Technical Report

TR-06-20

FEP report for the safety assessment SR-Can

Svensk Kärnbränslehantering AB

November 2006

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Preface

This report describes the FEP processing undertaken for the SR-Can project and the resulting version of the SKB FEP database containing the SR-Can FEP catalogue. The report is authored by Kristina Skagius, Kemakta Konsult AB. She also developed the structure of the FEP database and carried out all the FEP implementations and mappings in the database.

The work described in the report was planned by a group consisting of Kristina Skagius, Johan Andersson, JA Streamflow AB, and the undersigned. Many of the decisions regarding FEP classification etc were made by this group as is further explained in the report.

Several other experts and generalists have been involved at specific stages of the work, including Lena Morén, SKB (issues related to climate and future human actions), Jens-Ove Näslund, SKB (climate-related issues), Karin Pers, Kemakta Konsult AB (issues related to the initial state). The persons involved in the implementation of the results of the audit regarding internal processes were the experts involved in developing the process descriptions, with the main contributions being from Lars Werme, SKB (fuel and canister processes), Kastriot Spahiu, SKB (fuel processes), Patrik Sellin, SKB (buffer and backfill processes), Harald Hökmark, Clay Technology AB, (geosphere processes), Jan-Olof Selroos, SKB (geosphere processes), Ignasi Puigdomenech, SKB (geosphere processes) and Peter Jackson, Serco Assurance, UK (geosphere processes).

Stockholm, November 2006

Allan Hedin

Project leader, SR-Can

Summary

This report documents the analysis and processing of features, events and processes, FEPs, that has been carried out within the safety assessment SR-Can, and forms an important part of the reporting of the project. The SR-Can project is a preparatory stage for the SR-Site assessment, and the report from that project will be used in support of SKB's application to build a final repository.

The overall objective of the FEP analysis and processing included development of a database of features, events and processes, an SKB FEP database, in a format that facilitates both a systematic analysis of FEPs and documentation of that FEP analysis, as well as facilitating revisions and updates to be made in connection with new safety assessments. The overall objective also extended to the development of procedures for such a systematic FEP analysis as well as the application of those procedures in order to establish an SR-Can FEP catalogue within the framework of the SKB FEP database.

The work started by implementing the content of the SR 97 Process Report into a database format suitable for import and processing of FEP information from other sources. The SR 97 version of the database was systematically audited against the NEA database with Project FEPs, version 1.2. In addition, an earlier audit of the SR 97 process report against the interaction matrices developed for a deep repository of the KBS-3 type was revisited and updated.

Relevant FEPs identified through the audit process were sorted into three main categories i) FEPs related to the initial states of the repository system, ii) FEPs related to internal processes of the repository system, and iii) FEPs related to external impacts on the repository system. This resulted in additions to the SR 97 list of processes and to the lists of initial state FEPs and external factors to be addressed in further processing.

The further processing of the initial state FEPs revealed that those FEPs that are not covered by the description of the repository design or by the site description, concern deviations from the intended initial state as a consequence of, for example, mishaps or sabotage. These FEPs formed the basis for the definition of Initial state FEP records in the SR-Can FEP catalogue. These initial state FEPs were then propagated to the selection of scenarios. Suggestions arising from the FEP audit regarding additions to, and modifications of, internal processes were treated by the experts involved in the development of the SR-Can Process reports. These results are implemented in the updated versions of the process descriptions for the engineered barriers and the geosphere. Each process in these reports is also associated with a FEP record in the SR-Can FEP catalogue. Biosphere processes were not included in the SR 97 Process Report and there is thus not the same basis for updating these descriptions as for the engineered barriers and the geosphere. All biosphere FEPs from the audit have, therefore, been compiled and sorted to provisional FEP records in the SR-Can FEP catalogue awaiting the results of the processing of these FEP lists, which currently is ongoing in connection with the production of an SR-Can Biosphere process report. External FEPs from the audit were checked against the plans for managing these issues in SR-Can. The handling of climate-related issues and issues related to future human actions are described in the SR-Can Climate report and the FHA report, respectively, and these reports were the basis for definition of SR-Can FEPs in the FEP catalogue. Large-scale geological FEPs were compared against the plans for modelling these phenomena and it was found appropriate to address these few large-scale geological FEPs in the Geosphere process report. Corresponding records were also added to the SR-Can FEP catalogue.

The SR-Can FEP catalogue established based on the FEP processing contains initial state FEPs; processes in the system components fuel, canister, buffer, backfill in deposition tunnels and geosphere; variables in those same system components; external FEPs and provisional biosphere FEPs. In addition, the FEP catalogue also contains the categories Methodology FEPs

and Site-specific factors. The methodology FEPs relate to a number of issues relevant to the basic assumptions for the assessment and to the methodology employed in the assessment that were identified in the NEA FEP database. Most of these are of a very general nature, but, for the sake of comprehensiveness, they were also propagated to the SR-Can FEP catalogue. The site-specific factors represent issues that specifically have been identified as relevant for the SR-Can analysis, for example the effect of a deep mine excavation near, but outside the tectonic lens at Forsmark. The FEP catalogue also contains preliminary FEPs for system components that are not treated in detail in SR-Can. These components are tunnel plugs, backfill materials for cavities other than the deposition tunnels, the bottom plates in the deposition holes and borehole seals. These components are treated on the basis of simplified assumptions in SR-Can and the handling will be developed to a more comprehensive level in SR-Site.

Contents

1 Introduction

The SR-Can project is a preparatory stage for the SR-Site assessment, which will generate the report that will be used in support of SKB's application to build a final repository. The purposes of the safety assessment SR-Can are the following:

1. To make a first assessment of the safety of potential KBS-3 repositories at Forsmark and Laxemar to dispose of canisters as specified in the application to build the encapsulation plant.
2. To provide feedback to design development, to SKB's R&D programme, to further site investigations and to future safety assessment projects.
3. To foster a dialogue with the authorities that oversee SKB's activities, i.e. the Swedish Nuclear Power Inspectorate, SKI, and the Swedish Radiation Protection Authority, SSI, regarding interpretation of applicable regulations, as a preparation for the SR-Site project.

The assessment relates to the KBS-3 disposal concept in which copper canisters with a cast iron insert containing spent nuclear fuel are surrounded by bentonite clay and deposited at approximately 500 m depth in saturated, granitic rock. Preliminary data from the Forsmark and Laxemar sites, presently being investigated by SKB as candidates for hosting a KBS-3 repository are used in the assessment.

1.1 Role of this FEP report in the SR-Can assessment

This report documents the analysis and processing of features, events and processes, i.e. FEPs, that has been carried out within the safety assessment SR-Can, and forms an important part of the reporting of the project. The detailed assessment methodology, including the role of the FEP processing in the assessment, is described in the SR-Can Main report /SKB 2006b/. The following excerpts describe the methodology, and clarify the role of the FEP processing in the assessment.

The repository system, broadly defined as the deposited spent nuclear fuel, the engineered barriers surrounding it, the host rock and the biosphere in the proximity of the repository, will evolve over time. Future states of the system will depend on:

- the initial state of the system,
- a number of radiation-related, thermal, hydraulic, mechanical, chemical and biological processes acting within the repository system over time, and
- external influences acting on the system.

A methodology in ten steps has been developed for SR-Can, as summarised in Figure 1-1 and described below.

1. Identification of factors to consider (FEP processing).

   This step consists of identifying all the factors that need to be included in the analysis. Experience from earlier safety assessments and KBS-3 specific and international databases of relevant FEPs influencing long-term safety are utilised. An SKB FEP database is developed in which the great majority of FEPs are classified as being initial state FEPs, internal processes or external FEPs. Remaining FEPs are either related to assessment methodology in general or determined to be irrelevant for the KBS-3 concept. Based on the results of the FEP processing, an SR-Can FEP catalogue, containing FEPs to be handled in SR-Can, has been established. This step and the links to the subsequent steps are documented in this SR-Can FEP report.

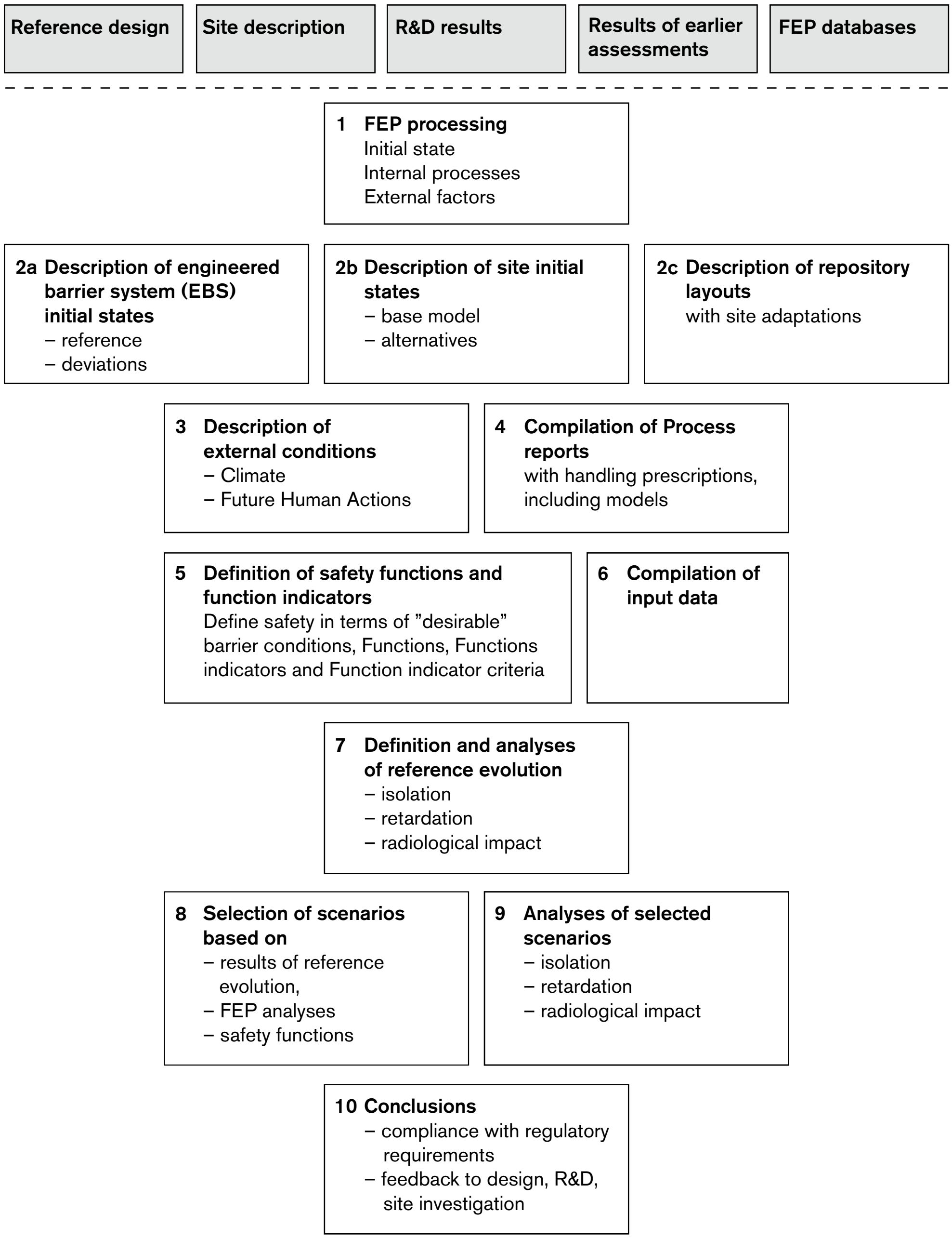

Figure 1-1. *An outline of the ten main steps of the SR-Can safety assessment. The boxes at the top above the dashed line are inputs to the assessment.*

2. Description of the initial state.

   The description of the initial state of the system is based on the design specifications of the KBS-3 repository, a descriptive model of the repository site and a site-specific layout of the repository. The initial state of the fuel and the engineered components is that immediately after deposition, as described in the SR-Can Initial state report /SKB 2006c/. The initial state of the geosphere and the biosphere is that of the natural system prior to excavation, as described in the site descriptive models /SKB 2005a, 2006a/. The repository layouts adapted to the sites are provided in underground design reports for each site /Brantberger et al. 2006, Janson et al. 2006/.

3. Description of external conditions.

   Factors related to external conditions are handled in the categories “climate related issues”, “large-scale geological processes and effects” and “future human actions”. The handling of climate related issues is described in the SR-Can Climate report /SKB 2006g/, whereas the few external, large-scale geosphere processes are addressed in the Geosphere process report /SKB 2006f/. The treatment of future human actions in SR-Can is described in the SR-Can FHA report /SKB 2006h/.

4. Description of processes.

   The identification of relevant processes is based on earlier assessments and FEP screening. All identified processes within the system boundary and relevant to the long-term evolution of the system are described in dedicated Process reports /SKB 2006def/. Short-term geosphere processes or alterations due to repository excavation are also described in these Process reports and are taken into account in the assessment. For each process, its general characteristics, the time frame in which it is important, the other processes to which it is coupled and how the process is handled in the safety assessment are documented.

5. Definition of safety functions, function indicators and function indicator criteria.

   This step consists of an account of the safety functions of the system and of how they can be evaluated by means of a set of function indicators that are, in principle, measurable or calculable properties of the system. Criteria for the safety function indicators are provided. The Process reports are important references for this step. A FEP chart is developed, showing how FEPs are related to the function indicators.

6. Input data selection

   Data to be used in the quantification of repository evolution and in dose calculations are selected using a structured procedure. The process of selection and the data adopted are reported in a dedicated Data report /SKB 2006i/. Also, a template for discussion of input data uncertainties has been developed and applied.

7. Definition and analysis of reference evolution.

   A reference evolution, providing a description of a plausible evolution of the repository system, is defined and analysed. The isolating potential of the system over time is analysed in a first step, yielding a description of the general system evolution and an evaluation of the safety function indicators. If the evolution indicates breaching of isolation, the retardation potential of the repository and its environs is analysed and dose consequences are calculated for the long-term conditions identified in the first step. Also, some canister failure modes not resulting from the reference evolution are analysed in order to further elucidate the retardation properties of the system. Each process is handled in accordance with the plans outlined in the process reports.

8. Selection of scenarios.

   A set of scenarios for the assessment is selected. A comprehensive main scenario is defined in accordance with SKI’s regulations SKIFS 2002:1. The main scenario is closely related to the reference evolution analysed in step 7. The selection of additional scenarios is focused on the safety functions of the repository and the safety function indicators defined in step 4 form an important basis for the selection. For each safety function, an assessment is made as to whether any reasonable situation where it is not maintained can be identified. If this is the case, the corresponding scenario is included in the risk evaluation for the repository, with the overall risk determined by a summation over such scenarios. The set of selected scenarios also includes e.g. scenarios explicitly mentioned in applicable regulations, such as human intrusion scenarios, and scenarios and variants to explore design issues and the roles of various components in the repository.

9. Analysis of scenarios.

   The main scenario is analysed essentially by referring to the reference evolution defined in step 7. An important result is a calculated risk contribution from the main scenario. The additional scenarios are analysed by focussing on the factors potentially leading to situations in which the safety function in question is not maintained. In most cases, these analyses are carried out by comparison with the evolution for the main scenario, meaning that they only encompass aspects of repository evolution for which the scenario in question differs from the main scenario. For these scenarios, as for the main scenario, a risk contribution is estimated.

10. Conclusions.

    This step includes integration of the results from the various scenario analyses, development of conclusions regarding safety in relation to acceptance criteria and feedback concerning design, continued site investigations and the R&D programme.

1.2 Objective and scope of the FEP processing

The overall objective of the work included development of a database of features, events and processes in a format that facilitates both a systematic analysis of FEPs and documentation of the FEP analysis, as well as facilitating revisions and updates to be made in connection with new safety assessments. The overall objective also extended to the development of procedures for such a systematic analysis and processing of FEPs, as well as the application of these procedures in order to arrive at an SR-Can version of the SKB FEP database.

The primary objective was to establish an SR-Can FEP catalogue within the framework of the SKB FEP database. This FEP catalogue was required to contain all FEPs that need to be handled in SR-Can.

The starting point for the development of the FEP database was the outcome of the FEP work conducted in SKB´s most recent major safety assessment, the SR 97 assessment, as reported in the SR 97 Process report /SKB 1999b/ and the supporting documentation on the Interaction matrices developed for a deep repository of the KBS-3 type /Pers et al. 1999/.

1.3 Experts used in developing the FEP database

The details of the FEP database development procedure were decided at meetings held at regular intervals during the course of the work. Participants in these meetings were Allan Hedin, SKB, Johan Andersson, JA Streamflow AB, and Kristina Skagius, Kemakta Konsult AB, in the forthcoming text referred to as the FEP group. This group also made decisions regarding the treatment of FEPs during the audit stage and participated in the further processing of the outcome of the auditing.

Karin Pers, Kemakta Konsult AB, and Lena Morén and Jens-Ove Näslund, SKB, participated in the work of the processing the lists of FEPs related to initial states and external factors.

The persons involved in the provision of additional information relating to internal processes identified as being required through the audit activities were the experts involved in developing the process descriptions, with the main contributions being from Lars Werme, SKB (fuel and canister processes), Kastriot Spahiu, SKB (fuel processes), Patrik Sellin, SKB (buffer and backfill processes), Harald Hökmark, Clay Technology AB, (geosphere processes), Jan-Olof Selroos, SKB (geosphere processes), Ignasi Puigdomenech, SKB (geosphere processes) and Peter Jackson, Serco Assurance, UK (geosphere processes). All experts involved in development of the process descriptions are listed in the SR-Can Process reports for the fuel and canister /SKB 2006d/, buffer and backfill /SKB 2006e/ and the geosphere /SKB 2006f/.

2 FEP processing procedures and prerequisites

As shown in the previous chapter, many of the steps in the methodology applied in SR-Can are related to the handling of FEPs. This chapter gives the prerequisites for the work and an overview of the different activities undertaken during the development of the SKB FEP database and the establishment of the SR-Can FEP catalogue. The development procedure is described in more detail in the following chapters together with the results from the different steps.

2.1 System definition

The SR-Can FEP database has been devised for the KBS-3 repository system. To be able to distinguish between FEPs belonging to the repository system and FEPs acting from outside the system, a definition of the system boundary is necessary. Furthermore, in the database, this system is divided into several system components. It should be noted that these definitions primarily were set up to facilitate the auditing procedure and the development of the SKB FEP database. Therefore, all these definitions are not necessarily relevant in subsequent treatments of FEPs in the safety assessment, e.g. through modelling.

2.1.1 System boundary

To be able to distinguish between FEPs belonging to the repository system and FEPs acting from outside the system, the following definitions related to the system boundary were applied:

- Roughly the portion of the biosphere studied in site investigations, e.g. an area of the order of 100–300 km^2 above the repository, is regarded as internal, whereas the biosphere on a larger scale is regarded as external. The analysis of the biosphere extends downward to the surface of the rocks in this assessment. Depending on the analysis context this definition may be somewhat modified.
- Local effects of climate are internal, but not the climate system on a larger scale.
- Roughly the corresponding portion of the geosphere down to a depth of about 1,000 m is regarded as part of the system. Depending on the analysis context, this definition may also be somewhat modified.
- Future human behaviour on a local scale is internal to the system, but not issues related to the characteristics and behaviour of future society at large.

It was also noted that, in general, a strict boundary definition is neither necessary nor indeed possible, and that the same boundaries are not necessarily relevant to all parts of the safety assessment.

In order to distinguish between factors affecting the initial state of the repository system and factors associated with the evolution of the system, the initial time for the evolution of engineered barriers was defined as the time of deposition. The initial state of the geosphere and the biosphere was defined as that of the natural system prior to excavation and construction of the repository. This means that the evolution of the natural conditions at the site as a result of construction is included in the system description.

2.1.2 System components

The repository system encompasses the spent nuclear fuel, the canisters, the buffer, the tunnel backfill, the geosphere and the biosphere local to the repository. In the SR 97 Process Report /SKB 1999b/, the buffer and tunnel backfill were treated as one system component and the biosphere was not included. When starting the development of the SKB FEP database, it was decided that the buffer and the tunnel backfill should be treated as two separate system components and that the biosphere system should be added.

During the audit work, it was further found convenient to increase the resolution in the definition of system components outside the buffer in order to obtain system components that are homogeneous in character and to make it possible to distinguish between system components that are more important to safety and those that are less important. However, the geometrical extent and materials included in the system components "Fuel/cavity in canister" and "Cast iron insert and copper canister" remain the same as in the SR 97 version.

After these modifications, the SKB FEP database included the following system components:

- *Fuel/cavity in canister.* This system component comprises the fuel assemblies with fuel pellets, cladding tubes, channel, handle, and spacers etc, as well as cavities in the canister that could become filled with water in case of a canister rupture.
- *Cast iron insert and copper canister.* This system component comprises the canister with its inner container of cast iron and outer shell of copper.
- *Buffer.* This system component comprises the buffer of bentonite clay that surrounds the canister in the deposition hole.
- *Bottom plate in deposition hole.* This system component comprises the concrete foundation in the bottom of each deposition holes and the copper plate on top of the concrete on which the buffer resides.
- *Backfill in deposition tunnels.* This system component comprises the material that will be emplaced in the deposition tunnels after deposition of the canisters and buffer in the deposition holes. In SR-Can, this system component also includes rock bolts and reinforcement nets that will be used as rock support as well as grout in the grout holes. These grout holes are used for grouting of the rock around the deposition tunnels during excavation and will be left grout-filled at repository closure. In order to obtain a more homogeneous system component, the possibility of defining rock reinforcements and grout as a separate system component has been discussed, but this has not been implemented in SR-Can.
- *Backfill in other repository cavities.* This system component comprises the material that will be emplaced in all other repository cavities except the deposition tunnels and deposition holes, e.g. the ramp, transport and main tunnels and shafts. In SR-Can, it is assumed that this material is the same as the backfill material in the deposition tunnels. Similarly to the system component backfill in deposition tunnels, this system component presently also includes rock reinforcement and grout in grout holes, which possibly will be separated into a system component of its own or be combined with rock reinforcement and grout in the deposition tunnels in SR-Site.
- *Plugs.* This system component comprises all operating seals or plugs in the repository that are left at closure, as well as all potential permanent plugs that will be installed for long-term safety reasons, e.g. plugs between deposition areas.
- *Borehole seals.* This system component comprises the backfill materials in all boreholes drilled for site characterisation during the surface-based site investigations as well as during repository excavation and construction. The backfill materials considered in SR-Can are highly compacted smectite clay contained in perforated copper tubes, rock cylinders pressed down in the uppermost part of surface-based holes, and well-compacted moraine and grout.

- *Geosphere.* This system component comprises the rock surrounding the repository and the investigation boreholes. It also includes grout injected into fractures in the rock during construction of the repository to prevent water inflow to tunnels and other repository cavities. In the upward direction, the geosphere is bounded by the geosphere-biosphere interface, defined as the top of the weathered host rock, which would be either at outcrop or at the interface with Quaternary deposits. For boundaries in the other directions, see definitions above regarding the system boundary.
- *Biosphere.* This system component comprises the near-surface properties and processes, both abiotic and biotic as well as humans and human behaviour, see also definitions above regarding system boundaries.

The various system components are also characterised by a number of variables, both in terms of the initial state of these variables and their states during repository evolution. The variables defined for the engineered barrier system components are given in the SR-Can Initial state report /SKB 2006c/. The sets of variables defined for each system component are essentially the same as those defined in the SR 97 Process Report /SKB 1999b/, with only small modifications resulting from the work with updating of the process descriptions for the system components fuel/cavity in canister, cast iron insert and copper canister, buffer, and backfill in deposition tunnels. The variables defined for the system components tunnel plugs, backfill materials for cavities other than the deposition tunnels, the bottom plates in the deposition holes and borehole seals should be regarded as preliminary. These components are not specifically addressed in Sr-Can, but treated using simplifying assumptions, and the handling will be developed to a more comprehensive level in SR-Site.

The variables defined for the system component geosphere are reported in the Geosphere process report /SKB 2006f/.

2.2 Overview of FEP processing procedure

The handling of FEPs in SR-Can is schematically illustrated in Figure 2-1 and summarised in the text below.

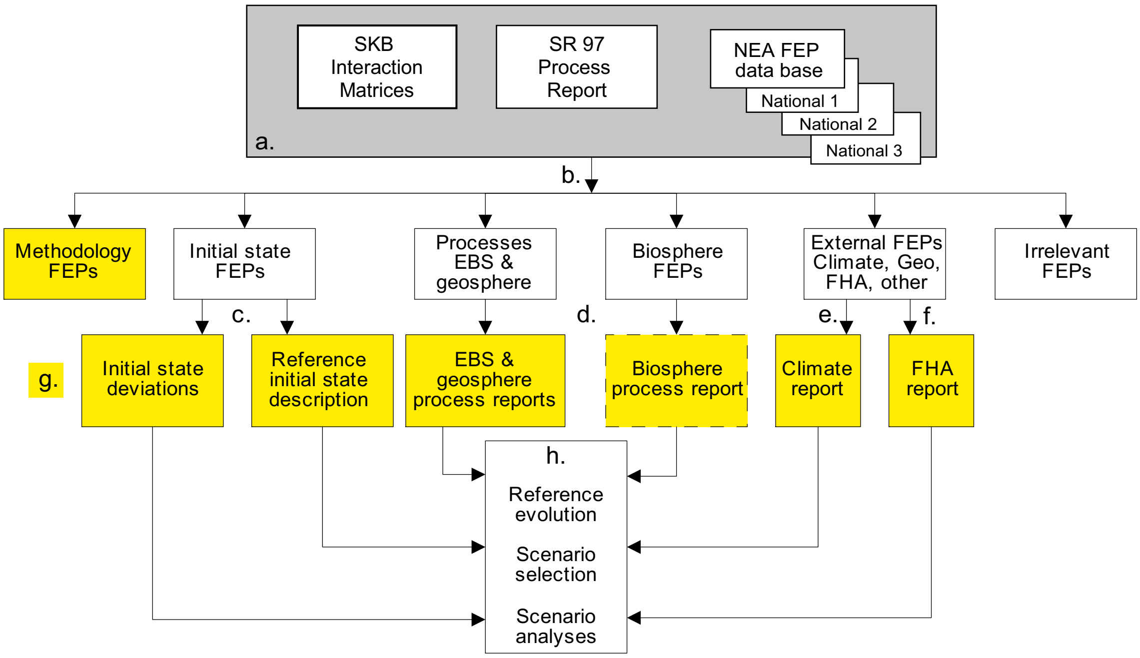

Figure 2-1. The handling of FEPs in SR-Can.

a) FEP sources

Three sources were used to identify relevant features, events and processes influencing the long-term safety of a KBS-3 type repository. These are the SR 97 Process Report /SKB 1999b/, the international NEA database with project FEPs version 1.2 /NEA 1999/ and the Interaction matrices developed for a deep repository of the KBS-3 type /Pers et al. 1999/.

b) FEP audit

The work started by implementing the content of the SR 97 Process Report /SKB 1999b/ into a database format suitable for import and processing of FEP information from other sources. This first version of the database was denoted version SR 97 and it contained descriptions of the components of the repository system, system variable definitions and process descriptions, all in accord with the SR 97 Process Report.

In the next step, the SR 97 version was systematically compared with all Project FEPs included in the NEA FEP database, version 1.2. In addition, an earlier audit of the SR 97 process report against the interaction matrices developed for a deep repository of the KBS-3 type /Pers et al. 1999/ was revisited and updated. The purpose of these audits was to ensure that all factors relevant to a KBS-3 repository were identified and to classify all relevant factors as being related to the *initial state of the repository system*, to *internal system processes* or to *external factors*. This resulted in additions to the SR 97 list of processes and to lists of initial state FEPs and external factors for further processing.

The FEP audit procedure and the results are described further in Chapter 3.

c) Processing of initial state FEPs

The compiled initial state FEPs were recognised to be related either to the intended initial state, further denoted the reference initial state, or to deviations from the intended initial state. The FEPs related to the reference initial state were associated with the appropriate variable and system component and included in the description of the reference initial state for the system component in question. Each variable constitutes a FEP record in the SR-Can FEP catalogue, see g) below.

Initial state FEPs that are related to deviations from the reference initial state and that need to be taken into account in the analyses formed the basis for the definition of Initial state FEP records in the SR-Can FEP catalogue, see g) below. These initial state FEPs were then propagated to the selection of scenarios.

The processing of initial state FEPs and the results obtained are described further in Section 4.2.

d) Processing of internal process FEPs and biosphere FEPs

Suggestions arising from the FEP audit regarding additions to, and modifications of, internal processes were addressed by the experts involved in the development of the SR-Can Process reports. The results of their work were implemented in the updated versions of the process descriptions for the engineered barriers and the geosphere. Each process in these reports also constitutes a FEP record in the SR-Can FEP catalogue, see g) below.

Biosphere processes were not included in the SR 97 Process report. Hence, the basis for updating these descriptions was not the same as for the engineered barriers and the geosphere. As a first step, all biosphere FEPs from the FEP audit were, therefore, collected in a single category and provisionally sorted to subcomponents of the biosphere system. In a second step, these biosphere FEPs were further addressed in conjunction with the development of a biosphere process report, which is currently on-going (November 2006). Since this biosphere process report is not yet completed, the SR-Can FEP catalogue contains provisional biosphere FEPs, corresponding to the sub-components of the biosphere system. However, once the biosphere process report is completed, the FEP catalogue will be updated with FEP records corresponding to the biosphere processes documented in the biosphere process report.

The treatment of process FEPs and the results obtained are described further in Section 4.1.

e and f) Processing of external FEPs

All NEA Project FEPs classified as external were further distinguished into the categories:

- Climate related issues.
- Large-scale geological processes and effects.
- Future human actions.
- Other.

These FEPs were checked against the plans for managing these issues in SR-Can, to ensure that all relevant external FEPs were being addressed. The handling of climate related issues is documented in the SR-Can Climate report /SKB 2006g/ and the structure of this report formed the basis for the definition of climate FEP records in the SR-Can FEP catalogue, see g) below.

Large-scale geological FEPs were compared against the plans for modelling these phenomena and it was found appropriate to address these few large-scale geological FEPs in the Geosphere process report /SKB 2006f/. Corresponding records were also added to the SR-Can FEP catalogue, see g) below.

The FEPs classified as being related to future human actions were compared with the handling in SR 97, which formed the basis for the approach in SR-Can. The handling in SR-Can is described in the SR-Can FHA report /SKB 2006h/, and the structure of this report has formed the basis for the definition of FHA FEP records in the SR-Can FEP catalogue, see g) below.

The FEP category "Other" contained one FEP only, namely Meteorite impact. A corresponding FEP record was included in the SR-Can FEP catalogue, but already at this stage, this FEP was excluded from further analysis. The reason for this is that the probability that a meteorite large enough to damage the repository will impact local to the repository footprint can be demonstrated to be extremely low. Furthermore, the direct effects of the event, namely a destruction of the local or regional biosphere including humans, are deemed to be much more severe than its possible radiological consequences. This motivation for excluding this FEP from further analysis is documented in the FEP record in the SR-Can FEP catalogue.

The processing of external FEPs and the results obtained are described further in Section 4.3.

g) Establishment of the SR-Can FEP catalogue

Based on the FEP processing briefly described above, an SR-Can FEP catalogue was established. This FEP catalogue contains the following FEP categories:

- Initial state FEPs.
- Processes in the system components fuel, canister, buffer, backfill in deposition tunnels and geosphere.
- Variables in the system components fuel, canister, buffer, backfill in deposition tunnels and geosphere.
- Biosphere FEPs.
- External FEPs.

In addition to the categories listed above, the FEP catalogue also contains the categories Methodology FEPs and Site-specific factors. The methodology FEPs address a number of issues relevant to the basic assumptions for the assessment and to the methodology used for the assessment that were identified in the NEA FEP database. Most of these are of a very general nature, but, for the sake of comprehensiveness, were also propagated to the SR-Can FEP catalogue. The site-specific factors represent issues that specifically have been identified as relevant for the SR-Can analysis, for example the effect of a deep mine excavation near, but outside the tectonic lens at Forsmark.

The FEP catalogue also contains preliminary FEPs for system components that are not treated in detail in SR-Can. These components are tunnel plugs, backfill materials for cavities other than the deposition tunnels, the bottom plates in the deposition holes and borehole seals. These components are treated using simplifying assumptions in SR-Can and the handling will be developed to a more comprehensive level in SR-Site.

The contents of the FEP catalogue are described in more detail in Chapter 5.

h) Repository evolution

The contents of the SR-Can FEP catalogue were propagated to the analysis of repository evolution. The reference initial state, all long-term processes and a reference external evolution was used to define a reference evolution for the repository system. Other FEPs were considered in the selection of scenarios. This step is described in the SR-Can Main report /SKB 2006b/ and is not further addressed in this FEP report, other than in respect of documentation aspects related to the FEP catalogue.

2.3 Quality assurance aspects

2.3.1 The SKB FEP database

The SKB FEP database was used as a tool for documentation of the outcome of the different steps in the FEP processing procedure as the work proceeded. Thus, the FEP database in itself is regarded as a quality assurance instrument. For that purpose, it contains all source information in terms of the Project FEPs included in the NEA FEP database version 1.2 /NEA 1999/, the contents of the SR 97 Process report /SKB 1999b/ in database format and the Interaction matrices developed for a deep repository of the KBS-3 type /Pers et al. 1999/, as well as the resulting SR-Can FEP catalogue. In addition, the SKB FEP database contains files created for documentation of the outcome of the FEP audit, one for the result of the audit against the NEA project FEPs (NEA Mapping) and one for the result of the audit against the Interaction matrices (Matrix Mapping). The overall structure of the SKB FEP database is shown in Figure 2-2.

In order to ensure a proper handling of the SKB FEP database, routines for the development and management of it were defined. These are summarised in the following sections and further addressed, where appropriate, in the following chapters.

2.3.2 Import of NEA FEPs and Matrix interactions

The database was created with the database programme FileMaker Pro, (version 5.5), which is the same database programme as was used to set up the NEA FEP database and the SKB Interaction matrices. This made it possible to import an electronic copy of the register in the NEA FEP database containing the Project FEPs (PROFEP) and of the registers containing the documentation on the Interaction matrices. These registers, NEA Project FEPs and SKB Interaction matrices in Figure 2-2, are, however, not used for documentation. The documentation is created in the registers NEA Mapping and Matrix mapping (see Figure 2-2). These registers were created by exporting the Project FEP number, the Project FEP name and the

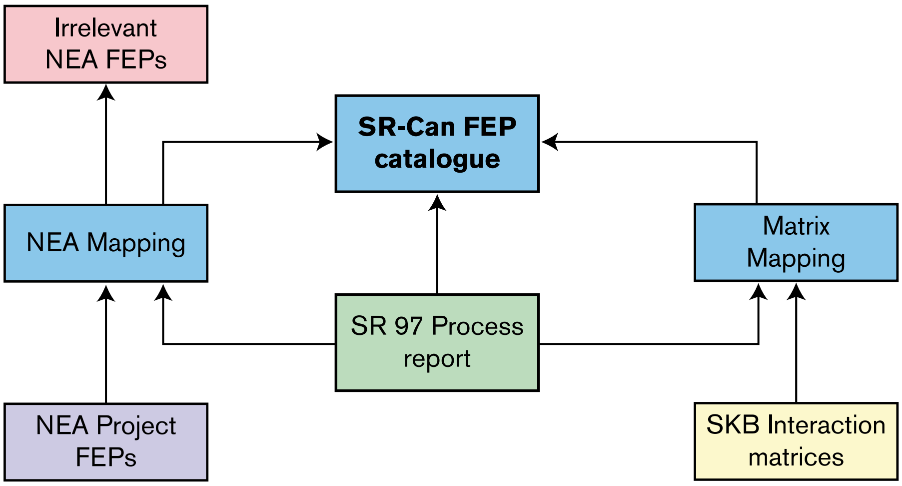

Figure 2-2. *Overall structure of the SKB FEP database.*

International FEP number from the NEA FEP database (register PROFEP) to corresponding records in the NEA Mapping register in the SKB database. For creating the Matrix Mapping register, the Matrix name, the interaction number and interaction name were exported from the register SKB Interaction matrices to corresponding records in the Matrix mapping register. This means that the full copies of the NEA Project FEP register and the Interaction matrices registers are used for displaying the definition/description of the NEA Project FEPs and the Matrix interactions only and no documentation was allowed in these registers. However, it should be noted that during the work with the development of the interim version of the FEP database it was found that descriptions were missing for two of the Project FEPs in the NEA FEP database version 1.2. After confirmation from the consultant responsible for the version 1.2 of the NEA FEP database (T. Summerling), the descriptions of these FEPs in version 1.0 of the NEA FEP database were copied into the NEA Project FEPs register in the SKB FEP database.

2.3.3 Routines for FEP processing and documentation of results

The FEP audit (b in Figure 2-1) was carried out following a set of general procedures and rules (Section 3.1.2). In addition, a number of criteria were defined that should be fulfilled in order to determine that a FEP is not relevant for the SKB system (Section 3.1.3). These procedures, rules and criteria were applied in the work and the results of the audit as well as decisions made during the course of the work were documented in the FEP database (NEA Mapping in Figure 2-2).

The audit procedure was carried out by generalists and no attempt was made at this stage to make definite decisions on the relevance or importance of the FEPs and Matrix interactions for repository evolution. Therefore, the results of the audit, in terms of relevant FEPs and Matrix interactions and, where relevant, their links to internal processes, was propagated to experts within the project for further processing, together with instructions on how to document the result of that processing. The information in the FEP database was provided as digital word-documents, which were created by exporting relevant information directly from the FEP database to the digital documents.

The experts documented the results of their FEP processing using protocols addressing, for each NEA Project FEP or Matrix interaction, whether it is handled or not handled in SR-Can and if not handled, the reason for this. The information developed under these protocols was then imported to the FEP database, where it is accessible for view via the FEP records in the SR-Can FEP catalogue (see Chapter 5). In addition, the expert responsible for the documentation of the handling is identified in the appropriate record in the database as well as the date of the final document provided for import to the database. Before entering the information into the database, its completeness and consistency was checked. Minor revisions of more administrative character, such as adding cross-references and duplicating documentation of handling of similar FEPs when this information was lacking, were made by the person responsible for checking the information delivered under the protocols without consulting the expert providing the information.

Print-outs of this information from the FEP database (FEP tables) are provided as Appendices to this report.

2.3.4 Routines for management of the FEP database

Some general rules for administration of the FEP database have been followed throughout the development work. These are:

- Only one person has been allowed to make modifications to the structure and content of the database. For the SR-Can project, this person has been Kristina Skagius, Kemakta Konsult AB.
- Suggested modifications in the structure of the database had to be checked and approved by the Project Manager Allan Hedin.
- Input of information to the database was required only to be made from documents that were dated, signed and provided by the experts assigned for the task.
- An informal log was active during the development of the FEP database to keep track of actions needed and made.
- No formal numbering of versions of the FEP database during the development was considered necessary, but dated copies were saved at regular intervals during the work. The final version was named the SR-Can version of the SKB FEP database.
- The final official SR-Can version of the FEP database was made available as a stand alone, write-protected version.

Before delivering a final version of the SR-Can FEP database, its content was checked. This check was made in order to ensure that:

1. All NEA Project FEPs in version 1.2 of the NEA FEP database are included in the SKB FEP database.
2. All Matrix interactions in the SR 97 Buffer, Near-field and Far-field matrices are included in the SKB FEP database.
3. All NEA Project FEPs and Matrix interactions included in the SKB FEP database are flagged as Relevant or Not relevant for the SKB repository system.
4. All NEA Project FEPs and Matrix Interactions included in the SKB FEP database and flagged as Not Relevant for the SKB repository system are associated with documentation justifying their omission.
5. All NEA Project FEPs and Matrix Interactions included in the SKB FEP database and flagged as Relevant for the SKB repository system are associated with a documented description of their handling in SR-Can.
6. All processes in process reports, defined categories of initial states, defined external factors, etc have a corresponding record in the SR-Can FEP catalogue.

The outcome of this check is provided in Appendix 2.

3 FEP audit

In the SR 97 Process report /SKB 1999b/, comprehensive sets of long-term processes relevant to repository safety for each of the system components, i.e. fuel, canister, buffer/backfill and geosphere, were identified. For each component, a set of variables needed to describe the evolution of the state of the component over time was also established. As a first step in the development of the SKB FEP database, these identified processes and variables were collected in an SR 97 FEP database, forming an important starting point for the SR-Can FEP handling. The SR 97 database was then systematically compared with other national databases included in the NEA international FEP database version 1.2 and with the content of the SKB interaction matrices reported in conjunction with the SR 97 safety assessment /Pers et al. 1999/. This part of the work is described in the following sections of this chapter.

3.1 Comparison with the NEA FEP database

3.1.1 Introduction

The NEA international FEP database is the outcome of work by the NEA FEP Database Working Group and it consists of two parts; the international FEP List and Project Databases. The audit was carried out using the Project Databases, which is a collection of FEP lists and databases compiled during repository assessment studies in various countries. Version 1.2 of the NEA FEP database includes project-specific records from eight projects. The main features of the repository concepts for each of these projects are given in Table 3-1.

To facilitate the audit against the Project FEPs in the NEA FEP database version 1.2 and documentation of the auditing results a "NEA mapping" file was created. This mapping file links information in the NEA Project data file (PROFEP) with information in the SR-Can database files.

At the start of the audit, the SR-Can files were identical to the corresponding SR 97 files. Because of the separation of the system components buffer and backfill, all but a few of the processes that were associated with the buffer/backfill system in the SR 97 version were duplicated for both the buffer and the backfill systems in the SR-Can version. The few exceptions concerned processes that, from the process description, were judged to refer to the buffer system and therefore were copied to the buffer system only.

3.1.2 General auditing procedure and rules

The NEA Project data file (PROFEP) contains 1,418 FEPs. In order to make the audit work more efficient, the mapping of the NEA Project FEPs was carried out by a single person (Kristina Skagius), but some general procedures and rules were followed in order to keep expert judgements regarding details of process understanding to a minimum at this stage. These general procedures and rules were defined by the FEP group and were as listed below.

- The NEA Project FEPs regarded as irrelevant were marked as such and justification for their screening had to be provided (see Section 3.1.3 for screening criteria).
- Relevant FEPs occurring outside the system boundary were classified as External factors (see Section 3.1.4).
- A NEA Project FEP that clearly could be linked to one or several processes, variables or the initial state of one or more variables was so linked.

- Suggestions on modifications to the descriptions of the processes and variables onto which the NEA Project FEPs were to be mapped were allowed at this stage. These modifications were required to be documented and all objects for which modifications were required to be marked in the database.
- All NEA Project FEPs not readily or fully fitting into one of the above categories were marked as suchfor further handling at a later stage.
- The mapping was required to be based on the FEP description, rather than the FEP name.
- Any associations outside the primary meaning of the FEP that arose from consideration of the FEP description were required to be documented.

All NEA Project FEPs that could not readily be mapped using the general auditing rules were discussed at regular meetings in the FEP group and decisions were made on the relevance and classification of these FEPs.

Table 3-1. Projects included in the NEA FEP database version 1.2.

Project	Code	Waste type	Host rock	Engineered barrier system concept
The Joint SKI/SKB Scenario Development Project, 1989	J	Spent PWR/BWR fuel	Crystalline basement	Corrosion-resistant copper containers, borehole emplacement with bentonite buffer
NEA Systematic Approaches to Scenario Development, 1992	N	Intermediate and low-level wastes	Hard rock	Steel and concrete packages, emplaced in caverns with cementitious grout and backfill
HMIP Assessment of Nirex Proposals – System Concept Group, 1993	H	Intermediate and low-level wastes	Tuff, Borrowdale Volcanic Group	Steel and concrete packages, emplaced in caverns with cementitious grout and backfill for ILW
AECL Scenario Analysis for EIS of Canadian Disposal Concept, 1994	A	Used CANDU fuel bundles	Plutonic rock of the Canadian Shield	Thin-walled titanium containers, borehole emplacement with bentonite-sand buffer
Nagra Scenario Development for Kristallin, 1994	K	Vitrified waste from reprocessing of spent PWR/BWR fuel	Crystalline basement under sedimentary cover in Northern Switzerland	Thick steel containers, in-tunnel emplacement with bentonite buffer
SKI SITE-94 Deep Repository Performance Assessment Project, 1995	S	Spent PWR/BWR fuel	Crystalline basement (based on geologic data from the Äspö site in south central Sweden)	Fuel, canister, bentonite buffer and tunnel backfill
US DOE Waste Isolation Pilot Plant, CCA, 1996	W	Contact- (CH) and remote handled (RH) Transuranic (TRU) waste	Salt (Salado Formation, New Mexico USA)	Magnesium oxide backfill as chemical conditioner, crushed salt, clay, concrete and asphalt seal components
AECL Issues for the 'Intrusion Resistant Underground Structure', 1997	I	Baled and bitumenised LLW from Chalk River Laboratories operations	Large sand ridge	Reinforced concrete vault above the water table

3.1.3 Relevance screening

The relevance of each NEA Project FEP for the SKB repository system was judged on the basis of relevance criteria defined by the FEP group. The FEP could be screened out if one of the following criteria was fulfilled:

- The FEP is not appropriate to the actual waste, canister design, repository design, geological or geographical setting.
- The FEP is defined by a heading without any description of what is meant by the heading, but from the interpretation of the heading it is judged that the FEP is covered by other NEA Project FEPs.
- The FEP is very general and covered by other more specific NEA Project FEPs.

It should be emphasised that certain aspects given in a FEP description could be relevant for the repository system defined for the SR-Can assessment, even if the FEP mainly is related to a system deviating from the SR-Can system. For example, NEA FEPs that are related to concrete barriers in an LLW/ILW repository concept are not necessarily screened out, since concrete is part of the SKB repository system and the aspects addressed in the NEA FEP description might therefore be relevant. In these cases, the FEP was judged as relevant and treated further as described in the following sub-sections.

It should also be noted that the general strategy in the screening of FEP relevance has been to judge FEPs as relevant rather than to screen them out at this stage, unless it is clearly obvious that they are irrelevant. By this approach, the final decision regarding the relevance of a FEP and reasons for the decision as to whether it should be included were left to the various experts involved in the further processing of the audit results.

3.1.4 Classification of relevant FEPs

NEA Project FEPs assessed to be relevant for the SKB repository system were classified into one or more of the following categories:

- System process.
- Variable/initial state.
- Biosphere.
- External factor.
- Assessment basis.
- Methodological comment.

System process

This category was used to classify FEPs that were judged to describe a process relevant to one or several of the system components defined for the SR-Can assessment, excluding the biosphere. The biosphere was treated differently because biosphere processes and variables were not included in the previous version of the SKB Process Report or FEP analyses related to a KBS-3 repository, see below.

Variable/initial state

This category was used to classify FEPs that were judged to affect a variable defined to describe the state of a system component in the SR-Can assessment, either the initial state of the system component or the state during evolution. If the FEP was considered to address both a process relevant for the evolution of a system component and a variable affected by that process, it is always assigned to the category system process, but not always also to the category variable/initial state. However, all FEPs that were judged to be relevant to the initial state of a system component were assigned to the category variable/initial state.

Biosphere

A separate treatment of biosphere FEPs was necessary because the SR 97 database does not contain any biosphere processes or variables. Therefore, NEA FEPs judged as being relevant for the SR-Can biosphere were classified into a separate category "Biosphere" for later audit and input to the development of a structure for a process report for the biosphere system component. The biosphere FEPs were further distinguished into the sub-categories Quaternary deposits, Surface waters, Atmosphere, Biota, Man and Others.

External factor

The category *External factors* was used for NEA FEPs that act outside the boundary of the repository system. During the auditing work, a further division was made into the sub-categories "Large-scale geological processes and effects", "Climatic processes and effects", "Future human actions" and "Other", i.e. the same classification as is used in the NEA database.

Assessment basis

The category *Assessment basis* was used for FEPs that did not need much further evaluation, but for which a clear decision on handling in the assessment is required. These include decisions regarding handling of biological evolution and regarding potential progress in treating detrimental effects of radiation, e.g. cancer.

Methodological comment

This category was used for FEPs that describe a general methodology or design issue. These FEPs are not relevant for the evolution of the repository system, but could point to issues to be considered when carrying out the safety assessment. Since the distinction between the categories assessment basis and methodological comments is not quite clear, these two categories were grouped together as *Methodology issues* in the further processing of the audit results.

3.1.5 Documentation of audit results

The results of the audit were documented in the NEA mapping file in the database. A short description of the type of documentation made is given here. Examples of the documentation are given in Appendix 1.

FEP relevance

The relevance of the FEP for the SKB system was documented in the NEA mapping file (see Figure 2-2) together with justification for the judgement "not relevant", when applicable. Out of the total number of 1,418 Project FEPs in the NEA database, 316 FEPs were screened out as being irrelevant for the SR-Can assessment. Examples of screened-out FEPs are those related to magmatic activity and volcanism, and FEPs addressing aspects specific to vitrified waste.

Processes and variables/initial states

All NEA FEPs assigned to the categories "System process" and "Variables/initial states" were marked as such in the mapping file. If the FEP was judged to be covered by a process or variable already included in the SR 97 database, the link to this process was documented in the NEA mapping file in the database. If the FEP could be linked to an SR 97 process, but certain aspects of the NEA FEP were not addressed in the process description, the link to the process was documented in the mapping file together with a marker indicating that modifications of the process description might be needed, and a comment regarding the missing aspect was made. If a NEA FEP was not addressed in the SR 97 database, this was marked and commented on in the mapping file.

The audit results revealed the need to add a number of processes to the SKB database as well as highlighting various FEPs of potential relevance to the initial state of the system components. To take care of this, process records were added to the SKB database together with four categories of initial states. These are named “Initial state – General”, “Initial state – Mishaps”, “Initial state – Design deviations” and “Initial state – Incomplete closure”. The earlier mapping of NEA Project FEPs was revisited and updated to match the new list of processes and Initial states.

The number of NEA FEPs assigned to the category “System process” was 546, whereas 194 NEA FEPs were assigned to the category “Variables/initial states”.

Biosphere

All NEA project FEPs classified as relevant for the biosphere in the SR-Can assessment were marked as such in the mapping file. Since no biosphere processes are included in the SR 97 Process Report, no mapping of these FEPs was made. However, based on the structure of the biosphere interaction matrix developed as a part of the most recent safety assessment of the Swedish repository for low and intermediate level waste (SFR), the SAFE project /SKB 2001/, six biosphere categories were defined. These are: “Quaternary deposits”, “Surface waters”, “Atmosphere”, “Biota”, “Man” and “Other”. Each NEA Project FEP classified as being relevant for the biosphere was also assigned to one or several of these categories by markers in the NEA mapping file. A comparison was also made to document if the NEA Project FEP matched any of the interactions defined in the SAFE biosphere interaction matrix /SKB 2001/. This was done in terms of a mapping comment in the NEA mapping file (see also Appendix 1). In total, 259 NEA FEPs were assigned to the Biosphere category.

External factors

All NEA project FEPs classified as relevant external factors for the SR-Can repository system were marked as such in the NEA mapping file. In addition, each FEP was marked as belonging to one of the categories “Climatic processes and effects”, “Large-scale geological processes and effects”, “Future human actions” or “Other”. Within each of these categories a further sorting of the FEPs was made and marked in the NEA mapping file. These sub-categories were later revised by the experts in their subsequent work on the processing of FEPs in conjunction with the structuring of the reporting of the handling of external FEPs in SR-Can.

The number of NEA FEPs classified as External factors to the SR-Can repository system is 175.

Assessment basis and methodology comment

All FEPs judged to belong to the categories “Assessment basis” or “Methodology comment” were marked as such in the NEA mapping file. In the subsequent FEP processing, the category “Methodology comment” was renamed to “Assessment methodology”, and the two categories were grouped under the heading “Methodology issues”. The number of NEA FEPs assigned to these categories is 111.

3.2 Audit against SR 97 interaction matrices

The content of the SKB interaction matrices reported in conjunction with the SR 97 safety assessment was mapped to the content in the SKB FEP database in a similar way as was done for the NEA Project FEPs. This mapping is largely similar to the mapping reported in /Pers et al. 1999/ with the exception of a few revisions and the addition of mapping to variables and initial states, which were not done by Pers et al. In addition, matrix interactions related to the biosphere system and considered as external factors to the SR-Can system have not been handled previously.

For carrying out the audit and for documentation of the results, a Matrix mapping file was created (see Figure 2-2). This file comprises a link between a file containing the information regarding all interactions in the SKB Interaction matrices developed for the buffer, the near-field and the far-field /Pers et al. 1999/ and the files in the SKB FEP database. The three Interaction matrices contain in total 646 defined interactions.

The various categories used for classification of the interactions are the same as those used in the audit against the NEA Project FEPs, namely "System process", "Variable/initial state", "External factor", "Biosphere", "Assessment basis" and "Methodological comment", also here later renamed to "Assessment methodology". For each interaction, this classification is marked in the Matrix mapping file.

Matrix interactions assigned to the categories "System process" and "Variable/initial states" were linked to the appropriate process, variable or initial state record in the SKB database. This link was documented in the Matrix mapping file. If the interaction was not addressed in the SKB FEP database, this was marked and commented on in the Matrix mapping file. Of all interactions defined in the three matrices, 594 were classified as relevant for a system process. The corresponding number of interactions assigned to the category "Variable/initial state" is 109. It should be pointed out that the primary focus of the matrix mapping was to identify the relevant process associated with the interaction. Therefore, all variables involved in the interactions are not systematically indicated in the mapping file, unless the interaction clearly is related to the initial state or deviations in the initial state of a system component.

Of all the interactions in the matrices, only four were classified as belonging to the category "External factors". These three interactions are related to human intrusion, earthquakes future climate changes and ice load during glaciation. These four interactions are either already addressed in the process descriptions or covered by NEA Project FEPs. Therefore, these interactions were not further treated.

Eleven of the interactions were classified as belonging to the category "Biosphere". Because of this low number, no further division of these interactions into biosphere sub-categories was made at this stage.

34 of the interactions were found to relate more to a general methodological or design issue than to a process, variable or initial state and were therefore assigned to the category "Methodological comment".

Examples of the documentation contained in the Matrix mapping file are given in Appendix 1.

4 Further processing of FEPs lists

The result of the audit against the NEA Project FEPs and the SKB Interaction matrices was used to create check lists for updating process descriptions for the SR-Can assessment and for the preparation of descriptions of the initial states of the repository system components. In addition, FEP lists from the audit were used as checklists for the handling of external factors as described in the SR-Can Climate report /SKB 2006g/ and the SR-Can FHA report /SKB 2006h/, as well as for the establishment of SKB FEPs for further consideration in the selection of scenarios. The different procedures applied for the post-processing of the audit results are described in this chapter.

4.1 Internal processes

The audit against the NEA Project FEPs and the SKB Interaction matrices, including discussions and decisions made by the FEP group, resulted in a list of proposed internal processes for each system component as well as comments on additions to, or revisions of, the descriptions given in the SR 97 version of the Process Report. These lists of internal processes and comments from the audit were then propagated to the experts responsible for preparing the process descriptions for consideration in their work of structuring the different SR-Can process reports. In addition, lists of all project FEPs in the NEA FEP database and Matrix interactions together with identification of the processes with which they were associated were provided to the experts. These lists were used to ensure that all relevant aspects of a process were addressed in the process description and appropriately handled in SR-Can and the handling of each FEP was documented in the tables created for this purpose.

