



Class IB Facilities **Guidance on Deep Geological Repository Site Characterization**

REGDOC-1.2.1

DRAFT

October 2018



Guidance on Deep Geological Repository Site Characterization

Regulatory document REGDOC-1.2.1

© Canadian Nuclear Safety Commission (CNSC) 2018

Cat. No. NNNNN

ISBN NNNNN

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Également publié en français sous le titre : Orientation sur la caractérisation des emplacements de dépôts géologiques en profondeur

Document availability

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Publishing history

[Month year]

Version x.0

Preface

This regulatory document is part of the CNSC's regulated facilities and activities series of regulatory documents. The full list of regulatory document series is included at the end of this document and can also be found on the [CNSC's website](#).

Regulatory document REGDOC-1.2.1, *Guidance on Deep Geological Repository Site Characterization*, sets out guidance for the site characterization stage of the siting process for a deep geological repository (DGR) facility for radioactive waste, as information gathered for site characterization may be used in subsequent licence applications.

This document supersedes R-72, *Geological Considerations in Siting a Repository for Underground Disposal of High-Level Radioactive Waste*, published in September 1987.

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1. Introduction

A deep geological repository (DGR) is an engineered facility where radioactive waste is emplaced in a deep, stable geological formation (usually several hundred metres or more below the surface) designed to isolate and contain radioactive waste to provide the long-term isolation of nuclear substances from the biosphere [1]. After closure there is no intention to retrieve or transfer the radioactive waste [2].

Site characterization involves detailed technical site investigations undertaken to increase the state of knowledge about a particular site. Site characterization involves desktop and both regional and site-specific investigations to identify and provide an understanding of particular features and processes. These processes are typically studied in different disciplines (hydrogeology, rock mechanics, geochemistry, etc.) but should be understood in an integrated manner.

The data gathered in the preliminary stages of the site characterization may be used to support the initial Canadian Nuclear Safety Commission (CNSC) licence application (i.e., licence to prepare site or a combined licence to prepare site and construct) and form part of the safety case.

Other regulators will have jurisdiction over activities carried out for site characterization before a site is selected and before an applicant engages in activities that would require a licence from the CNSC. It is recommended that site characterization activities be conducted in consultation with the relevant regulatory bodies early to ensure that regulatory expectations, permitting, licensing or other requirements are clearly understood, and that potential issues associated with data acceptance are identified and mitigated.

1.1 Purpose

This regulatory document sets out the CNSC's guidance for licence applicants on technical aspects that may be considered during the site characterization stage of the siting process for a DGR facility for radioactive waste.

1.2 Scope

REGDOC-1.2.1 provides guidance for a DGR's site characterization process. The guidance in this document focuses on technical matters.

The CNSC uses a comprehensive licensing system that covers the lifecycle of a DGR – from site preparation to construction, operation and decommissioning (closure and post-closure), and finally, release from the CNSC licence. This approach requires a licensing authorization at each phase, although the site preparation and site construction licence may be combined.

It is important to note that while in general, site characterization activities will begin before the CNSC's regulatory process, the methods and processes that are used and the data that are collected may form part of future licence applications and will be formally reviewed for quality and adequacy.

While this document does not provide guidance on finding or selecting a site, the site characterization stage will be carried out at a level sufficient to confirm the technical suitability of a site.

In this document, the pre-closure period of a DGR encompasses site preparation, construction, operation and decommissioning. The post-closure or long-term period is the period that follows the closure of a DGR facility, with a time frame of tens of thousands of years or more [3].

