, Sections 6.1.2, 7.1.2, 8.2.7, 9.2.8). Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7).	NEA No. 6182 (OECD/NEA 2007) GSR Part 4 (Rev. 1) (IAEA 2016), Requirement 6
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	Requirement 19	A disposal facility shall be closed in a way that provides for those safety functions that have been shown by the safety case to be important after closure. Plans for closure, including the transition from active management of the facility, shall be well defined and practicable, so that closure can be carried out safely at an appropriate time.	All	I	D	B	L	Closure design: Intermediate Depth (Ikonen et al. 2020, Figure 6-8, Section 6.3); DGR (Ikonen et al. 2020, Sections 2.1.2, 7.3); Deep Borehole (Ikonen et al. 2020, Section 8.3); Landfill (Ikonen et al. 2020, Section 9.3)	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	4.38	The safety of a disposal facility after closure will depend on a number of activities and design features, which can include the backfilling and sealing or capping of the disposal facility. Closure has to be considered in the initial design of the facility, and plans for closure and seal or cap designs have to be updated as the design of the facility is developed. Before construction activities commence, there has to be sufficient evidence that the performance of the backfilling, sealing and capping will function as intended to meet the design requirements.	All	I	D	B	L	Closure design: Intermediate Depth (Ikonen et al. 2020, Figure 6-8, Section 6.3); DGR (Ikonen et al. 2020, Sections 2.1.2, 7.3); Deep Borehole (Ikonen et al. 2020, Section 8.3); Landfill (Ikonen et al. 2020, Section 9.3)	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	4.39	The disposal facility has to be closed in accordance with the conditions set for closure by the regulatory body in the facility's authorization, with particular consideration given to any changes in responsibility that may occur at this stage. Consistent with this, the installation of closure features may be performed in parallel with waste emplacement operations.	All	I	D	B	L	Closure design: Intermediate Depth (Ikonen et al. 2020, Figure 6-8, Section 6.3); DGR (Ikonen et al. 2020, Sections 2.1.2, 7.3); Deep Borehole (Ikonen et al. 2020, Section 8.3); Landfill (Ikonen et al. 2020, Section 9.3)	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	4.40	Backfilling and the placement of seals or caps may be delayed for a period after the completion of waste emplacement, for example, to allow for monitoring to assess aspects relating to safety after closure or for reasons relating to public acceptability. If such features are not to be put in place for a period of time after the completion of waste emplacement, then the implications for safety during operation and after closure have to be considered in the safety case.	All	I	D	B	L	General requirement, not directly related to facility design	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	Requirement 20	Waste packages and unpackaged waste accepted for emplacement in a disposal facility shall conform to criteria that are fully consistent with, and are derived from, the safety case for the disposal facility in operation and after closure.	All	I	D	B	L	WAC issue. Packaging (Ikonen et al. 2020, Section 2.2.2). ILW packages (Ikonen et al. 2020, Figure 2-8); LILW packages (Ikonen et al. 2020, Figure 2-9); Deep Borehole waste packages (Ikonen et al. 2020, Section 8.2.3). Packaging plant (Ikonen et al. 2020, Sections 2.2.5, 5.7, Figure 5-5). Most of the waste is assumed to be packed outside the National Facility (Ikonen et al. 2020, abstract).	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	5.1	Waste acceptance requirements and criteria for a given disposal facility have to ensure the safe handling of waste packages and unpackaged waste in conditions of normal operation and anticipated operational occurrences. They also have to ensure the fulfilment of the safety functions for the waste form and waste packaging with regard to safety in the long term. Examples of possible parameters for waste acceptance criteria include the characteristics and performance requirements of the waste packages and the unpackaged waste to be disposed of, such as the radionuclide content or activity limits, the heat output and the properties of the waste form and packaging.	All	I	D	B	L	WAC issue. DGR: Thermal dimensioning (Ikonen et al. 2020, Sections 2.2.6, 7.1.1). Deep Borehole: Heat generation (Ikonen et al. 2020, Section 8.1.4). The concept description of the National Facility is, at this point, still flexible and able to be adjusted to different waste acceptance criteria or packaging options (Ikonen et al. 2020, Section 2.2.2). To be decided.	

SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	5.2	Modelling and/or testing of the behaviour of waste forms has to be undertaken to ensure the physical and chemical stability of the different waste packages and unpackaged waste under the conditions expected in the disposal facility, and to ensure their adequate performance in the event of anticipated operational occurrences or accidents.	All	I	D	B	L	WAC issue. Rock collapses and slides in rooms with waste package emplacements in progress or completed shall be prevented by keeping these rooms at a sufficient distance from excavation activities (Ikonen et al. 2020, Section 2.2.1). DGR: In the reloading hall, the security and absence of transfer damage to the canister will be verified (Ikonen et al. 2020, Section 7.1.1). Surface facilities need to be prepared in terms of sufficient space and equipment to perform relevant test for checking the fulfilment of the requirement Modelling: to be decided.	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	5.3	Waste intended for disposal has to be characterized to provide sufficient information to ensure compliance with waste acceptance requirements and criteria.	All	I	D	B	L	WAC issue. To be decided.	DGR, Intermediate Depth: SSG-14 (IAEA 2011), 6.39
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	5.3	Arrangements have to be put in place to verify that the waste and waste packages received for disposal comply with these requirements and criteria and, if not, to confirm that corrective measures are taken by the generator of the waste or the operator of the disposal facility.	All	I	D	B	L	WAC issue. To be decided.	DGR, Intermediate Depth: SSG-14 (IAEA 2011), 6.39
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	5.3	Quality control of waste packages has to be undertaken and is achieved mainly on the basis of records, preconditioning testing (e.g. of containers) and control of the conditioning process. Post-conditioning testing and the need for corrective measures have to be limited as far as practicable.	All	I	D	B	L	WAC issue. An appropriate quality system is deployed in implementing the disposal and its associated research and development work and safety assessments, and it is extended to all organisations having a material impact on the long-term safety of the disposal project. Advanced quality assurance programmes shall be applied (Ikonen et al. 2020, Section 2.2.7). Landfill: QC/QA (Ikonen et al. 2020, Section 9.1.1, 9.1.7).	DGR, Intermediate Depth: SSG-14 (IAEA 2011), 6.39
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	Requirement 21	A programme of monitoring shall be carried out prior to, and during, the construction and operation of a disposal facility and after its closure, if this is part of the safety case. This programme shall be designed to collect and update information necessary for the purposes of protection and safety. Information shall be obtained to confirm the conditions necessary for the safety of workers and members of the public and protection of the environment during the period of operation of the facility. Monitoring shall also be carried out to confirm the absence of any conditions that could affect the safety of the facility after closure.	All	I	D	B	L	Surveillance and monitoring (Ikonen et al. 2020, Sections 5.2, 5-6, 5-7, 6.2.8, 7.2.8, Figures 5-4, 5-5). Monitoring radiation safety (Ikonen et al. 2020, Section 2.2.1). Intermediate depth, DGR: Disposal facility monitoring and control systems (Ikonen et al. 2020, Sections 6.1.2, 7.1.2). Monitoring of the environmental impacts (Ikonen et al. 2020, Section 2.2.1) (Intermediate Depth, DGR: Ikonen et al. 2020, Sections 6.2.8, 7.2.8). Monitoring related to site, baseline studies (Ikonen et al. 2020, Sections 6.2.8, 7.2.8). Post-closure period (Ikonen et al. 2020, Section 2.2.7). Deep Borehole: Monitoring (Ikonen et al. 2020, Section 8.2.7). Landfill: Monitoring (Ikonen et al. 2020, Section 9.2.8). Planning of facility design.	DGR, Intermediate Depth: SSG-14 (IAEA 2011), 6.25 SSG-31 (IAEA 2014), Ch. 5
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	5.4	Monitoring has to be carried out at each step in the development and in the operation of a disposal facility. The purposes of the monitoring programme include: (a) Obtaining information for subsequent assessments; (b) Assurance of operational safety; (c) Assurance that conditions at the facility for operation are consistent with the safety assessment; (d) Confirmation that conditions are consistent with safety after closure. Guidance is provided in Ref. [RS-G-1.8]. Monitoring programmes have to be designed and implemented so as not to reduce the overall level of safety of the facility after closure.	All	I	D	B	L	Surveillance and monitoring (Ikonen et al. 2020, Sections 5.2, 5-6, 5-7, 6.2.8, 7.2.8, Figures 5-4, 5-5). Monitoring radiation safety (Ikonen et al. 2020, Section 2.2.1). Intermediate depth, DGR: Disposal facility monitoring and control systems (Ikonen et al. 2020, Sections 6.1.2, 7.1.2). Monitoring of the environmental impacts (Ikonen et al. 2020, Section 2.2.1) (Intermediate Depth, DGR: Ikonen et al. 2020, Sections 6.2.8, 7.2.8). Monitoring related to site, baseline studies (Ikonen et al. 2020, Sections 6.2.8, 7.2.8). Post-closure period (Ikonen et al. 2020, Section 2.2.7). Deep Borehole: Monitoring (Ikonen et al. 2020, Section 8.2.7). Landfill: Monitoring (Ikonen et al. 2020, Section 9.2.8).	DGR, Intermediate Depth: SSG-14 (IAEA 2011), 6.60
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	5.5	Plans for monitoring with the aim of providing assurance of safety after closure have to be drawn up before the construction of a geological disposal facility to indicate possible monitoring strategies. However, plans have to remain flexible and, if necessary, they will have to be revised and updated during the development and operation of the facility.	All	I	D	B	L	Monitoring related to site, baseline studies (Ikonen et al. 2020, Sections 6.2.8, 7.2.8). Monitoring of the environmental impacts of the project (Ikonen et al. 2020, Sections 2.2.1, 6.2.8, 7.2.8, 8.2.7, 9.2.8). Surveillance and monitoring (Ikonen et al. 2020, Sections 5.2, 5-6, 5-7, 6.2.8, 7.2.8, Figures 5-4, 5-5). Intermediate depth, DGR: Disposal facility monitoring and control systems (Ikonen et al. 2020, Sections 6.1.2, 7.1.2). Deep Borehole: Monitoring (Ikonen et al. 2020, Section 8.2.7). Landfill: Monitoring (Ikonen et al. 2020, Section 9.2.8).	IAEA-TECDOC-1208 SSG-31 (IAEA 2014), 4.12
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	Requirement 22	Plans shall be prepared for the period after closure to address institutional control and the arrangements for maintaining the availability of information on the disposal facility. These plans shall be consistent with passive safety features and shall form part of the safety case on which authorization to close the facility is granted.	All	I	D	B	L	Long-term safety is provided through the repository design by passive means to fulfil the requirements and shall not rely on extended monitoring or maintenance of the site (Ikonen et al. 2020, Section 2.2.1). Post-closure period (Ikonen et al. 2020, Section 2.2.7). Safety case and licensing (Ikonen et al. 2020, Section 2.2.1).	GSR Part 1 (Rev. 1) (IAEA 2016), 2.31 SSG-23 (IAEA 2012), 6.66–6.73 SSG-31 (IAEA 2014), 6.12, 6.13 NEA No. 7082 (OECD/NEA 2012), Ch. 5
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	5.6, 5.8	The long term safety of a disposal facility for radioactive waste has not to be dependent on active institutional control. Even the violation of passive safety features cannot give rise to the criteria for intervention being exceeded. Additionally, the safety of the disposal facility has not to be dependent solely on institutional controls. Institutional controls cannot be the sole or main component of safety for a near surface disposal facility. The ability of the institutional controls to provide the contributions to safety envisaged in the safety case has to be demonstrated and justified in the safety case.	All	I	D	B	L	Long-term safety is provided through the repository design by passive means to fulfil the requirements and shall not rely on extended monitoring or maintenance of the site (Ikonen et al. 2020, Section 2.2.1). Post-closure period (Ikonen et al. 2020, Section 2.2.7). Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7).	Landfill: SSG-29 (IAEA 2014), 7.7

SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	5.7	The risk of intrusion into a disposal facility for radioactive waste may be reduced over a longer timescale than that foreseen for active controls by the use of passive controls, such as the preservation of information by the use of markers and archives, including international archives.	All	I	D	B	L	Human intrusion (Ikonen et al. 2020, Sections 2.1.2 (DGR), 2.2.1, 2.2.7). If desired, signs can be left on the site to indicate the presence of radioactive waste underground (Ikonen et al. 2020, Section 2.2.7).	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	5.9	Near surface disposal facilities are generally designed on the assumption that institutional control has to remain in force for a period of time. For short lived waste, the period will have to be several tens to hundreds of years following closure. Such controls will be either active or passive in nature. For near surface disposal of waste from mining and mineral processing that includes very long lived radionuclides, and which generally comprises large volumes, activity concentrations have to be limited so that ongoing active institutional control does not have to be relied on as a safety measure. Waste with activity concentrations above the limitations has to be disposed of below the ground surface.	Intermediate Depth (LLW only), Landfill	I			L	The disposal concept is designed so that there will be no need for monitoring or other maintenance after the closure of connections to the repositories. If desired, signs can be left on the site to indicate the presence of radioactive waste underground. Post-closure monitoring can be included, if required (Ikonen et al. 2020, Section 2.2.7).	
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	Requirement 24	Measures shall be implemented to ensure an integrated approach to safety measures and nuclear security measures in the disposal of radioactive waste.	All	I	D	B	L	Security and emergency arrangements (Ikonen et al. 2020, Section 2.2.1). Security patrols and surveillance of the disposal facility are centralised in the operation building. This control post is manned at all times, so it is the logical point for controlling access (Ikonen et al. 2020, Section 5.7).	DGR, Intermediate Depth: SSG-14 (IAEA 2011), 6.76 Deep Borehole: SSG-1 (IAEA 2009), 4.52–4.54 Landfill: SSG-29 (IAEA 2014), 7.18, 7.19
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	Requirement 25	Management systems to provide for the assurance of quality shall be applied to all safety related activities, systems and components throughout all the steps of the development and operation of a disposal facility. The level of assurance for each element shall be commensurate with its importance to safety.	All	I	D	B	L	General requirement, not directly related to facility design. Advanced quality assurance programmes shall be applied (Ikonen et al. 2020, Section 2.2.7). Landfill: QC/QA (Ikonen et al. 2020, Section 9.1.1, 9.1.7).	GSR Part 2 (IAEA 2016), Requirement 7 GSG-7 (IAEA 2018), 2.23–2.26 SSG-29 (IAEA 2014), 7.20 NEA/RWM/R(2013)9 (OECD/NEA 2014), p. 153–162 DGR, Deep Borehole (spent fuel storage): SSG-15 (Rev. 1) (IAEA 2020), Chapter 4
SSR-5 (IAEA 2011)	Disposal of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1449_web.pdf)	A.2	A host geological formation and/or environment and site has to be identified that provide favourable conditions for the isolation of the waste from the accessible biosphere and the preservation of the engineered barriers (e.g. low groundwater flow rates and a favourable geochemical environment over the long term). The disposal facility has to be designed with account taken of the characteristics afforded by the host geological formation and/or environment and site, so as to optimize protection and safety and not to exceed the dose and/or risk constraints. The disposal facility then has to be developed in accordance with the assessed design so that the assumed safety characteristics of both the engineered barriers and the natural barriers are realized.	All (incl. site)	I	D	B	L	Affects site selections (favours sites with low groundwater flow rates and a favourable geochemical environment over the long term). The repositories are adapted to local (rock/surface) conditions so that the safety functions of the natural barrier are supported. The engineered barriers are designed and installed so that their safety functions are supported. Site selection (Ikonen et al. 2020, Ch. 4).	
GSG-1 (IAEA 2009)	Classification of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1419_web.pdf)	2.32	If the classification scheme is used, the specific types and properties of radioactive waste should be taken into account. The precise criteria according to which waste is assigned to a particular waste class will depend on the specific situation in the State in relation to the nature of the waste and the disposal options available or under consideration.	All	I	D	B	L	Waste inventory (Ikonen et al. 2020, Section 2.2.3, Table 2-4). From waste management process point of view, the facility will cover classification into different waste classes (Ikonen et al. 2020, Section 2.2.1).	
GSG-1 (IAEA 2009)	Classification of Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1419_web.pdf)	2.33	Although heat generation is a characteristic of HLW, other waste may also generate heat, albeit at lower levels. The amount of heat generated is dependent upon the types and amounts of radionuclides in the waste (e.g. half-life, decay energy, activity concentration and total activity). Furthermore, consideration of heat removal is very important (e.g. thermal conductivity, storage geometry and ventilation). Therefore, the significance of heat generation cannot be defined by means of a single parameter value. The impact of heat generation can vary by several orders of magnitude, depending on the influencing factors and the methods in place for heat removal. Management of decay heat should be considered if the thermal power of waste packages reaches several Watts per cubic metre. More restrictive values may apply, particularly in the case of waste containing long lived radionuclides.	All	I	D	B	L	Intermediate Depth, DGR: The exhaust air from the underground disposal facility is led via exhaust air shaft back to the ventilation building for heat recovery (Ikonen et al. 2020, Sections 6.1.2, 7.1.2). DGR: Thermal dimensioning (Ikonen et al. 2020, Sections 2.2.6, 7.1.1). Deep Borehole: Heat generation (Ikonen et al. 2020, Section 8.1.4). Landfill: no heat expected (waste under clearance levels).	
GSG-7 (IAEA 2018)	Occupational Radiation Protection (https://www-pub.iaea.org/MTCD/publications/PDF/PUB1785_web.pdf)	2.18, 3.49–3.158	In planned exposure situations, employers, registrants and licensees (hereinafter referred to simply as the 'management') are responsible for ensuring that protection and safety is optimized, that applicable dose limits are complied with, and that appropriate radiation protection programmes are established and implemented.	All	I	D	B	L	General requirement, not directly related to facility design. Radiation protection (Ikonen et al. 2020, Sections 6.2.5, 7.1.1, 7.2.5, 8.2.4, 9.2.5).	
GSG-7 (IAEA 2018)	Occupational Radiation Protection (https://www-pub.iaea.org/MTCD/publications/PDF/PUB1785_web.pdf)	3.16, 3.24–3.33, 3.122–3.128	The optimization of protection and safety should be considered at the design stage of equipment and installations, when some degree of flexibility is still available. The use of engineered controls should be examined carefully at this stage in defining the protection options. In image guided interventional procedures, for example, where there is a potential for workers to receive a significant dose to the lens of the eye, attention should be paid to the installation of fixed shielding and to the selection of equipment. Even if protection has been optimized at the design stage, however, the requirements for optimization in the operational phase still apply. At this stage, the content and the scale of the optimization process will depend on the situation. For example, when dealing with X ray machines, the optimization process can be quite straightforward, involving local rules and appropriate training of the operators. For nuclear facilities, situations are more complicated, and a structured approach should be followed as part of the radiation protection programme, including the use of decision aiding techniques (see paras 3.24–3.27), the establishment of dose constraints (see paras 3.28–3.33) and the establishment of investigation levels (see paras 3.122–3.128).	All	I	D	B	L	Radiation protection (Ikonen et al. 2020, Sections 6.2.5, 7.1.1, 7.2.5, 8.2.4, 9.2.5). Disposal facility monitoring and control systems (Ikonen et al. 2020, Sections 6.1.2, 7.1.2, 8.2.7, 9.2.8). Structures, systems and equipment containing significant amounts of radioactive substances shall be placed in separate rooms or shielded effectively. Adequate safety margins shall be incorporated in the design of radiation shielding (Ikonen et al. 2020, Section 2.2.1). DGR: During transfer, the canister is covered with a radiation shield (Ikonen et al. 2020, Section 7.1.2).	

GSG-7 (IAEA 2018)	Occupational Radiation Protection (https://www-pub.iaea.org/MTCD/publications/PDF/PUB1785_web.pdf)	3.57, 3.51	The prior radiological evaluation will help to determine what can be achieved at the design stage to establish satisfactory working conditions through the use of engineered features. Examples would be the provision of shielding, containment, ventilation or interlocks. These considerations should be aimed at minimizing the need for relying on administrative controls and personal protective equipment for protection and safety during normal operations (see para. 3.51). Consideration may then be given subsequently to additional operational procedures and restrictions that might be implemented to further control workers' exposure. Only if these measures are not sufficient to adequately restrict the doses received by workers will the prior evaluation need to include consideration of the use of special tools, personal protective equipment and specific task related training.	All	I	D	B	L	Radiation protection (Ikonen et al. 2020, Sections 6.2.5, 7.1.1, 7.2.5, 8.2.4, 9.2.5). Ventilation (Ikonen et al. 2020, Figures 6-1, 6-3, 7-1; Fischer et al. 2020, Section 5.3). Landfill: Waste emplacement is performed under open conditions.
GSG-7 (IAEA 2018)	Occupational Radiation Protection (https://www-pub.iaea.org/MTCD/publications/PDF/PUB1785_web.pdf)	7.31, 7.41(c)	In areas where the possibility of a sudden unexpected increase in exposure necessitates the continuous monitoring of the workplace (see para. 7.14(c)), workplace monitoring instruments should be permanently installed and should be fitted with appropriate audio and/or visual alarms to warn of unacceptable conditions. The display may be routed to a control room, where appropriate, for initiating prompt action.	All	I	D	B	L	Devices with an alarm function shall be employed for radiation monitoring so that during the operation of the disposal facility, significant unintentional exposure to radiation will not occur (Ikonen et al. 2020, Section 2.2.1). Monitoring radiation safety (Ikonen et al. 2020, Section 2.2.1). Control and maintenance rooms (Ikonen et al. 2020, Figure 6-1, Section 6.1.1, 6.1.4). Intermediate depth, DGR: Disposal facility monitoring and control systems (Ikonen et al. 2020, Sections 6.1.2, 7.1.2). Deep Borehole: Monitoring (Ikonen et al. 2020, Section 8.2.7). Landfill repository monitoring (Ikonen et al. 2020, Section 9.2.8).
GSG-7 (IAEA 2018)	Occupational Radiation Protection (https://www-pub.iaea.org/MTCD/publications/PDF/PUB1785_web.pdf)	7.138	A facility for individual monitoring should ideally be situated in a building remote from other laboratories or operations that give rise to the emission of radionuclides or penetrating radiation which could interfere with measurements. The monitoring area for direct measurement, containing shielded detectors and associated electronic equipment, would normally occupy a ground floor or basement location in view of floor loading specifications. There should also be waiting rooms for people coming for measurement, showers, toilets and rooms for the changing of clothes, and also separate rooms for collecting or dealing with excretion samples.	All	I	D	B	L	The monitoring and control data are collected in the control room in the operational building (Ikonen et al. 2020, Sections 6.1.2, 7.1.2).
GSG-7 (IAEA 2018)	Occupational Radiation Protection (https://www-pub.iaea.org/MTCD/publications/PDF/PUB1785_web.pdf)	7.139	The laboratory for analysis of excretion samples should be constructed in the same way as any other radiochemical laboratory. It should not also be used for the analysis of other, high activity process samples such as reactor coolant, in order to avoid any cross-contamination. Precautions for the handling of potentially infectious material should be taken into account when planning space for dealing with, or storage of, excretion samples.	All	I	D	B	L	A separate facility. To be decided.
GSG-7 (IAEA 2018)	Occupational Radiation Protection (https://www-pub.iaea.org/MTCD/publications/PDF/PUB1785_web.pdf)	9.1	Where the physical design features of a facility do not provide sufficient containment or shielding of radioactive material, additional engineered controls using facility systems and components should be used to protect individuals. For example, adequately designed and properly controlled ventilation systems are an effective means of minimizing exposure in workplaces prone to airborne contamination, such as in underground mines and in buildings in which dry processing of radioactive minerals is carried out. Installed fume hoods, glove boxes and manipulators are also examples of engineered controls.	All	I	D	B	L	Facilities where significant amounts of radioactive substances may be released shall be equipped with ventilation and filtering systems, which will reduce the concentrations of radioactive substances in these facilities, prevent the spread of radioactive substances to other parts of the facility and restrict the release of radioactive substances into the environment. These ventilation and filtering systems shall also be able to operate as designed during and after an anticipated operational transient or postulated accident (Ikonen et al. 2020, Section 2.2.1). Ventilation (Ikonen et al. 2020, Figures 6-1, 6-3, 7-1; Fischer et al. 2020, Section 5.3). Ventilation building (Ikonen et al. 2020, Figures 5-4 and 5-5, Section 5.7). Intermediate Depth: Ventilation system (Ikonen et al. 2020, Section 6.1.2). If the radon content of the air exceeds the permitted limit, ventilation is increased (Ikonen et al. 2020, Section 6.2.5). DGR: Ventilation system (Ikonen et al. 2020, Figure 7-4, Section 7.1.2). Landfill: Waste emplacement is performed under open conditions.
GSG-7 (IAEA 2018)	Occupational Radiation Protection (https://www-pub.iaea.org/MTCD/publications/PDF/PUB1785_web.pdf)	9.2	Appropriate monitoring should be performed to determine the adequacy and effectiveness of engineered controls. For instance, when engineered controls, such as ventilation, vacuum cleaners or containment devices, are used to reduce or to maintain activity concentrations of radionuclides in the work environment, air quality should be monitored. Generally, for installed physical design features, such as fume hoods, fixed location air sampling is preferred, whereas for temporary controls, such as portable ventilation or the use of vacuum cleaners, grab sampling is preferred. Real time air monitoring for determining the adequacy of installed controls may also be appropriate and should be made a requirement for some situations.	All	I	D	B	L	Monitoring radiation safety (Ikonen et al. 2020, Section 2.2.1). Surveillance and monitoring (Ikonen et al. 2020, Sections 5.2, 5-6, 5-7, 6.2.8, 7.2.8, 8.2.7, 9.2.8, Figures 5-4, 5-5). Intermediate depth, DGR: Disposal facility monitoring and control systems (Ikonen et al. 2020, Sections 6.1.2, 7.1.2). The purpose of the permanent ventilation system is to maintain sufficiently good air quality in the underground disposal facility (Ikonen et al. 2020, Sections 6.1.2, 7.1.2).
GSG-7 (IAEA 2018)	Occupational Radiation Protection (https://www-pub.iaea.org/MTCD/publications/PDF/PUB1785_web.pdf)	9.3, 9.4	Temporary engineered controls, such as temporary shielding, containment devices and portable or auxiliary ventilation, may need to be used during non-routine operations such as maintenance, modifications, and decontamination and decommissioning. Planning for non-routine operations should include an evaluation of the potential for the spread of contamination and an evaluation of the effectiveness of the engineered controls in reducing such potential.	All	I	D	B	L	Structures, systems and equipment containing significant amounts of radioactive substances shall be placed in separate rooms or shielded effectively. Adequate safety margins shall be incorporated in the design of radiation shielding (Ikonen et al. 2020, Section 2.2.1). During transfer, the canister is covered with a radiation shield (Ikonen et al. 2020, Section 7.1.2).

GSG-7 (IAEA 2018)	Occupational Radiation Protection (https://www-pub.iaea.org/MTCD/publications/PDF/PUB1785_web.pdf)	9.5	The exhausts from portable air handling systems used in contaminated areas, including vacuum cleaners, should be equipped either with high efficiency particulate air (HEPA) filters or with suitable adsorbers, as appropriate, and should be directed to installed systems that are so equipped. These provisions may not be necessary in areas where only tritium or radioactive noble gases are present, or when the material to be vacuumed is wet enough to preclude resuspension after entry into the system collection chamber. Improper use of vacuum cleaners and portable air handling equipment may result in the generation of airborne radioactive material or removable surface contamination. The prolonged use of air handling equipment may result in a significant buildup of radioactive material in ducts and filters. A radiological assessment of the operation of such equipment should be performed periodically by monitoring the exhaust air and accessible equipment surfaces.	All	I	D	B	L	Facilities where significant amounts of radioactive substances may be released shall be equipped with ventilation and filtering systems. These ventilation and filtering systems shall also be able to operate as designed during and after an anticipated operational transient or postulated accident (Ikonen et al. 2020, Section 2.2.1). Intermediate depth, DGR: Disposal facility monitoring and control systems (Ikonen et al. 2020, Sections 6.1.2, 7.1.2). Deep Borehole: Monitoring (Ikonen et al. 2020, Section 8.2.7). Landfill: Monitoring (Ikonen et al. 2020, Section 9.2.8).
GSG-7 (IAEA 2018)	Occupational Radiation Protection (https://www-pub.iaea.org/MTCD/publications/PDF/PUB1785_web.pdf)	9.6	When the use of physical design features, including specific engineered controls to limit individual exposures, is impractical or inadequate, administrative controls should be considered to ensure that protection and safety is optimized. Examples of administrative controls include the use of work authorizations and restrictions or controls on access to areas with the potential for contamination.	All	I	D	B	L	Operational safety issue. To be decided.
GSG-7 (IAEA 2018)	Occupational Radiation Protection (https://www-pub.iaea.org/MTCD/publications/PDF/PUB1785_web.pdf)	9.7	Control measures, such as quality in design, installation, maintenance and operation, together with administrative arrangements and instruction of personnel, should be used to the maximum extent possible before relying on personal protective equipment for ensuring the protection of workers. In circumstances in which engineered controls and administrative controls are not sufficient to provide adequate levels of protection of workers, personal protective equipment should be provided to restrict the exposures of workers.	All	I	D	B	L	Radiation protection (Ikonen et al. 2020, Sections 6.2.5, 7.1.1, 7.2.5, 8.2.4, 9.2.5). Exposure of operating personnel, limiting the radiation exposure of personnel (Ikonen et al. 2020, Section 2.2.1). Adequate instructions shall be in place for the operation, maintenance, periodic inspections and tests of the plans. The reliable operation of systems and components shall be ensured through maintenance and regular periodic inspections and tests (Ikonen et al. 2020, Section 2.2.1). Quality system, quality assurance programmes (Ikonen et al. 2020, Section 2.2.7). Deep Borehole: It can be concluded that a quality assured borehole for radioactive waste disposal can likely be implemented according to the requirements (Ikonen et al. 2020, Section 8.1.2). The safety class provides the basis for defining the quality assurance requirements for the systems, structures and components of a nuclear facility (Ikonen et al. 2020, Section 8.1.6). Landfill: QC/QA (Ikonen et al. 2020, Section 9.1.1, 9.1.7). Control and maintenance (Ikonen et al. 2020, Figure 6-1, Section 6.1.1, 6.1.4). Installation: Intermediate Depth (Ikonen et al. 2020, Section 6.2.2); DGR (Ikonen et al. 2020, Section 7.2.2, Figures 7-6, 7-7). Landfill (Ikonen et al. 2020, Sections 9.1.7, 9.2.2).
GSG-7 (IAEA 2018)	Occupational Radiation Protection (https://www-pub.iaea.org/MTCD/publications/PDF/PUB1785_web.pdf)	9.8, 9.9	The provision of shielding can be an effective form of engineered control. At the design stage, an adequate thickness of the shielding material should be provided to give an acceptable level of protection to the workers in normal operation as well as in abnormal situations. The design of shielding should be such as to ensure that the individual external dose in normal working conditions is lower than the dose constraint. The adequacy of the shielding in abnormal conditions, including accident situations leading to maximum foreseeable (worst case) radiological consequences, should be evaluated and, where necessary, additional shielding or other engineered controls (e.g. interlocks) should be considered. The likelihood of an accident or other incident giving rise to an unacceptable level of individual dose should be maintained at a very low level and any planned exposure situation that could cause the annual dose limit to be exceeded because of inadequate shielding should be prevented. The effectiveness of the shielding should be actively monitored by means of installed workplace monitoring instruments and/or by regular area surveys performed by suitably qualified personnel. Additional local shielding should be provided to reduce the radiation field as needed. Passive area monitors should also be used to determine doses integrated over time in various areas. The results should be analysed for trends, and the shielding should be improved, as appropriate.	All	I	D	B	L	Radiation protection (Ikonen et al. 2020, Sections 6.2.5, 7.1.1, 7.2.5, 8.2.4, 9.2.5). Monitoring radiation safety (Ikonen et al. 2020, Section 2.2.1). Exposure of operating personnel, limiting the radiation exposure of personnel (Ikonen et al. 2020, Section 2.2.1). Radiation protection (Ikonen et al. 2020, Sections 6.2.5, 7.1.1, 7.2.5, 8.2.4, 9.2.5). Incidents and accidents: Intermediate Depth (Ikonen et al. 2020, Section 6.2.6); DGR (Ikonen et al. 2020, Section 7.2.6); Deep Borehole (Ikonen et al. 2020, Section 8.2.5); Landfill (Ikonen et al. 2020, Section 9.2.6). Structures, systems and equipment containing significant amounts of radioactive substances shall be placed in separate rooms or shielded effectively. Adequate safety margins shall be incorporated in the design of radiation shielding (Ikonen et al. 2020, Section 2.2.1). During transfer, the canister is covered with a radiation shield (Ikonen et al. 2020, Section 7.1.2). Disposal facility monitoring and control systems: Intermediate depth, DGR (Ikonen et al. 2020, Sections 6.1.2, 7.1.2). Deep Borehole: Monitoring (Ikonen et al. 2020, Section 8.2.7). Landfill: Monitoring (Ikonen et al. 2020, Section 9.2.8). The reliable operation of systems and components shall be ensured through maintenance and regular periodic inspections and tests (Ikonen et al. 2020, Section 2.2.1).

GSG-7 (IAEA 2018)	Occupational Radiation Protection (https://www-pub.iaea.org/MTCD/publications/PDF/PUB1785_web.pdf)	9.10	The purpose of the primary ventilation system in a facility is to provide fresh air to workplaces to remove airborne contaminants generated by the operations. Careful attention should be given to the design of the ventilation network, including the calculation and verification of rates and velocities of air flow, to ensure that it is adequate for controlling airborne contamination. In many facilities, the control of airborne contamination is achieved by: (a) Maintaining adequate negative pressure with respect to atmospheric pressure. (b) Providing an adequate or prescribed number of air changes in the workplace. (c) Providing the appropriate exhaust air, off gas cleaning systems (including scrubbers, adsorbers and/or HEPA filtration) so that the discharges from the facility will be within authorized limits. The discharge of the exhaust air should be through a stack of appropriate height to provide the necessary dilution for the releases to protect members of the public.	All	I	D	B	L	Facilities where significant amounts of radioactive substances may be released shall be equipped with ventilation and filtering systems, which will reduce the concentrations of radioactive substances in these facilities, prevent the spread of radioactive substances to other parts of the facility and restrict the release of radioactive substances into the environment. These ventilation and filtering systems shall also be able to operate as designed during and after an anticipated operational transient or postulated accident (Ikonen et al. 2020, Section 2.2.1). Ventilation (Ikonen et al. 2020, Figures 6-1, 6-3, 7-1; Fischer et al. 2020, Section 5.3). Ventilation building (Ikonen et al. 2020, Figures 5 4 and 5-5, Section 5.7). Intermediate Depth: Ventilation system (Ikonen et al. 2020, Section 6.1.2). If the radon content of the air exceeds the permitted limit, ventilation is increased (Ikonen et al. 2020, Section 6.2.5). DGR: Ventilation system (Ikonen et al. 2020, Figure 7-4, Section 7.1.2). Landfill: Waste emplacement is performed under open conditions.
GSG-7 (IAEA 2018)	Occupational Radiation Protection (https://www-pub.iaea.org/MTCD/publications/PDF/PUB1785_web.pdf)	9.13, 9.18	In some workplaces, especially in underground mines and in buildings where dry processing of radioactive minerals is carried out, the fresh air supplied by the primary ventilation system might not be adequate to ventilate particular parts of the workplace. Examples of such workplaces include development ends in underground mine tunnelling operations and product bagging areas in facilities processing radioactive minerals. In these circumstances, auxiliary ventilation is commonly supplied to the affected parts of the workplace through flexible ducts. The positioning of auxiliary ventilation ducts should be such as to avoid recirculating eddies of contaminated air.	All	I	D	B	L	Intermediate Depth: The tunnel length for waste (VLLW and LLW halls) is 105 metres and the remaining 5 metres is for turning and plug reservation. With this length there are no remarkable challenges related to additional ventilation fans (Ikonen et al. 2020, Section 6.1.1). DGR: The maximum length of deposition tunnels is 180 metres from the transfer tunnel wall line. With this length, there are no remarkable challenges related to additional ventilation fans (Ikonen et al. 2020, Section 7.1.1).
GSG-7 (IAEA 2018)	Occupational Radiation Protection (https://www-pub.iaea.org/MTCD/publications/PDF/PUB1785_web.pdf)	9.14	The proper functioning of the primary and auxiliary ventilation systems throughout the operating phase of the facility should be ensured and, if necessary, should be indicated as audiovisual alarms in the control room display panel or the radiation protection officer's display panel, so that prompt action for the protection of workers can be initiated. The employer should put in place a programme of inspection and maintenance of ventilation equipment, including main fans, auxiliary fans and any heating or cooling systems. This programme should be documented and recorded.	All	I	D	B	L	Devices with an alarm function shall be employed for radiation monitoring so that during the operation of the disposal facility, significant unintentional exposure to radiation will not occur (Ikonen et al. 2020, Section 2.2.1). The reliable operation of systems and components shall be ensured through maintenance and regular periodic inspections and tests (Ikonen et al. 2020, Section 2.2.1).
GSG-7 (IAEA 2018)	Occupational Radiation Protection (https://www-pub.iaea.org/MTCD/publications/PDF/PUB1785_web.pdf)	9.16, 5.50	For the effective operation of primary and auxiliary ventilation systems in a facility: (a) Air intakes and exhausts should be separated to the extent practicable. (b) Ventilation should be considered an important safety related system. For equipment such as fans, blowers and HEPA filter systems consideration should be given to the provision of standby systems, including alternative power supplies (such as diesel generators), where necessary. In this way, process systems can be shut down safely during the conduct of maintenance activities while all monitoring systems will continue to work. Consideration should also be given to real time indicators of system performance to alert operators to failures or malfunctions of exhaust systems. (c) For the protection and safety of workers, every workplace should be supplied with air of a quantity and quality sufficient to ensure that exposure due to airborne contaminants, such as dust, radon and other radioactive gases, is minimized. (d) Air velocities should be high enough to dilute the airborne contaminants but not so high as to cause settled dust to be resuspended. (e) In the case of underground mines, the primary systems for ventilation and dust control should preferably be operated continuously; if the continuous operation of these systems is not practicable, the regulatory body may authorize intermittent operation subject to (f) below. (f) When the ventilation system has been changed, has failed or has been shut down, workers should be allowed to return to their workplaces only after the ventilation system has been restarted and appropriate monitoring has been performed to ensure that the concentrations of airborne contaminants have been reduced to acceptable levels.	All	I	D	B	L	Ventilation (including filtering systems) (Ikonen et al. 2020, Figures 6-1, 6-3, 7-1, Section 2.2.1). Ventilation building (Ikonen et al. 2020, Figures 5 4 and 5-5, Section 5.7). The purpose of the permanent ventilation system is to maintain sufficiently good air quality in the underground disposal facility (Ikonen et al. 2020, Sections 6.1.2, 7.1.2). Intermediate Depth: Ventilation system (Ikonen et al. 2020, Section 6.1.2). If the radon content of the air exceeds the permitted limit, ventilation is increased (Ikonen et al. 2020, Section 6.2.5). DGR: Ventilation system (Ikonen et al. 2020, Figure 7-4, Section 7.1.2). Deep Borehole: Ventilation (Fischer et al. 2020, Section 5.3). Intermediate depth, DGR: The following measurements can be carried out in the disposal facility: measurements of air, bedrock and water temperature; air humidity; drainage water level; air activity; CO-, CO2-, NOx- and radon content; air dust content; as well as smoke detection (Ikonen et al. 2020, Sections 6.1.2, 7.1.2). If the radon content of the air exceeds the permitted limit, ventilation is increased (Ikonen et al. 2020, Section 6.2.5). Landfill: Waste emplacement is performed under open conditions.
GSG-7 (IAEA 2018)	Occupational Radiation Protection (https://www-pub.iaea.org/MTCD/publications/PDF/PUB1785_web.pdf)	9.19	The location of fixed workstations in return airways or in areas of high external radiation should be avoided. Where appropriate, operator booths with a filtered air supply should be used in these circumstances to provide the necessary protection.	All	I	D	B	L	Intermediate Depth, DGR: Ventilation (Ikonen et al. 2020, Figures 6-1, 6-3, 7-1), ventilation building (Ikonen et al. 2020, Figures 5 4 and 5-5, Section 5.7), ventilation system (Ikonen et al. 2020, Section 6.1.2, Figure 7-4, Section 7.1.2). Deep Borehole: Ventilation (Fischer et al. 2020, Section 5.3). Landfill: Waste emplacement is performed under open conditions.
GSG-7 (IAEA 2018)	Occupational Radiation Protection (https://www-pub.iaea.org/MTCD/publications/PDF/PUB1785_web.pdf)	9.20, 9.21	In most operations involving the potential for high dust generation, for example mining and mineral processing, the adoption of dust control measures is usually a legal requirement because of the necessity of protecting workers against non-radiological hazards such as inhalation of silica particles. These measures generally provide sufficient restrictions on airborne dust concentrations to ensure adequate protection of workers against the inhalation of any radionuclides of natural origin that may be present in the dust.	All	I	D	B	L	Excavation causes dust emissions and the blasting explosion gases must be removed by temporary ventilation during construction stage (Ikonen et al. 2020, Sections 6.1.2, 7.1.2). Ventilation (Ikonen et al. 2020, Figures 6-1, 6-3, 7-1; Fischer et al. 2020, Section 5.3). Ventilation building (Ikonen et al. 2020, Figures 5 4 and 5-5, Section 5.7). Ventilation system: Intermediate Depth (Ikonen et al. 2020, Section 6.1.2); DGR (Ikonen et al. 2020, Figure 7-4, Section 7.1.2). Landfill: Waste emplacement is performed under open conditions.