The results of post-processing of the process lists and the tables with documentation of the handling of NEA Project FEPs and Matrix interactions were documented in the FEP database. Each process was defined as an SKB FEP and was incorporated in the SKB FEP catalogue (see Section 5.3). The documented handling was also added to the FEP database and linked to the SKB FEP in the FEP catalogue. The results for the different system components are further commented upon in the following sections.

4.1.1 Fuel/cavity in canister

Sixteen processes were defined for the system component *Fuel/cavity in canister* in the Fuel and canister process report /SKB 2006d/, and these are in the FEP database represented by FEP record identities F01 to F16 (see Table 5-2 in Section 5.3).

The SR-Can processes for the system component *Fuel/cavity in canister* is essentially the same as those in the SR 97 Process report /SKB 1999b/. One new process has been added, "Structural evolution of the fuel matrix" (F07), which refers to alteration of the fuel structure due to e.g. radiation damage (alpha recoil) and/or high temperature. Another process has been renamed from "Thermal expansion/cladding failure" in the SR 97 Process report /SKB 1999b/ to "Mechanical cladding failure" (F06) in the SR-Can Fuel and canister process report /SKB 2006d/. Furthermore, the SR 97 process "Speciation of corrosion products" has been merged into the canister process "Corrosion of cast iron insert" (C07) in the SR-Can Fuel and canister process report.

The tables documenting the handling of NEA Project FEPs associated with processes in the system component *Fuel/cavity in canister* are given in Appendix 4. These FEP tables are also included in the FEP database and linked to the corresponding FEP records in the SR-Can FEP catalogue. Tables with documentation of the handling of Matrix interactions are also accessible in the FEP database through the FEP records in the FEP catalogue.

4.1.2 Cast iron insert and copper canister

Fifteen processes were defined for the system component *Cast iron insert and copper canister* in the Fuel and canister process report /SKB 2006d/, and these are in the FEP database represented by FEP record identities C01 to C15 (see Table 5-3 in Section 5.3).

For SR-Can, two new processes have been added to the list of SR 97 processes for the system component *Cast iron insert and copper canister*. These are “Earth currents – Stray current corrosion” (C13) and “Deposition of salts on canister surface” (C14). The FEP tables with documentation of the handling of NEA Project FEPs associated with canister processes are given in Appendix 5 and they are also accessible in the FEP database together with tables with documentation of the handling of Matrix interactions associated with canister processes.

4.1.3 Buffer

Twenty-four processes were defined for the system component *Buffer* in the Buffer and backfill process report /SKB 2006e/, and these are in the FEP database represented by FEP record identities Bu01 to Bu24 (see Table 5-4 in Section 5.3).

The main differences compared with the SR 97 list of processes are the addition of a number of new processes and the combination of a number of SR 97 processes. For example, the process “Swelling/Mass redistribution” (Bu08) includes the SR 97 processes “Swelling”, “Mechanical interaction buffer/backfill”, “Mechanical interaction buffer/near-field rock” and “Thermal expansion”. Transport and retardation processes have been modified to describe the behaviour of components in water and gas phases, including radionuclides, while two more general processes specifically addressing the transport of radionuclides in water (Bu23) and gas phase (Bu24), respectively, have been defined. Other new processes compared with the SR 97 process list are: “Freezing” (Bu02), “Piping/erosion” (Bu07), “Liquefaction” (Bu09), “Pore water speciation” (Bu14) and “Osmosis” (Bu15). Some modifications in the SR 97 process names have also been made.

The FEP tables with documentation of how NEA Project FEPs associated with buffer processes are handled are provided in Appendix 6. These tables, as well as tables with documentation of the handling of Matrix interactions associated with buffer processes are also included in the FEP database.

4.1.4 Backfill in deposition tunnels

The system component *Backfill in deposition tunnels* was not included as a separate system in the SR 97 Process Report, but merged together with the buffer system. The similarity between these two system components in regard to processes to be considered in the evolution of the systems is also reflected in the SR-Can list of processes for the system component backfill in deposition tunnels. This list contains twenty-two processes all of which are found also in the SR-Can process list for the buffer. Two buffer processes related to the impact of radiation (Bu01 and Bu19 in Table 5-4) are not included in the list of processes for the backfill for obvious reasons.

The processes defined for the system component *Backfill in deposition tunnels* are in the FEP database represented by FEP record identities BfT01 to BfT22 (see Table 5-5). Two of these SR-Can FEPs are not described in the Buffer and backfill process report /SKB 2006e/. For BfT19, Colloid formation and transport, reference is made to the corresponding process in the Geosphere process report (Ge18 in Table 5-6) and the process BfT22, Transport of radionuclides in the gas phase, is addressed in the Sr-Can Main report /SKB 2006b/ (Section 10.9).

The FEP tables with documentation as to how NEA Project FEPs associated with backfill processes are handled are provided in Appendix 7. These tables, as well as tables with documentation of the handling of Matrix interactions associated with backfill processes, are also included in the FEP database.

4.1.5 Geosphere

Twenty-five processes were defined for the system component *Geosphere* in the Geosphere process report /SKB 2006f/, and these are in the FEP database represented by FEP record identities Ge01 to Ge25 (see Table 5-6 in Section 5.3).

For SR-Can, a number of new processes have been added to the list of SR 97 processes and some of the SR 97 processes have been merged. These latter relate to transport and retardation processes that in SR 97 were duplicated to distinguish radionuclides from solutes in general, but in SR-Can have been modified to describe the behaviour of components in water and gas phases, including radionuclides. In addition, two more general processes that specifically address the transport of radionuclides in the water phase (Ge24) and in the gas phase (Ge25), respectively, have been defined. Other new processes compared with the SR 97 processes are: "Freezing" (Ge02), "Surface weathering and erosion" (Ge09), "Erosion/sedimentation in fractures" (Ge10), "Radiation effects (rock and grout)" (Ge22) and "Earth currents" (Ge23). Furthermore, some modifications to the SR 97 process names have been made for the SR-Can version.

The FEP tables with documentation of how NEA Project FEPs associated with geosphere processes are handled are provided in Appendix 8. These tables, as well as tables with documentation of the handling of Matrix interactions associated with geosphere processes, are also included in the FEP database.

4.1.6 Remaining system components

The remaining system components *Bottom plate in deposition hole, Backfill of other repository cavities*, *Plugs* and *Borehole seals* were not considered in the SR 97 process report and are not treated in detail in SR-Can. Provisional process lists for these system components have been developed based on the outcome of the FEP audit and the processes identified for the system components analysed in SR-Can. For example, one assumption in SR-Can is that the same backfill material will be used in other repository cavities as in the deposition tunnels. This is reflected in the provisional process list for the system component *Backfill of other repository cavities* being identical to the process list for the system component *Backfill of deposition tunnel.*

Despite the proposed lists of processes for the system components not treated in detail in SR-Can being very preliminary, provisional SKB FEPs for these processes have been defined and entered into the SR-Can FEP catalogue. Tables listing all these FEPs are provided in Appendix 11. These provisional FEPs with their links to relevant NEA Project FEPs and Matrix interactions will be the starting point for further processing by experts in order to arrive at a final list of processes for these system components for consideration in SR-Site.

4.2 Initial states

All NEA Project FEPs and Matrix interactions classified as relevant for the initial state of the different repository components were compiled in lists for further processing, with the purpose of deciding how these should be handled in the SR-Can assessment. The processing of these lists was carried out jointly by the following persons: Allan Hedin, SKB, Johan Andersson, JA StreamFlow, Kristina Skagius and Karin Pers, Kemakta.

Initial state FEPs are related either to expected conditions within acceptable variations/ tolerances, denoted the reference initial state in SR-Can, or to deviations from these expected conditions. The former group of NEA Project FEPs and Matrix interactions was considered in the description of the initial states of the system components and the latter in the selection and definition of scenarios for repository evolution. In the FEP processing, all NEA Project FEPs and Matrix interactions in the list were documented as relevant for the reference initial state or for deviations in initial state together with additional comments arising during the processing. Thus, the outcome of this FEP processing was a checklist for the description of the reference initial states of the repository system and a checklist for consideration in scenario selection.

The checklist of NEA Project FEPs and Matrix interactions relevant to the reference initial state was further handled in the process of developing the descriptions of the initial states of the repository system components as documented in the SR-Can Initial state report /SKB 2006c/. The handling was documented in tables created for this purpose and added to the SKB FEP database with a link to the appropriate Variable FEP record in the SR-Can FEP catalogue (see Section 5.4).

The checklist of NEA Project FEPs and Matrix interactions relevant to deviations in the initial state was further processed, resulting in the definition of SR-Can Initial state FEPs for further consideration. These FEPs are related to deviations from the intended reference initial state of the canister, the buffer and the backfill of the deposition tunnels, or to more general deviations, and are included in the SR-Can FEP catalogue with FEP record identity starting IS and followed by a letter code, e.g. Gen for general deviations in initial state and Bu for buffer (Table 5-1 in Section 5.2).

In the further processing, it was decided to exclude two of the SR-Can FEPs of more general character from scenario selection. One of them (ISGen01) is related to severe perturbations like fire, explosions, sabotage and severe flooding (ISGen01). The reasons for excluding this FEP are i) the probabilities for such events are low and ii) if they occur, this will be known prior to repository sealing so that mitigation measures and assessment of possible effects on long-term safety can be based on the specific real event. It was also noted that probabilities for these types of events will depend on technical solutions and handling procedures and therefore will be dependent on the, not yet finalised, selection of these solutions and procedures. The other FEP excluded is related to effects detrimental to long-term safety caused by monitoring activities (ISGen04). This FEP was excluded from further analysis because this type of monitoring will not be accepted.

Another FEP in the SR-Can FEP catalogue refers the effects of phased operation (ISGen02). This affects mainly the geosphere and the subsequent development of the entire repository. The hydrological state of the bedrock is perturbed as soon as repository excavation starts (a smaller perturbation even occurs earlier during site investigations). Different parts of the repository, completed at different times, will be exposed to different hydrological conditions, affecting e.g. the saturation of the buffer and backfill. Possible upconing of saline water could also vary between different parts of the repository due to phased operation. Other factors to consider are the effects of blasting and underground traffic on completed parts of the repository. All these issues are part of the expected evolution of the repository, but are not automatically captured in the system of processes describing repository evolution over time or by the initial state descriptions. As they need to be adequately included in the discussion of repository evolution, they were propagated to the analysis of the reference evolution (see SR-Can Main report /SKB 2006b/, Section 4.1.2).

The last initial state FEP of more general character in the FEP catalogue concerns the effects of an unsealed or abandoned or monitored repository (ISGen03). These issues were propagated to scenario selection

The remaining initial state FEPs in the SR-Can FEP catalogue relate to deviations in design of the different system components due to undetected mishaps during manufacture, transportation, deposition and repository operations etc. These issues were propagated to scenario selection and scenario analyses (see SR-Can Main report /SKB 2006b/, Section 4.1.2).

The FEP tables with documentation of how NEA Project FEPs sorted to Initial state FEPs are handled are provided in Appendix 3. These tables as well as tables with documentation of the handling of Matrix interactions sorted to Initial state FEPs are also included in the FEP database.

4.3 External factors

As described in Section 3.1.4, NEA Project FEPs and Matrix interactions defined as External factors to the repository system were classified into the following four categories: “Climate processes and effects”, “Geological processes and effects”, “Future Human Actions”, and “Others”.

In the processing of the list of FEPs in the different categories of External FEPs, climate and large-scale geological FEPs were compared against the plans for modelling these phenomena, and FEPs related to future human actions were compared with the handling in SR 97 /SKB 1999a/, which formed the basis for the handling in SR-Can. This audit was carried out by Allan Hedin and Lena Morén, SKB, Johan Andersson, JA Streamflow, and Karin Pers, Kemakta. Further processing and documentation of the handling of these lists of FEPs was carried out by the different experts assigned to the task.

4.3.1 Climatic processes and effects

Climate issues and their handling in SR-Can are described in the SR-Can Climate report /SKB 2006g/. The list of NEA project FEPs associated with the category Climatic processes and effects was used by the experts responsible for developing the Climate report to ensure and to demonstrate that all relevant aspects were addressed in the descriptions of climate issues and appropriately handled in SR-Can.

Each NEA Project FEP was associated with climate issues/processes described in the Climate report /SKB 2006e/ and the handling of each FEP was documented in tables created for this purpose. Each climate issue/process was defined as an SKB FEP and was incorporated in the SKB FEP catalogue. The documented handling was also added to the FEP database and linked to the SKB FEP in the FEP catalogue.

Ten Climate FEPs were defined to represent the climate issues described in the SR-Can Climate report (see Table 5-10 in Section 5.6). The FEP tables with documentation of how NEA Project FEPs sorted to climate issues are handled are provided in Appendix 9. These tables are also included in the FEP database.

4.3.2 Large-scale geological processes and effects

NEA Project FEPs associated with this category are related to natural tectonic events such as uplift and plate movements. Such large-scale geological processes occurring in the past and currently ongoing and their impact on the current mechanical state of the Baltic Shield and the repository rock are described in the Geosphere process report /SKB 2006f/.

In order to cover these large-scale geological processes in the SR-Can FEP catalogue, two FEPs were defined; “Mechanical evolution of the Shield” (LSGe01) and “Earthquakes” (LSGe02) (see also Table 5-11 in Section 5.6). NEA project FEPs classified as large-scale geological processes were assigned to these two SR-Can FEPs and it was checked that relevant aspects of these NEA Project FEPs were covered in the descriptions of these large-scale processes provided in the Geosphere process report /SKB 2006f/. This check was documented in table format and these tables are provided in Appendix 9.

4.3.3 Future Human Actions

The NEA Project FEPs associated with the category Future Human Actions, FHA, are related to actions like rock drilling, mining, severe pollution, underground excavations in relation to urbanisation, and intentional or inadvertent repository intrusion. As mentioned above, these FEPs were audited against the results of the analyses of scenarios based on future human actions carried out in the SR 97 assessment /SKB 1999a/. This audit revealed that the majority of the identified NEA Project FEPs were included already in the SR 97 analyses.

A more formal check was conducted in connection with the preparation of the SR-Can FHA report /SKB 2006h/, which essentially is an update of the SR 97 documentation of the handling of FHA. All NEA Project FEPs categorised as related to FHA were sorted to different sections in the SR-Can FHA report and the handling of these FEPs in SR-Can was documented in tables produced for this purpose. These tables are provided in Appendix 9. Based on the structure of the SR-Can FHA report, seven SR-Can FEPs were defined (FEP identities FHA01 to FHA07, see Table 5-12 in Section 5.6) and included in the SR-Can catalogue.

4.3.4 Others

All NEA Project FEPs sorted to this group were related to meteorites and their impacts on repository performance. As mentioned earlier, meteorite impact was excluded from further analysis in SR-Can with the justification that the probability that a meteorite, large enough to damage the repository, will impact close to, or within, the footprint of the repository can be demonstrated to be extremely low. Furthermore, the direct effects of the event, namely a destruction of the local or regional biosphere including humans, are considered to be much more severe than its possible radiological consequences. For documentation purposes, meteorite impact was defined as a FEP in the SR-Can FEP catalogue (Oth01 Meteorite impact) and the FEP tables containing the documentation of the handling of NEA Project FEPs associated with this SR-Can FEP were linked to the SR-Can FEP record in the database. In addition, the justification for excluding this FEP from further analysis is documented in the FEP record in the SR-Can FEP catalogue.

4.4 Biosphere FEPs

NEA Project FEPs that, in the FEP audit, were classified as relevant for the biosphere are currently (October 2006) being considered in conjunction with the development of a process report for the biosphere. For documentation and traceability reasons, provisional Biosphere FEPs have been defined and included in the SR-Can FEP catalogue (see Section 5.5), awaiting the completion of the biosphere process report and the documentation of the results of the check of the NEA Project FEPs. These provisional SR-Can FEPs correspond to the sub-categories defined for sorting of NEA Project FEPs and Matrix interactions during the FEP audit (see Section 3.1.4). Once the biosphere process report is completed, the FEP catalogue will be updated with FEP records corresponding to the biosphere processes documented in the biosphere process report.

4.5 Methodological issues

A large number of the NEA Project FEPs are related to basic assumptions for the assessment and to the methodology adopted for the assessment. Most of them are of a very general nature and it could be argued that these issues are not FEPs in the sense that they affect the future evolution of a repository. However, for the sake of comprehensiveness, these issues were also propagated to the SR-Can FEP catalogue.

Two SR-Can FEPs were defined and included in the SR-Can FEP catalogue; Assessment basis (Meth01) and Assessment methodology (Meth02), i.e. one FEP for each category to which NEA Project FEPs and Matrix interactions were assigned during the FEP audit (see Section 3.1.5). NEA Project FEPs and Matrix interactions assigned to these two SR-Can FEPs were used as checklists for the basic assumptions in the SR-Can assessment and the assessment methodology and the result is documented in the SKB FEP database and linked to the SR-Can FEP records in the SR-Can FEP catalogue.

Only a few NEA Project FEPs (nine) were categorised as belonging to the assessment basis and none of them are considered in SR-Can. One sub-group of these FEPs relates to biological evolution that might lead to other effects of radiation in the future compared with today. Such effects are impossible to predict. It is, though, highly likely that man and biota in the future will be exposed to similar levels of natural background radiation as today. Therefore, it is unreasonable to assume that evolution would lead to higher sensitivity to radiation.

Another sub-group of FEPs relate to changes in society's ability to treat cancer or its view on radiation hazards, as reflected by regulatory dose or risk limits. It is likely that more effective cures for cancer will be developed, maybe even in the near future. However, since this is speculative, it cannot be taken credit for in the safety assessment. Furthermore, the compliance discussion in a safety assessment must be related to regulatory criteria that apply today.

Finally, some of the FEPs relate to issues that are properly addressed in an environmental impact assessment rather than in the safety assessment.

A large number of NEA Project FEPs (102) were assigned to the SR-Can FEP Assessment methodology. Many of these FEPs are related to data and modelling issues such as correlations and uncertainties, design issues and implementation of various features in the modelling. Most of these issues are handled in SR-Can.

5 The SR-Can FEP catalogue

Based on the FEP processing described in the previous chapters, an SR-Can FEP catalogue has been established. This catalogue contains all FEPs defined for the SR-Can assessment and it is the core of the SKB FEP database. In addition to the SR-Can FEP catalogue, the SKB FEP database also contains the sources used in the FEP processing (NEA Project FEPs, SR 97 processes, SR 97 Matrix interactions) and various registers for documentation of the FEP processing results (see Figure 2-2 in Section 2.3.1). However, all relevant documentation is contained in or can be accessed from the SR-Can FEP catalogue. The content of the SR-Can catalogue and the information it provides are described in this chapter. Instructions on how to navigate in the electronic version of the SKB FEP database are given in Appendix 1. The electronic version of the FEP database is provided on the enclosed CD.

5.1 General

The SR-Can FEP catalogue contains FEPs for the following categories.

- Initial state FEPs.
- Processes in fuel, canister, buffer, backfill and geosphere.
- Variables associated with fuel, canister, buffer, backfill and geosphere.
- Biosphere FEPs (provisional).
- External FEPs.
- Methodological issues.

The FEP catalogue also contains preliminary FEPs for system components that are not treated in detail in SR-Can. These components are tunnel plugs, backfill materials for cavities other than the deposition tunnels, the bottom plates in the deposition holes and borehole seals. These components are treated using simplifying assumptions in SR-Can and the handling will be developed to a more comprehensive level in SR-Site.

In addition, the catalogue contains a category of FEPs defined as Site-specific factors, which consists of issues specifically related to the sites and of potential relevance for the SR-Can assessment. These are factors that e.g. were identified in the preliminary safety evaluation of the sites /SKB 2005b, SKB 2006j/.

In the FEP catalogue, each SR-Can FEP is represented by a FEP record containing the SR-Can FEP ID, the FEP name, a short description/definition, a summary of the handling of the FEP in SR-Can and references to reports where more extensive documentation of the FEP and its handling are to be found. An example is given in Figure 5-1. More FEP-type specific information is also accessible through the FEP records. This is further discussed in the following sections.

In total, the SR-Can FEP catalogue contains 280 FEP records, of which 86 are provisional FEPs associated to the biosphere (6) and to the system components not treated in detail in SR-Can (80).

Figure 5-1. Print-out from the SR-Can FEP catalogue to illustrate the basic information available for each SR-Can FEP.

5.2 Initial state FEPs

The initial state FEPs in the SR-Can FEP catalogue are related to deviations from the intended reference initial state of the canister, the buffer and the backfill of the deposition tunnels, or to more general deviations. These FEPs are listed in Table 5-1. Initial state FEPs in the SR-Can FEP catalogue that are related to the reference initial state are handled in the category "variables" in the SR-Can FEP catalogue (see Section 5.4).

As mentioned in Section 4.2, two of these FEPs (ISGen01 and ISGen04) are excluded from the assessment. This and the reason for exclusion are documented in the FEP records. The remainder of the more general FEPs and the initial state FEPs for the canister, buffer and backfill were propagated to the scenario selection and scenario analysis in SR-Can. The handling of these FEPs in the analysis is documented in the FEP record and reference is given to appropriate section in the SR-Can Main report /SKB 2006b/ where the handling is described.

The FEP catalogue also contains initial state FEPs for the system components concrete bottom plate in the deposition holes, plugs in repository tunnels, backfill in other repository cavities and borehole seals. These system components are not specifically addressed in SR-Can, but the consequences of deviations in initial state of these system components are covered by simple bounding calculations undertaken in the SR-Can assessment. This is documented in the FEP records and reference is given to the section in the SR-Can Main report where these bounding calculations are reported.

Table 5-1. Initial state FEPs in the SR-Can FEP catalogue.

SR-Can FEP ID	SR-Can FEP name	Description
ISGen01	Major mishaps/accidents/ sabotage	Major mishaps/accidents like fire, explosions, earthquakes and flooding in encapsulation plant, during transport and repository operation. Possible decontamination following severe mishap. Ditto sabotage (chemical, physical etc), improper management
ISGen02	Effects of phased operation	Phased operation mainly affects the geosphere and the subsequent development of the entire repository. The hydrological state of the bedrock is perturbed as soon as repository excavation starts (a smaller perturbation even occurs earlier during site investigations). Different parts of the repository, completed at different times, will be exposed to different hydrological conditions, affecting e.g. the saturation of the buffer and backfill. Possible upconing of saline water could also vary between different parts of repository due to phased operation. Other factors to consider are the effects of blasting and underground traffic on completed parts of the repository. All these issues are part of the expected evolution of the repository, but are not automatically captured in the system of processes describing the repository evolution over time or by the initial state descriptions. As they need to be adequately included in the discussion of the repository evolution, they are propagated to the analysis of the reference evolution.
ISGen03	Incomplete closure	Concerns the effects of an unsealed, abandoned repository.
ISGen04	Monitoring activities	Implications of monitoring activities, including underground monitoring boreholes, on long-term safety.
ISC01	Mishaps – canister	Concerns mishandling and breakage of canisters during manufacture, sealing, transport and deposition. Random defects are considered, despite quality control in manufacturing and sealing. A number of defects may be related by a common cause, despite quality control in manufacturing and sealing.
ISC02	Design deviations – canister	Welding or material defects (geometry, material composition). E.g. loss of ductility due to impurities in the copper material or bad manufacturing methods or "Cold cracks" due to bad manufacturing methods. Random defects despite quality control in manufacturing and sealing. A number of defects may be related by a common cause, despite quality control in manufacturing and sealing.
ISBu01	Mishaps – buffer	Faulty or deviating buffer emplacement caused by e.g. difficulties due to inflow, problems with remote control handling, etc leading to e.g. inhomogeneous buffer and/or reduced density.
ISBu02	Design deviations – buffer	Deviations in buffer properties despite quality control.
ISBfT01	Mishaps – backfill of deposition tunnels	Faulty or deviating backfill emplacement due to e.g. difficulties due to inflow, etc leading to e.g. inhomogeneous backfill.
ISBfT02	Design deviations – backfill of deposition tunnels	Deviations in backfill properties despite quality control.
ISBP01	Mishaps – bottom plate in deposition holes	Faulty or deviating emplacement of bottom plate in deposition holes.
ISBP02	Design deviations – bottom plate in deposition holes	Deviations in structural material (concrete bottom "plate") properties despite quality control.
ISBfO01	Mishaps – backfill of other repository cavities	Faulty or deviating backfill emplacement due to e.g. difficulties due to inflow, etc leading to e.g. inhomogeneous backfill.
ISBfO02	Design deviations – backfill of other repository cavities	Deviations in backfill properties despite quality control.
ISPg01	Mishaps – plugs	Faulty or deviating emplacement of plugs.
ISPg02	Design deviations – plugs	Deviations in plug properties despite quality control.
ISBhS01	Mishaps/Design deviations – borehole seals	Faulty or deviating emplacement of borehole seals and deviations in properties despite quality control.

Other information accessed via the Initial state FEP records in the FEP catalogue is lists of NEA Project FEPs and Matrix interactions associated with each SR-Can FEP and if and how these are addressed by the SR-Can FEP, including the documentation related to the FEP. These FEP tables showing the handling of the NEA Project FEPs are provided in Appendix 3. How this information is accessed in the SR-Can FEP catalogue in the SKB FEP database is described in Appendix 1.

5.3 Process FEPs

All processes included in the SR-Can process reports are represented by a FEP record in the SR-Can FEP catalogue. The SR-Can FEP ID and a reference to the corresponding process description for all process FEPs are given in Table 5-2 (Fuel processes), Table 5-3 (Canister processes), Table 5-4 (Buffer processes), Table 5-5 (Backfill processes and in Table 5-6 (geosphere processes). This information is included in the FEP records in the FEP-catalogue together with a few lines describing the process and the handling in SR-Can as provided in the summary tables in the introductory chapters in the SR-Can process reports.

As for the Initial state FEPs, lists of NEA Project FEPs and Matrix interactions associated with the SR-Can Process FEPs are linked to the SR-Can FEP records as are also tables with documentation of the handling of the linked NEA Project FEPs and Matrix interactions. These FEP tables showing the handling of NEA Project FEPs as documented in the FEP database are provided in Appendices 4 through 8.

Table 5-2. SR-Can process FEPs for the system component Fuel/cavity in canister and reference to the corresponding process description in the SR-Can Fuel and canister process report /SKB 2006d/.

SR-Can FEP ID	SR-Can FEP name	Section in SR-Can process report
F01	Radioactive decay	2.1.1
F02	Radiation attenuation/heat generation	2.1.2
F03	Induced fission (criticality)	2.1.3
F04	Heat transport	2.2.1
F05	Water and gas transport in canister cavity, boiling/condensation	2.3.1
F06	Cladding failure	2.4.1
F07	Structural evolution of fuel matrix	2.4.2
F08	Advection and diffusion	2.5.1
F09	Residual gas radiolysis/acid formation	2.5.2
F10	Water radiolysis	2.5.3
F11	Metal corrosion	2.5.4
F12	Fuel dissolution	2.5.5
F13	Dissolution of gap inventory	2.5.6
F14	Speciation of radionuclides, colloid formation	2.5.7
F15	Helium production	2.5.8
F16	Radionuclide transport	2.6

Table 5-3. SR-Can process FEPs for the system component Cast iron insert and copper canister and reference to the corresponding process description in the SR-Can Fuel and canister process report /SKB 2006d/.

SR-Can FEP ID	SR-Can FEP name	Section in SR-Can process report
C01	Radiation attenuation/heat generation	3.1.1
C02	Heat transport	3.2.1
C03	Deformation of cast iron insert	3.4.2
C04	Deformation of copper canister from external pressure	3.4.3
C05	Thermal expansion (both cast iron insert and copper canister)	3.4.4
C06	Copper deformation from internal corrosion products	3.4.5
C07	Corrosion of cast iron insert	3.5.1
C08	Galvanic corrosion	3.5.2
C09	Stress corrosion cracking of cast iron insert	3.5.3
C10	Radiation effects	3.4.6
C11	Corrosion of copper canister	3.5.4
C12	Stress corrosion cracking, copper canister	3.5.5
C13	Earth currents – Stray current corrosion	3.5.6
C14	Deposition of salts on canister surface	3.5.7
C15	Radionuclide transport	3.6

Table 5-4. SR-Can process FEPs for the system component Buffer and reference to the corresponding process description in the SR-Can Buffer and backfill process report /SKB 2006e/.

SR-Can FEP ID	SR-Can FEP name	Section in SR-Can process report
Bu01	Radiation attenuation/heat generation	2.1.1
Bu02	Heat transport	2.2.1
Bu03	Freezing	2.2.2
Bu04	Water uptake and transport for unsaturated conditions	2.3.1
Bu05	Water transport for saturated conditions	2.3.2
Bu06	Gas transport/dissolution	2.3.3
Bu07	Piping/erosion	2.3.4
Bu08	Swelling/mass redistribution	2.4.1
Bu09	Liquefaction	2.4.2
Bu10	Advection	2.5.2
Bu11	Diffusion	2.5.3
Bu12	Sorption (including ion-exchange)	2.5.5
Bu13	Alterations of impurities	2.5.6
Bu14	Pore water speciation	2.5.7
Bu15	Osmosis	2.5.8
Bu16	Montmorillonite transformation	2.5.9
Bu17	Colloid release	2.5.10
Bu18	Radiation-induced transformations	2.5.11
Bu19	Radiolysis of pore water	2.5.12
Bu20	Microbial processes	2.5.13
Bu21	Colloid transport	2.5.4
Bu22	Speciation of radionuclides	2.5.14
Bu23	Transport of radionuclides in the water phase	2.6.1
Bu24	Transport of radionuclides in the gas phase	2.6.2

Table 5-5. SR-Can process FEPs for the system component Backfill in deposition tunnels and reference to the corresponding process description in the SR-Can Buffer and backfill process report /SKB 2006e/.

SR-Can FEP ID	SR-Can FEP name	Section in SR-Can process report
BfT01	Heat transport	3.1.1
BfT02	Freezing	3.1.2
BfT03	Water uptake and transport for unsaturated conditions	3.2.1
BfT04	Water transport for saturated conditions	3.2.2
BfT05	Gas transport/dissolution	3.2.3
BfT06	Piping/erosion	3.2.4
BfT07	Swelling/mass redistribution	3.3.1
BfT08	Liquefaction	3.3.2
BfT09	Advection	3.4.1
BfT10	Diffusion	3.4.2
BfT11	Sorption (including ion-exchange)	3.4.3
BfT12	Alterations of impurities	3.4.4
BfT13	Pore water speciation	3.4.5
BfT14	Osmosis	3.4.6
BfT15	Montmorillonite transformation	3.4.7
BfT16	Colloid release	3.4.8
BfT17	Radiation-induced transformations	3.4.9
BfT18	Microbial processes	3.4.10
BfT19	Colloid formation and transport	– [1)]
BfT20	Speciation of radionuclides	3.4.11
BfT21	Transport of radionuclides in the water phase	3.4.12
BfT22	Transport of radionuclides in the gas phase	– [2)]

[1)] This process is not specifically addressed in the Buffer and backfill process report, but the corresponding process is described in the Geosphere process report, see Ge18 in Table 5-6.

[2)] This process is not specifically addressed in the Buffer and backfill process report, but in Section 10.9 in the SR-Can Main report /SKB 2006b/.

Concerning the documentation of the handling of NEA Project FEPs and Matrix interactions mapped to SR-Can processes, the priority of the different experts involved in this procedure has been on the documentation of the handling of NEA Project FEPs. As a consequence, the documentation of the handling of Matrix interactions is not complete for all processes in the SR-Can catalogue. Even though this formal check is lacking, it is judged that all important aspects related to these interactions have been addressed in the SR-Can process descriptions, since these interactions were input to the development of the SR 97 process descriptions, which in turn are one of the sources to the current SR-Can descriptions.

Within a system component, each process is influenced by one or several of the variables describing the state of the component, and the process, in turn, influences one or several of the variables. These couplings within a system component are described by influence tables, one for each process, in the process reports. These influence tables have been included in the SKB FEP database. Based on these influence tables, process diagrams are automatically generated for each process and for each system component in the FEP database. The process diagram for a system component essentially takes the form of a table with the processes as rows and the variables as columns. The table matrix consists of arrows describing the influences between processes and variables.

Table 5-6. SR-Can process FEPs for the system component Geosphere and reference to the corresponding process description in the SR-Can Geosphere process report /SKB 2006f/.

SR-Can FEP ID	SR-Can FEP name	Section in SR-Can process report
Ge01	Heat transport	2.1
Ge02	Freezing	2.2
Ge03	Groundwater flow	3.1
Ge04	Gas flow/dissolution	3.2
Ge05	Displacements in intact rock	4.2
Ge06	Reactivation – Displacement along existing discontinuities	4.3
Ge07	Fracturing	4.4
Ge08	Creep	4.5
Ge09	Surface weathering and erosion	4.6
Ge10	Erosion/sedimentation in fractures	4.7
Ge11	Advection/mixing	5.2
Ge12	Diffusion and matrix diffusion	5.3
Ge13	Speciation and sorption	5.4
Ge14	Reactions groundwater/rock matrix	5.5
Ge15	Dissolution/precipitation of fracture-filling minerals	5.6
Ge16	Microbial processes	5.7
Ge17	Degradation of grout	5.8
Ge18	Colloid formation and transport	5.9
Ge19	Formation/dissolution/reaction of gaseous species	5.10
Ge20	Methane hydrate formation	5.11
Ge21	Salt exclusion	5.12
Ge22	Radiation effects (rock and grout)	5.13
Ge23	Earth currents	5.14
Ge24	Transport of radionuclides in the water phase	6.1
Ge25	Transport of radionuclides in the gas phase	6.2

Both the process diagrams and the underlying influence tables are accessible via the process FEP records in the FEP catalogue. An example is given in Figure 5-2, which shows the process diagram for the fuel process Radiation attenuation/heat generation (F02). The presence of an arrow or not and its colouring are automatically generated based on the contents of the influence tables. In general, these tables are clear concerning whether there is an influence or not, which determines the presence or absence of an arrow in the process diagram. The colouring is not that straightforward from the contents of the influence tables. A green arrow means that the influence is neglected and a red arrow represents an influence that is handled in SR-Can. Non-coloured arrows represents influences that are not handled at all. It is not totally clear in all cases from the text in the influence tables if the influence is handled or neglected. This means that there are some uncertainties connected to the colour-coding of the arrows in the process diagrams. Clearer instructions to the experts responsible for the development of the influence tables would have reduced these uncertainties. This will be considered when updating the process reports for the SR-Site assessment.

Provisional process FEPs for the system components not specifically addressed in SR-Can are also included in the SR-Can FEP catalogue. These provisional FEPs are listed in Appendix 11. Lists of NEA Project FEPs and Matrix interactions associated with these provisional FEPs are linked to the FEP records, and so are the tables for documentation of their handling, even if these tables currently do not contain any information. The future handling of this information in the FEP catalogue is coupled to the need for developing process reports covering these additional system components not addressed in SR-Can. This will be assessed in the planning of the SR-Site project.

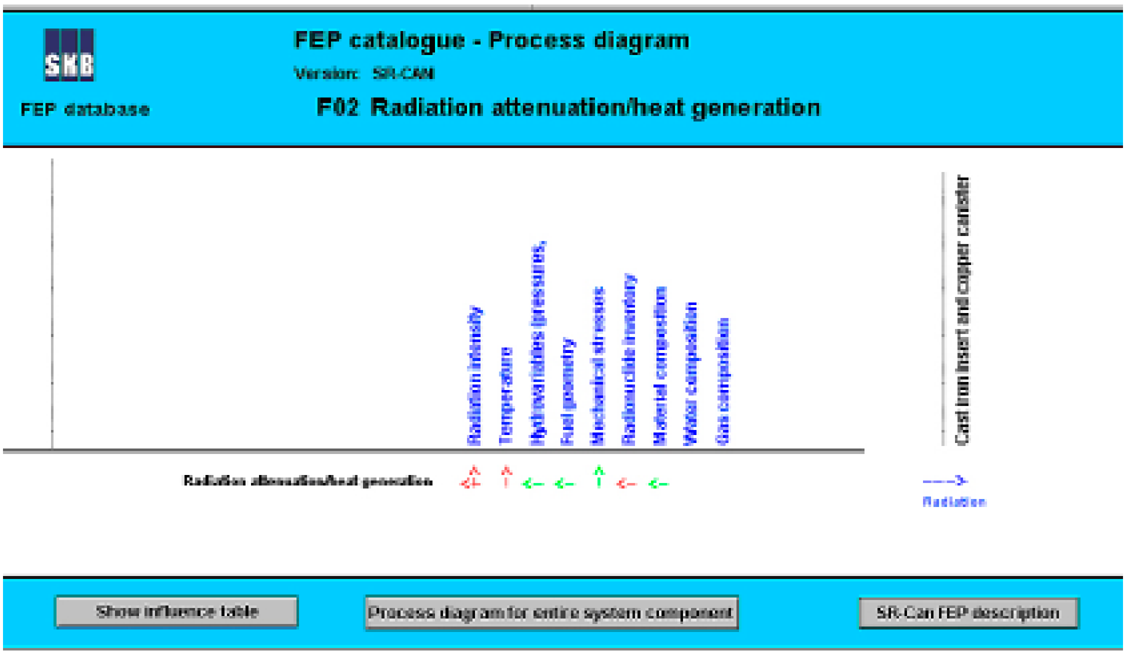

***Figure 5-2.** Example of a process diagram generated in the FEP database and accessible from the FEP records in the SR-Can FEP catalogue.*

5.4 Variables

These FEPs are the variables needed to describe the evolution of the state of the fuel, canister, buffer, backfill and geosphere over time. They are thus essentially tables with definitions. The identification of variables has been made by the experts responsible for the documentation of the processes relevant to long-term safety. The sets of variables were established in conjunction with the documentation of the processes, since it had to be ensured that the variable sets were suited to describing all conceivable alterations of the barrier properties as a result of the long-term processes.

Nine variables are defined for the system component "Fuel/cavity in canister" and five for the system component "Cast iron insert and copper canister". The corresponding number of variables for the system components "Buffer" and "Backfill in deposition tunnels" are twelve and ten, respectively, whereas thirteen variables are defined for the system component "Geosphere". The SR-Can FEP identity, FEP name and definition of these variables are given in Table 5-7 to Table 5-9. These definitions are also provided in the SR-Can Initial state report for the engineered barrier systems /SKB 2006c/ and in the SR-Can process reports. It should be noted that the FEP catalogue and the Initial state report also include and describe the system components not treated in detail in SR-Can, i.e. the "bottom plate in the deposition hole", "plugs", "borehole seals" and "backfill of other repository cavities", but no descriptions of processes for these system components are yet developed. In order to be able to capture potential impacts on the buffer from the bottom plate in deposition holes, a somewhat modified description of the buffer variable "Structural and stray materials" was used in the Buffer and backfill process report compared with that used in the Initial state report and in the FEP database (see note for VarBu12 in Table 5-8).

The variable FEPs are either related to the reference initial state of the system components or to the evolution in states as a result of on-going processes. This is also reflected in the NEA Project FEPs and Matrix interactions associated with the SR-Can variables. The documentation of the handling of these aspects linked to the SR-Can variables is therefore of two kinds, where one relates to the aspects being addressed in the description of the initial state and the other to the impact of system processes on the state. Documentation relating to the initial state was made in cooperation with the person responsible for developing the description of the reference initial state (Karin Pers, Kemakta Konsult), whereas documentation of the impact of processes were made by the person responsible for the FEP database (Kristina Skagius) based on the documented handling of processes provided by the experts developing the process descriptions. As for other FEP records in the SR-Can FEP catalogue, these tables, together with the documented handling, are accessible via the FEP records. In addition, each variable record contains a reference to the description of the reference initial state for that variable. For the engineered barrier system, this reference is to the appropriate section in the Initial state report. For variables in the geosphere system, reference is given to the section in the SR-Can Data report /SKB 2006i/ where data for this variable are assessed.

The FEP tables with documentation of how NEA Project FEPs sorted to variable FEPs are handled are provided in Appendix 10. These tables as well as tables with documentation of the handling of Matrix interactions associated with the geosphere processes are also included in the FEP database.

Table 5-7. SR-Can variable FEPs for the system components "Fuel/cavity in canister" and "Cast iron insert and copper canister" as defined in the FEP catalogue, as well as in the Fuel and canister process report /SKB 2006d/ and the SR-Can Initial state report /SKB 2006c/.

SR-Can FEP ID	SR-Can FEP name	SR-Can definition
VarF01	Radiation intensity	Intensity of α-, β-, γ- and neutron radiation as a function of time and space in the fuel assembly.
VarF02	Temperature	Temperature as a function of time and space in the fuel assembly.
VarF03	Hydrovariables (pressures, volumes and flows)	Flows, volumes and pressures of water and gas as a function of time and space in the cavities in the fuel and the canister.
VarF04	Fuel geometry	Geometric dimensions of all components of the fuel assembly, such as fuel pellets and Zircaloy cladding. Also includes the detailed geometry, including cracking, of the fuel pellets.
VarF05	Mechanical stresses	Mechanical stresses as a function of time and space in the fuel assembly.
VarF06	Radionuclide inventory	Occurrence of radionuclides as a function of time and space in the different parts of the fuel assembly. The distribution of the radionuclides in the pellets between matrix and surface is also described here.
VarF07	Material composition	The materials of which the different components in the fuel assembly are composed, excluding radionuclides.
VarF08	Water composition	Composition of water (including any radionuclides and dissolved gases) in the fuel and canister cavities.
VarF09	Gas composition	Composition of gas (including any radionuclides) in the fuel and canister cavities.
VarC01	Radiation intensity	Intensity of α-, β-, γ- and neutron radiation as a function of time and space in the canister components.
VarC02	Temperature	Temperature as a function of time and space in the canister components.
VarC03	Canister geometry	Geometric dimensions for the canister components. This also includes a description of any fabrication defects in welds etc.
VarC04	Material composition	Material composition of the canister components.
VarC05	Mechanical stresses	Mechanical stress as a function of time and space in the canister components.

Table 5-8. SR-Can variable FEPs for the system components “Buffer” and “Backfill in deposition tunnels” as defined in the FEP catalogue, as well as in the Buffer and backfill process report /SKB 2006e/ and the SR-Can Initial state report /SKB 2006c/.

SR-Can FEP ID	SR-Can FEP name	SR-Can definition
VarBu01	Radiation intensity	Intensity of (α-,β-),γ- and neutron radiation as a function of time and space in buffer.
VarBu02	Temperature	Temperature as a function of time and space in buffer.
VarBu03	Water content	Water content as a function of time and space in buffer.
VarBu04	Gas content	Gas contents (including any radionuclides) as a function of time and space in buffer.
VarBu05	Hydrovariables (pressures and flows)	Flows and pressures of water and gas as a function of time and space in buffer.
VarBu06	Buffer geometry	Geometric dimensions for buffer. A description of e.g. interfaces on the inside towards the canister and on the outside towards the geosphere.
VarBu07	Pore geometry	Pore geometry as a function of time and space in buffer. The porosity, i.e. the fraction of the volume that is not occupied by solid material, is often given.
VarBu08	Stress state	Stress conditions as a function of time and space in buffer.
VarBu09	Bentonite composition	Mineralogical/chemical composition of the bentonite (including any radionuclides) in time and space in buffer. Levels of impurities in time and space in buffer. Impurities also include minerals, other than montmorillonite.
VarBu10	Montmorillonite composition	Mineralogical composition and structure of the montmorillonite mineral in the bentonite. This variable also includes the charge compensating cations attached to the montmorillonite surface.
VarBu11	Pore water composition	Composition of the pore water (including any radionuclides and dissolved gases) in time and space in buffer.
VarBu12	Structural and stray materials	Chemical composition and quantity of structural and stray materials. Note: In SR-Can buffer and backfill process report, structural and stray materials is defined as the concrete bottom in the deposition hole. The reason is to capture any impact on the buffer from this system component, as it is not handled in detail in SR-Can.
VarBfT01	Temperature	Temperature as a function of time and space in backfill in deposition tunnels.
VarBfT02	Water content	Water content as a function of time and space in backfill in deposition tunnels.
VarBfT03	Gas content	Gas content (including any radionuclides) as a function of time and space in backfill in deposition tunnels.
VarBfT04	Hydrovariables (pressures and flows)	Flows and pressures of water and gas as a function of time and space in backfill in deposition tunnels.
VarBfT05	Backfill geometry	Geometric dimensions for backfill in deposition tunnels. A description of e.g. interfaces towards buffer and towards the geosphere.
VarBfT06	Backfill pore geometry	Pore geometry as a function of time and space in backfill in deposition tunnels. The porosity, i.e. the fraction of the volume that is not occupied by solid material, is often given.
VarBfT07	Stress state	Stress state as a function of time and space in backfill in deposition tunnels.
VarBfT08	Backfill materials - composition and content	Chemical composition and content of the backfill in deposition tunnels (including any radionuclides) in time and space. This variable also includes material sorbed to the surface.
VarBfT09	Backfill pore water composition	Composition of the pore water (including any radionuclides and dissolved gases) in time and space in backfill in deposition tunnels.
VarBfT10	Structural and stray materials	Chemical composition and quantity of structural materials (rock bolts, filling material in boreholes for grouting, nets etc) and stray materials in deposition tunnels.

Table 5-9. SR-Can variable FEPs for the system component "Geosphere" as defined in the FEP catalogue, as well as in the Geosphere process report /SKB 2006f/.

SR-Can FEP ID	SR-Can FEP name	SR-Can definition
VarGe01	Temperature	Temperature as a function of time and space in the geosphere.
VarGe02	Groundwater flow	Groundwater flow as a function of time and space in the geosphere's fracture system.
VarGe03	Groundwater pressure	Groundwater pressure as a function of time and space in the geosphere's fracture system.
VarGe04	Gas flow	Gas flow as a function of time and space in the geosphere's fracture system.
VarGe05	Repository geometry	Geometric description of deposition holes, tunnels, ramps, boreholes etc i.e. of all excavations.
VarGe06	Fracture geometry	All geosphere's cavities, from fracture zones to micropores in the matrix. Also included here is the excavation-disturbed zone (EDZ) and any other geometric changes in the fracture structure induced by construction.
VarGe07	Rock stresses	Rock stresses as a function of time and space in the geosphere.
VarGe08	Matrix minerals	Chemical composition of the rock matrix as a function of (time and) space, i.e. a description of the various minerals that occur and their extent.
VarGe09	Fracture minerals	Chemical composition of the fracture minerals as a function of time and space, i.e. a description of the various fracture-filling minerals that occur. Also the amount and composition of fracture-filling minerals in existing fractures.
VarGe10	Groundwater composition	Chemical composition of the groundwater as a function of time and space in the geosphere, i.e. concentrations of relevant components in the groundwater. This variable also includes quantities such as Eh and pH, as well as any radionuclides and dissolved gases.
VarGe11	Gas composition	Chemical description of gases in geosphere cavities including any radionuclides and naturally occurring gases.
VarGe12	Structural and stray materials	Chemical composition and quantities of grouts and other structural and stray materials injected/located in fractures in the rock.
VarGe13	Saturation	Degree of saturation.

5.5 Biosphere FEPs

As mentioned in Section 4.4, the development of a process report for the biosphere is currently ongoing (November 2006) and no feedback from that work has been available for implementation in the SKB FEP database within the framework of the SR-Can project. Therefore, the SR-Can FEP catalogue contains six provisional Biosphere FEPs with which NEA Project FEPs and Matrix interactions are associated. These provisional Biosphere FEPs are:

ProvBio01: Quaternary deposits.

ProvBio02: Surface waters.

ProvBio03: Atmosphere.

ProvBio04: Biota.

ProvBio05: Man.

ProvBio06: Other.

These provisional Biosphere FEPs were defined merely for keeping track of NEA Project FEPs and Matrix interactions judged as relevant for the biosphere. Once the biosphere process report is completed, the FEP catalogue will be updated with FEP records corresponding to the biosphere processes documented in the biosphere process report, and tables documenting the handling of the aspects addressed in the NEA Project FEPs and Matrix interactions will be included in the FEP database.

5.6 External FEPs

External FEPs included in the SR-Can FEP catalogue are Climate FEPs (Table 5-10), Large-scale geological FEPs (Table 5-11) and FHA FEPs (Table 5-12). In addition, the FEP catalogue contains one single FEP in the category "Other" – Oth01 Meteorite impact.

A with the process FEP records, the external FEP records contain a short description, a brief note on their handling in SR-Can and references to the SR-Can reports where the SR-Can FEP and its handling are described. As described in Section 4.3, lists of NEA Project FEPs associated with the SR-Can FEPs and tables with notes on how the aspects identified in the NEA Project FEPs are addressed in the SR-Can FEP are also included in the FEP database and accessible from the SR-Can FEP record. Printouts of these FEP tables are provided in Appendix 9.

Table 5-10. SR-Can Climate FEPs and references to corresponding descriptions in the SR-Can Climate report /SKB 2006g/.

SR-Can FEP ID	SR-Can FEP name	Section in SR-Can Climate report
Cli01	Climate system – Components of the climate system	2.1
Cli02	Climate system – Climate forcing	2.2
Cli03	Climate system – Climate dynamics	2.3
Cli04	Climate system – Climate-related conditions in Sweden	2.4
Cli05	Climate related issues – Development of permafrost	3.4
Cli06	Climate related issues – Ice-sheet dynamics	3.1
Cli07	Climate related issues – Ice-sheet hydrology	3.2
Cli08	Climate related issues – Glacial isostatic adjustment	3.3
Cli09	Climate related issues – Shore-line migration	3.3
Cli10	Climate related issues – End-glacial faulting	3.5

Table 5-11. SR-Can Large-scale geological FEPs and references to corresponding descriptions in the SR-Can Geosphere report /SKB 2006f/.

SR-Can FEP ID	SR-Can FEP name	Section in SR-Can process report
LSGe01	Mechanical evolution of the Shield	4.1.2
LSGe02	Earthquakes	4.1.3

Table 5-12. SR-Can FHA FEPs and references to corresponding descriptions in the SR-Can FHA report /SKB 2006h/.

SR-Can FEP ID	SR-Can FEP name	Section in SR-Can FHA report
FHA01	General considerations	2
FHA02	Societal analysis, considered societal aspects	5.2
FHA03	Technical analysis, general aspects	4.2
FHA04	Technical analysis, actions with thermal impact and purpose	4.4
FHA05	Technical analysis, actions with hydraulic impact and purpose	4.5
FHA06	Technical analysis, actions with mechanical impact and purpose	4.6
FHA07	Technical analysis, actions with chemical impact and purpose	4.7

5.7 Site-specific factors

The FEP catalogue has allowed for entering any issue that has, for whatever reason, been identified as relevant for the SR-Can analysis. Four such FEP entries have been defined.

The FEP SiteFact01 "Äspö HRL" relates to the impact of the underground research laboratory at Äspö on a potential repository at Laxemar. This issue has not specifically been addressed in SR-Can, but the potential impact on the hydrogeological conditions is currently under analysis as part of the ongoing site descriptive modelling. A firmer conclusion regarding the importance of this FEP will have to await the SR-Site assessment.

The FEP SiteFact02 "Construction of nearby rock facilities" relates to the impact of future construction of rock facilities similar to the existing repository for low-level waste at Forsmark (SFR) and the interim storage for spent fuel (CLAB) at Oskarshamn. Such potential future events have been considered in the selection of scenarios related to future human actions, which is reported in Section 12.10 in the SR-Can Main report /SKB 2006b/.

The FEP SiteFact03 "Nearby nuclear power plant" related to the potential impact of the nearby nuclear power plant at Forsmark and specifically the power cable to Finland. Corrosion has been observed in down-hole sampling equipment in a borehole at Forsmark, and the effect has been attributed to the influence of electric power cables. Since "Earth currents" is one of the processes included in the Geosphere process report /SKB 2006f/ and "Earth currents – Stray current corrosion" is included in the Fuel and canister process report /SKB 2006d/, it is judged that this site-specific factor is covered by the descriptions and handling of the processes as reported in the process reports. Therefore, references to these two process descriptions are given in the FEP record for SiteFact03.

The FEP SiteFact04 "Mine excavation" relates to the effect of a mine excavation near the repository, but outside the tectonic lens at Forsmark. Such a potential future event has been considered in the selection of scenarios related to future human actions, which is reported in Section 12.10 in the SR-Can Main report /SKB 2006b/.

5.8 Methodology issues

Although not regarded as FEPs in a strict sense, two FEP records to cover methodological issues are included in the FEP catalogue. These are Meth01 "Assessment basis" and Meth02 "Assessment methodology". The basis for including these FEPs and their meaning are already discussed in Section 4.5 and this material is not repeated here.

6 Concluding remarks

The development of the SKB FEP database and the SR-Can FEP catalogue has involved a comprehensive and time-consuming audit against the NEA FEP database with only a few additions of new FEPs to the list of SR-Can FEPs as a result. Currently, it is not seen as meaningful to repeat such an audit in the SR-Site assessment. Instead, the SR-Can FEP catalogue and experience from the SR-Can assessment will be the starting point for any updates of the FEP catalogue judged as necessary for SR-Site.

The FEP processing work has been conducted in a systematic way according to defined procedures and instructions involving requirements for documentation of the various steps. In broader terms, both the overall objective to develop a database of features, events and processes in a format that would facilitate both a systematic analysis of FEPs and documentation of the FEP analysis and the primary objective to establish an SR-Can FEP catalogue within the framework of the SKB FEP database have been fulfilled. However, it should be pointed out that the original scope of the work was not completely fulfilled. Specifically, the definition of Biosphere FEPs was not completed within the framework of SR-Can and there was incomplete documentation of the results of the processing of Matrix interactions associated with internal processes and variables. It is, however, not likely that these limitations have had any important implications for the SR-Can assessment. This is because the basis for the definition of Biosphere FEPs, the biosphere interaction matrix developed in the SAFE project /Kautsky 2001/ and its further development, has also been used for setting up the site investigation programmes and for developing biosphere models. Furthermore, the development of the SAFE version of this biosphere interaction matrix involved an audit against the NEA Project FEP database, version 1.0 /NEA 1997/ as reported in the Project SAFE Scenario and system analysis report /SKB 2001/. Concerning the Matrix interactions associated with internal processes, these were already used as input to the SR 97 Process report /SKB 1999b/ and essential aspects should, therefore, have been propagated to the SR-Can process descriptions through the update of the SR 97 process descriptions.

The need for further work on FEPs and process descriptions for the system components not specifically addressed in SR-Can is not yet decided, but will be assessed in the planning of the SR-Site project.

Finally, there are some actions that could improve the illustration in the FEP database of couplings between processes and variables. Firstly, the instructions for developing the influence tables could be made clearer to ensure that it is obvious from the table whether an influence is handled or neglected. This distinction is important for the automatic generation of process diagrams in the FEP database. Secondly, an interaction matrix is an alternative way to illustrate couplings between processes and variables and adding this option to the FEP database will be considered in the future.