Note that this document does not:

- apply to surface and near-surface waste management facilities, including waste from uranium mines and mills
- provide guidance on long-term waste management strategies

1.3 Relevant legislation

The *Nuclear Safety and Control Act (NSCA)* applies once site preparation activities begin. Accordingly, it is important to be aware of legislation other than the NSCA, such as provincial laws, that might apply to site characterization activity. Facilities for the long-term management of radioactive waste, such as a DGR, are generally licensed under *Class I Nuclear Facilities Regulations*. There is no regulatory process identified in this regulation for selecting a site. The regulatory process is not triggered until an application for a licence to prepare site or combined licence to prepare/construct site is received, which in turn would trigger a federal impact assessment. Note also that the *Nuclear Fuel Waste Act* is authoritative for Canada's nuclear fuel waste DGR.

A licence applicant may refer to licence application requirements in the *Class I Nuclear Facilities Regulations* to inform site characterization activities. For example, for a licence to prepare a site, paragraph 4(a) requires the applicant to provide “a description of the site evaluation process and the investigations and preparatory work that have been done and will be done on the site and in the surrounding area” and to “... determine the environmental baseline characteristics of the site and the surrounding area”.

Accordingly, regulatory approvals are not required for site selection, and some site investigation activities will be performed prior to licensing. The “site evaluation process and the investigations and preparatory work that have been done” refer to pre-licensing site characterization activities that are needed to collect enough site-specific data to design and assess the facility and to prepare the required documentation for environmental assessment and/or licensing. The extent of these pre-licensing activities should be discussed with the regulator to avoid initiating activities that require a licence. The purpose for collecting the site-specific data will determine the requirements for data quantity and quality that the site characterization plan should meet.

1.4 Early regulatory involvement

Early consultation with the regulator for clarity with respect to regulatory expectations and requirements is recommended. Included in this process is the identification of site characterization activities that may not require a licence from the CNSC.

The extent of consultation between the applicant and the regulator should be balanced in order to preserve the independence of the regulator while providing adequate guidance to the applicant. It is recommended that a service agreement be established between the regulator and the applicant.

As part of the service agreement, it is recommended that the regulator have the opportunity to conduct informal inspections and assessments – for example, to ensure that a licence applicant’s management system is commensurate with the scope of the project, as laid out in CSA standard N286-12, *Management system requirements for nuclear facilities*. For instance, assessments at this stage could investigate whether management system programs, methods of data collection and contractor procurement are in line with CNSC requirements.

It is further recommended that the applicant keep the CNSC apprised of key milestones and activities in regard to site characterization activities. Applicants are encouraged to inform the regulator early of potential requests for pre-licensing reviews by the CNSC, such as the site characterization program.

The CNSC may choose to observe activities or request information. Prior to a formal application being submitted, CNSC staff may also request data, results and materials from the site characterization activities in order, for example, for the CNSC to conduct independent research.

2. Overview of Siting Process

The objective of the siting process, which includes site characterization, should be to select a site that, along with a proper design and engineered barriers, has properties that provide adequate containment and isolation of radionuclides and hazardous substances from the accessible environment for the desired period of time, usually the assessment timeframe [4].

The process for selecting a site and the decision to choose a particular site are the responsibility of the licence applicant.

The data gathered in the preliminary stages of the siting process may form part of the initial licence application and part of the safety case. Information gathered at this stage may be used as baseline information to support the demonstration of safety throughout the lifecycle of the DGR facility.

The International Atomic Energy Agency (IAEA) identifies four stages to the siting process for a DGR [4]:

1. a conceptual and planning stage: desktop data compilation and interpretation
2. a survey stage: regional mapping and screening
3. a site characterization stage
4. a site confirmation stage

Site characterization, the focus of this regulatory document, begins at the earliest stage of the investigation of a site and is expected to become more intensive as the siting process progresses through to confirmation of the site [4].

Note: the transition from one stage to another is somewhat arbitrary owing to the inevitable overlap in siting activities.