GSG-7 (IAEA 2018)	Occupational Radiation Protection (https://www-pub.iaea.org/MTCD/publications/PDF/PUB1785_web.pdf)	9.22, 9.23	The employer should establish standard operating procedures to be followed in the event of any significant radiation hazard or potential radiation hazard arising from the spillage of radioactive material from a facility or during transport between facilities. Such standard operating procedures should include procedures for the following: (a) Cleaning up spillages; (b) Restricting access to the area; (c) Implementing contingency plans; (d) Monitoring affected persons; (e) Obtaining advice from the radiation protection officer or qualified expert; (f) Managing waste arisings; (g) Notifying the regulatory body or other relevant authorities as required.	All	I	D	B	L	Radiation protection (Ikonen et al. 2020, Sections 6.2.5, 7.1.1, 7.2.5, 8.2.4, 9.2.5). Spillages not explicitly discussed in the Ikonen et al. (2020) report (to be decided).	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	2.5	The graded application of the safety requirements for near surface disposal and geological disposal to borehole disposal will ensure an adequate level of safety. In all cases, reasonable assurance of safety should be demonstrated to the regulatory body and to other stakeholders.	Deep Borehole			B		General requirement, not directly related to facility design	GSR Part 4 (Rev. 1) (IAEA 2016), Requirement 4
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	3.2	Only very minor releases of radionuclides (such as small amounts of gaseous radionuclides) may be expected during pre-disposal activities and during the operation of a borehole disposal facility. The design should be such that, even in the event of an accident involving the breach of a waste package, releases are not likely to have any impact outside the facility. Relevant considerations should include the packaging, the waste form, the radionuclide content of the waste and control of contamination on packages and equipment.	Deep Borehole			B		Geochemically reducing conditions limit solubility and enhance the sorption of many radionuclides (Ikonen et al. 2020, Section 8.0). The safety concept of a borehole disposal system is very similar to that of DGRs. It relies on multi-barrier system that consists of canister, buffer, borehole backfill, borehole seal and the host rock. However, the safety concept has two significant differences compared with excavated repositories: the great depth of the disposal zone and the very compact geometry of the system (Ikonen et al. 2020, Section 2.1.3).	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	3.3	A radiological protection programme should be in place during the operational period. This should ensure that doses to workers are controlled and that the requirements for dose limitation are met. In addition, contingency measures should be in place to deal with accidents and incidents so that any associated radiation hazards are controlled to the extent possible.	Deep Borehole			B		Radiation protection (Ikonen et al. 2020, Section 8.2.4)	GSG-7 (IAEA 2018)
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	Box 1	The radiation doses and risks to workers and members of the public exposed as a result of operations at the borehole disposal facility are required to be kept as low as reasonably achievable, economic and social factors being taken into account, and the exposures of individuals are required to be kept within applicable dose limits.	Deep Borehole			B		Exposure of operating personnel, limiting the radiation exposure of personnel (Ikonen et al. 2020, Section 2.2.1). Radiation protection (Ikonen et al. 2020, Section 8.2.4).	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	Box 2, 3.7, 3.8, 3.9	Borehole disposal facilities are to be sited, designed, constructed, operated and closed so that protection in the post-closure period is optimized, social and economic factors being taken into account, and an assurance is provided that doses or risks to members of the public in the long term will not exceed the applicable dose or risk that was used as a design constraint.	Deep Borehole			B		General requirement that covers the full waste management lifetime	ICRP Publication 81 (1998) SSR-5 (IAEA 2011)
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	3.5	The primary goal of borehole disposal is to dispose of radioactive waste in a manner that protects human health and the environment in the long term, after the borehole disposal facility has been closed. This is achieved by means of design features that result in optimizing doses due to any migration of radionuclides from the facility while also complying with the dose constraints. It is recognized, however, that radiation doses and risks to individuals living in the distant future can only be estimated and the reliability of these estimates will decrease as the time period extending into the future increases. In this context, the optimization of protection is a judgemental process in which social and economic factors need to be taken into account, and it needs to be conducted in a structured but essentially qualitative way, supported by quantitative analysis.	Deep Borehole			B		Borehole design, closure design (Ikonen et al. 2020, Section 8.3), canister design, site selection	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	3.6	A well-designed and well-located borehole disposal facility should provide reasonable assurance that radiological impacts in the post-closure period will be low both in absolute terms and in comparison with any other waste management options that are currently available at reasonable cost. A site should be identified that provides favourable conditions for containment and isolation of the waste from the biosphere and for preservation of the engineered barriers (e.g. with low groundwater flow and a benign geochemical environment). The borehole disposal facility should be designed to take account of the characteristics offered by the site, to optimize protection and to keep doses within the dose and/or risk constraints. The borehole disposal facility should then be constructed, operated and closed according to the assessed design so that the assumed safety characteristics of both the engineered and the natural barriers are realized.	Deep Borehole (incl. site)			B		Site selection (Ikonen et al. 2020, Ch. 4)	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	3.10	Very low frequency natural events could degrade the borehole disposal facility barriers, leading to the release of radionuclides to the environment and the exposure of humans to radiation. In circumstances where there is a significant uncertainty associated with the occurrence of an event or process and the consequent exposures, the level of safety is best demonstrated by separate consideration of the probability of occurrence and the potential magnitude of exposures. In these situations, the treatment of exposures far into the future is considered conceptually similar to potential exposure situations and can be treated in a similar manner.	Deep Borehole			B		Site selection (Ikonen et al. 2020, Ch. 4)	ICRP Publication 81 (1998) ICRP Publication 64 (1993)

SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	3.11, 3.12	In the event of inadvertent human intrusion into a borehole disposal facility, a few individuals who take part in activities such as drilling or excavating into the facility could receive high doses. The doses and risks to these individuals should be estimated but, according to the latest ICRP recommendations [ICRP Publication 81], they need not be a deciding factor in assessing the safety and acceptability of the facility. The doses and consequences of such intrusion should be estimated in order to evaluate and determine the appropriate measures (administrative and physical) necessary to prevent intrusion or to mitigate its consequences.	Deep Borehole	B	Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7)	ICRP Publication 81 (1998)
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	3.13	The small 'footprint' of a borehole disposal facility will help to reduce the probability of human intrusion and this can be reduced still further by increasing the depth and length of the disposal zone. Siting of the facility away from known mineral and water resources will also decrease the likelihood of human intrusion. Over shorter timescales, actions such as preserving records, placing restrictions on land use, placing warning signs and maintaining passive institutional control should also help to reduce the incidence of such events.	Deep Borehole (incl. site)	B	Site design	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	3.17	The impact of non-radioactive materials present in a borehole disposal facility should also be assessed. Factors that should be considered may include the content of chemically or biologically toxic materials in the waste or in the engineered barrier materials, the protection of groundwater resources and the ecological sensitivity of the environment into which contaminants may be released. For example, if disused sealed sources were to be disposed of together with their lead shielding, safety assessments would need to examine the potential migration of the lead.	Deep Borehole	B	HLW/spent fuel canisters are planned to be disposed, along with other engineered barriers. Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7).	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	4.16	The requirements for operator responsibility for geological disposal place an obligation on the operator to develop a disposal facility that is both practicable and safe and to demonstrate its safety in compliance with regulatory requirements. In some cases, this may include collection of the waste at the waste generators' premises and its transport to the disposal site. In meeting this obligation, the operator should take into consideration the characteristics and quantities of disused sealed sources that are radioactive and other radioactive waste to be disposed of, the transport infrastructure, the sites available, the drilling and engineering techniques available, research needs and the national legal framework and regulatory requirements. Where the operator employs contractors to perform the work, the operator is responsible for ensuring that they also comply with the regulatory requirements.	Deep Borehole	B	Operation planning	SSR-5 (IAEA 2011)
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	4.17, 5.2–5.13, 5.33	The operator is charged in particular with the responsibility for preparing and submitting to the regulatory body a safety case on which decisions about the development of the disposal facility can be based. Borehole construction should not proceed until a licence has been granted.	Deep Borehole	B	Licensing (Ikonen et al. 2020, Section 2.2.1)	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	4.18	The operator should be responsible for conducting or commissioning the research and development needed to support the feasibility and safety of the facility design. This should include site investigations. The operator also has the responsibility for carrying out or commissioning all the investigations of sites and materials necessary to assess their suitability and to provide data for safety assessments. In the case of borehole disposal facilities, it is envisaged that the designs will rely almost entirely on tried and tested materials and working practices. This will largely confine research to desk studies and will shift the emphasis of the work towards demonstrations of the operability of the design and the suitability of the site.	Deep Borehole	B	Pre-disposal phase activities	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	4.19, 4.11, 5.60–5.64	The operator should establish and set limits, controls and conditions (e.g. technical specifications) derived from the safety assessments to ensure that the disposal facility is developed and operated in accordance with both the safety case and the licence conditions. This will require the recruitment and training of suitably qualified staff, the exercise of due control over the receipt, transport and emplacement of waste (e.g. waste acceptance criteria), and the implementation of appropriate security measures. Any changes to the design or operation of the facility that may have a potential impact on safety should be subject to a change control process.	Deep Borehole	B	General requirement, not directly related to facility design	SSG-1 (IAEA 2009), 5.46, 5.47
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	4.20	The operator should retain all the information relevant to the safety case, the supporting safety assessments for the disposal facility and the inspection records that show compliance with regulatory requirements and the operator's own specification, at least up until the information is superseded or responsibility for the disposal facility is passed to some other appointed agency (e.g. at closure). When this responsibility is transferred, the operator should hand over all the information that is relevant to the safety of the facility.	Deep Borehole	B	General requirement, not directly related to facility design	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	4.21	The operator should take full responsibility for the waste upon receipt. The operator should also have the responsibility for verifying that the waste is fully and correctly described in the accompanying documentation. The description may include the dose rate at the surface of the package and at 1 m distance, as well as details of removable surface contamination, volume, mass and physical status, and chemical and radionuclide composition of the waste.	Deep Borehole	B	General requirement, not directly related to facility design	

SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	4.26	In accordance with the requirements concerning the importance of safety in the development process, at each major decision point, the safety implications of available options are considered and taken into account. Ensuring safety is the overriding factor at each decision point. If more than one option is capable of providing the required level of safety, then other factors may also be considered. These other factors may include public acceptability, cost, security, site ownership, existing infrastructure and transport routes.	Deep Borehole (incl. site)	B	General requirement, not directly related to facility design	SSR-5 (IAEA 2011)
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	4.27, 4.28	A borehole disposal facility should be sited, designed and constructed so that, when closed, the post-closure safety of the facility will not depend on actions that would need to be taken after the closure.	Deep Borehole	B	The entire waste management process	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	4.30	Regardless of the degree and duration of post-closure institutional control, safety assessments should be conducted with the aim of providing reasonable assurance of an adequate level of passive safety for boreholes of both types. Factors contributing to passive safety include the use of chemically stable waste forms, high integrity containers, borehole backfill between the containers and the borehole casing, disposal at a depth greater than 30 m, nonchemically reactive groundwater, stable geology and disposal in a location that benefits from a low probability of human intrusion.	Deep Borehole	B	Institutional controls (Ikonen et al. 2020, Sections 8.2.1, 8.3.2.1). Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7).	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	4.31	Passive safety is not a requirement for the operational period, although, clearly, if the operational activities are organized to reduce the number of active measures needed to ensure safety, this will be beneficial. An example is the incorporation of shielding in packages to allow them to be contact handled. Passive safety is also assisted by keeping the operational period short. For instance, to avoid keeping a borehole open for an extended period, it may be preferable to drill, construct, emplace, backfill and close a borehole only when there is sufficient waste for disposal to allow this full sequence of activities to be enacted. This may require the capability to store the waste safely at the facility for a period of time.	Deep Borehole	B	Operation planning	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	4.32, 4.33, 4.34, 4.35	A borehole disposal facility should be designed and sited so that there is sufficient understanding of the features, events and processes that influence post-closure safety to gain the reasonable assurance of safety that is required to be established. This understanding should cover the time period during which the waste constitutes a significant potential hazard or, at least, over the time frame of the post-closure safety assessment (which may be fixed by regulation or agreed with the regulatory body).	Deep Borehole	B	FEP analysis (to be decided)	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	4.36	Ensuring that doses will be below the regulatory approved dose constraints is a necessary but not by itself sufficient condition for regulatory approval. This is because, for the optimization of protection, it is required that if safety can be enhanced without undue detriment, then it should be, economic and social factors being taken into consideration. Optimization of protection will often be judgemental because the decision on when a detriment changes from being acceptable to being undue will ultimately depend on the individual circumstances and the value judgements of those doing the judging. It follows that the optimization of protection is an issue that should be discussed in the light of the individual circumstances and, wherever possible, agreed in advance with the regulatory body. Safety assessments provide some of the most important inputs to the process of optimization.	Deep Borehole	B	The design as a whole. Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7).	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	4.37, 4.38	The optimization of protection during the operational phase of a facility is a key element of the design of the disposal facility itself, the predisposal facilities and the above ground operations. Relevant considerations include the separation of drilling and waste emplacement operations, the use of remote handling and radiation shielding during predisposal and disposal operations, the control of working environments, the reduction in the potential for accidents and their consequences and the minimization of maintenance requirements in radiation and contamination areas. Many of these issues are common to the operation of nuclear facilities generally and guidance is available [Safety Reports Series No. 21 (IAEA 2002)].	Deep Borehole	B	The design as a whole. Remote handling (Ikonen et al. 2020, Sections 8.2.2, 8.2.7). Radiation protection (Ikonen et al. 2020, Section 8.2.4).	Safety Reports Series No. 21 (IAEA 2002)
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	4.39	In some cases, there may be competing demands between operational and post-closure safety. A higher standard of packaging (e.g. a fully welded container or waste treatment to avoid gas generation) may benefit post-closure safety at the expense of somewhat higher occupational doses during predisposal activities (though doses should still fall below the regulatory dose constraint). It should be the responsibility of the operator to design the facility so that an appropriate balance is reached between any competing demands.	Deep Borehole	B	Waste packages (Ikonen et al. 2020, Section 8.2.3)	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	4.40	In general, post-closure safety is achieved by designing and implementing a disposal system in which the components work together to provide and ensure the required level of protection. This approach offers flexibility to the designer of a borehole disposal system to adapt the facility layout and engineered barriers to take advantage of the natural characteristics and barrier potential of the host environment. Operational safety should also be ensured and this may require consideration of a number of complex issues, including the possible impact of predisposal and disposal operations on the post-closure performance.	Deep Borehole	B	Barrier system (Ikonen et al. 2020, Section 2.1.3). Adaptation of design to match the bedrock conditions/rock suitability (Ikonen et al. 2020, Sections 8.0, 8.1.8).	

SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	4.41	The requirements concerning containment call for the engineered barriers, which include the waste form and packaging, to be designed and the natural barriers to be selected to provide containment of the radionuclides in the waste, especially during the initial period when the level of activity is most intense and radioactive decay can significantly reduce the hazard posed by the waste. This will allow the majority of shorter lived radionuclides to decay in situ. At the same time, release of gaseous radionuclides and a small fraction of some other highly mobile species may be inevitable from waste package of some types, but generally these radionuclides present relatively minor radiological hazards. In any event, the safety assessment should demonstrate that doses and risks arising from such releases fall within the regulatory constraints.	Deep Borehole	B	Safety assessment (Ikonen et al. 2020, Section 2.2.1)	SSR-5 (IAEA 2011), 3.39–3.42
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	4.42	Waste of higher radiotoxicity, which may include some disused radioactive sources, can be surrounded by an encapsulation matrix and placed in durable containers. The purpose of the encapsulation matrix is to contain the radionuclides in the waste through a combination of physical and chemical functions that are effective for hundreds or even thousands of years. Other engineered barriers, such as a borehole backfill, may allow this containment period to be extended even further, but complete containment of all radionuclides for all time cannot be expected. Containment of radionuclides is also provided by the natural barriers by means of geochemical and physicochemical retention processes that lead to retardation of the transport of radionuclides in the geosphere. Evidence from natural analogues indicates that these processes can be effective over very long timescales.	Deep Borehole	B	Canister and sealing design (Ikonen et al. 2020, Sections 2.1.3, 8.1.1, 8.2.3, 8.3.2)	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	4.44	In choosing sites, consideration should be given to erosion, tectonic uplift and landslip that might cause the waste to be brought close to the surface over the assessment period. One of the aims of isolation is to prevent human intrusion, which could affect the subsequent isolation of the waste and containment of the radionuclides within it. It is clear that isolation is also important in promoting security. While human intrusion is inherently unpredictable, some actions can be taken at the design stage to lessen both its probability and its consequences. If possible, for instance, borehole disposal facilities should be located away from known underground mineral and water resources. In general, disposal at greater depth should improve security and should help to reduce both the probability and the consequences of human intrusion.	Deep Borehole (site)	B	Site selection (Ikonen et al. 2020, Ch. 4)	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	4.46	For waste placed deeper than 30 m, isolation is primarily provided by the geosphere and the main factors to be considered in determining a depth that will provide an appropriate level of isolation are the rate of surface erosion, the timescale of the assessment and the depth of any permafrost. Of course, isolation is not the only issue to be considered when determining borehole depth: the influence of the host geological environment on containment should also be considered.	Deep Borehole	B	The depth of the disposal casing is 3500 m (Ikonen et al. 2020, Table 8-5).	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	4.47	A safety function is a specific purpose that must be accomplished for safety; the safety function could be provided by a physical or chemical quality or process that contributes to safety. Examples of safety functions include low groundwater flux, impermeability to fluids, resistance to corrosion, insolubility of radionuclides, adsorption of radionuclides onto engineered materials and surrounding rocks and disposal in geological formations having a low groundwater flow.	Deep Borehole	B	Barrier system (Ikonen et al. 2020, Section 2.1.3).	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	4.48	To provide confidence in long term safety, a waste disposal system should employ a number of complementary engineered and natural barriers. Often, these barriers will be effective over different timescales and will provide a number of safety functions. Depending on the hazards associated with the waste, the barriers may vary in number and complexity. They may include, for instance:	Deep Borehole	B	Canister and sealing design (Ikonen et al. 2020, Sections 2.1.3, 8.1.1, 8.2.3, 8.3.2)	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	4.48(a)	(a) A waste container made of a corrosion resistant material that gives a container lifetime of about a thousand years;	Deep Borehole	B	Canister design (Ikonen et al. 2020, Sections 2.1.3, 8.1.1, 8.2.3). Corrosion-resistant material (copper) is used in the canisters (Ikonen et al. 2020, Section 8.2.3).	SSG-1 (IAEA 2009), 5.18
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	4.48(b)	(b) A cement based backfill placed between the container and the borehole casing to create high pH conditions that limit solubility and promote sorption and so provide chemical containment for thousands of years;	Deep Borehole	B	Sealing design. Seal (Ikonen et al. 2020, Figure 8-1). Sealing and plugging (Fischer et al. 2020, Section 4.2.13).	SSG-1 (IAEA 2009), 5.18e
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	4.48(c)	(c) A location where the rate of groundwater movement and the degree of radionuclide sorption onto the surrounding rocks together ensure that the radionuclides would take many thousands of years to migrate to the biosphere.	Deep Borehole	B	Site selection, borehole design (depth)	

SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	4.49		Although the safety of a borehole disposal facility will ultimately be judged by global measures of the total system performance, these barriers should not be unduly dependent on each other. So, for instance, in the example just outlined, the container lifetime may be extended by the high pH conditions provided by water leaching from the cement backfill, and the longevity of the backfill will be assisted by low groundwater flow. However, a groundwater flow that is higher than expected should not result in rapid corrosion of the container and the release of its contents. Similarly, failure of the cement to provide the expected high pH conditions should not lead to failure of the container or a more rapid migration of radionuclides through the surrounding rocks. These unwanted possibilities could be prevented by using a container material that shows adequate corrosion resistance over a range of pH conditions and sufficient cement backfill to provide long lived high pH conditions even if the groundwater flow were at the top end of the range of possibilities. In this way, a worse than expected performance from one of the barriers would not lead to the failure of the entire system.	Deep Borehole			B		Barrier system (Ikonen et al. 2020, Section 2.1.3), design (Ikonen et al. 2020, Section 8.1.1)	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	4.52		The operator of a borehole disposal facility will be responsible for the security of the waste from the time it is received from the waste generator. Precautions should be taken at the disposal site to prevent persons from carrying out unauthorized actions that might jeopardize safety or allow unauthorized removal of the waste [IAEA-TECDOC-1355]. The extent of security arrangements should reflect the potential for damage to the facility and the assessed risk of unauthorized removal of the waste. The arrangements should, at least, include measures to prevent unauthorized access to the site during site operations. Clearly, waste such as high activity disused sealed radioactive sources will require stricter security than low level waste. Arrangements and appropriate liaison with competent authorities should be established to obtain timely assistance if this is required.	Deep Borehole			B		The National Facility site will be fenced (Ikonen et al. 2020, Figure 5-4). Security and emergency arrangements (Ikonen et al. 2020, Section 2.2.1). Security patrols and surveillance of the disposal facility are centralised in the operation building. This control post is manned at all times, so it is the logical point for controlling access (Ikonen et al. 2020, Section 5.7). The security guards work in three shifts. At night, surveillance of the operation building takes place from the security guard centre (Ikonen et al. 2020, Section 5.6).	IAEA-TECDOC-1355 (2003)
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	4.54, 5.53, 5.66		Even where all the waste in a borehole disposal facility is placed at a depth of more than 30 m, a site security presence will be required throughout the operational period. In cases where disposals occur in a series of campaigns, it may be preferable to seal all the boreholes that contain waste at the end of each campaign. Subsequent sealing of the boreholes and closure of the site should aim to allow the lifting of security measures at the site.	Deep Borehole			B		Operation planning	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.15, 5.39–5.59		An important issue that should be decided relatively early in the programme is the selection of an appropriate design of waste package, i.e. the container and its contents. This is essential for both the predisposal and the disposal periods as it provides containment for the waste during storage, transport, disposal operations and the post-closure phases. Factors such as the amount of in-built shielding (and therefore the need to handle the waste package remotely) and the dimensions and weight of the waste package, lifting and handling arrangements, corrosion and radiation resistance and the method of emplacement in the borehole will all have an influence on operational feasibility and safety. The long term performance of the waste package may play an important part in the post-closure safety of the disposal system. The durability of the waste package will depend on the properties of the materials used in its construction and their interactions with the other engineered barriers and in the geochemical environment.	Deep Borehole			B		Canister design (Ikonen et al. 2020, Sections 2.1.3, 8.1.1, 8.2.3)	
Strålevernloven (LOV-2000-05-12-36)	Lov om strålevern og bruk av stråling / Act on Radiation Protection and Use of Radiation (https://lovdata.no/dokument/NL/lov/2000-05-12-36/KAPITTEL_2#%C2%A79) (English: https://app.uio.no/ub/ujur/oversatte-lover/data/lov-20000512-036-eng.pdf)	Section 7	I virksomhet som omfattes av loven, skal de ansatte og andre tilknyttede personer i nødvendig utstrekning ha utdanning eller opplæring, som sikrer at de har tilstrekkelige kvalifikasjoner eller kunnskap innen strålevern og sikker bruk av stråling.	In enterprises encompassed by this Act, the employees and other associated persons shall have such instruction or training as is necessary to ensure that they have sufficient qualifications or knowledge in the field of radiation protection and safe use of radiation.	All	I	D	B	L	General requirement, not directly related to facility design	Strålevernforskriften, Section 16, 18 StrålevernHefte 2018:33, 11.1 GSG-7 (IAEA 2018), 3.141–3.156 NEA/RWM/R(2013)9 (OECD/NEA 2014), p. 139–140 DGR, Intermediate Depth: SSG-14 (IAEA 2011), 6.84 Deep Borehole: SSG-1 (IAEA 2009), 4.19, 5.42 Landfill: SSG-29 (IAEA 2014), 6.51, 6.52
Strålevernforskriften (FOR-2016-12-16-1659)	Forskrift om strålevern og bruk av stråling / Regulation on Radiation Protection and Use of Radiation (Radiation Protection Regulations) (https://lovdata.no/dokument/SF/forskrift/2016-12-16-1659) [Unauthorised translation as of 20 August 2017:] (https://www2.dsa.no/publikasjon/radiation-protection-regulations.pdf)	Section 6	Effektiv dose til allmennhet og ikke-yrkeseksponerte arbeidstakere skal ikke overstige 1 mSv/år for ioniserende stråling. Ekvivalent dose til øyelinse skal ikke overstige 15 mSv/år. Ekvivalent dose til hud skal ikke overstige 50 mSv/år, målt eller beregnet over et vilkårlig hudareal på 1 cm².	The effective dose to the public and non-occupationally exposed workers shall not exceed 1 mSv/year for ionising radiation. Equivalent dose to the lens of the eye shall not exceed 15 mSv/year. Equivalent dose to the skin shall not exceed 50 mSv/year, measured or calculated over any skin area of 1 cm².	All	I	D	B	L	The design as a whole	SSR-5 (IAEA 2011), 2.15(a) GSG-7 (IAEA 2018), 2.12–2.14 GSG-8 (IAEA 2018), 2.30–2.32, 3.49–3.54 ICRP Publication 26 (1977), 103, 119, 120, 130 ICRP Publication 46 (1985), 42 ICRP Publication 77 (1997), Section 5.2, 5.3, 6.1, 6.2 ICRP Publication 103 (2007), Section 5.10, 6.1 DGR, Deep Borehole, Intermediate Depth: ICRP Publication 122 (2013), 44, 49
Strålevernforskriften (FOR-2016-12-16-1659)	Forskrift om strålevern og bruk av stråling / Regulation on Radiation Protection and Use of Radiation (Radiation Protection Regulations) (https://lovdata.no/dokument/SF/forskrift/2016-12-16-1659) [Unauthorised translation as of 20 August 2017:] (https://www2.dsa.no/publikasjon/radiation-protection-	Section 6	Virksomheten skal planlegge strålingen og skjermingstiltakene slik at ikke-yrkeseksponerte arbeidstakere og allmennhet ikke eksponeres for en effektiv dose som overstiger 0,25 mSv/år.	The undertaking shall plan the use of radiation and protective measures to ensure that exposure of the non-occupationally exposed workers and the public, shall not be exposed to an effective dose exceeding 0.25 mSv/year.	All	I	D	B	L	The design as a whole. Exposure of operating personnel, limiting the radiation exposure of personnel (Ikonen et al. 2020, Section 2.2.1). Radiation protection (Ikonen et al. 2020, Sections 6.2.5, 7.1.1, 7.2.5, 8.2.4, 9.2.5). Operational safety during handling and storage of the waste and waste	cf. SSR-5 (IAEA 2011), 2.15(b) GSG-7 (IAEA 2018), 3.28–3.48 ICRP Publication 26 (1977), 103 ICRP Publication 81 (1998), 55, 63, 64

SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.20	In locating a suitable site for a borehole disposal facility, due consideration should be given to scientific, technical, socioeconomic and planning factors. Sites may be identified as possible sites in the selection process because they are on the locations of existing nuclear, waste management or governmental facilities and such sites are sometimes given a high weighting on the grounds of availability, practicality, transport needs and existing institutional control. A well-planned systematic approach will help with the site selection process and will provide opportunities for the involvement of stakeholders (interested parties). Meeting the required safety objectives is a primary consideration in site selection and the rest of this section focuses on this aspect.	Deep Borehole (site)	B	Site selection (Ikonen et al. 2020, Ch. 4)	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.25, 3.9, 5.26, 5.27, 5.29, 5.30, 5.31	The overall aim of site characterization is to gain a general understanding of the site in terms of its regional setting, its past evolution and its likely future natural evolution over the time frame of the assessment. The essential aspects of site characterization that should be carried out to obtain information for design and safety assessment purposes include, as a minimum, geology, hydrogeology, geochemistry, tectonics and seismicity, surface processes, meteorology, climate and the impact of human activities. While the extent of the efforts needed for the characterization of these properties for large near surface and geological disposal facilities is considerable, given a relatively simple site and borehole disposal on a small scale, the amount of effort need not be too onerous.	Deep Borehole (site)	B	Site characterisation (Ikonen et al. 2020, Section 4.3)	SSR-5 (IAEA 2011)
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.32, IV.21–IV.26	In post-closure safety assessment, the transport of radionuclides in groundwater (the ‘groundwater pathway’) is usually the dominant mechanism for the migration of radionuclides from the waste. Consequently, unsaturated sites or sites where groundwater movement is very slow (e.g. sites with rocks of very low permeability) may be advantageous in that, other things being equal, it will usually be easier to demonstrate compliance with a dose constraint or risk constraint than it would be for a site where groundwater movement were relatively rapid. Consequently, a saturated site in permeable rocks will generally require more effort to be expended on site characterization than would be the case for an unsaturated or very low permeability site. This subject is discussed at greater length in paras IV.21–IV.26 of Appendix IV.	Deep Borehole (site)	B	Safety assessment (Ikonen et al. 2020, Section 2.2.1)	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.34	Whether the construction of a borehole disposal facility is straightforward or complex depends primarily on rock conditions, the borehole diameter and the depth. Clearly, though, facility construction should deliver the approved design while also preserving the post-closure safety functions of the geological barrier. This is most likely to be achieved when construction is straightforward (i.e. when rock conditions are amenable to the required borehole dimensions).	Deep Borehole	B	Borehole construction (Ikonen et al. 2020, Sections 8.1.1, 8.2)	SSR-5 (IAEA 2011)
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.35	Construction should be accompanied by a planned programme of testing, commissioning and inspection (which is likely to include regulatory inspection). This programme should have the aim of demonstrating that construction of the facility is in accordance with the design and the associated technical specifications, and that the features revealed by its construction are consistent with what is known from the site characterization. This may require the removal and preservation of rock and groundwater samples.	Deep Borehole	B	Demonstrations of borehole disposal operation (Ikonen et al. 2020, Section 8.1.10)	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.36	Borehole construction should be carried out by suitably qualified and experienced personnel following previously approved written procedures [GS-G-3.4 (IAEA 2008)]. These procedures should be derived from assessments of conventional construction safety and should be updated as practical experience is gained. Borehole construction records should provide a complete description of the history of construction, including when, how and by whom the borehole was constructed, its depth and diameter, the geological formations encountered and any non-compliances with regard to the construction procedures.	Deep Borehole	B	General requirement, not directly related to facility design	GS-G-3.4 (IAEA 2008)
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.37	Construction of new boreholes could continue after the commencement of emplacement operations in boreholes already constructed. Such overlapping construction and operation activities should be planned and carried out to ensure both operational and post-closure safety following the specified licensing conditions.	Deep Borehole	B	Only one borehole is planned. However, it is possible to drill a second hole from the same site without interacting with the first borehole, if one borehole is not enough for the waste (Ikonen et al. 2020, 8.1.1).	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.38	Where boreholes pass through different hydrogeological regimes, drilling should avoid unnecessary disturbance. For instance, while the emplacement zone should avoid aquifers, it may be necessary to drill through an aquifer to reach the emplacement zone, and this will necessitate casing the borehole to isolate waste from the aquifer and to avoid the creation of pathways between different strata. Rock conditions and hydrogeology will vary from one borehole to another and there should be sufficient flexibility in the underground engineering techniques and/or the programme either to remediate marginally unsuitable boreholes or else to seal them off and close them without emplacing any waste. There are many ways in which a borehole can fail and contingency plans are needed to cover these eventualities.	Deep Borehole	B	Borehole construction (Ikonen et al. 2020, Sections 8.1.1, 8.2)	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.39	The operational phase of a borehole disposal facility includes commissioning activities, waste reception, waste emplacement, borehole backfilling, borehole sealing and site decommissioning and closure. In addition, there can be various engineering tasks, including temporary storage or final conditioning of the waste.	Deep Borehole	B	Activities and schedule (Ikonen et al. 2020, Section 8.2.1)	

SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.39	Only waste that complies with the waste acceptance criteria can be accepted for disposal.	Deep Borehole	B	The concept description of the National Facility is, at this point, still flexible and able to be adjusted to different waste acceptance criteria or packaging options (Ikonen et al. 2020, Section 2.2.2). To be decided.	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.44	The operational techniques should be tested and confirmed, especially those used for putting in place the engineered barriers and for emplacing the waste packages in the borehole. This may be done through the use of an inactive test facility and, later, through on-site commissioning tests.	Deep Borehole	B	Demonstrations of borehole disposal operation (Ikonen et al. 2020, Section 8.1.10)	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.45	For deeper, smaller diameter boreholes, where access and retrieval of waste packages are more difficult, consideration should be given to ensuring that: (a) The possibility of dropping waste packages is very unlikely.	Deep Borehole	B	The handling systems for spent fuel disposal canisters or other waste packages shall be designed so that a single equipment failure cannot cause a drop accident or another kind of accident where significant amounts of radioactive substances could be released from a package or canister (Ikonen et al. 2020, Section 2.2.1).	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.45(b)	(b) Waste packages are correctly positioned in the facility.	Deep Borehole	B	Repository operation (Ikonen et al. 2020, Section 8.2.2)	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.45(c)	(c) Waste packages are correctly backfilled.	Deep Borehole	B	The backfilling of residual cavities requires additional work as well as the performance of borehole measurements (Ikonen et al. 2020, Section 8.2.1). Closure (Ikonen et al. 2020, Section 8.3.2).	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.48	The operator should establish procedures for prescribed actions in the event of (i) emergencies or non-routine occurrences (e.g. jamming of waste packages in boreholes) and (ii) receipt of waste that does not conform to the waste acceptance criteria. The procedures should also specify when reports should be made to the regulatory body.	Deep Borehole	B	General requirement, not directly related to facility design	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.49	The operation of borehole disposal facilities may be performed on a continuous basis or a campaign basis or a combination of the two. With continuous operation, packages are placed in the borehole disposal facility as they arise and the operator may, therefore, need to exercise operational control over the site for several years. Campaign operation involves the accumulation of waste in stores until there is sufficient waste to be disposed of in a new borehole. This provides a short term operational disposal period and would allow individual boreholes to be drilled, filled and sealed in one complete exercise, thus reducing the chances of boreholes degrading or being mismanaged between disposal operations. Provided that waste packages are weather resistant, they could be stored in a secure, access controlled, open air compound. It is likely that continuous operation would be most appropriate in the case of large capacity boreholes where quite extensive storage facilities would be needed. In this case, rainwater and surface water should be prevented from entering the borehole, which should be fitted with a secure cover when operations are pending.	Deep Borehole	B	Facility construction in phases (Ikonen et al. 2020, Section 8.1.9). Activities and schedule (Ikonen et al. 2020, Section 8.2.1).	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.51	Following waste emplacement, there will usually be a need for the borehole to be backfilled. Materials that could be used for backfilling include cement, bentonite slurry, or a loose fill of bentonite granules, sand and so on. It may be necessary to design and to demonstrate measures to reduce the possibility of leaving voids after backfilling. These could include backfilling in stages.	Deep Borehole	B	Closure (Ikonen et al. 2020, Section 8.3.2)	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.52	For deeper boreholes, backfill would be introduced following the emplacement of individual packages. In this case, it may be possible to use pressure grouting to introduce the backfill, provided that the borehole is uncased (or screen cased). When boreholes of this type are fully cased and sealed at the bottom, it will be necessary to rely on gravity, although backfill placement could be assisted by pumping out the air beforehand.	Deep Borehole	B	Closure (Ikonen et al. 2020, Section 8.3.2)	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.53	Following waste emplacement and backfilling, the operator will seal each borehole following the method prescribed in the licence and the safety case. This activity, which may be overseen by the regulatory body, will place the borehole into its final configuration and preserve the safety functions on which post-closure safety depends. Boreholes may be sealed and closed individually or collectively at the end of a disposal campaign. If seals are not put in place for a period of time after the completion of waste emplacement, then the implications for operational and post-closure safety should be considered in the safety case. Likewise, the implications of any unexpected postponement of sealing should be considered.	Deep Borehole	B	Closure (Ikonen et al. 2020, Section 8.3.2)	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.55	Safe operations should be achieved through the application of recognized technical and managerial principles [GS-G-3.4 (IAEA 2008)]. Thus, the licence to operate may require the operator to conduct periodic reviews covering issues such as quality assurance audits, operating conditions, environmental sampling and analysis, occupational health and safety, and maintenance of records.	Deep Borehole	B	General requirement, not directly related to facility design	GS-G-3.4 (IAEA 2008)
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.57, 5.59	An important operational requirement is the recording of relevant information, as stipulated by the regulatory body. With respect to the waste itself, much of this information will have been obtained from the waste generators and will form part of an already existing national waste inventory. Each waste package should have a unique identification. For each waste package, information should be compiled on its principal characteristics (e.g. origin of the waste, radionuclide content of the package, method of encapsulation, materials of the waste container, method of closure).	Deep Borehole	B	General requirement, not directly related to facility design	

SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.58, 5.59	Operational records should describe when, how and by whom an operation was carried out and, especially, any non-compliances with the operating procedures. When waste is emplaced, for instance, the position of the waste package should be recorded (e.g. the number and location of the borehole and the position within the borehole). Processes such as backfilling and sealing should be similarly recorded.	Deep Borehole	B	General requirement, not directly related to facility design	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.66	When all boreholes are backfilled and sealed, the site itself should be closed. Regulatory approval for decommissioning and site closure (which are regarded as operational activities) will require the submission of an updated safety case using current data to demonstrate that the required post-closure performance will be achieved. The safety case should also include detailed plans for both decommissioning and closure. These plans should describe the decommissioning activities (e.g. site surveys, decontamination and removal of any redundant buildings and equipment, site remediation, final survey to confirm any necessary site cleanup and transfer of documents to other premises) and demonstrate that the closure activities will not impair the post-closure performance of the facility. An IAEA technical report discusses the decommissioning of small facilities [Technical Reports Series No. 414 (IAEA 2003)].	Deep Borehole	B	Closure and decommissioning (Ikonen et al. 2020, Section 8.3)	Technical Reports Series No. 414 (IAEA 2003)
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.67	The closure plan should also describe any arrangements intended for the post-closure institutional phase. These arrangements should include a system for archiving and preserving records. They might also include control of access to the site, maintenance of site security, a surveillance programme and a radiological monitoring plan. In each case, the closure plan should identify the organization responsible for conducting these activities. Ownership of the site should be clearly and appropriately allocated. When the closure operations have been satisfactorily completed, the period of post-closure institutional control can begin.	Deep Borehole	B	Closure and decommissioning (Ikonen et al. 2020, Section 8.3). Institutional control (Ikonen et al. 2020, Sections 8.2.1, 8.3.2.1).	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.68	Institutional control is defined as any form of institutional activity, from oversight by international agencies and national governments to very specific activities such as environmental monitoring. It is generally expected that institutional controls will assist with the societal acceptability of the disposal. Institutional controls are generally classified into 'active' and 'passive' controls.	Deep Borehole	B	Institutional control (Ikonen et al. 2020, Sections 8.2.1, 8.3.2.1)	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.68	Active institutional controls include: (a) Maintaining signs, fences and guards at sites to prevent unauthorized access and intrusion by animals. (b) Maintaining access, maintaining the grounds, weed control, etc. (c) Monitoring and surveillance (see paras 5.74–5.80). (d) Performing any remedial work that may become necessary, for instance, on the basis of the monitoring and surveillance programme.	Deep Borehole	B	Institutional control (Ikonen et al. 2020, Sections 8.2.1, 8.3.2.1)	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.68	Passive institutional controls include: (a) Long term markers; (b) Restrictions on land use and ownership; (c) Preservation of records; (d) Financial assurances.	Deep Borehole	B	Institutional control (Ikonen et al. 2020, Sections 8.2.1, 8.3.2.1)	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.69	Whether the duration of the institutional control period is defined by law or established on a case by case basis through the approval of closure plans, it should be specified in the site closure plan and justified by reference to its potential future hazard (e.g. the rate of radioactive decay of the waste, human intrusion scenarios or historical experience of the retention of information). Institutional control periods, often of the order of 100–300 a, are frequently part of the safety concept for many near surface disposal facilities associated with nuclear power programmes. The site closure plan, including any newly proposed institutional control period, should require the review and approval of the regulatory body before being implemented.	Deep Borehole	B	Institutional control (Ikonen et al. 2020, Sections 8.2.1, 8.3.2.1)	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.70, 5.71	The post-closure arrangements should be documented and should identify the institutional controls that are to be provided during the institutional control period, who is responsible for providing them and how long each control will stay in place. Earlier removal of any institutional controls should need the prior approval of the regulatory body.	Deep Borehole	B	Post-closure period, institutional control (Ikonen et al. 2020, Sections 8.2.1, 8.3.2.1)	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.72	Passive institutional controls can help to maintain knowledge of the facility's location and characteristics within societal institutions. Information that should be preserved with respect to a borehole disposal facility is primarily: (a) Its precise location; (b) Its geology, geochemistry and hydrology derived from site characterization data; (c) Design details of the facility, including descriptions of, for example, the backfill, casing and seals; (d) Detailed descriptions of the waste packages, including waste origin, radionuclide content, encapsulation matrix and containers; (e) Descriptions of the construction and operation, including dates and details such as measured water inflows to boreholes and, especially, any non-conformances and actions taken to rectify them; (f) The facility safety case and supporting information (e.g. from site characterization); (g) A description of the post-closure arrangements; (h) Outputs from the surveillance and monitoring programme, including baseline surveys.	Deep Borehole	B	Institutional control (Ikonen et al. 2020, Sections 8.2.1, 8.3.2.1)	

SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.73	Such information should be retained for as long as possible to provide a basis for any future decisions concerning the site. This may be most easily done by making use of national archives. Long term site markers may also help, although consideration should be given to their possible implications for security.	Deep Borehole			B	If desired, signs can be left on the site to indicate the presence of radioactive waste underground (Ikonen et al. 2020, Section 2.2.7).	
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.74, 5.75	A programme of surveillance and monitoring should form part of the safety case and should commence before a disposal facility becomes operational — usually during the site characterization programme. As the disposal programme moves from one phase to the next, the objectives of the surveillance and monitoring programme will change and additional surveillance and monitoring activities will be added [RS-G-1.8 (IAEA 2005)]. Some of these activities may continue through into the period of post-closure institutional control. Through the various phases of development of the facility, the surveillance and monitoring objectives should be set to allow the surveillance and monitoring programme to contribute to the building of confidence in the safety case by testing assumptions and demonstrating compliance.	Deep Borehole			B	Monitoring (Ikonen et al. 2020, Section 8.2.7). Post-closure period, institutional control (Ikonen et al. 2020, Sections 8.2.1, 8.3.2.1).	RS-G-1.8 (IAEA 2005)
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.76, 5.77	As part of site characterization, a baseline of environmental levels, radiation levels and activity concentration levels should be established for the purpose of subsequently determining the changes (if any) brought about by the emplacement of the waste. These data may include surface radiological data such as gamma radiation fields, the radionuclide content of airborne dust and the radionuclide (including radon) content of the soils, water and air on and around the site. These data and their current impact on humans should be used to gain an understanding of radionuclide transfer pathways, especially in areas where groundwater from the vicinity of the facility could discharge. The monitoring should also cover wider environmental information such as that on the local ecology, chemical pollutants, population density and habits, local agriculture, and natural and artificial features of the environment that might affect radionuclide transfer pathways [RS-G-1.8 (IAEA 2005)].	Deep Borehole			B	Baseline monitoring (Ikonen et al. 2020, Section 8.2.7)	RS-G-1.8 (IAEA 2005)
SSG-1 (IAEA 2009)	Borehole Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1418_web.pdf)	5.81	Systems for accounting and control of nuclear material have been developed to provide for the accountability of nuclear material so as to detect, in a timely manner, its diversion to unauthorized or unknown purposes in the short and medium terms. As presently organized, systems for accounting and control of nuclear material rely on active surveillance and controls.	Deep Borehole			B	Safeguard will ensure that the handling of nuclear material is controlled and handled in the purpose of disposal. The Ikonen et al. (2020) report does not cover plans for safeguards (Ikonen et al. 2020, Section 8.2.6).	Nuclear Energy Series No. NF-T-3 (IAEA 2018)
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	2.1	The depth chosen for disposal in a particular facility will depend on a number of factors including, but not limited to, climatic and groundwater conditions, rock stability, host rock composition and the nature and hazard of the waste.	DGR, Intermediate Depth	I	D		Design depth of the DGR: approximately 400 m (Ikonen et al. 2020, Section 7.1.1; Depth of the Intermediate Depth Repository: 100 m (Ikonen et al. 2020, Section 6.1.1). For all underground repositories, the depth will depend strongly on the site geology (Ikonen et al. 2020, Ch. 1). The eventual disposal depths will be decided based on site-specific conditions.	
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	4.5	Critical components of the disposal system (i.e. the disposal facility and the environment in which it is sited) should be qualified, as appropriate and practical, using standardized and accepted testing methods to gain confidence in their ability to perform the required function(s). If new techniques are employed, they should be developed and qualified within a time frame that is compatible with the project schedule.	DGR, Intermediate Depth	I	D		General requirement, not directly related to facility design. The reliable operation of systems and components shall be ensured through maintenance and regular periodic inspections and tests (Ikonen et al. 2020, Section 2.2.1).	
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	4.6, 5.1	Operational safety is provided by means of active and passive systems. Active systems could include monitoring for releases of radioactive material and operational controls, whereas passive systems could include engineered features such as shielding.	DGR, Intermediate Depth	I	D		Radiation protection (Ikonen et al. 2020, Sections 6.2.5, 7.1.1, 7.2.5). Monitoring radiation safety (Ikonen et al. 2020, Section 2.2.1). Disposal facility monitoring and control systems (Ikonen et al. 2020, Sections 6.1.2, 7.1.2). Instrumentation systems are used for gathering and processing information on the condition of the facility and ensuring that working safety is good in the facility. The monitoring and control data are collected in the control room in the operational building. The following measurements can be carried out in the disposal facility: measurements of air, bedrock and water temperature; air humidity; drainage water level; air activity; CO-, CO2-, NOx- and radon content; air dust content; as well as smoke detection (Ikonen et al. 2020, Sections 6.1.2, 7.1.2). Structures, systems and equipment containing significant amounts of radioactive substances shall be placed in separate rooms or shielded effectively. Adequate safety margins shall be incorporated in the design of radiation shielding (Ikonen et al. 2020, Section 2.2.1). DGR: During transfer, the canister is covered with a radiation shield (Ikonen et al. 2020, Section 7.1.2). Measuring and recording data on the quantities of radioactive substances released into the environment (Ikonen et al. 2020, Section 2.2.1). Safety centre (Ikonen et al. 2020, Sections 6.1.1, 6.1.4, Figure 7-1). The purpose of telecom systems is to allow communications between members of personnel working in the underground and above ground disposal facility (Ikonen et al. 2020, Section 6.1.2, 7.1.2). Landfill repository monitoring (Ikonen et al. 2020, Section 9.2.8).	INFCIRC/546 (24 December 1997), Article 24

SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	4.8	Containment of waste implies designing the disposal facility to postpone or minimize the release of radionuclides. Containment may be provided both by means of a durable waste form and packaging, compatible with the other engineered barriers and the host geological formation. The safety case and supporting safety assessment for the particular waste type and site will provide the required demonstration of the containment capability of the disposal system. A long containment period provided by durable waste packages may not be practicable or necessary for lower activity long lived waste.	DGR, Intermediate Depth	I	D	Containment: Intermediate depth (Ikonen et al. 2020, Table 2-1); DGR (Ikonen et al. 2020, Section 2.1.2). Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7). Packaging (Ikonen et al. 2020, Section 2.2.2). The methods used for the construction, operation and sealing off repositories and other underground openings shall be chosen so that the bedrock will maintain its natural containment characteristics in an optimal fashion (Ikonen et al. 2020, Section 2.2.6).	
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	4.9	For the most highly concentrated radioactive waste, such as spent nuclear fuel (if designated as radioactive waste) and vitrified waste from fuel reprocessing, it is necessary that the engineered barriers provide practically complete containment over a period of several hundreds of years to several thousand years. This will ensure that the majority of shorter lived radionuclides decay in situ and uncertainty associated with the degradation of the waste form and migration of radionuclides when pronounced thermal gradients are present is reduced (i.e. any release of radionuclides would occur only after the heat generated by radioactive decay has substantially decreased)	DGR		D	DGR: Containment (Ikonen et al. 2020, Section 2.1.2). In the DGR, the disposal method is KBS-3, which has been shown by previous assessments (SKB, Posiva) to provide complete containment for thousands of years.	NEA No. 6424 (OECD/NEA 2009), Section 3.2.4 NEA No. 6433 (OECD/NEA 2008), p. 7
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	4.10	Isolation means retaining the waste and keeping its associated hazard away from the biosphere in a disposal environment that provides substantial physical separation from the biosphere, making human access to the waste difficult without special technical capabilities, and that restricts the mobility of most of the long lived radionuclides. For geological disposal of radioactive waste, isolation is provided primarily by the host geological formation as a consequence of the depth of disposal.	DGR, Intermediate Depth	I	D	For all underground repositories, the depth will depend strongly on the site geology. The aim is to maintain maximum flexibility to allow changes in the design solutions (Ikonen et al. 2020, Ch. 1). The eventual disposal depths will be decided based on site-specific conditions.	
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	4.11	Location of a geological disposal facility at an appropriate depth in a stable geological formation provides protection of the facility from the disruptive effects of geomorphological processes such as erosion and glaciation. Location away from known areas of underground mineral resources and other valuable resources will reduce the likelihood of inadvertent disturbance of the geological disposal facility.	DGR, Intermediate Depth (site)	I	D	Site selection (e.g. avoidance of sites with valuable resources) and the depth of the repositories (Intermediate Depth: design depth 100 m (Ikonen et al. 2020, Section 6.1.1); DGR: approximately 400 m (Ikonen et al. 2020, Section 7.1.1)). For all underground repositories, the depth will depend strongly on the site geology (Ikonen et al. 2020, Ch. 1). The eventual disposal depths will be decided based on site-specific conditions.	
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	4.12	An appropriate depth for the geological disposal facility should be determined, with account taken of the nature and the hazard of the waste, local geological and hydrogeological conditions, including the hydraulic head gradients, and geochemical and geomechanical characteristics.	DGR, Intermediate Depth	I	D	Site selection (e.g. consideration of hydrogeological conditions) and the depth of the repositories (Intermediate Depth: design depth 100 m (Ikonen et al. 2020, Section 6.1.1); DGR: approximately 400 m (Ikonen et al. 2020, Section 7.1.1)). For all underground repositories, the depth will depend strongly on the site geology. The aim is to maintain maximum flexibility to allow changes in the design solutions (Ikonen et al. 2020, Ch. 1). The eventual disposal depths will be decided based on site-specific conditions.	
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	4.13	Multiple safety functions enhance both safety and confidence in safety by ensuring that the overall performance of the geological disposal system is not unduly dependent on a single safety function. The presence of multiple safety functions provides assurance that even if one safety function does not perform fully as expected (e.g. owing to an unforeseen process or an unlikely event), other safety functions will ensure that the overall performance of the disposal system as a whole is not jeopardized.	DGR, Intermediate Depth	I	D	Safety functions: Intermediate depth (Ikonen et al. 2020, Table 2-1, Section 2.1.1); DGR (Ikonen et al. 2020, Table 2-2, Section 2.1.2)	
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	4.14	In the long term, progressive degradation of the engineered barrier system cannot be ruled out and, consequently, radionuclides may be released into the geological environment where they may eventually migrate to the biosphere. The disposal system should provide a combination of natural and engineered characteristics to support efficient containment and isolation of the waste by maintaining package integrity, limiting the solubility of radionuclides and the waste form, minimizing where possible groundwater inflow and/or providing a long travel time for radionuclide transport from the disposal facility to the biosphere. Factors limiting inflows and contributing to long travel times include low permeability formations, low hydraulic gradients and dispersion characteristics of the geosphere. Any potential concentrations of radionuclides in the biosphere would be further reduced by the retardation and precipitation capability of the engineered barriers and the host rock. In addition, radioactive decay progressively reduces the activities of radionuclides present in the disposal system. Materials used for backfilling or sealing should have properties that do not degrade unduly the safety functions of the geological barriers.	DGR, Intermediate Depth	I	D	Limitation and retardation of radionuclide release and transport: Intermediate depth (Ikonen et al. 2020, Table 2-1); DGR (Ikonen et al. 2020, Section 2.1.2). The potential release routes and the environment of the facility shall in particular be subjected to monitoring. In order to monitor the potential release routes of radioactive substances, systems shall be designed for measuring and recording data on the quantities of radioactive substances released into the environment (Ikonen et al. 2020, Section 2.2.1). Backfill and plug materials: Intermediate Depth (Ikonen et al. 2020, Section 6.2.3); DGR (Ikonen et al. 2020, Section 7.2.3). Closure materials (Ikonen et al. 2020, Sections 2.2.7, 6.3.2). DGR: The EBS structures are designed to be compatible with the host rock and support its performance (Ikonen et al. 2020, Section 2.1.2). The chemical stability of bentonite shall be ensured for a very long period of time in order to guarantee the long-term safety of the HLW disposal solution (Ikonen et al. 2020, Section 2.2.6). Landfill: Material options (Ikonen et al. 2020, Table 9-3).	

SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	4.15	A safety function may be provided by means of a physical entity, such as the waste form, waste package, the backfill or the host geological formation, the characteristics of which inherently prevent or restrict the migration of radionuclides. A safety function may also be provided by means of a chemical property or process, such as solubility, corrosion rate, dissolution rate or leach rate. A particular barrier may perform a number of safety functions. For example, the backfill may provide chemical conditioning of the groundwater in addition to retention of radionuclides. Therefore, the requirement to ensure that safety is provided by means of multiple safety functions may be achieved through consideration of the safety functions offered by a single barrier, particularly for waste that poses a lower hazard.	DGR, Intermediate Depth	I	D	Safety functions: Intermediate depth (Ikonen et al. 2020, Table 2-1, Section 2.1.1); DGR (Ikonen et al. 2020, Table 2-2, Section 2.1.2)	
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	4.18	Safety after closure is provided by passive systems such as geological and engineered barriers. Geological disposal, at appropriate depths, provides isolation as an inherent safety feature. Monitoring or institutional controls is not to be relied on for the safety of the facility after closure. This does not mean that post-closure monitoring need not be carried out, if present or future generations choose to do so. It is likely that passive institutional controls, such as the use of markers and control on land use, will be implemented and maintained, at least for a certain period immediately after closure. Active institutional controls such as monitoring may also be applied for a period after closure of a geological disposal facility, for example, to address public concerns and licensing requirements or as protection against human intrusion.	DGR, Intermediate Depth	I	D	Isolation: Intermediate depth (Ikonen et al. 2020, Table 2-1), DGR (Ikonen et al. 2020, Section 2.1.2). Long-term safety is provided through the repository design by passive means to fulfil the requirements and shall not rely on extended monitoring or maintenance of the site (Ikonen et al. 2020, Section 2.2.1). If desired, signs can be left on the site to indicate the presence of radioactive waste underground (Ikonen et al. 2020, Section 2.2.7). Post-closure period (Ikonen et al. 2020, Section 2.2.7).	
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	5.18	The safety case should include plans for closure of the facility. These should be updated and refined as information is gained during site characterization and construction and operation of the disposal facility. An authorization to begin waste emplacement in a facility will include approval of preliminary closure plans, while recognizing that these plans will be updated as operations proceed. If possible, closure designs and plans in should be tested under conditions that are relevant for the facility.	DGR, Intermediate Depth	I	D	Closure design: Intermediate Depth (Figure 6-8, Section 6.3); DGR (Section 7.3). Safety case and licensing (Ikonen et al. 2020, Section 2.2.1).	NEA No. 6182 (OECD/NEA 2007)
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.9, 6.13–6.23, Appendix I	A detailed programme of site characterization should be carried out to provide the site specific data necessary to support the technical basis for safety assessments of the long term isolation and containment of the waste within the excavated portion of the geological disposal facility. Quantitative data of a level of detail sufficient for their end use should be obtained (in terms of accuracy and precision of the data and their representative nature with regard to spatial and temporal variability). Appendix I provides additional guidance on the types of information that are expected from a programme for site investigation and characterization. However, the listing may not be exhaustive and site specific circumstances will ultimately dictate what information is required and in what detail.	DGR, Intermediate Depth (site)	I	D	Affects site selection; the detailed guidance in the referenced Appendix I is to be taken into account. Site characterisation activities (Ikonen et al. 2020, Section 4.3).	
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.10	Ultimately, knowledge from site characterization will be necessary to provide a credible scientific description of the natural characteristics at the site and a demonstration of understanding concerning safety significant processes (e.g. geological, hydrological, geochemical, mechanical processes). This knowledge will be necessary to provide confidence in the technical basis for safety assessments of the geological disposal system.	DGR, Intermediate Depth (site)	I	D	General requirement, not directly related to facility design	
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.11	In addition to providing a description of the present day characteristics of a site, the site characterization programme should collate and interpret information in support of models describing the past evolution of the site. This should include an investigation of the long term stability of the geosphere in response to past environmental and climatic changes at the surface and the effects of tectonics, including faulting, rock fracturing and volcanism. Palaeohydrogeological studies are particularly relevant in this regard. The timescale for consideration of such changes should be at least comparable to the future timescale of interest in the safety assessment. Such information may be used in support of scenarios for the future natural evolution of the site and for evaluating the relevance of features, events and processes that could affect the performance of the disposal system, including interactions between the natural and engineered elements.	DGR, Intermediate Depth (site)	I	D	Affects site selection (implies important properties of the site). Site characterisation activities (Ikonen et al. 2020, Section 4.3).	
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.12	The site characterization programme should be conducted at spatial and temporal scales and of a scope sufficient to acquire an adequate understanding of the phenomena that could affect site safety for the time periods of interest and also to develop credible physical process models.	DGR, Intermediate Depth (site)	I	D	General requirement, not directly related to facility design. Site characterisation activities (Ikonen et al. 2020, Section 4.3).	
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.24	An environmental impact assessment, as required by appropriate national authorities, should be carried out in conjunction with the site characterization for safety purposes. Depending on relevant national laws, the environmental impact assessment may be very broad and may include an evaluation of the effects of the proposed disposal facility on public health and safety and on the environment. It may also include a discussion on avoiding or mitigating such effects and other local or regional impacts of locating the disposal facility at the site.	DGR, Intermediate Depth	I	D	General requirement, not directly related to facility design. Environmental impact factors (Ikonen et al. 2020, Section 2.2.11).	

SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.25	The facility design is required to provide safety during both the operational and post-closure periods and should take account of any requirements for monitoring, accounting and control of nuclear material, concurrent underground activities (such as excavation, waste emplacement and equipment maintenance, refurbishment and replacement) and retrievability of the waste or reversibility.	DGR, Intermediate Depth	I	D	Monitoring radiation safety (Ikonen et al. 2020, Section 2.2.1). Surveillance and monitoring (Ikonen et al. 2020, Sections 5.2, 5-6, 5-7, 6.2.8, 7.2.8, Figures 5-4, 5-5). Disposal facility monitoring and control systems (Ikonen et al. 2020, Sections 6.1.2, 7.1.2). DGR: Measurements related to nuclear material (high level waste) safeguards are also included (Ikonen et al. 2020, Section 7.1.2). Post-closure period (Ikonen et al. 2020, Section 2.2.7). Control and maintenance (Ikonen et al. 2020, Figure 6-1, Section 6.1.1, 6.1.4).	
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.26, 6.27	Whilst disposal is defined as the emplacement of waste in an appropriate facility without the intention of retrieval, in some situations, it may, nevertheless, be required that retrievability (design for the safe removal of waste) of the waste be allowed at any period of time before closure. If the ability to retrieve waste is a design requirement, it should be considered as early as possible in the design process in such a way as not to compromise the safety of the facility after closure. As with meeting any design requirement, an optimized approach should be adopted that is consistent with the design principles.	DGR, Intermediate Depth	I	D	To be decided	NEA No. 6433 (OECD/NEA 2008), p. 9 DGR, Deep Borehole, Intermediate Depth: ICRP Publication 122 (2013), 24
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.28	The design of the facility should be of sufficient detail and accuracy to enable the effect of the design requirements to be appropriately evaluated in the assessments of operational and post-closure safety. As the facility design evolves over the phases of facility development, safety assessments are updated to evaluate the effect of design changes on compliance with regulatory criteria.	DGR, Intermediate Depth	I	D	The details of the design will be defined based on site-specific conditions. Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7).	
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.29	The design of the facility for safety in the period after closure should meet the precepts of robustness, simplicity, technical feasibility and passivity; facility design for operational safety will include both active and passive systems. Facility design for the safety of surface based activities associated with the operational period (waste handling and storage) should reflect state of the art radiation protection and industrial safety practices, analogous to existing nuclear facilities. Facility design for the safety of possibly concurrent underground activities (excavation and waste emplacement) should reflect a combination of the best radiation protection, industrial, mining and civil engineering safety practices [SF-1, Safety Series No. 115, RS-G-1.1].	DGR, Intermediate Depth	I	D	Radiation protection (Ikonen et al. 2020, Sections 6.2.5, 7.1.1, 7.2.5). DGR: The safety concept is based on a robust system design that also includes the design of the deep geological repository. In this context, the robustness of the system means that isolated faults in the design and implementation, or lack of information and uncertainties related to future conditions may not lead to a significant deterioration of the safety features (Ikonen et al. 2020, Section 2.1.2). Storage (Section 5-7, Ch. 3, Figure 5-5). Transport within the site (transfer): Intermediate Depth (Ikonen et al. 2020, Sections 6.1.1, 6.1.2, 6.2.2, Figure 6-4); DGR (Ikonen et al. 2020, Sections 7.1.1, 7.1.2, 7.2.2, Figures 7-5, 7-6); Landfill (Ikonen et al. 2020, Table 9-5). Installation: Intermediate Depth (Ikonen et al. 2020, Section 6.2.2); DGR (Ikonen et al. 2020, Section 7.2.2, Figures 7-6, 7-7); Landfill (Ikonen et al. 2020, Sections 9.1.7, 9.2.2).	
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.30	The design of the geological disposal facility for safety in the post-closure period should make optimal use of the intrinsic features of the host geological environment and includes engineered barriers that complement the natural barrier system. Disposal facilities for both high level and intermediate level waste are expected to perform over much longer time periods than those usually considered in industrial applications. Investigation of the ways in which analogous natural materials have behaved in geological settings in nature, or how ancient artefacts and anthropogenic constructions have behaved over time, may contribute to confidence in the assessment of long term performance of the facility. It is important to demonstrate that both the fabrication of waste containers and the construction of engineered barriers are feasible (e.g. in underground laboratories) in order to gain confidence that an adequate level of performance can be achieved.	DGR, Intermediate Depth	I	D	DGR: The EBS structures are designed to be compatible with other EBS structures and the host rock and support their performance (Ikonen et al. 2020, Section 2.1.2). Many investigations and research projects have shown that copper has a good corrosion resistance in deep (reducing) groundwater (Ikonen et al. 2020, Section 2.2.2). The chemical stability of bentonite shall be ensured for a very long period of time in order to guarantee the long-term safety of the HLW disposal solution (Ikonen et al. 2020, Section 2.2.6). The disposal facility will be adapted to site-specific conditions.	
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.31	The geological disposal facility should be designed so that fissile material, when present, will remain in a subcritical configuration during the operational period. Assessment of the possible evolutions of the disposal system in the post-closure period should also address the criticality issue and should provide confidence that a subcritical condition will be maintained.	DGR, Intermediate Depth	I	D	The formation of such spent fuel configurations that would cause an uncontrolled chain reaction of fission shall be prevented by means of the structural design of systems and components. The waste canisters containing spent fuel shall be designed so that no critical fuel configurations may be formed in any operational situations, including any anticipated incident or postulated accident. The emplaced canisters shall retain their subcriticality also over the long term when the canisters' internal structures may be corroded and partly filled with groundwater (Ikonen et al. 2020, Section 2.2.1).	SSR-5 (IAEA 2011), 4.31, 4.37 SSG-27 (IAEA 2014), 5.2, 5.61
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.32	Operational activities should be classified on the basis of estimated radiation exposure conditions and the potential for contamination. Rooms requiring radiation control or with the potential for contamination should be located within a specified area of the facility to allow appropriate access control. In meeting operational requirements to control access, a zoned approach, working inwards towards areas requiring more stringent control, could be applied, where appropriate.	DGR, Intermediate Depth	I	D	Safety classification: Intermediate Depth (Ikonen et al. 2020, Section 6.1.3); DGR (Ikonen et al. 2020, Sections 6.1.3, 7.1.3). Disposal facility monitoring and control systems (Ikonen et al. 2020, Sections 6.1.2, 7.1.2).	

SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.33	Radiation monitoring in the operational period should be designed with consideration given to both anticipated operational conditions and postulated accidents. Monitoring stations should be established for measuring, for example, external radiation levels and air and groundwater contamination, as necessary. Such stations should be installed in the radiation controlled areas of the site and the non-controlled areas on-site and should be located selectively in the vicinity of the disposal facility, outside the site boundary.	DGR, Intermediate Depth	I	D	Disposal facility monitoring and control systems (Ikonen et al. 2020, Sections 6.1.2, 7.1.2). Monitoring radiation safety (Ikonen et al. 2020, Section 2.2.1). The purpose of condition monitoring is to monitor the condition of the disposal facility and systems during the operating phase. Instrumentation systems are used for gathering and processing information on the condition of the facility and ensuring that working safety is good in the facility. The monitoring and control data are collected in the control room in the operational building. The following measurements can be carried out in the disposal facility: measurements of air, bedrock and water temperature; air humidity; drainage water level; air activity; CO-, CO2-, NOx- and radon content; air dust content; as well as smoke detection (Ikonen et al. 2020, Sections 6.1.2, 7.1.2). Incidents and accidents: Intermediate Depth (Section 6.2.6); DGR (Ikonen et al. 2020, Section 7.2.6).
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.34	To maintain the assurance of robust safety assessment and safety case, the facility design process should be conducted within a management system providing for configuration change control. Design attributes of the engineered barriers for operational safety and post-closure safety should be classified to ensure application of design requirements is graded in accordance with the safety significance of the barrier.	DGR, Intermediate Depth	I	D	Safety classification: Intermediate Depth (Ikonen et al. 2020, Section 6.1.3); DGR (Ikonen et al. 2020, Sections 6.1.3, 7.1.3)
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.35	As with the management system requirements for data integrity, documentation of the facility design relevant to safety should be transparent and should be archived for the benefit of future generations.	DGR, Intermediate Depth	I	D	General requirement, not directly related to facility design
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.36	The proposed waste inventory and the waste acceptance criteria should be developed as part of the safety case and should be submitted to the regulatory body for approval of operations. The operations will ensure the safe handling of waste and the fulfilment of the safety functions by the waste form and waste packaging with regard to long term safety.	DGR, Intermediate Depth	I	D	Waste inventory (Ikonen et al. 2020, Section 2.2.3, Table 2-4). The concept description of the National Facility is, at this point, still flexible and able to be adjusted to different waste acceptance criteria or packaging options (Section 2.2.2). To be decided.
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.37	The final waste inventory received and emplaced should be tracked, submitted to the regulatory body for approval of facility closure and included in the safety case.	DGR, Intermediate Depth	I	D	Waste inventory (Ikonen et al. 2020, Sections 2.2.3, 2.2.10, Table 2-4, Figure 2-14)
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.38	The waste characteristics important to the safety of the operational and post-closure periods are part of the relevant safety case. Waste acceptance criteria may be developed by means of an iterative dialogue between regulatory body, the operator of the facility and the generator of the waste. The criteria should include the waste characteristics important to safety in the operational period and the period after closure and typically specify the following: (a) The permissible range of chemical and physical properties of the waste and the waste form; (b) The permissible dimensions, weight and other manufacturing specifications of each waste package; (c) Allowable levels of radioactivity in each package; (d) Allowable amounts of fissile material in each package; (e) Allowable surface dose rate and surface contamination; (f) Requirements for accompanying documentation; (g) Allowable decay heat generation for each package. Generators of waste and operators of facilities may wish to consider additional waste acceptance criteria, such as the waste conditioning method adopted in the treatment process, the potential for gas generation (e.g. through radiolysis, corrosion or the influence of microorganisms) or the composition of the waste (e.g. presence of free liquids, void volumes, organic content).	DGR, Intermediate Depth	I	D	Packaging (Ikonen et al. 2020, Section 2.2.2). ILW packages (Ikonen et al. 2020, Figure 2-8); LILW packages (Ikonen et al. 2020, Figure 2-9). Packaging plant (Ikonen et al. 2020, Sections 2.2.5, 5.7, Figure 5-5). DGR: Thermal dimensioning (Ikonen et al. 2020, Sections 2.2.6, 7.1.1). The concept description of the National Facility is, at this point, still flexible and able to be adjusted to different waste acceptance criteria or packaging options (Section 2.2.2). To be decided.
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.40	The management systems for records should be structured to accommodate the information associated with waste acceptance, including the data indicated in the previous paragraph, and records on waste generation and processing.	DGR, Intermediate Depth	I	D	General requirement, not directly related to facility design
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.41	The proposed waste acceptance criteria should be published at the earliest opportunity, to facilitate compatibility of the waste generated and its safe management at the waste generation sites prior to its emplacement in the disposal facility.	DGR, Intermediate Depth	I	D	The concept description of the National Facility is, at this point, still flexible and able to be adjusted to different waste acceptance criteria or packaging options (Section 2.2.2). To be decided.
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.42	Construction of a geological disposal facility commences only after the safety case for facility construction is approved in accordance with the requirements of the regulatory body. If it is proposed that an underground rock characterization or experimental facility will constitute a part of the disposal facility, adequate documentation should be available to demonstrate that the construction and operation of the characterization facility conforms with regulatory requirements for the disposal facility itself.	DGR, Intermediate Depth	I	D	DGR: Demonstration tunnels (Section 7.1.8, Figure 7-1).

SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.43	Construction of the facility should proceed in accordance with the approved facility design and any approved design modifications that may be necessary after commencing construction. The layout of the disposal facility will be constrained by host rock conditions and consequently design modifications are likely to be necessary as the construction proceeds. During the construction process, host rock investigations should be performed to verify the suitability of the layout of the disposal facility.	DGR, Intermediate Depth	I	D	Facility construction: Intermediate Depth (Ikonen et al. 2020, Section 6.1.7); DGR (Ikonen et al. 2020, Section 7.1.7, Figure 7-8). Layout flexibility and constraints (Ikonen et al. 2020, Section 2.2.6). Adaptation of design to match the bedrock conditions/rock suitability: Intermediate Depth (Ikonen et al. 2020, Section 6.1.7, 6.2.8); DGR (Ikonen et al. 2020, Sections 7.1.1, 7.1.7). Rock classification system (Ikonen et al. 2020, Sections 2.2.9, 7.1.7). Facility adaptation for different waste volumes: Intermediate Depth (Ikonen et al. 2020, Section 6.1.5); DGR (Ikonen et al. 2020, Section 7.1.5).
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.46	The safety of surface based construction activities should rely on state of the art industrial safety practices, analogous with existing nuclear or industrial facilities.	DGR, Intermediate Depth	I	D	Use of best available, proven technology (Ikonen et al. 2020, Section 2.2.7)
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.47	As an element of obtaining approval for operation (the licence), the operator is required to demonstrate, prior to commencement of operations involving radioactive material, the adequacy of the facility structures, systems, components, services, functions and procedures for the safe receipt, emplacement and, if necessary, retrieval of waste packages, including for off-normal events and emergency conditions. A commissioning period should be used to evaluate the adequacy of the design, including operating procedures, for the safe handling, emplacement and, if necessary, retrieval of waste as part of normal operations.	DGR, Intermediate Depth	I	D	General requirement, not directly related to facility design. Safety case and licensing (Ikonen et al. 2020, Section 2.2.1).
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.48	Following approval for commencement of operations involving radioactive material, the facility should be operated in accordance with the terms and conditions of the operating licence and relevant regulatory requirements to provide for adequate radiation protection of workers, the public and the environment. Operations should be conducted in accordance with approved procedures providing for safety [Safety Series No. 115, RS-G-1.1, GS-R-2].	DGR, Intermediate Depth	I	D	General requirement, not directly related to facility design. Radiation protection (Ikonen et al. 2020, Sections 6.2.5, 7.1.1, 7.2.5).
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.49, 6.69–6.74	Access to areas in which waste is handled, stored or emplaced should be controlled to ensure safety and the physical protection of material. Provision should be made for detection of any unauthorized intrusion and for the prompt taking of countermeasures.	DGR, Intermediate Depth	I	D	Controlled and uncontrolled areas and phases (Ikonen et al. 2020, Section 6.2.4, 7.2.4)
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.50	Closure activities are a part of the operational period of the facility and should be subject to separate approval by the regulatory body; the safety case should be periodically updated to reflect these closure activities. Some parts of the disposal facility, such as disposal tunnels, may be backfilled as soon as practicable in order to minimize the disturbance to the host rock. Such stepwise closure actions should be subject to regulatory approval.	DGR, Intermediate Depth	I	D	The repository openings shall be backfilled and sealed off immediately when the disposal operations and associated monitoring operations allow (Ikonen et al. 2020, Section 2.2.6). Closure design: Intermediate Depth (Figure 6-8, Section 6.3); DGR (Section 7.3)
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.52	Geological disposal facilities are likely to be operated for several decades for emplacement of waste from power plant operations or decommissioning. Operating procedures should cover maintenance and possibly refurbishment or replacement of equipment over this period of operation. Documentation of changes in equipment, procedures and conditions, and, where required, the safety case for them, should be clear and thorough.	DGR, Intermediate Depth	I	D	The reliable operation of systems and components shall be ensured through maintenance and regular periodic inspections and tests (Ikonen et al. 2020, Section 2.2.1). Control and maintenance rooms (Ikonen et al. 2020, Figure 6-1, Section 6.1.1, 6.1.4).
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.53	Monitoring of worker exposures and releases of radioactive material (primarily to the air) in the operational period should be used to inform design changes, including changes in procedures, to minimize releases and to keep exposures as low as reasonably achievable.	DGR, Intermediate Depth	I	D	Monitoring radiation safety (Ikonen et al. 2020, Section 2.2.1). The purpose of condition monitoring is to monitor the condition of the disposal facility and systems during the operating phase. Instrumentation systems are used for gathering and processing information on the condition of the facility and ensuring that working safety is good in the facility. The monitoring and control data are collected in the control room in the operational building. The following measurements can be carried out in the disposal facility: measurements of air, bedrock and water temperature; air humidity; drainage water level; air activity; CO-, CO2-, NOx- and radon content; air dust content; as well as smoke detection (Ikonen et al. 2020, Sections 6.1.2, 7.1.2).
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.54	As part of the demonstration of safety in the operational phase, the operator should analyse the consequences of various external events (e.g. fire, flooding, explosions) on the safety of the disposal facility and the safety of workers.	DGR, Intermediate Depth	I	D	Incidents and accidents (Ikonen et al. 2020, Section 2.2.1) (Intermediate Depth: Ikonen et al. 2020, Section 6.2.6; DGR: Ikonen et al. 2020, Section 7.2.6). Impacts caused by probable natural phenomena and other events external to the facility shall be considered in the design of the repository. The natural phenomena to be considered typically include lightning, earthquakes and floods. Other events external to the facility include electromagnetic interference, light airplane crashes, wildfires or explosions (Ikonen et al. 2020, Section 2.2.1).

SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.55	In some geological disposal programmes, it is envisaged that the facility could remain open for some considerable time after waste emplacement has ceased. This would extend the operating period even further, thus providing increasing amounts of monitoring data relevant to the performance of the facility after closure (e.g. corrosion of waste packages, wetting of backfill materials, changes in hydrological conditions). Procedures should be developed for the evaluation of monitoring data with respect to the impact of the extended operating period on the post-closure safety of the facility (e.g. re-evaluation of safety on the basis of the monitoring data). Documentation of the monitoring data, of any relevant changes from baseline conditions and, as necessary, of the impact of the extended operating period on post-closure safety should be clear and thorough.	DGR, Intermediate Depth	I	D	Leaving the disposal facility open after operations have ceased is not planned. Closure design: Intermediate Depth (Figure 6-8, Section 6.3); DGR (Sections 2.1.2, 7.3). Monitoring related to site, baseline studies (Ikonen et al. 2020, Sections 6.2.8, 7.2.8). Post-closure period (Ikonen et al. 2020, Section 2.2.7).	
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.56	Closure of a geological disposal facility involves activities such as backfilling and sealing of the underground openings of the disposal facility. The purpose of closure is to try to restore, as far as practicable, the initial natural conditions of the host rock before any excavation is started.	DGR, Intermediate Depth	I	D	Closure design: Intermediate Depth (Figure 6-8, Section 6.3); DGR (Sections 2.1.2, 7.3). Establishment of natural conditions (baseline studies) (Ikonen et al. 2020, Sections 6.2.8, 7.2.8).	
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.57	Post-closure performance of a geological disposal facility should be considered in the initial design and in subsequent updates to the safety case. Prior to regulatory approval for facility closure, the safety case should be updated to provide sufficient evidence that the closure system will be effective and that the safety of the geological disposal facility after closure will be in accordance with regulatory requirements. The effectiveness of the closure system could be shown by demonstrating an understanding of the natural evolution of the site, by in situ testing, by data analysis and modelling and by the use of suitable natural analogues.	DGR, Intermediate Depth	I	D	The design as a whole	
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.59	Closure of a geological disposal facility should also include decommissioning of surface facilities and undertaking any environmental restoration necessary, and may include the construction of durable markers.	DGR, Intermediate Depth	I	D	Closure design: Intermediate Depth (Figure 6-8, Section 6.3); DGR (Sections 2.1.2, 7.3); Landfill (Ikonen et al. 2020, Section 9.3). If desired, signs can be left on the site to indicate the presence of radioactive waste underground (Ikonen et al. 2020, Section 2.2.7). Decommissioning: Intermediate Depth (Ikonen et al. 2020, Section 6.3); DGR (Ikonen et al. 2020, Section 7.3); Landfill (Ikonen et al. 2020, Section 9.3).	
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.61	The monitoring programme should be defined prior to construction and in conjunction with development of the safety case. A baseline survey of the site, including the characteristics of the host rock, should be conducted before commencing construction activities. The monitoring programme should be revised periodically to reflect new information gained during construction and operation. A discussion of monitoring activities that could be conducted during the pre-operational and operational periods is provided in Ref. [IAEA-TECDOC-1208].	DGR, Intermediate Depth	I	D	Monitoring related to site, baseline studies (Ikonen et al. 2020, Sections 6.2.8, 7.2.8).	IAEA-TECDOC-1208 (2001)
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.62	A programme of monitoring should be included as part of the safety case and should be refined with each revision of the safety case. During the operational period, the monitoring programme should be used to demonstrate compliance with the regulatory requirements and licence conditions for operation, including compliance with safety requirements for environmental and radiation protection [4].	DGR, Intermediate Depth	I	D	Monitoring of the environmental impacts of the project (Ikonen et al. 2020, Sections 2.2.1, 6.2.8, 7.2.8). Radiation protection (Ikonen et al. 2020, Sections 6.2.5, 7.1.1, 7.2.5).	
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.64	For the post-closure period, the geological disposal facility should be of a passively safe design and should not require or rely on a post-closure monitoring programme to provide assurance of safety. Post-closure monitoring may be performed to provide public assurance, if required, by the government or the regulatory body, but should not compromise the passively safe design.	DGR, Intermediate Depth	I	D	Long-term safety is provided through the repository design by passive means to fulfil the requirements and shall not rely on extended monitoring or maintenance of the site (Ikonen et al. 2020, Section 2.2.1). Post-closure period (Ikonen et al. 2020, Section 2.2.7).	
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.67	Geological disposal facilities are designed to be passively safe in the post-closure period (i.e. not requiring intervention to ensure safety) and "The long term safety of a disposal facility for radioactive waste is not to be dependent on active institutional control" [1].	DGR, Intermediate Depth	I	D	Long-term safety is provided through the repository design by passive means to fulfil the requirements and shall not rely on extended monitoring or maintenance of the site (Ikonen et al. 2020, Section 2.2.1). The disposal concept is designed so that there will be no need for monitoring or other maintenance after the closure of connections to the repositories. If desired, signs can be left on the site to indicate the presence of radioactive waste underground. Post-closure monitoring can be included, if required (Ikonen et al. 2020, Section 2.2.7).	
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	6.67	Passive institutional controls should be established to prevent or reduce the likelihood of inadvertent human actions that could interfere with the waste or degrade the safety features of the geological disposal facility. Institutional controls may include the construction of durable markers, the posting of facility records in national and international archives accessible to future populations and the transfer of responsibility for the facility to a successor organization. A suitable mechanism may need to be developed for the transfer of responsibility from one generation to the next.	DGR, Intermediate Depth	I	D	Human intrusion (Ikonen et al. 2020, Sections 2.1.2 (DGR), 2.2.1, 2.2.7). If desired, signs can be left on the site to indicate the presence of radioactive waste underground (Ikonen et al. 2020, Section 2.2.7).	
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	I.23	The mechanical properties of the host rock should be favourable for the safe construction, operation and closure of the disposal facility and for ensuring the long term stability of the geological barrier surrounding the disposal facility. For heat generating waste, the thermal and thermo-mechanical properties of the host rock also need to be considered. Depending on the potential for gas generation by the disposal system, the gas transport properties of the geological barrier should also be considered in assessing its suitability for disposal.	DGR, Intermediate Depth (site)	I	D	Affects site selection (favours sites with favourable mechanical properties of the host rock). Site selection (Ikonen et al. 2020, Ch. 4). DGR: Thermal dimensioning (Ikonen et al. 2020, Sections 2.2.6, 7.1.1). In order to provide the basis for temperature calculations during the research phase, the thermal properties (thermal conductivity, heat capacity, possible anisotropy of properties) of the local bedrock in the actual disposal site are studied (Ikonen et al. 2020, Section 2.2.6).	

SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	I.25	The host rock should not be liable to be affected by future geodynamic phenomena (e.g. climate change, neotectonics, seismicity, volcanism, diapirism) to such an extent that these could unacceptably impair the containment and isolation capabilities of the overall disposal system.	DGR, Intermediate Depth (site)	I	D			Affects site selection (favours sites with low risk of major future geodynamic phenomena). Site selection (Ikonen et al. 2020, Ch. 4).	
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	I.28	The hydrogeological characteristics and the setting of the geological environment should tend to restrict groundwater flow within the disposal facility and should support the safe containment and isolation of waste for the required times. The groundwater system should be well enough understood to provide confidence that any radionuclides that might migrate from the disposal facility environment would be retarded due to limited connectivity or would be dispersed in the geosphere, resulting in sufficiently long travel times that reduce their concentration at the surface.	DGR, Intermediate Depth (site)	I	D			Affects site selection (favours sites where the hydrogeological characteristics and the setting of the geological environment should tend to restrict groundwater flow). Site selection (Ikonen et al. 2020, Ch. 4).	
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	I.32	The physicochemical and geochemical characteristics of the geological and hydrogeological environments should tend to limit the release of radionuclides from the disposal facility to the accessible environment or at least to restrict their migration.	DGR, Intermediate Depth (site)	I	D			Affects site selection (favours sites where the physicochemical and geochemical characteristics of the geological and hydrogeological environments limit the migration of radionuclides). Site selection (Ikonen et al. 2020, Ch. 4).	
SSG-14 (IAEA 2011)	Geological Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1483_web.pdf)	I.37	In the assessment of a host rock for a disposal facility, valuable or potentially valuable alternative uses of the host rock, such as for resource exploitation or the construction of storage cavities, should be considered. For example, the possible presence of gas or oil deposits and valuable mineral deposits and any significant geothermal energy potential should be taken into account to minimize the potential for human intrusion into the geological disposal system. Preference should be given to sites located in areas that minimize the likelihood that the host rock would be exploited for such uses.	DGR, Intermediate Depth (site)	I	D			Affects site selection (favours sites with no exceptional resources). Site selection (Ikonen et al. 2020, Ch. 4).	
SSG-15 (Rev. 1) (IAEA 2020)	Storage of Spent Nuclear Fuel (https://www-pub.iaea.org/MTCD/Publications/PDF/P1882_web.pdf)	2.2	If several nuclear installations (e.g. nuclear power plants, spent fuel storage facilities, reprocessing facilities) are located at the same site, the dose constraints for public exposure should take into account all sources of exposure that could be associated with activities at the site. Particularly in such cases, the regulatory body should require the operating organization(s) of the nuclear installation(s) on the site to develop constraints, subject to regulatory approval. Alternatively, the regulatory body may establish the dose constraints. Requirements on dose constraints are established in GSR Part 3 [IAEA 2014] and recommendations are provided in IAEA Safety Standards Series No. GSG-8, Radiation Protection of the Public and the Environment [IAEA 2018].	All	I	D	B	L	To be decided. Landfill: Waste under clearance levels.	GSR Part 3 (IAEA 2014) GSG-8 (IAEA 2018)
SSG-15 (Rev. 1) (IAEA 2020)	Storage of Spent Nuclear Fuel (https://www-pub.iaea.org/MTCD/Publications/PDF/P1882_web.pdf)	2.3, 6.44–6.46	The design of a spent fuel storage facility and the storage of spent fuel must be such that the workers, the public and the environment, present and future, will be protected from harmful effects of radiation exposure from all sources of ionizing radiation associated with current activities with spent fuel at the site [SF-1 (IAEA 2006)], with sufficient margins for foreseeable future activities at the site that might also give rise to exposure.	DGR, Deep Borehole (storage at National Facility site before disposal)		D	B		DGR: Storage, waste reception building (Ikonen et al. 2020, Section 5.7, Ch. 3, Figures 5-4, 5-5), Storage of canisters (Ikonen et al. 2020, Section 7.1.1, Figures 7-1, 7-2). Radiation protection (Ikonen et al. 2020, Sections 7.1.1, 7.2.5, 8.2.4). Exposure of operating personnel, limiting the radiation exposure of personnel (Ikonen et al. 2020, Section 2.2.1). The fulfilment of requirements concerning radiation safety during the operation of the disposal facility shall be ensured through continuous or regular measurements. The potential release routes and the environment of the facility shall in particular be subjected to monitoring. In order to monitor the potential release routes of radioactive substances, systems shall be designed for measuring and recording data on the quantities of radioactive substances released into the environment. It shall be possible to also monitor the emissions during an anticipated operational transient or a postulated accident (Ikonen et al. 2020, Section 2.2.1).	SF-1 (IAEA 2006)
SSG-15 (Rev. 1) (IAEA 2020)	Storage of Spent Nuclear Fuel (https://www-pub.iaea.org/MTCD/Publications/PDF/P1882_web.pdf)	2.4, 3.23	Discharges to the environment from spent fuel storage facilities should be controlled in accordance with the conditions imposed by the regulatory body and should be included when estimating doses to workers and to the public. Recommendations on discharge limits are provided in IAEA Safety Standards Series No. GSG-9, Regulatory Control of Radioactive Discharges to the Environment [IAEA 2018].	DGR, Deep Borehole (storage at National Facility site before disposal)		D	B		The potential release routes and the environment of the facility shall in particular be subjected to monitoring (Ikonen et al. 2020, Section 2.2.1).	GSG-9 (IAEA 2018)

SSG-15 (Rev. 1) (IAEA 2020)	Storage of Spent Nuclear Fuel (https://www-pub.iaea.org/MTCD/Publications/PDF/P1882_web.pdf)	2.5	The adequacy of control measures taken to limit the radiation exposure of workers and the public should be verified by monitoring and surveillance, both inside and outside the facility.	DGR, Deep Borehole (storage at National Facility site before disposal)	D	B	Radiation protection (Ikonen et al. 2020, Sections 7.1.1, 7.2.5, 8.2.4). Monitoring radiation safety (Ikonen et al. 2020, Section 2.2.1). Surveillance and monitoring (Ikonen et al. 2020, Sections 5.2, 5-6, 5-7, 6.2.8, 7.2.8, Figures 5-4, 5-5). Disposal facility monitoring and control systems (Ikonen et al. 2020, Sections 6.1.2, 7.1.2). Deep Borehole: Monitoring (Ikonen et al. 2020, Section 8.2.7). The purpose of condition monitoring is to monitor the condition of the disposal facility and systems during the operating phase. Instrumentation systems are used for gathering and processing information on the condition of the facility and ensuring that working safety is good in the facility. The monitoring and control data are collected in the control room in the operational building. The following measurements can be carried out in the disposal facility: measurements of air, bedrock and water temperature; air humidity; drainage water level; air activity; CO-, CO2-, NOx- and radon content; air dust content; as well as smoke detection (Ikonen et al. 2020, Sections 6.1.2, 7.1.2).	
SSG-15 (Rev. 1) (IAEA 2020)	Storage of Spent Nuclear Fuel (https://www-pub.iaea.org/MTCD/Publications/PDF/P1882_web.pdf)	3.17, 3.16, 3.18, 3.22, 3.24, 3.27, 3.28	The responsibilities of the operating organization of a spent fuel storage facility typically include the following: (a) Application to the regulatory body for permission to site, design, construct, commission, operate, modify or decommission a spent fuel storage facility; (b) Conduct of appropriate safety assessment and environmental assessment in support of the application for a licence; (c) Operation of the spent fuel storage facility in accordance with the requirements of the safety case, the licence conditions and the applicable regulations; (d) Development and application of acceptance criteria for the storage of spent fuel, as approved by the regulatory body; (e) Provision of periodic reports as required by the regulatory body (e.g. information on the actual inventory of spent fuel, any transfers of spent fuel into and out of the facility, any events that have occurred at the facility and which have to be reported to the regulatory body) and communication with interested parties and the general public.	DGR, Deep Borehole (storage at National Facility site before disposal)	D	B	General requirement, not directly related to facility design. Safety case and licensing (Ikonen et al. 2020, Section 2.2.1). DGR: Storage, waste reception building (Ikonen et al. 2020, Section 5.7, Ch. 3, Figures 5-4, 5-5), Storage of canisters (Ikonen et al. 2020, Section 7.1.1, Figures 7-1, 7-2).	
SSG-15 (Rev. 1) (IAEA 2020)	Storage of Spent Nuclear Fuel (https://www-pub.iaea.org/MTCD/Publications/PDF/P1882_web.pdf)	3.19	At an early stage in the lifetime of a spent fuel storage facility, the operating organization should prepare the initial plan for its eventual decommissioning. For new facilities, features that will facilitate decommissioning should be taken into consideration at the design stage. Such features should be included in the decommissioning plan, together with information on arrangements regarding how the availability of the necessary human and financial resources and information will be ensured, for presentation in the safety case.	DGR, Deep Borehole (storage at National Facility site before disposal)	D	B	DGR: Storage, waste reception building (Ikonen et al. 2020, Section 5.7, Ch. 3, Figures 5-4, 5-5), Storage of canisters (Ikonen et al. 2020, Section 7.1.1, Figures 7-1, 7-2). Decommissioning: Intermediate Depth (Ikonen et al. 2020, Section 6.3); DGR (Ikonen et al. 2020, Section 7.3).	
SSG-15 (Rev. 1) (IAEA 2020)	Storage of Spent Nuclear Fuel (https://www-pub.iaea.org/MTCD/Publications/PDF/P1882_web.pdf)	3.25	The operating organization should establish procedures on how to analyse the need for and how to implement modifications to the spent fuel storage facility, storage conditions and the spent fuel to be stored. As part of the procedures, the potential consequences of such modifications and of the works performed to implement them should be evaluated, including consequences for the safety of other facilities and also for the retrieval, transport, reprocessing and disposal of spent fuel. The procedures should be commensurate with the significance of the proposed modifications for safety.	DGR, Deep Borehole (storage at National Facility site before disposal)	D	B	DGR: Storage, waste reception building (Ikonen et al. 2020, Section 5.7, Ch. 3, Figures 5-4, 5-5), Storage of canisters (Ikonen et al. 2020, Section 7.1.1, Figures 7-1, 7-2). Transport within the site: Intermediate Depth (Ikonen et al. 2020, Sections 6.1.1, 6.1.2, 6.2.2, Figure 6-4); DGR (Ikonen et al. 2020, Sections 7.1.1, 7.1.2, 7.2.2, Figures 7-5, 7-6). DGR: In the case of reprocessing the high level waste and receiving vitrified waste form, the decreased waste volume can be fitted in eight Orano canisters. This will affect the number of deposition holes and the length of deposition tunnels. There will also be some changes for buffer and backfill methods (Ikonen et al. 2020, Section 7.4.1).	
SSG-15 (Rev. 1) (IAEA 2020)	Storage of Spent Nuclear Fuel (https://www-pub.iaea.org/MTCD/Publications/PDF/P1882_web.pdf)	3.29	There should be clear and unequivocal ownership of the spent fuel stored in the facility. The responsibilities of the spent fuel owner and the responsibilities of the operating organization, if they differ, should be clearly defined and documented. The spent fuel owner (namely, a body having legal title to the spent fuel, including financial liabilities) should be responsible for the overall strategy for the management of its spent fuel. In determining the overall strategy, the spent fuel owner should take into account interdependences between all stages of spent fuel management, the options available and the overall national spent fuel management strategy.	DGR, Deep Borehole (storage at National Facility site before disposal)	D	B	The disposal facility owner will also be the owner of the storage spaces.	
SSG-15 (Rev. 1) (IAEA 2020)	Storage of Spent Nuclear Fuel (https://www-pub.iaea.org/MTCD/Publications/PDF/P1882_web.pdf)	6.1, 6.2	Spent fuel storage facilities should provide for the safe, stable and secure storage of spent fuel before it is reprocessed or disposed of. The design features and the operation of the facility should be such as to provide confinement of radioactive material to ensure that radiation protection of workers, members of the public and the environment is optimized within the dose constraints in accordance with the requirements established in GSR Part 3 [IAEA 2014] and to maintain subcriticality, to ensure removal of decay heat and to ensure retrievability of the spent fuel. These safety functions should be maintained during normal operation, anticipated operational occurrences and accident conditions.	DGR, Deep Borehole (storage at National Facility site before disposal)	D	B	Prevention of criticality accidents (Ikonen et al. 2020, Section 2.2.1). DGR: Thermal dimensioning (Ikonen et al. 2020, Sections 2.2.6, 7.1.1). Deep Borehole: Heat generation (Ikonen et al. 2020, Section 8.1.4). DGR: Storage, waste reception building (Ikonen et al. 2020, Section 5.7, Ch. 3, Figures 5-4, 5-5), Storage of canisters (Ikonen et al. 2020, Section 7.1.1, Figures 7-1, 7-2). Radiation protection (Ikonen et al. 2020, Sections 7.1.1, 7.2.5, 8.2.4).	GSR Part 3 (IAEA 2014)

SSG-15 (Rev. 1) (IAEA 2020)	Storage of Spent Nuclear Fuel (https://www-pub.iaea.org/MTCD/Publications/PDF/P1882_web.pdf)	6.3	Although designs of spent fuel storage facilities may differ, in general they should consist of relatively simple, preferably passive, inherently safe systems intended to provide adequate safety over the design lifetime of the facility, which might span several decades. The lifetime of a spent fuel storage facility should be appropriate for the envisaged storage period. The design should also contain features to ensure that associated handling and storage operations are relatively straightforward.	DGR, Deep Borehole (storage at National Facility site before disposal)	D	B	DGR: Storage, waste reception building (Ikonen et al. 2020, Section 5.7, Ch. 3, Figures 5-4, 5-5), Storage of canisters (Ikonen et al. 2020, Section 7.1.1, Figures 7-1, 7-2).	
SSG-15 (Rev. 1) (IAEA 2020)	Storage of Spent Nuclear Fuel (https://www-pub.iaea.org/MTCD/Publications/PDF/P1882_web.pdf)	6.4	The storage facility should be designed to fulfil the main safety functions; that is, maintaining subcriticality, removal of heat, confinement of radioactive material and shielding from radiation and, in addition, retrievability of the fuel or spent fuel packages. The design should at least, if possible, include the following features: (a) Systems for the removal of heat from the spent fuel should be driven, if possible, by the energy generated by the spent fuel itself (e.g. natural convection). (b) A multibarrier approach should be adopted in ensuring confinement, with account taken of all elements, including the fuel matrix, the fuel cladding, the storage casks, the storage vaults and any building structures that can be demonstrated to be reliable and competent. (c) Safety systems should be designed to achieve their safety functions with minimum need for monitoring. (d) Safety systems should be designed to function with minimum human intervention. If the performance of safety systems depends on actions carried out by personnel, those human interactions with the facility or activity should be addressed in the safety assessment. (e) The storage building, or the cask in the case of dry storage, should be resistant to the hazards taken into consideration in the safety assessment. (f) Access should be provided for response to incidents. (g) The spent fuel storage facility should be such that retrieval of the spent fuel or spent fuel package for inspection or reworking is possible. (h) The spent fuel and the storage system should be sufficiently resistant to degradation. (i) The storage environment should not adversely affect the properties of the spent fuel, spent fuel package or storage system. (j) The spent fuel storage system should allow for inspections. (k) The spent fuel storage system should be designed to avoid or minimize the	DGR, Deep Borehole (storage at National Facility site before disposal)	D	B	DGR: Storage, waste reception building (Ikonen et al. 2020, Section 5.7, Ch. 3, Figures 5-4, 5-5), Storage of canisters (Ikonen et al. 2020, Section 7.1.1, Figures 7-1, 7-2).	
SSG-15 (Rev. 1) (IAEA 2020)	Storage of Spent Nuclear Fuel (https://www-pub.iaea.org/MTCD/Publications/PDF/P1882_web.pdf)	6.6, 6.7, 6.8	In the design process, appropriate analytical methods, procedures and tools should be used in conjunction with suitably selected input data and assumptions covering all operational states and accident conditions that are credible, with account taken of natural phenomena. Only verified and validated methods should be used for predicting the safety of operational states or the consequences of accidents. The input data selected should be conservative but still realistic. If possible, the degree of conservatism should be quantified. Where uncertainties in input data, analyses or predictions are unavoidable, appropriate allowances should be made to compensate for such uncertainties. The sensitivity of the assessment results to uncertainties should be evaluated.	DGR, Deep Borehole (storage at National Facility site before disposal)	D	B	Impacts caused by probable natural phenomena and other events external to the facility shall be considered in the design of the repository (Ikonen et al. 2020, Section 2.2.1).	
SSG-15 (Rev. 1) (IAEA 2020)	Storage of Spent Nuclear Fuel (https://www-pub.iaea.org/MTCD/Publications/PDF/P1882_web.pdf)	6.9	Items important to safety, including structures, systems and components, should be identified and classified in accordance with their importance to safety. Procedures should be established to ensure that the items important to safety will have appropriate functional and performance characteristics to perform their safety functions for the lifetime of the facility or for a defined replacement interval. Procedures relating to the control of design modifications in subsequent stages of the lifetime of the facility should also be defined.	DGR, Deep Borehole (storage at National Facility site before disposal)	D	B	Safety classification: DGR (Ikonen et al. 2020, Sections 6.1.3, 7.1.3); Deep Borehole (Ikonen et al. 2020, Section 8.1.6)	
SSG-15 (Rev. 1) (IAEA 2020)	Storage of Spent Nuclear Fuel (https://www-pub.iaea.org/MTCD/Publications/PDF/P1882_web.pdf)	6.27	In view of the decay heat generated by spent fuel, all thermal loads and processes should be given appropriate consideration in the design. Typical items for consideration should include the following: (a) Thermally induced stresses; (b) Internally and externally generated pressures; (c) Heat transfer requirements; (d) Evaporation and water make-up requirements; (e) The effects of temperature on subcriticality.	DGR, Deep Borehole (storage at National Facility site before disposal)	D	B	DGR: Thermal dimensioning (Ikonen et al. 2020, Sections 2.2.6, 7.1.1). Deep Borehole: Heat generation (Ikonen et al. 2020, Section 8.1.4). Rock stress monitoring (Ikonen et al. 2020, Section 7.2.8). Prevention of criticality accidents (Ikonen et al. 2020, Section 2.2.1).	
SSG-15 (Rev. 1) (IAEA 2020)	Storage of Spent Nuclear Fuel (https://www-pub.iaea.org/MTCD/Publications/PDF/P1882_web.pdf)	6.28	The anticipated lifetime of the storage facility will be a determining factor for aspects such as corrosion, creep, fatigue, shrinkage, radiation induced changes and associated radiation fields. In the design of the storage facility, consideration should be given to the impact of such processes.	DGR, Deep Borehole (storage at National Facility site before disposal)	D	B	To be decided	
SSG-15 (Rev. 1) (IAEA 2020)	Storage of Spent Nuclear Fuel (https://www-pub.iaea.org/MTCD/Publications/PDF/P1882_web.pdf)	6.29, 6.30–6.36	The design of a spent fuel storage facility is required to ensure an adequate margin of subcriticality under operational states and conditions that are referred to as credible abnormal conditions.	DGR, Deep Borehole (storage at National Facility site before disposal)	D	B	Prevention of criticality accidents (Ikonen et al. 2020, Section 2.2.1)	SSG-27 (IAEA 2014), 5.2, 5.61

SSG-15 (Rev. 1) (IAEA 2020)	Storage of Spent Nuclear Fuel (https://www-pub.iaea.org/MTCD/Publications/PDF/P1882_web.pdf)	6.37, 6.38–6.41	Spent fuel storage facilities should be designed with heat removal systems that are capable of reliably cooling the stored spent fuel when the fuel is initially received at the facility.	DGR, Deep Borehole (storage at National Facility site before disposal)	D	B	DGR: Storage, waste reception building (Ikonen et al. 2020, Section 5.7, Ch. 3, Figures 5-4, 5-5), Storage of canisters (Ikonen et al. 2020, Section 7.1.1, Figures 7-1, 7-2).
SSG-15 (Rev. 1) (IAEA 2020)	Storage of Spent Nuclear Fuel (https://www-pub.iaea.org/MTCD/Publications/PDF/P1882_web.pdf)	6.42, 6.43	In the design of spent fuel storage and handling systems, adequate and appropriate measures should be provided for containing radioactive material so as to prevent any uncontrolled release of radionuclides to the environment.	DGR, Deep Borehole (storage at National Facility site before disposal)	D	B	The spent fuel will be in canisters when temporarily stored in the National Facility.
SSG-15 (Rev. 1) (IAEA 2020)	Storage of Spent Nuclear Fuel (https://www-pub.iaea.org/MTCD/Publications/PDF/P1882_web.pdf)	6.47	Design aspects associated with the layout of a spent fuel storage facility are set out in the following: (a) Storage areas for spent fuel should be secured against unauthorized access and unauthorized removal of fuel. (b) The area used for storage should not be part of an access route to other operating areas. (d) The need to move heavy objects over stored spent fuel and items important to safety should be minimized by the layout. (h) The layout should facilitate access to any stored fuel without the need to move or handle other stored fuel. (o) The layout should provide for an easy exit by personnel in an emergency. (p) Penetrations should be designed in such a way as to prevent the ingress of foreign material (e.g. rain, inorganic solutions, organic materials) that could reduce subcriticality margins, impair heat transfer or increase corrosion and degradation of the storage facility in ways that might reduce the effectiveness of the main safety functions or prevent inspection or repair.	DGR, Deep Borehole (storage at National Facility site before disposal)	D	B	DGR: Storage, waste reception building (Ikonen et al. 2020, Section 5.7, Ch. 3, Figures 5-4, 5-5), Storage of canisters (Ikonen et al. 2020, Section 7.1.1, Figures 7-1, 7-2).
SSG-15 (Rev. 1) (IAEA 2020)	Storage of Spent Nuclear Fuel (https://www-pub.iaea.org/MTCD/Publications/PDF/P1882_web.pdf)	6.57, 6.59	Ventilation systems for the spent fuel storage facility should be designed and operated to maintain a safe and comfortable working environment during normal operation and to limit the potential for release of radioactive material in operational states and accident conditions, including design basis accidents and design extension conditions. In the design, consideration should be given to the potential for pressure buildup in the facility during an accident and the provision of a means to prevent concentration levels of hydrogen gas that could give rise to disruptive explosions.	DGR, Deep Borehole (storage at National Facility site before disposal)	D	B	Ventilation (Ikonen et al. 2020, Figures 6-1, 6-3, 7-1, Section 2.2.1; Fischer et al. 2020, Section 5.3). Ventilation building (Ikonen et al. 2020, Figures 5 4 and 5-5, Section 5.7). Intermediate Depth: Ventilation system (Ikonen et al. 2020, Sections 6.1.2, 6.2.5). DGR: Ventilation system (Ikonen et al. 2020, Figure 7-4, Section 7.1.2).
SSG-15 (Rev. 1) (IAEA 2020)	Storage of Spent Nuclear Fuel (https://www-pub.iaea.org/MTCD/Publications/PDF/P1882_web.pdf)	6.58	Ventilation systems should be designed in such a way as to control the accumulation of flammable or explosive gases (e.g. hydrogen gas formed by radiolysis). Consideration should also be given to the potential for the drawing in of hazardous gases from external sources.	DGR, Deep Borehole (storage at National Facility site before disposal)	D	B	To be decided
SSG-15 (Rev. 1) (IAEA 2020)	Storage of Spent Nuclear Fuel (https://www-pub.iaea.org/MTCD/Publications/PDF/P1882_web.pdf)	6.61	Instrumentation should be provided to detect conditions that could result in a loss of residual heat removal capability and excessive radiation levels. This instrumentation should provide appropriate alarms and indications at a protected location that would result in timely initiation of corrective actions by local operating personnel and operating personnel in main control rooms, and automatic initiation of protective actions when needed. The indicating range and design of the specified instrumentation should allow for monitoring of conditions during accidents, including design basis accidents and design extension conditions considered in the safety case. When practicable, control and protection functions should be designed to be mutually independent and not compromised by any corrective actions. Where independence is not feasible, detailed justification should be provided for the use of shared and interrelated systems. Account should be taken of ergonomic factors in the design of alarms and indications to the operating personnel. Control and monitoring equipment should be calibrated for its intended use.	DGR, Deep Borehole (storage at National Facility site before disposal)	D	B	Devices with an alarm function shall be employed for radiation monitoring so that during the operation of the disposal facility, significant unintentional exposure to radiation will not occur (Ikonen et al. 2020, Section 2.2.1). The facilities will be protected by an automatic fire alarm system (Ikonen et al. 2020, Section 6.1.4). Monitoring radiation safety (Ikonen et al. 2020, Section 2.2.1). DGR: Disposal facility monitoring and control systems (Ikonen et al. 2020, Section 7.1.2). Deep Borehole: Monitoring (Ikonen et al. 2020, Section 8.2.7).
SSG-15 (Rev. 1) (IAEA 2020)	Storage of Spent Nuclear Fuel (https://www-pub.iaea.org/MTCD/Publications/PDF/P1882_web.pdf)	6.62, 6.63, 6.64	Fire protection measures should be implemented in such a way as to limit risks to personnel and the risk of damage to items important to safety, spent fuel storage areas, spent fuel handling systems and support systems.	DGR, Deep Borehole (storage at National Facility site before disposal)	D	B	The tunnel portal building hosts also a pumping station for fire water and equipment for blending marker for underground water supply (Ikonen et al. 2020, Section 5.7). Fire safety: DGR (Ikonen et al. 2020, Sections 7.1.4, 7.1.2); Deep Borehole (Ikonen et al. 2020, Section 8.1.7).
SSG-15 (Rev. 1) (IAEA 2020)	Storage of Spent Nuclear Fuel (https://www-pub.iaea.org/MTCD/Publications/PDF/P1882_web.pdf)	6.67	Provision should be made for adequate and reliable lighting in support of normal operation, anticipated operational occurrences and accident conditions and to facilitate inspection of spent fuel storage areas.	DGR, Deep Borehole (storage at National Facility site before disposal)	D	B	DGR: The purpose of the lighting system is to provide suitable general lighting for the disposal facility and sufficiently efficient local lighting for places of work. The facilities will have a battery-backed emergency lighting system (Ikonen et al. 2020, Section 7.1.2).