7 References

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Appendix 1

Short instructions for navigating in the SKB FEP database

This appendix contains a description of the contents of the SKB FEP database and gives guidance as to how different information in the database is accessed. The database is created with the database programme FileMaker Pro, Version 5.5. This programme allows for relational data files, which is utilised in the SKB FEP database. The SR-Can version of the database is delivered as a runtime version on the enclosed CD, which means that the database can be used without having access to the programme Filemaker Pro, Version 5.5.

List of contents

Contents of the SKB FEP database

The SKB FEP database has been used as a tool for documentation of the outcome of the different steps in the FEP processing procedure as the work proceeded. For that purpose, it contains all source information in terms of the Project FEPs included in the NEA FEP database version 1.2 /NEA 1999/, the contents of the SR 97 Process report /SKB 1999b/ in database format and the Interaction matrices developed for a deep repository of the KBS-3 type /Pers et al. 1999/, as well as the resulting SR-Can FEP catalogue. In addition, the SKB FEP database contains files created for documentation of the outcome of the FEP audit, one for the result of the audit against the NEA project FEPs (NEA Mapping) and one for the result of the audit against the Interaction matrices (Matrix Mapping). The overall structure of the SKB FEP database is shown in Figure A1-1.

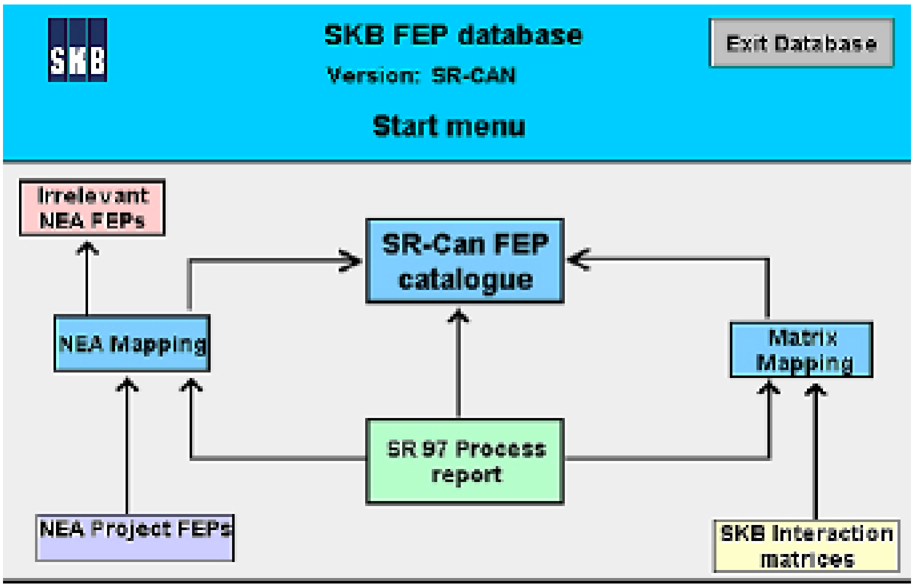

Figure A1-1. SKB FEP database – Start menu.

Starting and closing the FEP database and the SR-Can FEP catalogue

The FEP database is entered by opening the file Start_FEPdatabase.exe, which will display the Start menu in the FEP database (Figure A1-1). The database is also closed from this position in the FEP database via the button "Exit database".

The SR-Can FEP catalogue is entered via the box "SR-Can FEP catalogue" (works as a button) in the Start menu (Figure A1-1). This will display a layout showing the different FEP categories in the SR-Can FEP catalogue (Figure A1-2). Exit from the FEP catalogue is via the button "Start menu FEP database", which again displays the FEP database start menu (Figure A1-1), irrespective of in which layout in the FEP catalogue the button appears.

From the layout "FEP categories" in the FEP catalogue lists of FEPs in the different categories are accessed via the "List" buttons. The button "List all SR-Can FEPs" displays a list of all SR-Can FEPs in every layout it appears.

The yellow button "Find SR-Can FEPs" and other yellow buttons in other layouts are only functioning appropriate and should only be used for finding records. This is further described under the heading "Find records in the SR-Can FEP catalogue" below.

Navigating in the SR-Can FEP catalogue

From the layout "FEP categories" (Figure A1-2), lists of SR-Can FEPs in the different FEP categories are accessed via the "List" button. The further access to FEP records and linked information is here exemplified for the category "Internal processes", but the same procedures are also applicable for the other FEPs categories, if not otherwise stated.

The FEP list accessed display the FEP ID and FEP name of all FEPs in the selected FEP category (Figure A1-3). The button "Content categories" will, in every layout where it appears, display the layout "FEP categories" shown in Figure A1-2. By using the scroll bar to the right on the screen (not shown in Figure A1-3), all FEPs in the list can be examined.

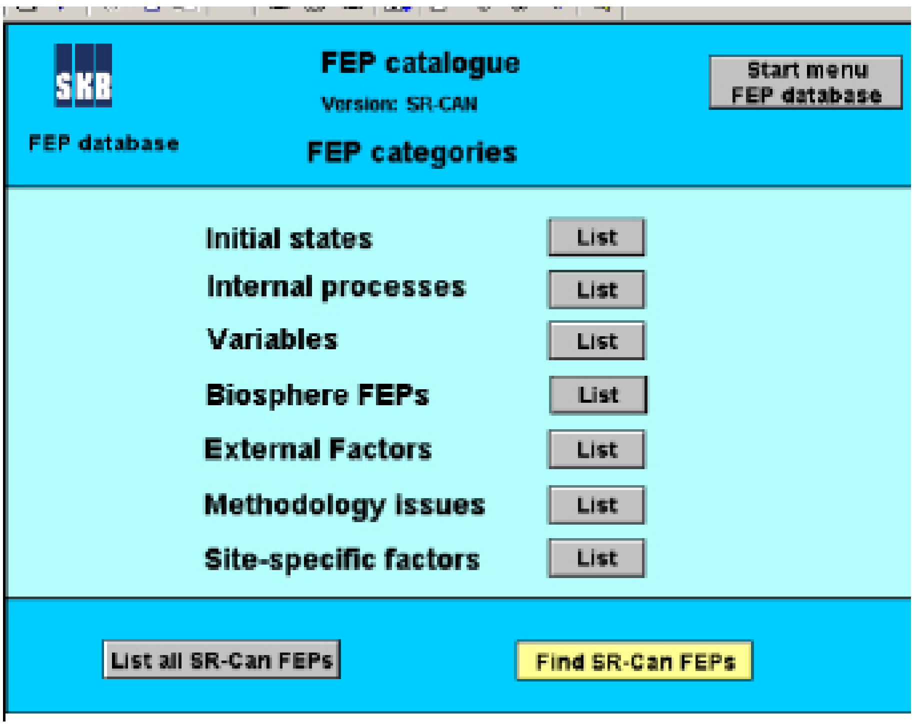

Figure A1-2. *Layout FEP categories in the SR-Can FEP catalogue.*

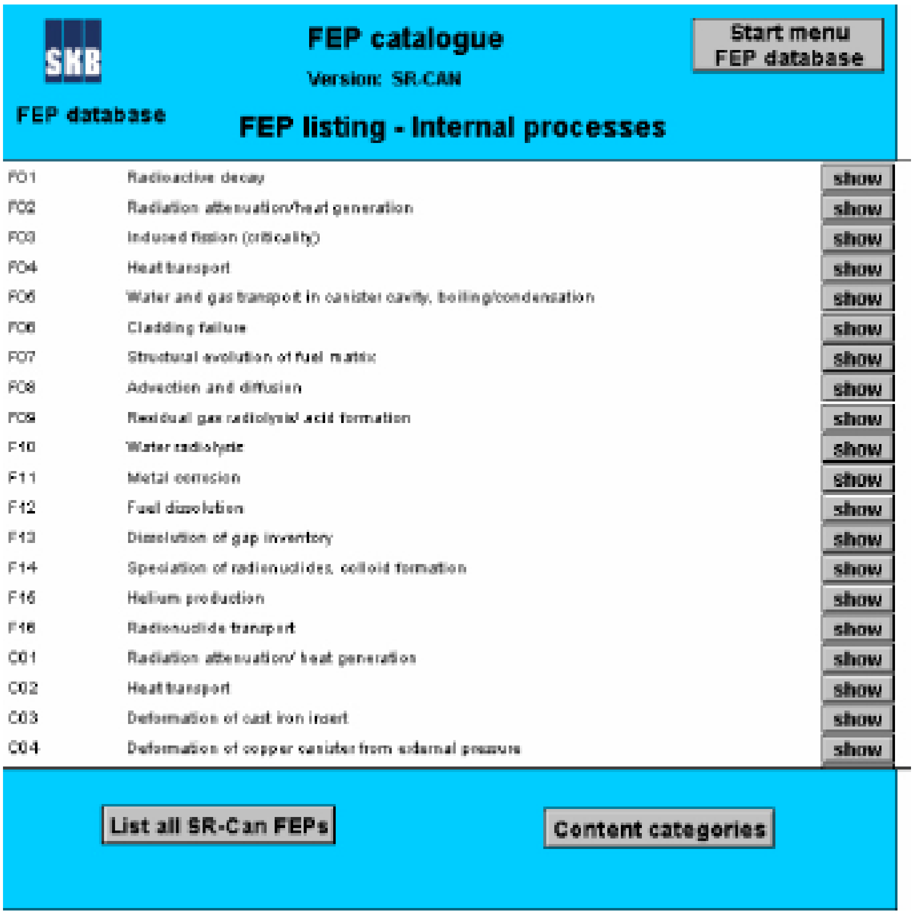

Figure A1-3. *Layout FEP listing – Internal processes in the SR-Can FEP catalogue.*

The SR-Can FEP description is displayed in the layout "SR-Can FEP record" (Figure A1-4), which is accessed via the button "show" for a selected FEP in the FEP list (Figure A1-3). This layout also shows the handling of this Sr-Can FEP and references to relevant SR-Can reports for additional information.

In the layout "SR-Can FEP record" (Figure A1-4), return to the list of internal processes is possible via the button "List internal processes". In addition, various information linked to the FEP can be viewed from the layout "SR-Can FEP record". The button "Linked NEA FEPs" displays all NEA FEPs linked to the SR-Can FEP (Figure A1-5), a list of Matrix interactions linked to the FEP is shown via the button "Linked Matrix interactions", and the button "Process diagram" shows a process diagram automatically generated based on tabulated influences between the process and the variables defined for the system component in question, i.e. for the system component "Fuel/cavity in canister" in the example illustrated in Figure A1-4. These buttons have the same function in whatever layout they appear in the SR-Can FEP catalogue. However, process diagrams are only relevant for the FEP category "Internal processes".

The list of NEA FEPs displayed via the button "Linked NEA FEPs" allows for access to definition of the NEA Project FEPs and to documentation of handling of the NEA Project FEPs in SR-Can (Figure A1-5). The full list of NEA Project FEPs linked to the SR-Can FEP can be examined by using the scroll bar on the right hand side of the FEP list field.

The documentation of the handling of NEA Project FEPs associated with the SR-Can FEP is accessed via the button "Handling NEA FEPs" (Figure A1-5), which displays the information in table format (Figure A1-6). For each NEA FEP (leftmost column), aspects of the NEA FEP addressed, and if not addressed, the reason why, are displayed as documented by the expert

Figure A1-4. *Layout SR-Can FEP record in the SR-Can FEP catalogue.*

named in the field below the table. The full table can be examined by using the rightmost scroll-bar in the layout (indicated in Figure A1-6) and the full text in each text field can be examined by using the scrollbar on the right side of the text field (indicated in Figure A1-6). The button "SR-Can FEP description" is used to switch to the layout "SR-Can FEP record" (Figure A1-4) and the function of this button is the same in every layout in the SR-Can catalogue.

The description of each NEA Project FEP linked to the SR-Can FEP is displayed via the button "show" in the list of NEA Project FEPs in the layout "Linked NEA Project FEPs" (Figure A1-5). This button activates a script that opens the corresponding NEA Project FEP record in the register "NEA mapping" (see Figure A1-1). The layout entered is shown in Figure A1-7. The full description of the NEA Project FEP is examined by using the scrollbar on the right side of the text field. Return to the SR-Can FEP catalogue occurs via the button "Fortsätt" in the left margin outside the actual layout (marked by an arrow in Figure A1-7). This button continues the script, but it is possible to examine other information via other layouts in the NEA Mapping register before continuing this script, since this script button will appear in the left margin until the script is continued or cancelled via the button just below ("Avbryt"). If the script is cancelled, the only return to the SR-Can FEP catalogue is via the FEP database start menu.

The functioning of the other buttons appearing in the layout NEA Project FEP description in the NEA Mapping register is described under the heading "Navigating in the NEA Mapping register" below.

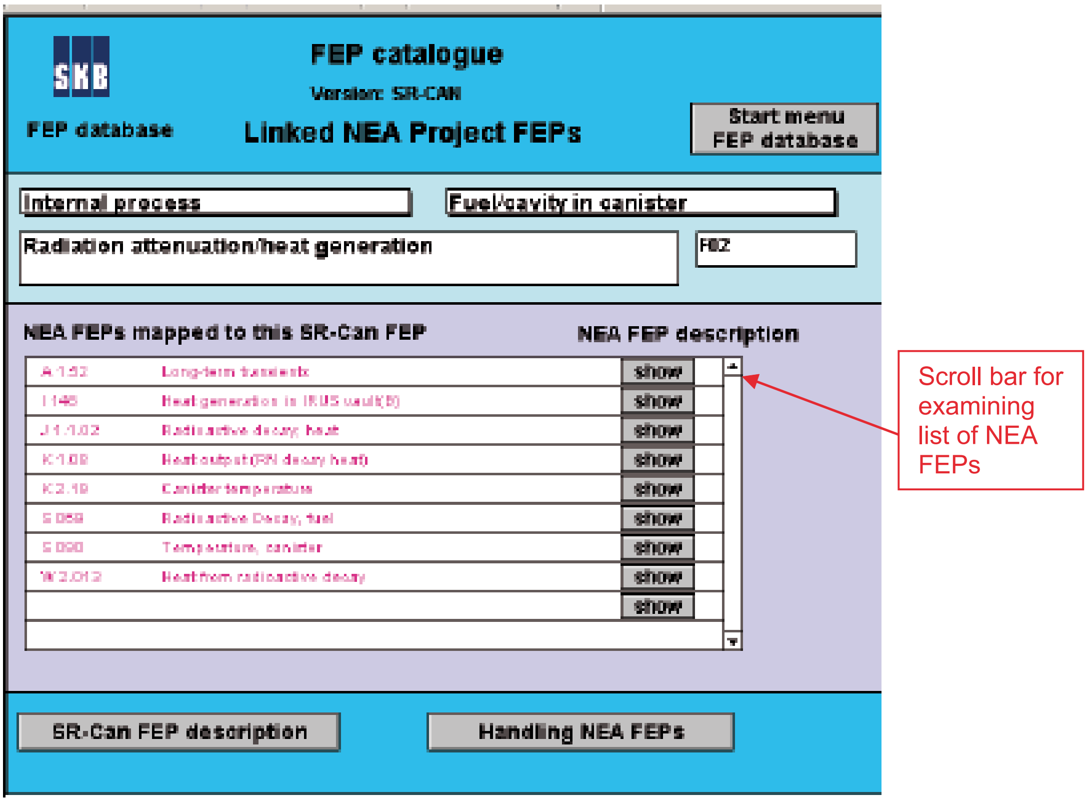

Figure A1-5. *Layout "Linked NEA Project FEPs" in the SR-Can FEP catalogue.*

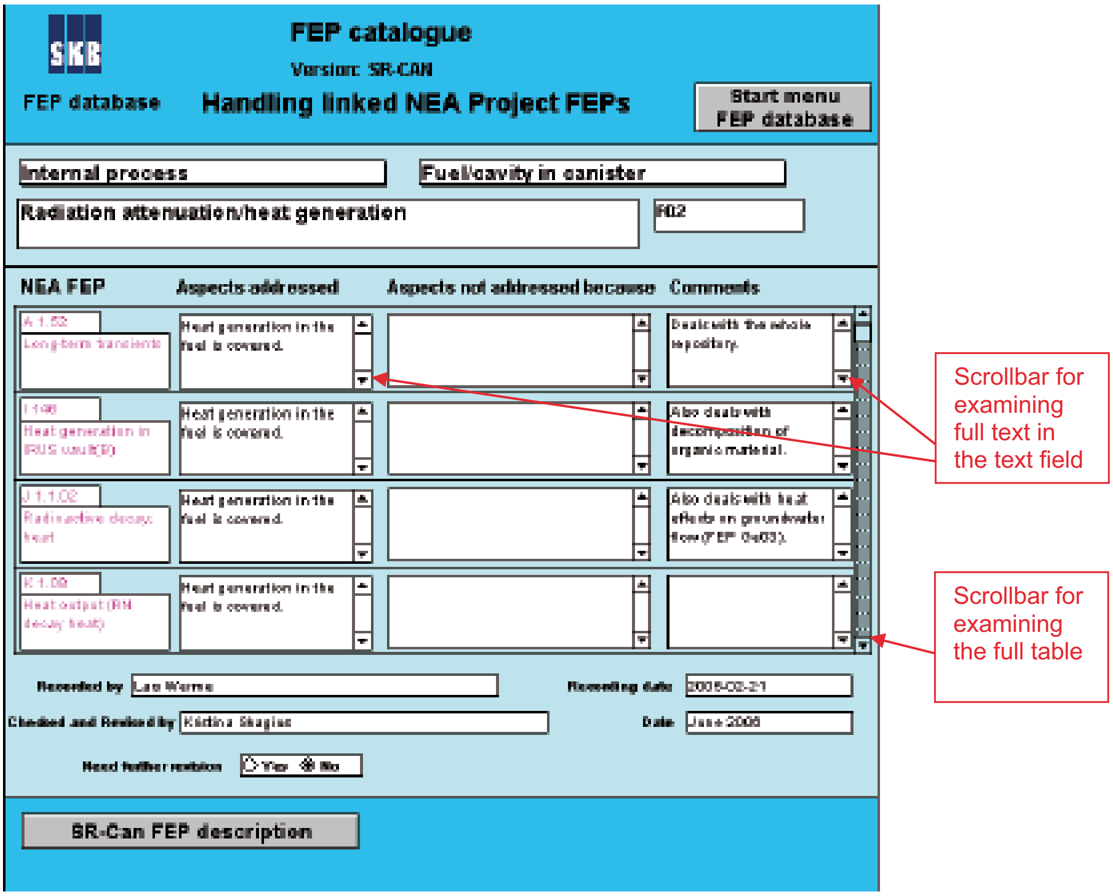

Figure A1-6. *Layout "Handling linked NEA Project FEPs" in the SR-Can FEP catalogue showing the handling of each NEA Project FEP as documented by the experts.*

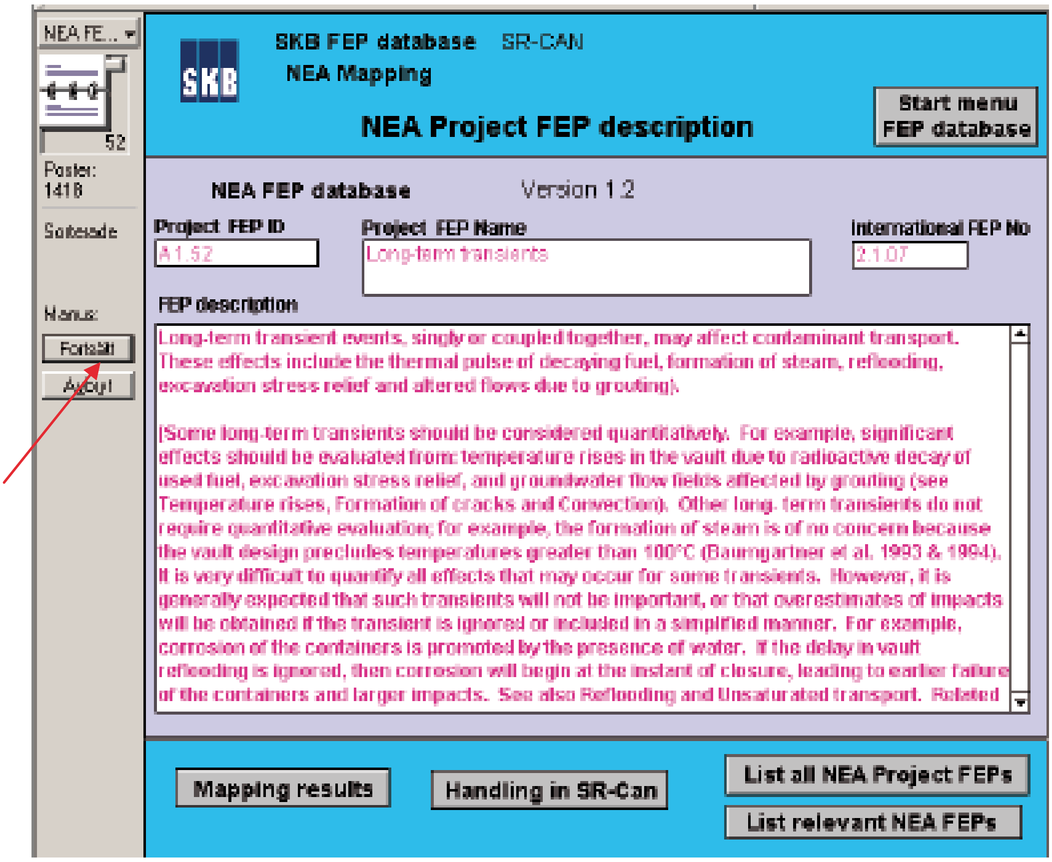

Figure A1-7. Layout "NEA Project FEP description in the NEA Mapping register as accessed from the SR-Can FEP catalogue. The arrow marks the button for return to the SR-Can FEP catalogue, layout "Linked NEA Project FEPs" (Figure A1-5).

In the layout "SR-Can FEP record" (Figure A1-4), automatically generated process diagrams are accessible through the button "Process diagram". An example is shown in Figure 5-2 in the main text of this report. These diagrams are based on information in the influence tables published in the SR-Can Process reports. Corresponding influence tables have been created in the FEP database with the requirement that the table in the FEP database must distinguish the presence of an influence or not by Yes or No and the handling of the influence by Neglected, Handled, or Not handled. This is because the presence of an arrow or not and its colouring in the process diagrams in the FEP database automatically are generated based on this information. In general, the original influence tables in the Process reports are clear concerning whether there is an influence or not, which determines the presence or absence of an arrow in the process diagram (a question mark indicates that this information is not available in the table). The colouring is not that straightforward from the contents of the influence tables. A green arrow means that the influence is neglected and a red arrow represents an influence that is handled in SR-Can. Non-coloured arrows represents influences that are not handled at all. It is not totally clear in all cases from the text in the influence tables if the influence is handled or neglected. This means that there are some uncertainties connected to the colour-coding of the arrows in the process diagrams. The influence tables in the FEP catalogue are accessed via the button "Influence table" in the layout "Process diagram".

Process diagrams for an entire system component are displayed via the button "Process diagram for entire system component" in the layout "Process diagram". An example is shown in Figure A1-8. The full diagram is examined by using the scrollbar on the right-hand side of the screen (not shown in Figure A1-8).

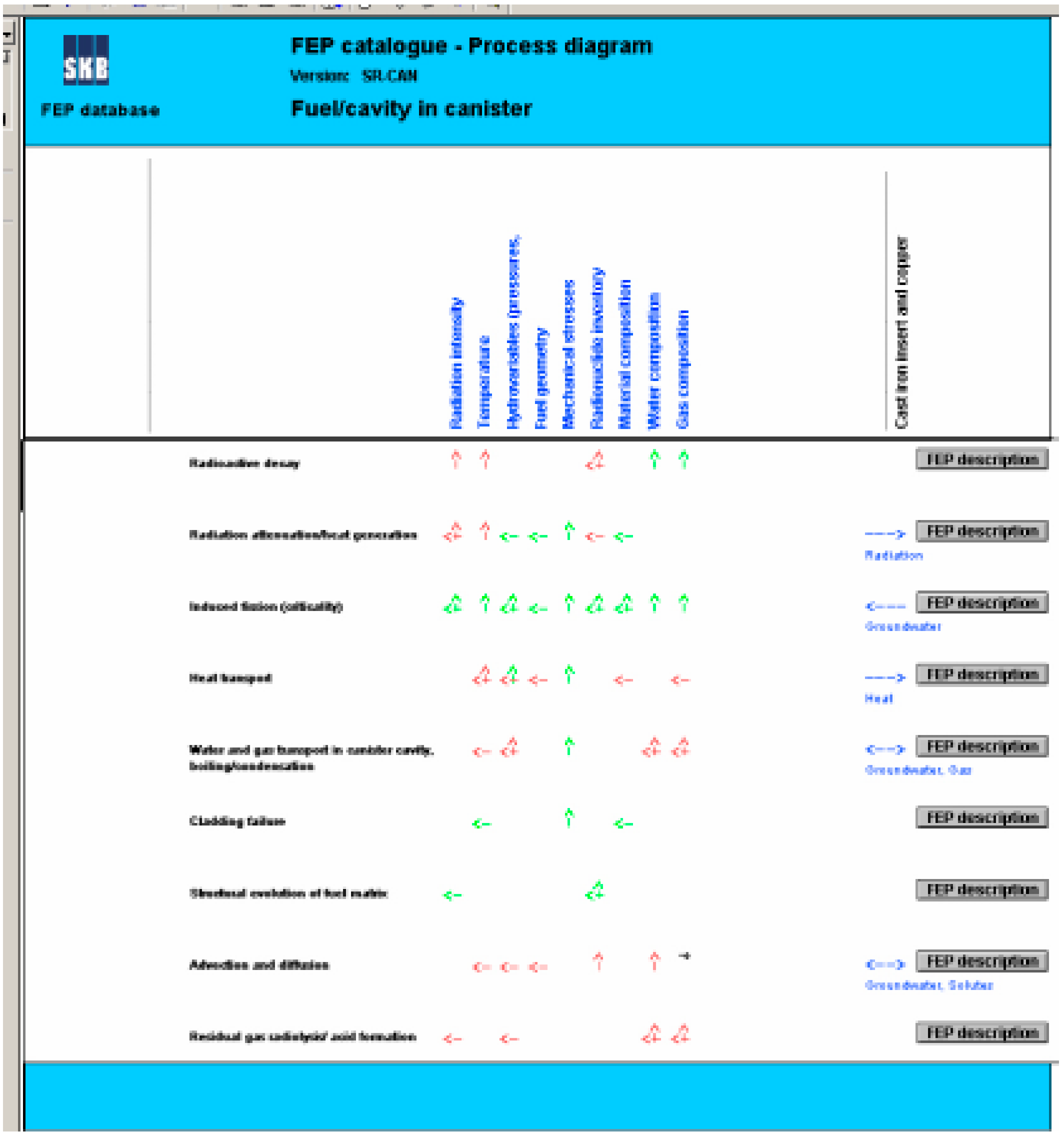

Figure A1-8. *Process diagram for the system component Fuel/cavity in canister as displayed in the SR-Can FEP catalogue. The total diagram is examined by using the scrollbar on the right-hand side of the screen (not shown in the figure).*

The same procedures are applicable for access to lists of Matrix interactions and the tables with documentation on handling in SR-Can as those for NEA Project FEPs, but via the buttons:

- "Linked Matrix interactions" in the layout "SR-Can FEP record, and
- "Handling Matrix interactions" in the layout "Linked SR 97 Matrix interactions".

Furthermore, the definitions of the Matrix interactions are displayed by activating a script via the button "show" in the layout "Linked SR 97 Matrix interactions". This script opens the corresponding Matrix interaction record in the register "Matrix mapping" (see Figure A1-1) and, as for NEA Project FEPs, return to the SR-Can FEP catalogue occurs via the button "Fortsätt" in the left margin outside the actual layout.

Find records in the SR-Can FEP catalogue

It is possible to do a text search for finding records in the SR-Can catalogue. For this purpose, only the yellow buttons are to be used. The search is activated by the button "Find SR-Can FEPs" in the layout "FEP categories" (Figure A1-2). This will activate a script that displays a layout for entering a text request in one of the fields defining the SR-Can FEPs (Figure A1-9). The text request is entered in one of the fields and the script is continued by clicking the button "Fortsätt" in the left margin (marked with an arrow in Figure A1-9).

If no records match the request, a message will appear on the screen stating that no records match the request. Via the button "Modify find" in this message, a new text request can be entered into one of the fields. Choosing the button "Cancel" in the message will cancel the search and once again display the layout "FEP categories" (Figure A1-2).

If there are records in the FEP-catalogue that matches the request, these are displayed as a list showing the SR-Can FEP ID and FEP name (Figure A1-10). The button "show" to the right of the selected FEP will display the full description of the FEP as it appears in the layout "SR-Can FEP record" (Figure A1-4). In order to examine descriptions of other FEPs found in the search, the list of found FEPs must once again be entered via the button "Return to found records" in the layout "SR-Can FEP record" (Figure A1-4).

Note! A search will limit the accessible FEP records to those matching the search request. In order to make all FEP records accessible for a new search or for examination of other information in the FEP catalogue as described above, these activities must start from the layouts "FEP categories" (Figure A1-2) or "Start menu" (Figure A1-1), which are accessed via the buttons "Content categories" and "Start menu FEP database, respectively. These buttons are available in most of the layouts in the SR-Can catalogue.

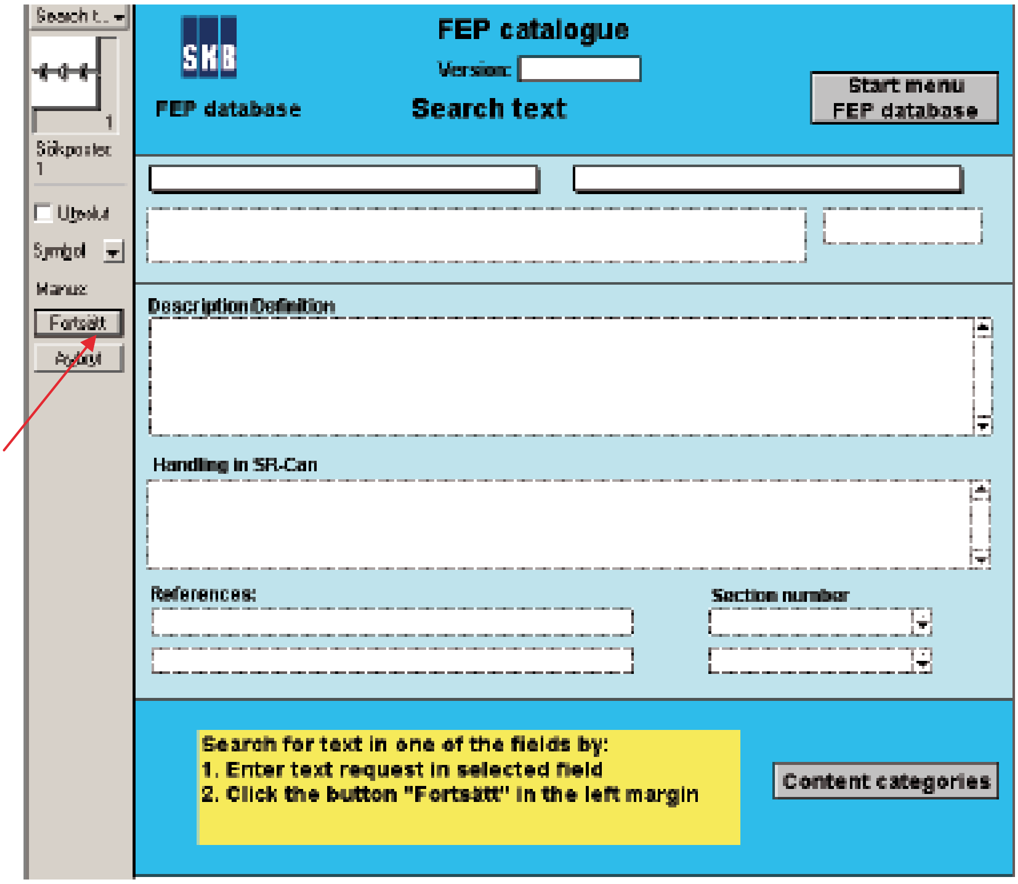

__Figure A1-9.__ Layout for entering a text request for finding SR-Can FEP records that matches the request.

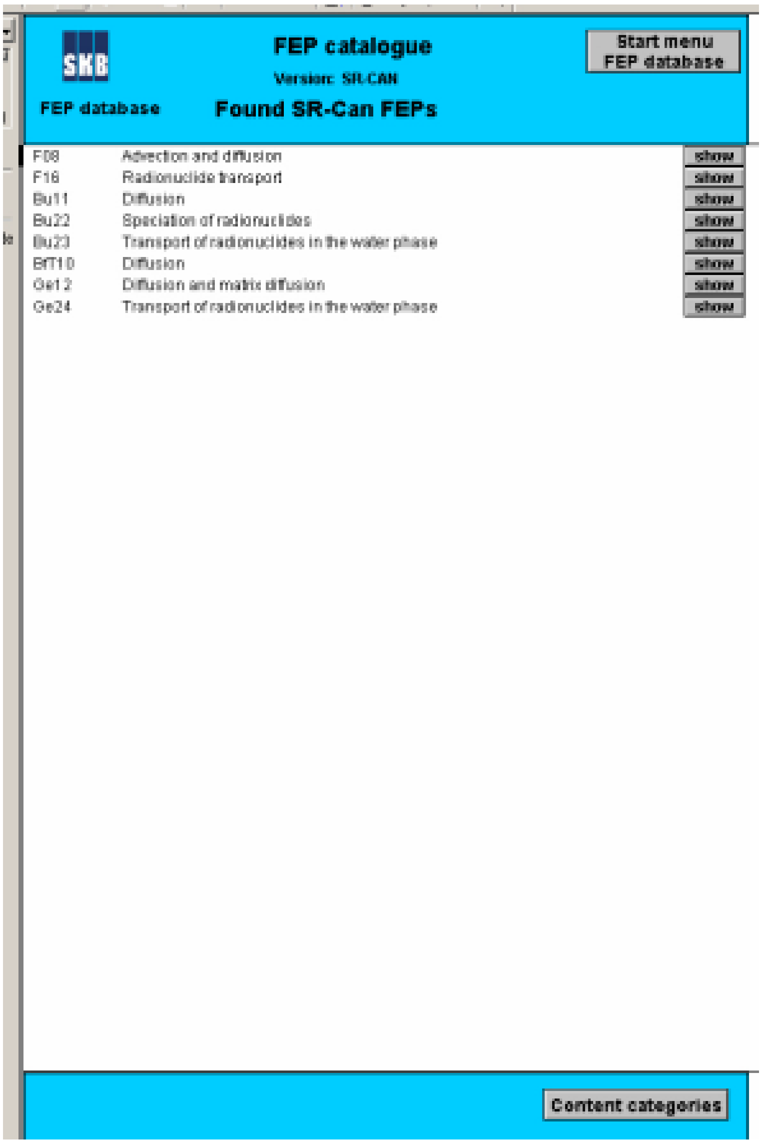

Figure A1-10. *Layout for listing found records that matches a text request.*

Navigating in the NEA mapping register

The NEA mapping register is entered via the box "NEA mapping" (works as a button in the Start menu (Figure A1-1), or directly from the SR-Can catalogue in the layout "Linked NEA Project FEPs", as described above. Entering from the FEP database Start menu will display a list of all NEA project FEPs in the register (Figure A1-11). Exit from the NEA mapping register is via the button "Start menu FEP database", which again displays the FEP database start menu (Figure A1-1), irrespective of in which layout in the NEA mapping register the button appears.

In the layout "NEA Project FEP listing", the NEA project FEPs can be sorted via the buttons "Sort Alphabetical" and "Sort Numerical". To examine the full list of FEPs, the scrollbar on the right-hand side of the screen (not shown in Figure A1-11) is used. The buttons "show" will display the NEA Project FEP description, further addressed below. The button "List of NEA FEPs relevant to the SKB system" will produce a similar NEA Project FEP listing, but this list contains only those FEPs that are judged as relevant for the SKB system.

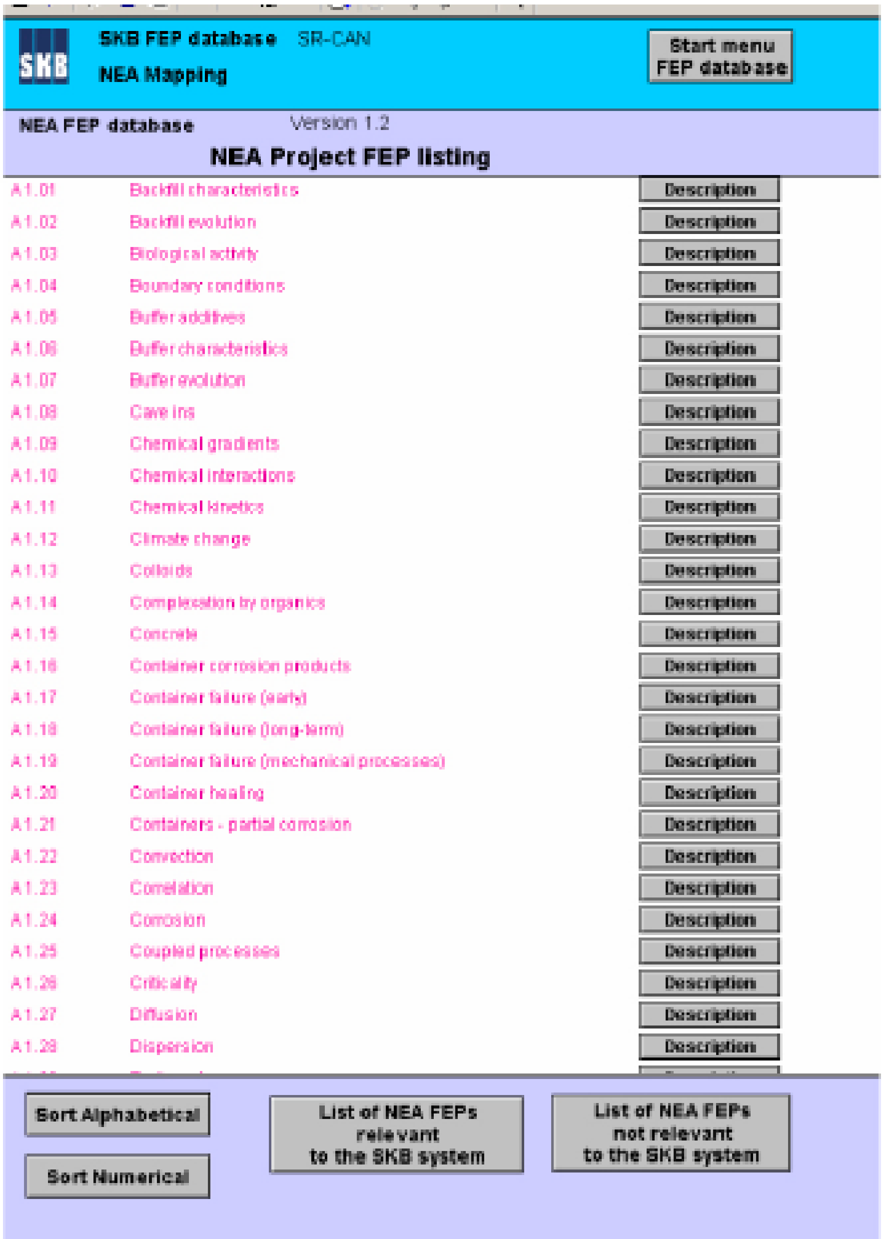

Figure A1-11. *Start layout in the NEA mapping register listing all NEA Project FEPs in the register.*

The button "List of NEA FEPs not relevant to the SKB system" will display a list of those FEPs judged as irrelevant to the SKB system together with the motivation for this judgement (Figure A1-12). This layout is also entered directly from the FEP database Start menu via the box "Irrelevant NEA FEPs".

To examine the full list of FEPs, the scrollbar on the right-hand side of the screen (not shown in Figure A1-12) is used. To view the full motivation for disregarding the FEP, if not displayed, the scrollbar to the right in the text field is used. The button "Description" will display the NEA Project FEP description.

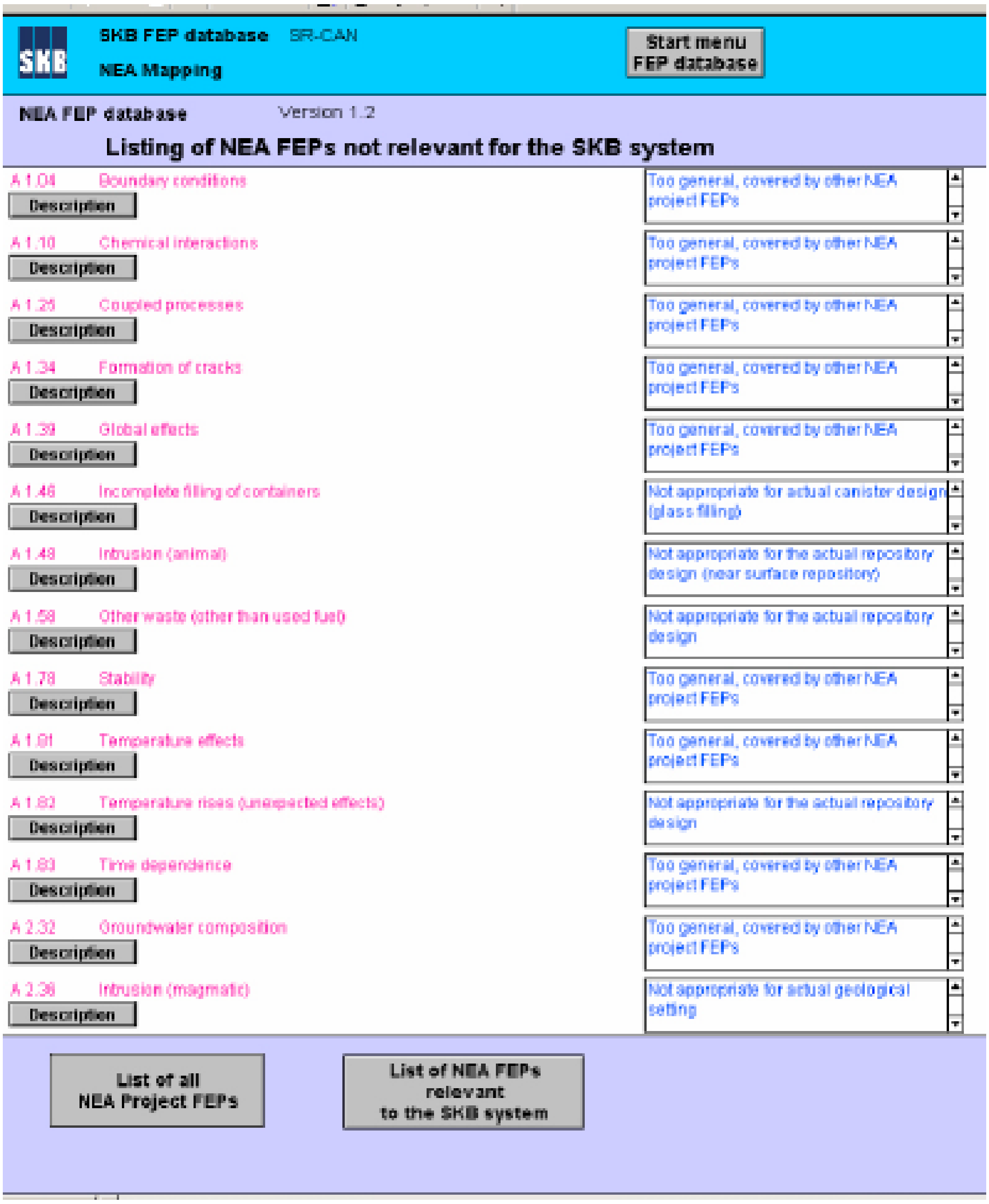

Figure A1-12. *Layout displaying a list of all NEA Project FEPs judged as irrelevant to the SKB system.*

The layout entered via the button "Description" is shown in Figure A1-13. This is the same layout as is accessed from the SR-Can FEP catalogue via a script activated by the button "show" in the layout "Linked NEA Project FEPs" (see Figure A1-7), but without the script activated. From this layout, a list of all SR-Can FEPs to which the NEA Project FEP is associated is displayed via the button "Mapping results". The button "Handling in SR-Can" displays how the NEA Project FEP is addressed by the different SR-Can FEPs to which it is associated (Figure A1-15). What is shown here, builds on the same information as that shown in the SR-Can FEP catalogue in the layout "Handling linked NEA Project FEPs" (Figure A1-6), but here the information related to each NEA Project FEP is shown, whereas the layout in the SR-Can FEP catalogue provides the information related to each SR-Can FEP.

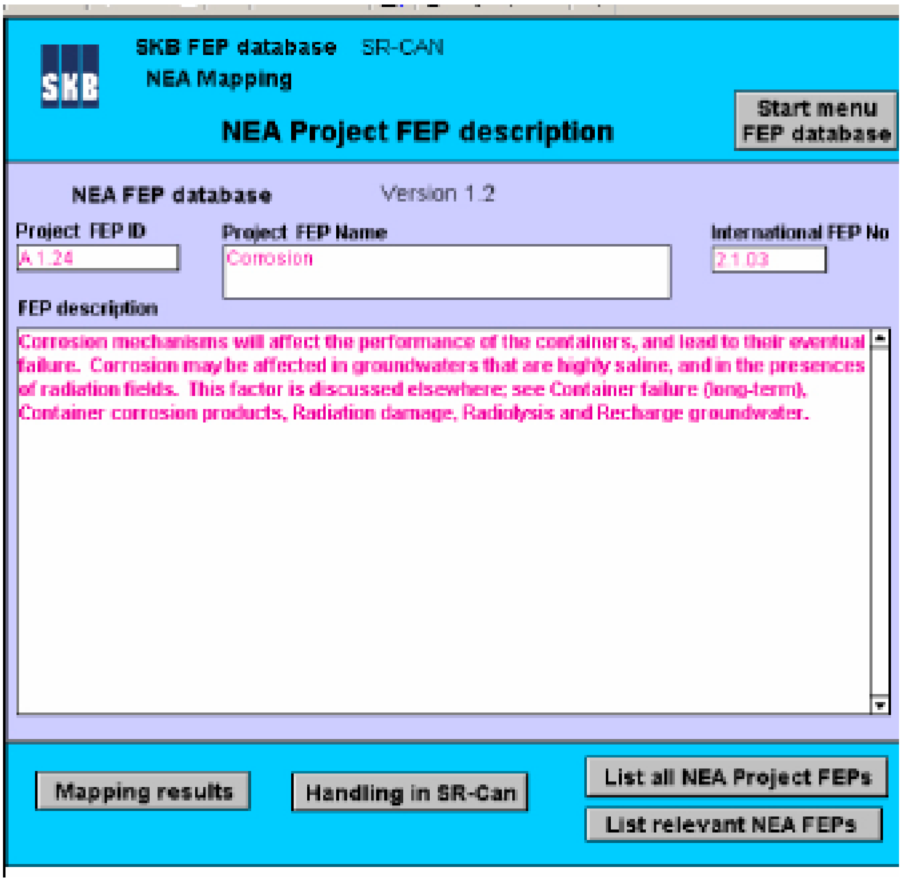

Figure A1-13. *Layout in the NEA Mapping register that shows NEA Project FEP descriptions.*

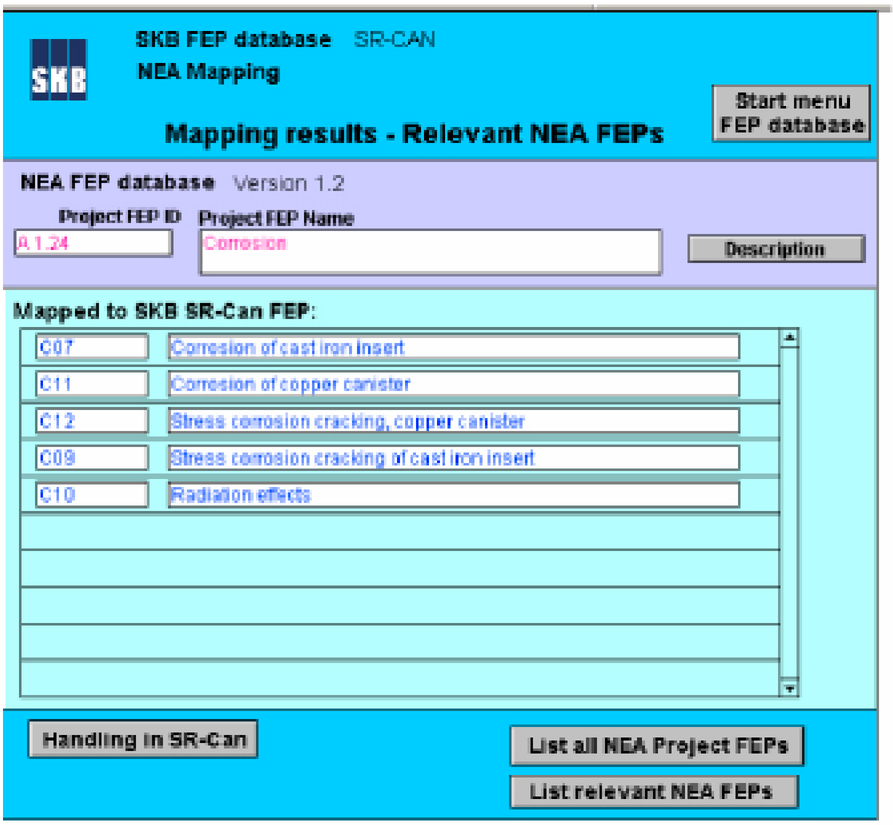

Figure A1-14. *Layout in the NEA Mapping register that shows all SR-Can FEPs to which the NEA FEP is associated.*

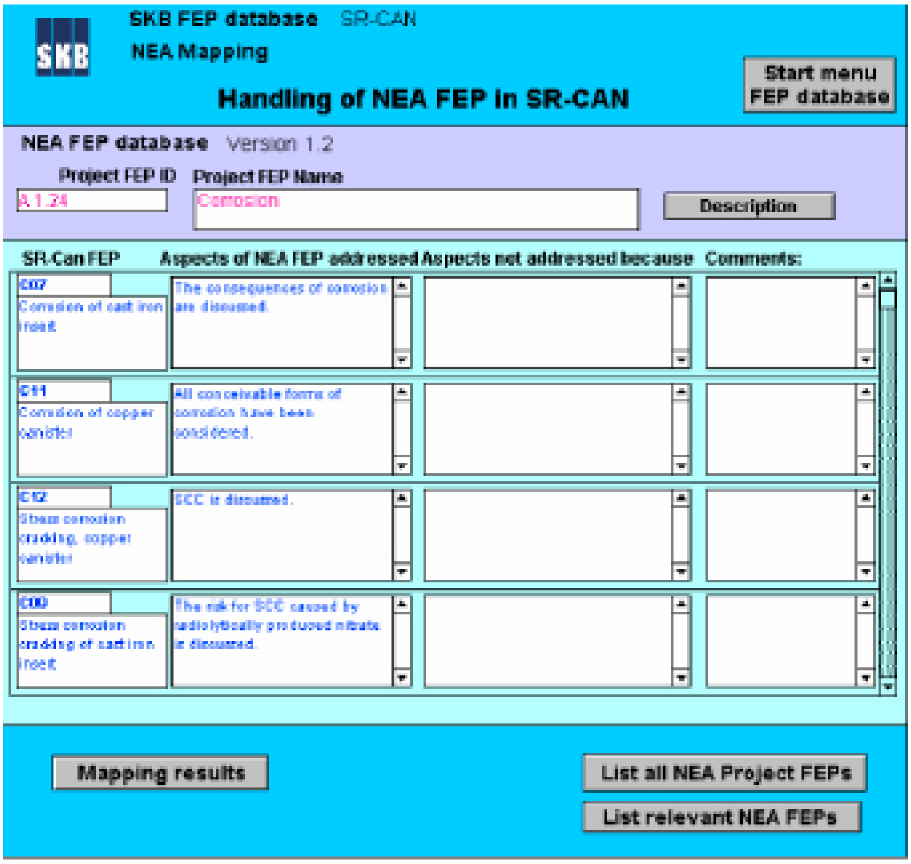

Figure A1-15. *Layout "Handling of NEA FEP in SR-Can" in the NEA Mapping register showing how the NEA FEP is addressed by the different SR-Can FEPs to which it is associated.*

Navigating in the Matrix mapping register

The Matrix mapping register is accessed via the box "Matrix mapping" (works as a button) in the FEP database Start menu (Figure A1-1), or directly from the SR-Can catalogue in the layout "Linked SR 97 Matrix interactions" via activating a script. As for the NEA mapping register, entering from the FEP database start menu will display a list of all Matrix interactions. The procedures for navigating in the Matrix mapping register from this list of matrix interactions are analogues to those set up for the NEA mapping register, and are, therefore, not further described here.

Navigating in the SR 97 Process register

The FEP database also contains process descriptions, variable definitions and descriptions of initial states as reported in the SR 97 Process report /SKB 1999b/. This information is accessed via the box "SR 97 process report" in the FEP database start menu (works as a button) in the FEP database Start menu (Figure A1-1). This will display the Main menu in the SR 97 process report register (Figure A1-16). From this Main menu, lists of processes and variables are displayed via the different buttons marked with the system components. From the list of processes and variables for the various system components, it is possible to return to the Main menu in the SR 97 Process report register (button SR 97 Main Menu) and to display lists of processes or variables for the other system components.

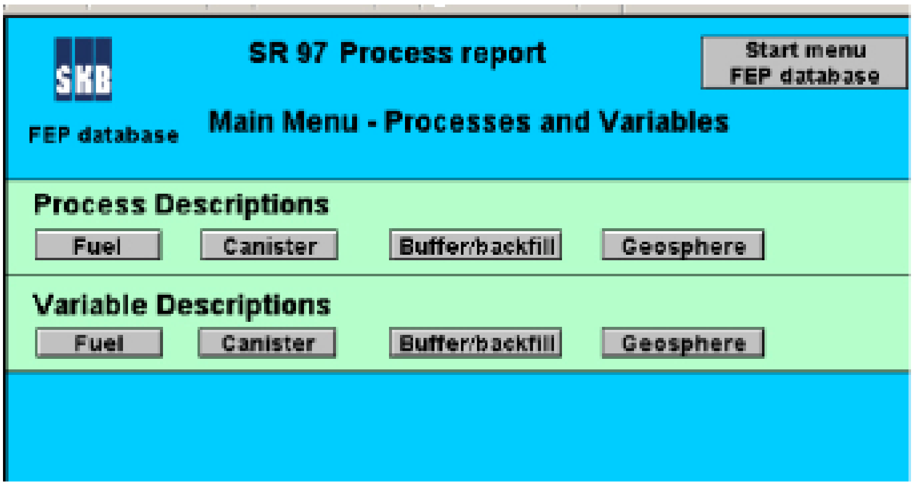

Figure A1-16. *Main menu in the SR 97 Process report register.*

The description of a process or a variable is accessed via the button ”Description” in the lists of processes or variables. If a process description is selected, this will display a “Contents” layout with buttons for further selection of one of the subsections in the process description (Figure A1-17). These subsections correspond to the subsections in the SR 97 Process report and the text in each subsection is displayed in full via the button named with the heading of the subsection. The text field to the left of the button shows the first lines of the description (Figure A1-17) and an empty field means that there is no text in that particular subsection for the selected process. From this “Contents” layout, it is also possible to display the lists of processes for the various system components and to return to the SR 97 Main menu (Figure A1-16). In addition, the Process (or THMC) diagram for the system component in question, corresponding to the THMC diagram in the SR 97 Process report, can be viewed via the button “Process (THMC) diagram”.