Following confirmation of the site and the initial phases of licensing, characterization activities are normally expected to continue into the site preparation, construction and operational phases. The characterization activities continue through these phases in order to contribute further to an adequate baseline for future monitoring, as well as to help confirm assumptions made in earlier safety cases and reduce any residual uncertainties in the safety case [4]. Those characterization

activities that continue until closure of the DGR are usually defined in a geoscience verification program. The safety case and associated safety assessment should identify uncertainties and assess the robustness of the facility so that the geoscience verification program can be developed and a research program designed and executed to address these uncertainties throughout the lifecycle of the DGR.

2.1 Conceptual and planning stage

The goal of the conceptual and planning stage is the development of an overall plan for the site selection process and includes the identification of desirable features as a basis for the second stage, as well as the conceptualization of a generic facility design based on the type, volume and radionuclide content of the radioactive waste to be managed (for guidance, see REGDOC-2.11.1, Waste Management, Volume II: *Assessing the Long Term Safety of Radioactive Waste Management* [5] and CSA N292.0-14, *General principles for the management of radioactive waste and irradiated fuel*). Site screening criteria should be developed for selecting or rejecting potential sites, and eventually, a preferred site.

2.2 Survey stage

The survey stage involves the screening of identified potential siting areas and regional geological mapping and other regional scale characterization activities (e.g., airborne geophysical surveys). Other constraints that should be accounted for include engineering concerns and environmental constraints. The goal of activities carried out at the surveying stage is to inform the screening process, which may narrow down potential sites.

2.3 Site characterization stage

The site characterization stage involves extensive field work and laboratory study, usually to gather site-specific data on a range of site conditions, including a site's geology, geochemistry and geomechanical suitability.

Early-stage site characterization activities involve scientific studies and desktop data compilation work, and include activities such as geophysical surveys and borehole drilling, though such activities would stop short of breaking the ground to excavate a shaft.

Preliminary safety assessments should be completed at this time to test the site's suitability to host a DGR facility, as well as to guide further characterization and confirmation activities. These safety assessments may also form part of a comparative analysis of the remaining site (if applicable), which would lead to the next stage of site confirmation, in which detailed, extensive work would be focused on one site.

2.4 Site confirmation stage

Site confirmation generally consists of detailed, extensive field and laboratory studies at the selected site. It is at this stage that evaluation of whether sinking a shaft or construction of an underground research facility (URF) may be necessary to obtain more information.

A final safety assessment should be prepared based on all of the data gathered during prior siting stages and in combination with geological and hydrogeological information, and information about other barriers such as the engineered barrier system, canister design and radioactive waste characteristics. This information may be used to develop the safety case that will be submitted in

the initial licence application (i.e., licence to prepare site or combined licence to prepare site and construct).

3. Site Characterization Program

As part of the siting process, the licence applicant should prepare and implement a program for site characterization for the proposed site for a DGR facility. The program should provide information sufficient to support a general understanding of the site in its current state and how it is expected to evolve over extended time frames associated with the safety case [6]. The site characterization program should establish baseline conditions for the site and environment in its present condition; support the understanding of the normal evolution; identify any events and processes associated with the site that might disturb the normal evolution of the DGR system; and support the understanding of the effect on safety of any features, events and processes associated with the DGR system [6].

Data collected during site characterization will form the basis of descriptive site models and geological, hydrogeological, geochemical and geomechanical frameworks that will be relied on to evaluate long-term safety. The data will provide baseline data for detecting potential short- and long-term environmental impacts at various stages and for tracking throughout the CNSC's licensing lifecycle for a DGR. Data needs include relevant regional- and site-scale information.

Baseline data include the biosphere and geosphere, and support an understanding of current conditions at the site, its geological history, and its likely future evolution over the safety case time frame. These data provide the initial information for safety assessments at the conceptual stage and during initial facility design. They will serve as the basis for the first iteration of the full safety case and any initial geoscience verification program at the site once it has been selected. As well as in the event that development (at any phase) is licensed to proceed.

The order of the criteria described herein does not imply priority of one element of characterization over another; relative relevance of specific criteria will in some cases be site specific. Specific criteria provided for the collection of baseline data may not be exhaustive and may constitute recommendations. Alternative approaches and innovative techniques that address additional elements of site characterization are also valid.