SSG-15 (Rev. 1) (IAEA 2020)	Storage of Spent Nuclear Fuel (https://www-pub.iaea.org/MTCD/Publications/PDF/P1882_web.pdf)	6.70, 6.71	Area monitoring should include measurements of radiation dose rates and airborne radionuclides. In controlled areas, fixed, continuously operating instruments with local alarms and unambiguous readouts should be installed to provide information on radiation dose rates. Such instruments should have characteristics and ranges that are sufficient to cover potential radiation levels, during normal operation, anticipated operational occurrences and accident conditions, including design basis accidents and design extension conditions.	DGR, Deep Borehole (storage at National Facility site before disposal)		D	B		Devices with an alarm function shall be employed for radiation monitoring so that during the operation of the disposal facility, significant unintentional exposure to radiation will not occur (Ikonen et al. 2020, Section 2.2.1). Monitoring radiation safety (Ikonen et al. 2020, Section 2.2.1). DGR: Disposal facility monitoring and control systems (Ikonen et al. 2020, Section 7.1.2). Deep Borehole: Monitoring (Ikonen et al. 2020, Section 8.2.7).	
SSG-15 (Rev. 1) (IAEA 2020)	Storage of Spent Nuclear Fuel (https://www-pub.iaea.org/MTCD/Publications/PDF/P1882_web.pdf)	6.75	In addition to the design features of a spent fuel storage facility considered above, a number of other support systems may be necessary to ensure the operation and safety of spent fuel storage facilities (e.g. an emergency power supply). It should be ensured that such support systems are available.	DGR, Deep Borehole (storage at National Facility site before disposal)		D	B		Emergency-related systems: Intermediate Depth (Ikonen et al. 2020, Sections 6.1.2, 6.2.6); DGR (Ikonen et al. 2020, Sections 7.1.2, 7.2.6).	
SSG-15 (Rev. 1) (IAEA 2020)	Storage of Spent Nuclear Fuel (https://www-pub.iaea.org/MTCD/Publications/PDF/P1882_web.pdf)	6.76	Where the safety of spent fuel storage is dependent upon the supply of utilities (e.g. systems for compressed air or water), adequate sources should be reliably available.	DGR, Deep Borehole (storage at National Facility site before disposal)		D	B		To be decided	
SSG-15 (Rev. 1) (IAEA 2020)	Storage of Spent Nuclear Fuel (https://www-pub.iaea.org/MTCD/Publications/PDF/P1882_web.pdf)	6.77, 6.78–6.88	Commissioning involves a logical progression of tasks intended to demonstrate the correct functioning of features specifically incorporated into the design to provide for safe storage of spent fuel. In addition, in commissioning, operating procedures are verified and the readiness of staff to operate the spent fuel storage facility is demonstrated. The operating procedures should cover normal operation, anticipated operational occurrences and accident conditions.	DGR, Deep Borehole (storage at National Facility site before disposal)		D	B		To be decided	
SSG-15 (Rev. 1) (IAEA 2020)	Storage of Spent Nuclear Fuel (https://www-pub.iaea.org/MTCD/Publications/PDF/P1882_web.pdf)	6.89, 6.90–6.146	Spent fuel storage facilities are required to be operated in accordance with written procedures prepared by the operating organization. These documents and their updates should be prepared in cooperation with the organizations responsible for the design of the spent fuel storage facility. However, the operating organization is responsible for ensuring that the procedures are prepared, reviewed, approved and issued appropriately. These procedures should take into account human factors associated with handling operations and should, as a minimum, be such as to ensure compliance with the operational limits and conditions for the spent fuel storage facility and, more generally, with the safety assessment.	DGR, Deep Borehole (storage at National Facility site before disposal)		D	B		To be decided	
SSG-27 (IAEA 2014)	Criticality Safety in the Handling of Fissile Material (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1594_web-51742615.pdf	5.63	Criticality safety for waste operations should be based on the application of appropriate limits on the waste package contents. Criticality safety measures may include the design of the packages and the arrangements for handling, storage and disposal of many packages within a single facility. Where practicable, package limits should be applicable to all operations along the waste management route, including operations at a subsequent disposal facility, so that subsequent repacking, with its associated hazards, may be avoided.	DGR, Deep Borehole, Intermediate Depth	I	D	B		DGR, Deep Borehole: The formation of such spent fuel configurations that would cause an uncontrolled chain reaction of fission shall be prevented by means of the structural design of systems and components. The waste canisters containing spent fuel shall be designed so that no critical fuel configurations may be formed in any operational situations, including any anticipated incident or postulated accident. The emplaced canisters shall retain their subcriticality also over the long term when the canisters' internal structures may be corroded and partly filled with groundwater (Ikonen et al. 2020, Section 2.2.1).	
SSG-27 (IAEA 2014)	Criticality Safety in the Handling of Fissile Material (https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1594_web-51742615.pdf)	5.65	Assessment of criticality safety for the period after closure for a disposal facility presents particular challenges. Among these are the very long timescales that need to be considered. Following closure of a disposal facility, engineered barriers provided by the package design and the form of the waste will tend to degrade, allowing the possibility of separation, relocation and accumulation of fissile nuclides (as well as the possible removal of absorbers from fissile material). In addition, a previously dry environment may be replaced by a water saturated environment. Consideration of the consequences of criticality after closure of a disposal facility will differ from that for, for example, fuel stores or reprocessing plants, where a criticality accident may have immediate recognizable effects. In the case of a disposal facility, disruption of protective barriers and effects on transport mechanisms of radionuclides are likely to be more significant than the immediate effects of direct radiation from a criticality event, because the radiation would be shielded by the surrounding host rock formation and/or backfill materials.	DGR, Deep Borehole, Intermediate Depth	I	D	B		DGR, Deep Borehole: The formation of such spent fuel configurations that would cause an uncontrolled chain reaction of fission shall be prevented by means of the structural design of systems and components. The waste canisters containing spent fuel shall be designed so that no critical fuel configurations may be formed in any operational situations, including any anticipated incident or postulated accident. The emplaced canisters shall retain their subcriticality also over the long term when the canisters' internal structures may be corroded and partly filled with groundwater (Ikonen et al. 2020, Section 2.2.1).	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	2.3, 2.4	The overall programme for siting, construction and operation of a near surface disposal facility is likely to last an extended period, typically of the order of a few to several decades. In the context of radiation safety, it is conventional to identify three broad periods associated with the development, operation and closure of a near surface disposal facility: the pre-operational period, the operational period and the post-closure period.	Landfill				L	General requirement, not directly related to facility design	SSR-5 (IAEA 2011)

SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	2.5	The development, operation and closure of a near surface disposal facility is likely to last over many years. Given such timescales, and the large volume and diversity of information necessary to support the process (e.g. through the acquisition of data on waste and from engineering activities, site characterization and other activities that will support the safety case), it is appropriate to subdivide the programme into a series of steps involving formal stages at which the programme is reviewed and evaluations of safety are undertaken before decisions are made to progress.	Landfill	L	General requirement, not directly related to facility design	SSR-5 (IAEA 2011)
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	2.6, 2.7	After site selection, consistent with the phases described above, a number of activities grouped in broad areas should be undertaken — namely, detailed site characterization and site confirmation that the site meets the selection criteria, design of the disposal facility, construction of the disposal facility, operation of the disposal facility (i.e. receipt and emplacement of waste) and closure of the disposal facility. The last three of these correspond to three important steps in the regulatory approval of a near surface disposal facility (see Fig. 1). Site characterization and design activities, as well as associated record keeping, may be expected to continue, at some level, up to facility closure. Key information on the disposal facility should also be placed in appropriate archives.	Landfill (incl. site)	L	Affects site selection. Site selection (Ikonen et al. 2020, Ch. 4).	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	3.11	In developing the design of a safe near surface disposal facility, the operator should establish a safety strategy that will clearly set out how the facility is to comply with all the safety requirements. The strategy should indicate how the safety principles will be applied and should take into consideration the characteristics and quantities of the radioactive waste to be disposed of, the characteristics of the available site or sites, the available engineering techniques, and the national legal infrastructure and regulatory requirements. The safety strategy should also indicate how the management system will provide assurance of the necessary quality of work to be carried out and, among other things, it should establish the necessary frameworks for organization of the work (e.g. interaction between designers, assessors, site investigators and researchers). The safety strategy should be presented in the safety case for the facility, which the operator should develop in accordance with the detailed guidance provided in IAEA Safety Standards Series No. SSG-23, The Safety Case and Safety Assessment for the Disposal of Radioactive Waste [IAEA 2012].	Landfill	L	Landfill design described in Ikonen et al. (2020), Ch. 9. Site selection (Ikonen et al. 2020, Ch. 4).	SSG-23 (IAEA 2012)
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	3.12	In conducting the research necessary to support the understanding of the processes on which the safety of the near surface disposal facility depends, the operator has to carry out all the necessary investigations of the site and materials used in construction and operation (including packaging and other engineered barriers). The operator has to assess the suitability of materials for a given application and has to ensure the availability of other data required for the safety assessment.	Landfill	L	Site characterisation (Ikonen et al. 2020, Section 4.3).	SSR-5 (IAEA 2011)
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	3.14	The operator should identify and seek to prevent potential conflicts between efforts to address long term safety objectives and operational objectives: for example, operational expediency should not jeopardize long term safety functions, nor should site workers be subjected to undue risks in the interests of long term safety.	Landfill	L	Not a design issue	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	3.15	The need to preserve records for long time periods during operation and after closure should be taken into account in selecting the location, format and materials to be used for such records.	Landfill	L	Not a design issue	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.1	The safety approach includes all the ways in which protection of people and protection of the environment are ensured throughout the lifetime of a near surface disposal facility. As the long term safety of a disposal facility for radioactive waste is required not to be dependent on active institutional control [SSR-5 (IAEA 2011)], the safety of a near surface disposal facility largely rests on the quality of the selected site and the capability of the design of the facility to contain and to isolate the waste. This emphasizes the importance that should be given to all steps in the development of a near surface disposal facility that precede the actual construction and operation of the facility.	Landfill	L	Landfill design described in Ikonen et al. (2020), Ch. 9. Site selection (Ikonen et al. 2020, Ch. 4).	SSR-5 (IAEA 2011)
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.2, 4.3	Within the framework set by the national policy for near surface disposal of radioactive waste, the operator, in consultation with the regulatory body, should set out elements of the national policy in a formal safety strategy document that is produced as early as possible in the disposal programme and is updated periodically. The safety strategy is the high level integrated approach adopted for achieving safe disposal. It should include strategies to select a site and to design, construct, operate and close a disposal facility. In addition, it should include recommendations for the preparation and maintenance of the safety case for use in decision making and procedures for regulatory approval for the assumed duration of the period of institutional control. Throughout the whole process, safety should be the central and main consideration in all decisions taken in the development and operation of a near surface disposal facility	Landfill	L	Not a design issue	

SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.6	SSR-5 [IAEA 2011], when applied to near surface disposal facilities, requires that long term safety is to be ensured by: (a) The capability of the features of the disposal facility to contain the waste and isolate it from the accessible biosphere; (b) The capability of the features of the site to contribute to the containment and isolation of the waste; (c) The limitations placed on the radiological inventory, mainly with regard to long lived radionuclides, that can be disposed of in the facility; (d) The measures for surveillance and control of the disposal facility and its immediate surroundings that are applied to prevent or restrict any human activities that could disturb the facility barriers and lead to increased exposures.	Landfill	L	Landfill design described in Ikonen et al. (2020), Ch. 9. Site selection (Ikonen et al. 2020, Ch. 4).	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.7	Consequently, near surface disposal is an appropriate disposal option only for VLLW and LLW. The location of a near surface disposal facility at or near the surface makes it susceptible to processes and events that will degrade its containment and isolation capacity over much shorter periods of time (up to several hundreds of years). In near surface disposal, the facility is located in the biosphere where most human activities take place, and the possibility of human intrusion into a near surface disposal facility after the period of institutional control is considerably greater than in the case of geological disposal. Therefore, human intrusion after the period of institutional control has to be taken into account, and the adequacy of the limitations placed on the radioactive inventory should be assessed and confirmed, principally in terms of allowable quantities of long lived radionuclides in the waste packages.	Landfill	L	Landfill design described in Ikonen et al. (2020), Ch. 9. Site selection (Ikonen et al. 2020, Ch. 4).	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.8, 6.2–6.5	The development, operation and closure of a near surface disposal facility involves an iterative process of site characterization and design and evolution of the safety case and supporting safety assessment to provide an optimized level of operational and post-closure safety (see the appendix to SSR-5 [IAEA 2011]). Throughout this process, all relevant characteristics of the waste to be disposed of should be identified and taken into account in the design of the facility and in the safety assessment. This iterative process may take several years, and key decisions, such as those on the choice of design concept, siting, detailed design, allowable inventory and construction of the facility, should be made in a step by step process as the project develops. In this process, optimization of the disposal facility and its safety performance through the evaluation and comparison of options should generally progress from more strategic considerations to detailed choices for design and operation. Optimization of the long term safety of a near surface disposal facility should mainly be achieved by means of decisions on the site and the design of the facility, and by a cautious approach followed in safety assessment to set adequate limitations on the inventory. Societal and economic factors, such as public acceptance of the disposal facility, and natural factors, such as surface geology, can constrain the available options for siting the facility. However, optimization of the design of the facility should take due account of all the favourable and unfavourable site characteristics and should be based on best practices.	Landfill (incl. site)	L	Landfill design described in Ikonen et al. (2020), Ch. 9.	SSR-5 (IAEA 2011) IAEA-TECDOC-1256 (2001) SSG-29 (IAEA 2014), 2.5, 4.8, 4.11
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.9	Decisions should be made on the basis of the quantitative or qualitative information available at the time and the confidence that can be placed in that information. Therefore, a systematic identification and assessment of uncertainties that can affect the safety of the facility should be part of the development, operation and closure, and should be factored in at each major decision point that relates, directly or indirectly, to the safety of the facility. Facility development, operation and closure decisions are also influenced by external factors, such as national policy and preferences.	Landfill	L	Design analysis. To be decided.	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.10	At each major decision point (siting, design, operation, closure and post-closure), an adequate level of confidence in safety should be developed so that the available options can be evaluated and the best protective options can be selected, with all relevant societal and economic factors taken into account. If more than one option is capable of providing the required and optimized level of safety, then factors other than safety also have to be considered. These factors could include public acceptability, cost, site ownership, existing infrastructure and transport routes [SSR-5 (IAEA 2011)].	Landfill	L	General requirement, not directly related to facility design	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.11	Throughout the iterative process of site characterization, disposal facility design and safety assessment, the critical components for the safety of the disposal system should be identified. Different complementary approaches should be put in place to identify these critical components: — In the design process, analysis of the safety function(s) of each component on the basis of the provision of defence in depth; — In the iterative safety assessments, integration of all main safety relevant elements of the system and all available information (including a systematic analysis of uncertainties) regarding the performance and evolution of system components; — Assessment of the technical feasibility of the operation of the system and its components in a manner that meets the functional requirements.	Landfill	L	To be decided	

SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.12	The critical components should be qualified, as appropriate and practicable, using standardized and appropriate testing methods to gain confidence in their ability to perform the required function(s) over the required timescale(s). If new techniques are employed, they should be developed and qualified in a time frame that is compatible with the project schedule. Research activities focusing on critical components should be used to improve further the understanding of system and component performance and should lead (a) to further optimization steps, even when development of the system has started, or (b) to improvement of the safety assessment to the extent that a more accurate assessment of system performance and safety can be made. A continued research programme on critical components of the disposal system is an important element of the safety strategy. However, the existence of such a programme should not be used to justify the taking of decisions early in the programme without an adequate level of confidence in the safety of the system. The balance between the level of confidence at a certain point and the prospects of additional insights from a continued research programme should be a central element in the process of interaction between the operator and the regulatory body.	Landfill	L	To be decided
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.13	Operational safety should be provided by means of active and passive control systems. Active systems could include operational controls (e.g. control of incoming waste for surface contamination or contact dose rate, and control of waste emplacement activities) and monitoring for radioactive releases, whereas passive systems could include engineered features such as shielding. Normal operating conditions, as well as anticipated operational occurrences and incident and accident conditions, should be considered in the development of operational safety systems. Both internal events (e.g. a fall of a waste package during waste handling operations) and external events (e.g. the risk of external explosion, strong winds, flooding and earthquakes) can lead to anticipated operational occurrences, incidents or accidents and should be assessed for the specific site and design of the facility. Where appropriate, the development of operational safety systems should make use of operational experience and technologies (e.g. techniques for waste handling) adopted from other types of nuclear facility. Consideration should be given to the fact that conventional risks may be more significant than radiological risks, especially if the waste to be disposed of is conditioned waste with only a small risk of dispersion of radioactive material.	Landfill	L	Radiation protection (Ikonen et al. 2020, Section 9.2.5). Fire safety (Ikonen et al. 2020, Section 9.1.4). Incidents and accidents (Ikonen et al. 2020, Section 9.2.6)
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.14	Safety mechanisms for the post-closure period are distinct from those employed in the operational period, or for other types of facility. In the post-closure period, a near surface disposal facility is required to provide the necessary degree of containment and isolation, so that the migration of radionuclides from the waste into the biosphere is reduced to an acceptably low level and so that the likelihood of, and all possible consequences of, human intrusion are sufficiently reduced. This should be achieved primarily through passive means and using multiple safety barriers, supported by surveillance and control measures, as described in the following subsections.	Landfill	L	Basic design considerations
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.15	The concept of near surface disposal covers a wide range of facilities (e.g. disposal at the surface in engineered vaults or trenches, or disposal at varying depths — from a few metres to a few tens of metres — in facilities with various types of engineered barriers). The components of the disposal system, both engineered and natural, that contribute to the containment and isolation of the waste after the facility is closed can therefore differ to a large extent. Throughout the development, operation and closure, an adequate understanding should be developed of the performance, durability and longevity of all the components that contribute to the overall system for containment and isolation of the waste. In order to develop an adequate understanding of the behaviour of the disposal facility, a focused effort should be made to characterize and to assess the system components in terms of their initial performance and the expected or possible evolution of their performance due to degradation or disturbing events and processes. The fact that the extent to which the engineered components of the system, or the natural components, or both, contribute to the overall containment and isolation can differ widely for different types of near surface disposal facility should be taken into account.	Landfill	L	Design R&D

SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.16	Through the process of optimization, all decisions should be taken with the aim of selecting the best protective options, in line with policy decisions (e.g. on the type of near surface disposal facility to be developed) and with account taken of societal and economic factors (e.g. expression of local acceptance or refusal for a particular site or sites). Once the type of disposal facility has been decided and the site selected, the main effort of optimization should be on making all the design choices with respect to the engineered components of the disposal system in a manner that all relevant characteristics of the site are correctly taken into account (e.g. chemical characteristics of the site that influence or determine the lifetime and performance of the engineered components, and mechanical and seismic characteristics of the site that can affect the stability and integrity of the engineered components). In order to design the facility in such a manner that the natural and engineered components of the disposal system are compatible and complementary, all relevant information with respect to the features of the site and the components of the facility should be used. When system specific information is lacking and generic information is used, a cautious and transparent approach to safety should be ensured.	Landfill	L Safety culture (Ikonen et al. 2020, Sections 2.2.1, 2.2.7)
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.17	Throughout the process of developing the disposal facility, its robustness should be evaluated in a systematic and structured manner to understand how disturbances that might be expected to occur or remaining uncertainties can affect the performance of the components and the safety of the disposal system. Both siting and design decisions should be made on the basis of an evaluation of robustness (e.g. the selection of sites that are less likely to be affected by external events such as floods or earthquakes) or the dimensioning of system components with a sufficient performance margin.	Landfill	L Landfill design described in Ikonen et al. (2020), Ch. 9. Site selection (Ikonen et al. 2020, Ch. 4).
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.19	Containment of radioactive waste implies that the disposal facility should be sited and designed to prevent or to minimize the release of radionuclides. As near surface disposal is only suitable for classes of waste containing mainly short lived radioactive waste and potentially with limited amounts of long lived radionuclides, the time frames over which containment has to be ensured are largely determined by the objective to limit the potential for a release of radionuclides from the waste to the biosphere. Absolute containment of long lived radionuclides is not possible — in particular in the long term — but should be aimed at for an appropriate period of time to allow for complete radioactive decay of the short lived radionuclides within the disposal system before they can reach the biosphere.	Landfill	L Landfill design described in Ikonen et al. (2020), Ch. 9. Site selection (Ikonen et al. 2020, Ch. 4).
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.20	Containment can be provided by physical or chemical means. Physical containment relates to the prevention of radionuclide migration by means of physical barriers such as a metal container or barriers with low permeability to water. Chemical containment relates primarily to waterborne migration and refers to the retardation of the migration of radionuclides by reduction of their solubility and/or by sorption of radionuclides onto some immovable substrate material. Chemical containment is often provided by the use of cementitious waste forms and various facility components. In most environments, prevention and limitation of ingress of water, coupled with chemical containment, are key determinants of the safety of near surface disposal.	Landfill	L Landfill design described in Ikonen et al. (2020), Ch. 9. Site selection (Ikonen et al. 2020, Ch. 4).
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.21	Depending on the type of near surface disposal facility, containment should be provided by a variety of means. The degree of containment provided by engineered barriers (i.e. the waste package, backfill and the facility structure including the final cap) and the natural environment (the geological surface layers within which the facility is situated or around the facility) can vary significantly. The overall system containment should be realized through a combination of engineered and natural barriers and should be compatible with the safety strategy and supported by scientific and technical arguments in the safety case. Designing for containment means that both the ingress of water into the facility towards the waste and the migration of radionuclides from the waste to the biosphere should be prevented or limited to the extent possible. The containment should prevent both the release of radionuclides in gaseous form (e.g. ^{3}H, ^{14}C and ^{129}I) as well as their release through migration in the liquid phase (i.e. via dissolution of radionuclides in the water that has entered the facility and their migration in the liquid phase to the biosphere). The construction of barriers with low water permeability around the waste, the slow dissolution of the waste form, and the physical and chemical characteristics of the engineered and natural barriers around the waste that favour sorption of the radionuclides in the solid phase should all contribute to containment of the waste and its radionuclides. External factors, such as low annual precipitation, that directly affect the containment capacity of a near surface disposal system should also be considered in the siting process.	Landfill	L Landfill design described in Ikonen et al. (2020), Ch. 9. Site selection (Ikonen et al. 2020, Ch. 4).
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.22	The various components contributing to containment should be compatible with each other, in order to prevent interactions between components — for example, in the case of chemical processes — leading to a degradation of the containment capacity of one or more components. Especially, the physical and chemical characteristics of the waste should be systematically evaluated when selecting materials for the engineered barriers around the waste.	Landfill	L Landfill design described in Ikonen et al. (2020), Ch. 9

SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.23	When natural barriers are important contributors to containment, their contribution should be evaluated on the basis of information obtained from site characterization. Uncertainties due to, for example, spatial variability of site characteristics or resulting from the techniques applied for field observation and measurement campaigns should be taken into account when assessing the containment capabilities of the natural components of the disposal system.	Landfill	L	Site characterisation (Ikonen et al. 2020, Section 4.3).
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.24	The contribution of the engineered barriers to containment will depend on: (a) The way in which they are used in the design of the disposal facility (their location). (b) Their relevant characteristics (such as low permeability to water or high sorption capacity). (c) The evolution of these characteristics with time as a result of: (i) Physical and chemical processes (e.g. concrete degradation and erosion of the final cap); (ii) External events affecting these characteristics (e.g. seismic events, site flooding and mechanical instability of the site). In the design and construction of the engineered barriers, attention should be paid to the lifetime of the barriers, both in terms of their expected lifetime (or in terms of the expected evolution of performance of the barriers with time) as well as in terms of demonstrability of their lifetime (or of the evolution of performance of the barriers). The activities of designing the engineered barriers and the supporting research activities necessary to characterize the barrier performance and its evolution with time should generate all the information necessary for the safety assessments of the performance of the engineered barrier within the overall system and its evolution with time. Account should be taken of the fact that an overly optimistic assessment of performance of the barriers will lead to an underestimation of future radiological consequences. An overly pessimistic or conservative assessment of the long term performance of the engineered barriers can lead to unnecessary restrictions on the amounts of waste that can be disposed of in the planned facility.	Landfill	L	Landfill design described in Ikonen et al. (2020), Ch. 9
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.25, 4.26, 6.48, 6.64, 7.11	The safety case should integrate all the information on which the assumptions for safety assessment with respect to the performance of the components and its evolution is based (e.g. research results, modelling, natural evidence and from comparison with natural analogues).	Landfill	L	General requirement, not directly related to facility design. Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7).
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.28	For near surface disposal, isolation means retaining the waste and keeping its associated hazard away from the biosphere in a suitably located and appropriately designed disposal facility, with appropriate control in the post-closure period to prevent disturbance of the facility (e.g. prevention of inadvertent human access to the waste). The location and design of the facility should also take into account the potential impacts of external events.	Landfill	L	Landfill design described in Ikonen et al. (2020), Ch. 9. Site selection (Ikonen et al. 2020, Ch. 4).
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.29	The isolation capability of near surface disposal facilities should be ensured for periods of up to several hundreds of years. The isolation capability should be ensured mainly through passive means, in order neither to impose an excessive burden on future generations nor to rely on active measures to ensure safety over a period of time that is incompatible with the confidence placed in institutional and financial stability. As active means can be relied upon only for a limited period (up to a few hundred years), the possibility of human intrusion into the facility after such a period should be considered when assessing the safety of a near surface disposal facility.	Landfill	L	Landfill design described in Ikonen et al. (2020), Ch. 9. Site selection (Ikonen et al. 2020, Ch. 4).
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.30	The passive means that contribute to the isolation of the waste are mainly the durable physical barriers placed around the waste that make inadvertent intrusion into the waste more difficult without specific efforts (e.g. drilling into the facility). The isolation capability of a near surface disposal facility might be enhanced by locating the facility at some depth (a few tens of metres), as this can affect or limit the type of human activities that would be necessary to intrude into the facility and waste, as compared to a facility located at the surface.	Landfill	L	Landfill design described in Ikonen et al. (2020), Ch. 9
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.31	The active means that contribute to the isolation of the waste are controls such as monitoring and surveillance of the facility and site in order to prevent human access to the waste and prevent disturbance of the facility by human activities. As long as active institutional controls are in place at the site, the potential for human intrusion into the facility can be assumed to be negligible. Therefore, a main element of the national policy and the safety strategy for near surface disposal should be to keep the facility under institutional control for as long as possible and reasonable. This intention should also be expressed in the licence of the disposal facility, and the periodic safety assessments of the closed facility during the period of institutional control should be used as a means to reconfirm this duration of institutional control. Active means can only be relied upon for a limited period, of a few hundred years at the longest, and the safety assessment for a near surface disposal facility and its licensing have to be based on the assumption that surveillance and control will cease after a certain period.	Landfill	L	Landfill repository design and monitoring described in Ikonen et al. (2020), Ch. 9

SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.32	The general approach to the surveillance and control of a near surface disposal facility should broadly define how active institutional control of the facility under the nuclear regulatory system passes first to control of the site by a governmental organization (e.g. by restrictions on land use to ensure that activities that might disturb the facility are prevented) and subsequently to more passive institutional controls (e.g. the use of markers on the site, transfer of information on the facility to future generations through various means, archiving of information). Although passive means still might reduce the likelihood of human intrusion, a cautious approach should be followed and such passive means are not to be relied on in assessment of the safety of the facility and in setting activity limits for the waste that can be disposed of in the facility.	Landfill	L	Landfill repository design and monitoring described in Ikonen et al. (2020), Ch. 9	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.33	The siting of a near surface disposal facility should take into consideration the potential hazards to the facility posed by the disruptive effects of geomorphologic and meteorological processes such as erosion or seismic activity (see Appendix II). Location away from known areas of underground mineral, geothermal and groundwater resources will reduce the likelihood of inadvertent disturbance of the disposal facility.	Landfill (site)	L	Affects siting	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.34, Box 1	In assessment of the safety of a near surface disposal facility, the treatment of human intrusion should be carried out on the basis of 'stylized' scenarios, which have been agreed with the regulatory body and meet the criteria set out in Box 1. This is because there is very limited scientific basis for defining human intrusion scenarios and the associated uncertainties (e.g. in timing, in the type of intrusion, in the number of potentially exposed people and in the likelihood of recognition of the radiation risk associated with the intrusion). In order to ensure safety after the period of active institutional control, when human intrusion can no longer be excluded, the amount of long lived radionuclides that can be disposed of in the near surface disposal facility should be limited. Through the assessment of the radiological consequences of stylized human intrusion scenarios, limits on the activity of long lived radionuclides can be set. The scope of the stylized human intrusion scenarios used in safety assessment is largely a matter to be agreed upon by the operator and the regulatory body.	Landfill	L	Requires a design, but not a design issue per se. Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7).	SSR-5 (IAEA 2011), 2.15
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.35	The establishment of multiple safety functions, which should be fulfilled by various barriers and system features, provides for defence in depth. Defence in depth implies that safety is not unduly dependent: on a single element of the disposal system, such as the waste package; or on a control measure, such as verification of the inventory of waste packages; or on the fulfilment of a single safety function, such as containment of radionuclides or retardation of their migration: or on an administrative process such as procedures for controlling access to the site or for maintenance of the facility. Adequate defence in depth should be ensured by demonstrating that long term safety is provided by means of multiple safety functions.	Landfill	L	Landfill design described in Ikonen et al. (2020), Ch. 9. Safety functions (Ikonen et al. 2020, Section 2.1.4).	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.36	In accordance with the application of a graded approach, the ability of a disposal system to provide containment and isolation of the waste is required to be commensurate with the hazard potential of the waste [GSR Part 3 (IAEA 2014)]. As a consequence, the type and number of barriers and features necessary to meet the requirements for containment and isolation will depend on the type of waste to be disposed of and on the hazard posed by the waste, which will change with time through radioactive decay. The required assessment of defence in depth should comprise an evaluation of the performance of the disposal system and its components and features in terms of their ability to perform the safety functions over time, both in situations that are expected to occur (such as the normal degradation of barriers) and in situations where disturbance of the system might occur.	Landfill	L	Landfill design described in Ikonen et al. (2020), Ch. 9. Containment and isolation (Ikonen et al. 2020, Section 2.1.4).	GSR Part 3 (IAEA 2014)
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.37	In the safety case, all elements of the system design and all features of the disposal site that are important for demonstrating defence in depth of the planned disposal facility should be identified and assessed in a structured manner. Assessments should be performed to verify that a defect in one safety related characteristic, or a decrease of performance with time of one or more components, is compensated for by the performance of the safety functions or by a decrease of the hazard through radioactive decay. A systematic safety assessment of the various scenarios of evolution of the system and its components should be conducted to demonstrate that adequate defence in depth will be maintained. This assessment should also address how the increase in uncertainty with respect to the performance of components and the system for longer time frames is considered in the demonstration of safety and is taken into account in the design of the disposal facility.	Landfill	L	Landfill design described in Ikonen et al. (2020), Ch. 9. Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7).	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.38	The capability of the system as a whole to provide adequate containment and isolation is of prime importance, and the facility should be designed in a manner that is sufficiently flexible to take due account of the features of the site that can be considered less favourable. All relevant site features that could determine or influence the design of the facility should be systematically identified.	Landfill	L	Landfill design described in Ikonen et al. (2020), Ch. 9. Site selection (Ikonen et al. 2020, Ch. 4). Containment and isolation (Ikonen et al. 2020, Section 2.1.4).	

SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.39	A safety function (e.g. the confinement of radionuclides to prevent or control their release) may be performed by means of a physical entity or a chemical property or process that contributes to containment of the radionuclides and/or isolation of the waste within the disposal system, such as impermeability or low permeability of a barrier to water, limited corrosion rate, and low solubility and high sorption capacity of radionuclides, which result in low leach rates.	Landfill	L	Landfill design described in Ikonen et al. (2020), Ch. 9. Safety functions (Ikonen et al. 2020, Section 2.1.4).
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.40	A barrier means a physical entity, such as the waste, waste packaging, the backfill or liner and cap of the facility, the characteristics of which restrict (or, for a limited time, prevent) the migration of radionuclides or render direct access to the waste more difficult. A particular barrier may perform a number of safety functions, while a single safety function may be provided by a number of barriers. The use of a number of barriers and safety functions enhances both safety and confidence in safety and will ensure that the overall performance of the disposal system is not unduly dependent on a single barrier or safety function. Hence, even if a barrier or safety function does not perform fully as expected (e.g. owing to an unexpected process or an unlikely event), it should be demonstrated that the disposal facility is still safe.	Landfill	L	Landfill design described in Ikonen et al. (2020), Ch. 9. Barrier system (Ikonen et al. 2020, Section 2.1.4).
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.41	The performance of a near surface disposal system is dependent on different barriers having different safety functions, the importance of which may vary over different time periods. The safety case should explain and justify the confidence attached to the safety functions provided by each barrier and should indicate the time periods over which they are expected to perform. The safety case should set out the scientific and technical arguments that support these claims and should also identify the complementary safety functions that will be effective if a barrier does not fully perform.	Landfill	L	Landfill design described in Ikonen et al. (2020), Ch. 9. Safety functions (Ikonen et al. 2020, Section 2.1.4). Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7).
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.42	The disposal system should use a combination of natural and engineered characteristics to support efficient containment and isolation by maintaining integrity of the waste packages, by, for example, limiting the solubility of radionuclides and by minimizing the ingress of meteoric water (i.e. derived from precipitation). The importance of the contribution of the natural barriers and the engineered barriers to the containment and isolation of the waste will depend to a large extent on the type of near surface disposal facility (i.e. surface or subsurface) and on the characteristics of the site where the facility is to be located. In the long term, progressive degradation of the engineered barrier system cannot be ruled out, and consequently, radionuclides may be released to the geosphere or biosphere, depending on the type of near surface disposal facility. While radioactive decay is an important factor for the short lived radionuclides in limiting the magnitude of a potential release from a near surface disposal facility over time, other considerations are also important and should be considered. Factors limiting the ingress of water (which in turn may contribute to prolonging the integrity of waste packages) that should be considered include the use of durable barriers with low water permeability and design of the system so that it maintains low hydraulic gradients for the required period of time. The potential for a release of radionuclides to the biosphere should be further reduced by maintaining low flow rates as well as by means of the retardation and precipitation capability of the engineered barriers and the host environment. Materials used for the backfill or elsewhere in the engineered system should have properties that do not contribute to degrading unduly the safety functions of the other barriers.	Landfill	L	Landfill design described in Ikonen et al. (2020), Ch. 9. Containment and isolation (Ikonen et al. 2020, Section 2.1.4). Suitable barrier materials (Ikonen et al. 2020, Table 9-3).
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.43	The role and importance of safety for the operational period of a near surface disposal facility is similar to that for any nuclear fuel cycle facility — that is, during the operational period, active control measures (such as control measures during waste handling and control of contamination and radiation levels in and around the facility) will be carried out. However, where possible, and necessary, passive safety measures should be applied, such as shielding of the waste during handling operations. For the post-closure period, the period of active management should be kept as short and as limited, in terms of effort and activities, as is practicable, consistent with the radionuclide content of the waste. After waste emplacement activities have ended, all steps should be undertaken to close the facility as soon as possible and to bring it to a passive state. This concludes the period of active management of the facility (namely, its construction, operation and closure). The steps taken towards closure of the facility may be determined to some extent by social and economic requirements and constraints, for example a decision may be taken to undertake a period of observation of the facility before it is completely closed, but this should not preclude the establishment of a strict plan for closure and the agreement on this plan by the parties involved (the operator, the regulatory body and other interested parties).	Landfill	L	Radiation protection (Ikonen et al. 2020, Section 9.2.5). Fire safety (Ikonen et al. 2020, Section 9.1.4). Incidents and accidents (Ikonen et al. 2020, Section 9.2.6). Monitoring (Ikonen et al. 2020, Section 9.2.8).
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.44	The safety of a disposal facility may depend on some future actions such as maintenance, surveillance and control, but this dependence should be minimized to the extent possible. In the case of a near surface disposal facility, such actions might be necessary for a period after closure of the facility (of a few decades up to a few hundred years). Measures taken during the period of active management might include, for example, repair to the cap of the disposal facility. Engineered structures that are necessary to provide safety in the post-closure period should have sufficient longevity as not to require maintenance during the post-closure period.	Landfill	L	Landfill design described in Ikonen et al. (2020), Ch. 9. Maintenance (Ikonen et al. 2020, Section 9.2.1). Monitoring and surveillance (Ikonen et al. 2020, Section 9.3.1).

SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.45	Closure of the disposal facility indicates the start of the period of institutional control. This period can be subdivided into active and passive phases, whose durations may be prescribed by regulation. Activities during the active phase of the period of institutional control will include preservation of knowledge, prevention of human intrusion, and monitoring and surveillance. If damage to, or deterioration of, the barriers is detected by means of monitoring or surveillance, remedial measures should be taken to restore any lost safety functionality to the parts of the disposal facility that remain accessible, at a minimum. However, the possible need for maintenance should not detract from the need to meet the requirement that safety is to be ensured primarily by passive means. In the passive phase of the period of institutional control, all active measures, including monitoring, surveillance and maintenance, cease (or, for the purposes of the safety assessment, are assumed to cease). Passive measures that continue may include the retention of records, the construction of durable warning markers and the control of land ownership. At the end of the period of active institutional control, it is assumed that, while further passive control is applied, inadvertent human intrusion becomes possible or even inevitable, although the site of the facility has been chosen to reduce the possibility to the extent possible.	Landfill	L	Closure (Ikonen et al. 2020, Section 9.3). Institutional control (Ikonen et al. 2020, Sections 9.2.1, 9.3.1).	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.46	In the case of near surface disposal, the period of active institutional control is required to be such that isolation of the waste is ensured for a period commensurate with the hazard posed by the waste. This period should also be used to increase confidence in the passive containment provided by the disposal system, by verifying the proper functioning of the components that are installed to contain the waste. Even if absolute confinement is not an attainable objective and some release of radionuclides to the biosphere might occur, such releases should at all times be sufficiently minimal as not to require any future corrective action. The safety case should provide all the elements and arguments necessary to support this claim.	Landfill	L	Institutional control (Ikonen et al. 2020, Sections 9.2.1, 9.3.1). Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7).	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.47	The long term safety of a near surface disposal facility depends on the quality of all the passive safety features that ensure long term containment and isolation, on the limitations placed on long lived radionuclides in the waste, and on the appropriate level of surveillance and control that has been applied to preserve and to protect the passive safety features. As the long term safety of a disposal facility is required not to be dependent on active institutional control, all passive safety features and the limitations on long lived activity in the disposed waste should be assessed and employed without assumption of surveillance and control beyond a period of a few hundred years at most.	Landfill	L	Containment and isolation (Ikonen et al. 2020, Section 2.1.4). Institutional control (Ikonen et al. 2020, Sections 9.2.1, 9.3.1). Monitoring and surveillance (Ikonen et al. 2020, Section 9.3.1).	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	4.48, 4.49–4.51	For near surface disposal facilities, surveillance and control measures should be employed during active post-closure management of the disposal site, to provide assurance of the continued effectiveness of passive safety barriers. Surveillance and control should be achieved through monitoring and institutional control activities such as site protection and access restrictions; inspection of physical conditions coupled with retention of appropriate maintenance capabilities to address possible degradation of barriers; and monitoring as a method of confirming whether the continued performance of barriers is as specified. Since the safety of disposal facilities mainly relies on passive means, the intent of surveillance and monitoring is not to measure radiological parameters (e.g. radiological monitoring of the environment at the disposal site and in its surroundings), but to ensure the continuing fulfilment of safety functions [SSR-5 (IAEA 2011)].	Landfill	L	Landfill repository design and monitoring described in Ikonen et al. (2020), Ch. 9. Monitoring (Ikonen et al. 2020, Section 9.2.8).	SSR-5 (IAEA 2011)
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	5.1, 5.2–5.38	The safety case for a near surface disposal facility should address both operational safety and post-closure safety, although sometimes it is presented separately as an 'operational safety case' (i.e. a demonstration that the facility will be safe during operation) and a 'post-closure safety case' (i.e. a demonstration that the facility will be safe after it is closed). Comprehensive guidance on safety assessment is provided in IAEA Safety Standards Series No. SSG-23 [IAEA 2012].	Landfill	L	Requires a design, but not a design issue per se. Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7).	SSG-23 (IAEA 2012)
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.9, 6.6–6.8	An important part of characterization of the site lies in understanding how the site will behave over the long term. Site characterization should provide information on the effects the natural environment will have on the containment and isolation of radionuclides. Although the effects of many processes can be mitigated during operation, it is passive controls that will be relied upon in the post-closure period. Therefore, the potential effects of erosion, flooding, seismicity and other disruptive processes should be well understood.	Landfill (site)	L	Site characterisation (Ikonen et al. 2020, Section 4.3).	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.10, 6.11–6.18	Site characterization should contribute to a comprehensive description of the site that is sufficient to support development of the safety case and its supporting assessments. For near surface disposal facilities, this description should include information concerning the surrounding populations and land use.	Landfill (site)	L	Site characterisation (Ikonen et al. 2020, Section 4.3).	

SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.19	Near surface disposal facilities are expected to perform over much longer time periods than the time frames usually considered in engineering applications. Investigation of the ways in which analogous materials have behaved in nature, or how ancient artefacts and anthropogenic constructions have behaved over time, should be undertaken to contribute to the confidence in the assessment of long term performance of the facility. A technical justification to support the durability of materials over time should also be developed by means of testing that are appropriate for the material in the given application. Demonstration of the feasibility of the fabrication of waste packages and of the construction of engineered components and their features should be carried out in order to assess whether and to generate confidence that an adequate level of performance can be achieved. The feasibility of construction should also be demonstrated for novel, one-of-a-kind disposal facilities. Information on similar designs and the use of similar materials in other disposal projects should be provided to improve confidence in the safety case and supporting safety assessment.	Landfill	L	Design R&D
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.20	The design of the facility is required to ensure safety during both the operational and post-closure periods. It should also consider requirements for monitoring, security, concurrent activities (excavation and waste emplacement), and, if requested, retrievability and reversibility. The closure arrangements for the facility and the measures for institutional control should be taken into consideration at an early stage of the facility design. The facility design should be of sufficient detail and accuracy to enable the effect of the design requirements to be appropriately evaluated in the assessments of operational and post-closure safety. As the facility design evolves and becomes progressively more detailed over the phases of facility development, operation and closure, safety assessments should be updated to evaluate the effects of the design changes on compliance with regulatory criteria.	Landfill	L	Landfill design described in Ikonen et al. (2020), Ch. 9. Monitoring (Ikonen et al. 2020, Section 9.2.8). Closure (Ikonen et al. 2020, Section 9.3). Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7). Retrieval possible at any time.
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.21	The design of the facility should take into account the waste that will be disposed of at the site. The types and quantity of waste for which the facility is developed should be identified at an early stage of the development process. Prior to the conceptual and planning stage, the national waste management policy and strategy should consider the type of waste (e.g. LLW and VLLW from the operation and/or decommissioning of nuclear power plants; radioactive waste generated in medicine, industry, agriculture, research and education), the quantities and characteristics of the waste, and the radioactive inventory of the waste proposed for disposal at the facility. In the course of design of the facility, information about the waste should be used to support the identification of a concept and the actual design.	Landfill	L	Waste inventory (Ikonen et al. 2020, Section 2.2.3). WAC issue.
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.22	The initial design of the facility should be used to validate the suitability of a candidate site for the disposal facility. The design of the facility, the physical characteristics of the site, and the characteristics of the waste or inventory are mutually interdependent and should be managed in such a way that a set of independent and complementary safety functions can be proposed in order to achieve the desired performance of the disposal system. The initial design of the facility should be used to demonstrate that the site, in combination with the design of the facility and the characteristics of the waste, will provide adequate containment and isolation of radionuclides for the necessary period of time. The initial design should be made subject to formal approval within the licensing process.	Landfill (incl. site)	L	Landfill design described in Ikonen et al. (2020), Ch. 9. Safety functions, containment, isolation (Ikonen et al. 2020, Section 2.1.4).
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.23	The design of the facility and the quality of its construction should also be compatible with the foreseen duration of institutional control and with the post-closure needs. The need to maintain and to repair accessible elements of the disposal facility (such as the final cap) during the period of institutional control should be minimized in accordance with the principles of relying, as far as practicable, on passive controls and of not imposing undue burdens on future generations.	Landfill	L	Landfill design described in Ikonen et al. (2020), Ch. 9. Institutional control (Ikonen et al. 2020, Sections 9.2.1, 9.3.1).
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.24	The design of the facility should accommodate the proposed operational activities and radiation protection practices (i.e. access control and zoning), which should be determined based on the estimated radiation exposure conditions and the potential for contamination. As noted in Section 4, design of the facility for operational safety may include both active and passive systems and should rely on radiation protection related and industrial best practices and techniques.	Landfill	L	Landfill design described in Ikonen et al. (2020), Ch. 9. Radiation protection (Ikonen et al. 2020, Section 9.2.5).
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.25	Means for radiation monitoring during operation should be designed with consideration given to anticipated operational occurrences, incidents and postulated accidents. A monitoring programme, including monitoring devices, should be established on the basis of likely receptor locations and should reflect realistic pathways. Exposure pathways may be different for workers and for members of the public, and differences in exposure pathways should be reflected in the types and locations of radiation monitoring stations. Appropriate monitoring stations should be established for measuring external radiation levels, airborne contamination and water contamination (groundwater and surface water, as appropriate). The programme should include measurement points within controlled and non-controlled areas on the site and off the site to account for public exposure pathways.	Landfill	L	Landfill repository design and monitoring described in Ikonen et al. (2020), Ch. 9. Monitoring (Ikonen et al. 2020, Section 9.2.8).

SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.26, 7.20–7.33	The process for facility design should be made subject to an appropriate management system that also provides for configuration change control. Design attributes of the engineered barriers for operational safety and post-closure safety should be characterized to ensure that the management system applies a degree of control commensurate with the significance to the safety of such barriers.	Landfill	L	Development of a comprehensive management system was out of the scope of the Ikonen et al. (2020) report.
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.27	Although disposal is defined as the emplacement of waste in an appropriate facility without the intention of retrieval, in some national systems it may nevertheless be required that retrievability (design for safe removal of waste) of the waste be allowed at any period before closure. If the ability to retrieve waste is a design requirement, it should be considered in the conceptual design and in the subsequent design process in such a way as not to compromise the safety of the facility after closure. As with meeting any design requirement, an optimized approach should be adopted that is consistent with the design principles. Although retrievability can be envisaged for all phases of development, operation and closure of the facility, post-closure retrievability should be considered an exceptional condition.	Landfill	L	Landfill design described in Ikonen et al. (2020), Ch. 9. Retrieval possible at any time.
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.28	The design of the facility for safety in the period after closure should meet the precepts of robustness, simplicity, technical feasibility and passive operation of barriers. The disposal facility should be designed and operated to achieve long term stability of the disposal site and to eliminate, to the extent practicable, the need for ongoing active maintenance of the disposal site following closure. The design of the facility should take the intrinsic features of the host environment into account (including the potential for erosion, flooding, seismicity and other disruptive phenomena). However, the relative importance of these processes will vary from site to site, and the design of the facility should focus on those processes that pose the most substantial challenge to meeting the performance objectives and regulatory requirements.	Landfill	L	Landfill design described in Ikonen et al. (2020), Ch. 9. Site selection (Ikonen et al. 2020, Ch. 4). Post-closure period (Ikonen et al. 2020, Sections 9.2.1, 9.2.8, 9.3.1).
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.29	The types of waste that will be disposed of in any radioactive waste disposal facility will be the prime determinant of the potential hazard that the facility and its operation could present to workers and the public. Consequently, the characteristics of the waste intended for disposal, both its activity levels and other characteristics, should be considered in the design of the facility and the safety assessment. When waste is emplaced in a disposal facility, the operator should ensure through a waste acceptance process that the waste packages and, if applicable, unpackaged waste comply with the waste acceptance criteria for the facility. This waste acceptance process should ensure that: — The disposal facility will be safely operated (e.g. through the safe handling of waste packages in both normal operation conditions and in anticipated operational occurrences). — The waste form and waste packaging will fulfil their attributed safety functions for the operational phase and, if applicable, for the post-closure phase. — The waste emplaced in the facility complies with all limitations on radionuclide concentrations and/or total activity. — The characteristics of the waste will not negatively affect other components of the system to the extent that this would lead to failure or to a significant decrease of performance of safety functions.	Landfill	L	Waste inventory (Ikonen et al. 2020, Section 2.2.3). WAC issue.
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.30	Waste intended for near surface disposal should be characterized to provide sufficient information to ensure compliance with waste acceptance criteria. Arrangements should be put into place to verify that the waste and waste packages received for disposal comply with these criteria, and if not, to ensure that corrective measures will be taken by the responsible party, either the waste generator or the operator of the disposal facility. Waste characterization activities should take place early in the process of waste management (i.e. at the stage of waste generation and waste processing). The quality controls applied to waste packages should be determined on the basis of records of the waste treatment, preconditioning testing (e.g. of containers) and control of the conditioning process. Post-conditioning testing and the need for corrective measures should be limited to the extent practicable.	Landfill	L	WAC compliance issue
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.31	The waste acceptance process established by the operator should take into account the steps of waste generation and waste processing. Depending on national responsibilities, the waste generator, the waste management organization or the operator of the disposal facility should establish and/or apply waste acceptance criteria and technical specifications and procedures for controlling waste generation, waste processing and waste characterization. This should ensure that there will be mechanisms (e.g. procedures and controls) in place during the process of waste generation and management that will ensure that the waste acceptance criteria for disposal can and will be met. As part of the waste acceptance process, the operator should carry out verifications and controls when waste is received for disposal. The major elements of the waste acceptance process should be presented to the regulatory body for approval, for example as part of the safety case for the application of a licence.	Landfill	L	WAC compliance issue

SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.32, 6.33	In the development of the waste acceptance criteria, emphasis should be given to the fact that near surface disposal is intended for short lived radioactive waste containing only limited amounts of long lived radionuclides and that, generally, longer lived waste needs greater levels of containment and isolation that cannot be provided by near surface disposal. The national policy for radioactive waste management should ensure that these limitations on long lived radionuclides are respected and that waste with higher concentrations of long lived radionuclides is disposed of in facilities designed to accept such waste.	Landfill	L	WAC issue	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.34	The waste acceptance criteria should include the waste characteristics important for safety in the operational and post-closure period, and should specify the following: — Allowable levels of activity in each package and allowable levels of long lived radionuclides in each package; — Allowable surface dose rate and surface contamination; — The permissible range of chemical and physical properties of the waste and the waste form; — Substances or properties that are not permissible in waste for disposal; — The permissible dimensions, mass and other manufacturing specifications of each waste package; — Limitations on allowable uncertainties in respect of waste characterization; — Requirements for accompanying documentation. As stated in para. 2.26 of IAEA Safety Standards Series No. GSG-1, Classification of Radioactive Waste [IAEA 2009], restrictions on levels of activity concentration for long lived radionuclides in individual waste packages may be complemented by restrictions on average levels of activity concentration or by operational techniques such as emplacement of waste packages with higher levels of activity concentration at selected locations within the near surface disposal facility.	Landfill	L	WAC issue	GSG-1 (IAEA 2009)
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.35	The properties of the waste actually disposed of influence the arrangements that will need to be put in place at the end of facility operation, such as the arrangements for closure, the planned or foreseen time frame for licence termination and the post-closure activities, including both active and passive institutional controls. Various factors should be considered when closing the facility and putting in place a control programme for the closed facility, and determining the minimum time period until termination of the licence and for subsequent institutional controls. Example factors include the presence of considerable amounts of mobile radionuclides that could reach the biosphere in the time frame of the control period, the possibility of the generation of non-radioactive gases and the total inventory of long lived radionuclides.	Landfill	L	Design input	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.36	Optimization of a near surface disposal system from the perspective of the radioactive waste inventory should mainly be dealt with by means of a cautious approach adopted to limit the activity, especially the activity of long lived radionuclides, that can be disposed of in the facility and through an adequate waste acceptance process. If further steps of optimization are considered, a broad view should be taken in respect of the different steps of radioactive waste management (e.g. additional separation of waste at the point of waste generation, waste processing and the feasibility of lowering the amounts of long lived radionuclides present in specific waste streams to be disposed of in the near surface disposal facility). In taking such a broad view, the gain in safety for the near surface disposal facility should be put in perspective with any increase in occupational exposures in waste management facilities and with economic factors.	Landfill	L	Safety culture (Ikonen et al. 2020, Sections 2.2.1, 2.2.7)	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.37	In accordance with a graded approach and the assumptions made in the safety case, modelling and/or testing of the behaviour of waste forms should be undertaken to ensure the physical and chemical stability of the different waste packages and unpackaged waste under the conditions expected in the disposal facility, and to ensure their adequate performance in the case of accidents, incidents or abnormal conditions.	Landfill	L	Waste and waste package related, input to design.	GSR Part 4 (Rev. 1) (IAEA 2016), Requirement 1
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.38	Records of the receipt and disposal of waste should be structured to accommodate the information associated with waste acceptance.	Landfill	L	Waste and waste package related, input to design.	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.39	Construction of the facility should proceed in accordance with the approved facility design and any approved design modification that may be necessary after commencing construction. Construction of the systems and components that are important to the safety of the facility should not commence until the construction of the facility is approved in accordance with the requirements of the regulatory body.	Landfill	L	Landfill repository construction (Ikonen et al. 2020, Sections 9.1.1, 9.1.6, 9.1.7, 9.2.1)	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.40, 6.41	Prior to construction, appropriate documentation should be in place and maintained by means of an efficient document management system. Detailed design and construction drawings, technical specifications and fabrication techniques, among other things, should all be developed and maintained. Applicable codes and standards for all buildings (structures), systems and components should be identified.	Landfill	L	General requirement, not directly related to facility design	

SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.43	The initial construction phase of the facility includes a variety of activities, such as site preparation, construction of buildings, construction and installation of equipment and utilities, and construction of associated support systems. Disturbances to the host environment, such as the development of unnecessarily extensive excavation or excessive disturbed zones, and the introduction of chemically adverse substances into the local environment, should be avoided or limited during the construction of the disposal facility. Best practices for construction techniques should be identified and incorporated into construction procedures. All construction activities should be performed in such a way that the intrinsic containment and isolation features of the host environment are preserved to the greatest extent practicable.	Landfill	L	Construction issue	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.44	Emphasis should be given to control of the quality of safety related activities (namely, those activities that have to be identified in the safety case and approved by the regulatory body) performed during construction in order to ensure that the realization of the facility complies with the design as set out in the safety case or that 'as-built' modifications have been evaluated and shown to have no effect on the safety case.	Landfill	L	Landfill repository construction (Ikonen et al. 2020, Sections 9.1.1, 9.1.6, 9.1.7, 9.2.1). Quality control (QC), and quality assurance (QA) (Ikonen et al. 2020, Section 9.1.1, 9.1.7).	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.45	At the end of the initial construction phase, the systems and components should be subjected to a series of commissioning tests to determine whether they function in accordance with the approved design and have met the required performance criteria. A commissioning period should be used to perform these tests and to evaluate the adequacy of the design and the operating procedures.	Landfill	L	Testing (Ikonen et al. 2020, Sections 9.1.1, 9.1.7)	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.46	Construction activities may continue during the operation of the facility as waste disposal cells and trenches are opened and closed. Operational activities, which include ongoing construction and waste emplacement, should be performed in a manner that ensures occupational health and safety. The management and performance of all activities should reflect a combination of best practices in radiation protection, industrial safety and civil engineering. The safety of facility construction activities should rely on up to date safety practices analogous to those at existing nuclear or industrial facilities. Best practices in radiation protection should be adopted and followed for operational activities taking place during the construction of the facility to protect both workers and the public.	Landfill	L	Construction (Ikonen et al. 2020, Sections 9.1.6, 9.1.7). Radiation protection (Ikonen et al. 2020, Section 9.2.5). Fire safety (Ikonen et al. 2020, Section 9.1.4). Incidents and accidents (Ikonen et al. 2020, Section 9.2.6).	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.47	As an element of obtaining approval for operation (the licence), and prior to the receipt of the first waste at the facility, the operator should satisfy the applicable regulatory requirements to demonstrate the adequacy of the facility structures, systems and components. In addition, the operator should also verify that the required services, functions and procedures are in place. This demonstration should be performed for normal and abnormal events and for emergency conditions. A commissioning programme should be used to evaluate the operability of safety related equipment and the adequacy of operating procedures, including procedures to safely handle, emplace and, if necessary, retrieve waste as part of normal operations.	Landfill	L	General requirement, not directly related to facility design	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.49, 6.48, 6.52	Policies and procedures should be developed for all activities necessary for the safe operation of the facility. Procedures should be formally documented and maintained as part of the document management system for the facility. Explicit instructions, formal training and certification of workers should be provided to ensure that workers can adequately carry out their work.	Landfill	L	Training is a general requirement, not directly related to facility design. Adequate instructions shall be in place for the operation, maintenance, periodic inspections and tests of the plans (Ikonen et al. 2020, Section 2.2.1). Radiation protection (Ikonen et al. 2020, Section 9.2.5). Fire safety (Ikonen et al. 2020, Section 9.1.4). Incidents and accidents (Ikonen et al. 2020, Section 9.2.6).	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.50	Operations should be conducted in accordance with approved procedures providing for occupational radiation protection [GSR Part 3 (IAEA 2014)]. The operator is responsible for ensuring that such procedures and instructions are followed by workers at the facility.	Landfill	L	Radiation protection (Ikonen et al. 2020, Section 9.2.5).	GSR Part 3 (IAEA 2014) GSG-7 (IAEA 2018)
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.53	Maintenance procedures should be put in place to ensure that structures and equipment continue to perform their intended function (safety and non-safety related) throughout the lifetime of the facility. Items important to safety (e.g. equipment for waste handling or waste management) should be inspected, tested and maintained in accordance with the established procedures. Periodic maintenance for support equipment (mechanical, civil and electrical structures, systems and components) should also be conducted in accordance with established policies and procedures.	Landfill	L	The reliable operation of systems and components shall be ensured through maintenance and regular periodic inspections and tests (Ikonen et al. 2020, Section 2.2.1). Active maintenance during the until National Facility closure (Ikonen et al. 2020, Table 9-6).	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.54	As a near surface disposal facility will operate for long periods before its final closure, a programme to manage ageing (e.g. a programme of preventing maintenance) should be put in place for both active and passive systems. Active components should be the focus of the maintenance programme. An ageing management programme should also be put in place for passive structures (e.g. engineered features) that are required to maintain integrity in the operational phase as well as in the post-closure period. Ageing management programmes should be designed to detect problems in construction and operation that might not otherwise be discovered until after closure.	Landfill	L	To be decided	

SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.55	Quality assurance procedures should be put in place to allow the operator to validate the competence of the workers, to assess the effectiveness of the training and certification programmes, and to promote a safe working environment. The purpose of such procedures is to ensure that activities at the facility are being conducted in accordance with standard operational procedures, and that a graded approach is applied to safety which focuses resources on the aspects of the facility operations that are associated with the highest risk and that present the greatest hazard.	Landfill	L	General requirement, not directly related to facility design. Advanced quality assurance programmes shall be applied (Ikonen et al. 2020, Section 2.2.7). QC/QA (Ikonen et al. 2020, Section 9.1.1, 9.1.7).	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.56	Emergency procedures should be established to address emergencies that may arise and have on-site or off-site consequences. The safety case should give an indication of what factors could contribute to a scenario that would result in significant on-site and/or off-site consequences. The resultant scenarios should reflect operating reality but should also consider analysis of worst case situations. Emergency plans should be developed to address these cases or scenarios. The emergency plans should be tested at appropriate intervals in accordance with national regulations.	Landfill	L	Security and emergency arrangements (Ikonen et al. 2020, Section 2.2.1)	GSR Part 7 (IAEA 2015)
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.57	Access to areas in which waste is handled, stored or emplaced should be controlled to ensure safety and the physical protection of the waste. Provisions should be put in place for detecting any unauthorized intrusion and for taking countermeasures promptly.	Landfill	L	The National Facility site will be fenced (Ikonen et al. 2020, Figure 5-4). Security patrols and surveillance of the disposal facility are centralised in the operation building. This control post is manned at all times, so it is the logical point for controlling access (Ikonen et al. 2020, Section 5.7). The security guards work in three shifts. At night, surveillance of the operation building takes place from the security guard centre (Ikonen et al. 2020, Section 5.6). Access controls to the site will be in place throughout the operations and in the post-closure phase as part of institutional control (Ikonen et al. 2020, Section 9.2.4). Perimeter protection and access control may be included in the monitoring programme (Ikonen et al. 2020, Section 9.2.8).	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.58	Maintenance of mechanical, civil and electrical structures and equipment should be carried out in accordance with a schedule for preventive maintenance. Elements important to safety (e.g. equipment for waste handling and waste lifting) should be inspected, tested and maintained in accordance with the maintenance schedules for the disposal facility. Disposal units (e.g. vaults, trenches and areas of the facility) that have already been closed, as well as those that are still open, during the operational phase should be included in the maintenance schedule. There should be clear and thorough documentation of all changes and modifications to equipment, procedures and conditions; and, where required, such changes and modifications should be justified in the safety case.	Landfill	L	The reliable operation of systems and components shall be ensured through maintenance and regular periodic inspections and tests (Ikonen et al. 2020, Section 2.2.1).	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.59	Modifications to the design and improvements in processes are inevitable parts of facility operation. A system for configuration control and management should be developed to document and to allow for approval of modifications and to track changes at the facility. A near surface disposal facility may need design modifications for a number of reasons, including internal and external influences. Process improvements originate from the need for better human resource management or improved management of exposures. For example, the monitoring of occupational exposure rates and releases of radioactive material may suggest the need for design changes, including revisions in procedures that could result in improved performance, decreased exposure and reductions in off-site releases of radioactive material. Similarly, environmental monitoring (e.g. groundwater monitoring) might give an indication whether processes and features modelled in the safety assessment are performing as anticipated.	Landfill	L	To be decided	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.60	The period between the emplacement of the last waste package and the closure of the last disposal cell or trench should be as short as possible, in order to take full advantage of the passive safety features as soon as possible.	Landfill	L	Activities and schedule (Ikonen et al. 2020, Section 9.2.1). Landfill repository construction in phases (Ikonen et al. 2020, Section 9.1.6).	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.61	The control of access to the site and radiologically controlled areas is an important part of ensuring that exposure to workers and the public is as low as reasonably achievable.	Landfill	L	The National Facility site will be fenced (Ikonen et al. 2020, Figure 5-4). Security patrols and surveillance of the disposal facility are centralised in the operation building. This control post is manned at all times, so it is the logical point for controlling access (Ikonen et al. 2020, Section 5.7).	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.62	Closure of a near surface disposal facility should include the decommissioning of operational systems and components, and the placing of the facility in a State that has been demonstrated to provide the safety functions necessary for long term safety.	Landfill	L	Decommissioning and closure (Ikonen et al. 2020, Section 9.3)	

SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.63, 6.64, 6.67, 6.68	The process of facility closure should be documented in a plan for facility closure. Typically, portions or segments of the site may be closed as waste is emplaced and disposal units become full. Elsewhere at the facility, disposal activities may be ongoing until waste capacities are reached and final site closure activities are completed. The facility closure plan should be developed during the operation of the facility and should provide order and structure to planned disposal activities. The facility closure plan should take into account factors such as the type of waste that will be disposed of at the facility, the timing of disposal actions, annual estimates of waste volumes, the location of waste within the facility if retrieval may be required (especially with regard to the emplacement of waste of higher levels of activity concentration at selected locations), and the phased interim closure of individual disposal units (vaults, cells or trenches). Finally, the facility closure plan should describe the installation of final engineered barriers and site markers (if applicable) and how the facility will be transferred into the period of institutional control. The regulatory body should review the facility closure plan for approval. The facility closure plan should also serve as a tool for communication with the public, by informing them of long term plans and how those plans might impact on the local community.	Landfill	L	Decommissioning and closure (Ikonen et al. 2020, Section 9.3)	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.65	Before construction activities commence and disposal units are filled, there should be sufficient evidence available that the closure features will function as intended. As disposal activities begin, goals for post-closure performance should be used to inform decisions on operational factors such as waste placement and the interim design of the cap. Closure activities should commence early in the lifetime of the facility as disposal units are filled. The impact of the closing of individual disposal units on the safety case for the entire facility should be well understood and adequately documented.	Landfill	L	Decommissioning and closure (Ikonen et al. 2020, Section 9.3)	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.66	Closure activities for each disposal unit will collectively determine the post-closure performance of the facility. There should be sufficient evidence that the performance of engineered barriers of the disposal units (e.g. backfilling, sealing and capping) will function as intended to meet the design requirements. Over the course of operations, the design of disposal units may be modified as a result of many factors, such as improvements in materials and in construction techniques, improved information on site features and characteristics, and changes in waste characteristics or waste forms. A record keeping system should be put in place to document these changes and to verify, through updates to the safety case, that performance requirements will continue to be met. Information management systems should be put in place to track any change that could potentially impact the post-closure performance of the facility.	Landfill	L	Decommissioning and closure (Ikonen et al. 2020, Section 9.3)	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.69	The minimum duration of institutional controls to contribute to safety should be defined in the arrangements for closure and should be justified in the safety case. Active institutional controls should remain in place until the consequences of human intrusion will not exceed the criteria specified in SSR-5 [IAEA 2011]. Beyond this period, consideration should be given to the type of passive control necessary and, in particular, the site may be placed under the jurisdiction of the local planning authority for land use. The institutional control measures put in place should include the following: — The prevention of unauthorized use of the site and human intrusion into the disposal facility; — Monitoring and surveillance of the disposal system; — Maintenance and remedial actions, if required; — The transfer of knowledge to future generations.	Landfill	L	Institutional controls (Ikonen et al. 2020, Sections 9.2.4, 9.2.8, 9.3.1 Table 9-6)	SSR-5 (IAEA 2011)
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.70	The closure method, including the materials and techniques to be used, as well as the expected performance of the components used in closure, should be outlined in the closure plan. The closure method should be optimized in the light of available materials and techniques in order to provide the degree of post-closure performance required from the disposal system throughout the period of institutional control and beyond. The proposed closure method should be described in the safety case developed for obtaining authorization to close the disposal facility.	Landfill	L	Decommissioning and closure (Ikonen et al. 2020, Section 9.3)	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.71	The effectiveness of the closure system should be demonstrated by developing an understanding of the natural evolution of the site and by in situ testing, data analysis and modelling. Testing the actual in situ behaviour of the closure system should be carried out to provide an insight into performance and to reduce the uncertainty in models and in the safety assessment. Information that cannot be determined through site specific analysis should be obtained through the use of suitable analogues, including experience with similar systems either within the State or elsewhere.	Landfill	L	Decommissioning and closure (Ikonen et al. 2020, Section 9.3)	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.72	Closure of the facility should also include plans for final closure of the disposal units, final physical preparation of the site (e.g. installation of the cap), institutional controls and decommissioning of the facilities on the site. In closing the disposal units and preparing the site for closure, consideration should be given to requirements for post-closure monitoring and commitments in respect of the licensing process, as well as to design features relied upon in the safety case for long term performance.	Landfill	L	Decommissioning and closure (Ikonen et al. 2020, Section 9.3)	

SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	6.73	Facility closure should also include decommissioning of the parts of the facility which are not part of the disposal system itself (e.g. administrative buildings, and components and equipment used for operating the disposal facility) and any environmental restoration needed, and should consider measures to prevent or to reduce the likelihood of human actions. The disposal facility should ultimately be closed in accordance with the conditions set for closure by the regulatory body in the licence for the facility, with particular consideration given to any changes in responsibility that may occur at this stage.	Landfill	L	Decommissioning and closure (Ikonen et al. 2020, Section 9.3)	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	7.2, 7.1, 7.3–7.5	The monitoring programme should be defined prior to construction and in coordination with development of the safety case. A baseline survey of the site, including characteristics of the host environment, should be conducted before commencing construction activities. The monitoring programme should be revised periodically to reflect new information gained during construction, operation and closure.	Landfill	L	Landfill repository design and monitoring described in Ikonen et al. (2020), Ch. 9. Monitoring (Ikonen et al. 2020, Section 9.2.8).	SSG-31 (IAEA 2014)
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	7.6	Institutional controls following closure should be considered as a means of providing additional assurance of the safety of the disposal facility. Institutional controls may contribute to safety by preventing or reducing the likelihood of human actions that could inadvertently interfere with the waste or degrade the safety features of the disposal system. Institutional controls may also contribute to increasing public acceptability of a near surface disposal facility.	Landfill	L	Landfill repository design and monitoring described in Ikonen et al. (2020), Ch. 9. Institutional controls (Ikonen et al. 2020, Sections 9.2.4, 9.2.8, 9.3.1 Table 9-6).	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	7.8	The operator should prepare plans for institutional controls to be put in place in consultation with the regulatory body and any local, regional or national authority responsible for the administration of the area where the site is located. The plans should define the intended function of the institutional controls, describe how they will be effected, state their assumed period of effectiveness, and provide arguments and evidence that they can be relied upon. The plans may initially be flexible and conceptual in nature, when the facility is first constructed, but they should be developed and refined progressively as closure of the facility and release of the site from regulatory control approaches.	Landfill	L	Landfill repository design and monitoring described in Ikonen et al. (2020), Ch. 9. Institutional controls (Ikonen et al. 2020, Sections 9.2.4, 9.2.8, 9.3.1 Table 9-6).	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	7.9	Institutional controls may be active (i.e. controls requiring active maintenance by the operator) or passive (i.e. measures that may persist without future actions by the operator or others). Active institutional controls may include measures to prevent members of the public from having access to the site (e.g. maintaining a site fence and security personnel) and monitoring activities with respect to the radionuclide concentration in environmental media as well as to the integrity and performance of engineered barriers. Passive institutional controls may include the placing of information about the disposal facility in local, national or international records and archives (to enable future generations to make decisions on the disposal facility and its safety), the use of durable markers at the site [4], and the placing of legal restrictions on the use of the land.	Landfill	L	Landfill repository design and monitoring described in Ikonen et al. (2020), Ch. 9. Institutional controls (Ikonen et al. 2020, Sections 9.2.4, 9.2.8, 9.3.1 Table 9-6).	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	7.10, 7.11	The operator should distinguish clearly between plans for the institutional controls to be put in place and any assumptions concerning the duration and effectiveness of institutional controls made for the purposes of the safety assessment. An assumption in a safety assessment that, for example, active institutional controls will be effective in preventing human intrusion for 100 years, does not necessarily mean that active institutional controls will actually be removed after 100 years. The decision to release a site from regulatory control and to move from the period of active to passive institutional control is a decision that will need to be taken in the future by the operator in conjunction with the regulatory body, with account taken of the views of relevant interested parties.	Landfill	L	Landfill repository design and monitoring described in Ikonen et al. (2020), Ch. 9. Institutional controls (Ikonen et al. 2020, Sections 9.2.4, 9.2.8, 9.3.1 Table 9-6).	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	7.12, 7.13	The results of the safety assessment may provide input to decisions on the plan for institutional controls, but they should not be the only factor considered; rather, the views of all interested parties should be taken into account to provide a strong and well supported safety case. The possibility of disruptive events that could affect the facility should also be considered in developing plans for institutional control. In general, radioactive decay will cause the hazard posed by the waste and the associated doses and risks to decrease over time. However, in some cases (e.g. near surface disposal facilities that contain appreciable quantities of long lived radionuclides), assessed doses may remain relatively constant with time, or even increase slightly, because of growth in the content of daughter radionuclides.	Landfill	L	Institutional controls (Ikonen et al. 2020, Sections 9.2.4, 9.2.8, 9.3.1 Table 9-6)	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	7.14	The operator should justify any claims made in the safety case and in the plan for institutional controls regarding the duration of effectiveness of institutional controls. Typically, the safety case and supporting safety assessment should assume that institutional controls will remain effective for no more than a few hundred years.	Landfill	L	Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7). Institutional controls (Ikonen et al. 2020, Sections 9.2.4, 9.2.8, 9.3.1 Table 9-6).	
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	7.15	Different organizations are likely to be responsible for different institutional control activities. The operator will often be responsible for active institutional control, while State organizations may be responsible for activities such as the archiving of records and land use controls. At an appropriate stage, regulatory approval may be sought for a transfer of responsibility for the site from the operator to, for example, the government.	Landfill	L	Institutional controls (Ikonen et al. 2020, Sections 9.2.4, 9.2.8, 9.3.1 Table 9-6)	

SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	7.21	The first particular aspect that should be considered when the operator and the regulatory body develop the management system for a near surface disposal facility for radioactive waste is that, after termination of the active institutional controls in the post-closure phase, safety and environmental protection will depend on a passive system that has to ensure adequate containment and isolation of the waste. Depending on the type of near surface disposal facility (on the surface or at a shallow depth, with highly engineered vaults or a more simple trench design), passive containment and isolation of the waste will rest on engineered barriers, natural barriers, when present, and favourable features of the natural environment of the disposal facility (e.g. its long term stability). This reliance on a passive system affects the development and application of the management system, in which the performance, stability, complementarity and longevity of all components contributing to the containment and isolation of the waste should be given systematic attention from the design phase until the moment of termination of institutional controls on the site.	Landfill	L	Development of a comprehensive management system was out of the scope of the Ikonen et al. (2020) report.
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	7.22	A second specific aspect that should be considered is that, after closure of the disposal facility and before termination of active institutional control takes place, a long period of institutional surveillance and control (a few decades up to a few hundred years, largely depending on the activity of long lived radionuclides in the emplaced waste) is necessary to ensure that the passive system put in place is not disturbed by human activities that could lead to inadvertent intrusion into the disposal facility. During this long period, surveillance of the site to restrict access to the facility and control of the passive functioning of the system will take place. The management system should give particular emphasis during the development, operation and closure of the disposal facility to the recording of information about both what has been done and the reasons why decisions were taken. This should be done to meet the challenge of managing all relevant knowledge and information of the disposal system over such a long period, in order to enable a step by step decision making process until termination of all control activities at the site.	Landfill	L	Development of a comprehensive management system was out of the scope of the Ikonen et al. (2020) report.
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	7.23	A third specific aspect that should be considered is the requirement to ensure appropriate limitation of the waste inventory in terms of the activity, mainly of long lived radionuclides, that can be disposed of. A waste acceptance process should therefore be put in place that integrates all elements (waste characterization, and a management system for the waste acceptance for disposal) that are necessary to ensure that this limitation is complied with during waste emplacement activities.	Landfill	L	Development of a comprehensive management system was out of the scope of the Ikonen et al. (2020) report.
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	7.27	The elements of the management system that provide assurance of the quality of safety related processes should take into account uncertainties in the host environment. The host environment, while important for safety, cannot be designed or manufactured but only characterized to a certain level of detail. Furthermore, a disposal facility is developed through several sequential steps in design, characterization and assessment, with an increasing degree of detail and accuracy. However, a degree of uncertainty will always remain, and the management system should ensure that these uncertainties are appropriately taken into account in the demonstration of safety.	Landfill	L	Development of a comprehensive management system was out of the scope of the Ikonen et al. (2020) report.
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	II.6	The geology of the disposal site should contribute to the isolation of waste and the limitation of release of radionuclides to the biosphere. It should also contribute to the stability of the disposal system and should provide sufficient volume and favourable properties (geological, mechanical, geochemical, hydrogeological, etc.) for disposal. Preference should be given to sites with a uniform and predictable geology, which can be readily characterized through geological investigative techniques.	Landfill (site)	L	Affects site selection. Site selection (Ikonen et al. 2020, Ch. 4).
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	II.8	The hydrogeological characteristics of the host site should include low groundwater flow ~~paths~~ and long flow paths in order to restrict the migration of radionuclides. Expected changes in important hydrogeological conditions (e.g. gradient) due to natural events and the construction of the disposal facility should be evaluated. Preference should be given to sites with a simple geological setting that could make characterizing or modelling of the hydrogeological system easy and reliable. The dispersion characteristics of the hydrogeological system may also be important and should be evaluated.	Landfill (site)	L	Affects site selection. Site selection (Ikonen et al. 2020, Ch. 4).
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	II.10	The geochemistry of groundwater and the geological media should contribute to limiting the release of radionuclides from the disposal facility and should not significantly reduce the longevity of engineered barriers. Preference should be given to sites where geochemical conditions promote sorption and precipitation and co-precipitation of radionuclides that could be released from the disposal system, and inhibit the formation of chemical compounds of radionuclides that migrate readily.	Landfill (site)	L	Affects site selection. Site selection (Ikonen et al. 2020, Ch. 4).
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	II.14	The site should be located in an area of low tectonic and seismic activity such that the isolation capability of the disposal system will not be endangered. Areas of low tectonic and seismic activity should be selected in the regional analysis. Preference should be given to areas or sites where the potential for adverse tectonic, volcanic or seismic events is sufficiently low that it would not affect the ability of the disposal system to meet safety requirements.	Landfill (site)	L	Affects site selection. Site selection (Ikonen et al. 2020, Ch. 4).

SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	II.15	In the application of site selection criteria, the following conditions should be considered: — Recent or historic evidence of active faulting, tectonic processes or igneous activities; — Historical earthquakes of such magnitude and intensity that, if they recurred, could adversely affect isolation of the waste; — The potential for natural events such as subsidence or volcanic activity that could change the regional hydrogeological system; — Evidence of soil liquefaction in seismic loads.	Landfill (site)				L	Affects site selection. Site selection (Ikonen et al. 2020, Ch. 4).
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	II.18	It should be verified that surface processes such as flooding of the disposal site, landslides or erosion do not occur with such frequency or intensity that they could affect the ability of the disposal system to meet safety requirements. The disposal site should be generally well drained and free of areas of flooding or frequent ponding. Accumulation of water in upstream drainage areas due to precipitation or snowmelt and the failure of water control structures, channel obstruction or landslides should be evaluated and minimized so as to decrease the amount of runoff that could erode or inundate the facility. Preference should be given to areas or sites with topographical and hydrological features that preclude the potential for flooding.	Landfill (site)				L	Affects site selection. Site selection (Ikonen et al. 2020, Ch. 4).
SSG-29 (IAEA 2014)	Near Surface Disposal Facilities for Radioactive Waste (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1637_web.pdf)	II.23	The site should be located so that activities carried out by present, or future, generations at or near the site will not be likely to affect the isolation capability of the disposal system. Areas in the immediate vicinity of major hazardous facilities, airports or transport routes carrying significant quantities of hazardous materials should be evaluated. In addition, areas or sites should be evaluated for valuable geological resources or potential future resources, including groundwater suitable for irrigation or drinking water, that are likely to give rise to interference activities resulting in a release of radionuclides in quantities beyond the acceptable limits. A site should be considered less suitable where previous or future activities could create significant release pathways between the waste and the biosphere. Screening of potential sites should include consideration of the distance from such facilities and the associated impacts.	Landfill (site)				L	Affects site selection. Site selection (Ikonen et al. 2020, Ch. 4).
SSG-31 (IAEA 2014)	Monitoring and Surveillance of Radioactive Waste Disposal Facilities (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1640_web.pdf)	5.2	Monitoring activity associated with near surface disposal facilities containing LLW will aim to provide confidence in the performance of the system for hundreds of years. Examples of safety related features, events and processes for near surface disposal facilities that, in practice, could be detected by monitoring are any released radionuclides in groundwater or in the surrounding environment, and intrusion by humans or animals.	Landfill				L	Landfill repository design and monitoring described in Ikonen et al. (2020), Ch. 9. Monitoring (Ikonen et al. 2020, Section 9.2.8).
SSG-31 (IAEA 2014)	Monitoring and Surveillance of Radioactive Waste Disposal Facilities (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1640_web.pdf)	5.3	Geological disposal is suitable for waste, such as ILW and high level waste (HLW), that require a greater degree of containment and isolation from the accessible environment in order to ensure long term safety. In this case, monitoring is focused on providing confidence in the containment system. Monitoring after closure of the facility, if required and stipulated by the regulatory body, may focus on detection of the presence of radionuclides in the environment. As early releases to the environment are highly unlikely, this kind of monitoring is implemented generally for reassurance of the public rather than for ensuring the performance of the disposal system. Examples of safety related features, events and processes for deep geological disposal facilities that, in practice, could be detected by monitoring are the generation of corrosion gases, water inflow and human intrusion.	DGR, Deep Borehole, Intermediate Depth	I	D	B		Isolation: Intermediate depth (Ikonen et al. 2020, Table 2-1); DGR (Ikonen et al. 2020, Section 2.1.2); Deep Borehole (Ikonen et al. 2020, Section 2.1.3). Containment: Intermediate depth (Ikonen et al. 2020, Table 2-1); DGR (Ikonen et al. 2020, Section 2.1.2). The disposal concept is designed so that there will be no need for monitoring or other maintenance after the closure of connections to the repositories. If desired, signs can be left on the site to indicate the presence of radioactive waste underground. Post-closure monitoring can be included, if required (Ikonen et al. 2020, Section 2.2.7).
SSG-31 (IAEA 2014)	Monitoring and Surveillance of Radioactive Waste Disposal Facilities (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1640_web.pdf)	8.9	As the facility moves into the operational period, monitoring and surveillance should be continued in order to provide information about operating performance, which can be used to update the safety case. The operational safety case is developed prior to the granting of a licence for construction and operation. Residual uncertainties are often managed using conservative estimates of system functions with respect to their implications for safety. Available monitoring information prior to construction, which may be sufficient to develop the safety case, should continue to be updated throughout the operational period, as part of a monitoring programme for confirming performance of the disposal facility. This programme should lead to progressive improvement in understanding of the disposal system, which in turn should be used to improve operating approaches, definition of safety functions, facility design, and design of the monitoring programme. For example, monitoring data on the corrosion rate of a material collected as part of a monitoring programme for confirming performance may lead to a modification in the acceptable inventory limits in the disposal facility. Ideally, if the operational safety case is based on conservative estimates, then changes or improvements in understanding will lead to less restrictive and less costly operating approaches.	All	I	D	B	L	Safety case and licensing (Ikonen et al. 2020, Section 2.2.1). Monitoring related to site, baseline studies (Ikonen et al. 2020, Sections 6.2.8, 7.2.8). Surveillance and monitoring (Ikonen et al. 2020, Sections 5.2, 5-6, 5-7, 6.2.8, 7.2.8, Figures 5-4, 5-5). Intermediate depth, DGR: Disposal facility monitoring and control systems (Ikonen et al. 2020, Sections 6.1.2, 7.1.2). Deep Borehole: Monitoring (Ikonen et al. 2020, Section 8.2.7). Landfill repository design and monitoring described in Ikonen et al. (2020), Ch. 9.
SSG-31 (IAEA 2014)	Monitoring and Surveillance of Radioactive Waste Disposal Facilities (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1640_web.pdf)	7.7	For near surface disposal facilities, surveillance should start in the pre-operational period and should continue in the period after closure until the end of the period of active institutional control. Barriers that should typically be inspected during the post-closure period are surface covers of the disposal facility.	Landfill				L	Landfill repository design and monitoring described in Ikonen et al. (2020), Ch. 9.
SSG-31 (IAEA 2014)	Monitoring and Surveillance of Radioactive Waste Disposal Facilities (https://www-pub.iaea.org/MTCD/publications/PDF/Pub1640_web.pdf)	7.8	For geological disposal facilities, surveillance should start in the pre-operational period and will typically end at closure of the facility, when access to the engineered barriers is no longer possible.	DGR, Deep Borehole, Intermediate Depth	I	D	B		Monitoring related to site, baseline studies (Ikonen et al. 2020, Sections 6.2.8, 7.2.8, 8.2.7). Surveillance and monitoring (Ikonen et al. 2020, Sections 5.2, 5-6, 5-7, 6.2.8, 7.2.8, Figures 5-4, 5-5).

IAEA-TECDOC-764 (1994)	Interfaces Between Transport and Geological Disposal Systems for High Level Radioactive Waste and Spent Nuclear Fuel (https://www-pub.iaea.org/MTCD/Publications/PDF/te_764_web.pdf)	3.1.3, 4.1.4	The waste transfer system includes the areas and equipment required for transfer of the HLW in its waste disposal package from the preparation area to the underground emplacement area. It requires vehicles and ancillary equipment within the surface facilities as well as in the underground drifts. In addition, it may include hoisting devices in a shaft or a ramp between the surface level and the repository level.	DGR, Deep Borehole		D	B		DGR: Transfer tunnel to the DGR level (Ikonen et al. 2020, Section 7.1.1); Transfer systems (Ikonen et al. 2020, Section 7.1.2, Figures 7-5, 7-6); Transfer and installation of canisters and buffer (Ikonen et al. 2020, Section 7.2.2). Deep Borehole: Transfer casks (Fischer et al. 2020, Ch. 3, Section 4.1).	
ICRP Publication 26 (1977)	Recommendations of the ICRP (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2026)	12(b)	All exposures shall be kept as low as reasonably achievable (ALARA), economic and social factors being taken into account (optimisation of protection).	All	I	D	B	L	Exposure of operating personnel, limiting the radiation exposure of personnel (Ikonen et al. 2020, Section 2.2.1).	ICRP Publication 46 (1985), 41 ICRP Publication 37 (1982) ICRP Publication 77 (1997), 3, Section 6.1 ICRP Publication 81 (1998), Section 3.2, 4.4 ICRP Publication 103 (2007), 203, Section 5.8 SF-1 (IAEA 2006), 3.21, 3.39 SSR-5 (IAEA 2011), 2.9, 2.18, A.3 GSG-7 (IAEA 2018), 2.10, 3.10–3.27 GSG-8 (IAEA 2018), 2.14–2.29, 3.31–3.48 NEA/RWM/R(2013)9 (OECD/NEA 2014), p. 71 DGR, Deep Borehole, Intermediate Depth: ICRP Publication 122 (2013), 44, Section 4.8
ICRP Publication 26 (1977)	Recommendations of the ICRP (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2026)	14	Although the principal objective of radiation protection is the achievement and maintenance of appropriately safe conditions for activities involving human exposure, the level of safety required for the protection of all human individuals is thought likely to be adequate to protect other species, although not necessarily individual members of those species. The Commission therefore believes that if man is adequately protected then other living things are also likely to be sufficiently protected.	All	I	D	B	L	Radiation protection (Ikonen et al. 2020, Sections 6.2.5, 7.1.1, 7.2.5, 8.2.4, 9.2.5)	
ICRP Publication 26 (1977)	Recommendations of the ICRP (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2026)	221…227	Except for trivial amounts of activity, all releases of radioactive substances to the environment (including the disposal of solid wastes) should be subject to authorizations issued by the competent national authority. These authorizations should be based on preoperational studies which should, if necessary, include the assessment of the dose-equivalent commitment to different population groups. These studies should be carried out at an early stage of a project when it is still possible to introduce modifications.	All	I	D	B	L	The fulfilment of requirements concerning radiation safety during the operation of the disposal facility shall be ensured through continuous or regular measurements. The potential release routes and the environment of the facility shall in particular be subjected to monitoring. In order to monitor the potential release routes of radioactive substances, systems shall be designed for measuring and recording data on the quantities of radioactive substances released into the environment. It shall be possible to also monitor the emissions during an anticipated operational transient or a postulated accident (Ikonen et al. 2020, Section 2.2.1). Intermediate Depth, DGR: Monitoring of the environmental impacts of the project (Ikonen et al. 2020, Sections 6.2.8, 7.2.8, 8.2.7, 9.2.8).	
ICRP Publication 46 (1985)	Principles for the Disposal of Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2046)	17	Interim storage of wastes implies surveillance and maintenance of the storage facility. Storage, therefore, involves operational exposures to personnel involved in maintenance and surveillance; continuing risks of accidental releases; as well as financial provision to cover operating expenditure.	All (storage at National Facility site before disposal)	I	D	B	L	Radiation protection (Ikonen et al. 2020, Sections 6.2.5, 7.1.1, 7.2.5, 8.2.4, 9.2.5). The reliable operation of systems and components shall be ensured through maintenance and regular periodic inspections and tests (Ikonen et al. 2020, Section 2.2.1). Devices with an alarm function shall be employed for radiation monitoring so that during the operation of the disposal facility, significant unintentional exposure to radiation will not occur (Ikonen et al. 2020, Section 2.2.1). Surveillance and monitoring (Ikonen et al. 2020, Sections 5.2, 5-6, 5-7, 6.2.8, 7.2.8, 8.2.7, 9.2.8, Figures 5-4, 5-5). Storage (Ikonen et al. 2020, Section 5.7, Ch. 3, Figure 5-5). Intermediate Depth, DGR: Storage, waste reception building (Ikonen et al. 2020, Section 5.7, Ch. 3, Figures 5-4, 5-5); Storage of canisters, reloading hall (DGR) (Ikonen et al. 2020, Section 7.1.1, Figures 7-1, 7-2).	
ICRP Publication 46 (1985)	Principles for the Disposal of Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2046)	45, 46	The application of the individual dose limits to the dose distribution from normal releases from a waste repository is the same as for releases from other types of facilities.	All	I	D	B	L	General requirement, not directly related to facility design	

ICRP Publication 46 (1985)	Principles for the Disposal of Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2046)	47, 48, 49	The underlying basis for the dose limitation system is a judgment of the lower boundary of an implied range of risks to individuals deemed to be unacceptable; this judgment is based upon other types of risk that an individual can modify only to a small degree and that can be regulated by national authorities. Since significant doses might result from events that disrupt the normal behaviour of a disposal facility and which have an assumed probability of occurrence, in a given time, less than one, the objective of protecting individuals from all of the exposure events associated with radioactive waste disposal is best achieved by reverting to an individual risk limitation requirement. By dealing consistently in terms of risk, both the probability of an exposure and the magnitude of the exposure can be included. To take account of this, the Commission recommends that a risk limit and risk upper bound be established in direct analogy to the dose limits and upper bounds for normal releases. Such a risk limit should be consistent with the risk implied by the dose limits, such that the overall risk to an individual remains below the level considered unacceptable.	All	I	D	B	L	General requirement, not directly related to facility design	
ICRP Publication 46 (1985)	Principles for the Disposal of Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2046)	50	In dealing with the long-term aspects of radioactive waste disposal, a decision must be made on the level of protection to be afforded future individuals. The Commission recommends that risks to future individuals should be limited on the same basis as are those to individuals living now.	All	I	D	B	L	General requirement, not directly related to facility design	
ICRP Publication 46 (1985)	Principles for the Disposal of Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2046)	70	Optimization of protection is a requirement that should be seen to apply at all levels in developing systems and procedures for radioactive waste management. Once the options have been screened to eliminate those either impractical or unacceptable from the point of view of individual risks, there will be a need to assess further the merits of remaining alternatives, giving due consideration to the appropriate measures of radiation impact.	All	I	D	B	L	Benefits and disadvantages of a single disposal facility site (Ikonen et al. 2020, Section 4.1). Using different repository types for wastes with different radiological hazard (e.g. a deeper repository for high-level waste) is a way to optimise protection. The merits of the different repository types have been studied in previous projects (e.g. Posiva, Fortum).	ICRP Publication 37 (1982)
ICRP Publication 46 (1985)	Principles for the Disposal of Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2046)	71, 72	Optimization of protection can apply at four levels: (i) Comparison of design alternatives for a specific facility such as a waste repository. (ii) Comparison of different disposal options for particular waste streams. (iii) Comparison of different overall management systems for particular waste streams. (iv) Comparison of complete waste management systems, including conditioning, storage, transport and disposal alternatives for a given source or practice.	All	I	D	B	L	Benefits and disadvantages of a single disposal facility site (Ikonen et al. 2020, Section 4.1). Using different repository types for wastes with different radiological hazard (e.g. a deeper repository for high-level waste) is a way to optimise protection. The merits of the different repository types have been studied in previous projects (e.g. Posiva, Fortum).	
ICRP Publication 46 (1985)	Principles for the Disposal of Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2046)	73	Attention needs to be given to the interrelationships between conditioning, storage, transport and disposal in ensuring that the radiation impact is as low as reasonably achievable throughout a whole waste management system.	All	I	D	B	L	Design as a whole	IAEA-TECDOC-764 (1994)
ICRP Publication 77 (1997)	Radiological Protection Policy for the Disposal of Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2077)	6	The Commission's policies are based on limiting by all reasonable means the risk of stochastic effects, not of eliminating that risk entirely. It follows that its waste management policies should be based, at least in part, on the concept of the acceptability of a risk from defined practices and thus on the resulting dose (and probability of dose) to people.	All	I	D	B	L	General requirement, not directly related to facility design	
ICRP Publication 77 (1997)	Radiological Protection Policy for the Disposal of Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2077)	31, 33	No practice involving exposures to radiation should be adopted unless it produces at least sufficient benefit to the exposed individuals or to society to offset the radiation detriment it causes (called the justification of a practice).	All	I	D	B	L	General requirement, not directly related to facility design. The radioactive wastes have been generated elsewhere, and the benefits of those practices are out of the scope here.	FOR-2016-12-16-1659, Section 5 SF-1 (IAEA 2006), 3.18 GSG-8 (IAEA 2018), 2.9–2.13, 3.25–3.30 ICRP Publication 26 (1977), 12(a) ICRP Publication 81 (1998), 79 ICRP Publication 103 (2007), 203, Section 5.7 DGR, Deep Borehole, Intermediate Depth: ICRP Publication 122 (2013), 44
ICRP Publication 77 (1997)	Radiological Protection Policy for the Disposal of Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2077)	34	Waste management and disposal operations are an integral part of the practice generating the waste. It is wrong to regard them as a free standing practice that needs its own justification. The waste management and disposal operations should therefore be included in the assessment of the justification of the practice generating the waste. If the national waste disposal policy has changed and the practice is continuing, it may be necessary to reassess the justification of the practice. If the practice has ceased, intervention, rather than the practice, has to be considered for justification.	All	I	D	B	L	General requirement, not directly related to facility design	DGR, Deep Borehole, Intermediate Depth: ICRP Publication 122 (2013), 44
ICRP Publication 77 (1997)	Radiological Protection Policy for the Disposal of Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2077)	35	To the extent that the justification of a practice involves collective dose, the Commission's policy requires an estimate of the total collective dose attributable to the practice, including the waste management and disposal operations. The differential comparisons used in the selection of options in the optimisation of protection are not sufficient for justification.	All	I	D	B	L	General requirement, not directly related to facility design	
ICRP Publication 77 (1997)	Radiological Protection Policy for the Disposal of Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2077)	41	An important component of the optimisation of protection is the constraint on individual dose delivered by the source for which protection is being optimised.	All	I	D	B	L	General requirement, not directly related to facility design	

ICRP Publication 77 (1997)	Radiological Protection Policy for the Disposal of Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2077)	42	The magnitude of the constraint is specific to the source and situation for which protection is being optimised. In waste management, the source should usually be the whole site giving rise to the waste or, in the case of a repository, the whole repository that may give rise to public exposure. In practice, it may be possible to start by analysing each route of disposal or exposure separately, but it must be remembered that the waste treatment and conditioning will transfer activity from one disposal route to another. This transfer calls for a final check of the optimisation of protection for the whole site.	All	I	D	B	L	General requirement, not directly related to facility design	
ICRP Publication 77 (1997)	Radiological Protection Policy for the Disposal of Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2077)	45	The models used to assess doses are usually selected to cover a wide range of variation of environmental conditions. However, extreme conditions, e.g. those occurring with a frequency of less than about one in 100 years, and the occurrence of accidents and disruptive events will be outside the scope of the models used to assess normal conditions. If they occur, these events may cause exposures that are larger than normal. These exposures should be treated as potential exposures. Their magnitude and probability should be taken into account in reaching waste management decisions.	All	I	D	B	L	Exposure of operating personnel, limiting the radiation exposure of personnel (Ikonen et al. 2020, Section 2.2.1). Radiation protection (Ikonen et al. 2020, Sections 6.2.5, 7.1.1, 7.2.5, 8.2.4). Incidents and accidents: Intermediate Depth (Ikonen et al. 2020, Section 6.2.6); DGR (Ikonen et al. 2020, Section 7.2.6); Deep Borehole (Ikonen et al. 2020, Section 8.2.5); Landfill (Ikonen et al. 2020, Section 9.2.6). Emergency-related systems: Intermediate Depth (Ikonen et al. 2020, Sections 6.1.2, 6.2.6); DGR (Ikonen et al. 2020, Sections 7.1.2, 7.2.6). Impacts caused by probable natural phenomena and other events external to the facility (Ikonen et al. 2020, Section 2.2.1).	
ICRP Publication 77 (1997)	Radiological Protection Policy for the Disposal of Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2077)	49	The assessment of doses resulting from the disposal of waste involves the use of environmental and metabolic models. These models should aim to be representative of reality, thus avoiding serious misapplication of resources.	All	I	D	B	L	General requirement, not directly related to facility design	
ICRP Publication 81 (1998)	Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2081)	13	Solid wastes containing only short-lived radionuclides may, after a sufficient period of storage, be released into the environment.	Landfill				L	All the waste deposited in the landfill repository is cleared waste	
ICRP Publication 81 (1998)	Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2081)	13	With heat-generating waste, disposal may be more easily facilitated after some decades of storage because the heat is mainly caused by short-lived radionuclides.	DGR, Deep Borehole, Intermediate Depth	I	D	B		DGR: Thermal dimensioning (Ikonen et al. 2020, Sections 2.2.6, 7.1.1). Deep Borehole: Heat generation (Ikonen et al. 2020, Section 8.1.4). Intermediate Depth: ILW package design.	
ICRP Publication 81 (1998)	Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2081)	16	Ordinary refuse disposal may be suitable for waste with very low radionuclide contents.	Landfill				L	To be decided	
ICRP Publication 81 (1998)	Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2081)	16	Shallow land burial in trenches, engineered facilities, or via in situ stabilisation may be suitable for large volumes of solid wastes such as the residues from the mining and milling of uranium bearing ores and short-lived low and intermediate level waste from the nuclear fuel cycle. The geologic and engineered barriers can immobilise and retain the radionuclides for a considerable time. The proximity of the waste to the surface may, however, require institutional control, maintenance, and surveillance for extended periods of time to reduce the possibility of inadvertent human intrusion or loss of containment due to natural processes.	Landfill				L	Landfill design described in Ikonen et al. (2020), Ch. 9. Site selection (Ikonen et al. 2020, Ch. 4).	NEA No. 5990 (OECD/NEA 2006), Section 5.2.1
ICRP Publication 81 (1998)	Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2081)	16	Disposal in deep geologic formations has the potential to provide a very long period of isolation from the accessible environment and a greatly reduced possibility of inadvertent human intrusion if proper characteristics are selected for both the natural and the engineered barriers within the disposal system.	DGR, Deep Borehole, Intermediate Depth	I	D	B		Isolation: Intermediate depth (Ikonen et al. 2020, Table 2-1), DGR (Ikonen et al. 2020, Section 2.1.2); Deep Borehole (Ikonen et al. 2020, Section 2.1.3). Human intrusion (Ikonen et al. 2020, Sections 2.1.2 (DGR), 2.2.1, 2.2.7).	
ICRP Publication 81 (1998)	Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2081)	19	The radiological assessment of a disposal system for solid radioactive waste needs to consider the various possibilities for human exposure. Processes that could lead to human exposures have to be identified on a site-specific basis.	DGR, Deep Borehole, Intermediate Depth	I	D	B		General requirement, not directly related to facility design. Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7). Exposure of operating personnel, limiting the radiation exposure of personnel (Ikonen et al. 2020, Section 2.2.1).	
ICRP Publication 81 (1998)	Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2081)	20	Human actions in the future may also disrupt a waste disposal system. A human action affecting repository integrity and potentially having radiological consequences is known as human intrusion. The consequences for a deliberate intruder are primarily considered the intruder's responsibility. There is also the possibility of inadvertent human intrusion after knowledge of the disposal system has been lost, i.e. actions taken unknowingly by someone that disrupt the waste disposal system. These actions include inadvertent drilling into a deep repository and inadvertent construction on a shallow repository. Such inadvertent actions are the main issue for human intrusion in the long term.	DGR, Deep Borehole, Intermediate Depth	I	D	B		Human intrusion (Ikonen et al. 2020, Sections 2.1.2 (DGR), 2.2.1, 2.2.7)	SSG-23 (IAEA 2012), 6.52–6.65 DGR, Deep Borehole, Intermediate Depth: ICRP Publication 122 (2013), 25, 55, 63
ICRP Publication 81 (1998)	Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2081)	21	Site specific assessments are essential in order to evaluate the radiological consequences of waste disposal. They are also necessary to understand, describe, quantify, and optimise the role of the different barriers of the disposal system and its subsystems. Assessments consider a number of scenarios where a scenario is defined as one possible combination of specified processes affecting the disposal system that could lead to radiological consequences. Typically, an assessment consists of the following elements, which are usually dealt with in an iterative manner: system understanding, scenario analysis, development of conceptual and detailed system models, consequence analysis, uncertainty and sensitivity analysis, and interpretation of the calculated results. An integrated assessment will evaluate the expected system evolution as well as less likely system evolutions including those caused by disruptive events of natural origin or as a result of human intrusion.	DGR, Deep Borehole, Intermediate Depth	I	D	B		General requirement, not directly related to facility design. Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7). Site has not yet been selected.	

ICRP Publication 81 (1998)	Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2081)	39, 48, 50	The principal means of achieving protection of the public is through a process of constrained optimisation.	DGR, Deep Borehole, Intermediate Depth	I	D	B	Using different repository types for wastes with different radiological hazard (e.g. a deeper repository for high-level waste) is a way to optimise protection. The merits of the different repository types have been studied in previous projects (e.g. Posiva, Fortum).	NEA No. 6836 (OECD/NEA 2010), p. 10–11 (bullet 4, 6)
ICRP Publication 81 (1998)	Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2081)	40	The principal objective of disposal of solid radioactive waste is the protection of current and future generations from the radiological consequences of waste produced by the current generation. However, permanent total isolation is not likely to be achievable and some fraction of the waste inventory may migrate to the biosphere, potentially giving rise to exposures hundreds or thousands of years in the future. Doses to individuals and populations over such long time-scales can only be estimated and the reliability of these estimates will decrease as the time period into the future increases. Nevertheless, the Commission acknowledges a basic principle, that individuals and populations in the future should be afforded at least the same level of protection from actions taken today as is the current generation. Moreover, for many disposal systems, steps could also be taken during the disposal system development process to preserve choices for future generations (e.g. retrievability) but under no circumstances should these impair disposal system safety.	DGR, Deep Borehole, Intermediate Depth	I	D	B	The design as a whole. Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7). Retrievability: to be decided.	OECD/NEA 1995 NEA No. 6182 (OECD/NEA 2007), p. 19–22 DGR, Deep Borehole, Intermediate Depth: ICRP Publication 122 (2013), p. 5–6, para. 17, 22
ICRP Publication 81 (1998)	Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2081)	41, Section 4.4	The objective of protecting future generations to at least the same level as current generations implies the use as indicators of the current quantitative dose and risk constraints derived from considering the associated health detriment. Doses and risks, as measures of health detriment, cannot be forecast with any certainty for periods beyond around several hundreds of years into the future [ICRP Publication 77, 1997]. Instead, estimates of doses or risks for longer time periods can be made and compared with appropriate criteria in a test to give an indication of whether the repository is acceptable given current understanding of the disposal system. Such estimates must not be regarded as predictions of future health detriment.	DGR, Deep Borehole, Intermediate Depth	I	D	B	General requirement, not directly related to facility design. Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7).	
ICRP Publication 81 (1998)	Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2081)	42	It cannot be assumed that future generations will have knowledge of disposals undertaken by the current generation. Therefore, the protection of future generations from the disposal of radioactive waste should be achieved primarily by passive measures at the repository development stage, and should not rely unduly on active measures taken in the future. However, the Commission recognises that institutional controls maintained over a disposal facility after closure may enhance confidence in the safety of the disposal facility particularly by reducing the likelihood of intrusion. The Commission feels that there is no reason why these controls may not continue for extended periods of time and, therefore, may make a significant contribution to the overall radiological safety of shallow disposal facilities in particular. Furthermore, for surface or near surface disposal of uranium mill tailings, these controls may be relied on for long periods of time in situations where, if the controls fail, consequences will be generally lower than those associated with other long-lived radioactive wastes.	DGR, Deep Borehole, Intermediate Depth	I	D	B	Human intrusion (Ikonen et al. 2020, Sections 2.1.2 (DGR), 2.2.1, 2.2.7). Long-term safety is provided through the repository design by passive means to fulfil the requirements and shall not rely on extended monitoring or maintenance of the site (Ikonen et al. 2020, Section 2.2.1). The disposal concept is designed so that there will be no need for monitoring or other maintenance after the closure of connections to the repositories. If desired, signs can be left on the site to indicate the presence of radioactive waste underground. Post-closure monitoring can be included, if required (Ikonen et al. 2020, Section 2.2.7).	
ICRP Publication 81 (1998)	Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2081)	51, Section 4.4.2, 4.4.3	There are two broad categories of exposure scenarios that have to be considered: natural processes and human intrusion. Optimisation should explore and apply reasonable measures to reduce the probability and/or magnitude of exposures due to natural processes by considering, e.g. seismic properties, retention capability, canister design, and due to inadvertent human intrusions by considering, e.g. presence of natural resources, institutional control measures, selection of repository depth.	DGR, Deep Borehole, Intermediate Depth	I	D	B	The design as a whole. Many investigations and research projects have shown that copper has a good corrosion resistance in deep (reducing) groundwater (Ikonen et al. 2020, Section 2.2.2). The chemical stability of bentonite shall be ensured for a very long period of time in order to guarantee the long-term safety of the HLW disposal solution (Ikonen et al. 2020, Section 2.2.6). Human intrusion (Ikonen et al. 2020, Sections 2.1.2 (DGR), 2.2.1, 2.2.7). If desired, signs can be left on the site to indicate the presence of radioactive waste underground (Ikonen et al. 2020, Section 2.2.7).	
ICRP Publication 81 (1998)	Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2081)	65	The Commission recommends that technical and managerial principles for potential exposure situations [ICRP Publication 64, 1993] should be applied during the disposal system development process to enhance confidence that radiation safety will be maintained throughout the post-closure period. These principles should be applied to disposal systems in a manner consistent with the inherent hazard level of the waste as well as with the level of residual uncertainty identified in the assessment.	DGR, Deep Borehole, Intermediate Depth	I	D	B	The design as a whole	ICRP Publication 64 (1993)
ICRP Publication 81 (1998)	Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2081)	67(a)	Disposal system development activities should be based on sound engineering principles and practices which are proven by testing and experience to the extent feasible, considering the need for research and innovation to improve safety. Such improvements should be reflected, to the extent possible, in approved codes and standards or other appropriate documentation.	DGR, Deep Borehole, Intermediate Depth	I	D	B	In order to ensure the safe operation and long-term safety of the disposal facility, for the design, construction and operation of the facility as well as for the sealing of the facility, proven or otherwise carefully examined high quality technology shall be employed (Ikonen et al. 2020, Section 2.2.7).	
ICRP Publication 81 (1998)	Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2081)	67(b)	A comprehensive system of quality assurance should ensure that the repository system is constructed as planned and designed.	DGR, Deep Borehole, Intermediate Depth	I	D	B	An appropriate quality system is deployed in implementing the disposal and its associated research and development work and safety assessments, and it is extended to all organisations having a material impact on the long-term safety of the disposal project. Advanced quality assurance programmes shall be applied (Ikonen et al. 2020, Section 2.2.7).	

ICRP Publication 81 (1998)	Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2081)	67(c)	All personnel involved in the disposal system development phases, whose behaviour can affect radiation safety, should be trained and qualified to perform their duties. The possibility of human induced errors should be taken into account.	DGR, Deep Borehole, Intermediate Depth	I	D	B		Training is a general requirement, not directly related to facility design. The multibarrier system ensures that the radionuclide releases from the waste into the surface environment are effectively retarded and limited, even if a single or even several safety features do not fulfil their intended purpose (Ikonen et al. 2020, Section 2.1.1). This provides safety margin also against human errors.	
ICRP Publication 81 (1998)	Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2081)	67(d)	Radiological assessments should be conducted iteratively throughout the development of the disposal system until closure to identify potential vulnerabilities and sensitivities in the system. These assessments should be rigorously conducted in order to show whether the safety criteria could be met. Consideration should be given to inherent limitations in the assessment methodology, potential gaps in data, and alternative interpretations of existing data to ensure that numerical results adequately represent or bound system performance. Concepts like peer review, transparency of documentation, openness to public participation, and multiple lines of reasoning are also important contributors to enhanced confidence.	DGR, Deep Borehole, Intermediate Depth	I	D	B		General requirement, not directly related to facility design. Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7).	
ICRP Publication 81 (1998)	Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2081)	67(e)	A feedback mechanism should be established so that the results of the assessments could be taken into account to guide the development process. Close cooperation among all parties involved in repository development is essential for safety improvements.	DGR, Deep Borehole, Intermediate Depth	I	D	B		General requirement, not directly related to facility design	
ICRP Publication 81 (1998)	Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2081)	68	In addition to the technical principles, an essential managerial principle for all individuals and organisations involved in the repository development process is to establish and maintain a consistent and pervading approach to safety which governs all their actions. This principle has been referred to as a `safety culture'. It was first defined in the context of nuclear safety as `that assembly of characteristics and attitudes in organisations and individuals which establish that, as an overriding priority [...] safety issues receive the attention warranted by their significance' [cf. INSAG Series No. 12 (IAEA 1999)].	DGR, Deep Borehole, Intermediate Depth	I	D	B		In order to ensure the safe operation and long-term safety of the disposal facility, for the design, construction and operation of the facility as well as for the sealing of the facility, an advanced safety culture shall be maintained (Ikonen et al. 2020, Sections 2.2.1, 2.2.7).	INSAG Series No. 12 (IAEA 1999) SSG-15 (Rev. 1) (IAEA 2020), 2.6, 3.16 ICRP Publication 81 (1998)
ICRP Publication 81 (1998)	Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2081)	70	In a long-term radiological assessment, doses or risks are calculated under reasonable selected test conditions as if they were doses or risks as defined in the Commission's framework. In the Commission's view they should be considered as performance measures or `safety indicators' indicating the level of radiological safety provided by the disposal system. To provide additional insight it may be useful to make qualitative comparisons particularly for the distant future, e.g. of the remaining hazard potential of a disposal system with the risks imposed by other natural or human-induced sources. Such comparisons may help to put judgements on the radiological acceptability of a disposal system in proper perspective.	DGR, Deep Borehole, Intermediate Depth	I	D	B		General requirement, not directly related to facility design. Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7).	
ICRP Publication 81 (1998)	Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2081)	71	To evaluate the performance of waste disposal systems over long time scales, one approach is the consideration of quantitative estimates of dose or risk on the order of 1000 to 10,000 years. This approach focuses on that period when the calculation of doses most directly relates to health detriment and also recognises the possibility that over longer time frames the risks associated with cataclysmic geologic changes such as glaciation and tectonic movements may obscure risks associated with the waste disposal system. Another approach is the consideration of quantitative calculations further into the future making increasing use of stylised approaches and considering the time periods when judging the calculated results. Qualitative arguments could provide additional information to this judgmental process.	DGR, Deep Borehole, Intermediate Depth	I	D	B		General requirement, not directly related to facility design. Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7).	SSG-23 (IAEA 2012), 6.43–6.51 DGR, Deep Borehole, Intermediate Depth: ICRP Publication 122 (2013), 48
ICRP Publication 81 (1998)	Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2081)	74, 73, 75	In view of the complexity of the disposal system, efforts should be undertaken during the development of the system to understand the significance of uncertainties and to reduce or bound uncertainties through site characterisation and experimentation. In addition, over the past decade improvements have been made in the methods used to understand and evaluate the significance of these uncertainties. Despite best efforts to reduce uncertainties, residual uncertainties will exist at the time of decision-making. Expert judgement should be used to evaluate the significance of these residual uncertainties and the findings should be fully documented.	DGR, Deep Borehole, Intermediate Depth	I	D	B		The barrier system is based on disposal projects in other countries, which have accumulated considerable understanding of related uncertainties. Site-specific studies are needed to fulfil this requirement at the National Facility site. To be decided.	
ICRP Publication 81 (1998)	Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2081)	76, 77, 78	Demonstration that radiological protection criteria will be met in the future is not as simple as straightforward comparison of estimated doses/risks with the constraints. Proof that the disposal system satisfies criteria cannot be absolute because of the inherent uncertainties, especially in understanding the evolution of the geologic setting, biosphere, and engineered barriers over the long term. Adequate assessments should be scientifically sound, accommodate reasonable conceptual understandings of system behaviour, use stylised approaches and reasonably conservative assumptions as appropriate, and typically be peer reviewed by consulting experts. These assessments should also address the remaining uncertainties by means of suitable presentations of their results (e.g. as ranges of numbers or bounding estimates). Thus, a decision on the acceptability of a disposal system should be based on reasonable assurance rather than on an absolute demonstration of compliance.	DGR, Deep Borehole, Intermediate Depth	I	D	B		General requirement, not directly related to facility design. Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7).	
ICRP Publication 103 (2007)	2007 Recommendations of the International Commission on Radiological Protection (https://icrp.org/publication.asp?id=ICRP%20Publication%20103)	23	The primary aim of the Commission's Recommendations is to contribute to an appropriate level of protection for people and the environment against the detrimental effects of radiation exposure without unduly limiting the desirable human actions that may be associated with such exposure.	All	I	D	B	L	Human intrusion (Ikonen et al. 2020, Sections 2.1.2 (DGR), 2.2.1, 2.2.7)	

ICRP Publication 103 (2007)	2007 Recommendations of the International Commission on Radiological Protection (https://icrp.org/publication.asp?id=ICRP%20Publication%20103)	193, 194	The Commission now recommends the use of the 'Representative Person' for the purpose of radiological protection of the public instead of the earlier critical group concept. The Commission provides guidance on characterising the Representative Person and assessing doses to the Representative Person in ICRP Publication 101 [2006].	All	I	D	B	L	General requirement, not directly related to facility design	ICRP Publication 101a (2006) DGR, Deep Borehole, Intermediate Depth: ICRP Publication 122 (2013), Section 5.1
ICRP Publication 103 (2007)	2007 Recommendations of the International Commission on Radiological Protection (https://icrp.org/publication.asp?id=ICRP%20Publication%20103)	262	In planned exposure situations, a certain level of exposure is reasonably expected to occur. However, higher exposures may arise following deviations from planned operating procedures, accidents including the loss of control of radiation sources, and malevolent events. Such exposures are not planned to occur, although the situation is planned. These exposures are referred to by the Commission as potential exposures. Deviations from planned operating procedures and accidents can often be foreseen and their probability of occurrence estimated, but they cannot be predicted in detail. Loss of control of radiation sources and malevolent events are less predictable and call for a specific approach.	All	I	D	B	L	Incidents and accidents: Intermediate Depth (Ikonen et al. 2020, Section 6.2.6); DGR (Ikonen et al. 2020, Section 7.2.6); Deep Borehole (Ikonen et al. 2020, Section 8.2.5); Landfill (Ikonen et al. 2020, Section 9.2.6). Impacts caused by probable natural phenomena and other events external to the facility shall be considered in the design of the repository. The natural phenomena to be considered typically include lightning, earthquakes and floods. Other events external to the facility include electromagnetic interference, light airplane crashes, wildfires or explosions (Ikonen et al. 2020, Section 2.2.1).	ICRP Publication 81 (1998), Section 4.3 DGR, Deep Borehole, Intermediate Depth: ICRP Publication 122 (2013), 91
ICRP Publication 103 (2007)	2007 Recommendations of the International Commission on Radiological Protection (https://icrp.org/publication.asp?id=ICRP%20Publication%20103)	265	Potential exposure broadly covers ... events in which the potential exposures could occur far in the future, and the doses be delivered over long time periods, e.g., in the case of solid waste disposal in deep repositories: Considerable uncertainties surround exposures taking place in the far future. Thus dose estimates should not be regarded as measures of health detriment beyond times of around several hundreds of years into the future. Rather, they represent indicators of the protection afforded by the disposal system. The Commission has given specific guidance for the disposal of long-lived solid radioactive waste in ICRP Publication 81 [1998]. This guidance remains valid.	All	I	D	B	L	General requirement, not directly related to facility design	ICRP Publication 81 (1998)
ICRP Publication 103 (2007)	2007 Recommendations of the International Commission on Radiological Protection (https://icrp.org/publication.asp?id=ICRP%20Publication%20103)	305	The primary responsibility for achieving and maintaining a satisfactory control of radiation exposures rests on the management bodies of the institutions conducting the operations giving rise to the exposures. When equipment or plant is designed and supplied by other institutions, they, in turn, have a responsibility to see that the items supplied will be satisfactory, if used as intended. Governments have the responsibility to set up national authorities, which then have the responsibility for providing a regulatory, and often also an advisory, framework to emphasise the responsibilities of the management bodies while, at the same time, setting and enforcing overall standards of protection. They may also have to take direct responsibility when, as with exposures to many natural sources, there is no relevant management body.	All	I	D	B	L	General requirement, not directly related to facility design	
ICRP Publication 122 (2013)	Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%20122)	6, 64	At great distances from the surface, geological formations can be identified that exhibit very long stable geological conditions (i.e. many thousands to millions of years). A properly chosen geological formation assures stable chemical and physical conditions for the waste, and will reduce and delay any releases of radionuclides to the geosphere. In this context, 'distance' can imply horizontal or vertical distance as, for example, the case of a disposal facility sited deep within a mountain. Additionally, if a site is chosen in an area with no known natural resources, the likelihood for inadvertent human intrusion into the facility may be limited.	DGR, Deep Borehole, Intermediate Depth (site)	I	D	B		Human intrusion (Ikonen et al. 2020, Sections 2.1.2 (DGR), 2.2.1, 2.2.7). Site selection (Ikonen et al. 2020, Ch. 4).	
ICRP Publication 122 (2013)	Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%20122)	28	The pre-operational phase: During this phase, the disposal facility is designed, the site is selected and characterised, the manmade materials are tested and the engineering feasibility is demonstrated, safety assessments for operational and postoperational phases are developed, the licences for building and operation are applied for and received, and construction begins. A baseline monitoring programme of environmental conditions is also established.	DGR, Deep Borehole, Intermediate Depth	I	D	B		Safety case and licensing (Ikonen et al. 2020, Section 2.2.1). The reliable operation of systems and components shall be ensured through maintenance and regular periodic inspections and tests (Ikonen et al. 2020, Section 2.2.1). Monitoring related to site, baseline studies (Ikonen et al. 2020, Sections 6.2.8, 7.2.8, 8.2.7); Monitoring of the environmental impacts of the project (Ikonen et al. 2020, Sections 6.2.8, 7.2.8). DGR: Demonstration tunnels (Ikonen et al. 2020, Section 7.1.8, Figure 7-1). Deep Borehole: Tests of the emplacement technology, such as with dummy canisters, must be taken into account (Ikonen et al. 2020, Section 8.2.1).	
ICRP Publication 122 (2013)	Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%20122)	29, 30	The operational phase: During this phase, the waste is emplaced, followed by a period of observation prior to closure. For a period during this phase, some galleries may be filled and sealed having reached their final configuration, while others may still be open and being filled.	DGR, Deep Borehole, Intermediate Depth	I	D	B		Activities and schedule: Intermediate depth (Ikonen et al. 2020, Section 6.2.1); DRG (Ikonen et al. 2020, Section 7.2.1).	
ICRP Publication 122 (2013)	Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%20122)	31, 33, 38, 39	The postoperational phase: During this phase, the presence of man is no longer required to directly manage the facility. This is the longest phase, and is divided into two relevant time periods. - The period of indirect oversight. After closure, safety is assured totally through the intrinsic, built-in safety provisions of the design of the disposal facility. Nevertheless, it is expected that monitoring of the baseline environmental conditions will continue for a period of time as well as regulatory or societal oversight. Archives of technical data and configuration of waste packages and the disposal facility are kept, and the use of warning signs or markers to remind coming generations of its existence may be considered. The relevant international safeguards and controls continue to apply. Inadvertent human intrusion in the disposal facility can be ruled out. - The period of no oversight.	DGR, Deep Borehole, Intermediate Depth	I	D	B		Human intrusion (Ikonen et al. 2020, Sections 2.1.2 (DGR), 2.2.1, 2.2.7). The disposal concept is designed so that there will be no need for monitoring or other maintenance after the closure of connections to the repositories. If desired, signs can be left on the site to indicate the presence of radioactive waste underground. Post-closure monitoring can be included, if required (Ikonen et al. 2020, Section 2.2.7). Monitoring related to site, baseline studies (Ikonen et al. 2020, Sections 6.2.8, 7.2.8, 8.2.7). Safeguards (Ikonen et al. 2020, Sections 2.2.8, 7.2.7, 7.1.2, 7.2.3).	NEA/RWM/RF(2014)2 (OECD/NEA 2014)