The layouts accessed via the subsection buttons is exemplified in Figure A1-18. These layouts contain the text as it appears in the SR 97 Process report under the subheading in question, and the full text can be viewed by using the scrollbar to the right in the text field. Any figures that are associated with the text under the subheading can be viewed via the buttons to the right of the text field that are named with a figure caption. From the figure layout (not shown here), the text layout is once again displayed via a button named with the subsection in question, in this example a button named “General description”. From all text layouts, it is possible to return to the “Contents” layout for the process in question (button “Contents”) and to the SR 97 Main menu (button “SR 97 Main Menu).

Selecting the button “References” in the “Contents” layout (Figure A1-17) will display a list of all literature references for the process in question.

Selecting a variable description via the button “Description” in the list of variables accessed from the layout “SR 97 Main menu” (Figure A1-16) will display a layout where the definition of the variable and, if present in the SR 97 Process report, a description of the initial state are shown (Figure A1-19). By using the scrollbars to the right in the text fields, the full text can be examined. The buttons to the right of the text fields that are named with a figure caption can be used to view any figures associated with the text. The button “References” below the text fields will display a list of all literature references mentioned in the text.

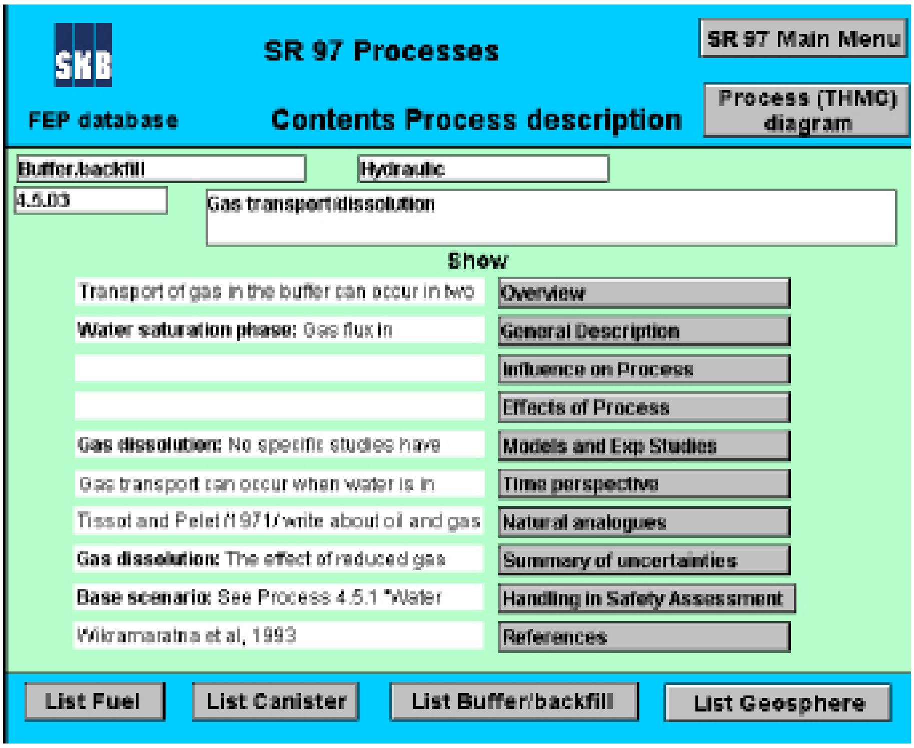

Figure A1-17. *Layout "Contents Process description" in the SR 97 Process report register for further selection and access to the text under various subheadings in the process description.*

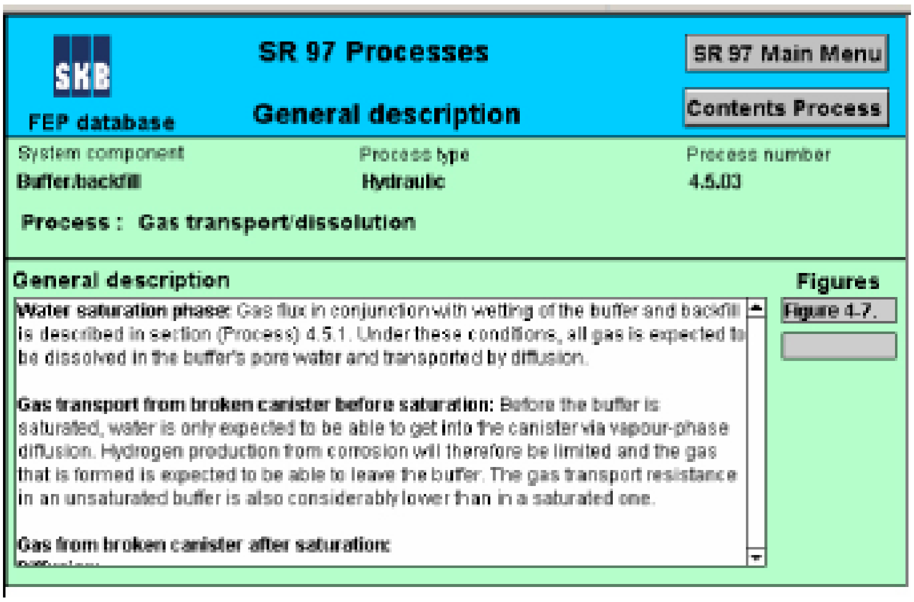

Figure A1-18. *Layout "General description" in the SR 97 Process report register exemplifying layouts for examining the text under the various subheadings in the SR 97 process descriptions.*

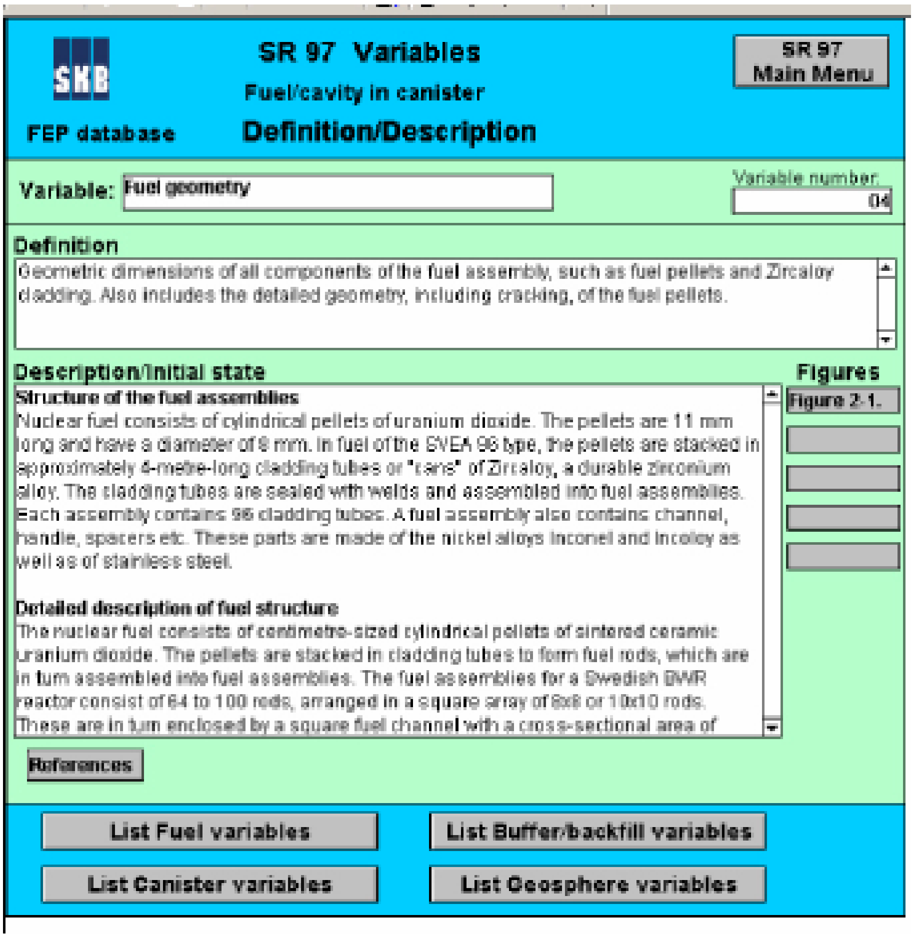

Figure A1-19. *Layout "Definition/Description" in the SR 97 Variables register showing the definition of the variable and, if present in the SR 97 Process report, a description of the initial state.*

Appendix 2

Result of checking the final content of the SKB FEP database – version SR-Can

1. All NEA Project FEPs in version 1.2 of the NEA FEP database are included in the SKB FEP database.

   Yes.

   Number of records in NEA Project FEP register PROFEP = 1418.

   Number of records in SKB FEP database register NEA Mapping = 1418.

   No records in the NEA Mapping register with duplicate NEA Project FEP numbers or without NEA Project FEP number found when scrolling through the NEA Project FEP listing in the NEA Mapping register.

2. All Matrix interactions in the SR 97 Buffer, Near-field and Far-field matrices are included in the SKB FEP database.

   Yes.

   Number of interaction records in the Buffer, Near-field, and Far-field matrices = 794.

   Number of records in the SKB FEP database register Matrix mapping = 794.

3. All NEA Project FEPs included in the SKB FEP database are flagged as Relevant or Not relevant for the SKB repository system.

   Yes.

   Number of records in NEA Mapping register flagged as Not relevant = 316.

   Number of records in NEA Mapping register flagged as Relevant = 1102.

   Sum of records in NEA mapping register flagged as Not relevant or Relevant = 1418.

   Number of records in Matrix mapping register flagged as Relevant = 646.

   Number of records in Matrix mapping register flagged as Not relevant = 148.

   Sum of records in Matrix mapping register flagged as Not relevant or Relevant = 794.

4. All NEA Project FEPs and Matrix interactions included in the SKB FEP database and flagged as Not relevant for the SKB repository system have a motivation documented for the omission.

   Yes.

   Search in NEA mapping register for text in field for documenting reason for not being relevant reveals 316 records, i.e. the number of records flagged as Not relevant.

   Search in Matrix mapping register for text in field for documenting reason for not being relevant reveals 148 records, i.e. the number of records flagged as Not relevant.

5. All NEA Project FEPs and Matrix interactions included in the SKB FEP database and flagged as Relevant for the SKB repository system have a documented description of the handling in SR-Can.

   NEA Project FEPs; Yes, except for NEA Project FEPs or aspects of FEPs that are sorted to the system components that are not specifically addressed in SR-Can (bottom plate in deposition holes, plugs, backfill in other repository cavities than deposition tunnels, rock reinforcements and borehole seals) or to the biosphere system.

Matrix interactions; No. The documentation of handling of Matrix interactions is not complete.

Checked by comparing records in the NEA mapping register flagged as relevant with records in the register used for documenting the handling in SR-Can.

6. All processes in process reports, defined categories of initial states, defined external factors, etc have a corresponding record in the SR-Can FEP catalogue register.

   Yes.

   List of SR-Can FEPs in the SR-Can catalogue compared with list of contents of the associated SR-Can reports. All SR-Can FEP records have a reference to the corresponding section in the associated SR-Can report.

Appendix 3

Handling of NEA Project FEPs sorted to SR-Can Initial states

SR-Can FEP ISGen01 Major mishaps/accidents/sabotage

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.32 Explosions	Explosions are included in the FEP definition.		
A 1.44 Improper operation	See NEA FEP A 1.70.		
A 1.61 Preclosure events	Flooding is included in the FEP definition.		
A 1.70 Sabotage and improper operation	Sabotage, explosions, flooding, fires, terrorist activities are included in the FEP definition.		
A 2.23 Explosion	Explosions are included in the FEP definition.		
A 2.56 Sabotage	Sabotage is included in the FEP definition		
J 1.4 Sudden energy release	Sabotage is included in the FEP definition.		
J 5.04 Decontamination materials left	Possible decontamination following severe mishap is included in the FEP description.		
J 5.05 Chemical sabotage	Sabotage is included in the FEP definition.		
H 1.2.7 Flammability	Explosions and fires are included in the FEP definition.		
W 2.027 Gas explosions	Explosions are included in the FEP definition.		
I 022 Explosions/bombs/ blasting/collision/ impacts/vibration	Explosions in the repository before closure are covered by the FEP definition.		Impact of construction activities are discussed, see e.g. SKB FEPs Ge07 and Ge03.
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP ISGen02 Effects of phased operation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.61 Preclosure events	Effects of underground traffic is mentioned in SR-Can.		
I 022 Explosions/bombs/ blasting/collision/ impacts/vibration	Effects of blasting and vibration on completed parts of the repository are mentioned.		
A 2.01 Blasting and vibration	Effects of blasting on completed parts of the repository.		
N 2.2.12 Effects of phased operation	Effects of phased operation.		
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP ISGen03 Incomplete closure

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.45 Incomplete closure	Incomplete construction and/or premature abandonment.		
J 5.02 Non-sealed repository	A non-closed repository is part of the FEP definition.		
A 2.47 Open boreholes	Non-sealed shafts are part of the FEP definition.		
A 2.70 Vault closure (incomplete)	Incomplete or improper closure of vaults.		
J 5.09 Unsealed boreholes and/or shafts	Unsealed shafts are part of the FEP definition.		
I 203 Monitoring shaft (failure to close)	Unsealed shafts are part of the FEP definition.		
A 1.70 Sabotage and improper operation	Incompletely backfilled/sealed drifts and boreholes.		
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP ISGen04 Monitoring activities

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 5.25 Exploratory boreholes (sealing)	Monitoring activities are part of FEP definition.		
A 1.56 Monitoring and remedial activities	Monitoring activities are part of FEP definition.		
J 5.39 Postclosure monitoring	Monitoring activities are part of FEP definition.		
W 2.011 Postclosure monitoring	Monitoring activities are part of FEP definition.		
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP ISC01 Mishaps - canister

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.17 Container failure (early)	Mishandling and breakage during transport.		
A 1.70 Sabotage and improper operation	Failure of quality assurance of engineering and construction		
J 2.5.01 Random canister defects - quality control	Random defects despite quality control.		
J 2.5.02 Common cause canister defects - quality control	Defects related by a common cause		
J 5.10 Accidents during operation	Accidents during operation.		
K 1.26 Handling accidents	Handling accidents.		
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP ISC02 Design deviations - canister

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 2.22 Mis-sealed canister	Welding defects.		
A 1.17 Container failure (early)	Welding or material defects.		
J 2.3.04 Loss of ductility	Material defects and bad manufacturing methods.		
J 2.3.06 Cracking along welds	Bad manufacturing methods.		
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP ISBu01 Mishaps - buffer

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.70 Sabotage and improper operation	Failure of quality assurance of engineering and construction		
K 3.23 Poor emplacement of buffer	Faulty emplacement of buffer.		
I 011b Backfill (faulty emplacement)	Faulty emplacement.		
I 029 Buffer (faulty emplacement)	Faulty emplacement.		
J 5.10 Accidents during operation	Accidents during operation.		
A 1.33 Faulty buffer emplacement	Faulty emplacement of buffer.		
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP ISBu02 Design deviations - buffer

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 3.1.01 Degradation of the bentonite by chemical reactions	Material deficiencies.		
J 3.2.01.2 Uneven swelling of bentonite	Material deficiences.		
J 3.2.11 Backfill material deficiencies	Material deficiences.		
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP ISBfT01 Mishaps - backfill of deposition tunnels

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.70 Sabotage and improper operation	Failure of quality assurance of engineering and construction		
J 5.10 Accidents during operation	Accidents during operation.		
I 011b Backfill (faulty emplacement)	Faulty emplacement		
J 4.2.01 Mechanical failure of repository	Lack of QA during excavation of the vault (improper rock inforcement).		
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP ISBfT02 Design deviations - backfill of deposition tunnels

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 3.2.11 Backfill material deficiencies	Backfill material deficiences.		
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP ISBP01 Mishaps - bottom plate in deposition holes

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 5.10 Accidents during operation	Accidents during operation.		
A 1.70 Sabotage and improper operation	Failure of quality assurance of engineering and construction		
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP ISBP02 Design deviations - bottom plate in deposition holes

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
I 062a1 Concrete (incorrect structural design)	Deviation in properties.		
I 062a2 Concrete (incorrect mix design)	Deviation in properties.		
I 062b Concrete (incorrect preparation/emplacement)	Deviation in properties.		
I 062f Concrete (poor quality - procurement)	Deviation in properties.		
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP ISBfO01 Mishaps - backfill of other repository cavities

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.70 Sabotage and improper operation	Failure of quality assurance of engineering and construction		
I 011b Backfill (faulty emplacement)	Faulty emplacement		
J 5.10 Accidents during operation	Accidents during operation		
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP ISBfO02 Design deviations - backfill of other repository cavities

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 3.2.11 Backfill material deficiencies	Backfill material deficiences.		
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP ISPg01 Mishaps - plugs

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.70 Sabotage and improper operation	Failure of quality assurance of engineering and construction		
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP ISPg02 Design deviations - plugs

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
I 062a1 Concrete (incorrect structural design)	Deviation in properties.		
I 062a2 Concrete (incorrect mix design)	Deviation in properties.		
I 062b Concrete (incorrect preparation/emplacement)	Deviation in properties.		
I 062f Concrete (poor quality - procurement)	Deviation in properties.		
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP ISBhS01 Mishaps/Design deviations - borehole seals

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 5.09 Unsealed boreholes and/or shafts	Unsealed boreholes and shafts.		
A 2.47 Open boreholes	Open or improperly sealed boreholes.		
K 5.25 Exploratory boreholes (sealing)	Open boreholes.		
W 3.031 Natural borehole fluid flow	Unsealed/poorly sealed boreholes,		
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

Appendix 4

Handling of NEA Project FEPs sorted to SR-Can Fuel processes

SR-Can FEP F01 Radioactive decay

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.65 Radioactive decay	Radioactive decay is covered.		
A 2.51 Radioactive decay		This FEP appears to deals with radioactive decay after release from the fuel.	This FEP is more relevant for radio-nuclide transport (FEP F17)
H 1.3.1 Radioactive decay and ingrowth	Radioactive decay and ingrowth of new radionuclides are covered.		
I 045 Progency nuclides (critical radionuclides)	The ingrowth of new radionuclides in the fuel has been covered.		The FEP also deals with decay and daughter nuclides after release from the fuel, see e.g. FEP Bu23.
I 146 Heat generation in IRUS vault(B)		This FEP deals with heat generation as a consequence of radioactive decay.	See FEP F02
K 0.1 Radioactive decay	Radioactive decay is covered.		
S 005 Changes in radionuclide inventory	Radioactive decay and ingrowth of new radionuclides are covered.		
S 069 Radioactive Decay, fuel	Radioactive decay and ingrowth of new radionuclides are covered.		This FEP also deals with heat generation as a consequence of radioactive decay, see FEP F02.
S 070 Radioactive decay of mobile nuclides		This FEP deals with radioactive decay after release from the fuel.	This FEP is more relevant for radio-nuclide transport (see e.g. FEP Bu23)
Recorded by: Lars Werme			**Date:** 2005-02-21
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP F02 Radiation attenuation/heat generation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.52 Long-term transients	Heat generation in the fuel is covered.		Deals with the whole repository
I 146 Heat generation in IRUS vault(B)	Heat generation in the fuel is covered.		Also deals with decomposition of organic material.
J 1.1.02 Radioactive decay; heat	Heat generation in the fuel is covered.		Also deals with heat effects on groundwater flow (FEP Ge03)
K 1.08 Heat output (RN decay heat)	Heat generation in the fuel is covered.		
K 2.19 Canister temperature		This FEP deals with the consequences of heat generation in the fuel on the canister temperature and corrosion rates.	See FEPs C07, C11

SR-Can FEP F02 Radiation attenuation/heat generation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 069 Radioactive Decay, fuel	Heat generation in the fuel is covered.	This FEP deals with the consequences of heat generation in the fuel on the canister temperature.	
S 090 Temperature, canister		This FEP deals with the consequences of heat generation in the fuel on the canister temperature.	See FEP C02. Also deals with criticality, see FEP F03
W 2.013 Heat from radioactive decay	Heat generation in the fuel is covered.		
Recorded by: Lars Werme			**Date:** 2005-02-21
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP F03 Induced fission (criticality)

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.26 Criticality	Criticality is covered. Criticality outside the canister can be excluded in a KBS 3 repository.		
J 1.1.01 Criticality	Criticality in a canister is covered. Criticality outside the canister can be excluded in a KBS 3 repository.		
S 017 Criticality	Criticality in a canister is covered. Criticality outside the canister can be excluded in a KBS 3 repository.		
H 1.3.2 Nuclear criticality	Criticality is covered. Criticality outside the canister can be excluded in a KBS 3 repository.		
K 0.4 Nuclear criticality	Criticality in a canister is covered. Criticality outside the canister can be excluded in a KBS 3 repository.		
W 2.014 Nuclear criticality: heat	Criticality in a canister is covered. Criticality outside the canister can be excluded in a KBS 3 repository.	The risk for criticality can be neglected. Therefore, any heat generation caused by criticality can also be neglected.	
W 2.028 Nuclear explosions		Criticality outside the canister can be excluded in a KBS 3 repository. Therefore, there will be no risk for a nuclear explosion.	
I 081 Criticality event	Criticality is covered. Criticality outside the canister can be excluded in a KBS 3 repository.		
S 005 Changes in radionuclide inventory	Criticality and the changes in criticality with time are covered.		
S 090 Temperature, canister		The risk for criticality can be neglected. Therefore, any heat generation caused by criticality can also be neglected.	
Recorded by: Lars Werme			**Date:** 2005-02-21
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP F04 Heat transport

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.52 Long-term transients		This FEP deal with contaminant transport during the thermal pulse. It is not applicable to the fuel/cavity and the time scale for possible water intrusion.	
S 090 Temperature, canister	The heat transport in the fuel and in the cavity is covered.	This FEP deals with the consequences of heat generation in the fuel on the canister temperature.	Also deals with criticality, see FEP F03
Recorded by: Lars Werme			**Date:** 2005-02-21
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP F05 Water and gas transport in canister cavity, boiling/condensation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.84 Transport in gases or of gases		This FEP deals with transport by gases of volatile materials through the buffer.	See SR-Can FEP Bu06
S 040 Gas escape from canister	Gas generation and impact on water and gas transport in failed canister is discussed.		This FEP deals mainly with gas transport through the buffer, see SR-Can FEP Bu06.
S 105 Water turnover, copper canister	Gas generation and impact on water and gas transport in failed canister is discussed.		This FEP deals mainly with water transport in and out of the gap between copper shell and the cast iron insert.
S 106 Water turnover, steel vessel	Gas generation and impact on water and gas transport in failed canister is discussed.		This FEP deals mainly with water transport in and out of the cavity in the canister.
H 1.2.1 Hydrogen by metal corrosion	Gas generation and impact on water and gas transport in failed canister is discussed.		
H 1.2.6 Gas transport		This FEP deals with transport of gas through the buffer.	See SR-Can FEP Bu06
K 2.17 Effect of hydrogen on corrosion		The build-up of hydrogen pressure will not have a major impact on the corrosion rate.	This NEA FEP is based on an incorrect assumption.
A 1.35 Formation of gases	Gas generation and impact on water and gas transport in failed canister is discussed.		Residual gas radiolysis is covered in F09. Any gas generation caused by radiolysis after water intrusion will be negligible compared to gas generated by corrosion of the insert.

SR-Can FEP F05 Water and gas transport in canister cavity, boiling/condensation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 1.2.04 Gas generation	Gas generation and impact on water and gas transport in failed canister is discussed.		Residual gas radiolysis is covered in F09. Any gas generation caused by radiolysis after water intrusion will be negligible compared to gas generated by corrosion of the insert.
S 041 Gas flow and transport, buffer/backfill	Gas generation and impact on water and gas transport in failed canister is discussed.		This FEP deals mainly with gas transport through the buffer, see SR-Can FEP Bu06.
S 034 Failure of copper canister	Gas generation and impact on water and gas transport in failed canister is discussed.		This FEP also deals with failure due to mechanical impact, see SR-Can FEPs C04, C06.
Recorded by: Lars Werme			**Date:** 2005-02-21
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP F06 Cladding failure

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.42 Hydride cracking	Hydride induced cracking is covered.		
S 019 Degradation of fuel elements	Failure of the cladding is covered.		Degradation of fuel is covered in F07 & F15.
S 053 Internal pressure	Failure of the cladding is covered due to helium build-up is covered		Gas generation due to corrosion is covered in F05
Recorded by: Lars Werme			**Date:** 2005-02-21
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP F07 Structural evolution of fuel matrix

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 2.015 Radiological effects on waste	Alpha damage to the fuel matrix has been covered.		
S 019 Degradation of fuel elements	Alpha damage to the fuel matrix has been covered.		
W 2.099 Alpha recoil	Alpha damage to the fuel matrix has been covered.		This FEP also concerns possible release from the fuel of the recoil nucleus. This contribution to the radionuclide release is of negligible importance.

SR-Can FEP F07 Structural evolution of fuel matrix

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.64 Radiation damage	Alpha damage to the fuel matrix has been covered.		
J 1.1.03 Recoil of alpha-decay	Alpha damage to the fuel matrix has been covered.		
Recorded by: Lars Werme			**Date:** 2005-02-21
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP F08 Advection and diffusion

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.09 Chemical gradients		This FEP deals with chemical gradients due to temperature changes, radiolysis and ingress of salt water in the near field. The canister is expected to be intact during the period when radiolysis and high temperatures prevail. Salinity has a very limited effect of fuel dissolution.	
A 2.16 Diffusion	Diffusion and advection are covered.		
S 102 Water chemistry, canister	Diffusion and advection are covered.		The water chemistry and its effects on corrosion are discussed in F11, F14, C07 & C11. Fuel corrosion is discussed in F12
Recorded by: Lars Werme			**Date:** 2005-02-21
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP F09 Residual gas radiolysis/ acid formation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.66 Radiolysis	The effects of radiolysis on the residual gases in the cavity are covered.		
S 072 Radiolysis prior to wetting	The effects of radiolysis on the residual gases in the cavity are covered.		
S 014 Corrosion prior to wetting	The effects of radiolysis on the residual gases in the cavity are covered.		Other corrosion aspects of residual water in the cavity are covered in F14.
S 069 Radioactive Decay, fuel	The effects of radiolysis on the residual gases in the cavity are covered.		
S 045 Gas generation, canister	The effects of radiolysis on the residual gases in the cavity are covered.		Other aspects of gas generation are covered in F11 & F16
Recorded by: Lars Werme			**Date:** 2005-02-22
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP F10 Water radiolysis

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 1.2.01 Radiolysis	Addressed/covered.		Also discussed in F09, F12 and F14.
J 1.2.08 Redox potential	Parameter, addressed/covered in the radiolysis effects in the near field.		Also discussed in F12, F14 and C07.
J 1.2.09 Dissolution chemistry		Not covered, concerns dissolution of fuel matrix.	Addressed/covered in F12. Equilibria also discussed in F14
J 3.1.09 Radiolysis	Addressed/covered.		Same as J 1.2.01, screened out for administrative reasons.
J 3.1.11 Redox front		Addressed/covered in F12, not relevant for this process.	Only the redox front at the fuel surface (third one) relevant in canister.
S 071 Radiolysis	Gamma radiolysis addressed/covered.	Radiolysis in fuel dissolution addressed in F12.	
S 074 Redox front		Addressed/covered in F12, not relevant for this process.	Same as FEP J.3.1.11
S 102 Water chemistry, canister	The impact of water chemistry is discussed.		
K 1.23 Radiolysis		Concerns radiolysis in vitrified waste canister.	
K 3.19 Radiolysis	Gamma radiolysis addressed/covered.	Radiolysis prior to failure covered in F09 and radiolysis in fuel dissolution addressed in F12.	Discusses also redox conditions in canister and redox front in buffer.
I 238 Radiation effects		FEP relevant to low level waste as bituminized waste	
A 1.09 Chemical gradients		Not relevant for this process.	Radiolytic change of local redox conditions covered in F12. Pessimistically neglected pore plugging in F12 and F15.
A 1.66 Radiolysis	Addressed/covered.		Also discussed in F09 and F12.
S 069 Radioactive Decay, fuel	Radiolysis of water by gamma radiation and gas production addressed/covered.	Other consequences of decay as heat generation, radiolysis outside canister etc. discussed elsewhere.	Discussed mainly in F01, F02, F07 and F12.
A 1.35 Formation of gases	Relevant parts as hydrogen production addressed/ covered.	Methane and H2S production by organic matter decomposition not relevant for a KBS 3 repository.	FEP concerns a low level waste repository with no carbon steel
S 045 Gas generation, canister	Radiolytic decomposition of water by gamma radiation addressed/covered.	Other aspects of gas production are not covered here, but in other processes.	Also addressed in F09, F12, F15, F16, C09, C15.

SR-Can FEP F10 Water radiolysis

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 2.049 Gases from metal corrosion	Gas from water radiolysis is discussed.		
J 1.2.04 Gas generation	Gas generation by radiolysis addressed/ covered.	Carbon dioxide and organic matter decomposition not covered because irrelevant for a KBS 3 repository	Helium production addressed mainly in F15
Recorded by: Kastriot Spahiu			**Date:** 2005-02-03
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP F11 Metal corrosion

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.11 Chemical kinetics		The FEP deals with the effects on Eh of chemical kinetics. The fast reaction between water and cast iron will control the Eh. The effects of corrosion of other metal parts will be negligible.	The corrosion of the cast iron insert is covered in C07.
A 1.75 Source terms (expected)	The release of radionuclides from the metal parts of the fuel is covered.		
S 012 Corrosion of metal parts	The corrosion of the metal parts of the fuel is covered.		The build-up of hydrogen will not reach a pressure where the corrosion is suppressed.
S 077 Release from metal parts	The release of radionuclides from the metal parts of the fuel is covered.		
W 2.049 Gases from metal corrosion	The corrosion of the metal parts of the fuel is covered.		
I 065 Waste container (metal corrosion products)	The corrosion of the metal parts of the fuel is covered.		
S 045 Gas generation, canister	The corrosion of the metal parts of the fuel is covered.		The corrosion of the cast iron insert is covered in C07. Helium formation is covered in F16.
H 1.2.1 Hydrogen by metal corrosion	The corrosion of the metal parts of the fuel is covered.		Hydrogen produced through corrosion of the iron insert is covered in C07.
S 095 Total release from fuel elements	The release of radionuclides from the metal parts of the fuel is covered.		Release from the fuel is covered in F12 & F13.
Recorded by: Lars Werme			**Date:** 2005-02-22
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP F12 Fuel dissolution

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.62 Precipitation and dissolution	Dissolution of UO2 addressed/covered	Solubility constraints, dissolution of zircaloy not covered; discussed elsewhere	Also discussed in F11, F13, F15.
A 1.76 Source terms (other)		Not covered because irrelevant. Mechanical breakdown discussed in F07, other aspects highly improbable.	FEP considered irrelevant in NEA database.
A 1.79 Stability of UO2	Addressed/covered		
J 1.2.06 Solubility within fuel matrix	Addressed/covered		Also discussed in F15.
J 1.2.07 Recrystallization		Pessimistically neglected in F15 Recrystallization in cement not relevant.	Ill-formulated FEP concerning recrystallization coupled to radiolysis.
J 5.44 Solubility and precipitation	Potential effects of precipitates on fuel dissolution and solubility of UO2(s) addressed/covered	Factors that affect solubility mainly discussed elsewhere	Also discussed in F14
S 038 Fuel dissolution and conversion	Addressed/covered		
S 060 Precipitation/dissolution	Addressed/covered redox front at fuel surface	Precipitation/dissolution of elements released from fuel and their transport not covered; discussed elsewhere.	Discussed mainly in F14 and F16.
S 076 Release from fuel matrix	Addressed/covered		
S 095 Total release from fuel elements	Two components of total release (instant release and matrix dissolution) addressed/covered	Release from metallic parts covered in F11, instant release in F13	Also discussed in F11, F13 and F16.
W 2.060 Kinetics of precipitation and dissolution		Not covered because discusses kinetics of precipitation/dissolution of radionuclides released from WIPP waste. Certain aspects addressed/covered in F15.	
W 2.066 Reduction-oxidation kinetics	Addressed/covered		Other aspects of redox kinetics also covered.
W 2.099 Alpha recoil		Not addressed because irrelevant consequences for fuel.	FEP relevant to actinide waste, judged irrelevant in WIPP.
A 1.11 Chemical kinetics	Addressed/covered	Poorly poised Eh not relevant. Concentrations below solubility limits pessimistically neglected in F15	Other aspects of chemical kinetics covered
A 1.30 Electrochemical gradients		Not covered because the effect on fuel dissolution inside the massive Fe/Cu canister is expected to be negligible.	
A 1.75 Source terms (expected)	Addressed/covered		Also discussed in F11, F13.

SR-Can FEP F12 Fuel dissolution

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 1.2.08 Redox potential	Addressed/covered in relevant parts		Also discussed in F14, C07.
J 1.2.09 Dissolution chemistry	Addressed/covered.		Also discussed in F14.
J 2.1.02 Coupled effects (electrophoresis)		Not covered because affects migration of radionuclides. Effect on fuel dissolution negligible.	See F17.
J 3.1.11 Redox front	Third aspect (close to fuel) addressed/covered. Post closure transient covered only inside canister	Effect of oxidizing waters in far field not covered.	
S 074 Redox front	Third aspect (close to fuel) addressed/covered. Post closure transient covered only inside canister	Effect of oxidizing waters in far field not covered.	FEP identical to J. 3.1.11.
A 1.09 Chemical gradients		Not covered due to negligible relevance inside canister	FEP concerns mainly buffer
A 1.66 Radiolysis	Addressed/covered		Also discussed in F09, F10.
Recorded by: Kastriot Spahiu			**Date:** 2005-01-20
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP F13 Dissolution of gap inventory

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 1.2.05 I, Cs-migration to fuel surface	Addressed/covered.		Modeled as part of IRF.
S 039 Gap and grain boundary release	Addressed/covered.		Modeled as part of IRF.
S 050 I, Cs-migration to fuel surface	Addressed/covered.		Modeled as part of IRF.
S 095 Total release from fuel elements	Gap inventory component addressed/covered.	Release from fuel matrix and release from metallic parts not covered. They are discussed respectively in F12 and F11.	
A 1.75 Source terms (expected)	Addressed/covered.		Modeled as part of IRF. Also discussed in F07.
Recorded by: Kastriot Spahiu			**Date:** 2005-01-20
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP F14 Speciation of radionuclides, colloid formation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.14 Complexation by organics		Not relevant in canister.	
A 1.37 Geochemical pump	Addressed/covered.		
S 010 Colloids/particles in canister		Addressed/covered in F12. If necessary the discussion may be repeated also in this process.	Colloid transport in geosphere discussed elsewhere.
K 3.18 Elemental solubility/precipitation	Addressed/covered		
W 2.056 Speciation	Addressed/covered	Sorption pessimistically neglected, effect of cementious water not covered because irrelevant	
I 233 Source term & solubility limits		Not considered because discusses solubility limits in far field.	
A 1.13 Colloids	Addressed/covered		Also discussed in F12 and C07.
A 1.77 Speciation	Addressed/covered	Pressure effect on speciation considered negligible.	Also discussed in F11, F12 and C07.
J 1.2.06 Solubility within fuel matrix	Solubility limits addressed/covered	Dissolution of fuel matrix discussed in F12.	
J 5.44 Solubility and precipitation	Addressed/covered		Also discussed in F11, F12 and F13
S 051 Interaction with corrosion products		Neglected as irrelevant because discusses effect of oxidized iron corrosion products on radionuclide sorption/ coprecipitation.	RN immobilization on anoxic Fe corrosion products pessimistically neglected.
S 060 Precipitation/dissolution	Addressed/covered	Radiolysis effect covered mainly in F12.	
S 076 Release from fuel matrix	The solubility of elements addressed/covered	Release from fuel matrix discussed mainly in F12.	
K 2.14 Chemical buffering (canister corrosion products)	Addressed/covered		Discussed mainly in C07.
W 2.057 Kinetics of speciation	Addressed/covered		
W 2.064 Effect of metal corrosion	Hydrogen production and influence of metal corrosion on redox conditions addressed/covered	Oxic corrosion of metals and aerobic degradation of organic material not covered because irrelevant for a KBS 3 repository.	Also discussed in C07.
W 2.066 Reduction-oxidation kinetics	Addressed/covered		
J 1.2.09 Dissolution chemistry	Chemical equilibria addressed/covered.	Dissolution chemistry and radionuclide transport discussed in F12 and F16.	

SR-Can FEP F14 Speciation of radionuclides, colloid formation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 095 Total release from fuel elements		Not addressed here. Addressed/covered in F11, F12 and F13.	
J 1.2.08 Redox potential	Parameter addressed/covered in relevant parts		Also discussed in F12 and C07.
J 3.1.11 Redox front		Not discussed/covered because none of the three aspects is relevant for the process. Another redox front (see A 1.37) is discussed.	Discussed in F12 and C07.
S 074 Redox front		Not discussed/covered because none of the three aspects is relevant for the process. Another redox front (see A 1.37) is discussed.	Third aspect of redox front addressed in F12.
I 065 Waste container (metal corrosion products)	Influence in canister environment addressed/covered.	Sorption on container corrosion products pessimistically neglected.	Fe corrosion products discussed mainly in C07.
Recorded by: Kastriot Spahiu			**Date:** 2005-01-20
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP F15 Helium production

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.35 Formation of gases		The FEP refers to formation of other gases than He.	
J 1.1.04 Gas generation: He production	The helium production by the fuel is covered.		
S 045 Gas generation, canister	The helium production by the fuel is covered.		The hydrogen production through corrosion is covered in F14 and C07.
K 1.24 He gas production	The helium production by the fuel is covered.		The escape of He from the canister is not considered to be of any consequence for that safety assessment.
W 2.054 Helium gas production	The helium production by the fuel is covered.		
J 1.2.04 Gas generation	The helium production by the fuel is covered.		
W 2.049 Gases from metal corrosion	The helium production by the fuel is covered.		The hydrogen production through corrosion is covered in C07.
Recorded by: Lars Werme			**Date:** 2005-02-22
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP F16 Radionuclide transport

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.36 Galvanic coupling		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradient.	
A 1.73 Sorption	Sorption is considered.		
A 1.74 Sorption - nonlinear	Saturation of sorption sites is discussed.		Considered to be irrelevant.
A 2.58 Saturation	Saturation of sorption sites is discussed.		
J 1.5 Release of radionuclides from the failured canister	Radionuclide transport is considered.		
J 2.1.04 Role of the eventual channeling within the canister		No transport resistances within canister are considered.	
S 024 Diffusion in and through failed canister	Transport through canister is discussed.		
S 061 Preferential pathways in canister		No transport resistances within canister are considered.	
S 097 Transport and release of nuclides, failed canister	Radionuclide transport is considered.		
H 1.2.4 Radioactive gases	Radionuclide transport in gas phase is considered.		
H 1.6.4 Thermal effects: Transport (diffusion) effects	The effect of temperature on diffusion is discussed.		
K 0.3 Gaseous and volatile isotopes	Radionuclide transport in gas phase is considered.		
K 1.15 Elemental solubility limits	Solubility limits are discussed.		
K 2.15 Radionuclide sorption and co-precipitation	Sorption and co-precipitation is discussed.		
K 2.18 Corrosion products (physical effects)	The corrosion products are discussed in canister evolution.		
K 2.20 Radio-nuclide transport	Radionuclide transport is considered.		
W 2.055 Radioactive gases	Radionuclide transport in gas phase is considered.		
W 2.061 Actinide sorption	Sorption is considered.		
W 2.067 Localized reducing zones	The chemical effects of corrosion products on fuel stability are discussed.		
W 2.089 Transport of radioactive gases	Radionuclide transport in gas phase is considered.		
A 2.16 Diffusion	Diffusion is considered.		
S 038 Fuel dissolution and conversion	Fuel dissolution is considered.		

SR-Can FEP F16 Radionuclide transport

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
H 1.1.4 Electrochemical effects of metal corrosion		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradient.	
W 2.050 Galvanic coupling		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradient.	
W 2.095 Galvanic coupling		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradient.	
W 2.096 Electrophoresis		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradient.	
A 1.21 Containers - partial corrosion	Partially damaged canisters are considered.		
J 2.1.02 Coupled effects (electrophoresis)		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradient.	
J 2.1.06.2 Natural telluric electrochemical reactions		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradient.	
S 029 Electrochemical effects/gradients		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradient.	
S 051 Interaction with corrosion products	The chemical effects of corrosion products on fuel stability are discussed.		
S 063 Properties of failed canister	Partially damaged canisters are considered.		
S 035 Failure of steel vessel	The canister evolution is discussed.		
S 095 Total release from fuel elements	Release from different parts of the fuel is discussed.		
I 065 Waste container (metal corrosion products)		The effect of corrosion products on transport is neglected - considered small compared to other barriers.	
Recorded by: Patrik Sellin			**Date:** 2006-11-10
Checked and revised by: Kristina Skagius			**Date:** 2006-11-10

Appendix 5

Handling of NEA Project FEPs sorted to SR-Can Canister processes

SR-Can FEP C01 Radiation attenuation/ heat generation

No NEA Project FEP associated with this SR-Can FEP

SR-Can FEP C02 Heat transport

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 2.19 Canister temperature	The transport in the canister is covered.		The heat transfer in the canister is an integrated part of the thermal evolution in the repository.
K 1.08 Heat output (RN decay heat)		This FEP deals with the heat generated by the decay of radionuclides. This is covered in F02.	The decay heat and its evolution with time is the source for the heat transfer in the canister and are covered in F02.
S 090 Temperature, canister	The transport in the canister is covered.	Heat generated by criticality is not covered since criticality has been excluded as a possible scenario. Other aspects of increased temperatures such as copper creep, corrosion, microbial activities will be covered elsewhere.	The decay heat and its evolution with time is the source for the heat transfer in the canister.
Recorded by: Lars Werme			**Date:** 2005-02-23
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP C03 Deformation of cast iron insert

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 2.3.07.1 External stress	External stress caused by rock displacement is addressed.		
J 2.3.08 Internal pressure	Addressed: internal pressure build-up caused by alpha decay is negligible with the present canister design.		
A 1.19 Container failure (mechanical processes)	Addressed: the canister is designed to withstand the pressures in the repository.		The FEP seems to address the stability of a titanium container.
J 2.2 Creeping of copper	Copper creep is addressed.		
J 2.3.07.2 Hydrostatic pressure on canister	Addressed: The hydrostatic load (5MPa) is a negligible stress.		
S 016 Creeping of steel/copper	Addressed: the creep ductility of the copper is sufficient for not to leading to creep failure.		

SR-Can FEP C03 Deformation of cast iron insert

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 053 Internal pressure	Addressed: Pressure increase due to helium build-up. Not addressed: Pressure build-up due to radiolysis and corrosion prior to canister failure is totally insignificant if resulting at all in a pressure build-up.		Pressure build-up after canister failure is dealt with in C07.
S 055 Mechanical impact on canister	Addressed: the canister is designed to withstand the pressures in the repository.		
S 075 Reduced mechanical strength	Addressed: corrosion of a failed canister will eventually lead to collapse and enlargement of the initial penetration.		Weakening of the strength of the insert due to radiation is dealt with in C10.
S 035 Failure of steel vessel	Addressed: the canister is designed to withstand the pressures in the repository. Not addressed: collapse of the insert due to weakening from corrosion.		Weakening from corrosion will only occur in an already failed canister.
A 1.80 Swelling pressure	Addressed: the canister is designed to withstand the pressures in the repository.	Not addressed: Any effect of pressure on solubilities at these low pressures.	
S 003 Bentonite swelling, buffer	Addressed: consequences of the swelling for the canister are considered.		Most of the FEP refers to processes inside the buffer as a result of swelling. These are not considered here.
K 3.04 Bentonite swelling pressure	Addressed: the effect of the swelling pressure on the canister	Not addressed: the effect of the swelling pressure on the host rock.	
Recorded by: Lars Werme			**Date:** 2005-02-09
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP C04 Deformation of copper canister from external pressure

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 2.3.07.2 Hydrostatic pressure on canister	Addressed: the canister is designed to withstand all hydrostatic loads in the repository.		
J 2.3.07.1 External stress	Addressed: the canister is designed to withstand shear movements of up to 10 cm.		
A 1.19 Container failure (mechanical processes)	Addressed: the canister is designed to withstand all hydrostatic loads in the repository.		
J 2.2 Creeping of copper	Addressed: the design of the canister will limit any creep deformation to well below the creep ductility of copper.		
S 016 Creeping of steel/copper	Addressed: the design of the canister will limit any creep deformation to well below the creep ductility of copper.		
S 035 Failure of steel vessel		Addressed in e.g. C07	

SR-Can FEP C04 Deformation of copper canister from external pressure

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 055 Mechanical impact on canister	Addressed: the canister is designed to withstand the pressures in the repository.		
S 034 Failure of copper canister		Addressed in e.g. C11	
A 1.80 Swelling pressure	Addressed: the canister is designed to withstand all hydrostatic loads in the repository.		
S 003 Bentonite swelling, buffer	Addressed: consequences of the swelling for the canister are considered.		Most of the FEP refers to processes inside the buffer as a result of swelling. These are not considered here.
K 3.04 Bentonite swelling pressure	Addressed: the effect of the swelling pressure on the canister	Not addressed: the effect of the swelling pressure on the host rock.	
Recorded by: Lars Werme			**Date:** 2005-02-09
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP C05 Thermal expansion (both cast iron insert and copper canister)

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 2.3.01 Thermal cracking		Not addressed: copper will not behave like a brittle material for the temperatures that will exist in the repository.	
S 022 Differential thermal expansion of near-field barriers	Addressed: the canister is designed to withstand these loads, which are small compared to the maximum design load.		
W 2.031 Differing thermal expansion of repository components	Addressed: the canister is designed to withstand any loads caused by the heat generation in the fuel.		The FEP refers to a salt repository and most of the effects discussed are irrelevant for a repository in hard rock.
K 2.10 Other canister degradation processes		Not addressed: high temperature creep and hydrogen embrittlement are not expected to lower the strength of an intact canister.	Radiation damage is addressed in C10.
J 2.2 Creeping of copper	Addressed: the design of the canister will limit any creep deformation to well below the creep ductility of copper.		
S 055 Mechanical impact on canister	Addressed: the canister is designed to withstand the pressures in the repository.		
Recorded by: Lars Werme			**Date:** 2005-02-09
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP C06 Copper deformation from internal corrosion products

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.19 Container failure (mechanical processes)	Addressed: the canister is designed to withstand all hydrostatic loads and the load from the swelling of the bentonite.		This FEP does not address the deformation from internal corrosion products.
J 2.2 Creeping of copper	Addressed: the design of the canister will limit any creep deformation to well below the creep ductility of copper.		This FEP does not address the deformation from internal corrosion products.
J 3.2.07 Swelling of corrosion products	Addressed: Several scenarios for the development of a failed canister are discussed but they all eventually lead to collapse of the cast iron insert.		
S 016 Creeping of steel/copper	Addressed: the design of the canister will limit any creep deformation to well below the creep ductility of copper.		
S 055 Mechanical impact on canister	Addressed: the canister is designed to withstand the pressures in the repository.		
S 063 Properties of failed canister		Addressed in F05.	
S 100 Volume increase of corrosion products	Addressed: copper corrosion is too slow to have any significant effect.		
K 2.18 Corrosion products (physical effects)	Addressed: copper corrosion is too slow to have any significant effect.		This FEP is related to a steel canister.
S 075 Reduced mechanical strength			Weakening of the strength of the insert due to radiation is dealt with in C10.
S 034 Failure of copper canister		Addressed in C11.	
Recorded by: Lars Werme			**Date:** 2005-02-09
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP C07 Corrosion of cast iron insert

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.03 Biological activity		No bacterial activity is expected inside the bentonite barrier.	
A 1.13 Colloids		Any colloids produced by corrosion are not expected to be able to pass through the buffer barrier.	
A 1.18 Container failure (long-term)		The corrosion of the insert is controlled mainly by the availability of water. Other factors of marginal importance.	
A 1.21 Containers - partial corrosion	The consequences of limited access to water are discussed.		The possible transport resistance to release is a migration issue.
A 1.24 Corrosion	The consequences of corrosion are discussed.		
A 1.60 Pitting		Pitting corrosion is of no consequence for the cast iron insert.	
A 1.77 Speciation		The chemical speciation of the corrosion products will not be temperature dependent or pressure dependent in the temperature and pressure ranges that are expected in the canister.	
A 1.86 Uniform corrosion	The consequences of corrosion are discussed.		
J 2.1.07 Pitting		Pitting corrosion is of no consequence for the cast iron insert.	
J 4.1.08 Change of groundwater chemistry in nearby rock		The presence of water is the most important factor that controls the corrosion of the insert.	
S 013 Corrosion of steel vessel	The anaerobic corrosion of the cast iron insert has been discussed.	Possible effects of components from the fuel on the corrosion rate are of no consequence.	Galvanic corrosion is discussed in C08.
S 014 Corrosion prior to wetting	Corrosion prior to failure of the copper shell has been discussed and is considered to have negligible consequences.		
S 035 Failure of steel vessel	The size and shape of the hole in the cast iron insert will control the availability of water to the void in the insert.		
S 051 Interaction with corrosion products	Sorption and precipitation on solid corrosion products are covered.		
S 075 Reduced mechanical strength		Obviously the corrosion will eventually lead to mechanical failure of the canister.	When and how the canister fails depend on the external circumstances.

SR-Can FEP C07 Corrosion of cast iron insert

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
H 1.1.1 Container metal corrosion	Only anaerobic corrosion is discussed.		Water access to the insert is assumed to occur only after the repository has gone anaerobic.
K 2.03 Corrosion on wetting	Corrosion in water and water vapour has been considered.		In fact, the corrosion in water vapour is not very much lower than that in liquid water.
K 2.04 Oxic corrosion		Corrosion of the cast iron inseret is expected to occur only after the repository has become anaerobic.	
K 2.06 Anoxic corrosion	Anoxic corrosion of the cast iron insert is the only form of corrosion that we consider after failure of the copper shell.		
K 2.07 Localised corrosion		Pitting corrosion is of no consequence for the cast iron insert.	
K 2.14 Chemical buffering (canister corrosion products)	Gas generated through corrosion is covered.		The redox potential in the canister will be controlled by the corroding iron.
K 2.16 Hydrogen production	Hydrogen gas generation has been considered.		
K 3.15 Gas permeability	The build-up of hydrogen gas does not affect the corrosion rate.		
W 2.057 Kinetics of speciation		The effects of reaction kinetics are irrelevant for iron corrosion	
W 2.064 Effect of metal corrosion	Generation soluble and solid iron corrosion products and their effects on the chemical environment inside the canister are covered.		
I 015 Gas generation (CH4, CO2, H2)	The formation of hydrogen gas is discussed.	No bacterial degradation of organic material is expected inside the canister.	
I 300 Termperature effects (on transport)		The influence of the changes in temperature during the time the insert corrodes on the corrosion rate is negligible.	The possible consequences for transport in the near field is a migration issue
A 1.42 Hydride cracking		Possible hydride cracking is not discussed.	
S 063 Properties of failed canister	The size and shape of the hole in the cast iron insert will control the availability of water to the void in the insert.		
H 1.2.1 Hydrogen by metal corrosion	The formation of hydrogen gas is discussed.		Any consequences for microbes in concrete are not discussed.

SR-Can FEP C07 Corrosion of cast iron insert

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 2.05 Microbially-mediated corrosion		No bacterial activity is expected inside the bentonite barrier.	
W 2.049 Gases from metal corrosion	Hydrogen production through corrosion has been considered.	Other sources of gas will give negligible contributions to the gas pressure inside the canister.	There will, most likely, be no organic material inside the canister.
W 2.051 Chemical effects of corrosion	Gas generated through corrosion is covered.		The FEP concerns the effects of corrosion products on brines.
I 012 Biological activity (bacteria & microbes)		No bacterial activity is expected inside the bentonite barrier.	
A 1.11 Chemical kinetics	Chemical kinetics is unimportant in comparison to transport kinetics.		
J 1.2.08 Redox potential	Gas generated through corrosion is covered.		The redox potential in the canister will be controlled by the corroding iron.
J 3.1.11 Redox front		The redox potential in the canister will be controlled by the corroding iron. There will be no redox front originating from the canister.	
S 074 Redox front		The redox potential in the canister will be controlled by the corroding iron. There will be no redox front originating from the canister.	Also addressed in F12.
S 102 Water chemistry, canister	The water chemistry has an effect on the corrosion rate, but the most important factor for the corrosion is the availability of water.		
K 2.10 Other canister degradation processes		Possible hydride cracking and high temperature creep are not discussed.	
K 2.18 Corrosion products (physical effects)	Transport through the corrosion products is the rate limiting step in the corrosion process.		
K 2.19 Canister temperature		The influence of the changes in temperature during the time the insert corrodes on the corrosion rate is negligible.	
I 065 Waste container (metal corrosion products)		The release of Fe(II) from the insert to the buffer will be negligible as long as the copper shell remains largely intact.	
A 1.35 Formation of gases	The formation of hydrogen gas is discussed.		
S 034 Failure of copper canister	The size and shape of the hole in the copper canister will control the availability of water to the cast iron insert.		

SR-Can FEP C07 Corrosion of cast iron insert

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 1.2.04 Gas generation	Gas generated through corrosion is covered.	Helium production has no consequences for the corrosion of the insert.	Gas generated through radiolysis is covered in F09 and F15. There will, most likely, be no organic material to decompose inside the canister.
S 045 Gas generation, canister	Hydrogen production through corrosion has been considered.	Other sources of gas will give negligible contributions to the gas pressure inside the canister.	There will, most likely, be no organic material inside the canister.
S 103 Water chemistry in near-field rock	The water chemistry has an effect on the corrosion rate, but the most important factor for the corrosion is the availability of water.		
Recorded by: Lars Werme			**Date:** 2005-02-17
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP C08 Galvanic corrosion

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.30 Electrochemical gradients			See Stray current corrosion C13.
J 2.1.02 Coupled effects (electrophoresis)		The electrophoresis in connection with galvanic corrosion is not discussed. The galvanic does not lead to noticeable increase in the corrosion rate.	
J 2.1.06.2 Natural telluric electrochemical reactions			See Stray current corrosion C13.
S 029 Electrochemical effects/gradients	The galvanic coupling between iron and copper does not lead to noticeable increase in the corrosion rate.		See Stray current corrosion C13.
H 1.1.4 Electrochemical effects of metal corrosion		This FEP discusses a situation where all the canister in the repository are in contact with each other.	
W 2.050 Galvanic coupling	The galvanic coupling between iron and copper does not lead to noticeable increase in the corrosion rate.		
W 2.095 Galvanic coupling	The galvanic coupling between iron and copper does not lead to noticeable increase in the corrosion rate.		
I 126 Corrosion (galvanic coupling)	The galvanic coupling between iron and copper does not lead to noticeable increase in the corrosion rate.		