In this document, the pre-closure period of a DGR encompasses site preparation, construction, operation and decommissioning. The post-closure or long-term period is the period that follows the closure of a DGR facility, with a time frame of tens of thousands of years or more [3].

3.1 Site characteristics I: geological environment

The data gathered during the siting phase on the characteristics listed in this section form a significant component of the long-term safety assessments and safety case.

The characteristics of the geological environment are necessary to assess the long-term safety of a DGR. The key characterization factors of the geological environment should include:

- containment and isolation characteristics of the host rock: geological, hydrogeological, mineralogical, chemical and mechanical
- past and future geological stability of the site, including orogeny, seismicity, glaciation and volcanism

- sufficient extent of suitable host rock at the repository depth
- site characteristics that would allow the development of a robust safety case
- demonstrated isolation of groundwaters at selected repository depth from shallow groundwater systems
- characteristics favourable for sorption, precipitation or other mechanisms to limit contaminant release and transport away from a DGR
- low potential for inadvertent future human intrusion

Note that for future NSCA licensing applications, quantitative data should be provided in addition to qualitative descriptions where possible.

As siting progresses, more extensive geological information would be gathered to verify the initial safety case and to update the safety case iteratively. Although this guidance is focused on the site characterization activities during the siting process, it should be noted that data collection would continue until closure of the DGR, and possibly for some time after closure, in order to verify and update the safety case, and demonstrate long-term safety is maintained.

The key geological factors that are used to assess the long-term evolution of the repository are demonstrated through the documentation of the following characteristics.

3.1.1 Geological setting

The geological characteristics, in combination with the engineered barriers and the design of the DGR, should indicate that a DGR at the chosen site would remain safe for the entire time period of concern – for tens of thousands to millions of years.

This information should include:

- tectonic setting
- structural geology
- stratigraphy
- chosen host rock type, predictability, extent
- fracture characteristics: frequency, orientation, mineralogy, spacing
- history of glacial cycles
- petrology
- geomechanical properties
- natural resource potential

Natural resource potential should be assessed, preferably in a quantitative way, and should include historical and current data.

3.1.2 Hydrogeological setting

Similar to the geological setting, hydrogeological setting characteristics should demonstrate site suitability. Information should include the following data:

- definition of regional hydrogeological regime and/or units
- regional and site-specific groundwater flow conditions
- flow rate
- direction

- hydrogeology of major rock units
- porosity
- hydraulic conductivity
- hydraulic heads and gradients
- location of existing and predicted future significant water-use areas (e.g., groundwater wells)

3.1.3 Geochemistry

Together with the geological and hydrogeological, the geochemical conditions provide essential information for predicting how contaminants could migrate from a DGR to the biosphere. Special emphasis should be placed on geochemical properties that can affect the migration of radionuclides in groundwater.

Information should include:

- mineralogy, including petrographic study
- groundwater/porewater geochemistry
- effective diffusion rates of radionuclides
- solubility, speciation and retardation of radionuclides
- groundwater corrosivity toward engineered barriers
- potential for gas generation
- water-rock interaction

Any process that can be shown to demonstrate the potential for radionuclide migration or retardation from the DGR engineered facility through the geological environment should be documented.

3.1.4 Geological stability

The site should be located in a seismically stable region, with low potential for seismic or volcanic events. It should be demonstrated that any credible geological event that could occur during the assessment time frame would not impact the isolation and containment capability of a DGR.