ICRP Publication 122 (2013)	Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%20122)	32	During the operational phase (time of direct oversight), it will be possible to evaluate the protection capability of the disposal facility based on regular updates of the safety case. The safety case provided by the developer of a disposal facility must address the operational and the postoperational phases and, specifically, the distant future when controls and interventions cannot be relied upon.	DGR, Deep Borehole, Intermediate Depth	I	D	B	Long-term radiation safety is demonstrated through a safety case, i.e. the collection of arguments and evidence to demonstrate the safety of a disposal facility (Ikonen et al. 2020, Section 2.2.1). Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7).	
ICRP Publication 122 (2013)	Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%20122)	34	If oversight ceases to exist in the postclosure period, the repository is still a functioning facility and continues to be so. The potential to contain and isolate the radioactive waste is an inherent feature of the radioactive waste repository that continues into the distant future, and responds to the considered evolution of the disposal system under natural processes and events. The multibarrier, multifunction system that is at the basis of the disposal system design must have the potential to constrain releases of radionuclides from the radioactive waste repository. If indirect oversight ceased to exist, there is the possibility that inadvertent human intrusion into the facility might occur. The location of the disposal facility, deep underground, isolated from the environment that humans normally inhabit and in a geological environment with no exploitable resources, together with its technical design, provide protection against inadvertent human intrusion.	DGR, Deep Borehole, Intermediate Depth	I	D	B	Barrier system: Intermediate depth (Ikonen et al. 2020, Figure 2-1, Section 2.1.1); DGR (Ikonen et al. 2020, Figures 2-1, 2.5, Section 2.1.2); Deep Borehole (Ikonen et al. 2020, Section 2.1.3). Human intrusion (Ikonen et al. 2020, Sections 2.1.2 (DGR), 2.2.1, 2.2.7).	
ICRP Publication 122 (2013)	Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%20122)	40	Some national approaches plan emplacement and backfilling strategies that will result in direct oversight of the site lasting for several tens of years after the start of operations. It is not possible to know the criteria that may be used by the people making decisions in the future. The different decisions to be made relating to the evolution of oversight should be discussed with stakeholders.	DGR, Deep Borehole, Intermediate Depth	I	D	B	General requirement, not directly related to facility design	
ICRP Publication 122 (2013)	Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%20122)	43	The Commission views the potential exposures to humans and the environment associated with the expected evolution of the geological disposal of long lived solid radioactive as a planned exposure situation. The management of the source is deliberate and clearly planned and there is obligation to provide controls to ensure that during the operation and postoperational phases of a geological disposal facility adoptimized protection is ensured.	DGR, Deep Borehole, Intermediate Depth	I	D	B	Exposure of operating personnel, limiting the radiation exposure of personnel (Ikonen et al. 2020, Section 2.2.1). Monitoring of the environmental impacts of the project (Ikonen et al. 2020, Sections 6.2.8, 7.2.8), 8.2.7.	
ICRP Publication 122 (2013)	Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%20122)	46, 47	For potential exposures of the public, the Commission continues to recommend a risk constraint of $1 \cdot 10^{5}$ $year^{-1}$, or to apply the dose constraint in case of adoption of a disaggregated approach for dose and probability of scenarios. Due to the considerable uncertainties surrounding exposures that may arise in the future they are also considered as potential exposures.	DGR, Deep Borehole, Intermediate Depth	I	D	B	The design as a whole	
ICRP Publication 122 (2013)	Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%20122)	49	Waste emplacement activities are subject to the same principles of dose limitations and the requirement to optimise below constraints as those in any nuclear facility. Both occupational and public exposures are expected from the transportation, handling, and disposal activities, and thus are planned exposures including potential exposures from deviations from the normal operations. The possibility also exists for incidents due to low-probability/high-consequence-initiating events, some of which may lead to an emergency situation. Operations would be expected to be optimised consistent with the Commission's 2007 Recommendations [ICRP Publication 103, 2007].	DGR, Deep Borehole, Intermediate Depth	I	D	B	Exposure of operating personnel, limiting the radiation exposure of personnel (Ikonen et al. 2020, Section 2.2.1). Radiation protection (Ikonen et al. 2020, Sections 6.2.5, 7.1.1, 7.2.5, 8.2.4). Incidents and accidents: Intermediate Depth (Ikonen et al. 2020, Section 6.2.6); DGR (Ikonen et al. 2020, Section 7.2.6); Deep Borehole (Ikonen et al. 2020, Section 8.2.5). Emergency-related systems: Intermediate Depth (Ikonen et al. 2020, Sections 6.1.2, 6.2.6); DGR (Ikonen et al. 2020, Sections 7.1.2, 7.2.6). Impacts caused by probable natural phenomena and other events external to the facility shall be considered in the design of the repository. The natural phenomena to be considered typically include lightning, earthquakes and floods. Other events external to the facility include electromagnetic interference, light airplane crashes, wildfires or explosions (Ikonen et al. 2020, Section 2.2.1). Transport within the site: Intermediate Depth (Ikonen et al. 2020, Sections 6.1.1, 6.1.2, 6.2.2, Figure 6-4); DGR (Ikonen et al. 2020, Sections 7.1.1, 7.1.2, 7.2.2, Figures 7-5, 7-6). Installation: Intermediate Depth (Ikonen et al. 2020, Section 6.2.2); DGR (Ikonen et al. 2020, Section 7.2.2, Figures 7-6, 7-7). Landfill (Ikonen et al. 2020, Section 9.2.2).	ICRP Publication 103 (2007)
ICRP Publication 122 (2013)	Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%20122)	53, 54	The process of evaluating the potential exposure from emplaced waste includes understanding the potential mechanisms of radionuclide release from the engineered facility, including modelling transport through the geosphere to the biosphere, and the resultant release into an appropriate environmental compartment that could give rise to exposures to humans and the environment. Depending on the level of knowledge, probabilities may be estimated for these release scenarios. However, at the long time scales considered in geological disposal, evolution of the biosphere and, possibly, the geosphere and the engineered system will increase the uncertainty of these probabilities. Hence, the results of any dose or risk assessments need to be interpreted in a qualitative way at long time scales.	DGR, Deep Borehole, Intermediate Depth	I	D	B	The fulfilment of requirements concerning radiation safety during the operation of the disposal facility shall be ensured through continuous or regular measurements. The potential release routes and the environment of the facility shall in particular be subjected to monitoring. In order to monitor the potential release routes of radioactive substances, systems shall be designed for measuring and recording data on the quantities of radioactive substances released into the environment. It shall be possible to also monitor the emissions during an anticipated operational transient or a postulated accident (Ikonen et al. 2020, Section 2.2.1).	

ICRP Publication 122 (2013)	Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%20122)	58, 56, 57	The Commission recommends that the two different types of natural events should be considered separately. For natural events that are included in the design-basis evolution, the Commission recommends application of the risk constraint or the dose constraint for planned exposure situations. For severe natural disruptive events not taken into account in the design-basis evolution, application of the risk constraint or the dose constraint for planned exposure situations does not apply. If the events were to occur when there is still (direct or indirect) oversight of the disposal facility, the ensuing situation would be considered by the competent authority and the relevant protection measures would be implemented.	DGR, Deep Borehole, Intermediate Depth	I	D	B	Impacts caused by probable natural phenomena and other events external to the facility shall be considered in the design of the repository. The natural phenomena to be considered typically include lightning, earthquakes and floods. Other events external to the facility include electromagnetic interference, light airplane crashes, wildfires or explosions (Ikonen et al. 2020, Section 2.2.1).	
ICRP Publication 122 (2013)	Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%20122)	62	Waste is disposed of in a geological disposal facility for the purposes of containment and isolation (one aspect of which is avoidance of human intrusion). It is necessary to distinguish between deliberate and inadvertent human intrusion into the facility. The former is not discussed further in this report as it is considered outwith the scope of the responsibility of the current generation to protect a deliberate intruder (i.e. a person who is aware of the nature of the facility). The design and siting of the facility have to include features to reduce the possibility of inadvertent human intrusion.	DGR, Deep Borehole, Intermediate Depth	I	D	B	Human intrusion (Ikonen et al. 2020, Sections 2.1.2 (DGR), 2.2.1, 2.2.7). Site selection (Ikonen et al. 2020, Ch. 4).	
ICRP Publication 122 (2013)	Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%20122)	66, 65	In the case of geological disposal, intrusion means that many of the barriers that were considered in the optimisation of protection for the disposal system have been by-passed. As a future society may be unaware of exposures resulting from such events, any protective actions required should be considered during the development of the disposal facility through siting and design of a geological repository. Furthermore, evaluation of the robustness of the disposal system against human intrusion can increase confidence in its safety case.	DGR, Deep Borehole, Intermediate Depth	I	D	B	Human intrusion (Ikonen et al. 2020, Sections 2.1.2 (DGR), 2.2.1, 2.2.7). Site selection (Ikonen et al. 2020, Ch. 4).	
ICRP Publication 122 (2013)	Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%20122)	68	The design basis considers a range of incidents, accidents, and natural events, and attempts to ensure that these events are prevented if possible and/or consequences are mitigated.	DGR, Deep Borehole, Intermediate Depth	I	D	B	Incidents and accidents: Intermediate Depth (Ikonen et al. 2020, Section 6.2.6); DGR (Ikonen et al. 2020, Section 7.2.6); Deep Borehole (Ikonen et al. 2020, Section 8.2.5). Impacts caused by probable natural phenomena and other events external to the facility shall be considered in the design of the repository. The natural phenomena to be considered typically include lightning, earthquakes and floods. Other events external to the facility include electromagnetic interference, light airplane crashes, wildfires or explosions (Ikonen et al. 2020, Section 2.2.1).	
ICRP Publication 122 (2013)	Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%20122)	72, 82	The stepwise decision process for geological disposal system development and implementation constitutes the framework for the optimisation process. As a central component, optimisation and the application of Best Available Techniques have to cover all elements of the disposal system in an integrative approach [i.e. site (including host rock formation), facility design, waste package design, waste characteristics] as well as all relevant time periods.	DGR, Deep Borehole, Intermediate Depth	I	D	B	Overall schedule with key steps (Ikonen et al. 2020, Section 2.2.4, 2.2.7, Ch. 3, Figure 2-13). In order to ensure the safe operation and long-term safety of the disposal facility, for the design, construction and operation of the facility as well as for the sealing of the facility, proven or otherwise carefully examined high quality technology shall be employed (Ikonen et al. 2020, Section 2.2.7). Facility construction in phases: Intermediate Depth (Ikonen et al. 2020, Sections 6.1.6, 6.2); DGR (Ikonen et al. 2020, Sections 7.1.6, 7.2); Deep Borehole (Ikonen et al. 2020, Section 8.1.9); Landfill (Ikonen et al. 2020, Sections 9.1.6).	NEA No. 6433 (OECD/NEA 2008), p. 10 NEA No. 6836 (OECD/NEA 2010), p. 27 Deep Borehole: SSG-1 (IAEA 2009), 5.1
ICRP Publication 122 (2013)	Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%20122)	74	Socio-economic factors (including policy decisions and societal acceptance issues) can bound the optimisation process to various extents, such as by limiting the available options (e.g. siting) and/or by defining additional conditions (e.g. retrievability). It is important that these considerations are identified in a manner transparent to all involved stakeholders, and that their safety implications are generally and broadly understood [NEA R&R (OECD/NEA 2011)].	DGR, Deep Borehole, Intermediate Depth	I	D	B	Site selection (Ikonen et al. 2020, Ch. 4)	NEA R&R (OECD/NEA 2011)
ICRP Publication 122 (2013)	Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%20122)	79	Geological disposal facilities are sited, designed, and implemented to provide for robust long-term isolation and containment, resulting in potential impacts on humans and the environment only in the very distant future. Consequently, the assessment of postclosure radiological impacts through the estimation of effective dose or risk to a reference person, given the increasing uncertainties with time and the cautious assumptions to be made, can only provide an indication or illustration of the robustness of the system, rather than predictions of future radiological consequences. Thus, when considering the distant future, dose and risk values lose their intrinsic meaning and only retain a value as relative comparators of potential radiological impact.	DGR, Deep Borehole, Intermediate Depth	I	D	B	Site selection (Ikonen et al. 2020, Ch. 4). Safety case (Ikonen et al. 2020, Section 2.2.1, Figure 2-7).	
ICRP Publication 122 (2013)	Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%20122)	80	The elements guiding or directing the optimisation process should be those that directly or indirectly determine the quality of the components of the facility as built, operated, and closed, where quality refers to the capacity of the components to fulfil the safety functions of containment and isolation in a robust manner. The assessment and judgement of the quality of system components essentially includes the site characteristics, elements of Best Available Technique, as well as the concepts of good practice, sound engineering, and managerial principles. These elements complement and support radiological optimisation when potential impacts in the distant future have to be dealt with.	DGR, Deep Borehole, Intermediate Depth	I	D	B	Quality system, quality assurance programmes (Ikonen et al. 2020, Section 2.2.7). Use of best available, proven technology (Ikonen et al. 2020, Section 2.2.7).	

ICRP Publication 122 (2013)	Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%20122)	81	Judgement of the quality of the system design developed or implemented has to be made, and reviewed critically when needed, in a well-structured and transparent process, with the involvement of all relevant stakeholders. At the heart of this process is the interaction, transparent for all other stakeholders, between the developer and the safety authorities.	DGR, Deep Borehole, Intermediate Depth	I	D	B		An appropriate quality system is deployed in implementing the disposal and its associated research and development work and safety assessments, and it is extended to all organisations having a material impact on the long-term safety of the disposal project. Advanced quality assurance programmes shall be applied (Ikonen et al. 2020, Section 2.2.7). Provisions are made for stakeholder visitors to the security controlled area. The largest individual group of stakeholder visitors is two vans equal to 2 x 9 persons including the guides. The visitor centre is for all visitors and can receive much larger groups (Ikonen et al. 2020, Section 5.2). Interaction between the developer and the safety authorities is otherwise not a design issue.	
ICRP Publication 122 (2013)	Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%20122)	84	The way in which the various elements of a disposal system can be optimised in an integrative manner during system development varies to a large extent. First of all, stepwise optimisation decisions mainly have to be taken in chronological order (e.g. the decisions on the choice of a host rock and on one or a limited number of sites are often prior to decisions on a detailed design). For the selection of a site, a balance has to be struck between technical criteria related to the safety of a disposal system (long-term stability, barrier for radionuclide migration, absence or presence of natural resources in the vicinity), and local or supralocal economic and societal factors. Favourable sites can, in a first step, be identified on the basis of broadly defined 'required qualities', taking due account of the containment and isolation function(s) of the natural barriers and the natural environment in the disposal system.	DGR, Deep Borehole, Intermediate Depth (site)	I	D	B		Overall schedule with key steps (Ikonen et al. 2020, Section 2.2.4, 2.2.7, Ch. 3, Figure 2-13). Facility construction in phases: Intermediate Depth (Ikonen et al. 2020, Sections 6.1.6, 6.2); DGR (Ikonen et al. 2020, Sections 7.1.6, 7.2); Deep Borehole (Ikonen et al. 2020, Section 8.1.9); Landfill (Ikonen et al. 2020, Sections 9.1.6).	
ICRP Publication 122 (2013)	Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%20122)	85	If several suitable sites can be identified and evaluated, the decision in favour of one specific host rock or site will always be a multifactor decision, based on both qualitative and quantitative judgements. Radiological criteria (e.g. calculated effective dose or risk) are often of limited value for this multifactor decision due to: (1) the increasing uncertainties for longer assessment time scales, and (2) the observation that calculated radiological design-basis impacts are often so low that they do not constitute a discriminating factor for the choice of a site.	DGR, Deep Borehole, Intermediate Depth (site)	I	D	B		Site selection (Ikonen et al. 2020, Ch. 4)	
ICRP Publication 122 (2013)	Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%20122)	87	The general implementation of the Commission's recommendations on the disposal of radioactive waste requires that organisational and managerial structures and processes are put into place, and that technical principles are applied. Organisational structures and processes can differ between countries, but should be based on the principles laid down by the International Atomic Energy Agency in its fundamental safety principles and safety standards on management systems [SF-1 (IAEA 2006), GS-G-3.4 (IAEA 2008)].	DGR, Deep Borehole, Intermediate Depth	I	D	B		General requirement, not directly related to facility design	SF-1 (IAEA 2006) GS-G-3.4 (IAEA 2008)
ICRP Publication 122 (2013)	Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%20122)	88, 89	The Commission recommends that management principles and requirements should be applied to the disposal system development and implementation process to enhance confidence that the protection of humans and the environment will be ensured for as long as needed. This requires the implementation of a management system that integrates safety, health, environmental, security, quality, and economic elements, with safety being the fundamental principle upon which the management system is based [NEA No. 6182 (OECD/NEA 2007), NEA/RWM/RF(2009)1 (OECD/NEA 2010)].	DGR, Deep Borehole, Intermediate Depth	I	D	B		Quality system (Ikonen et al. 2020, Section 2.2.7). Requirements management system (Ikonen et al. 2020, Section 2.2.9). Development of a comprehensive management system was out of the scope of the Ikonen et al. (2020) and Fischer et al. (2020) reports.	NEA No. 6182 (OECD/NEA 2007) NEA/RWM/RF(2009)1 (OECD/NEA 2010)
ICRP Publication 122 (2013)	Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste (https://www.icrp.org/publication.asp?id=ICRP%20Publication%20122)	96, 97, 98, 99, 100	Illustration that the environment is or will be protected against the harmful effects of releases from facilities is an increasing requirement in national legislation, and in relation to many human activities including the management of long-lived waste. ICRP has responded to this need, as well as to a number of other requirements of an ethical nature [ICRP Publication 91, 2003], by addressing environmental protection directly and specifically in ICRP Publication 103 [2007], and by offering a methodology to address this issue, as outlined in ICRP Publication 108 [2008] and supplemented in ICRP Publication 114 [2009].	DGR, Deep Borehole, Intermediate Depth	I	D	B		Measuring and recording data on the quantities of radioactive substances released into the environment (Ikonen et al. 2020, Section 2.2.1). Environmental impact factors (Ikonen et al. 2020, Section 2.2.11). Monitoring of the environmental impacts of the project (Ikonen et al. 2020, Sections 6.2.8, 7.2.8, 8.2.7).	ICRP Publication 91 (2003) ICRP Publication 103 (2007) ICRP Publication 108 (2008) ICRP Publication 114 (2009)
NEA No. 5990 (OECD/NEA 2006)	Advanced Nuclear Fuel Cycles and Radioactive Waste Management (https://www.oecd-nea.org/jcms/pl_14008)	Section 5.2.2	Long-lived LILW has to be disposed of in a deep geological repository.	Intermediate Depth	I				LLW disposal (Sections 6.1.1, 2.1.1, Figures 6-1, 6-2), ILW disposal (Sections 6.1.1, 2.1.1, Figures 6-1, 6-2)	
NEA No. 6182 (OECD/NEA 2007)	Regulating the Long-term Safety of Geological Disposal: Towards a Common Understanding of the Main Objectives and Bases of Safety Criteria (https://www.oecd-nea.org/jcms/pl_14206/regulating-the-long-term-safety-of-geological-disposal)	p. 22	At a fundamental level, the design of a repository involves not only limitation of risks but also their redistribution, both spatially and temporally. This raises issues of fairness, among them the issue of balancing real (conventional as well as radiological) risks to workers involved in constructing, operating and maintaining a repository prior to closure versus the hypothetical risks to future generations or the preservation of their ability to make choices as represented in requirements for step-wise development and reversibility.	DGR, Deep Borehole, Intermediate Depth	I	D	B		Design as a whole	
NEA No. 6244 (OECD/NEA 2008)	Timing of High-level Waste Disposal (https://www.oecd-nea.org/jcms/pl_14254)	p. 71	The availability of skilled staff should be planned over the implementation period to avoid unnecessary interruptions in what has become a very lengthy process in many countries.	All	I	D	B	L	General requirement, not directly related to facility design	
NEA No. 6395 (OECD/NEA 2010)	Geoscientific Information in the Radioactive Waste Management Safety Case: Main Messages from the AMIGO Project (https://www.oecd-nea.org/jcms/pl_14414)	p. 13	Safety functions related to the geosphere may be defined or evaluated in terms of, for example: the geological and mechanical predictability of the host formation, the predictability of groundwater flow, the retention properties with regard to any released radionuclides, the predictability of the composition of the groundwater and the absence of resources in the host rock (and its immediate vicinity).	DGR, Deep Borehole, Intermediate Depth	I	D	B		Safety functions of the host rock: Intermediate depth (Ikonen et al. 2020, Table 2-1); DGR (Ikonen et al. 2020, Section 2.1.2)	

NEA No. 6395 (OECD/NEA 2010)	Geoscientific Information in the Radioactive Waste Management Safety Case: Main Messages from the AMIGO Project (https://www.oecd-nea.org/jcms/pl_14414)	p. 36	The process of adapting a repository design to increasing amounts of site-specific information can be guided by preferences, guidelines or criteria that indicate, for example, the conditions that must be met for a particular volume of rock to be suitable for emplacing a waste package.	DGR, Deep Borehole, Intermediate Depth	I	D	B		Layout flexibility and constraints (Ikonen et al. 2020, Section 2.2.6). Adaptation of design to match the bedrock conditions/rock suitability: Intermediate Depth (Ikonen et al. 2020, Sections 6.1.7, 6.2.8); DGR (Ikonen et al. 2020, Sections 7.1.1, 7.1.7); Deep Borehole (Ikonen et al. 2020, Sections 8.0, 8.1.8). A rock classification system needs to be created for defining the desired properties for host rock material and for developing the acceptance criteria regarding the suitability of any given host rock volume for disposal purposes, including the acceptance criteria for (DGR) deposition holes and tunnels (Ikonen et al. 2020, Sections 2.2.9, 7.1.7).	
NEA No. 6424 (OECD/NEA 2009)	Considering Timescales in the Post-closure Safety of Geological Disposal of Radioactive Waste (https://www.oecd-nea.org/jcms/pl_14446)	Section 3.2.1	The isolation of the waste from humans is regarded as an essential function of the geological environment, and must be provided at all times considered in a safety case. Thus, the factors that are taken into account in site selection generally include low rates of uplift and erosion in the siting region, low likelihood of significant disturbances to a repository by geological phenomena such as seismicity and volcanism, and absence of resources that might attract disturbance by humans.	DGR, Deep Borehole, Intermediate Depth (site)	I	D	B		Isolation: Intermediate depth (Ikonen et al. 2020, Table 2-1), DGR (Ikonen et al. 2020, Section 2.1.2); Deep Borehole (Ikonen et al. 2020, Section 2.1.3). Site selection (Ikonen et al. 2020, Ch. 4).	
NEA No. 6424 (OECD/NEA 2009)	Considering Timescales in the Post-closure Safety of Geological Disposal of Radioactive Waste (https://www.oecd-nea.org/jcms/pl_14446)	Section 3.2.3	In addition to its isolation role, the geological environment also provides a transport barrier that prevents or delays and attenuates the releases to the biosphere of any radionuclides from the repository. The geosphere can fulfil its role as a transport barrier in different ways. In many geological media, it is the slow movement of groundwater (in the case of some argillaceous media, leading to diffusion-dominated migration) and geochemical retardation or immobilisation, as well as physical retardation by matrix diffusion in the case of fractured media, that ensure long travel times and consequent radioactive decay for most radionuclides should they be released from a repository. These physical processes lead to a spreading of released radionuclides in time and space through diffusion, retention, hydrodynamic dispersion and dilution. They all serve to reduce the rates of release of any radionuclides to the surface environment, and consequently, the concentrations that might occur there.	DGR, Deep Borehole, Intermediate Depth (site)	I	D	B		Limitation and retardation of radionuclide transport in the bedrock: Intermediate depth (Ikonen et al. 2020, Table 2-1); DGR (Ikonen et al. 2020, Section 2.1.2). One benefit from the Deep Borehole concept is that the geological barrier will hardly be damaged (Ikonen et al. 2020, Section 8.0).	
NEA No. 6433 (OECD/NEA 2008)	Moving Forward with Geological Disposal of Radioactive Waste: A Collective Statement by the NEA Radioactive Waste Management Committee (RWMC) (https://www.oecd-nea.org/jcms/pl_14450/moving-forward-with-geological-disposal-of-radioactive-waste)	p. 7-8	The overwhelming scientific consensus worldwide is that geological disposal is technically feasible. This is supported by the extensive experimental data accumulated for different geological formations and engineered materials from surface investigations, underground research facilities and demonstration equipment and facilities; by the current state of the art in modelling techniques; by the experience in operating underground repositories for other classes of waste; and by the advances in best practice for performing safety assessments of potential disposal systems.	DGR, Deep Borehole, Intermediate Depth	I	D	B		Geological disposal is to be used for LILW and HLW (spent fuel).	
NEA No. 6836 (OECD/NEA 2010)	Optimisation of Geological Disposal of Radioactive Waste: National and International Guidance and Questions for Further Discussion (https://www.oecd-nea.org/jcms/pl_14506/optimisation-of-geological-disposal-of-radioactive-waste)	p. 17 (bullet 1)	Radiological protection has different meaning/interpretation in the pre-closure phase and in the post-closure phase of a repository. In the latter phase, the absence of the elements of feedback from operation, and control of protection, and the fact that exposure can only be estimated raise a fundamental issue of whether even the same term can be used to indicate protection before and after closure. Thus a clear distinction should be made between optimisation in the active plant and in the far future.	All	I	D	B	L	General requirement, not directly related to facility design	
ISBN 92-64-18498-8 / EUR 19964 EN (OECD/NEA 2003)	Engineered Barrier Systems and the Safety of Deep Geological Repositories: State-of-the-art Report (https://www.oecd-nea.org/jcms/pl_13634/engineered-barrier-systems-and-the-safety-of-deep-geological-repositories)	p. 3	Repositories for the disposal of radioactive waste generally rely on a multi-barrier system to isolate the waste from the biosphere. This multi-barrier system typically comprises the natural geological barrier provided by the repository host rock and its surroundings and an engineered barrier system (EBS). This multi-barrier principle creates an overall robustness of the system that enhances confidence that the waste will be successfully contained. Ensuring that an EBS will perform its desired functions requires integration of site-characterisation data, data on waste properties, data on engineering properties of potential barrier materials, in situ and laboratory testing, and modelling.	DGR, Deep Borehole, Intermediate Depth	I	D	B		Barrier system: Intermediate depth (Ikonen et al. 2020, Figure 2-1, Section 2.1.1); DGR (Ikonen et al. 2020, Figures 2-1, 2.5, Section 2.1.2); Deep Borehole (Ikonen et al. 2020, Section 2.1.3). Many investigations and research projects have shown that copper has a good corrosion resistance in deep (reducing) groundwater (Ikonen et al. 2020, Section 2.2.2).	NEA No. 6424 (OECD/NEA 2009), Section 3.1.1
ISBN 92-64-18498-8 / EUR 19964 EN (OECD/NEA 2003)	Engineered Barrier Systems and the Safety of Deep Geological Repositories: State-of-the-art Report (https://www.oecd-nea.org/jcms/pl_13634/engineered-barrier-systems-and-the-safety-of-deep-geological-repositories)	p. 4	The "engineered barrier system" represents the man-made, engineered materials placed within a repository, including the waste form, waste canisters, buffer materials, backfill and seals.	DGR, Deep Borehole, Intermediate Depth	I	D	B		Barrier system: Intermediate depth (Ikonen et al. 2020, Figure 2-1, Section 2.1.1); DGR (Ikonen et al. 2020, Figures 2-1, 2.5, Section 2.1.2); Deep Borehole (Ikonen et al. 2020, Section 2.1.3). DGR: Canister (Ikonen et al. 2020, Sections 2.1.2, 2.2.2, Figure 2-10), buffer (Ikonen et al. 2020, Sections 2.1.2, 2.2.6), backfill (Ikonen et al. 2020, Sections 2.1.2, 7.2.3), closure (Ikonen et al. 2020, Figure 6-8, Section 7.3).	NEA No. 5990 (OECD/NEA 2006), Section 5.3.4
ISBN 92-64-18498-8 / EUR 19964 EN (OECD/NEA 2003)	Engineered Barrier Systems and the Safety of Deep Geological Repositories: State-of-the-art Report (https://www.oecd-nea.org/jcms/pl_13634/engineered-barrier-systems-and-the-safety-of-deep-geological-repositories)	p. 9	The general purpose of an EBS is to prevent and/or delay the release of radionuclides from the waste to the repository host rock, at least during the first several hundred years after repository closure when the fission-product content is high, and where they might be mobilised by natural groundwater flow. In many disposal concepts, the EBS, operating under stable and favourable geosphere conditions, is designed to contain most of the radionuclides for much longer periods.	DGR, Deep Borehole, Intermediate Depth	I	D	B		Limitation and retardation of releases: Intermediate Depth (Ikonen et al. 2020, Table 2-1); DGR (Ikonen et al. 2020, Section 2.1.2). Containment: Intermediate depth (Ikonen et al. 2020, Table 2-1); DGR (Ikonen et al. 2020, Section 2.1.2); Deep Borehole (Ikonen et al. 2020, Sections 2.1.3, 8.2.1).	

ISBN 92-64-18498-8 / EUR 19964 EN (OECD/NEA 2003)	Engineered Barrier Systems and the Safety of Deep Geological Repositories: State-of-the-art Report (https://www.oecd-nea.org/jcms/pl_13634/engineered-barrier-systems-and-the-safety-of-deep-geological-repositories)	p. 9	To be effective, an EBS must be tailored to the specific environment in which it is to function. Consideration must be given to factors such as: the heat that will be produced by the waste, the pH and redox conditions that are expected, the expected groundwater flux, the local groundwater chemistry, possible interactions among different materials in the waste and EBS, the mechanical behaviour of the host rock after repository closure, and the evolution of conditions over time. Ensuring that an EBS will perform its desired functions requires an integration, often iterative, of site-characterisation data, data on waste properties, data on engineering properties of potential barrier materials, in situ and laboratory testing, and modelling.	DGR, Deep Borehole, Intermediate Depth	I	D	B	Barrier system: Intermediate depth (Ikonen et al. 2020, Figure 2-1, Section 2.1.1); DGR (Ikonen et al. 2020, Figures 2-1, 2.5, Section 2.1.2); Deep Borehole (Ikonen et al. 2020, Section 2.1.3). DGR: Thermal dimensioning (Ikonen et al. 2020, Sections 2.2.6, 7.1.1). Deep Borehole: Heat generation (Ikonen et al. 2020, Section 8.1.4). DGR: The EBS structures are designed to be compatible with other EBS structures and the host rock and support their performance (Ikonen et al. 2020, Section 2.1.2). For example, the canister is designed for reducing conditions typical for groundwater in deep crystalline bedrock of Fennoscandia. The conditions of the geological environment need to be considered in detail in the site selection.
ISBN 92-64-18498-8 / EUR 19964 EN (OECD/NEA 2003)	Engineered Barrier Systems and the Safety of Deep Geological Repositories: State-of-the-art Report (https://www.oecd-nea.org/jcms/pl_13634/engineered-barrier-systems-and-the-safety-of-deep-geological-repositories)	p. 58	The waste matrix is designed to provide a stable waste form that is resistant to leaching and gives slow rates of radionuclide release for the long-term.	DGR, Deep Borehole, Intermediate Depth	I	D	B	Limitation and retardation of releases by waste/waste packages: Intermediate Depth (Ikonen et al. 2020, Table 2-1); DGR (Ikonen et al. 2020, Section 2.1.2)
ISBN 92-64-18498-8 / EUR 19964 EN (OECD/NEA 2003)	Engineered Barrier Systems and the Safety of Deep Geological Repositories: State-of-the-art Report (https://www.oecd-nea.org/jcms/pl_13634/engineered-barrier-systems-and-the-safety-of-deep-geological-repositories)	p. 58	The container/overpack is designed to facilitate waste handling, emplacement and retrievability, and to provide containment for up to 1 000 years or longer depending on the waste type.	DGR, Deep Borehole, Intermediate Depth	I	D	B	Packaging (Ikonen et al. 2020, Section 2.2.2). Intermediate Depth: ILW packages (Ikonen et al. 2020, Figure 2-8), LILW packages (Ikonen et al. 2020, Figure 2-9). DGR: Canister (Ikonen et al. 2020, Sections 2.1.2, 2.2.2, Figure 2-10). Deep borehole: Waste packages/canisters (Ikonen et al. 2020, Section 8.2.3).
ISBN 92-64-18498-8 / EUR 19964 EN (OECD/NEA 2003)	Engineered Barrier Systems and the Safety of Deep Geological Repositories: State-of-the-art Report (https://www.oecd-nea.org/jcms/pl_13634/engineered-barrier-systems-and-the-safety-of-deep-geological-repositories)	p. 58	The buffer/backfill is designed to stabilise the repository excavations and the thermo-hydro-mechanical-chemical conditions, and to provide low permeabilities and/or diffusivities, and/or long-term retardation.	DGR, Deep Borehole, Intermediate Depth	I	D	B	Safety functions of the backfill: Intermediate depth (Ikonen et al. 2020, Table 2-1); DGR (Ikonen et al. 2020, Table 2-2). Safety functions of the buffer: DGR (Ikonen et al. 2020, Table 2-2). DGR: The EBS structures are designed to be compatible with other EBS structures and the host rock and support their performance. For example, backfilling and sealing of the repository cavities (including tunnels, shafts and boreholes) support the safety functions of the host rock by giving mechanical support to the rock and preventing the formation of transport pathways (flow paths) (Ikonen et al. 2020, Section 2.1.2).
ISBN 92-64-18498-8 / EUR 19964 EN (OECD/NEA 2003)	Engineered Barrier Systems and the Safety of Deep Geological Repositories: State-of-the-art Report (https://www.oecd-nea.org/jcms/pl_13634/engineered-barrier-systems-and-the-safety-of-deep-geological-repositories)	p. 58	The other EBS components (e.g. seals) are designed to prevent releases via tunnels and shafts and to prevent access to the repository.	DGR, Deep Borehole, Intermediate Depth	I	D	B	Barrier system: Intermediate depth (Ikonen et al. 2020, Figure 2-1, Section 2.1.1); DGR (Ikonen et al. 2020, Figures 2-1, 2.5, Section 2.1.2); Deep Borehole (Ikonen et al. 2020, Section 2.1.3)
ISBN 92-64-18425-2 (OECD/NEA 2000)	Geologic Disposal of Radioactive Waste in Perspective. General information (https://www.oecd-nea.org/jcms/pl_13396)	p. 20	A key feature of the geological barrier is low groundwater flow, since dissolution and transport in groundwater is generally the most important pathway by which wastes may be carried away from a deep underground repository and to the human environment.	DGR, Deep Borehole, Intermediate Depth (site)	I	D	B	Affects site selection (favours sites with low groundwater flow). Site selection (Ikonen et al. 2020, Ch. 4).
ISBN 92-64-18425-2 (OECD/NEA 2000)	Geologic Disposal of Radioactive Waste in Perspective. General information (https://www.oecd-nea.org/jcms/pl_13396)	p. 23	Robust engineered components should be simple and conservative in their design and must be chemically compatible with and functionally complementary to the natural systems. The massive copper canisters being developed in Sweden for spent fuel are a prime example of the robust engineering approach.	DGR, Deep Borehole, Intermediate Depth	I	D	B	DGR: Sealed gas- and water-tight copper-iron canisters (Ikonen et al. 2020, Sections 2.1.2, 2.2.2), similar to the ones used in Sweden, are planned to be used. Robustness (Ikonen et al. 2020, Section 2.1.2).