SR-Can FEP C08 Galvanic corrosion

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 011 Corrosion of copper canister		The galvanic coupling between iron and copper does not lead to copper corrosion.	
S 013 Corrosion of steel vessel	The galvanic coupling between iron and copper does not lead to noticeable increase in the corrosion rate.		
A 1.86 Uniform corrosion			See Corrosion of cast iron insert C07
Recorded by: Lars Werme			**Date:** 2005-02-17
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP C09 Stress corrosion cracking of cast iron insert

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 2.3.06 Cracking along welds		There are no welds in the cast iron insert.	
S 014 Corrosion prior to wetting	The risk for SCC caused by radiolytically produced nitrate is discussed.		Other aspects of cast iron corrosion are discussed in C07
S 035 Failure of steel vessel	The risk for SCC caused by radiolytically produced nitrate is discussed.		Other aspects of cast iron corrosion are discussed in C07
K 2.09 Stress corrosion cracking	The risk for SCC caused by radiolytically produced nitrate is discussed.		
S 013 Corrosion of steel vessel	The risk for SCC caused by radiolytically produced nitrate is discussed.		Other aspects of cast iron corrosion are discussed in C07
A 1.24 Corrosion	The risk for SCC caused by radiolytically produced nitrate is discussed.		
S 055 Mechanical impact on canister	The risk for SCC caused by radiolytically produced nitrate is discussed.		Other aspects of cast iron corrosion are discussed in C07
Recorded by: Lars Werme			**Date:** 2005-02-17
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP C10 Radiation effects

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.64 Radiation damage	Addressed: the effect of neutron and gamma radiation is negligible.		
J 2.3.05 Radiation effects on canister	Addressed: the effect of neutron and gamma radiation is negligible.		
S 068 Radiation effects on canister	Addressed: the effect of neutron and gamma radiation is negligible.		
K 2.10 Other canister degradation processes	Addressed: the effect of radiation on mechanical strength.		Not addressed: high temperature creep and hydrogen embrittlement are not expected to lower the strength of an intact canister. See C05.
W 2.016 Radiological effects on containers	Addressed: the effect of neutron and gamma radiation is negligible.		
I 238 Radiation effects	Addressed: the effect of neutron and gamma radiation is negligible.		
A 1.24 Corrosion		Addressed in C09 and C11.	
Recorded by: Lars Werme			**Date:** 2005-02-09
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP C11 Corrosion of copper canister

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.20 Container healing		Possible healing of a hole in the copper shell due to clogging by iron corrosion products is not discussed because the probability for such an event cannot be assessed.	
J 2.1.01 Chemical reactions (copper corrosion)	Corrosion is considered.		
J 2.1.03 Internal corrosion due to waste		Any corrosion caused by fission products is totally negligible. All the iodine in a canister can corrode less 100 g of Cu.	
J 2.1.05 Role of chlorides in copper corrosion	The role of chloride has been considered.		
J 2.1.08 Corrosive agents, Sulphides, oxygen etc	Uniform corrosion controlled by the supply of sulphides is considered in the long term.		
J 2.1.09 Backfill effects on Cu corrosion	Initially trapped oxygen is considered. Uniform corrosion controlled by the supply of sulphides is considered in the long term.		
S 011 Corrosion of copper canister	Uniform corrosion controlled by the supply of sulphides is considered in the long term. During the aerobic period, pitting and SCC could be possible.		

SR-Can FEP C11 Corrosion of copper canister

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 034 Failure of copper canister	Uniform corrosion controlled by the supply of sulphides is considered in the long term. During the aerobic period, pitting and SCC could be possible.		
K 2.05 Microbially-mediated corrosion	Bacterial activity in the bentonite barrier is considered and dismissed.		
I 012 Biological activity (bacteria & microbes)	Bacterial activity in the bentonite barrier is considered and dismissed.		
A 1.03 Biological activity	Bacterial activity in the bentonite barrier is considered and dismissed.		
A 1.18 Container failure (long-term)	Uniform corrosion controlled by the supply of sulphides is considered in the long term. During the aerobic period, pitting and SCC could be possible.		Hydrogen cracking is not considered a failure mode for oxygen-free copper.
A 1.21 Containers - partial corrosion		This has no consequence for copper corrosion.	
A 1.24 Corrosion	All conceivable forms of corrosion have been considered.		
A 1.60 Pitting	During the aerobic period, pitting could be possible.		
A 1.86 Uniform corrosion	Uniform corrosion controlled by the supply of sulphides is considered in the long term is considered.		
J 2.1.07 Pitting	During the aerobic period, pitting could be possible.		
J 4.1.08 Change of groundwater chemistry in nearby rock		The changes in groundwater chemistry caused by the construction are considered to be of negligible importance for the long-term corrosion.	
S 075 Reduced mechanical strength		Reduced strength of the cast iron insert has no consequence for the copper corrosion.	
K 2.07 Localised corrosion	During the aerobic period, pitting and SCC could be possible.		
I 300 Termperature effects (on transport)	The effect of temperature on transport of corrodants is considered and found to be of limited importance.		
J 5.01 Saline (or fresh) groundwater intrusion		Chemical equilibrium will not be reached for the corrosion reaction.	
S 063 Properties of failed canister		A hole in the copper shell has consequences for the corrosion of the insert but not for copper corrosion.	

SR-Can FEP C11 Corrosion of copper canister

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 2.19 Canister temperature	The effect of temperature on copper corrosion can be neglected. The effect of temperature on transport of corrodants is considered and found to be of limited importance.		
A 1.66 Radiolysis	The consequences of radiolytically generated corrosive gases are discussed.		
S 103 Water chemistry in near-field rock	Initially trapped oxygen is considered. Uniform corrosion controlled by the supply of sulphides is considered in the long term.		The changes in groundwater chemistry caused by the construction are considered to be of negligible importance for the long-term corrosion.
Recorded by: Lars Werme			**Date:** 2005-02-17
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP C12 Stress corrosion cracking, copper canister

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 2.3.03 Stress corrosion cracking	SCC is discussed.		
J 2.3.06 Cracking along welds	SCC is discussed with no particular emphasis on the welds. Any part of the canister with tensile stresses canin principle be susceptible to SCC		
K 2.09 Stress corrosion cracking	SCC is discussed.		
S 034 Failure of copper canister	SCC is discussed but not identified as a potential failure mode.		
A 1.24 Corrosion	SCC is discussed.		
S 011 Corrosion of copper canister	SCC is discussed.		
S 055 Mechanical impact on canister	Considered: external pressure can give rise to tensile stresses.		
Recorded by: Lars Werme			**Date:** 2005-02-17
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP C13 Earth currents - Stray current corrosion

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 2.094 Electrochemical effects	The corrosion aspects for the canister of telluric currents are discussed.		
W 2.096 Electrophoresis	The corrosion aspects for the canister of telluric currents are discussed.		
J 2.1.06.2 Natural telluric electrochemical reactions	The corrosion aspects for the canister of telluric currents are discussed.		
S 029 Electrochemical effects/gradients	The corrosion aspects for the canister of telluric currents are discussed.		
H 1.1.4 Electrochemical effects of metal corrosion	The corrosion aspects for the canister of electrical fields underground are discussed.		
W 2.050 Galvanic coupling	The corrosion aspects for the canister of telluric currents are discussed.		This FEP relates to a repository for long lived low level waste in salt.
W 2.095 Galvanic coupling	The corrosion aspects for the canister of telluric currents are discussed.		This FEP relates to a repository for long lived low level waste in salt.
Recorded by: Lars Werme			**Date:** 2005-02-18
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP C14 Deposition of salts on canister surface

No NEA Project FEP associated with this SR-Can FEP

SR-Can FEP C15 Radionuclide transport

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 024 Diffusion in and through failed canister	Transport through canister is discussed.		
Recorded by: Patrik Sellin			**Date:** 2006-11-10
Checked and revised by: Kristina Skagius			**Date:** 2006-11-10

Appendix 6

Handling of NEA Project FEPs sorted to SR-Can Buffer processes

SR-Can FEP Bu01 Radiation attenuation/ heat generation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.52 Long-term transients	Decay heat is discussed		
J 1.1.02 Radioactive decay; heat	Decay heat is discussed		
S 069 Radioactive Decay, fuel	Decay heat is discussed		
W 2.013 Heat from radioactive decay	Decay heat is discussed		
Recorded by: Patrik Sellin			**Date:** 2005-04-22
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP Bu02 Heat transport

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.52 Long-term transients	Decreasing decay heat is considered		
H 1.2.8 Thermo-chemical effects	The effect of gas filled gaps around the canister is discussed		The effect of gas generation on the thermal evolution is not considered since the processes occur in different time frames
K 3.02 Thermal evolution	The effect of buffer properties on the thermal evolution is considered		
S 089 Temperature, bentonite buffer	The thermal evolution in the near field is discussed		
Recorded by: Patrik Sellin			**Date:** 2005-04-26
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP Bu03 Freezing

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 5.17 Permafrost	The properties of a frozen backfill is discussed		
K 10.13 Permafrost		This FEP does not discuss freezing at repository level.	
S 059 Permafrost	The properties of a frozen backfill is discussed		Identical to J.5.17
Recorded by: Patrik Sellin			**Date:** 2006-05-29
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP Bu04 Water uptake and transport for unsaturated conditions

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.52 Long-term transients	Resaturation is discussed		
A 1.68 Reflooding	Reflooding is discussed		SKB does not use the term reflooding
A 1.84 Transport in gases or of gases	The effect of a gas phase is discussed		
K 1.08 Heat output (RN decay heat)	Resaturation is discussed		
K 3.03 Bentonite saturation	The effect of heat on resaturation is discussed		
S 079 Resaturation of bentonite buffer	Resaturation is discussed		
W 2.013 Heat from radioactive decay	The effect of heat on resaturation is discussed		This FEP may not be relevant for this process?
W 2.098 Osmotic processes	The effect of salinity is discussed		
Recorded by: Patrik Sellin			**Date:** 2005-04-22
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP Bu05 Water transport for saturated conditions

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.40 Hydraulic conductivity	The effect of varying hydraulic conductivity is discussed		
J 3.2.09 Flow through buffer/backfill			Handled in process Bu07
K 3.08 Buffer impermeability	Low permeability is discussed		
S 037 Flow through buffer/backfill	The effect of an increased conductivity is discussed		
W 2.013 Heat from radioactive decay	The effect of temperature on conductivity is discussed		Thermally driven flow under saturated conditions is neglected
W 2.098 Osmotic processes	The effect of salinity is discussed		
Recorded by: Patrik Sellin			**Date:** 2005-04-22
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP Bu06 Gas transport/dissolution

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.35 Formation of gases	Gas generation is discussed		
A 1.84 Transport in gases or of gases	The effect of gas on buffer transport properties is discussed		
H 1.2.6 Gas transport	Gas transport in the near field is discussed		
J 3.2.12 Gas transport in bentonite	Gas transport in bentonite is discussed		
K 3.15 Gas permeability	Gas transport in bentonite is discussed		
S 040 Gas escape from canister	Gas transport in bentonite is discussed		
S 041 Gas flow and transport, buffer/backfill	Gas transport in bentonite is discussed		
S 044 Gas generation, buffer/backfill	Gas generation is discussed		
Recorded by: Patrik Sellin			**Date:** 2005-04-22
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP Bu07 Piping/erosion

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.40 Hydraulic conductivity	Increased conductivity caused by piping is discussed		
I 027 Buffer (channelling)	The effect of pathways in the buffer is discussed		
J 3.2.04 Erosion of buffer/backfill	Erosion is discussed		
J 3.2.08 Preferential pathways in the buffer/backfill			Do not understand this FEP
J 3.2.09 Flow through buffer/backfill	The effect of pathways in the buffer is discussed		
K 3.06 Bentonite erosion	Erosion is discussed		
S 025 Dilution of buffer/backfill	Erosion is discussed		
S 031 Erosion of buffer/backfill	Erosion is discussed		
S 037 Flow through buffer/backfill			This FEP is discussed in Bu05 and Bu10
Recorded by: Patrik Sellin			**Date:** 2005-04-25
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP Bu08 Swelling/Mass redistribution

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.08 Cave ins	Rock buffer interactions are considered		
A 1.31 Excessive hydrostatic pressures	Thermal expansion is considered		
A 1.47 Interfaces (boundary conditions)	Mechanical interactions are considered		
A 1.80 Swelling pressure	Mechanical interactions are considered		
I 298 Swelling pressure (clay)	Swelling pressure is considered		
J 3.2.01.1 Swelling of bentonite into tunnels and cracks	Mechanical interactions are considered		
J 3.2.01.2 Uneven swelling of bentonite	Uneven swelling is considered		
J 3.2.02 Movement of canister in buffer/backfill	Canister movement is considered		
J 3.2.03 Mechanical failure of buffer/backfill	Interaction with rock is considered		
J 3.2.07 Swelling of corrosion products	Mechanical interactions are considered		
J 4.2.02.1 Excavation /backfilling effects on nearby rock			Basically a geosphere FEP, see Ge06
J 4.2.09 Creeping of rock mass			Basically a geosphere FEP, see Ge08
K 2.18 Corrosion products (physical effects)	Mechanical interactions are considered		
K 3.03 Bentonite saturation	Build up of pressure is considered		
K 3.04 Bentonite swelling pressure	Swelling pressure is considered		
K 3.05 Bentonite plasticity	Mechanical properties are considered		
K 3.07 Canister sinking	Mechanical interactions are considered		
K 4.04 Effect of bentonite swelling on EDZ	Mechanical interactions are considered		Basically a geosphere FEP.
S 003 Bentonite swelling, buffer	Swelling pressure is considered		
S 004 Cave in	Rock buffer interactions are considered		
S 015 Creeping of rock mass, near-field			Basically a geosphere FEP, see Ge08
S 022 Differential thermal expansion of near-field barriers	Thermal expansion is considered		
S 025 Dilution of buffer/backfill	Loss of mass is considered		Also covered in colloid formation Bu17
S 030 Enhanced rock fracturing			Basically a geosphere FEP, see Ge07

SR-Can FEP Bu08 Swelling/Mass redistribution

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 034 Failure of copper canister	Mechanical interactions are considered		
S 056 Mechanical impact/failure, buffer/backfill	Mechanical interactions are considered		
S 058 Movement of canister in buffer/backfill	Mechanical interactions are considered		
S 062 Properties of bentonite buffer	Very general FEP - most aspects are considered		
S 065 Properties of near-field rock	Mechanical interactions are considered		Basically a geosphere FEP, see e.g. Ge07
S 066 Properties of tunnel backfill	Mechanical interactions are considered		
S 100 Volume increase of corrosion products	Mechanical interactions are considered		
W 2.031 Differing thermal expansion of repository components	Thermal expansion is considered		
W 2.035 Mechanical effects of backfill	Mechanical interactions are considered		
Recorded by: Patrik Sellin			**Date:** 2006-05-30
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP Bu09 Liquefaction

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
I 277 Soil liquefaction (seismic)	Liquefaction is considered		
Recorded by: Patrik Sellin			**Date:** 2006-05-30
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP Bu10 Advection

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.22 Convection	Convection(advection) is discussed		
A 1.28 Dispersion		Not considered within the buffer - pure diffusion will dominate under normal circumstances	
J 3.2.08 Preferential pathways in the buffer/backfill	Advection in the buffer is discussed		
K 3.08 Buffer impermeability			Diffusion/advection is discussed in Bu05
K 3.16 Radionuclide transport through buffer			Diffusion in buffer is discussed in Bu11 and Bu23
S 096 Transport and release of nuclides, bentonite buffer			RN transport is discussed in Bu11and Bu23 as well as in the Fuel process report
W 2.090 Advection	Advection in the buffer is discussed		
Recorded by: Patrik Sellin			**Date:** 2005-05-11
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP Bu11 Diffusion

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.27 Diffusion	Diffusion is discussed		
J 3.2.06 Diffusion - surface diffusion	Surface diffusion is discussed		
J 3.2.10 Soret effect		The process is neglected due to the small thermal gradients over the buffer	
S 002 Anion-exclusion	Anion-exclusion is discussed		
S 023 Diffusion	Included by definition		
S 083 Soret effect		The process is neglected due to the small thermal gradients over the buffer	
K 4.02 Natural radionuclides/elements		Naturally occurring radioelements are not included in SR-Can (pessimistically)	
W 2.093 Soret effect		The process is neglected due to the small thermal gradients over the buffer	
A 1.36 Galvanic coupling		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradients	
J 3.2.08 Preferential pathways in the buffer/backfill			Loss of the diffusion barrier is discussed in the "advection" process Bu10
H 1.6.4 Thermal effects: Transport (diffusion) effects	Increased diffusivity of species is discussed in the modeling of the chemical evolution		It is assumed that the radionuclide transport will take place after the thermal pulse

SR-Can FEP Bu11 Diffusion

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 3.10 Radionuclide retardation	Sorption and diffusion of radionuclides are discussed		
K 3.16 Radionuclide transport through buffer	Sorption and diffusion of radionuclides are discussed		
A 2.16 Diffusion	Diffusion is discussed		
S 096 Transport and release of nuclides, bentonite buffer	Discussed in the "radionuclide transport" process Bu23		
H 1.1.4 Electrochemical effects of metal corrosion		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradients	
W 2.050 Galvanic coupling		Not relevant here - canister process	
W 2.095 Galvanic coupling		Not relevant here - canister process	
W 2.096 Electrophoresis		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradient.	
I 300 Termperature effects (on transport)	Increased diffusivity of species is discussed in the modeling of the chemical evolution		
A 1.09 Chemical gradients	Concentration gradients are discussed		
J 2.1.06.2 Natural telluric electrochemical reactions		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradient.	
S 029 Electrochemical effects/gradients		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradient.	
Recorded by: Patrik Sellin			**Date:** 2006-11-01
Checked and revised by: Kristina Skagius			**Date:** 2006-11-08

SR-Can FEP Bu12 Sorption (including ion-exchange)

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.06 Buffer characteristics			The FEP is included in "water transport under saturated conditions" (Bu05) and "advection" (BU10)
A 1.14 Complexa-tion by organics		Not a buffer process	
A 1.16 Container corrosion products			Discussed in process alteration of impurities, Bu13
A 1.51 Long-term physical stability			Discussed in montmorillonite transformation Bu16 and osmosis Bu15

SR-Can FEP Bu12 Sorption (including ion-exchange)

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.73 Sorption	Sorption is discussed		
A 1.74 Sorption - nonlinear		Non-linear sorption is not included - the Kd approach is however justified.	
A 2.58 Saturation		Not considered - amount of sorbing species is low	
I 028a Buffer (degradation)			The FEP is discussed in Montmorillonite transformation Bu16
I 028b Buffer (quality)			The FEP is discussed in the description of the initial state
I 182 Buffer (chemical saturation)	The effect of ground water ionic strength is discussed		
J 3.1.01 Degradation of the bentonite by chemical reactions			The FEP is discussed in Montmorillonite transformation Bu16
J 3.1.02 Saturation of sorption sites		Non-linear sorption is not included - the Kd approach is however justified.	
J 3.1.03 Effects of bentonite on groundwater chemistry			Discussed in alteration of impurities Bu13
J 3.1.10 Interactions with corrosion products and waste			Discussed in alteration of impurities Bu13
J 4.1.04 Sorption	Sorption is discussed		
J 4.1.08 Change of groundwater chemistry in nearby rock			Discussed in alteration of impurities Bu13
J 4.1.09 Complexing agents		Not a buffer process	
K 3.09 Bentonite porewater chemistry			Discussed in alteration of impurities Bu13
K 3.10 Radio-nuclide retardation	Sorption and diffusion of radionuclides are discussed		
K 3.12a Mineralogical alteration - short term			The FEP is discussed in Montmorillonite transformation Bu16
K 3.16 Radionuclide transport through buffer	Sorption and diffusion of radionuclides are discussed		
K 3.25 Interaction with cement components			The FEP is discussed in Montmorillonite transformation Bu16
S 006 Chemical alteration of buffer/backfill			The FEP is discussed in Montmorillonite transformation Bu16 and alterations of impurities Bu13

SR-Can FEP Bu12 Sorption (including ion-exchange)

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 018 Deep saline water intrusion	Impact of water composition on sorption discussed.		Also discussed in Osmosis Bu15 and alterations of impurities Bu13
S 062 Properties of bentonite buffer	Very general FEP - most aspects discussed		
S 084 Sorption	Sorption is discussed		
W 2.061 Actinide sorption	Sorption is discussed		
W 2.062 Kinetics of sorption		Not discussed - sorption coefficient are based on laboratory experiments where on fast kinetics is detected.	
Recorded by: Patrik Sellin			**Date:** 2005-06-16
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP Bu13 Alterations of impurities

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.07 Buffer evolution			The FEP is discussed in Montmorillonite transformation Bu16
A 1.43 Hydrothermal alteration	Transport of species in thermal gradient is discussed		The FEP is also discussed in Montmorillonite transformation Bu16
A 1.51 Long-term physical stability	Transport of species in thermal gradient and the precipitation of minerals is discussed		The FEP is also discussed in Montmorillonite transformation Bu16
A 1.62 Precipitation and dissolution	Dissolution/precipitation is discussed		
I 028a Buffer(degradation)			The FEP is discussed in Montmorillonite transformation Bu16
I 048 Buffer (degradation by concrete)			The FEP is discussed in Montmorillonite transformation Bu16
J 3.1.01 Degradation of the bentonite by chemical reactions	Dissolution/precipitation of impurities is discussed		The FEP is also discussed in Montmorillonite transformation Bu16
J 3.1.03 Effects of bentonite on groundwater chemistry	Changes in groundwater/porewater composition is discussed		
J 3.1.10 Interactions with corrosion products and waste	Effects of corrosion products are discussed		
J 3.2.05 Thermal effects on the buffer material			The FEP is discussed in Montmorillonite transformation Bu16

SR-Can FEP Bu13 Alterations of impurities

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 4.1.08 Change of groundwater chemistry in nearby rock	Changes in groundwater/porewater composition is discussed		
J 5.11 Degradation of hole- and shaft seals			The FEP describes a mix of several processes - all of them are discussed
K 3.09 Bentonite porewater chemistry	Changes in groundwater/porewater composition are discussed		
K 3.12a Mineralogical alteration - short term			The FEP is discussed in Montmorillonite transformation Bu16
K 3.13 Bentonite cementation			The FEP is discussed in Montmorillonite transformation Bu16
K 3.14 Canister/bentonite interaction	Effect of iron is discussed		
K 3.25 Interaction with cement components			The FEP is discussed in Montmorillonite transformation Bu16
S 006 Chemical alteration of buffer/backfill	All aspects mentioned are discussed		
S 062 Properties of bentonite buffer	Very general FEP - most aspects discussed		
S 079 Resaturation of bentonite buffer	The potential effect is identified		
S 094 Thermal degradation of buffer/backfill	Dissolution/precipitation of impurities is discussed		The FEP is also discussed in Montmorillonite transformation Bu16
Recorded by: Patrik Sellin			**Date:** 2005-06-16
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP Bu14 Pore water speciation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 3.09 Bentonite porewater chemistry			Discussed in alterations of impurities Bu13
W 2.057 Kinetics of speciation		Homogeneous aqueous geochemical speciation reactions involving relatively small inorganic species occur rapidly	
Recorded by: Patrik Sellin			**Date:** 2005-06-16
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP Bu15 Osmosis

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.09 Chemical gradients			Discussed in the Diffusion process Bu11
W 2.098 Osmotic processes	Osmosis is discussed		
Recorded by: Patrik Sellin			**Date:** 2005-06-16
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP Bu16 Montmorillonite transformation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.07 Buffer evolution	The effect of elevated temperatures is discussed		
A 1.43 Hydro-thermal alteration	The effect of elevated temperatures is discussed		
A 1.51 Long-term physical stability	The long-term stability is discussed		
I 028a Buffer (degradation)	Different mechanisms for montmorillonite transformation are discussed.		Unclear description
I 048 Buffer (degradation by concrete)	The effect of high pH is discussed		
J 3.1.01 Degradation of the bentonite by chemical reactions	Degradation is discussed		
J 3.1.03 Effects of bentonite on groundwater chemistry			The FEP is discussed in Alteration of impurities Bu13
J 3.1.10 Interactions with corrosion products and waste			The FEP is discussed in Alteration of impurities Bu13
J 3.2.05 Thermal effects on the buffer material	The effect of elevated temperatures is discussed		
J 4.1.08 Change of groundwater chemistry in nearby rock			The FEP is discussed in Alteration of impurities Bu13
J 5.11 Degradation of hole- and shaft seals	Degradation is discussed		
K 3.09 Bentonite porewater chemistry			The FEP is discussed in Alteration of impurities Bu13
K 3.12a Minera-logical alteration - short term	The effect of elevated temperatures is discussed		
K 3.12b Minera-logical alteration - long term	Degradation is discussed		
K 3.14 Canister/bentonite interaction	The effect of iron is discussed		

SR-Can FEP Bu16 Montmorillonite transformation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 3.25 Interaction with cement components	The effect of high pH is discussed		
S 006 Chemical alteration of buffer/backfill	Degradation is discussed		
S 062 Properties of bentonite buffer	Very general FEP - most aspects discussed		
S 094 Thermal degradation of buffer/backfill	The effect of elevated temperatures is discussed		The FEP is also discussed in Alteration of impurities Bu13
Recorded by: Patrik Sellin			**Date:** 2005-06-16
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP Bu17 Colloid release

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.63 Pseudo-colloids		Not a buffer issue	Discussed in radionuclide transport in the geosphere
A 2.50 Pseudo-colloids	Colloid generation from the buffer is discussed		
J 3.1.04 Colloid generation - source	Colloid generation from the buffer is discussed		
J 3.1.05 Coagulation of bentonite	Colloid generation from the buffer is discussed - this is the reverse process - included by definition		
J 3.1.06 Sedimentation of bentonite			Sedimentation of bentonite occurs in the geosphere - it is however considered in the integrated description of colloid release.
J 3.2.04 Erosion of buffer/backfill	Colloid generation from the buffer is discussed		
J 5.11 Degradation of hole- and shaft seals			Unclear meaning of FEP
S 007 Coagulation of bentonite	Colloid generation from the buffer is discussed - this is the reverse process - included by definition		
S 009 Colloid generation-source	Colloid generation from the buffer is discussed		
S 031 Erosion of buffer/backfill	Erosion as a consequence of colloid release is discussed		
S 082 Sedimentation of bentonite			Sedimentation of bentonite occurs in the geosphere - it is however considered in the integrated description of colloid release.
K 3.06 Bentonite erosion	Colloid generation from the buffer is discussed		

SR-Can FEP Bu17 Colloid release

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 4.12 Colloids	Colloid generation from the buffer is discussed		
W 2.082 Suspen-sions of particles		Not relevant	
W 2.083 Rinse		Not relevant	
I 058 Colloid formation (natural and vault generated)	Colloid generation from the buffer is discussed		Does not really fit the FEP description
S 025 Dilution of buffer/backfill	Loss of buffer mass is a consequence of colloid generation - yes		
K 3.05 Bentonite plasticity		Has nothing to do with colloid release	
A 1.13 Colloids	Colloid generation from the buffer is discussed		
S 065 Properties of near-field rock	Very general FEP - the colloid aspects are discussed		
Recorded by: Patrik Sellin			**Date:** 2006-11-01
Checked and revised by: Kristina Skagius			**Date:** 2006-11-08

SR-Can FEP Bu18 Radiation-induced transformations

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.51 Long-term physical stability	Radiation effects are discussed		
A 1.64 Radiation damage	Radiation effects are discussed		
I 238 Radiation effects	Radiation effects are discussed		
J 3.1.13 Radiation effects on bentonite	Radiation effects are discussed		
K 2.11 Radiation shielding	Credit is taken for shielding		
S 067 Radiation effects on buffer/backfill	Exactly what is covered in this process		
Recorded by: Patrik Sellin			**Date:** 2006-05-16
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP Bu19 Radiolysis of pore water

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.66 Radiolysis	Radiolysis is discussed		
I 238 Radiation effects	Radiolysis is discussed		
J 1.2.01 Radiolysis	Radiolysis is discussed		
J 1.2.02 Hydrogen/oxygen explosions		Not addressed - sounds speculative	
J 3.1.09 Radiolysis	Radiolysis is discussed		
K 2.11 Radiation shielding	Credit is taken for shielding		
S 044 Gas generation, buffer/backfill		Not discussed - gamma-radiolysis is expected to give very little gas - corrosion gas will dominate in the case of a breached canister	
Recorded by: Patrik Sellin			**Date:** 2006-05-16
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP Bu20 Microbial processes

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.03 Biological activity	Microbes are considered		
A 1.35 Formation of gases		Gas generation from microbial activity is not relevant in a spent fuel repository	
A 1.51 Long-term physical stability		The buffer is not expected to be affected by microbes	Reduction of iron may be an exception
A 1.53 Methylation		Organic compounds are not expected to have any significant effect on the buffer - since the levels are very low	
A 1.54 Microbes		The buffer is not expected to be affected by microbes	Reduction of iron may be an exception
A 1.55 Microorganisms	Microbes are considered		
I 012 Biological activity (bacteria & microbes)	Microbes are considered		
J 2.1.10 Microbes	Microbes are considered		
K 3.17 Microbial activity	Microbes are considered		
S 044 Gas generation, buffer/backfill		Gas generation from microbial activity is not relevant in a spent fuel repository.	
S 057 Microbial activity	Microbes are considered		
W 2.044 Degradation of organic material		Gas generation from microbial activity is not relevant in a spent fuel repository.	
W 2.045 Effect of temperature on microbial gas generation		Gas generation from microbial activity is not relevant in a spent fuel repository.	

SR-Can FEP Bu20 Microbial processes

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 2.046 Effect of pressure on microbial gas generation		Gas generation from microbial activity is not relevant in a spent fuel repository.	
W 2.047 Effect of radiation on microbial gas generation		Gas generation from microbial activity is not relevant in a spent fuel repository.	
W 2.048 Effect of biofilms on microbial gas generation		Gas generation from microbial activity is not relevant in a spent fuel repository.	
W 2.088 Biofilms		Not a buffer process.	
Recorded by: Patrik Sellin			**Date:** 2006-05-17
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP Bu21 Colloid transport

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.13 Colloids			Included in "Colloid release Bu 17
A 1.63 Psuedo-colloids	Transport of radionuclides sorbed onto colloids is discussed		
K 3.11 Colloid filtration	Criteria for colloid filtration is discussed		
S 009 Colloid generation-source			Included in "Colloid release Bu 17
S 096 Transport and release of nuclides, bentonite buffer	Criteria for colloid filtration is discussed		
Recorded by: Patrik Sellin			**Date:** 2006-05-15
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP Bu22 Speciation of radionuclides

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.14 Complexation by organics			Most aspects of speciation of radionuclides is discussed in the fuel/canister process report
A 1.37 Geochemical pump		The process as such is not discussed in the report - however, the concept is included in the transport model.	
A 1.77 Speciation	Speciation is discussed.		Most aspects of speciation of radionuclides is discussed in the fuel/canister process report, see F14
J 4.1.04 Sorption	Sorption is discussed		
J 4.1.09 Complexing agents	Speciation is discussed		
K 0.2 Speciation	Speciation is discussed		
K 2.14 Chemical buffering (canister corrosion products)			Most aspects of speciation of radionuclides is discussed in the fuel/canister process report
K 5.21 Organics		Not relevant for a spent fuel repository	
K 6.21 Organics		Not relevant for a spent fuel repository	
S 018 Deep saline water intrusion			Covered in Bu12 (sorption)
S 060 Precipitation/dissolution			Most aspects of speciation of radionuclides is discussed in the fuel/canister process report
S 084 Sorption	Sorption is discussed		
S 096 Transport and release of nuclides, bentonite buffer			Discussed in Bu23
W 2.056 Speciation	Speciation is discussed		
W 2.057 Kinetics of speciation		Assumed to be fast	
W 2.060 Kinetics of precipitation and dissolution			Most aspects of speciation of radionuclides is discussed in the fuel/canister process report
W 2.071 Kinetics of organic complexation		Not relevant for a spent fuel repository	
Recorded by: Patrik Sellin			**Date:** 2006-05-16
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP Bu23 Transport of radionuclides in the water phase

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.28 Dispersion		Only diffusion is considered in the buffer	
A 1.65 Radioactive decay	Radioactive decay is considered		
A 2.51 Radioactive decay	Chain decay is considered		
H 1.3.1 Radioactive decay and ingrowth	Chain decay is considered		
I 027 Buffer (channelling)	Preferential pathways is discussed		
I 045 Progency nuclides (critical radionuclides)	Chain decay is considered		
J 3.2.08 Preferential pathways in the buffer/backfill	Preferential pathways is discussed		
K 0.1 Radioactive decay	Radioactive decay is considered		
K 3.16 Radionuclide transport through buffer	Yes		
S 070 Radioactive decay of mobile nuclides	Radioactive decay is considered		
S 096 Transport and release of nuclides, bentonite buffer	Most aspects are covered		
W 2.090 Advection	Advection is considered		Not a relevant FEP
Recorded by: Patrik Sellin			**Date:** 2006-05-24
Checked and revised by: Kristina Skagius			**Date:** June 2006

SR-Can FEP Bu24 Transport of radionuclides in gas phase

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
H 1.2.4 Radioactive gases	Radioactive gases are considered		
K 0.3 Gaseous and volatile isotopes	Radioactive gases are considered		
K 3.16 Radionuclide transport through buffer			This FEP neglects gas transport
S 096 Transport and release of nuclides, bentonite buffer	Gas transport is considered		
W 2.055 Radioactive gases	Radioactive gases are considered		
W 2.089 Transport of radioactive gases	Gas transport is considered		
Recorded by: Patrik Sellin			**Date:** 2006-05-24
Checked and revised by: Kristina Skagius			**Date:** June 2006

Appendix 7

Handling of NEA Project FEPs sorted to SR-Can Backfill processes

SR-Can FEP BfT01 Heat transport

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.52 Long-term transients	Decreasing decay heat is considered.		
H 1.2.8 Thermo-chemical effects		The effect of gas generation on the thermal evolution is not considered since the processes occur in different time frames.	
S 093 Temperature, tunnel backfill	Temperature evolution of the backfill is considered		
Recorded by: Patrik Sellin			**Date:** 2006-05-29
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP BfT02 Freezing

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 5.17 Permafrost	The properties of a frozen backfill is discussed.		
K 10.13 Permafrost		This FEP does not discuss freezing at repository level.	
S 059 Permafrost	The properties of a frozen backfill is discussed.		Identical to J.5.17
Recorded by: Patrik Sellin			**Date:** 2006-05-29
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP BfT03 Water uptake and transport for unsaturated conditions

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.68 Reflooding	Reflooding is discussed.		SKB does not use the term reflooding.
A 1.84 Transport in gases or of gases	The effect of a gas phase is discussed.		
S 080 Resaturation of tunnel backfill	Resaturation is discussed.		
W 2.013 Heat from radioactive decay	The effect of heat on resaturation is discussed.		This FEP may not be relevant for this process?
W 2.098 Osmotic processes	The effect of salinity is discussed.		
Recorded by: Patrik Sellin			**Date:** 2006-05-29
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP BfT04 Water transport for saturated conditions

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.40 Hydraulic conductivity	The effect of varying hydraulic conductivity is discussed.		
A 1.52 Long-term transients		None of the processes are expected to occur in the backfill.	
A 1.59 Percolation in shafts	Convection is mentioned, but not considered.		Basically a geosphere process.
A 2.60 Shaft seal failure	Impact of degradation of plugs on flow in deposition tunnels is mentioned.		Degradation of tunnel and shaft seals is not specifically described in the SR-Can process reports.
J 3.2.09 Flow through buffer/backfill			Handled in process "Piping/erosion" BfT06.
S 037 Flow through buffer/backfill	The effect of an increased conductivity is discussed.		
W 2.013 Heat from radioactive decay	The effect of temperature on conductivity is discussed.		Thermally driven flow under saturated conditions is neglected.
W 2.098 Osmotic processes	The effect of salinity is discussed.		
Recorded by: Patrik Sellin			**Date:** 2006-05-29
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP BfT05 Gas transport/dissolution

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.84 Transport in gases or of gases	The effect of gas on buffer transport properties is discussed.		
H 1.2.6 Gas transport	Gas transport in the near field is discussed.		
S 041 Gas flow and transport, buffer/backfill	Gas transport in the near field is discussed.		
S 044 Gas generation, buffer/backfill		Not expected to be an issue in a spent fuel repository.	
S 066 Properties of tunnel backfill	The effect of gas in the backfill is considered.		
S 104 Water chemistry, tunnel backfill		Gas is not expected to be of concern for the chemistry of the water in the backfill.	
Recorded by: Patrik Sellin			**Date:** 2006-05-29
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP BfT06 Piping/erosion

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.40 Hydraulic conductivity	Increased conductivity caused by piping is discussed.		
I 027 Buffer (channelling)	The effect of pathways in the backfill is discussed.		
J 3.2.04 Erosion of buffer/backfill	Erosion is discussed.		
J 3.2.08 Preferential pathways in the buffer/backfill			Do not understand this FEP.
J 3.2.09 Flow through buffer/backfill	The effect of pathways in the buffer is discussed.		
K 3.06 Bentonite erosion	Erosion is discussed.		
S 025 Dilution of buffer/backfill	Erosion is discussed.		
S 031 Erosion of buffer/backfill	Erosion is discussed.		
S 037 Flow through buffer/backfill			This FEP is discussed in process "Water transport under saturated conditions" BfT04 and process "Advection" BfT09.
Recorded by: Patrik Sellin			**Date:** 2006-05-29
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP BfT07 Swelling/Mass redistribution

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.08 Cave ins	Rock backfill interactions are considered.		
A 1.31 Excessive hydrostatic pressures	Thermal expansion is considered.		
A 1.47 Interfaces (boundary conditions)	Mechanical interactions are considered.		
H 1.4.2 Vault collapse	Rock backfill interactions are considered.		
I 298 Swelling pressure (clay)	Swelling pressure is considered.		
J 3.2.01.2 Uneven swelling of bentonite	Uneven swelling is considered.		
J 3.2.03 Mechanical failure of buffer/backfill	Interaction with rock is considered.		
J 4.2.02.1 Excavation/backfilling effects on nearby rock			Basically a geosphere FEP, see processes "Reactivation" Ge06 and "Fracturing" Ge07.
J 4.2.09 Creeping of rock mass			Basically a geosphere FEP, see process "Creep" Ge08.
S 004 Cave in	Rock backfill interactions are considered.		

SR-Can FEP BfT07 Swelling/Mass redistribution

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 015 Creeping of rock mass, near-field			Basically a geosphere FEP, see process "Creep" Ge08.
S 025 Dilution of buffer/backfill	Loss of mass is considered.		Also covered in process "Colloid release" BfT16.
S 056 Mechanical impact/failure, buffer/backfill	Mechanical interactions are considered.		
S 066 Properties of tunnel backfill	Very general FEP - most aspects are covered.		
S 088 Swelling of tunnel backfill	Swelling pressure is considered.		
W 2.022 Roof falls	Mechanical interactions are considered.		
W 2.035 Mechanical effects of backfill	Mechanical interactions are considered.		
Recorded by: Patrik Sellin			**Date:** 2006-05-30
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP BfT08 Liquefaction

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
I 277 Soil liquefaction (seismic)	Liquefaction is considered.		
Recorded by: Patrik Sellin			**Date:** 2006-05-30
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP BfT09 Advection

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.22 Convection	Convection(advection) is discussed.		
A 1.28 Dispersion		Only advection and diffusion are considered.	
A 2.18 Dispersion		Only advection and diffusion are considered.	
J 3.2.08 Preferential pathways in the buffer/backfill	Piping is considered.		
S 099 Transport and release of nuclides, tunnel backfill			RN transport is discussed in processes "Diffusion" (BfT10) and "Transport of radionuclides in the water phase (BfT21) as well as in the Fuel process report.
W 2.090 Advection	Advection in the backfill is discussed.		
Recorded by: Patrik Sellin			**Date:** 2006-05-29
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP BfT10 Diffusion

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 023 Diffusion	Included by definition.		
S 083 Soret effect		The process is neglected due to the small thermal gradients over the backfill.	
A 1.27 Diffusion	Diffusion is discussed.		
S 099 Transport and release of nuclides, tunnel backfill	Discussed in the "radionuclide transport" process, BfT21		
A 1.36 Galvanic coupling		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradients.	
A 2.16 Diffusion	Diffusion is discussed.		
J 3.2.06 Diffusion - surface diffusion	Surface diffusion is discussed.		
J 3.2.10 Soret effect		The process is neglected due to the small thermal gradients over the backfill.	
S 002 Anion-exclusion	Anion-exclusion is discussed.		
H 1.6.4 Thermal effects: Transport (diffusion) effects	Increased diffusivity of species is discussed in the modeling of the chemical evolution.		It is assumed that the radionuclide transport will take place after the thermal pulse.
K 4.02 Natural radionuclides/elements		Naturally occurring radioelements are not included in SR-Can (pessimistically).	
W 2.093 Soret effect		The process is neglected due to the small thermal gradients over the backfill.	
J 2.1.06.2 Natural telluric electrochemical reactions		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradient.	
J 3.2.08 Preferential pathways in the buffer/backfill	Loss of the diffusion barrier is discussed in the "advection" process.		
S 029 Electrochemical effects/gradients		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradient.	
H 1.1.4 Electrochemical effects of metal corrosion		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradients.	
W 2.050 Galvanic coupling		Not relevant here - canister process	See FEP C08.
W 2.095 Galvanic coupling		Not relevant here - canister process.	See FEP C08.
W 2.096 Electrophoresis		Transport due to the presence of an electrical field is not considered. It is assumed to be negligible compared to concentration gradient.	
I 300 Termperature effects (on transport)	Mentioned, but not considered.		

Recorded by: Patrik Sellin **Date:** 2006-11-01

Checked and revised by: Kristina Skagius **Date:** 2006-11-08

SR-Can FEP BfT11 Sorption (including ion-exchange)

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.01 Backfill characteristics			The FEP is included in "water transport under saturated conditions" (BfT04) and "advection" (BfT09)
A 1.14 Complex-ation by organics		Not a backfill process.	
A 1.51 Long-term physical stability			Discussed in montmorillonite transformation (BfT15) and osmosis (BfT14)
A 1.73 Sorption	Sorption is discussed.		
A 1.74 Sorption - nonlinear		Non-linear sorption is not included - the Kd approach is however justified.	
A 2.58 Saturation		Not considered - amount of sorbing species is low.	
J 3.1.01 Degradation of the bentonite by chemical reactions			The FEP is discussed in Montmorillonite transformation (BfT15).
J 3.1.03 Effects of bentonite on groundwater chemistry			Discussed in alteration of impurities (BfT12)
J 4.1.04 Sorption	Sorption is discussed.		
J 4.1.09 Complexing agents		Not a backfill process.	
K 3.09 Bentonite porewater chemistry			Discussed in alteration of impurities (BfT12).
K 3.25 Interaction with cement components			The FEP is discussed in Montmorillonite transformations (BfT15).
S 006 Chemical alteration of buffer/backfill			The FEP is discussed in Montmorillonite transformation (BfT15) and alteration of impurities (BfT12).
S 018 Deep saline water intrusion	Impact of water composition on sorption discussed.		Also discussed in Osmosis (BfT14) and alteration of impurities (BfT12).
S 066 Properties of tunnel backfill	Very general FEP - most aspects discussed.		
S 084 Sorption	Sorption is discussed.		
S 099 Transport and release of nuclides, tunnel backfill	Sorption is discussed.		Also discussed in "radionuclide transport" (BfT21).
S 104 Water chemistry, tunnel backfill			Discussed in alteration of impurities (BfT12).

SR-Can FEP BfT11 Sorption (including ion-exchange)

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 2.061 Actinide sorption	Sorption is discussed.		
W 2.062 Kinetics of sorption		Not discussed - sorption coefficient are based on laboratory experiments where on fast kinetics is detected.	
Recorded by: Patrik Sellin			**Date:** 2006-05-29
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP BfT12 Alterations of impurities

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.02 Backfill evolution			The FEP is discussed in Montmorillonite transformations (BfT15).
A 1.43 Hydrothermal alteration	Transport of species in thermal gradient is discussed.		The FEP is also discussed in Montmorillonite transformations (BfT15).
A 1.51 Long-term physical stability	Transport of species in thermal gradient and the precipitation of minerals is discussed.		The FEP is also discussed in Montmorillonite transformations (BfT15).
A 1.62 Precipitation and dissolution	Dissolution/precipitation is discussed.		
I 048 Buffer (degradation by concrete)			The FEP is discussed in Montmorillonite transformations (BfT15).
J 3.1.01 Degradation of the bentonite by chemical reactions	Dissolution/precipitation of impurities is discussed.		The FEP is also discussed in Montmorillonite transformations (BfT15).
J 3.1.03 Effects of bentonite on groundwater chemistry	Changes in groundwater/porewater composition is discussed.		
K 3.09 Bentonite porewater chemistry	Changes in groundwater/porewater composition are discussed.		
K 3.25 Interaction with cement components			The FEP is discussed in Montmorillonite transformations (BfT15).
S 006 Chemical alteration of buffer/backfill	All aspects mentioned are discussed.		
S 066 Properties of tunnel backfill	Very general FEP - most aspects discussed.		
S 080 Resaturation of tunnel backfill	The potential effect is identified.		

SR-Can FEP BfT12 Alterations of impurities

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 094 Thermal degradation of buffer/backfill	Dissolution/precipitation of impurities is discussed.		The FEP is also discussed in Montmorillonite transformations (BfT15).
S 104 Water chemistry, tunnel backfill	Many aspects are discussed.		
Recorded by: Patrik Sellin			**Date:** 2006-05-29
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP BfT13 Pore water speciation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 3.09 Bentonite porewater chemistry			Discussed in alterations of impurities (BfT12).
S 104 Water chemistry, tunnel backfill	Relevant aspects are discussed.		
W 2.057 Kinetics of speciation		Homogeneous aqueous geochemical speciation reactions involving relatively small inorganic species occur rapidly.	
Recorded by: Patrik Sellin			**Date:** 2006-05-29
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP BfT14 Osmosis

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.09 Chemical gradients			Discussed in the Diffusion process (BfT10).
W 2.098 Osmotic processes	Osmosis is discussed.		
Recorded by: Patrik Sellin			**Date:** 2006-05-29
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP BfT15 Montmorillonite transformation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.02 Backfill evolution	The effect of elevated temperatures is discussed.		
A 1.43 Hydrothermal alteration	The effect of elevated temperatures is discussed.		
I 048 Buffer (degradation by concrete)	The effect of high pH is discussed.		
J 3.1.01 Degradation of the bentonite by chemical reactions	Degradation is discussed.		
J 3.1.03 Effects of bentonite on groundwater chemistry			The FEP is discussed in Alteration of impurities (BfT12).
K 3.09 Bentonite porewater chemistry			The FEP is discussed in Alteration of impurities (BfT12).
K 3.12b Mineralogical alteration - long term	Degradation is discussed.		
K 3.25 Interaction with cement components	The effect of high pH is discussed.		
S 006 Chemical alteration of buffer/backfill	Degradation is discussed.		
S 066 Properties of tunnel backfill	Very general FEP - most aspects discussed.		
S 094 Thermal degradation of buffer/backfill	The effect of elevated temperatures is discussed.		The FEP is also discussed in Alteration of impurities (BfT12).
S 104 Water chemistry, tunnel backfill	Relevant aspects are discussed.		
Recorded by: Patrik Sellin			**Date:** 2006-05-29
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP BfT16 Colloid release

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.50 Pseudo-colloids	Colloid generation from the backfill is discussed.		
J 3.1.05 Coagulation of bentonite	Colloid generation from the buffer is discussed - this is the reverse process - included by definition.		
J 3.2.04 Erosion of buffer/backfill	Colloid generation from the buffer is discussed.		
S 007 Coagulation of bentonite	Colloid generation from the buffer is discussed - this is the reverse process - included by definition.		
S 009 Colloid generation-source	Colloid generation from the buffer is discussed.		
S 031 Erosion of buffer/backfill	Erosion as a consequence of colloid release is discussed.		

SR-Can FEP BfT16 Colloid release

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 082 Sedimentation of bentonite			Sedimentation of bentonite occurs in the geosphere - it is however considered in the integrated description of colloid release.
S 088 Swelling of tunnel backfill		Has nothing to do with colloids.	
K 3.06 Bentonite erosion	Colloid generation from the buffer is discussed.		
K 4.12 Colloids	Colloid generation from the buffer is discussed.		
W 2.082 Suspensions of particles		Not relevant.	
W 2.083 Rinse		Not relevant.	
I 058 Colloid formation (natural and vault generated)	Colloid generation from the backfill is discussed.		Does not really fit the FEP description.
A 1.63 Psuedo-colloids		Not a buffer issue.	Discussed in radionuclide transport in the geosphere (Ge24).
S 025 Dilution of buffer/backfill	Loss of buffer mass is a consequence of colloid generation - yes.		
A 1.13 Colloids	Colloid generation from the buffer is discussed.		
S 066 Properties of tunnel backfill	Colloid aspects are discussed.		
A 1.51 Long-term physical stability	Loss of backfill is discussed.		
Recorded by: Patrik Sellin			**Date:** 2006-11-01
Checked and revised by: Kristina Skagius			**Date:** 2006-11-08

SR-Can FEP BfT17 Radiation-induced transformations

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.64 Radiation damage	Radiation effects are discussed.		
I 238 Radiation effects	Radiation effects are discussed.		
S 066 Properties of tunnel backfill		Radiation effects on properties are neglected.	
S 067 Radiation effects on buffer/backfill	Radiation effects are discussed.		
W 2.017 Radiological effects on seals		Radiation effects on properties are neglected.	
Recorded by: Patrik Sellin			**Date:** 2006-05-29
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP BfT18 Microbial processes

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.03 Biological activity	Microbes are considered.		
A 1.51 Long-term physical stability		The buffer is not expected to be affected by microbes.	Reduction of iron may be an exception.
A 1.53 Methylation		Organic compounds are not expected to have any significant effect on the buffer - since the levels are very low.	
A 1.54 Microbes		The buffer is not expected to be affected by microbes.	Reduction of iron may be an exception.
A 1.55 Microorganisms	Microbes are considered.		
H 1.2.3 Gas generation from concrete		Microbial effects on concrete are not considered.	
I 012 Biological activity (bacteria & microbes)	Microbes are considered.		
J 2.1.10 Microbes	Microbes are considered.		
K 3.17 Microbial activity	Microbes are considered.		
S 044 Gas generation, buffer/backfill		Gas generation from microbial activity is not relevant in a spent fuel repository.	
S 057 Microbial activity	Microbes are considered.		
W 2.044 Degradation of organic material	Organic stray materials are discussed.		
W 2.045 Effect of temperature on microbial gas generation		Gas generation from microbial activity is not relevant in a spent fuel repository.	
W 2.046 Effect of pressure on microbial gas generation		Gas generation from microbial activity is not relevant in a spent fuel repository.	
W 2.048 Effect of biofilms on microbial gas generation		Gas generation from microbial activity is not relevant in a spent fuel repository.	
W 2.076 Microbial growth on concrete		Concrete structures are not assigned any long-term properties.	
W 2.088 Biofilms		Not a backfill process.	
Recorded by: Patrik Sellin			**Date:** 2006-05-29
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP BfT19 Colloid formation and transport

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.13 Colloids			Included in "Colloid release" (BfT16).
A 1.63 Psuedo-colloids	Transport of radionuclides sorbed onto colloids is discussed.		
S 009 Colloid generation-source			Included in "Colloid release" (BfT16).
S 099 Transport and release of nuclides, tunnel backfill	Transport of radionuclides sorbed onto colloids is discussed.		Considered to be mainly a geosphere process.
W 2.097 Chemical gradients		Not relevant for KBS-3.	
Recorded by: Patrik Sellin			**Date:** 2006-05-29
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP BfT20 Speciation of radionuclides

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.14 Complexation by organics			Most aspects of speciation of radionuclides is discussed in the fuel/canister process report, see SKB FEP F14.
A 1.37 Geochemical pump		The process as such is not discussed in the report - however, the concept is included in the transport model.	
A 1.77 Speciation	Speciation is discussed		Most aspects of speciation of radionuclides is discussed in the fuel/canister process report, see SKB FEP F14
A 2.09 Complexation by organics			Most aspects of speciation of radionuclides are discussed in the fuel/canister process report (see e.g. SKB FEP F14).
J 4.1.04 Sorption	Sorption is discussed.		
J 4.1.09 Complexing agents	Speciation is discussed.		
K 5.21 Organics		Not relevant for a spent fuel repository.	
K 6.21 Organics		Not relevant for a spent fuel repository.	
S 060 Precipitation/dissolution			Most aspects of speciation of radionuclides is discussed in the fuel/canister process report.
S 084 Sorption	Sorption is discussed.		
S 099 Transport and release of nuclides, tunnel backfill			Discussed in radionuclide transport (BfT22).
W 2.057 Kinetics of speciation		Assumed to be fast.	
W 2.060 Kinetics of precipitation and dissolution			Most aspects of speciation of radionuclides is discussed in the fuel/canister process report, see SKB FEP F14.
W 2.071 Kinetics of organic complexation		Not relevant for a spent fuel repository.	
Recorded by: Patrik Sellin			**Date:** 2006-05-30
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP BfT21 Transport of radionuclides in the water phase

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.28 Dispersion		Only diffusion is considered.	
A 1.65 Radioactive decay	Radioactive decay is considered.		
A 2.18 Dispersion		Only diffusion is considered.	
A 2.51 Radioactive decay	Chain decay is considered.		
H 1.3.1 Radioactive decay and ingrowth	Chain decay is considered.		
I 027 Buffer (channelling)	Preferential pathways are discussed.		
I 045 Progency nuclides (critical radionuclides)	Chain decay is considered.		
J 3.2.08 Preferential pathways in the buffer/backfill	Preferential pathways are discussed.		
K 0.1 Radioactive decay	Radioactive decay is considered.		
S 070 Radioactive decay of mobile nuclides	Radioactive decay is considered.		
S 099 Transport and release of nuclides, tunnel backfill	Most aspects are covered.		
W 2.090 Advection	Advection is considered.		Not a relevant FEP.
Recorded by: Patrik Sellin			**Date:** 2006-05-30
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP BfT22 Transport of radionuclides in the gas phase

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
H 1.2.4 Radioactive gases	Radioactive gases are considered.		
K 0.3 Gaseous and volatile isotopes	Radioactive gases are considered.		
S 099 Transport and release of nuclides, tunnel backfill		The gas pathway is assumed to be a short cut.	
W 2.055 Radioactive gases	Radioactive gases are considered.		
W 2.089 Transport of radioactive gases		The gas pathway is assumed to be a short cut.	
Recorded by: Patrik Sellin			**Date:** 2006-05-30
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

Appendix 8

Handling of NEA Project FEPs sorted to SR-Can Geosphere processes

SR-Can FEP Ge01 Heat transport

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 091 Temperature, far-field	Influence of natural geothermal temperature on the nearfield temperature; Effects on farfield of heat generation in the nearfield. Permafrost depth.		
S 092 Temperature, near-field rock	Near field rock thermal properties		
K 5.13 Geothermal regime	Geothermal temperature at repository depth.		
K 6.13 Geothermal regime	Geothermal temperature at repository depth.		The FEP definition is covered by the previous FEP (K 5.13)
A 2.69 Unsaturated rock		For heat transport, the degree of rock saturation is not important.	
A 1.52 Long-term transients	Thermal pulse of decaying fuel.		
Recorded by: Harald Hökmark			**Date:** 2005-03-25
Checked and revised by: Kristina Skagius			**Date:** Nov 2005

SR-Can FEP Ge02 Freezing

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
H 3.1.2 Climate change: Natural	Permafrost growth. Changes in groundwater recharge during glacial cycle.		
K 10.16 Ice sheet effects (loading, melt water recharge)	Groundwater recharge in relation to permafrost distribution.		
S 047 Glaciation		FEP not relevant for freezing.	
H 1.5.5 Transport of chemically-active substances into the near-field	Freeze-out of salt during permafrost growth.		Preliminary study conducted.
J 5.17 Permafrost	Permafrost growth. Freezing in buffer erosion cavities.		
S 059 Permafrost	Permafrost growth and groundwater recharge. Freezing in buffer erosion cavities.		
K 10.13 Permafrost	Permafrost growth. Presence of taliks. Permafrost - biosphere interaction.		
S 091 Temperature, far-field	Dependence of far-field groundwater recharge, from ice sheet basal melting, on ground temperature /freezing during glacial coverage.		
Recorded by: Jens-Ove Näslund			**Date:** 2006-11-10
Checked and revised by: Kristina Skagius			**Date:** 2006-11-10

SR-Can FEP Ge03 Groundwater flow

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.41 Hydraulic head	Hydraulic head and resulting gradients as driving forces.		
A 1.67 Recharge groundwater	Variations in the chemistry of recharging groundwater over time are addressed. Saline intrusion and also saline upcoming beneath the repository are considered.		
A 1.68 Reflooding	Resaturation.		The term resaturation is used in the Process Report for the process in question.
A 2.15 Dewatering	Dewatering during construction and operation phases is addressed.		The process is represented in some models, which address drawdown and saline intrusion.
A 2.17 Discharge zones	Discharge zones for groundwater flow.		These are determined by the flow calculation. Note that the locations where radionuclides migrating from the repository would discharge are determined by particle tracking calculations. This is done for flow fields corresponding to specific times.
A 2.28 Geothermal gradient effects	Impact of thermal gradients on flow.		Geothermal gradient taken into account in the flow calculations.
A 2.35 Hydraulic properties - evolution	Factors causing change in fracture transmissivity over time.		See also "Dissolution/ precipitation of fracture-filling minerals" (Ge15).
A 2.38 Isostatic rebound	Effect on topography and sea-level.		Included in the shore-line displacement function used as BC for groundwater flow simulations.
A 2.57 Salinity effects on flow	Variable-density flow.		Density driven flow included in groundwater flow models.
A 2.59 Sea level change	Sea level change as a result of climate change is considered.		Shore-line displacement considered as BC for groundwater flow simulations.
A 2.69 Unsaturated rock	The (relatively very thin) un-saturated region near the ground surface and the unsaturated region that will develop as a result of groundwater drawdown because of repository construction are addressed.		Unsaturated flow is not explicitly modelled.