The information that should be collected for the site and region include:

- evidence of recent or historic active tectonic processes (neotectonics) - e.g., information on quaternary faulting and movement, soil liquefaction and volcanism
- record of seismicity at the site, documentation of historical earthquakes, their epicentres, magnitude and intensity, and recurrence (link with regional tectonics, structural geology)
- resistance of the site to future glacial events, over the time frame of the safety case, linking to hydrogeological, geochemical and geomechanical rock properties and glacial history

3.1.5 Geomechanical characteristics

Geomechanical characteristics should be collected and used to assess the pre-closure and long-term stability of the underground excavations, and the evolution of the damage zone around those excavations.

Geomechanical characteristics should include:

- the magnitude and orientation of the *in situ* stress
- the stress-strain-strength properties of the intact rock, the fractures and rock mass
- the influence of time, temperature, scale, anisotropy, pore fluid pressure and other relevant factors on stress-strain-strength properties

3.2 Site characteristics II: surface environment

Baseline environmental data is needed to ensure that the environment will be adequately protected and any potentially adverse effects mitigated. For example, baseline data will support assessment of potential interactions with the environment and potential for associated effects. Surface processes at the site should be sufficiently characterized to ensure that natural hazard events such as flooding, landslides and erosion would not impact the ability of the radioactive waste management system to function safely during the pre-closure of a DGR facility.

3.2.1 Climate

The site area climate should be characterized in such a way that the effect of unexpected extreme meteorological conditions can be adequately identified and considered in the design of the DGR facility. Meteorological conditions should be determined from onsite and nearby meteorological stations where possible, and used to predict potential effects of extreme precipitation on the hydrological and hydrogeological systems at the site. This data should also be used as baseline data to evaluate the transport of potential airborne releases during the pre-closure period of the DGR facility. The minimum meteorological data (i.e., number of years of site-specific data) provided should be justified by the applicant and demonstrated to be commensurate with the type of project and the chosen site. Climate normal data (30 years of climate data) should also be included.

Specific information that should be collected includes:

- local and regional climatic history and expected future trends at both the regional and more global scale
- meteorological data, which should be collected at the site, local and regional scales to adequately capture future meteorological conditions that could occur over the time scales of the project
- regional and local precipitation characteristics (precipitation and snow)
- extreme and average data on temperature, precipitation, snow, wind speed and any other relevant phenomenon for the chosen site
- wind and atmospheric dispersion characteristics for potential atmospheric releases
- potential for extreme weather phenomena, such as hurricanes, tornadoes and severe winter storms
- ground frost and snow cover
- evapotranspiration: evaporation and transpiration from soils, water bodies and plants
- ice dynamics on lakes and streams
- air quality

3.2.2 Aquatic and terrestrial environment

Site characterization should contribute to the identification of the Valued Ecosystem Components that will be used as environmental assessment end points. Appropriate measurement end points should also be identified. Where possible, consideration should be given to documentation of specific attribute(s) and a rationale for their selection in the assessment. The ecosystem components should be characterized in sufficient detail to assess their importance, potential interaction with the project and the potential for environmental effects arising from the project activities. When undertaking characterization, consideration is to be given to both radiological and non-radiological aspects of a given medium (e.g., soil quality).

The elements of the aquatic ecology that should be characterized in the area of interest include:

- surface water quality
- sediment quality
- phytoplankton communities
- aquatic macrophytes
- zooplankton communities
- benthic macroinvertebrates
- fish
- fish habitat
- species designated as “at risk”

The elements of the terrestrial ecology that should be characterized in the area of interest include:

- soil quality
- vegetation
- wildlife
- terrestrial habitat
- species designated as “at risk”

The aspects and level of detail in the description of each of the above components should be in proportion to the potential for interactions.

3.2.3 Topography, hydrology and flooding

The drainage systems in the area should be assessed to determine the confining capacity of the site during the pre-closure period of the DGR facility. Stream, lake, pond and wetland networks in the vicinity of the planned facility should be characterized to evaluate potential for flooding, erosion, sediment transport and associated consequences.

Information that should be collected and evaluated includes:

- topography of the site and drainage features, including contributing drainage basin limits (extent, shape)
- magnitude and frequency of floods in the region
- location of surface water bodies
- gradient of the land surface
- density of the drainage network
- slope of the major stream channels

- identification and characterization of groundwater recharge areas and discharge areas (including receiving water bodies)
- drainage basins water balance
- regional and local water table characteristics, and seasonality

For sites along large lakes or seashores, consideration should be given to flooding potential as a result of tsunamis, seiches or tidal waves.

3.2.4 Geomorphology characterization

The existing geomorphology of a site will permit an understanding of the Quaternary geological history of an area relevant for siting a DGR. It will also contribute to the geotechnical characterization. Characterization includes:

- the distribution of land forms and thickness of surficial material (depth to bedrock)
- documentation of surface deposits and any existing or potential aggregate resources
- Quaternary geological history

This may be done via:

- topographical mapping
- aerial photograph interpretation
- soil sampling to assess soil deposition and transportation processes

3.2.5 Geotechnical characterization of surficial deposits

Geotechnical characterization of surficial deposits is important, as the integrity of the surface infrastructure could be affected by geotechnical properties of overburden materials during the pre-closure period of the DGR facility. Areas of concern include slope stability, excavation activities, physical stability and degradation of material stockpiles, stability of facility foundations, quality of human-made barriers constructed using overburden or other materials, waste settlement, settlement and damage of the facility covers, or any issue that could cause water infiltration and contaminant migration.

Geotechnical studies should include standard geotechnical sampling, field investigations and laboratory studies to assess:

- past occurrence of landslides and other potentially unstable slopes in the area
- soil properties (typically grain size, plasticity, dispersion, cohesive properties, etc.)
- shear strength parameters
- bearing capacity of foundation material
- liquefaction potential of loose granular material
- compaction properties
- hydraulic conductivity
- other site or facility design-specific properties

4. Human Activities and Land Use

The siting process will collect information that will eventually be included in the safety case for a DGR. Information on past, present and potential future human activities at or near the site should be collected, and the likelihood of whether these activities could have an impact should be assessed.

To limit adverse impacts on human activities and land use, the following information should be considered:

- economically valuable resources (e.g., groundwater wells, mineral resources)
- known and potential for competing land-use activities at the proposed site
- current and historical mineral exploration and mining activities – records of boreholes, shafts and other features that could represent potential instabilities or radionuclide migration pathways

5. Data Acquisition and Verification Activities

The licence applicant would demonstrate in their licence application that the results of site characterization activities are accurate, complete, reproducible, traceable and verifiable.

5.1 Management system

In accordance with the *General Nuclear Safety and Control Regulations*, section 3(1)(k), the applicant for a licence describes the organizational management structure, including the internal allocation of functions, responsibilities and authority. *Class I Nuclear Facilities Regulations*, section 3(d), specifies that the applicant proposes the management system, including measures to promote and support safety culture for the activity to be licensed. The adequacy of the quality assurance program (management system) for a licence is assessed by CNSC staff. By implementing a management system, the organization would demonstrate compliance, ensure consistency in meeting requirements, set priorities and continuously improve.

The licence applicant should develop and implement a management system for site characterization in accordance with the requirements specified in CSA N286-12, *Management system requirements for nuclear facilities* [7].

Topics covered under management system governance documentation are expected to include the generic and specific requirements for site characterization processes and practices.

5.2 Data management program

The integrity, accuracy and completeness of the information and data generated as a result of the site characterization activities are of utmost importance. The licence applicant should ensure the consistency and quality of the data used to develop the safety case submitted in support of any formal licence application.

The licence applicant should establish quality assurance and quality control programs to ensure high data quality and traceability. The programs should be focused on the production of documentary evidence to demonstrate that the required data quality has been achieved. Wherever

possible, data should be collected, presented, stored and archived in a suitably standardized controlled fashion. Data should be compiled in a format that facilitates examination, comparison, identification of information gaps and independent review. For each site characterization component, the documentation should clearly indicate the properties being investigated, the data collection and investigation methods used, the results, and the associated assumptions and uncertainties.