SR-Can FEP Ge03 Groundwater flow

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.71 Vault heating effects	The impact of the heat generated by the waste on the flow is discussed.		Effects of the heat from the waste on the flow not included in main calculations but addressed in separate scoping calculations.
A 2.73 Wells	Impact of wells on flow. Wells included in biosphere and in assessment calculations. Well yield or consumption used for assessing dilution.		Wells not included in groundwater flow models; assumption that typical wells will not change ground-water flow field much. Wells included in biosphere and in dose calculations. Well yield or con-sumption used for assessing dilution.
A 2.74 Wells (high-demand)		This FEP has an insignificant effect on groundwater flow or is not relevant to it for the sites considered.	
J 4.2.03 Extreme channel flow of oxidants and nuclides	Channeling of flow is discussed. This can affect the flow itself primarily through its effect on the specific fracture surface available for matrix diffusion, which may affect the salinity and hence the flow.		Moderate channelling can be taken into account through variation oft he transmissivity over fractures. Extreme channelling cannot be dealt with as readily. See also Ge11.
J 4.2.04 Thermal buoyancy	The impact of thermal buoyancy on flow is taken into account.		The effect of the natural geothermal gradient is taken into account in the main flow calcula-tions. The effect of heat generated by the waste is taken into account in scoping calculations.
J 5.01 Saline (or fresh) groundwater intrusion	The effects of variations in salinity on the flow are addressed.		
J 5.14 Resaturation	Resaturation discussed.		Resaturation addressed and handled in open repository calculation. Assumption made that two-phase flow not needed for such calculations. This is argued with help of supporting analyses.
J 5.27 Human induced actions on groundwater recharge	Wells, dams, tunnels, vaults etc, human effects on climate discussed.		See also SKB FHA FEPs.

SR-Can FEP Ge03 Groundwater flow

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 5.42 Glaciation	Impact of glacial conditions on flow is discussed.		Special simulation of groundwater flow during glacial conditions performed. Input from ice-sheet model on e.g. glacier thickness, surface and basal melt rate of glacier. See also SKB Climate FEPs and NEA FEP A 2.30.
J 6.13 Geothermally induced flow .	Impact of thermal gradients on flow addressed.		The effects of natural geothermal gradients taken into account in the flow calculations.
J 7.07 Human induced changes in surface hydrology	Discussed.		Handled through variants in Main Scenario, but will likely not result in special cases for groundwater flow model. See also SKB FHA FEPs.
S 018 Deep saline water intrusion	Density driven flow addressed.		Density driven flow included in groundwater flow model. Geochemical implications, see Chemical processes, e.g. "Advection/mixing" (Ge11), "Speciation/ sorption" (Ge13),
S 028 Earth tides		This process may be utilized in interpreting experimental measurements, but occurs on a much shorter time scale about 12.5 hours) than the time scales relevant to repository performance.	
S 033 External flow boundary conditions	Addressed.		Topography and changes in sea-level included in gw model.
S 047 Glaciation	Impact of glacial condition on flow discussed.		Special simulation of groundwater flow during glacial conditions performed. Input from ice-sheet model on e.g. glacier thickness, surface and basal melt rate of glacier. See also SKB Climate FEPs.
S 049 Groundwater flow	All aspects addressed.		

SR-Can FEP Ge03 Groundwater flow

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 078 Resaturation, near-field rock	Resaturation addressed.		Resaturation addressed in open repository calculation. Assumption made that two-phase flow not needed for such calculations. This is argued with help of supporting analyses.
H 1.5.1 Desaturation (pumping) effects	Desaturation addressed. Pumping considered in the open repository simulations, where specifically up-coning and changes on groundwater table are addressed.		See NEA FEP A 1.68
H 1.5.2 Disturbed zone (hydromechanical) effects	Effects of EDZ on flow are addressed.		See NEA FEP A 2.01
H 1.5.3 Unsaturated flow due to gas production	Impacts of gas on flow is addressed.		Not included in hydrogeology modelling because the volumes of gas produced are expected to be small.
H 1.5.4 Saturated groundwater flow	This is the primary flow process, and is considered.		
H 1.6.2 Thermal effects: Hydrogeological changes	Impact of thermal gradients on flow.		See NEA FEP A 2.71.
H 2.2.2 Rock property changes	The main processes affecting the relevant rock properties (fracture transmissivity, fracture porosity and matrix porosity) are stress changes (due to ice loading during glaciation) formation of permafrost, and precipitation and dissolution.	Changes due to the alkaline plume are not considered in SR-Can.	
H 2.3.11 Far-field transport: Gas induced groundwater transport	Impact of gas on flow addressed.		Scoping calculations carried out.
H 4.1.1 Groundwater discharge to soils and surface waters	Groundwater discharge addressed.		See NEA FEP A 2.17.
K 4.01 Excavation-disturbed zone (EDZ)	Impact of EDZ addressed.		See NEA FEP A 2.01.
K 4.03 Desaturation/resaturation of EDZ	Desaturation and resaturation addressed.		
K 4.07 Water flow at the bentonite-host rock interface	Impact of EDZ addressed.		Water flow through the EDZ is handled in the gw flow model for saturated conditions.
K 5.11 Intrusion of saline groundwater	Variable-density flow.		See NEA FEP A 2.57.

SR-Can FEP Ge03 Groundwater flow

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 5.12 Density-driven groundwater flow (thermal)	The impact of thermal buoyancy on flow is taken into account.		See NEA FEP J 4.2.04.
K 5.17 Gas pressure effects	Effects of gas pressure id discussed.		See NEA FEP A 1.35.
K 6.11 Intrusion of saline groundwater	Variable-density flow.		See NEA FEP A 2.57.
K 6.12 Density-driven groundwater flows (thermal)	The impact of thermal buoyancy on flow is taken into account.		See NEA FEP J 4.2.04.
K 6.17 Gas pressure effects	Effects of gas pressure id discussed.		See NEA FEP A 1.35.
K 7.13 Density-driven groundwater flows (temperature/salinity differences)	Discussed.		See NEA FEPs J 4.2.04 and J 5.01
K 10.16 Ice sheet effects (loading, melt water recharge)	Impact of glacial conditions addressed.		Special simulation of groundwater flow during glacial conditions performed. Input from ice-sheet model on e.g. glacier thickness, surface and basal melt rate of glacier. See also SKB Climate FEPs.
W 1.024 Unsaturated groundwater flow	The (relatively very thin) unsaturated region near the ground surface and the unsaturated region that will develop as a result of groundwater drawdown because of repository construction are addressed.		See NEA FEP A 2.69.
W 1.025 Fracture flow	Considered.		
W 1.026 Density effects on groundwater flow	Variable-density flow.		See NEA FEP A 2.57.
W 1.028 Thermal effects on groundwater flow	Addressed.		See NEA FEPs J 4.2.04, H 1.6.1, H 2.3.12.
W 1.029 Saline intrusion	Salinity effects discussed.		See NEA FEP A 2.57.
W 1.035 Freshwater intrusion	Freshwater intrusion mainly addressed and handled as a consequence of a melting glacier.		See chemical processes e.g. "Advection/mixing" Ge11 for geochemical aspects. See also SKB Climate FEPs.
W 1.053 Groundwater discharge	Groundwater discharge addressed.		See NEA FEP A 2.17.
W 1.056 Changes in groundwater recharge and discharge	Cause for changes addressed.		See NEA FEP A 2.17.

SR-Can FEP Ge03 Groundwater flow

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 2.042 Fluid flow due to gas production	Impact of gas generation and flow addressed.		See NEA FEP A 2.27.
W 2.043 Convection	Impact of thermal gradients on flow addressed.		See NEA FEP J 4.2.04
W 3.031 Natural borehole fluid flow			Existing boreholes are not specifically described in SR-Can, but location is part of the SDM. For impact of drilling of future boreholes, see SKB FHA FEPs.
I 143 Groundwater (redirection of)	The processes leading to changes in groundwater flow direction such as groundwater abstraction from wells, or the effects of climate change are considered.		
A 2.06 Cavitation		Is considered not to be an issue for crystalline rock.	
K 4.08 Radionuclide migration	Impact of EDZ on water flow discussed.		Other aspects addressed in "Advection/mixing" (Ge11) and "Radionuclide transport in water phase" (Ge24).
W 3.033 Flow through undetected boreholes		Undetected boreholes can be ruled out for the present application.	
A 2.27 Gases and gas transport	Impact of gas on GW flow is discussed in the sections addressing gas (see also Ge04)		Scoping calculations carried out. Possible two-phase flow effects handled in RD&D programme (although this is mainly for open repository applications).
A 2.30 Glaciation	Changes to topography, sea-level, the possible development of permafrost and the upper boundary condition for the flow, leading to changes in recharge and discharge zones, are considered.		Special simulation of groundwater flow during glacial conditions perform-ed. Input from ice-sheet model on e.g. glacier thickness, surface and basal melt rate of glacier.
J 1.1.02 Radioactive decay; heat	The impact of the heat generated by the waste is discussed.		Not included in far-field models in general. Only included in scoping calculations.
H 2.3.7 Far-field transport: Changes in groundwater chemistry and flow direction	Changes in groundwater flow direction are addressed. In-so-far as changes in groundwater chemistry are the result of mixing of groundwaters with different compositions, this is addressed.		
W 1.034 Saline intrusion	Salinity effects discussed.		Density driven flow included in groundwater flow models.

SR-Can FEP Ge03 Groundwater flow

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.04 Borehole seal failure	Boreholes and failed boreholes are discussed in process description.		
K 10.13 Permafrost	Impact of permafrost on flow addressed.		See also "Freezing" Ge02 and SKB Climate FEPs.
H 5.1.1 Loss of integrity of borehole seals	This is discussed.		
W 2.013 Heat from radioactive decay	Impact of thermal gradients on flow addressed.		See NEA FEP J 1.1.02
A 1.52 Long-term transients	The following processes listed under this FEP are taken into account: effect of the thermal pulse on flow, resaturation, effects of grouting. Other processes such as land uplift and climate change leading to shore-line displacement and changes to recharge, possible development of permafrost and ice sheet cover are also taken into account,		
A 2.01 Blasting and vibration	The effects of blasting and vibration during the construction of the repository are incorporated in the EDZ.		The EDZ is explicitly incorporated in the some flow models.
A 2.13 Damaged zone	The EDZ is addressed.		The EDZ is explicitly incorporated in some gw flow models.
A 2.22 Erosion	Erosion of the bedrock and redistribution of Quaternary deposits as a result of glaciation is discussed.		Rates of erosion of bedrock are expected to be low so this process is not considered quantitatively (see also Ge09)
H 2.2.1 Changes in geometry and driving forces of the flow system	This FEP really deals with changes over time to the flow in the vicinity of the repository as a result of process such as land uplift and climate change. These processes are considered.		
H 2.4.1 Generalised denudation	The main erosion process will be glacial erosion, and the main effect of this will be redistribution of the Quaternary deposits, which may affect recharge. This is discussed.		
H 2.4.2 Localised denudation			See NEA FEP H 2.4.1.
H 5.1.2 Loss of integrity of shaft or access tunnel seals	This is discussed.		See NEA FEP A 1.72
I 022 Explosions/bombs /blasting/collision/ impacts/vibration	Blasting/vibration during repository construction leads to the formation of the EDZ, whose effects are discussed.		See NEA FEP A 2.01.
J 4.2.02.1 Excavation/backfilling effects on nearby rock	The effect of the EDZ is taken into account.		See NEA FEP A 2.01.

SR-Can FEP Ge03 Groundwater flow

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 4.2.07 Thermo-hydro-mechanical effects	The FEP is discussed.		
J 5.16 Uplift and subsidence	Uplift and subsidence are discussed.		The effects of uplift and subsidence on the shoreline are taken into account in the flow calculations. Possible effects on the rock properties are not currently modelled.
K 6.18 Hydraulic gradient changes (magnitude, direction)	Changes over time to the flow in the vicinity of the repository as a result of process such as land uplift and climate change are discussed.		See NEA FEP H 2.2.1
K 7.11 Erosion	Erosion of the bedrock and redistribution of Quaternary deposits as a result of glaciation is discussed.		See NEA FEP A 2.22
K 9.07 Erosion/ denudation	Erosion of the bedrock and redistribution of Quaternary deposits as a result of glaciation is discussed.		See NEA FEP A 2.22
K 10.14 Glacial erosion/ sedimentation	Impact or erosion discussed.		See NEA FEP A 2.22.
S 001 Alteration/weathering of flow paths	Discussed.		See NEA FEP H 2.2.1
S 032 Excavation effects on nearby rock	Excavation effects on flow are discussed.		See NEA FEP A 2.01.
S 059 Permafrost	Impact of permafrost on flow discussed.		See also processes "Freezing" (Ge02), "Gas flow/ dissolution" (Ge04), "Salt exclusion" (Ge21) and SKB Climate FEPs.
S 064 Properties of far-field rock	Discussed.		
S 065 Properties of near-field rock	Discussed.		
S 086 Stress field	The effects of the stress field on the rock properties (porosity and fracture transmissivity) are discussed.		The effects of changing stress fields are not taken into account in the flow calculations.
S 091 Temperature, far-field	The effects of the temperature on groundwater properties (density and viscosity) and the driving force for groundwater flow are discussed.		The geothermal gradient is taken into account in the flow calculations
S 092 Temperature, near-field rock	The effects of the temperature on groundwater properties (density and viscosity) and the driving force for groundwater flow are discussed.		The effects of the heat generated by the waste are not addressed in the main flow calculations, but are taken into account in scoping calculations

SR-Can FEP Ge03 Groundwater flow

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 1.009 Changes in fracture properties	Factors causing change in fracture transmissivity over time.		See NEA FEP A 2.35.
W 1.022 Fracture infills	Factors causing change in fracture transmissivity over time.		See NEA FEP A 2.35.
W 1.030 Freshwater intrusion	Variable-density flow.		See NEA FEP A 2.57.
W 2.018 Disturbed rock zone	Impact on flow addressed.		See NEA FEP A 2.01.
A 2.48 Ozone layer	Changes in groundwater flow as a result of climate changes are discussed.		See also SKB FEP Cli01.
A 1.12 Climate change	Impact on groundwater flow due to climate change is discussed.		
I 049 Climate change	Inpact of climate change on groundwater flow is discussed.		See also SKB Climate FEPs Cli03 and Cli04.
J 5.17 Permafrost	The possible development of permafrost and the upper boundary condition for the flow, leading to changes in recharge and discharge zones, are considered.		See also SKB Climate FEPs.
H 3.1.2 Climate change: Natural	Influence of climate related conditions on groundwater flow is discussed.		See also SKB Climate FEPs.
J 5.31 Change in sealevel	Changes in groundwater flow and salinity due to shore-line migration are considered.		See also SKB Climate FEPs.
S 081 Sea level changes	Changes in groundwater flow and salinity due to shore-line migration are considered.		See also SKB Climate FEPs.
I 266 Sea level (rising)	Impact on groundwater flow of changes in sea level is considered.		
J 4.2.06 Faulting	The effects of changes to the rock properties are discussed.		
K 5.18 Hydraulic gradient changes (magnitude, direction)	Changes over time as a result of process such as land uplift and climate change.		
K 9.06 Stress changes - hydrogeological effects	Effects of stress changes on the transmissivity are discussed.		
S 036 Faulting	The effects of changes to the rock properties are discussed.		
W 1.031 Hydrological response to earthquakes		Effects of earthquakes on groundwater flow not explicitily considered, but the potential impact on radionuclide transport is illustrated by simple calculations.	
H 2.1.6 Seismicity		Effects of earthquakes on groundwater flow not explicitily considered, but the potential impact on radionuclide transport is illustrated by simple calculations.	
A 2.60 Shaft seal failure	The FEP is discussed.		

SR-Can FEP Ge03 Groundwater flow

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 3.035 Borehole-induced mineralization		The effect is considered to be small and localized.	Existing boreholes are not specifically described in SR-Can, but location is part of the SDM (see SKB FEP VarGe05). For impact of drilling of future boreholes, see SKB FHA FEPs.
W 3.036 Borehole-induced geochemical changes		The effect is considered to be small and localized.	Existing boreholes are not specifically described in SR-Can, but location is part of the SDM (see SKB FEP VarGe05). For impact of drilling of future boreholes, see SKB FHA FEPs.
Recorded by: Jan-Olof Selroos, Peter Jackson			**Date:** June 2006
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP Ge04 Gas flow/dissolution

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.27 Gases and gas transport	This FEP is discussed.		Scoping calculations carried out. Possible two-phase flow effects handled in RD&D programme (although this is mainly for open repository applications).
J 6.02 Gas transport	This FEP is discussed.		
S 042 Gas flow and transport, near-field rock/far-field	Gas and two-phase flow discussed.		
S 103 Water chemistry in near-field rock		Concerns impact of dissolution of entrapped air on groundwater chemistry.	More relevant for "Formation/dissolution/ reaction of gaseous species" (Ge19).
J 5.22 Accumulation of gases under permafrost	The FEP is discussed.		
S 046 Gas generation, near-field rock	Sources for gas in the geosphere addressed.		See also "Microbial processes" (Ge16) and "Formation/ dissolution/reaction of gaseous species" (Ge19).
H 1.5.3 Unsaturated flow due to gas production	This FEP is discussed.		

SR-Can FEP Ge04 Gas flow/dissolution

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
H 2.3.11 Far-field transport: Gas induced ground-water transport	Gas phase and two-phase flow discussed.		
K 5.17 Gas pressure effects	Discussed.		See NEA FEP A 1.35.
K 6.17 Gas pressure effects	Discussed.		See NEA FEP A 1.35.
W 1.024 Unsaturated groundwater flow	Unsaturated water flow as a special case (simplification) of two-phase flow is discussed.		See NEA FEP A 2.24.
W 2.042 Fluid flow due to gas production	Gas phase flow discussed.		
S 043 Gas generation and gas sources, far-field	Sources for gas in the geosphere addressed.		See also "Microbial processes" (Ge16) and "Formation/ dissolution/reaction of gaseous species" (Ge19).
H 1.2.6 Gas transport	This FEP is discussed.		See NEA FEP A 2.27.
A 1.35 Formation of gases	Sources for gas in the geosphere addressed and the effect of the pressure due to gas formation is discussed.		See also e.g. processes "Water radiolysis" (F10) and "Corrosion of cast iron insert" (C07)
A 1.68 Reflooding	Resaturation.		The term resaturation is used in the Process Report for the process in question.
A 2.15 Dewatering	Dewatering during construction and operation phases is discussed.		
A 2.69 Unsaturated rock	The unsaturated region that will develop as a result of groundwater drawdown because of repository construction is addressed.		See process "Groundwater flow" Ge03.
H 1.5.1 Desaturation (pumping) effects	Desaturation and resaturation is discussed.		
H 2.1.9 Effects of natural gases.	The effects of dissolved natural gases are discussed.		
H 4.1.3 Gas discharge	The possible consequences of this FEP are discussed.		
J 5.14 Resaturation	Resaturation is discussed.		
J 5.43 Methane intrusion	This FEP is discussed.		See also Ge19 and Ge20.
K 4.03 Desaturation/resaturation of EDZ	Discussed.		
K 5.24 Geogas	Natural gas content and the gas flow characteristics addressed.		See also SKB FEP Ge25
K 6.24 Geogas	Natural gas content and the gas flow characteristics addressed.		See also SKB FEP Ge25
S 064 Properties of far-field rock	Discussed.		
S 065 Properties of near-field rock	Discussed.		

SR-Can FEP Ge04 Gas flow/dissolution

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 078 Resaturation, near-field rock	Resaturation addressed.		See also "Groundwater flow" Ge03.
W 1.032 Natural gas intrusion	The effects of dissolved natural gases are noted in the Process Report .		
J 5.17 Permafrost	Accumulation of gas under permafrost is discussed.		See also SKB Climate FEPs.
S 059 Permafrost	Accumulation of gas under permafrost is discussed.		See also processes "Freezing" (Ge02), "Groundwater flow" (Ge03), "Salt exclusion" (Ge21) and SKB Climate FEPs.
Recorded by: Jan-Olof Selroos, Peter Jackson			**Date:** June 2006
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP Ge05 Displacements in intact rock

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 4.2.02.1 Excavation/backfilling effects on nearby rock	The role of excavation peripheries as near-field rock stress boundaries.		FEP seems to regard mainly effects on permeability.
J 4.2.07 Thermo-hydro-mechanical effects	Thermally induced stresses.		FEP definition looks similar to NEA FEP J.4.2.02.1
S 065 Properties of near-field rock	Near-field rock properties considered are the volumetric heat expansion and the bulk modulus.		
S 086 Stress field	Thermally induced stresses		
H 1.6.1 Thermal effects: Rock-mass changes	Thermally induced stresses.		This FEP regards intermediate level waste with "modest envisaged heating", not HLW.
W 2.029 Thermal effects on material properties		Intact rock properties are not sensitive to temperatures in expected temperature interval.	FEP regards repository in salt.
W 2.030 Thermally-induced stress changes	Thermally induced stresses.		FEP regards repository in salt.
A 2.71 Vault heating effects	Thermally induced stresses.		
W 2.013 Heat from radioactive decay	Thermally induced stresses.		FEP regards repository in salt
Recorded by: Harald Hökmark			**Date:** 2005-03-02
Checked and revised by: Kristina Skagius			**Date:** Dec 2005

SR-Can FEP Ge06 Reactivation - Displacement along existing discontinuities

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.29 Earthquakes	Induced shear movements on fractures that may potentially intersect canister positions.		
A 2.21 Earthquakes	Induced shear movements on fractures that may potentially intersect canister positions.		
A 2.24 Faulting	Induced shear movements on fractures that may potentially intersect canister positions.		
A 2.30 Glaciation	Change of load on fractures and following fracture movements.		
A 3.045 Earthquakes	Induced shear movements on fractures that may potentially intersect canister positions.		
J 4.2.01 Mechanical failure of repository	Induced shear movements on fractures that may potentially intersect canister		
J 4.2.06 Faulting	Seismically induced (secondary) slip across deposition holes.		
S 036 Faulting	Seismically induced (secondary) slip across deposition holes.		
S 064 Properties of far-field rock	Change of load on fractures and following fracture movements.		
H 2.1.7 Faulting/fracturing	Reactivation and causes.		
W 1.010 Formation of new faults		Site-specific FEP, which mainly address fault movement covered by FEP W1.011.	
W 1.011 Fault movement	Secondary displacements induced by fault movements.		
J 4.2.02.1 Excavation/backfilling effects on nearby rock	Change of load on fractures and following fracture movements.		
J 4.2.07 Thermo-hydro-mechanical effects	Permeability changes caused by shear and fracture displacement due to thermal load.		
J 5.42 Glaciation	Change of load on fractures and following fracture movements .		
S 047 Glaciation	Change of load on fractures and following fracture movements.		
S 065 Properties of near-field rock	Change of load on fractures and following fracture movements.		
S 086 Stress field	Initial stress is input to all analyses relevant to fracture movements. Stress change is output and is used to forecast scope and extent of fracture movements.		
H 1.6.1 Thermal effects: Rock-mass changes	Changes in fracture apertures.		
H 2.2.2 Rock property changes	Changes in fracture apertures.		
W 2.029 Thermal effects on material properties		Temperature dependence of crystalline rock properties (in relevant temperature range) is too small to be of importance.	
A 2.71 Vault heating effects	Change of load on fractures and following fracture movements.		

SR-Can FEP Ge06 Reactivation - Displacement along existing discontinuities

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
H 5.1.2 Loss of integrity of shaft or access tunnel seals		Not relevant for KBS-3.	
J 5.15 Earthquakes	Seismically induced (secondary) slip across deposition holes.		
K 9.06 Stress changes - hydrogeological effects	Reactivation and causes.		
Recorded by: Harald Hökmark			**Date:** 2005-03-01
Checked and revised by: Kristina Skagius			**Date:** Dec 2005

SR-Can FEP Ge07 Fracturing

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.01 Blasting and vibration	Schematically assumed EDZ properties .		,
A 2.13 Damaged zone	Schematically assumed EDZ properties .		
J 4.2.08 Enhanced rock fracturing	Reference to near-field rock discrete fracture stress-deformation analyses to assess scope and extent of stress-induced fracturing.		
S 030 Enhanced rock fracturing	Reference to near-field rock discrete fracture stress-deformation analyses to assess scope and extent of stress-induced fracturing.		
S 032 Excavation effects on nearby rock	Reference to near-field rock discrete fracture stress-deformation analyses to assess scope and extent of stress-induced fracturing.		
W 1.008 Formation of fractures		Stress changes will not be large enough to create new fractures.	
W 2.018 Disturbed rock zone	Schematically assumed EDZ properties.		
W 2.019 Excavation-induced changes in stress	Schematically assumed EDZ properties.		FEP regards fracturing in salt.
I 022 Explosions/bombs /blasting/collision /impacts/vibration	Impact of excavation discussed.		
A 2.21 Earthquakes		Fracturing effects overshadowed by effects of reactivation.	Addressed in "Reactivation - displacements along existing discontinuities" Ge06.
A 2.30 Glaciation	The change in the existing fracture geometry caused by fracture propagation or formation of new fractures will be too small to be of importance to the host rock permeability. Fracturing in the near-field: see A 1.08 (Cave ins).		

SR-Can FEP Ge07 Fracturing

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.045 Earthquakes		FEP does not concern fracturing.	Addressed in "Reactivation - displacements along existing discontinue-ties" Ge06.
J 4.2.01 Mechanical failure of repository		FEP concerns reactivation rather than fracturing.	See SKB FEP Ge06.
J 4.2.06 Faulting		FEP concerns reactivation rather than fracturing.	Addressed in "Reactivation - displacements along existing discontinue-ties" Ge06.
S 036 Faulting		Fracturing effects overshadowed by effects of reactivation.	Addressed in "Reactivation - displacements along existing discontinue-ties" Ge06.
S 064 Properties of far-field rock		FEP does not concern fracturing.	
H 1.5.2 Disturbed zone (hydro-mechanical) effects	Schematically assumed EDZ properties.		
H 2.1.7 Faulting/fracturing	Changes in fracture geometry caused by fracturing are concluded to be too minor to be of any concern (compared with effects of reactivation).		
W 1.010 Formation of new faults		FEP does not concern fracturing.	Addressed in "Reactivation - displacements along existing discontinue-ties" Ge06.
W 2.022 Roof falls		FEP relevant to conditions in salt.	
A 1.08 Cave ins	Reference to near-field rock discrete fracture stress-deformation analyses to assess scope and extent of stress-induced fracturing.		
J 4.2.02.1 Excavation/backfilling effects on nearby rock	Reference to near-field rock discrete fracture stress-deformation analyses to assess effects of stress cycle (excavation, thermal, ice-load) on fracture apertures.		FEP does not concern fracturing.
J 4.2.07 Thermo-hydro-mechanical effects	Reference to near-field rock discrete fracture stress-deformation analyses to assess effects of stress cycle (excavation, thermal, ice-load) on fracture apertures.		FEP does not concern fracturing.
J 5.42 Glaciation	Glaciation treated as load case in near-field rock discrete fracture stress-deformation analyses.		
S 004 Cave in	Reference to near-field rock discrete fracture stress-deformation analyses to assess scope and extent of stress-induced fracturing.		There is no indication that fracturing, even with complete loss of the support pressure, could be sufficiently extensive that deposition holes could collapse

SR-Can FEP Ge07 Fracturing

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 047 Glaciation	Glaciation treated as load case in near-field rock discrete fracture stress-deformation analyses.		
S 065 Properties of near-field rock	Reference to near-field rock discrete fracture stress-deformation analyses to assess scope and extent of stress-induced fracturing		
S 086 Stress field	Initial stress is input to all analyses relevant to fracturing. Stress change is output and is used to forecast scope and extent of fracturing.		
H 1.4.2 Vault collapse	Schematically assumed EDZ properties .		
H 1.6.1 Thermal effects: Rock-mass changes		FEP does not concern fracturing.	Addressed in "Reactivation - displacements along existing discontinue-ties" Ge06.
H 2.2.2 Rock property changes		FEP does not concern fracturing.	Addressed in "Reactivation - displacements along existing discontinue-ties" Ge06.
K 4.01 Excavation-disturbed zone (EDZ)	Schematically assumed EDZ properties.		
W 2.029 Thermal effects on material properties		FEP relevant to conditions in salt.	
A 2.71 Vault heating effects	Mechanical aspects: Reference to near-field rock discrete fracture stress-deformation analyses to assess scope and extent of stress-induced fracturing.		
J 5.15 Earthquakes		FEP does not concern Fracturing.	Addressed in "Reactivation - displacements along existing discontinue-ties" Ge06.

Recorded by: Harald Hökmark **Date:** 2005-03-25
Checked and revised by: Kristina Skagius **Date:** Dec 2005

SR-Can FEP Ge08 Creep

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 4.2.09 Creeping of rock mass	Creep in discontinuities.		
S 015 Creeping of rock mass, near-field	Creep in discontinuities.		
J 4.2.01 Mechanical failure of repository	Creep in discontinuities.		
J 4.2.06 Faulting		FEP does not match the process definition.	Addressed in "Reactivation - displacements along existing discontinuities" Ge06.
S 036 Faulting		FEP does not match the process definition.	Addressed in "Reactivation - displacements along existing discontinuities" Ge06.
H 2.1.7 Faulting/fracturing		FEP does not match the process definition.	Addressed in "Reactivation - displacements along existing discontinuities" Ge06 and "Fracturing" Ge07.
W 2.022 Roof falls		FEP does not match the process definition.	Not relevant for Swedish conditions as FEP regards repository in salt.
A 1.08 Cave ins	Convergence of repository openings		
J 4.2.02.1 Excavation/backfilling effects on nearby rock		FEP does not match the process definition	Addressed in "Reactivation - displacements along existing discontinuities" Ge06.
J 4.2.07 Thermo-hydro-mechanical effects		FEP does not match the process definition.	Addressed in "Reactivation - displacements along existing discontinuities" Ge06.
S 004 Cave in	Creep in discontinuities.		
S 086 Stress field		FEP does not match the process definition.	Addressed in "Reactivation - displacements along existing discontinuities" Ge06.
A 1.52 Long-term transients		FEP does not match the process definition.	
Recorded by: Harald Hökmark			**Date:** 2005-03-03
Checked and revised by: Kristina Skagius			**Date:** Dec 2005

SR-Can FEP Ge09 Surface weathering and erosion

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.22 Erosion	Erosion during temperate/boreal, permafrost and glacial conditions.		
J 5.26 Erosion on surface/sediments	Sediment and bedrock erosion during temperate/boreal, permafrost and glacial conditions.		
H 2.1.8 Major incision	Glacial erosion by ice streams in valleys.		
H 2.2.1 Changes in geometry and driving forces of the flow system	Glacial and very long-term - several millions of years - aspects mentioned.		In Sweden erosion is of minor significance in this context in relation to glaciation and related isostatic and eustatic processes.
H 2.4.1 Generalised denudation	Denudation during temperate/boreal, permafrost and glacial conditions.		
H 2.4.2 Localised denudation	Denudation during temperate/boreal, permafrost and glacial conditions.		
H 4.1.2 Solid discharge via erosional processes	Erosion and redistribution of contaminated sediments.		
K 5.18 Hydraulic gradient changes (magnitude, direction)	Glacial and very long-term - several millions of years - aspects mentioned.		
K 6.18 Hydraulic gradient changes (magnitude, direction)	See NEA FEP H 2.2.1		
K 7.11 Erosion	See NEA FEP A 2.22		
K 9.07 Erosion/denudation	See NEA FEPs A 2.22, J 5.26, H 2.4.1 and H 2.4.2		
K 10.12 Surface denudation	See NEA FEPs A 2.22, J 5.26, H 2.4.1 and H 2.4.2		
K 10.14 Glacial erosion/sedimentation	Loosening of rock fragments, including previous weathering, fracturing and crushing; evacuation of fragments from sediments and the bedrock and their entrainment in the ice, transport in the ice and by melt water in the ice/bed interface and deposition, sorting and sedimentation of transported material.		
K 10.15 Glacial-fluvial erosion/sedimentation	Evacuation of fragments from sediments and the bedrock, transport by melt water in the ice/bed interface and deposition, sorting and sedimentation of transported material.		
W 1.009 Changes in fracture properties		There is no direct impact of surface erosion on fracture properties. However, erosion of the bedrock and erosion/redistribution of sediments will alter the stress field and cause compression/ dilatation of fractures. This process is considered insignificant in the studied time frame.	Erosion/sedimentation in fractures described separately, see SKB FEP Ge10.

SR-Can FEP Ge09 Surface weathering and erosion

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 1.041 Mechanical weathering	Pressure relaxation, crystallization processes, temperature effects, saturation/drying and biological processes.		
W 1.042 Chemical weathering	Mineral alteration/metamorphosis: hydration, hydrolysis, reduction and oxidation.		
K 10.06 Glacial climate	Glacial erosion and weathering are discussed.		See also SKB Climate FEP Cli04.
I 049 Climate change	Different types of erosion processes are discussed.		See also SKB Climate FEPs Cli03 and Cli04.
S 047 Glaciation	Glacial erosion is discussed.		See also SKB Climate FEPs.
Recorded by: Lena Morén			**Date:** 2004-11-30
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP Ge10 Erosion/sedimentation in fractures

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.06 Cavitation		Cavitation due to rapid groundwater flows is not expected during construction or operation of the repository. Safe tunnel construction practices require grouting where large groundwater flows may be expected, i.e. in places where the tunnel will intercept highly conductive fracture-zones. Not expected after repository closure either.	
Recorded by: Ignasi Puigdomenech			**Date:** April 2005
Checked and revised by: Kristina Skagius			**Date:** Dec 2005

SR-Can FEP Ge11 Advection/mixing

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.11 Convection	Convection of solutes in the groundwater is described.		Equivalent to NEA FEP A 1.22
A 2.18 Dispersion	Dispersion of solutes in the groundwater is described.		Equivalent to NEA FEP A 1.28
A 2.53 Recharge groundwater	Different types of recharge waters are considered. These types vary as a function of time.		Equivalent to NEA FEP A 1.67
J 6.04 Dispersion	Dispersion of solutes is described.		
S 026 Dispersion	Dispersion of solutes is described.		See also "Transport of radionuclides in the water phase" (Ge24).
S 052 Interface different waters		No such sharp interface has been observed in Fennoscandian sites. The effect (colloid formation) is considered instead to be dependent on low salinity conditions.	

SR-Can FEP Ge11 Advection/mixing

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
H 1.5.5 Transport of chemically-active substances into the near-field	Transport of solutes is described. Introduction of organics, colloids and microbes from the geosphere into the buffer (= near field?) and consequences of this are neglected.		
H 2.3.7 Far-field transport: Changes in groundwater chemistry and flow direction		This is discussed in "Microbial processes" (Ge16). Microbial activities at repository depth are expected to occur even in the event of a glaciation, as some microbes are expected to be energetically independent of surface conditions: they will consume methane and hydrogen emanating from the Earth's mantle.	
H 2.3.13 Far-field transport: Biogeochemical changes	Changes in water chemistry as a result of climate change are discussed.	Effects of changes of groundwater chemistry on sorption properties, it should be discussed under sorption (radionuclide transport)	See "Speciation and sorption" Ge13.
K 5.08 Groundwater chemistry	The effect of salinity on groundwater flow is described. Effects of advection on groundwater composition are also described.		
K 6.08 Groundwater chemistry	The effect of salinity on groundwater flow is described. Effects of advection on groundwater composition are also described.		Equivalent to NEA FEP K 5.08.
K 7.08 Groundwater chemistry	The effect of salinity on groundwater flow is described. Effects of advection on groundwater composition are also described.		Equivalent to NEA FEP K 5.08.
W 1.030 Freshwater intrusion	The effect of changes in recharge waters is mentioned. Effects of advection on groundwater composition are described.		
W 1.034 Saline intrusion	The effect of changes in recharge waters is mentioned. Effects of advection on groundwater composition are described.		
W 2.090 Advection	Advection is described.		
W 3.036 Borehole-induced geochemical changes		The effects due to a borehole (future human action), on changes in advection-mixing-dispersion, are expected to be local. These effects can be neglected when compared with other advection-mixing factors from future glaciations.	Existing boreholes are not specifically described in SR-Can, but location is part of the SDM (see SKB FEP VarGe05). For impact of drilling of future boreholes, see SKB FHA FEPs.
I 040 Farfield chemical interactions	The effect of salinity on groundwater flow is described. Effects of advection on groundwater composition are also described.		Consequences for colloid formation etc are described in the text for the corre-sponding processes (Ge14, Ge15, Ge18).
A 1.67 Recharge groundwater	Different types of recharge waters are considered. These types vary as a function of time.		

SR-Can FEP Ge11 Advection/mixing

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 5.01 Saline (or fresh) groundwater intrusion	The effect of salinity on groundwater flow is described.		See also "Groundwater flow" (Ge03). Consequences for colloid formation etc are described in the text for the corresponding process (Ge13, Ge18).
S 018 Deep saline water intrusion	The effect of salinity on groundwater flow is described.		Equivalent to J 5.01
H 1.5.1 Desaturation (pumping) effects		There are no expected effects on advection or mixing of solutes in the geosphere as a consequence of the drying-out of the rock during repository operation (e.g. the EDZ)	
K 5.11 Intrusion of saline groundwater		Site-specific FEP (intrusion from sedimentary Permo-Caboniferous Trough) not relevant for SR-Can.	
K 6.11 Intrusion of saline groundwater		Site-specific FEP (intrusion from sedimentary Permo-Caboniferous Trough) not relevant for SR-Can.	
W 1.035 Freshwater intrusion	The effect of changes in recharge waters is mentioned. Effects of advection on groundwater composition are described.		
A 1.22 Convection	Convection of solutes in the groundwater is described.		See also "Transport of radionuclides in the water phase" (Ge24).
A 1.28 Dispersion	Dispersion of solutes in the groundwater is described.		See also "Transport of radionuclides in the water phase" (Ge24).
S 048 Groundwater chemistry	Effects of advection on groundwater composition are described.		
W 3.035 Borehole-induced mineralization		The effects due to a borehole (future human action), on changes in advection-mixing-dispersion, are expected to be local. These effects can be neglected when compared with other advection-mixing factors from future glaciations.	Existing boreholes are not specifically described in SR-Can, but location is part of the SDM (see SKB FEP VarGe05). For impact of drilling of future boreholes, see SKB FHA FEPs.
S 103 Water chemistry in near-field rock		The evolution of water chemistry in the vicinity of deposition holes is not dealt with separately or in a different manner than the groundwater chemistry of the far field rock. Some aspects however are considered specially: the effect of grouting and the operation phase.	See SKB FEPs Ge15, Ge17, Ge19.

Recorded by: Ignasi Puigdomenech **Date:** April 2005
Checked and revised by: Kristina Skagius **Date:** Dec 2005

SR-Can FEP Ge12 Diffusion and matrix diffusion

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.41 Matrix diffusion	Diffusion into the rock matrix is described.		
J 4.1.05 Matrix diffusion	Matrix diffusion and implications of fracture fillings and the rock mass (porosity and mineralogy) is addressed.		
S 054 Matrix diffusion	Anion exclusion and characteristics affecting matrix diffusion are addressed.		
H 2.3.2 Far-field transport: Diffusion	Diffusion in water and in the rock matrix, including surface diffusion, is addressed.		
K 5.06 Matrix diffusion	Matrix diffusion and impact of pore geometry (formation factor), charge of pore surfaces and size and charge of diffusing species, extent of connected porosity, fracture infill and altered zones are addressed.		
K 6.06 Matrix diffusion	Matrix diffusion and impact of pore geometry (formation factor), charge of pore surfaces and size and charge of diffusing species, extent of connected porosity, fracture infill and altered zones are addressed.		Equivalent to NEA FEP K 5.06
W 2.091 Diffusion	Molecular diffusion in pores of the rock is addressed.		
W 2.092 Matrix diffusion	Matrix diffusion and factors controlling matrix diffusion are addressed.		
S 028 Earth tides		The effects of tides are not discernible in the site modelling. These effects are expected to be minor when compared with yearly variations and long-time climate effects, such as shore displacements and glaciations.	
K 4.09 Radionuclide retardation		Handled elsewhere.	See "Transport of radionuclides in the water phase" Ge24.
K 5.05 Radionuclide transport through LPD	Retardation of advective transport due to matrix diffusion is addressed.		See also SKB FEP Ge24.
K 6.05 Radionuclide transport through MWCF	Retardation of advective transport due to matrix diffusion is addressed.		Equivalent to NEA FEP K 5.05
J 3.2.06 Diffusion - surface diffusion	Diffusion and surface diffusion is addressed.		
J 3.2.10 Soret effect		FEP primarily concerns effects in bentonite. No significant chemical consequences are foreseen in the geosphere. The effect on radionuclide transport is certainly negligible in the geosphere - too small temperature gradients.	
S 002 Anion-exclusion	Anion exclusion in rock is addressed.		

SR-Can FEP Ge12 Diffusion and matrix diffusion

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 023 Diffusion	Anion exclusion and surface diffusion in the rock matrix as well as characteristics affecting these are addressed.		
S 083 Soret effect		FEP primarily concerns effects in bentonite. No significant chemical consequences are foreseen in the geosphere. The effect on radionuclide transport is certainly negligible in the geosphere- too small temperature gradients.	
K 4.02 Natural radionuclides/elements		FEP concerns impact on radionuclide release through bentonite buffer.	See SKB FEP Bu11.
W 2.093 Soret effect		No significant chemical consequences are foreseen. The effect on radionuclide transport is certainly negligible in the geosphere - too small temperature gradients.	
A 2.16 Diffusion	Diffusion is described.		
A 1.36 Galvanic coupling		Electrokinetic effects are discussed under "earth currents"	See SKB FEP Ge23.
S 001 Alteration/weathering of flow paths	Matrix diffusion and impact of pore geometry (formation factor), charge of pore surfaces and size and charge of diffusing species, extent of connected porosity, fracture infill and altered zones are addressed.		
Recorded by: Ignasi Puigdomenech			**Date:** April 2006
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP Ge13 Speciation and sorption

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.09 Complexation by organics	The effect of humic and fulvic acids on sorption characteristics is addressed.		
A 2.26 Fulvic acid	The effect of humic and fulvic acids on sorption characteristics is addressed.		
A 2.34 Humic acid	The effect of humic and fulvic acids on sorption characteristics is addressed.		
A 2.62 Sorption	Different processes described as sorption are discussed. Covered: minerals involved, mineral surface area, electro-chemical potential, salinity, pH and available complexing ligands.		
A 2.63 Sorption - nonlinear	The possibility of sorption saturation and the use of non-linear isotherms are addressed.		
A 2.64 Speciation	Speciation as a function of in-organic and organic components of water is addressed.		

SR-Can FEP Ge13 Speciation and sorption

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 4.1.09 Complexing agents	The effect of humic and fulvic acids on sorption characteristics are addressed.		
J 7.05 Isotopic dilution		Not handled in the context of sorption since concentrations are too small to have any effect. However, mentioned in connection with radionuclide transport	See "Transport of radionuclides in the water phase" (Ge24).
H 2.3.4 Far-field transport: Solubility constraints	Solubility constraints due to high ionic strength groundwater indirectly taken care of as Kd values specified for different salinities.	Solubility constraints in the far-field due to the alkaline (high pH) plume not considered, since low pH grouting assumed to be available for the construction of the repository.	
H 2.3.5 Far-field transport: Sorption including ion-exchange	Different processes described as sorption are discussed as well as different aspects limiting or hindering sorption.		
H 2.3.12 Far-field transport: Thermal effects on hydrochemistry		Not discussed; relevance considered low.	
K 4.09 Radionuclide retardation		Handled elsewhere.	See "Transport of radionuclides in the water phase" Ge24.
K 4.10 Elemental solubility		Precipitation of nuclides with colloids not considered.	
K 5.07 Mineralogy	The effect of mineralogy on sorption is addressed.		
K 5.09 Sorption	Different processes described as sorption are discussed.		
K 5.10 Non-linear sorption	Non-linear sorption is addressed. Only linear sorption employed in calculations of SR-Can, based on arguments in the process description.		
K 5.16 Solubility limits/colloid formation	Precipitation and coprecipitation is mentioned.		See also "Transport of radionuclides in the water phase" Ge24.
K 6.07 Mineralogy	The effect of mineralogy on sorption is addressed.		Equivalent to NEA FEP K 5.07.
K 6.09 Sorption	Different processes described as sorption are discussed.		Equivalent to NEA FEP K 5.09.
K 6.10 Non-linear sorption	Non-linear sorption is addressed. Only linear sorption employed in calculations of SR-Can,		Equivalent to NEA FEP K 5.10.
K 6.16 Solubility limits/colloid formation	Precipitation and coprecipitation is mentioned		See also "Transport of radionuclides in the water phase" (Ge24).
K 7.09 Radionuclide sorption	Different processes described as sorption are discussed.		Equivalent to NEA FEP K 5.09.
W 1.036 Changes in groundwater Eh	Effect of groundwater chemistry on sorption discussed (redox/oxidation state effect).		See also "Transport of radionuclides in the water phase" (Ge24).

SR-Can FEP Ge13 Speciation and sorption

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 1.037 Changes in groundwater pH	Effect of groundwater chemistry on sorption discussed. Effect of pH mainly considered through use of reference waters, for which e.g Kd values are proposed.		See also "Transport of radionuclides in the water phase" (Ge24).
W 2.071 Kinetics of organic complexation	The effect of humic and fulvic acids on sorption characteristics is addressed. Since the effect of organic complexation is treated as a reduction in Kd values, the effect of kinetics is disregarded.		
W 2.081 Colloid sorption		Handled elsewhere.	See "Colloid formation and transport" (Ge18) and "Transport of radionuclides in the water phase" (Ge24).
J 4.1.06 Reconcentration	Immobilisation processes such as surface complexation and co-precipitation and subsequent dissolution of solid phases containing radionuclides, if chemical conditions change, is not handled in SR-Can, but brought up as an uncertainty in the process description.		
S 073 Reconcentration	Immobilisation processes such as surface complexation and co-precipitation and subsequent dissolution of solid phases containing radionuclides, if chemical conditions change, is not handled in SR-Can, but brought up as an uncertainty in the process description.		See also "Transport of radionuclides in the water phase" (Ge24).
H 2.3.7 Far-field transport: Changes in groundwater chemistry and flow direction	Impact of changes in groundwater composition is discussed.		
K 0.2 Speciation	Speciation is addressed.		
J 4.1.04 Sorption	Different processes described as sorption are addressed.		
S 018 Deep saline water intrusion	Impact of salinity on chemical equilibria and sorption characteristics is addressed.		
S 084 Sorption	Different processes described as sorption are addressed.		
H 2.3.6 Far-field transport: Changes in sorptive surfaces	The fracture surface area through which the inner surfaces of the matrix is reached is discussed in a sorption context.	Changes in surface area not explicitly handled in SR-Can, but mentioned in process report.	See "Transport of radionuclides in the water phase" (Ge24).
K 4.08 Radionuclide migration		Handled elsewhere.	See "Transport of radionuclides in the water phase" Ge24.
K 5.05 Radionuclide transport through LPD		Handled elsewhere.	See "Transport of radionuclides in the water phase" Ge24.

SR-Can FEP Ge13 Speciation and sorption

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 5.11 Intrusion of saline groundwater	Impact of salinity on chemical equilibria and sorption characteristics is addressed. Prevailing salinity for different time periods assessed through hydrogeochemical modelling in SR-Can.		
K 6.11 Intrusion of saline groundwater	Impact of salinity on chemical equilibria and sorption characteristics is addressed. Prevailing salinity for different time periods assessed through hydrogeochemical modelling in SR-Can.		Equivalent to NEA FEP K 5.11.
W 1.034 Saline intrusion	Effect of groundwater chemistry on sorption is discussed (salinity effect).		See also "Transport of radionuclides in the water phase" (Ge24).
W 2.056 Speciation	Speciation as a function of temperature, pressure, and salinity is addressed.		
A 1.37 Geochemical pump	Immobilisation processes such as surface complexation and co-precipitation and subsequent dissolution of solid phases containing radionuclides, if chemical conditions change, is not handled in SR-Can, but brought up as an uncertainty in the process description.		
A 2.58 Saturation	The possibility of sorption saturation and the use of non-linear isotherms are addressed.		
S 048 Groundwater chemistry	Impact of groundwater chemistry on speciation and sorption is addressed.		
K 5.08 Groundwater chemistry	The effect of groundwater chemistry on speciation and sorption is discussed.		
K 6.08 Groundwater chemistry	The effect of groundwater chemistry on speciation and sorption is discussed.		Equivalent to NEA FEP K 5.08.
K 7.08 Groundwater chemistry	The effect of groundwater chemistry on speciation and sorption is discussed.		Equivalent to NEA FEP K 5.08.
W 1.035 Freshwater intrusion	Effect of groundwater chemistry on sorption is discussed (salinity effect).		See also "Transport of radionuclides in the water phase" (Ge24).
W 2.060 Kinetics of precipitation and dissolution	Precipitation-dissolution is discussed. Kinetics of precipitation-dissolution not handled since precipitation-dissolution not included in quantitative manner in analyses.		
A 1.77 Speciation	Effects of temperature and pressure addressed.		
S 060 Precipitation/dissolution	Precipitation/dissolution as a type of sorption reaction is discussed.		See also "Transport of radionuclides in the water phase" (Ge24).
A 1.14 Complexation by organics	The effect of humic and fulvic acids on sorption characteristics is addressed.		

SR-Can FEP Ge13 Speciation and sorption

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
I 040 Farfield chemical interactions	Impact of groundwater composition on sorption is discussed.		
W 2.061 Actinide sorption	Different processes described as sorption are discussed.		
W 2.062 Kinetics of sorption	The fact that sorption may be kinetic is discussed. Kinetic sorption models not utilized in the quantitative analyses for SR-Can; however, indirectly accounted for when Kd data is suggested (by conservative choices and uncertainty ranges).		
W 2.057 Kinetics of speciation	Kinetics of sorption addressed, but handled; deemed to be of minor relevance (speciation is fast).		
S 001 Alteration/weathering of flow paths	Impact of alteration on sorption is addressed.		
K 5.22 Microbial activity	Impact of microbial activity on sorption mentioned. Handled in SR-Can by assigning uncertainty spans in Kd.		See also "Transport of radionuclides in the water phase" Ge24.
Recorded by: Jan-Olof Selroos			**Date:** 2005-02-04
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP Ge14 Reactions groundwater/rock matrix

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 4.1.02 pH-deviations	The effect of pH on dissolution precipitation is described.		
J 6.06 Weathering of flow paths		The overall effect of weathering of the rock matrix on fracture porosity is expected to be small as the on the whole the weathering reactions produce mineral transformations, i.e. dissolution of granite minerals with subsequent formation of secondary solids, e.g. fracture filling minerals.	
S 001 Alteration/weathering of flow paths	The effect of minerals on groundwater chemistry through dissolution and precipitation is described. Effects on fracture flow are not discussed.		
S 048 Groundwater chemistry	The effect of minerals on groundwater chemistry through dissolution and precipitation is described.		
K 4.05 Geochemical alteration		The main geochemical alterations in the EDZ during excavation and backfilling are expected to be limited to the oxidation of Fe(II) minerals if the EDZ becomes water un-saturated. These changes are not expected to affect substantially the chemical properties of the geosphere.	