The process of data evaluation and establishing site-related parameters involves technical and engineering analyses and judgments, which requires extensive experience and knowledge. In many cases the parameters and analyses may not lend themselves to direct verifications through inspections and tests, or by other techniques that can be precisely identified and controlled. Therefore, these evaluations should be reviewed and verified by independent individuals or groups (e.g., peer review) that are separate from those who initially did the work. The reviews should be carried out at the different stages of the siting process in accordance with the work instructions and procedures.

5.3 Sampling and testing procedures

Site characterization is necessary to confirm, refine and adapt initial interpretations based on the initial data acquired at the earlier siting phase. The following activities (where applicable) may serve to obtain the data necessary to guide later development phases and updates to safety assessments and the safety case:

- geoscientific data compilation
- airborne geophysical surveys (e.g., magnetic, gravity)
- geological mapping
- geochemical rock property testing
- borehole drilling

Site characterization involves the collection of reliable information on the subsurface conditions that can only be collected by conducting various tests in and between boreholes drilled specifically for this purpose. Accordingly, the site characterization program should describe the following:

- number, locations and types (i.e., diamond drill vs. air percussion) of boreholes to be drilled on the site
- purpose of each borehole and its intended orientation, length and diameter
- types of drilling lubricants and drilling fluid tracers that will be used during drilling
- types of and schedule for borehole deviation monitoring to control orientation
- core recovery specifications, sampling intervals, and core logging and storage procedures, or chip sampling, logging and storage procedures
- number and types of physical tests to be done on core samples or chip samples
- schedule for drilling advance and for downtime for testing
- types of hydrogeologic testing (drill stem shut-in testing, pulse testing, tracer testing, etc.) to be performed during the drilling program
- groundwater samples that will be collected during drilling and the types of analyses of the groundwater that will be done
- borehole development and completion procedures (flushing, casing and grouting)
- borehole sealing procedures that will be followed should a borehole require abandonment

A borehole quality assurance and quality control program should be used to ensure that the objectives of the drilling program are achieved and controlled, including:

- maintenance of a drilling journal by a qualified drill-site geologist who records drilling and relevant drilling-related activities such as the cleaning of drill rods prior to commencement of drilling, surface casing installation and grouting procedures, drilling penetration rates, core recovery, presence of water-producing intervals and flow rates, amount of drilling fluid added and zones of water loss, measurements of tracer concentrations in drilling fluid and return water, additions of drilling lubricants, borehole development related to the removal of residual drill cuttings and drilling fluid, and core or chip sample information
- recording of “static” water-level information during shutdowns in drilling operations and the “field chemistry” of groundwater that is airlifted to the surface during the drilling of air percussion boreholes, and the procedures followed to collect and preserve such water samples
- conducting post-drilling borehole surveys to confirm that the borehole has been drilled to the prescribed depth, diameter and orientation
- Establishing an electronic record that documents all borehole drilling activities and measurements

5.4 Integration and interpretation

Site characterization involves the quantification and interpretation of a large number of physical and environmental components that interact with each other to a greater or lesser degree. This results in several more or less independent systems of related or interacting components. The components in each system are usually interpreted to develop a site model for that system. For example, the stratigraphy, lithology and spatial distribution of *in situ* stress can be interpreted to give a conceptual model of both current and evolutionary structural geology of the site, while the distribution of mineralogy in the rock matrix and in fracture infilling can be interpreted to give a separate model of the geological evolution of the site.

Each scientific and engineering discipline can contribute to one or more independent site models. This is particularly true for geochemistry, in which several independent chemical systems coexist. Since all of these chemical and physical systems coexist at the one site, the independent models derived from each system should be consistent. For example, there should not be inconsistencies between evolutionary models based on mineralization, and dating methods.

The different site models from different surveys and disciplines, then, should be integrated into a single consistent model of the site’s geological and hydrogeological history, current conditions and expected (unperturbed) evolution. The model of current conditions at a site provides the necessary information for design purposes. The history of the site should provide a model of how the site has responded to past perturbations. Extrapolating the history of the site through the current conditions should provide a model of how the site is expected to evolve if not used. Applying estimates of the perturbations imposed by the planned facility and the site response to past perturbations to the model of undisturbed site evolution should provide a model of the anticipated evolution of the site with the facility.

Such integration and interpretation of the site characteristics are documented in a geosynthesis report, which will constitute an important supporting document to the safety case.

6. Facilities for Verification and Characteristic Activities

An underground research facility (URF) is an underground facility typically constructed at depth to provide an environment to acquire knowledge and training, help characterize the geology, conduct experiments, test equipment and designs, and help demonstrate feasibility of a DGR.

Many geoscientific characteristics cannot be obtained from the above-ground activities. Therefore, verification and characterization activities (e.g., underground excavation and research that would typically be carried out in an underground research facility) have been conducted by other countries as a best practice for DGRs for high-level radioactive waste, including used nuclear fuel [8]. Those activities reduce uncertainties and therefore provide a stronger safety case.

Setting up an underground research facility is a very time-consuming process, and there may be a significant time lapse between the selection of a potential site and the availability of such a facility at that site. Therefore, it is best practice to start planning for this facility as early as possible in the siting process, and build support and expertise by using available underground research facilities.

It is important for the licence applicant to discuss its plans with the CNSC early for verification of site characteristics, such as an underground research facility or similar facility, to clarify the regulatory approval process and to identify those site characterization activities. These consultations are also necessary to identify those site characterization activities that may not require a CNSC licence to prepare site and/or licence to construct.

Glossary

For definitions of terms used in this document, see [REGDOC-3.6, *Glossary of CNSC Terminology*](#), which includes terms and definitions used in the [Nuclear Safety and Control Act](#) and the regulations made under it, and in CNSC regulatory documents and other publications. REGDOC-3.6 is provided for reference and information.

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CNSC Regulatory Document Series

Facilities and activities within the nuclear sector in Canada are regulated by the Canadian Nuclear Safety Commission (CNSC). In addition to the *Nuclear Safety and Control Act* and associated regulations, these facilities and activities may also be required to comply with other regulatory instruments such as regulatory documents or standards.

Effective April 2013, the CNSC's catalogue of existing and planned regulatory documents has been organized under three key categories and twenty-six series, as set out below. Regulatory documents produced by the CNSC fall under one of the following series:

1.0 Regulated facilities and activities

- Series 1.1 Reactor facilities
- 1.2 Class IB facilities
- 1.3 Uranium mines and mills
- 1.4 Class II facilities
- 1.5 Certification of prescribed equipment
- 1.6 Nuclear substances and radiation devices

2.0 Safety and control areas

- Series 2.1 Management system
- 2.2 Human performance management
- 2.3 Operating performance
- 2.4 Safety analysis
- 2.5 Physical design
- 2.6 Fitness for service
- 2.7 Radiation protection
- 2.8 Conventional health and safety
- 2.9 Environmental protection
- 2.10 Emergency management and fire protection
- 2.11 Waste management
- 2.12 Security
- 2.13 Safeguards and non-proliferation
- 2.14 Packaging and transport

3.0 Other regulatory areas

- Series 3.1 Reporting requirements
- 3.2 Public and Aboriginal engagement
- 3.3 Financial guarantees
- 3.4 Commission proceedings
- 3.5 CNSC processes and practices
- 3.6 Glossary of CNSC terminology

Note: The regulatory document series may be adjusted periodically by the CNSC. Each regulatory document series listed above may contain multiple regulatory documents. For the latest list of regulatory documents, visit the [CNSC's website](#).