SR-Can FEP Ge14 Reactions groundwater/rock matrix

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 4.06 Groundwater chemistry		In case of de-saturation of the EDZ during excavation and backfilling it is to be expected a change to oxidizing conditions in the matrix porewater. The conditions will however return to reducing after re-saturation of the backfill. This effect may be neglected when considering the large amount of air entrapped in the backfill.	
K 5.19 Influx of oxidising water	The possible effect of the influx of oxidizing surface waters during repository operation is described		
K 6.19 Influx of oxidising water	The possible effect of the influx of oxidizing surface waters during repository operation is described.		Equivalent to NEA FEP K 5.09.
W 1.038 Effects of dissolution	Dissolution of minerals is described.		It is not clear in this FEP what dissolution means: dissolution of what?
W 2.065 Reduction-oxidation fronts	A large scale intrusion of oxidizing waters can only be envisaged under a glaciation period, and this is described.		
W 3.035 Borehole-induced mineralization		This concerns future human actions: drilling. The precipitation-dissolution effects from a borehole, due to changes in advection-mixing-dispersion, are expected to be minor and local. These effects can be neglected when compared with other advection-mixing factors from future glaciations.	Existing boreholes are not specifically described in SR-Can, but location is part of the SDM (see SKB FEP VarGe05). For impact of drilling of future boreholes, see SKB FHA FEPs.
S 064 Properties of far-field rock	Changes in rock properties due to dissolution-precipitation reactions are described.		
H 1.5.1 Desaturation (pumping) effects		Desaturation of the rock might expand the oxidizing zone a few metres into the rock matrix. Because the overall porosity is so low (compared with the backfill) the increased amount of O2 on repository closure is negligible.	
K 5.08 Groundwater chemistry	The effect of minerals on groundwater chemistry through dissolution and precipitation is described.		
K 6.08 Groundwater chemistry	The effect of minerals on groundwater chemistry through dissolution and precipitation is described.		Equivalent to NEA FEP K 5.08.
K 7.08 Groundwater chemistry	The effect of minerals on groundwater chemistry through dissolution and precipitation is described.		Equivalent to NEA FEP K 5.08.

SR-Can FEP Ge14 Reactions groundwater/rock matrix

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 3.036 Borehole-induced geochemical changes		This concerns future human actions: drilling. The precipitation-dissolution effects from a borehole, due to changes in advection-mixing-dispersion, are expected to be minor and local. These effects can be neglected when compared with other advection-mixing factors from future glaciations.	Existing boreholes are not specifically described in SR-Can, but location is part of the SDM (see SKB FEP VarGe05). For impact of drilling of future boreholes, see SKB FHA FEPs.
J 3.1.11 Redox front	There are three types of redox fronts described in this FEP. Type 1) recharge of surface waters: this will depend on the climatic conditions. When the site is above sea level under temperate climate the redox front is close to the surface, i.e. it may be assumed that reducing conditions prevail already a short distance from the ground surface. During glaciation the redox front might be deeper, and this is modeled in SR-Can. Type 2) conditions shortly after repository closure: the consumption of oxygen in the backfill are modelled in SR-Can. Type 3) radiolysis close to the spent fuel: this does not concern the geosphere.		Type 3) redox front due to radiolysis close to the spent fuel is addressed in SKB FEP F10.
S 074 Redox front	Equivalent to NEA FEP J 3.1.11		
I 040 Farfield chemical interactions	Chemistry changes due to dissolution precipitation are described.		
S 065 Properties of near-field rock	Changes in rock properties due to dissolution-precipitation reactions are described		
W 2.057 Kinetics of speciation		The rate of most reactions in aqueous solutions may be considered instantaneous in this context. Some redox re-actions are on the contrary hindered unless mediated by microbes, e.g. sulfate reduction, and their kinetics may also be disregarded.	
K 5.07 Mineralogy	The effect of mineralogy on groundwater chemistry through dissolution and precipitation is described.		
K 6.07 Mineralogy	The effect of mineralogy on groundwater chemistry through dissolution and precipitation is described.		Equivalent to NEA FEP K 5.07.
Recorded by: Ignasi Puigdomenech			**Date:** April 2005
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP Ge15 Dissolution/precipitation of fracture-filling minerals

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.29 Geochemical interactions	The chemical interactions between groundwater and fracture filling minerals are described		
A 2.33 Groundwater - evolution		The temperature effects on groundwater chemical evolution are expected to be minor, as discussed in the description of this FEP.	
A 2.49 Precipitation and dissolution		The temperature effects on mineral dissolution-precipitation and its effects on groundwater flow are expected to be minor. This FEP will affect the near vicinity of the repository, and the overall effect on the geosphere chemical properties is minor.	
W 1.022 Fracture infills	The interaction between minerals and groundwater through dissolution and precipitation is described.		Effects on fracture geometry are described, but the consequences for groundwater flow are not discussed here.
W 2.059 Precipitation	The interaction between minerals and groundwater through dissolution and precipitation is described.		
W 3.035 Borehole-induced mineralization		This concerns future human actions: drilling. The precipitation-dissolution effects from a borehole, due to changes in advection-mixing-dispersion, are expected to be minor and local. These effects can be neglected when compared with other advection-mixing factors from future glaciations.	Existing boreholes are not specifically described in SR-Can, but location is part of the SDM (see SKB FEP VarGe05). For impact of drilling of future boreholes, see SKB FHA FEPs.
A 2.35 Hydraulic properties - evolution		The temperature effects on mineral dissolution-precipitation and its effects on groundwater flow are expected to be minor, as discussed in the description of this FEP.	
A 2.53 Recharge groundwater	Different types of recharge waters are discussed in the report. These types vary as a function of time.		
J 4.1.02 pH-deviations	The effect of pH on dissolution precipitation is described.		
J 6.06 Weathering of flow paths		The overall effect of weathering of the fracture minerals on fracture porosity is expected to be small as the on the whole the weathering reactions produce mineral transformations, i.e. dissolution of granite minerals with subsequent formation of secondary solids, e.g. fracture filling minerals.	

SR-Can FEP Ge15 Dissolution/precipitation of fracture-filling minerals

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 001 Alteration/weathering of flow paths	The effect of minerals on groundwater chemistry through dissolution and precipitation is described.		Effects on fracture geometry are described, but the consequences for groundwater flow are not discussed here.
S 048 Groundwater chemistry	The effect of minerals on groundwater chemistry through dissolution and precipitation is described.		
S 103 Water chemistry in near-field rock	Impact of water composition on dissolution-precipitation reactions is described.		
H 2.3.6 Far-field transport: Changes in sorptive surfaces	Changes in mineralogy due to dissolution-precipitation reactions are described.		See also "Degradation of grout" (Ge17) and "Transport of radionuclides in the water phase" (Ge24).
K 4.05 Geochemical alteration		The main geochemical alterations in the EDZ during excavation and backfilling are expected to be limited to the oxidation of Fe(II) minerals if the EDZ becomes water un-saturated. These changes are not expected to affect substantially the chemical properties of the geosphere.	
K 4.06 Groundwater chemistry		In case of de-saturation of the EDZ during excavation and backfilling it is to be expected a change to oxidizing conditions in the matrix porewater. The conditions will however return to reducing after re-saturation of the backfill. This effect may be neglected when considering the large amount of air entrapped in the backfill.	
K 5.08 Groundwater chemistry	The effect of minerals on groundwater chemistry through dissolution and precipitation is described.		
K 5.19 Influx of oxidising water	The possible effect of the influx of oxidizing surface waters during repository operation is described		
K 6.08 Groundwater chemistry	The effect of minerals on groundwater chemistry through dissolution and precipitation is described.		Equivalent to NEA FEP K 5.08.
K 6.19 Influx of oxidising water	The possible effect of the influx of oxidizing surface waters dur-ing repository operation is described		Equivalent to NEA FEP K 5.19.
K 7.08 Groundwater chemistry	The effect of minerals on groundwater chemistry through dissolution and precipitation is described.		Equivalent to NEA FEP K 5.08.
W 1.038 Effects of dissolution	Dissolution of minerals is described.		It is not clear in this FEP what dissolution means: dissolution of what?

SR-Can FEP Ge15 Dissolution/precipitation of fracture-filling minerals

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 2.065 Reduction-oxidation fronts	A large scale intrusion of oxidizing waters can only be envisaged under a glaciation period, and this is described.		
W 3.036 Borehole-induced geochemical changes		This concerns future human actions: drilling. The precipitation-dissolution effects from a borehole, due to changes in advection-mixing-dispersion, are expected to be minor and local. These effects can be neglected when compared with other advection-mixing factors from future glaciations.	Existing boreholes are not specifically described in SR-Can, but location is part of the SDM (see SKB FEP VarGe05). For impact of drilling of future boreholes, see SKB FHA FEPs.
H 2.3.7 Far-field transport: Changes in groundwater chemistry and flow direction	Changes in mineralogy due to dissolution-precipitation reactions are described.		
I 040 Farfield chemical interactions	The interaction between groundwater chemistry and minerals due to dissolution-precipitation reactions is described.		
S 064 Properties of far-field rock	Changes in rock properties due to dissolution-precipitation reactions are described.		
H 1.5.1 Desaturation (pumping) effects		Desaturation of the rock might expand the oxidizing zone a few metres into the rock matrix. Because the overall porosity is so low (compared with the backfill) the increased amount of O2 on repository closure is negligible.	
H 2.2.2 Rock property changes		The effect of an alkaline plume from cement degradation is discussed under "grout degradation".	See SKB FEP Ge17.
S 065 Properties of near-field rock	Similar to NEA FEP S 064		
W 2.057 Kinetics of speciation		The rate of most reactions in aqueous solutions may be considered instantaneous in this context. Some redox reactions are on the contrary hindered unless mediated by microbes, e.g. sulphate reduction, and their kinetics may also be disregarded.	
W 1.009 Changes in fracture properties	Changes in rock properties due to dissolution-precipitation reactions are described.		Effects on fracture geometry are described, but the consequences for groundwater flow are not discussed here.
K 6.07 Mineralogy	The effect of mineralogy on groundwater chemistry through dissolution and precipitation is described.		Equivalent to NEA FEP K 5.07.
K 5.07 Mineralogy	The effect of mineralogy on groundwater chemistry through dissolution and precipitation is described.		

Recorded by: Ignasi Puigdomenech — **Date:** April 2005

Checked and revised by: Kristina Skagius — **Date:** Sept 2006

SR-Can FEP Ge16 Microbial processes

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.45 Microbes	Microbial processes affecting radionuclide transport are described.		
S 043 Gas generation and gas sources, far-field	Microbial processes involving gaseous components are described.		
H 2.3.9 Far-field transport: Transport of radionuclides bound to microbes	Microbial processes affecting radionuclide transport are described.		
K 5.22 Microbial activity	Microbial processes in the geosphere, including those affecting radionuclide behaviour, are described.		
K 6.22 Microbial activity	Microbial processes in the geosphere, including those affecting radionuclide behaviour, are described.		
W 2.087 Microbial transport	Microbial processes in the geosphere, including those affecting radionuclide behaviour, are described.		
A 2.49 Precipitation and dissolution	Microbial processes affecting radionuclide transport are described.		
W 2.044 Degradation of organic material	Microbial processes in the geosphere, including degradation of organic matter, are described.		
I 015 Gas generation (CH4, CO2, H2)	Microbial processes involving gaseous components are described.		
A 1.53 Methylation	The process is described. Note that methylation of metals is not considered important for the chemical properties of the geosphere. Only a few metals are susceptible of methylation: As(V) , Cd(II), Te(IV), Se(IV), Sn(II), Hg(II), Pb(IV).		
A 1.54 Microbes	Microbial processes in the geosphere are described.		
A 1.55 Microorganisms	Microbial processes in the geosphere are described.		
J 2.1.10 Microbes	Microbial processes in the geosphere, including those affecting radionuclide behaviour, are described.		
S 046 Gas generation, near-field rock	Microbial processes involving gaseous components are described.		
S 057 Microbial activity	Microbial processes in the geosphere, including those affecting gaseous components and processes influencing radionuclide behaviour, are described.		
K 3.17 Microbial activity	Microbial processes in the geosphere, including those affecting radionuclide behaviour, are described.		

SR-Can FEP Ge16 Microbial processes

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 2.048 Effect of biofilms on microbial gas generation	Microbial processes involving gaseous components are described.		
W 2.076 Microbial growth on concrete		The effect of microbes on grout (the only cement component of the geosphere) is described in the grout degradation process (Ge17).	
W 2.088 Biofilms	Microbial processes in the geosphere, including those affecting radionuclide behaviour, are described.		
S 048 Groundwater chemistry	Microbial processes in the geosphere, including those affecting gaseous components and processes influencing radionuclide behaviour, are described.		
H 1.5.1 Desaturation (pumping) effects		This FEP does not deal with microbes.	Also mapped to other processes, e.g. "Dissolution/ precipitation of fracture-filling minerals" (Ge15).
H 2.2.2 Rock property changes	Microbial processes in the geosphere are described.		
J 3.1.11 Redox front		This FEP does not deal with microbes.	Also mapped to other processes, e.g. "Reactions groundwater-rock matrix" (Ge14).
S 074 Redox front		This FEP does not deal with microbes.	Also mapped to other processes, e.g. "Reactions groundwater-rock matrix" (Ge14).
J 4.1.08 Change of groundwater chemistry in nearby rock		This FEP does not deal with microbes.	
A 1.03 Biological activity	Microbial processes in the geosphere are described.		
A 1.35 Formation of gases	Microbial processes involving gaseous components are described.		
I 012 Biological activity (bacteria & microbes)	Microbial processes in the geosphere, including those affecting radionuclide behaviour, are described.		

Recorded by: Ignasi Puigdomenech **Date:** April 2005

Checked and revised by: Kristina Skagius **Date:** Sept 2006

SR-Can FEP Ge17 Degradation of grout

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.15 Concrete	The processes and consequences of concrete degradation are described. Low pH concrete and grouts (porewaters with pH 11) will be used at the repository, in order to ensure clay stability.		
A 1.71 Seal evolution	The processes and consequences of concrete degradation are described. Low pH concrete and grouts (porewaters with pH 11) will be used at the repository, in order to ensure clay stability.		
J 3.1.07 Reactions with cement pore water	The processes and consequences of concrete degradation are described.		
S 021 Degradation of rock reinforcement and grout	The processes and consequences of concrete degradation are described. Rock bolts are not part of the geosphere, but the corrosion process is mentioned.		
W 2.037 Mechanical degradation of seals	The processes and consequences of concrete degradation are described.	Asphalt and compacted salt are not addressed because these materials are not relevant for a KBS-3 repository.	
I 061 Concrete (influence on vault chemistry)		This FEP does not concern the chemical properties of the geosphere.	Impact of pH on the tunnel backfill is handled in SKB FEP BfT15.
J 1.2.07 Recrystallization	The processes and consequences of concrete degradation are described.		
H 1.1.2 Physico-chemical degradation of concrete	The processes and consequences of concrete degradation are described. Low pH concrete and grouts (porewaters with pH 11) will be used at the repository, in order to ensure clay stability.		
H 1.4.2 Vault collapse		Rock bolts and shotcrete are not part of the geosphere system.	Handled in the buffer/backfill system, see SKB FEP BfT07.
W 2.074 Chemical degradation of seals	The processes and consequences of concrete degradation are described. Low pH concrete and grouts (porewaters with pH 11) will be used at the repository, in order to ensure clay stability.		
W 2.097 Chemical gradients	The processes and consequences of concrete degradation are described. The diffusion of calcium and hydroxide from the cement matrix into the surrounding groundwater is mentioned.		
A 1.72 Seal failure	The processes and consequences of concrete degradation are described. Low pH concrete and grouts (porewaters with pH 11) will be used at the repository, in order to ensure clay stability.		The consequences of seal degradation on repository safety are not addressed here.

SR-Can FEP Ge17 Degradation of grout

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.04 Borehole seal failure	The processes and consequences of concrete degradation are described. Low pH concrete and grouts (porewaters with pH 11) will be used at the repository, in order to ensure clay stability.		Borehole seals are not a geosphere component.
A 2.60 Shaft seal failure	The processes and consequences of concrete degradation are described. Low pH concrete and grouts (porewaters with pH 11) will be used at the repository, in order to ensure clay stability.		Tunnel and shaft seals are not a geosphere component.
S 103 Water chemistry in near-field rock	The processes and consequences of concrete degradation are described. The diffusion of calcium and hydroxide from the cement matrix into the surrounding groundwater is mentioned.		
S 065 Properties of near-field rock	The processes and consequences of concrete degradation are described. The formation of calcium-silicate-hydrates when cement porewaters react with rock minerals is mentioned.		
H 5.1.2 Loss of integrity of shaft or access tunnel seals		This FEP is related to shaft and tunnel seals and not grout in fractures.	
I 048 Buffer (degradation by concrete)		This FEP does not concern the chemical properties of the geosphere.	Handled for buffer/backfill, see SKB FEPs Bu16 .
H 1.5.1 Desaturation (pumping) effects		This FEP appears to have no relation to grout, seals, cement, concrete or shotcrete.	Handled in other process, e.g. "Reactions groundwater-rock matrix" (Ge14).
J 4.1.08 Change of groundwater chemistry in nearby rock	The processes and consequences of concrete degradation are described.		
W 2.076 Microbial growth on concrete	The effect of microbes on grout is described.		
Recorded by: Ignasi Puigdomenech			**Date:** April 2005
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP Ge18 Colloid formation and transport

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.08 Colloid formation	Colloids and colloid stability are discussed. However, colloid formation is of no consequence for the chemical properties of the geosphere.		Colloid-facilitated radionuclide transport is further discussed in process "Transport of radionuclides in the water phase" (Ge24).
J 5.45 Colloid generation and transport	Colloids and colloid stability are discussed. However, colloid formation is of no consequence for the chemical properties of the geosphere.		Colloid-facilitated radionuclide transport is further discussed in process "Transport of radionuclides in the water phase" (Ge24).
S 008 Colloid generation and transport	Colloids and colloid stability are discussed. Colloid formation is of no consequence for the chemical properties of the geosphere. Sorption of radionuclides on colloids is mentioned.		Colloid-facilitated radionuclide transport is further discussed in process "Transport of radionuclides in the water phase" (Ge24).
H 2.3.8 Far-field transport: Colloid transport	Sorption of radionuclides on colloids is mentioned.		Colloid-facilitated radionuclide transport is further discussed in process "Transport of radionuclides in the water phase" (Ge24).
K 5.15 Natural colloids	Colloids and colloid stability are discussed. However, colloid formation is of no consequence for the chemical properties of the geosphere.		
K 6.15 Natural colloids	Colloids and colloid stability are discussed. However, colloid formation is of no consequence for the chemical properties of the geosphere.		
W 2.078 Colloid transport	Colloids, colloid stability and transport are discussed.		Colloid-facilitated radionuclide transport is further discussed in process "Transport of radionuclides in the water phase" (Ge24).
W 2.079 Colloid formation and stability	Colloids and colloid stability are discussed. However, colloid formation is of no consequence for the chemical properties of the geosphere. Sorption of radionuclides on colloids is mentioned.		Colloid-facilitated radionuclide transport is further discussed in process "Transport of radionuclides in the water phase" (Ge24).
W 2.080 Colloid filtration	Colloids, colloid stability and transport are discussed.		

SR-Can FEP Ge18 Colloid formation and transport

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.45 Microbes	Bacteria as colloids is mentioned.		Microbial processes affecting radionuclide transport are described elsewhere, see e.g. SKB FEP Ge16.
H 1.5.5 Transport of chemically-active substances into the near-field		Transport of salt and oxygen are described elsewhere. Introduction of organics, colloids and microbes from the geosphere into the buffer are disregarded.	See SKB FEP Ge11.
H 2.3.9 Far-field transport: Transport of radionuclides bound to microbes		The interactions between microbes and radionuclides are described in "Microbial processes" (Ge16).	
K 5.22 Microbial activity		The interactions between microbes and radionuclides are described in "Microbial processes" (Ge16).	
K 6.22 Microbial activity		The interactions between microbes and radionuclides are described in "Microbial processes" (Ge16).	
W 1.034 Saline intrusion	The influence of salinity on colloid stability is mentioned. Saline waters will de-stabilize colloids.		
W 2.081 Colloid sorption	Sorption of radionuclides on colloids is mentioned.		Colloid-facilitated radionuclide transport is further discussed in process "Transport of radionuclides in the water phase" (Ge24).
W 2.087 Microbial transport	The transport of colloids is mentioned.	Microbe-facilitated radionuclides transport is described in "Microbial processes" (Ge16).	
I 040 Farfield chemical interactions		Colloids are not mentioned in this NEA FEP	
A 2.50 Pseudo-colloids	Colloids and colloid stability are discussed. However, colloid formation is of no consequence for the chemical properties of the geosphere.		Colloid-facilitated radionuclide transport is further discussed in process "Transport of radionuclides in the water phase" (Ge24).
K 4.12 Colloids	Colloids and colloid stability are discussed. However, colloid formation is of no consequence for the chemical properties of the geosphere.		Colloid-facilitated radionuclide transport is further discussed in process "Transport of radionuclides in the water phase" (Ge24).

SR-Can FEP Ge18 Colloid formation and transport

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 1.035 Freshwater intrusion	The influence of salinity on colloid stability is mentioned. Colloid concentrations from e.g. bentonite might increase in diluted waters. However, these colloids are of no consequence for the overall chemical properties of the geosphere.		Colloid-facilitated radionuclide transport is further discussed in process "Transport of radionuclides in the water phase" (Ge24).
W 2.097 Chemical gradients	Colloids and colloid stability are discussed. However, colloid formation is of no consequence for the chemical properties of the geosphere. Sorption of radionuclides on colloids is mentioned.		
I 058 Colloid formation (natural and vault generated)	Colloids and colloid stability are discussed. However, colloid formation is of no consequence for the chemical properties of the geosphere.		Colloid-facilitated radionuclide transport is further discussed in process "Transport of radionuclides in the water phase" (Ge24).
S 018 Deep saline water intrusion	The influence of salinity on colloid stability is mentioned. Saline waters will de-stabilize colloids.		
A 1.63 Psuedo-colloids	Colloids and colloid stability are discussed. However, colloid formation is of no consequence for the chemical properties of the geosphere.		
A 1.13 Colloids	Colloids and colloid stability are discussed. However, colloid formation is of no consequence for the chemical properties of the geosphere.		Colloid-facilitated radionuclide transport is further discussed in process "Transport of radionuclides in the water phase" (Ge24).
S 074 Redox front	The formation of colloidal Fe(III) hydrous oxides or hydroxides is mentioned.		Colloid-facilitated radionuclide transport is further discussed in process "Transport of radionuclides in the water phase" (Ge24).
H 1.5.1 Desaturation (pumping) effects	The formation of colloidal Fe(III) hydrous oxides or hydroxides is mentioned.		Colloid-facilitated radionuclide transport is further discussed in process "Transport of radionuclides in the water phase" (Ge24).
Recorded by: Ignasi Puigdomenech			**Date:** April 2005
Checked and revised by: Kristina Skagius			**Date:** Feb 2006

SR-Can FEP Ge19 Formation/dissolution/reaction of gaseous species

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 5.43 Methane intrusion	Methane hydrates as a possible source of methane is mentioned.		The formation of methane clathrates is described in "Methane hydrate formation" (Ge20).
S 046 Gas generation, near-field rock	Gaseous groundwater components and their behaviour are described. Various sources of gas are mentioned.		
H 2.1.9 Effects of natural gases.	Natural gases are addressed.		The formation of methane clathrates is described in "Methane hydrate formation" (Ge20).
W 1.032 Natural gas intrusion		This FEP is very specific to the WIPP repository. Contrary to the WIPP site, no large source of hydrocarbons or natural gas has been identified under or near the investigated sites in Sweden.	
A 2.27 Gases and gas transport	Gaseous groundwater components and their behaviour are described.		Radionuclide gas transport is discussed elsewhere, see SKB FEP Ge25
J 6.02 Gas transport	See handling of NEA FEP A 1.35 for geosphere chemical processes associated with gas production.		Gas transport discussed in "Gas flow/ dissolution" (Ge04).
S 042 Gas flow and transport, near-field rock/far-field	Gaseous groundwater components and their behaviour are described.		Radionuclide gas transport is discussed in "Transport of radionuclides in the gas phase" (Ge25).
S 043 Gas generation and gas sources, far-field	Gaseous groundwater components and their behaviour are described.		
K 4.06 Groundwater chemistry	The possible desaturation of the EDZ during excavation and backfilling is described. The amount of gas involved is negligible compared with the porosity of the backfill.		
I 040 Farfield chemical interactions		This NEA FEP is very specific for a repository design which is different from SKB's. Furthermore, the formation/dissolution of gases is not discussed in this NEA FEP.	Changes in groundwater chemistry over time are described elsewhere (e,g, Ge11, Ge14, Ge15). Two critical parameters are emphasized: salinity and redox (dissolved O2 concentration).
S 048 Groundwater chemistry	The interactions between groundwater chemistry and reactive gases are described.		
A 1.35 Formation of gases	Gases originating from microbial processes are discussed. Water radiolysis is mentioned in "radiation effects" (Ge22). Corrosion of metals is not considered.		No metal parts are assumed to be present in the geosphere. Rock bolts are part of the backfill.
H 2.3.11 Far-field transport: Gas induced groundwater transport	Change in groundwater chemistry as gases dissolve during upward movement of groundwater covered.		Radionuclide gas transport is discussed elsewhere, see SKB FEP Ge25

Recorded by: Ignasi Puigdomenech — **Date:** April 2005

Checked and revised by: Kristina Skagius — **Date:** March 2006

SR-Can FEP Ge20 Methane hydrate formation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 5.22 Accumulation of gases under permafrost	The formation of methane clathrates is described.		Accumulation of gases under permafrost is described in "Gas flow/ dissolution" (Ge04).
J 5.43 Methane intrusion	The formation of methane clathrates is described.		Accumulation of gases under permafrost is described in "Gas flow/ dissolution" (Ge04).
H 2.1.9 Effects of natural gases.	The formation of methane clathrates is described.		
W 1.032 Natural gas intrusion		This FEP does not deal with methane clathrates.	Covered in "Formation/ dissolution/reaction of gaseous species" (Ge19).
Recorded by: Ignasi Puigdomenech			**Date:** April 2005
Checked and revised by: Kristina Skagius			**Date:** March 2006

SR-Can FEP Ge21 Salt exclusion

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
H 1.5.5 Transport of chemically-active substances into the near-field	The generation of saline groundwaters as a consequence of a permafrost event is described.		Transport of salt and oxygen is described in "Advection/mixing" (Ge11).
S 059 Permafrost	The generation of saline groundwaters as a consequence of a permafrost event is described.		
Recorded by: Ignasi Puigdomenech			**Date:** April 2005
Checked and revised by: Kristina Skagius			**Date:** March 2006

SR-Can FEP Ge22 Radiation effects (rock and grout)

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.52 Radiation effects	The possible effects of radioactivity are discussed.		
A 1.64 Radiation damage	The possible effects of radioactivity are discussed.		
S 046 Gas generation, near-field rock	The possible generation of H2 by radiolysis in the geosphere is mentioned.		
Recorded by: Ignasi Puigdomenech			**Date:** April 2005
Checked and revised by: Kristina Skagius			**Date:** March 2006

SR-Can FEP Ge23 Earth currents

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 2.094 Electrochemical effects	Possible processes in the geosphere as a consequence of electric potential gradients are described.		
W 2.096 Electrophoresis		The electric potential fields arising from galvanic cells due to canister corrosion are deemed to be too small to have any effect in the surrounding rock.	The first part of this NEA FEP is identical to NEA FEP W2.094. The second part deals with galvanic corrosion as possible source of electric potential to produce electrophoresis (see SKB FEP C13).
J 2.1.06.2 Natural telluric electrochemical reactions	Possible processes in the geosphere are described.		This FEP affects canister corrosion and transport of solutes in the buffer, see SKB FEPs C13, Bu11 and Bft10.
S 029 Electrochemical effects/gradients	Possible processes in the geosphere are described.		This FEP affects canister corrosion and transport of solutes in the buffer, see SKB FEPs C13, Bu11 and Bft10.
Recorded by: Ignasi Puigdomenech			**Date:** April 2005
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP Ge24 Transport of radionuclides in the water phase

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 4.1.06 Reconcentration	Immobilisation processes are addressed.		See also "Speciation and sorption" (Ge13).
W 1.035 Freshwater intrusion	Effect of groundwater chemistry on sorption is discussed (salinity effect).		See also "Speciation and sorption" (Ge13).
S 073 Reconcentration	Immobilisation processes addressed.		See also "Speciation and sorption" (Ge13) .
S 098 Transport and release of nuclides, near-field rock	Transport processes described.		
H 2.3.1 Far-field transport: Advection	Is discussed as one of the main mechanisms for radionuclide transport.		
H 2.3.3 Far-field transport: Hydrodynamic dispersion	Is discussed as one of the mechanisms for radionuclide transport. Distinction made between dispersion along flow channels and macro-dispersion due to varying velocity field.		
W 1.036 Changes in groundwater Eh	Effect of groundwater chemistry on sorption discussed (redox/oxidation state effect).		See also "Speciation and sorption" (Ge13).
K 4.08 Radionuclide migration	Retention in EDZ is discussed, but not quantitatively handled in SR-Can (conservative assumption).		

SR-Can FEP Ge24 Transport of radionuclides in the water phase

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 5.05 Radionuclide transport through LPD	Sorption, matrix diffusion, dispersion, channeling, sorption onto colloids are addressed in the process description.		
K 6.05 Radionuclide transport through MWCF	Sorption, matrix diffusion, dispersion, channeling, sorption onto colloids are addressed in the process description.		
W 1.037 Changes in groundwater pH	Effect of groundwater chemistry on sorption discussed. Effect of pH mainly considered through use of reference waters, for which e.g Kd values are proposed.		See also "Speciation and sorption" (Ge13).
H 2.3.8 Far-field transport: Colloid transport	Colloid facilitated transport discussed.		
K 4.01 Excavation-disturbed zone (EDZ)	Retention in EDZ is discussed, but not quantitatively handled in SR-Can (conservative assumption).		
K 5.15 Natural colloids	Colloids in the context of radionuclide transport are addressed.		See also "Colloid formation and transport" (Ge18).
K 6.15 Natural colloids	Colloids in the context of radionuclide transport are addressed.		See also "Colloid formation and transport" (Ge18).
W 2.078 Colloid transport	Colloid-facilitated transport is mentioned.		See also "Colloid formation and transport" (Ge18).
W 2.080 Colloid filtration	Colloid-facilitated transport including filtration is mentioned.		See also "Colloid formation and transport" (Ge18).
H 2.3.9 Far-field transport: Transport of radionuclides bound to microbes	Colloid facilitated transport discussed, also case of micro-organisms acting as colloids.		
K 5.22 Microbial activity	Effect of micro-organisms on mobility of radionuclides is mentioned.		See also "Speciation and sorption" (Ge13) and "Microbial processes" (Ge16).
K 6.22 Microbial activity	Effect of micro-organisms on mobility of radionuclides is mentioned.		See also "Microbial processes" (Ge16).
W 2.081 Colloid sorption	Colloid-facilitated transport including sorption is mentioned.		See also "Colloid formation and transport" (Ge18).
W 2.087 Microbial transport	Effect of micro-organisms on mobility of radionuclides is mentioned.		See also "Speciation and sorption" (Ge13) and "Microbial processes" (Ge16).
A 1.65 Radioactive decay	Radioactive decay included, with reference to process as such in fuel and canister process report.		See SKB FEP F01.
A 2.51 Radioactive decay	Radioactive decay included, with reference to process as such in fuel and canister process report.		See SKB FEP F01.
S 070 Radioactive decay of mobile nuclides	Radioactive decay included, with reference to process as such in fuel and canister process report.		See SKB FEP F01.

SR-Can FEP Ge24 Transport of radionuclides in the water phase

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 1.034 Saline intrusion	Effect of groundwater chemistry on sorption is discussed (salinity effect).		See also "Speciation and sorption" (Ge13) .
H 1.3.1 Radioactive decay and ingrowth	Radioactive decay included, with reference to process as such in fuel and canister process report.		See SKB FEP F01.
K 0.1 Radioactive decay	Radioactive decay included, with reference to process as such in fuel and canister process report.		See SKB FEP F01.
I 045 Progency nuclides (critical radionuclides)	Radioactive decay included, with reference to process as such in fuel and canister process report.		See SKB FEP F01.
I 058 Colloid formation (natural and vault generated)	Colloid-facilitated transport is mentioned.		See also "Colloid formation and transport" (Ge18).
A 1.37 Geochemical pump	Immobilisation and mobilisation of radionuclides addressed.		See also "Speciation and sorption" (Ge13).
A 2.45 Microbes	Effect of micro-organisms on mobility of radionuclides is mentioned.		See also "Speciation and sorption" (Ge13) and "Microbial processes" (Ge16).
H 2.3.4 Far-field transport: Solubility constraints	Is discussed in context of precipitation/dissolution.		
H 2.3.5 Far-field transport: Sorption including ion-exchange	Sorption in the context of radionuclide transport is described.		See also "Speciation and sorption" (Ge13).
H 2.3.6 Far-field transport: Changes in sorptive surfaces	The fracture surface area through which the inner surfaces of the matrix is reached is discussed in a sorption context.		See also "Speciation and sorption" (Ge13).
H 2.3.12 Far-field transport: Thermal effects on hydrochemistry		Not discussed; relevance considered low.	
J 7.05 Isotopic dilution	Isotopic dilution mentioned in process description.		
K 4.09 Radionuclide retardation	Retention in EDZ is discussed, but not quantitatively handled in SR-Can (conservative assumption).		
K 6.16 Solubility limits/colloid formation	Solubility limits mentioned in process description.		
S 060 Precipitation/dissolution	Precipitation/dissolution mentioned.		See also "Speciation and sorption" (Ge13).

Recorded by: Jan-Olof Selroos — **Date:** 2005-01-19

Checked and revised by: Kristina Skagius — **Date:** Sept 2006

SR-Can FEP Ge25 Transport of radionuclides in the gas phase

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.88 Unsaturated transport		Transport for unsaturated conditions not addressed. Unsaturated vaults not relevant for KBS-3.	
H 2.3.10 Far-field transport: Transport of radioactive gases	Transport of radionuclides in gas phase covered.		Gas trapped during permafrost conditions discussed in "Gas flow/dissolution" (Ge04).
H 4.1.3 Gas discharge		No specific gas modelling transport done to identify gas discharge locations and not specifically addressed in process description.	
K 5.24 Geogas	Transport in gas phase and with colloids discussed.		Natural gas content and the gas flow characteristics are discussed in "Gas flow/dissolution" (Ge04).
K 6.24 Geogas	Transport in gas phase and with colloids discussed.		Natural gas content and the gas flow characteristics are discussed in "Gas flow/dissolution" (Ge04).
S 098 Transport and release of nuclides, near-field rock	Transport of radionuclides in gas phase covered for all of geosphere.		In the assessment, the geosphere is neglected as a barrier for transport of radionuclides in the gas phase. Release from engineered barriers addressed in SKB FEP Bu24.
H 1.2.4 Radioactive gases	Transport in gas phase addressed.	Biological degradation of waste forming gases not relevant for SR-Can application.	
K 0.3 Gaseous and volatile isotopes	Transport of radionuclides in gas phase covered.		
W 2.055 Radioactive gases	Gaseous radionuclides identified and their transport in gas phase addressed.		See also "Formation/dissolution/reaction of gaseous species" (Ge19).
W 2.089 Transport of radioactive gases	Transport of radionuclides in gas phase covered.		
H 2.3.11 Far-field transport: Gas induced groundwater transport	Transport of radionuclides in gas phase covered.		Change in groundwater chemistry as gases dissolve during upward movement of groundwater covered in "Formation/dissolution/reaction of gaseous species" (Ge19).
A 2.27 Gases and gas transport	Transport of radionuclides in gas phase covered.		
Recorded by: Jan-Olof Selroos			**Date:** 2005-01-20
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

Appendix 9

Handling of NEA Project FEPs sorted to SR-Can External factors

SR-Can FEP Cli01 Climate system - Components of the climate system

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.07 Climate change	Natural climate variability, increased greenhouse effect and destruction of the ozone layer.		The atmosphere's importance for the radiation balance and climate are covered.
A 2.31 Greenhouse effect	The increased greenhouse effect could lead to changes in temperature and precipitation.		Changes at the studied sites are described in the climate scenarios with variations. See also NEA FEP A 2.07.
A 2.40 Magnetic poles (reversal)		Changes in the Earth's ionization layer are not considered since they are considered insignificant for the radiation balance.	
A 2.48 Ozone layer	Destruction or damage to the earth's ozone layer may lead to changes in the climate.	Changes in groundwater flow patterns are not considered. Groundwater flow is a geosphere process.	See also SKB FEP Ge03.
A 3.051 Flipping of earth's magnetic poles		Temporary changes in the Earth's ionization layer and increased solar radiation are not considered since they are considered insignificant for the radiation balance.	See NEA FEP A 2.40.
A 3.059 Greenhouse effect	Carbon dioxide and other greenhouse gases in the atmosphere that allow solar radiation through to the Earth's surface but absorbs parts of the outgoing radiation, resulting in a warmer atmosphere.		See NEA FEP A 2.07.
A 3.078 Ozone layer failure	Destruction of the earth's ozone layer. Reflection of ultraviolet (UV) radiation by the ozone layer and possible increase in solar radiation if the ozone layer is destroyed.	UV radiation can induce skin cancer. Only cancers that are caused by the repository is included in the safety assessment.	Coverage see comment to NEA FEP A 2.07
W 3.049 Damage to the ozone layer	Destruction of the earth's ozone layer and its possible effects on climate.	Alteration of the climate in the vicinity of the WIPP repository (Carlsbad, New Mexico, USA).	
Recorded by: Jens-Ove Näslund/Lena Morén			**Date:** June 2006/ March 2005
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP Cli02 Climate system - Climate forcing

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.07 Climate change	Natural climate variability, increased greenhouse effect and destruction of the ozone layer.	Reversal of magnetic poles is not covered. It is considered to be of minor importance for the climate system.	
A 2.40 Magnetic poles (reversal)		Reversal of magnetic poles is not covered. It is considered to be of minor importance for the climate system.	
A 3.051 Flipping of earth's magnetic poles		Reversal of magnetic poles is not covered. It is considered to be of minor importance for the climate system.	
J 5.20 Changes of the magnetic field		Reversal of magnetic poles is not covered. It is considered to be of minor importance for the climate system.	
J 5.42 Glaciation	Orbital forcing parameters obliquity, the eccentricity of the Earth's orbit, and the precession of the equinoxes induce repeated glacial cycles.		
S 047 Glaciation	Periodic changes in the Earth's orbit and corresponding alteration of the amount and distribution of solar radiation reaching the Earth induce repeated glacial cycles.		
W 1.061 Climate change	Climate changes due to changes in the earth's orbit around the sun, fluctuations in radiation intensity from the sun.	Alteration of the groundwater table and groundwater flow in the vicinity of the WIPP repository (Carlsbad, New Mexico, USA).	Feedback mechanisms within the atmosphere and hydrosphere.

Recorded by: Jens-Ove Näslund/Lena Morén	**Date:** June 2006/ March 2005
Checked and revised by: Kristina Skagius	**Date:** Sept 2006

SR-Can FEP Cli03 Climate system - Climate dynamics

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.12 Climate change	Increased or decreased rates of meteoric precipitation.	Volume and rate of groundwater flow past the disposal vault is not covered. Groundwater flow is a geosphere process.	The hydrological cycle, formation of groundwater and its dependence on climate conditions are covered.
A 2.07 Climate change	Natural climate variability, increased greenhouse effect and destruction of the ozone layer.		The radiation balance and how it is affected by the state of the climate system components is covered.
A 2.19 Drought	The current levels of meteoric precipitation could change substantially leading to much less flow of water through the geosphere.	Accompanying changes to the biosphere are not covered. Changes to the biosphere are biosphere processes.	Coverage - see comment to NEA FEP A 1.12.
A 2.25 Flood	The current levels of meteoric precipitation could change substantially, leading to much greater flows of water through the geosphere.	Accompanying changes to the biosphere are not covered. Changes to the biosphere are biosphere processes.	Coverage - see comment to NEA FEP A 1.12.

SR-Can FEP Cli03 Climate system - Climate dynamics

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.31 Greenhouse effect	The greenhouse effect could increase concentrations of carbon dioxide and other gases in the atmosphere.		Feedback processes for example temperature-carbondioxide due to decreases solubility of carbondioxide in water with increasing water temperatures and release of methane from melting permafrost are covered.
A 3.043 Dust storms and desertification	Large scale desertification as a result of extended drought.	Deforestation, disappearance of grassland, transport of contaminants in soil, dispersion of contaminants due to wind erosion, no human habitats and formation of alkali flats are biosphere processes. Erosion is a geosphere process including wind erosion and dust storms.	Coverage - see comment to NEA FEP A 1.12.
A 3.059 Greenhouse effect	Human-produced increase in greenhouse gases in the atmosphere over the last 150 years. The duration of human induced greenhouse effect on the climate and the rate of disappearance of the greenhouse gases from the atmosphere.	For the Shield, this might mean a warmer and drier climate for, perhaps, hundreds of years. Conditions in North America are not covered since the repository shall be sited in Sweden.	Effects on the global and Scandinavian climate conditions are handled.
J 5.32 Desert and unsaturation	Dry climate and lowering of groundwater surface.	Deep wells are regarded as future human actions at the repository site. Unsaturated flow and the effects of unsaturated conditions on technical and geological barriers are not external processes.	Coverage - see comment to NEA FEP A 1.12.
J 5.42 Glaciation	The possible impact of the increased Greenhouse effect on the initiation of the next glaciation.		Alterations of the initiation of glacials are included in the climate scenarios with variations. Possible variations of the Swedish climate in a 100 000 year perspective are discussed in "Climate related conditions in Sweden" (SKB FEP Cli04).
H 3.1.1 Climate change: Human induced	Changes to the climate and climate system due to human activities e.g. release of greenhouse gases to the atmosphere. Impact of the increased greenhouse effect on the initiation of the next glaciation.	Ecological consequences of a warmer climate are biosphere processes.	Alterations of the initiation of glacials are included in the climate scenarios with variations.
H 3.1.2 Climate change: Natural	Glacial/interglacial cycles. Changes in temperature, sea-level, precipitation, evaporation, groundwater recharge and ecosystems.		

SR-Can FEP Cli03 Climate system - Climate dynamics

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
H 3.1.3 Exit from glacial/interglacial cycling	Causes to the current situation with glacial cycles and factors that may disturb it.	At present groundwater storage is basically at its maximum, the additional water during deglaciations would not alter groundwater flow significantly.	
H 3.1.4 Intensification of natural climate change	Alteration of the periodicity of glacial cycles.		Alterations of the length of glacial periods are included in the climate scenarios with variations.
K 10.07 Warmer climate - arid	Arid climate conditions and why and where they may exist.	Ecological consequences of a warmer arid climate are biosphere processes.	
K 10.08 Warmer climate - seasonal humid	Warm humid climate conditions with marked seasonality between warm, humid, rainy seasons and cool, dry seasons and why and where they may exist.		
K 10.09 Warmer climate - equable humid	Climate with high temperatures, precipitation and moderate evapotranspiration with minor seasonality, why and where such conditions may exist.		
K 10.10 Greenhouse effect	Global climate changes due to emissions of greenhouse gases.		
K 11.09 Human-induced climate change	The impact of anthropogenic greenhouse gases (e.g. CO2, CH4 etc.) on the climate.		Consequences for onset of next period of permafrost or glacial conditions are included in the main scenario with variations.
W 1.056 Changes in groundwater recharge and discharge	Groundwater recharge and discharge given different climate conditions.	Alteration of the groundwater table and groundwater flow in the vicinity of the WIPP repository (Carlsbad, New Mexico, USA).	See also SKB FEP Ge03.
W 1.061 Climate change	Feedback mechanisms within the Earth's climate system.	Alteration of the groundwater table and groundwater flow in the vicinity of the WIPP repository (Carlsbad, New Mexico, USA).	
W 3.047 Greenhouse gas effects	Alteration of the climate due to emissions of greenhouse gases.	Alteration of the climate in the vicinity of the WIPP repository (Carlsbad, New Mexico, USA).	

SR-Can FEP Cli03 Climate system - Climate dynamics

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
I 049 Climate change	The greenhouse effect and destruction of the ozone layer. Increase of greenhouse gases due to human activities and immobilization of the gases into peat, the seas and sedimentary deposits. Substances that may lead to the thinning or destruction of the ozone layer. Short-term natural fluctuations in climatic conditions. Desertification, changes in the current levels of meteoric precipitation. Periods of drought.	The influence of temperature on heating fuel needs and radionuclide concentrations in indoor air. Climate changes in the vicinity of the IRUS repository (Canada) and their possible impact on the IRUS repository. Alteration of groundwater flow is a geosphere process. The impact of climate changes on the biosphere is included among the biosphere processes. Deforestation, disappearance of grassland, transport of contaminants in soil, dispersion of contaminants due to wind erosion, no human habitats and formation of alkali flats are biosphere processes. Erosion is a geosphere process including wind erosion and dust storms. Increase of skin cancer if the ozone layer is destroyed.	Initiation of the next period of glacial conditions is part of the main scenario. See also SKB FEPs Ge03 and Ge09.
Recorded by: Jens-Ove Näslund/Lena Morén			**Date:** June 2006/ March 2005
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP Cli04 Climate system - Climate related conditions in Sweden

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.12 Climate change	Changes to the current climate that may affect the performance of the vault.		General succession of climate related conditions that can be expected in Sweden in a 100 000 year time perspective and their possible impact on the repository are covered.
A 2.07 Climate change	Changes of the current climate to wetter, drier, warmer, cooler and/or permafrost conditions, affecting flow properties of the geosphere (including recharge volumes). Glaciation.		Coverage - see comment to NEA FEP A 1.12.
A 3.024 Climate change	Climate changes on due to anthropogenic and natural causes. Focus is on natural causes. Occurrence of continental glaciations.		Coverage - see comment to NEA FEP A 1.12.
J 6.10 No ice age	Temperate/boreal climate conditions in most parts of Sweden.		It is unclear what the authors of the FEP mean by no ice age, it is said to be "a variation of ice age". It is assumed that the FEP refers to interglacial periods and warm phases (interstadials) of glacial periods.

SR-Can FEP Cli04 Climate system - Climate related conditions in Sweden

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 10.03 Seasonality of climate	The degree of seasonality of climate.	Alternative biosphere scenarios if the present warm period is the end of the Quaternary ice ages. The effect on biosphere conditions by alterations of the length of temperate periods are biosphere processes.	Alterations of the length of temperate/boreal periods are included in the climate scenarios with variations.
K 10.04 Future climatic conditions	Conceivable variations of climate related conditions during the assessment period.		Evolution of climate related conditions are included in the main scenario. Possible alterations are included in variations of the main scenario.
K 10.05 Tundra climate	Tundra climate, general conditions and possible subsurface impact.		
K 10.06 Glacial climate	Glacial climate, general conditions and possible subsurface impact.		Initiation of the next period with glacial conditions is included in the main scenario. Glacial erosion and weathering is discussed in SKB FEP Ge09.
W 1.062 Glaciation	Description of the glacial domain.	Glaciations in the vicinity of the WIPP repository (Carlsbad, New Mexico, USA) are unrealistic.	
W 1.063 Permafrost	Description of the permafrost domain.	Permafrost in the vicinity of the WIPP repository (Carlsbad, New Mexico, USA) is unrealistic.	
I 049 Climate change	Changes of the current climate to wetter, drier, warmer, cooler and/or permafrost conditions and/or glacial conditions. Possible subsurface impact.	The influence of temperature on heating fuel needs and radionuclide concentrations in indoor air. Climate changes in the vicinity of the IRUS repository (Canada) and their possible impact on the IRUS repository. Alteration of groundwater flow is a geosphere process. The impact of climate changes on the biosphere is included among the biosphere processes. Deforestation, disappearance of grassland, transport of contaminants in soil, dispersion of contaminants due to wind erosion, no human habitats and formation of alkali flats are biosphere processes. Erosion is a geosphere process including wind erosion and dust storms. Increase of skin cancer if the ozone layer is destroyed.	Initiation of the next period of glacial conditions is part of the main scenario. See also SKB FEPs Ge03 and Ge09.
Recorded by: Jens-Ove Näslund/Lena Morén			**Date:** June 2006/ March 2005
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP Cli05 Climate related issues - Development of permafrost

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.30 Glaciation	Permafrost could affect rock and groundwater flow characteristics.		Aggradation and degradation of permafrost and its potential impact on the repository are covered.
A 2.38 Isostatic rebound	The presence of ice sheets may compress the underlying rock.		Altered pressures due to compression of the bedrock are considered in calculations of sub-glacial frozen depths. Changes in relative sea-level are considered.
J 5.17 Permafrost	Permafrost in Sweden in a glacial time scale. Current occurrence of permafrost. Relationship between mean annual air temperature and permafrost depth. Effect of surface conditions on development of permafrost. Effect of geothermal heat flow on development of permafrost. Potential subsurface effects of permafrost. Temperature gradients.	Groundwater flow in areas of permafrost. Accumulation of gas and radionuclides below the lower surface of the permafrost. Groundwater flow, accumulation of gas and radionuclides are not external processes.	See also SKB FEPs Ge02, Ge03 and Ge04
S 059 Permafrost	Permafrost in Sweden in a glacial time scale. Current occurrence of permafrost. Relationship between mean annual air temperature and permafrost depth. Effect of surface conditions on development of permafrost. Effect of geothermal heat flow on development of permafrost. Potential subsurface effects of permafrost. Temperature gradients.	Groundwater flow in areas of permafrost. Accumulation of gas and radionuclides below the lower surface of the permafrost. Groundwater flow, accumulation of gas and radionuclides are not external processes.	See also SKB FEPs Ge02, Ge03,Ge04 and Ge21.
H 3.1.2 Climate change: Natural	Seasonally and permanently frozen ground.		
K 10.13 Permafrost	Development of permafrost and its dependence on surface temperature and conditions and geological conditions. Current occurrence of permafrost. Possible permafrost depths given defined surface and subsurface conditions. Active layer, groundwater recharge/discharge in unfrozen zones, "taliks".		
Recorded by: Lena Morén			**Date:** March 2005
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP Cli06 Climate related issues - Ice sheet dynamics

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.38 Glaciation	Changes of stress fields, flow regimes and temperatures. Many complex effects on processes occurring in the vault.		The development of the Scandinavian ice sheet and the basal conditions of the ice sheet. Ice sheet mass-balance, ice flow, ice load, basal temperatures, basal melt-rates and basal sliding and their impact on the repository are covered.
A 2.30 Glaciation	Glaciation may cause changes in topography, changes in hydraulic heads, changes in groundwater recharge and discharge zones. These effects may significantly change rock and flow characteristics.		The development of the Scandinavian ice sheet and the basal conditions of the ice sheet. Ice sheet mass-balance, ice flow, ice load, basal temperatures, basal melt-rates and basal sliding and their impact on the repository are covered.
A 3.057 Glaciation	Glaciation may influence the disposal system.	Massive disruptions in the biosphere since they are biosphere processes.	Coverage - see comment to NEA FEP A 1.38.
S 047 Glaciation	Basal frozen conditions.		Glacial erosion is mainly covered by the geosphere process weathering and erosion (Ge09). The FEP says "The ice will constitute a shielding barrier layer which will bind most of the precipitation, thus limiting recharge and flow through the (most probably permafrosted) bedrock." It is assumed that this refers to a cold based ice where there is no liquid water available.
Recorded by: Lena Morén			**Date:** March 2005
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP Cli07 Climate related issues - Ice sheet hydrology

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.30 Glaciation	Glaciation may cause changes in hydraulic heads, changes in groundwater recharge and discharge zones. These effects may significantly change flow characteristics.		The hydrological system of the ice sheet with its supra-, en- and sub-glacial system components, melt-water rates and its diurnal and yearly variation, storage of water in the ice sheet and flow between the system components and related groundwater heads and the potential impact on groundwater flow are covered.
J 5.42 Glaciation	Groundwater heads at the ice margin, alterations of inflow and outflow areas.	The effect of the isostatic processes on groundwater flow at depth and at the surface. Since the isostatic depression happens over a large area the direct impact of this process on groundwater flow can be neglected, the impact on gradients is in the order of per mille. Indirectly the process influence groundwater flow via shore line migration, this is discussed in the SKB Climate FEP "Shore-line migration" (Cli09).	The NEA FEP claims that the depression of the earth crust "may also cause extreme groundwater heads at the ice edge, change the position of the inflow and outflow areas and cause sea level changes." The impact of depression of the earth crust on groundwater heads can be neglected, however the presence of the ice sheet will alter groundwater heads, inflow and outflow areas. Isostatic depression does not cause sea level change, however if and when the crust is depressed below the contemporary sea level it will be covered by the sea.
S 047 Glaciation	Melt water discharged at the ice margin driven by the slope of the ice. Occurrence of glacier lakes on the ice sheet surface and their connection to en- and sub-glacial systems. Excessive recharge, of possibly oxidizing water, at the ice margin. Rise of water pressures to levels equalling and even exceeding the ice pressure and formation of conduits in the subglacial layer. The effect of low bed permeability on water pressures. Hydrofracturing of the ice.	Hydrofracturing of the bedrock and alteration of fracture aperture due to freezing of subglacial meltwater are not external processes.	See also SKB FEPs Ge02, Ge03, Ge06 and Ge07.
H 3.1.2 Climate change: Natural	The potential impact of ice sheets on groundwater flow.		

SR-Can FEP Cli07 Climate related issues - Ice sheet hydrology

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 10.16 Ice sheet effects (loading, melt water recharge)	Groundwater recharge from basal melting of the ice sheet. Occurrence of sub-glacial rivers and other conductive features in the ice/bed interface. Hydrological conditions if permafrost occurs at the ice margin.		
Recorded by: Jens-Ove Näslund/Lena Morén			**Date:** June 2006/ March 2005
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP Cli08 Climate related issues - Glacial isostatic adjustment

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.30 Glaciation	Glaciation may cause isostatic depression. These effects may significantly change rock and flow characteristics. During interglacial periods isostatic rebound could affect rock and flow characteristics.		Isostatic adjustment due to the redistribution of water masses from the oceans to land based ice sheets and vice versa and its potential impact on the repository are covered.
A 2.38 Isostatic rebound	The presence of ice sheets will depress the crust followed later by rebound effects when the load is removed.		Associated changes in relative sea-level are covered.
J 5.16 Uplift and subsidence	Ongoing isostatic uplift in Sweden. Current rate of uplift. Largest isostatic uplift in connection to retreat of the ice sheet. Total isostatic uplift since LGM. Remaining isostatic uplift.	Tectonic uplift and crustal movements are not considered except for registration of current uplift rates which include both isostatic and tectonic components.	Coverage - see comment to NEA FEP A 2.30.
J 5.31 Change in sealevel	Redistribution of water masses during a glacial cycle. The effect of redistribution of soil material due to erosion and sedimentation on isostatic adjustment.	It is said that exposed sea bottoms suffers extensive erosion close to the ice rim during interglacial periods, but during interglacial periods there are only ice sheets on Greenland and in Antarctica and sea levels are high. Consequently this aspect has not been considered.	It is unclear whether the NEA FEP refers to the eustatic or isostatic process or their combined effect on shore-line migration.
J 5.42 Glaciation	The weight of the ice sheet will cause an isostatic depression of the Earth's crust.		
S 047 Glaciation	Isostatic depression of the Earth's crust.		
W 1.005 Regional uplift and subsidence	Isostatic uplift in Sweden (see handling of NEA FEP J 5.16).		
H 2.1.1 Regional tectonic activity	Isostatic adjustment		
Recorded by: Jens-Ove Näslund/Lena Morén			**Date:** June 2006/ March 2005
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP Cli09 Climate related issues - Shore-line migration

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.59 Sea level change	Climate changes and different stages of glacial cycles will raise and lower sea levels, possibly affecting groundwater flow and contaminant transport.		It is assumed that "different stages of glacial cycles" refers to the resulting shore line migration due to the eustatic and isostatic processes. See also comments to NEA FEP A 2.30.
J 5.31 Change in sealevel	Resulting shore-level migration from isostatic and eustatic processes and their coupling to climate and ice sheet extent.	Shore-level migration due to erosion/sedimentation is not covered. Along the Swedish coasts this process is considered to be of minor importance in the studied time perspective and in relation to shore-line migration due to glaciations. Changes in groundwater flow and salinity due to shore-line migration are not external processes.	See also Glacial isostatic adjustment (Cli08). Erosion and sedimentation are also described as geosphere and biosphere processes.
J 5.42 Glaciation	Impact of the isostatic process on shore-level migration.		See also geosphere processes; Ge03, Ge06, Ge07.
S 047 Glaciation	The combined effect of isostitic and eustatic processes on the shore-level.		See also geosphere processes; Ge03, Ge06, Ge07.
S 081 Sea level changes	Resulting shore-level migration from isostatic and eustatic processes and their coupling to climate and ice sheet extent. The impact of temperature on sea level.	Changes in groundwater flow and salinity due to shore-line migration are not external processes. Alteration of biosphere conditions due to shore line migration is a biosphere process. Exposed sea bottoms suffers extensive erosion close to the ice rim during interglacial periods, but during interglacial periods there are only ice sheets on Greenland and in Antarctica and sea levels are high. Consequently this aspect has not been considered.	
H 3.1.3 Exit from glacial/interglacial cycling	Alteration of sea level if glaciers and icecaps melt.		
W 1.068 Sea level changes	Sea level change due to build up of inland ice sheets. Sea level change if the climate gets warmer for instance due to anthropogenic global warming.	Short-term changes in sea level, brought about by events such as meteorite impact, tsunamis, seiches, and hurricanes as their impact on sea levels in the Baltic are neglectable for the safety of the repository. Shore-level migration will not impact the WIPP repository (Carlsbad, New Mexico, USA).	
I 266 Sea level (rising)	The combined effect of isostitic and eustatic processes on the shoreline.	The affect on groundwater flow and contaminant transport of shore-line migration are geosphere processes. Shore-line migration in the vicinity of the IRUS repository (Canada).	See also SKB FEP Ge03.

Recorded by: Jens-Ove Näslund/Lena Morén	**Date:** June 2006/ March 2005
Checked and revised by: Kristina Skagius	**Date:** Sept 2006

SR-Can FEP Cli10 Climate related issues - End-glacial faulting

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.38 Glaciation	Glaciation will change stress fields, flow regimes and temperatures. It could have many complex effects on processes occurring in the vault.		Current stress situation due to tectonic regime and alterations of rock stresses during glaciation and deglaciation and given this the alteration of fault stability and the depression and rebound as well as the compression of the crust are covered.
A 2.30 Glaciation	Glaciation may cause activation and creation of faults. These effects may significantly change rock characteristics. During interglacial periods isostatic rebound could affect rock characteristics.		Coverage - see comment to NEA FEP A 1.38.
A 2.38 Isostatic rebound	The presence of ice sheets may compress the underlying rock.		
J 4.2.01 Mechanical failure of repository	Mechanical rupture due to sudden changes in stress e.g. earthquakes etc and due to slow motions (creep) in the rockmass due to loading-unloading.	Plate motions. Alteration of rock permeability, flow paths and flow distribution close to the repository. Creation of new pathways through the repository. Canister failure. Mechanical damage on the buffer material. Alterations of the near field rock, canister failures and mechanical damage to the buffer are not external processes.	The current tectonic regime is considered in the initial stress situation, plate motions altering the current regime are considered as a climate forcing factor but as a cause of mechanical failure it is not considered as an external climate related issue. See also geosphere processes, e.g. Ge06.
J 4.2.06 Faulting	Faulting due to changes in the stress situation e.g. earth quakes etc and due to slow motions (creep) in the rockmass due to loading-unloading of an ice load. Fracturing and movements along the fractures.	Further orogenic events, stability of the barriers and the transport of released radionuclides, variation of the opening of fractures are not considered. Stability of barriers, transport of radionuclides and variation of fracture properties are not external processes.	Orogenic events are considered as climate forcing factors but as a cause of faulting they are not considered as external climate related issues. See also geosphere processes, e.g. Ge03, Ge06.
J 5.15 Earthquakes	Large earthquakes occurring during the last deglaciation. The build up of stresses in the rockmass due to land uplift after a glaciation. Possible release of stresses by a movement along a pre-existing fault or by a new fracture.	Plate movements and ridge push. Ground motions and interference waves at the surface, wave propagation at repository depth. Canister emplacement and geometrical distribution of canister positions versus known fracture zones. Earthquake mechanisms are covered by the external process earthquake. Canister emplacement and positioning of deposition holes are not external processes.	Plate movements see comments to NEA FEP J 4.2.01.

SR-Can FEP Cli10 Climate related issues - End-glacial faulting

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 5.16 Uplift and subsidence	Subsurface impact of ice load. Movements in the major fracture zones.	Variation of fracture opening and resulting alteration of permeability since they are not external processes.	Coverage - see comment to NEA FEP A 1.38. See also SKB FEP Ge03
J 5.42 Glaciation	The effect of an ice load on the regional stress field. Possible movements along fracture zones and formation of new fractures. The possibility of seismic events due to glacial loading and unloading.		
S 047 Glaciation	Impact of ice load on stress field, possible movements along fractures and fracture zones. Possible formation of new fractures. Tensional forces and/or shearing. Impact on the magnitude of principle stresses, and stress orientations.	Alteration of fracture aperture and permeability of fractures and fracture zones/faults since this is considered to be geosphere processes	See also geosphere processes; Ge03, Ge06, Ge07.
H 2.1.7 Faulting/fracturing	Faulting and fracturing due to glacial load.		
W 1.010 Formation of new faults	Formation of new faults in association with glaciations.	Subsidence above natural dissolution features are not relevant.	
W 1.011 Fault movement	Fault movement in association with glaciations.		
S 036 Faulting	Faulting due to changes in the stress situation e.g. earth quakes etc and due to slow motions (creep) in the rockmass due to loading-unloading of an ice load. Fracturing and movements along the fractures.	Further orogenic events, stability of the barriers and the transport of released radionuclides, variation of the opening of fractures are not considered. Stability of barriers, transport of radionuclides and variation of fracture properties are not external processes.	Orogenic events are considered as climate forcing factors but as a cause of faulting they are not considered as external climate related issues. See also geosphere processes, e.g. Ge03, Ge06.
Recorded by: Jens-Ove Näslund/Lena Morén			**Date:** June 2006/ March 2005
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP LSGe01 Mechanical evolution of the Shield

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 4.2.06 Faulting	Large-scale changes in tectonic conditions.		See also SKB FEP LSGe02
H 2.1.1 Regional tectonic activity	Regional tectonic activity		
W 1.003 Changes in regional stress	Reginal tectonics and changes in stress in the Baltic Shield.	Tectonics in the Delaware Basin is not representative for Swedish rock.	
W 1.004 Regional tectonics	Reginal tectonics and changes in stress in the Baltic Shield.	Tectonics in the Delaware Basin is not representative for Swedish rock.	
W 1.005 Regional uplift and subsidence	Reginal tectonics and changes in stress in the Baltic Shield.	Tectonics in the Delaware Basin is not representative for Swedish rock.	
W 1.011 Fault movement	Reginal tectonics (Baltic Shield) including fault movement.		
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP LSGe02 Earthquakes

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.29 Earthquakes	Seismic activity in Scandinavia.		See also SKB FEP Ge06.
A 2.21 Earthquakes	Seismic activity in Scandinavia.		See also SKB FEP Ge06.
A 3.045 Earthquakes	Seismic activity in Scandinavia.		See also SKB FEP Ge06.
J 4.2.01 Mechanical failure of repository	Seismic activity in Scandinavia.		See also SKB FEP Ge06.
J 4.2.06 Faulting	Seismic activity in Scandinavia.		See also SKB FEPs Cli10 and Ge06.
J 5.15 Earthquakes	Seismic activity in Scandinavia.		
S 036 Faulting	Seismic activity in Scandinavia.		See also SKB FEPs Cli10 and Ge06.
H 2.1.6 Seismicity	Seismic activity in Scandinavia.		
K 9.05 Seismic activity	Seismic activity in Scandinavia.		
K 9.06 Stress changes - hydrogeological effects	Seismic activity in Scandinavia.		See also SKB FEP Ge03 and Ge06.
W 1.011 Fault movement	Seismic activity in Scandinavia.		See also SKB FEP Ge06.
W 1.012 Seismic activity	Seismic activity in Scandinavia.		
W 1.031 Hydrological response to earthquakes	Seismic activity in Scandinavia.		See also SKB FEP Ge03.
I 100 Seismic events	Seismic activity in Scandinavia.		
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP FHA01 General considerations

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.69 Retrievability		Requirement to retrieve the spent fuel. This issue is not discussed within the long-term safety assessment.	
A 2.56 Sabotage	Intent and responsibilities.		
A 3.070 Intrusion (deliberate)	Intent and responsibilities.		
A 3.071 Intrusion (inadvertent)	Intent and responsibilities.		
J 5.33 Waste retrieval, mining	Intent and responsibilities, knowledge of the repository.		
J 5.38 Explosions	Intent and responsibilities.		The FEP concerns sabotage
H 5.2.2 Deliberate intrusion	Intent and responsibilities.		
H 5.2.3 Malicious intrusion	Intent and responsibilities		

SR-Can FEP FHA01 General considerations

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 11.10 Repository records, markers	Conservation of information, countermeasures against unintentional intrusion.		
K 11.11 Planning restrictions	Countermeasures against unintentional intrusion.		
W 3.012 Deliberate drilling intrusion	Intent and responsibilities.		
W 3.018 Deliberate mining intrusion	Intent and responsibilities.		
I 008b Archaeology (a find during post-closure period)	Intent (deliberate intrusion due to discovery of archaeological findings)		
I 167 Intrusion (human/deliberate)	Intent and responsibilities.		
I 169 Intrusion (human/inadvertent)	Intent and responsibilities.		
I 190 Loss of records	Conservation of information, countermeasures against unintentional intrusion.		
I 253 Retrievability	Intent and responsibilities.		Only intent and responsibility is discussed, the question of whether it should be possible to retrieve canisters from the repository is discussed elsewhere.
Recorded by: Lena Morén			**Date:** 2006-04-01
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP FHA02 Societal analysis, considered societal aspects

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.49 Intrusion (human)	Access useful material.		
J 5.37 Archeological intrusion	Possible purposes of unintentional intrusion.		
J 7.09 Loss of records	Knowledge of the repository.		
W 3.056 Demographic change and urban development	Human settlements and demographic pattern.		
W 3.057 Loss of records	Knowledge of the repository.		
I 189 Loss of markers (misinterpretation)	Knowledge of the repository.		
I 200 Minerals (exploration, exploitation)	Possible purposes of unintentional intrusion.		
I 223 Political (loss of institutional control)	Capacity of society's information system, legitimacy of government and degree of governability.		
Recorded by: Lena Morén			**Date:** April 2006
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP FHA03 Technical analysis, general aspects

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.49 Intrusion (human)	Access useful material.		
A 2.61 Solution mining		Solution mining. Solution mining is used for extracting soluble ores such as potash and salt, these kind of minerals will not be available at the potential repository sites.	
A 3.071 Intrusion (inadvertent)	Explorations.		
J 5.35 Other future uses of crystalline rock	Granite as a valuable raw material.		
Recorded by: Lena Morén			**Date:** April 2006
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP FHA04 Technical analysis, actions with thermal impact and/or purpose

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.061 Heat storage in lakes or underground	Build heat store.		
J 5.34 Geothermal energy production	Extract geothermal energy, build heat pump system.		
K 11.03 Geothermal exploitation	Extract geothermal energy, build heat pump system.		
W 3.007 Geothermal	Extract geothermal energy.		
Recorded by: Lena Morén			**Date:** April 2006
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP FHA05 Technical analysis, actions with hydraulic impact and/or purpose

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.068 Industrial water use	Construct well, build dam, irrigation, drainage or infiltration system, change the course or extent of surface water bodies (streams, lakes, sea) and their connections with other surface water bodies.		
A 3.115 Water management projects	Build dam, hydropower or irrigation system,		
J 5.27 Human induced actions on groundwater recharge	Change conditions for groundwater recharge by changes in land use, construct well or dam.		
J 7.07 Human induced changes in surface hydrology	Construct well, build dam, irrigation, drainage or infiltration system, change the course or extent of surface water bodies (streams, lakes, sea) and their connections with other surface water bodies. Change conditions for groundwater recharge by changes in land use.		

SR-Can FEP FHA05 Technical analysis, actions with hydraulic impact and/or purpose

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 7.11 City on the site	Change conditions for groundwater flow by changes in land use.		
K 11.06 Water management schemes	Construct well, build dam, irrigation, drainage or infiltration system, change the course or extent of surface water bodies (streams, lakes, sea) and their connections with other surface water bodies.		
W 3.005 Groundwater exploitation	Construct well.		
W 3.021 Drilling fluid flow	The transport of radionuclides with the bore fluid (water) during drilling.	Loss of bore fluid to an under pressurized subsurface unit. Outflow of brine from isolated over pressurized volumes. These kinds of features do not exist at the candidate sites.	
W 3.022 Drilling fluid loss		Borehole fluid lost to (thief) fracture zones, If contaminated borehole fluid is lost to fracture zones, this would mitigate the consequences of an unintentional drilling through a canister. Since this effect is hard to quantify it is neglected. The escape of borehole fluid in boreholes not intersecting a canister is omitted since the duration of drilling is short, the affected area deemed to be limited in space and the fluid generally consist of water.	
W 3.023 Blowouts		During drilling, fluid could flow from pressurized zones through the borehole to the land surface (blowout). If isolated pressurized zones exist in crystalline rock the amount of water in them is limited and the effect on groundwater flow can be neglected.	
W 3.026 Groundwater extraction	Construct well.		
W 3.028 Enhanced oil and gas production		Injection of fluids altering fluid-flow patterns. Oil and gas is not available at the candidate sites.	
W 3.037 Changes in groundwater flow due to mining	Build rock cavern, tunnel, shaft, etc.		
W 3.039 Changes in groundwater flow due to explosions		Direct effect on groundwater flow due to an explosion. The direct effect on groundwater flow due to an explosion is of very short duration and can be neglected.	

Recorded by: Lena Morén — **Date:** April 2006

Checked and revised by: Kristina Skagius — **Date:** Sept 2006

SR-Can FEP FHA06 Technical analysis, actions with mechanical impact and/or purpose

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.32 Explosions	Subsurface and surface explosions (bomb or blast).		
A 1.49 Intrusion (human)	Drill in the rock, build rock cavern, tunnel, shaft, etc.		
A 2.02 Bomb blast	Surface explosions (bomb or blast).		
A 2.05 Boreholes - exploration	Drill in the rock.		
A 2.20 Earthmoving	Construct quarry or landfill.		
A 2.37 Intrusion (mines)	Drill in the rock, build rock cavern, tunnel, shaft, etc.		
A 2.46 Mines	Drill in the rock, build rock cavern, tunnel, shaft, etc.		
A 3.044 Earthmoving projects	Construct quarry or landfill.		
A 3.025 Collisions, explosions and impacts	Subsurface and surface explosions (bomb or blast).	Collision by aircraft has no impact on repository safety. Meteorite impact is not a human action.	
J 5.28 Underground dwellings	Drill in the rock, build rock cavern, tunnel, shaft, etc.		
J 5.30 Underground test of nuclear devices	Subsurface bomb or blast.		
J 6.07 Nuclear war	Surface explosions (bomb or blast).		
J 7.11 City on the site	Build rock cavern, tunnel, shaft, etc.		
H 5.2.4 Accidental intrusion	Drill in the rock, build rock cavern, tunnel, shaft, etc.		
K 8.37 Earthworks (human actions, dredging, etc.)	Construct quarry or landfill.		
K 11.01 Exploratory drilling	Drill in the rock.		
K 11.02 Mining activities	Drill in the rock, build rock cavern, tunnel, shaft, etc.		
W 2.028 Nuclear explosions		The spent fuel explodes as a nuclear bomb. Not physically possible.	
W 2.084 Cuttings	Drill in the rock.		The amount of cuttings and doses from cuttings are analyzed in the main report.
W 2.085 Cavings	Drill in the rock.		The amount of cavings and doses from cavings are analyzed in the main report.
W 2.086 Spallings		The particulate material introduced into drilling mud by the movement of gas from the waste into the borehole annulus. Neither the content of gas nor the gas flow from the canister is large enough to cause erosion.	

SR-Can FEP FHA06 Technical analysis, actions with mechanical impact and/or purpose

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 3.001 Oil and gas exploration	Drill in the rock.		
W 3.002 Potash exploration	Drill in the rock.		
W 3.003 Water resources exploration	Drill in the rock.		
W 3.004 Oil and gas exploitation		Oil and gas exploitation. Oil and gas is not available at the candidate sites.	
W 3.006 Archeological investigations	Drill in the rock,	Archeological investigations at the surface. Activities at the surface do not impact the repository.	
W 3.008 Other resources	Drill in the rock.		
W 3.009 Enhanced oil and gas recovery		Oil and gas recovery. Oil and gas is not available at the candidate sites.	
W 3.011 Hydrocarbon storage	Drill in the rock, build rock cavern, tunnel, shaft, etc.		Primarily an activity related to oil and gas exploitation and thus not relevant for the Swedish case.
W 3.013 Potash mining	Drill in the rock, build rock cavern, tunnel, shaft, etc.	Solution mining, potash exploitation. Solution mining see NEA FEP A 2.61. Potash is not available at the candidate site.	
W 3.014 Other resources	Drill in the rock, build rock cavern, tunnel, shaft, etc.		
W 3.015 Tunneling	Build rock cavern, tunnel, shaft, etc.		
W 3.016 Construction of underground facilities (for example storage, disposal, accomodation)	Drill in the rock, build rock cavern, tunnel, shaft, etc.		
W 3.017 Archeological excavations	Drill in the rock, build rock cavern, tunnel, shaft, etc.	Archeological excavations close to the surface. Activities at the surface do not impact the repository.	
W 3.019 Explosions for resource recovery	Subsurface explosions (bomb or blast).		
W 3.020 Underground nuclear device testing	Subsurface explosions (bomb or blast).		
W 3.025 Oil and gas extraction		Removal of confined fluid from oil- or gas-bearing units causing compaction, subvertical fracturing and surface subsidence. There are no confinements of oil or gas available at the candidate sites.	
W 3.041 Surface disruptions	Construct quarry or landfill.		

SR-Can FEP FHA06 Technical analysis, actions with mechanical impact and/or purpose

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
I 022 Explosions/bombs/blasting/collision/impacts/vibration	Surface explosions (bomb or blast).	Collision by aircraft has no impact on repository safety.	See NEA FEP A 3.025.
I 099 Earth moving projects (civil)	Construct quarry or landfill.		
Recorded by: Lena Morén			**Date:** April 2006
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

SR-Can FEP FHA07 Technical analysis, actions with chemical impact and/or purpose

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 3.001 Acid rain	Acidify air, soil and bedrock.		
J 5.12 Near storage of other waste	Store waste in the rock, construct sanitary landfill.		
J 7.08 Altered surface water chemistry by humans	Acidify air, soil and/or bedrock or cause accident resulting in chemical contamination.		
H 5.2.4 Accidental intrusion	Store waste in the rock.		
K 11.04 Liquid waste injection	Store waste in the rock.		
K 11.07 Groundwater pollution	Acidify or in other way pollute air, water, soil and/or bedrock, cause accident resulting in chemical contamination.		
K 11.08 Surface pollution (soils, rivers)	Acidify or in other way pollute air, water, soil and/or bedrock, cause accident resulting in chemical contamination.		
W 3.010 Liquid waste disposal	Store waste in the rock.		
W 3.011 Hydrocarbon storage	Store waste in the rock.		Primarily an activity related to oil and gas exploitation and thus not relevant for the Swedish case.
W 3.024 Drilling-induced geochemical changes	Fluid flow during drilling that pollute the bedrock.	Flow through abandoned boreholes. The alteration of groundwater composition due to the presence of abandoned boreholes is deemed to be negligible in crystalline rock.	
W 3.027 Liquid waste disposal	Store waste in the rock.		
W 3.029 Hydrocarbon storage	Store waste in the rock.		Primarily an activity related to oil and gas exploitation and thus not relevant for the Swedish case.

SR-Can FEP FHA07 Technical analysis, actions with chemical impact and/or purpose

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 3.030 Fluid injection-induced geochemical changes		Injection of fluids through a leaking borehole. The escape of borehole fluid in boreholes is omitted since the duration of drilling is short, the affected area deemed to be limited in space and the fluid generally consists of water.	
W 3.038 Changes in geochemistry due to mining		Hydrological disturbances altering groundwater composition. The drainage of a mine may cause enhanced groundwater flow during a limited period. However, the resulting alterations of groundwater composition are expected to lie within the range of naturally occurring alterations in the studied time frame.	
W 3.046 Altered soil or water surface chemistry by human activities	Acidify or in other way pollute air, water, soil and/or bedrock.	Surface activities associated with potash mining. Potash is not available at the candidate sites.	
W 3.048 Acid rain	Acidify or in other way pollute air, water, soil and/or bedrock.		
I 001 Acid rain	Acidify or in other way pollute air, water, soil and/or bedrock.		
I 046a Waste management sites adjacent (additive effects of contaminants)	Store waste in the rock, construct sanitary landfill.	Effects (doses) of contaminants from other facilities. It is unclear whether "effects" refer to doses from adjacent facilities or the possible impact of contaminants on the analysed repository. Only impact on the analysed repository is considered in the SKB FEP. Doses from other facilities are considered in the dose acceptance criteria.	
I 046b Waste management sites adjacent (effects on vault)	Store waste in the rock, construct sanitary landfill.		
Recorded by: Lena Morén			**Date:** April 2006
Checked and revised by: Kristina Skagius			**Date:** Sept 2006

Appendix 10

Handling of NEA Project FEPs sorted to SR-Can Variables

SR-Can FEP VarF01 Radiation intensity

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 1.3 Damaged or deviating fuel	Surface dose rate at time of deposition.		
S 069 Radioactive Decay, fuel	Type of radiation is described.		
W 2.003 Heterogeneity of wasteforms		Variation in radionuclide inventory and radiation not specifically addressed, but maximum surface radiation intensity for a canister is limited to 1Gy/h and maximum heat decay in one canister is limited to 1700W.	See SKB FEP VarC01, VarC02.
Recorded by: Kristina Skagius/Karin Pers			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarF02 Temperature

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 090 Temperature, canister	Impact of radioactive decay and heat transport on temperature is addressed.		See processes "Radiation attenuation/heat generation" (F02) and "Heat transport" (F04 and C02).
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarF03 Hydrovariables (pressure, volumes and flows)

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 053 Internal pressure	Pressure build-up due to helium production and canister corrosion is addressed.		See processes "Helium production" (F15) and "Corrosion of cast iron insert" (C07).
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarF04 Fuel geometry

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.64 Radiation damage	Geometry of the fuel including defective cladding tubes at deposition.		
I 238 Radiation effects	Geometry of the fuel including defective cladding tubes at deposition.		
J 1.1.03 Recoil of alpha-decay	Geometry of the fuel including defective cladding tubes at deposition.		See also SKB FEP F09.
J 1.3 Damaged or deviating fuel	Geometry of the fuel including defective cladding tubes at deposition.	Variation in fuel geometry between canisters not specifically addressed	
S 019 Degradation of fuel elements	Geometry of the fuel including defective cladding tubes at deposition.		
W 2.015 Radiological effects on waste	Geometry of the fuel including defective cladding tubes at deposition.		
W 2.099 Alpha recoil	Geometry of the fuel including defective cladding tubes at deposition.		See also SKB FEP F09.
Recorded by: Kristina Skagius/Karin Pers			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarF05 Mechanical stresses

No NEA Project FEP associated with this SR-Can FEP

SR-Can FEP VarF06 Radionuclide inventory

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.50 Inventory	Radionuclide inventory.		
I 173 Inventory (inadequate control)	Radionuclide inventory including uncertainties.	No information available on MOX and fuel from Ågesta.	
J 1.2.05 I, Cs-migration to fuel surface	Distribution of radionuclides in the fuel.		See also SKB FEP F13.
J 1.3 Damaged or deviating fuel	Radionuclide inventory for different burn-ups (BWR and PWR).	No information available on MOX and fuel from Ågesta.	
K 1.08 Heat output (RN decay heat)	Radionuclide inventory for different burn-ups (BWR and PWR).	No information available on MOX and fuel from Ågesta.	
K 1.27 Deviant inventory flask		Variation in radionuclide inventory and radiation not specifically addressed, but maximum surface radiation intensity for a canister is limited to 1Gy/h and maximum heat decay in one canister is limited to 1700W.	See SKB FEP VarC01 and VarC02.
S 005 Changes in radionuclide inventory	Radionuclide inventory for different burn-ups (BWR and PWR).	No information available on MOX and fuel from Ågesta.	
W 2.003 Heterogeneity of wasteforms		Variation in radionuclide inventory and radiation not specifically addressed, but maximum surface radiation intensity for a canister is limited to 1Gy/h and maximum heat decay in one canister is limited to 1700W.	See SKB FEP VarC01, VarC02.
Recorded by: Kristina Skagius/Karin Pers			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarF07 Material composition

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.50 Inventory	Composition of reference fuel assemblies including potentially chemotoxic elements.		
J 1.3 Damaged or deviating fuel	Composition of reference fuel assemblies.	No information available on MOX and fuel from Ågesta.	
Recorded by: Kristina Skagius/Karin Pers			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarF08 Water composition

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.09 Chemical gradients	Redox front close to fuel is addressed.	Otherwise not relevant inside canister.	See processes "Water radiolysis (F10) and Fuel dissolution (F12).
J 1.2.09 Dissolution chemistry	Dissolution chemistry is addressed.		See processes "Fuel dissolution" (F12) and "Speciation of radionuclides, colloid formation" (F14).
J 3.1.11 Redox front	Redox front close to fuel addressed.		See process "Fuel dissolution" (F12).
S 038 Fuel dissolution and conversion	Impact of fuel dissolution on water composition addressed.		See process "Fuel dissolution" (F12).
S 074 Redox front	Redox front close to fuel addressed.		See process "Fuel dissolution" (F12).
S 102 Water chemistry, canister	Effects of radiolysis and corrosion on water chemistry are discussed.		See processes "Water radiolysis" (F10), "Metal corrosion" (F11), "Speciation of radionuclides, colloid formation" (F14), "Corrosion of cast iron insert" (C07)
K 2.14 Chemical buffering (canister corrosion products)	Effects of metal corrosion on water composition are addressed.		See processes "Speciation of radionuclides, colloid formation" (F14) and "Corrosion of cast iron insert" (C07).
W 2.051 Chemical effects of corrosion	Effects of metal corrosion on water composition are addressed.		See processes "Speciation of radionuclides, colloid formation" (F14) and "Corrosion of cast iron insert" (C07).
W 2.064 Effect of metal corrosion	Impact of metal corrosion on water composition is addressed.		See processes "Speciation of radionuclides, colloid formation" (F14) and "Corrosion of cast iron insert" (C07).
I 065 Waste container (metal corrosion products)	Impact of metal corrosion on water composition is addressed.		See processes "Metal corrosion" (F11) and "Speciation of radionuclides, colloid formation" (F14).
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarC01 Radiation intensity

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 1.27 Deviant inventory flask	Maximum surface radiation intensity for a canister is limited to 1Gy/h and maximum heat decay in one canister is limited to 1700W.		
Recorded by: Kristina Skagius/Karin Pers			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarC02 Temperature

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 090 Temperature, canister	Impact of radioactive decay and heat transport on temperature is addressed.		See processes "Radiation attenuation/heat generation" (F02) and "Heat transport" (F04 and C02).
K 2.19 Canister temperature	Impact of radioactive decay and heat transport on temperature is addressed.		See processes "Radiation attenuation/heat generation" (F02) and "Heat transport" (F04 and C02).
K 1.27 Deviant inventory flask	Maximum surface radiation intensity for a canister is limited to 1Gy/h and maximum heat decay in one canister is limited to 1700W.		
Recorded by: Kristina Skagius/Karin Pers			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarC03 Canister geometry

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 063 Properties of failed canister	Initial welding defects.	Initial defects in steel insert and copper component will be handled in SR-Site.	
W 2.004 Container form	Canister dimensions.		
Recorded by: Kristina Skagius/Karin Pers			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarC04 Material composition

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.50 Inventory	Composition of copper canister and iron insert including potentially chemotoxic elements.		
J 2.3.04 Loss of ductility	Impurities in copper material.		
Recorded by: Kristina Skagius/Karin Pers			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarBu01 Radiation intensity

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 069 Radioactive Decay, fuel	Impact of radiation in buffer is addressed.		See process "Radiation attenuation/heat generation" (Bu01).
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarBu02 Temperature

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.06 Buffer characteristics	Effect of temperature on the movement of water in the buffer is discussed.		See process "Water transport under saturated conditions" (Bu05).
A 1.31 Excessive hydrostatic pressures	Influence of temperature on porewater pressure is discussed.		See process "Swelling/Mass redistribution (Bu08).
S 089 Temperature, bentonite buffer	The thermal evolution in the near field is discussed		See process "Heat transport" (Bu02).
S 094 Thermal degradation of buffer/backfill	The thermal evolution of the near field is discussed.		See process "Heat transport" (Bu02)
K 1.08 Heat output (RN decay heat)	The thermal evolution of the near field is discussed.		See process "Heat transport" (Bu02)
K 3.02 Thermal evolution	The thermal evolution of the near field is discussed.		See process "Heat transport" (Bu02).
J 3.2.05 Thermal effects on the buffer material	Impact of temperature on montmorillonite transformation is discussed.		See process "Montmorillonite transformation" (Bu16)
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarBu03 Water content

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 062 Properties of bentonite buffer	Water and gas content in the buffer discussed.		See processes "Water uptake and transport for saturated conditions" (Bu04) and "Gas transport/dissolution" (Bu06).
Recorded by: Kristina Skagius/Karin Pers			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarBu04 Gas content

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 062 Properties of bentonite buffer	Initial air content. Water and gas content in the buffer discussed.		See processes "Water uptake and transport for saturated conditions" (Bu04) and "Gas transport/dissolution" (Bu06).
Recorded by: Kristina Skagius/Karin Pers			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarBu05 Hydrovariables (pressure and flows)

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.31 Excessive hydrostatic pressures	Influence of temperature on porewater pressure is discussed.		See process "Swelling/Mass redistribution (Bu08).
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarBu06 Buffer geometry

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 003 Bentonite swelling, buffer	Changes in buffer geometry as a consequence of swelling into intersecting cracks and into backfill in deposition tunnels are discussed.		See process "Swelling/Mass redistribution" (Bu06).
S 062 Properties of bentonite buffer	Changes in buffer geometry over time are discussed.		See process "Swelling /Mass redistribution" (Bu06).
J 3.2.08 Preferential pathways in the buffer/backfill	Initial gap between buffer and rock; design specification 50 mm.		
K 3.22 Quality Control	Initial gap between buffer and rock; design specification 50 mm. Initial gap between canister and buffer; design specification 10 mm.	Initial gap between bentonite blocks/rings not discussed because no such gaps are expected.	Emplacement and quality control is discussed in the Initial state report (Section 5.1).
Recorded by: Kristina Skagius/Karin Pers			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarBu07 Pore geometry

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.06 Buffer characteristics	Effect of pore geometry on the movement of water in the buffer is discussed.		See process "Water transport under saturated conditions" (Bu05).
J 3.2.06 Diffusion - surface diffusion	Impact of porosity on diffusion is discussed.		See process "Diffusion" (Bu11).
S 023 Diffusion	Impact of porosity on diffusion is discussed.		See process "Diffusion" (Bu11).
I 028a Buffer(degradation)	Impact of montmorillonite transformation on buffer properties is discussed.		See process "Montmorillonite transformation" (Bu16).
I 028b Buffer (quality)	Initial pore geometry (porosity).		
Recorded by: Kristina Skagius/Karin Pers			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarBu08 Stress state

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 3.2.05 Thermal effects on the buffer material	Impact of montmorillonite transformation on the buffer swelling capacity is discussed.		See process "Montmorillonite transformation" (Bu16)
S 003 Bentonite swelling, buffer	Swelling pressure is considered.		See process "Swelling/Mass redistribution" (Bu08).
S 062 Properties of bentonite buffer	Swelling pressure and changes over time are discussed.		See e.g. processes "Swelling/Mass redistribution" (Bu08) and "Montmorillonite transformation" (Bu16).
K 3.04 Bentonite swelling pressure	Swelling pressure is considered		See process "Swelling/Mass redistribution" (Bu08).
I 028a Buffer(degradation)	Impact of montmorillonite transformation on buffer properties is discussed.		See process "Montmorillonite transformation" (Bu16).
I 298 Swelling pressure (clay)	Swelling pressure is considered.		See process "Swelling/Mass redistribution" (Bu08).
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarBu09 Bentonite composition

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 3.1.03 Effects of bentonite on groundwater chemistry	Bentonite composition.		
J 3.2.05 Thermal effects on the buffer material	Impact of montmorillonite transformation on buffer composition is discussed.		See process "Montmorillonite transformation" (Bu16)
S 062 Properties of bentonite buffer	Bentonite composition and changes over time are discussed.		See e.g. processes "Alteration of impurities" (Bu13) and "Montmorillonite transformation" (Bu16).
S 094 Thermal degradation of buffer/backfill	Impact of thermal degradation on buffer composition is discussed.		See processes "Alteration of impurities" (Bu13) and "Montmorillonite transformation" (Bu16).
A 1.50 Inventory	Bentonite composition including potentially chemotoxic elements.		
K 5.21 Organics	Content of organic carbon.		
K 6.21 Organics	Content of organic carbon.		
K 3.01 Bentonite emplacement and composition	Bentonite composition.		Quality control of material is described in Initial state report Section 5.1.
A 1.05 Buffer additives	Material composition.		No additives for enhancing buffer function are foreseen.
I 028b Buffer (quality)	Bentonite composition.		Quality control of material is described in Initial state report Section 5.1.
Recorded by: Kristina Skagius/Karin Pers			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarBu10 Montmorillonite composition

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
J 3.2.05 Thermal effects on the buffer material	Impact of montmorillonite transformation on buffer composition is discussed.		See process "Montmorillonite transformation" (Bu16)
S 062 Properties of bentonite buffer	Montmorillonite composition and changes over time are discussed.		See process "Montmorillonite transformation"
S 094 Thermal degradation of buffer/backfill	Impact of thermal degradation on montmorillonite composition is discussed.		See process "Montmorillonite transformation" (Bu16).
K 3.01 Bentonite emplacement and composition	Montmorillonite composition.		
I 028b Buffer (quality)	Montmorillonite composition.		
Recorded by: Kristina Skagius/Karin Pers			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarBu11 Pore water composition

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.09 Chemical gradients	Concentration gradients are discussed.		Discussed in the Diffusion process Bu11
J 3.1.03 Effects of bentonite on groundwater chemistry	Changes in groundwater/porewater composition is discussed.		See process "Alteration of impurities" (Bu13).
J 3.2.05 Thermal effects on the buffer material	Impact of porewater composition, e.g. K-concentration, is discussed.		See process "Montmorillonite transformation" (Bu16).
J 3.2.06 Diffusion - surface diffusion	Impact of porewater composition on diffusion is discussed.		See process "Diffusion" (Bu11).
S 018 Deep saline water intrusion	Impact of saline water on chemical conditions in buffer is discussed.		See processes "Alteration of impurities" (BU13) and "Osmosis" (Bu15).
S 023 Diffusion	Impact of porewater composition on diffusion is discussed.		See process "Diffusion" (Bu11).
S 101 Water chemistry, bentonite buffer	The evolution of chemical conditions in the buffer during resaturation and for the thermal phase and the post-thermal long-term phase is considered.		See e.g. process "Alteration of impurities" (Bu13).
S 103 Water chemistry in near-field rock	The impact of near-field groundwater on the chemical conditions in the buffer during resaturation and for the thermal phase and the post-thermal long-term phase is considered.		See e.g. process "Alteration of impurities" (Bu13).
K 2.14 Chemical buffering (canister corrosion products)	Effects of metal corrosion on water composition are addressed.		See e.g. process "Corrosion of cast iron insert" (C07).
K 3.09 Bentonite porewater chemistry	Changes in groundwater/porewater composition are discussed.		See process "Alteration of impurities" (Bu13).
W 2.097 Chemical gradients	Very general FEP. Chemical gradients are considered in evaluating the chemical evolution of the buffer.		See e.g. process "Alteration of impurities" (Bu13).
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarBu12 Structural and stray materials

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.50 Inventory	Potential stray materials in the deposition holes are discussed.		
J 5.03 Stray materials left	Potential stray materials in the deposition holes are discussed.		
K 4.18 Oil or organic fluid spill	Potential stray materials in the deposition holes are discussed.		
K 5.21 Organics	Potential stray materials in the deposition holes are discussed.		
K 6.21 Organics	Potential stray materials in the deposition holes are discussed.		
W 2.068 Organic complexation	Potential stray materials in the deposition holes are discussed.		
W 2.069 Organic ligands	Potential stray materials in the deposition holes are discussed.		
I 044 Chealting agents	Potential stray materials in the deposition holes are discussed.		
I 071 Corrosive chemicals (in vault)	Potential stray materials in the deposition holes are discussed.		
K 3.24 Organics/contamination of bentonite	Potential stray materials in the deposition holes are discussed.		
Recorded by: Kristina Skagius/Karin Pers			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarBfT01 Temperature

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.01 Backfill characteristics	Effect of temperature on the movement of water in the backfill is discussed.		See process "Water transport for saturate conditions" (BfT04).
A 1.02 Backfill evolution	The effect of elevated temperatures is discussed.		See process "Montmorillonite transformation" (BfT15).
A 1.31 Excessive hydrostatic pressures	Thermal expansion of the backfill is discussed.		See process "Swelling/Mass redistribution (BfT07).
S 093 Temperature, tunnel backfill	Temperature evolution of the backfill is discussed.		See process "Heat transport" (BfT01).
S 094 Thermal degradation of buffer/backfill	Temperature evolution of the backfill is discussed.		See process "Heat transport" (BfT01).
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarBfT02 Water content

No NEA Project FEP associated with this SR-Can FEP

SR-Can FEP VarBfT03 Gas content

No NEA Project FEP associated with this SR-Can FEP

SR-Can FEP VarBfT04 Hydrovariables (pressures and flows)

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.02 Backfill evolution	Effect of backfill evolution on hydraulic conductivity is discussed.		See process "Montmorillonite transformation" (BfT15).
A 1.31 Excessive hydrostatic pressures	Influence of temperature on porewater pressure is discussed.		See process "Swelling/Mass redistribution (BfT07).
S 066 Properties of tunnel backfill	Hydraulic properties of the backfill is discussed.		See e.g. processes "Water transport for saturated conditions" (BfT04) and "Gas transport/dissolution" (BfT05).
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarBfT05 Backfill geometry

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 066 Properties of tunnel backfill	Impact of various processes on backfill geometry is discussed.		See e.g. process "Swelling/Mass redistribution" (BfT07)
W 2.007 Seal physical properties	Geometry of tunnels and potential slots in the backfilled tunnels.		See also section 7.1.
Recorded by: Kristina Skagius/Karin Pers			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarBfT06 Backfill pore geometry

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.01 Backfill characteristics	Effect of pore geometry on the movement of water in the backfill is discussed.		See process "Water transport under saturated conditions" (BfT04).
J 3.2.06 Diffusion - surface diffusion	Impact of porosity on diffusion is discussed.		See process "Diffusion" (BfT10).
S 023 Diffusion	Impact of porosity on diffusion is discussed.		See process "Diffusion" (BfT10).
S 066 Properties of tunnel backfill	Impact of various processes on backfill pore geometry is discussed.		See e.g. processes "Swelling/Mass redistribution" (BfT07) and "Montmorillonite transformation" (BfT15).
W 2.007 Seal physical properties	Pore volumes and voids.		See also section 7.1.
Recorded by: Kristina Skagius/Karin Pers			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarBfT07 Stress state

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 066 Properties of tunnel backfill	Swelling pressure and changes over time are discussed.		See e.g. processes "Swelling/Mass redistribution" (BfT07) and "Montmorillonite transformation" (BfT15).
I 298 Swelling pressure (clay)	Swelling pressure is considered.		See process "Swelling/Mass redistribution" (BfT07).

Recorded by: Kristina Skagius **Date:** Sept 2006

Checked and revised by: **Date:**

SR-Can FEP VarBfT08 Backfill materials - composition and content

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.02 Backfill evolution	Changes in backfill composition are discussed.		See process "Montmorillonite transformation" (BfT15).
J 3.1.03 Effects of bentonite on groundwater chemistry	The mineral composition of Friedland clay and bentonite composition.		
S 066 Properties of tunnel backfill	Backfill composition and changes over time are discussed.		See e.g. "Alteration of impurities" (BfT12) and "Montmorillonite transformation" (BfT15).
S 094 Thermal degradation of buffer/backfill	Impact on backfill composition discussed.		See process "Montmorillonite transformation" (BfT15).
A 1.50 Inventory	The mineral composition of Friedland clay and bentonite composition.		
K 5.21 Organics	Content of organic carbon in bentonite.	Organics in Friedland clay not available.	
K 6.21 Organics	Content of organic carbon in bentonite.	Organics in Friedland clay not available.	

Recorded by: Kristina Skagius/Karin Pers **Date:** Sept 2006

Checked and revised by: **Date:**

SR-Can FEP VarBfT09 Backfill pore water composition

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.09 Chemical gradients	Concentration gradients are discussed.		See e.g. process "Diffusion" (BfT10).
A 1.15 Concrete	Gradients in pH and effects on backfill are discussed.		See process "Montmorillonite transformation" (BfT15).
J 3.1.03 Effects of bentonite on groundwater chemistry	Changes in groundwater/porewater composition is discussed.		See process "Alteration of impurities" (BfT12).
J 3.1.07 Reactions with cement pore water	Impact of pH on backfill properties is discussed.		See processes "Alteration of impurities" (BfT12) and "Montmorillonite transformation" (BfT15).
J 3.2.06 Diffusion - surface diffusion	Impact of porewater composition on diffusion is discussed.		See process "Diffusion" (BfT10).
S 018 Deep saline water intrusion	Impact of saline water on chemical conditions in buffer is discussed.		See processes "Alteration of impurities" (BfT12) and "Osmosis" (Bu14).
S 023 Diffusion	Impact of porewater composition on diffusion is discussed.		See process "Diffusion" (BfT10).
S 103 Water chemistry in near-field rock	The impact of near-field groundwater on the chemical conditions in the backfill is considered.		See e.g. process "Alteration of impurities" (BfT12).
S 104 Water chemistry, tunnel backfill	The evolution of chemical conditions in the backfill is considered.		See e.g. process "Alteration of impurities" (BfT12).
K 3.09 Bentonite porewater chemistry	Changes in groundwater/porewater composition are discussed.		See process "Alteration of impurities" (BfT12).
W 2.097 Chemical gradients	Very general FEP. Chemical gradients are considered in evaluating the chemical evolution of the backfill.		See e.g. process "Alteration of impurities" (BfT12).
I 061 Concrete (influence on vault chemistry)	Impact of pH on thebackfill material is discussed.		See process "Monmorillonite transformation" (BfT15).
W 2.008 Seal chemical composition	Impact of pH on backfill properties is discussed.		See processes "Alteration of impurities" (BfT12) and "Montmorillonite transformation" (BfT15).
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarBfT10 Structural and stray materials

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 1.15 Concrete	Anchoring grout around rock bolts and injection grout in grout holes, amount and composition. Concrete in stray materials, amount.		
A 1.50 Inventory	Composition (recipes) and amount of grout, rock bolts and nets.		
J 3.1.07 Reactions with cement pore water	Degradation of concrete materials in the deposition tunnels is not specifically discussed, but the impact of high pH on the backfill material is addressed.		See process "Montmorillonite transformation" (BfT15).
J 4.2.10 Chemical effects of rock reinforcement	Amount of rock bolts and nets (iron).		
J 5.03 Stray materials left	Amount of different stray materials.		
J 5.04 Decontamination materials left		Currently, decontamination by other means than by water (high pressure) is not planned.	
K 4.18 Oil or organic fluid spill	Oil or organic fluid spill is discussed and quantified.		
K 5.21 Organics	Organics discussed and quantified.		
K 6.21 Organics	Organics discussed and quantified.		
K S1.2 Waste Emplacement and Repository	Anchoring grout around rock bolts and injection grout in grout holes, amount and composition. Concrete in stray materials, amount.		
W 2.008 Seal chemical composition	Anchoring grout around rock bolts and injection grout in grout holes, amount and composition. Concrete in stray materials, amount.		
W 2.068 Organic complexation	Organics discussed and quantified.		
W 2.069 Organic ligands	Organics discussed and quantified.		
I 044 Chealting agents	Recipes (chemical composition) of grout. Amount of stray materials.		
I 061 Concrete (influence on vault chemistry)	Anchoring grout around rock bolts and injection grout in grout holes, amount and composition. Concrete in stray materials, amount.		
I 071 Corrosive chemicals (in vault)	Amount of different stray materials.		
Recorded by: Kristina Skagius/Karin Pers			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarGe01 Temperature in bedrock

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 001 Alteration/weathering of flow paths	Impact of temperature on chemical reactions is mentioned.		See process "Dissolution/precipitation of fracture-filling minerals" (Ge15).
S 020 Degradation of hole and shaft seals		Degradation of hole and shaft seals is not specifically described in SR-Can process reports.	See SKB FEPs ISBhS01 and ISBhS02.
S 091 Temperature, far-field	See SKB FEP Ge01, Ge02, Ge03.		
S 092 Temperature, near-field rock	Thermal evolution of the near-field is discussed.		See processes "Heat transport" (Ge01) and "Freezing (Ge02).
K 5.13 Geothermal regime	Geothermal temperature at repository depth.		See process "Heat transport" (Ge01).
K 6.13 Geothermal regime	Geothermal temperature at repository depth.		See process "Heat transport" (Ge01).
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarGe02 Groundwater flow

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 020 Degradation of hole and shaft seals		Degradation of hole and shaft seals is not specifically described in SR-Can process reports.	See SKB FEPs ISBhS01 and ISBhS02.
W 1.034 Saline intrusion	Salinity effects discussed.		See process "Groundwater flow" (Ge03).
W 3.035 Borehole-induced mineralization		See process "Groundwater flow" (Ge03).	Existing boreholes are not specifically described in SR-Can, but location is part of the SDM. For impact of drilling of future boreholes, see SKB FHA FEPs.
W 3.036 Borehole-induced geochemical changes		See process "Groundwater flow" (Ge03).	Existing boreholes are not specifically described in SR-Can, but location is part of the SDM (see SKB FEP VarGe05). For impact of drilling of future boreholes, see SKB FHA FEPs.
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarGe03 Groundwater pressure

No NEA Project FEP associated with this SR-Can FEP

SR-Can FEP VarGe04 Gas flow

No NEA Project FEP associated with this SR-Can FEP

SR-Can FEP VarGe05 Repository geometry

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
W 3.033 Flow through undetected boreholes		Per definition, the location and geometry of undetected boreholes are not considered since they are not known. However, the possibility for undetected boreholes at the investigated sites is judged as low.	See also SKB FEP Ge03.
W 3.035 Borehole-induced mineralization		Existing boreholes are not specifically described in SR-Can, but location is part of the SDM.	For impact of drilling of future boreholes, see SKB FHA FEPs.
W 3.036 Borehole-induced geochemical changes			Existing boreholes are not specifically described in SR-Can, but location is part of the SDM (see SKB FEP VarGe05). For impact of drilling of future boreholes, see SKB FHA FEPs.
A 1.89 Vault geometry	Preliminary repository layout including geometry of tunnels.		
K 4.16 Access tunnels and shafts	Site-specific, preliminary repository layout.		
W 2.038 Investigation boreholes			Existing boreholes are not specifically described in SR-Can, but location is part of the SDM. For impact of drilling of future boreholes, see SKB FHA FEPs.
W 3.031 Natural borehole fluid flow			Existing boreholes are not specifically described in SR-Can, but location is part of the SDM. For impact of drilling of future boreholes, see SKB FHA FEPs.
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarGe06 Fracture geometry

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 001 Alteration/weathering of flow paths	Impact of chemical reactions on fracture apertures is mentioned.		See process "Dissolution/precipitation of fracture-filling minerals" (Ge15).
A 2.01 Blasting and vibration	Properties of EDZ.		See "Fracturing" (Ge07) and "Groundwater flow" (Ge03).
A 2.13 Damaged zone	Properties of EDZ.		See "Fracturing" (Ge07) and "Groundwater flow" (Ge03).
A 2.35 Hydraulic properties - evolution	Impact of dissolution/precipitation is addressed but is expected to be minor.		See process "Dissolution/precipitation of fracture-filling minerals" (Ge15).
A 2.54 Rock properties	Site-specific fracture characteristics including porosity.		
A 2.55 Rock properties - undetected features	Undetected features addressed in terms of uncertainties in SDM propagated to and assessed in SR-Can.		
J 3.2.06 Diffusion - surface diffusion	Impact of porosity on diffusion is discussed.		See process "Diffusion and matrix diffusion" (Ge12).
J 4.1.05 Matrix diffusion	Matrix diffusion and implications of fracture fillings and the rock mass (porosity and mineralogy) is addressed.		Se process "Diffusion and matrix diffusion" (Ge12).
J 4.2.02.1 Excavation/backfilling effects on nearby rock	Effects of excavation considered.		See processes "Groundwater flow " (Ge03) and "Reactivation - Displacement along existing discontinuities" (Ge06).
J 4.2.07 Thermo-hydro-mechanical effects	Coupling between flow and rock stress/deformation is discussed.		See processes "Groundwater flow " (Ge03) and "Reactivation - Displacement along existing discontinuities" (Ge06).
J 6.01 Undetected fracture zones	Undetected features addressed in terms of uncertainties in SDM propagated to and assessed in SR-Can.		
S 004 Cave in	Stress-induced fracturing.		See process "Fracturing" (Ge07).
S 023 Diffusion	Impact of porosity on diffusion is discussed.		See process "Diffusion and matrix diffusion" (Ge12).
S 030 Enhanced rock fracturing	Stress-induced fracturing		See process "Fracturing" (Ge07).
S 032 Excavation effects on nearby rock	Stress-induced fracturing.		See process "Fracturing" (Ge07).
S 054 Matrix diffusion	Impact of fracture geometry (porosity) is discussed.		See process "Diffusion and matrix diffusion" (Ge12).
S 064 Properties of far-field rock	Changes in fracture geometry are discussed.		See e.g. process "Dissolution/precipitation of fracture-filling minerals" (Ge15).

SR-Can FEP VarGe06 Fracture geometry

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 065 Properties of near-field rock	Changes in fracture geometry are discussed.		See e.g. process "Dissolution/precipitation of fracture-filling minerals" (Ge15).
S 086 Stress field	Stress-induced fracturing.		See process "Fracturing" (Ge07)
H 1.5.2 Disturbed zone (hydromechanical) effects	EDZ and effects on flow are discussed.		See processes "Fracturing" (Ge07) and "Groundwater flow" (Ge08).
H 2.2.2 Rock property changes	Various processes affecting fracture properties are discussed.		See e.g. process "Dissolution/precipitation of fracture-filling minerals" (Ge15).
H 2.3.6 Far-field transport: Changes in sorptive surfaces	The fracture surface area through which the inner surfaces of the matrix is reached is discussed in a sorption context.		See process "Speciation and sorption" (Ge13).
K 4.01 Excavation-disturbed zone (EDZ)	EDZ and impact on flow and transport is discussed.		See processes "Groundwater flow" (Ge03) and "Transport of radionuclides in the water phase" (Ge24).
K 5.06 Matrix diffusion	Impact of pore geometry is discussed.		See process "Diffusion and matrix diffusion" (Ge12).
K 6.06 Matrix diffusion	Impact of pore geometry is discussed.		See process "Diffusion and matrix diffusion" (Ge12).
W 1.009 Changes in fracture properties	Changes in fracture geometry due to dissolution-precipitation.		See process "Dissolution/precipitation of fracture-filling minerals" (Ge15).
W 1.022 Fracture infills	Impact of dissolution-precipitation on fracture geometry and subsequent changes in transmissivity.		See processes "Dissolution/precipitation of fracture-filling minerals" (Ge15) and "Groundwater flow" (Ge03).
W 2.018 Disturbed rock zone	The disturbed rock zone (EDZ) is discussed.		See e.g. process "Fracturing" (Ge07).
W 2.019 Excavation-induced changes in stress	Stress-induced fracturing.		See process "Fracturing" (Ge07).
W 2.059 Precipitation	Impact of fracture geometry of mineral precipitation is discussed.		See process "Dissolution/precipitation of fracture-filling minerals" (Ge15).
W 2.091 Diffusion	Impact of porosity on diffusion is discussed.		See process "Diffusion and matrix diffusion" (Ge12).
W 2.092 Matrix diffusion	Impact of porosity on diffusion is discussed.		See process "Diffusion and matrix diffusion" (Ge12).
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarGe07 Rock stresses

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 001 Alteration/weathering of flow paths	Indirect impact of rock stresses on chemical reactions is mentioned.		See process "Dissolution/precipitation of fracture-filling minerals" (Ge15).
S 020 Degradation of hole and shaft seals		Degradation of hole and shaft seals is not specifically described in SR-Can process reports.	See SKB FEP ISGen04
J 4.2.02.1 Excavation/backfilling effects on nearby rock	Effects of excavation considered.		See process "Reactivation - Displacement along existing discontinueties" (Ge06).
J 4.2.07 Thermo-hydro-mechanical effects	Coupling between flow and rock stress/deformation is discussed.		See processes "Groundwater flow " (Ge03) and "Reactivation - Displacement along existing discontinueties" (Ge06).
S 004 Cave in	Stress-induced fracturing.		See process "Fracturing" (Ge07).
S 032 Excavation effects on nearby rock	Stress-induced fracturing.		See process "Fracturing" (Ge07).
S 064 Properties of far-field rock	Changes in rock stresses are discussed.		See e.g. process "Reactivation - Displacement along existing discontinuities" (Ge06).
S 065 Properties of near-field rock	Changes in rock stresses are discussed.		See e.g. process "Reactivation - Displacement along existing discontinuities" (Ge06).
S 086 Stress field	Stress-induced fracturing.		See process "Fracturing"
W 1.009 Changes in fracture properties	Changes in rock stress due to surface erosion.		See process "Surface weathering and erosion" (Ge09).
W 2.019 Excavation-induced changes in stress	Stress-induced fracturing.		See process "Fracturing" (Ge07).
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarGe08 Matrix minerals

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.35 Hydraulic properties - evolution	Impact of dissolution/precipitation is addressed but is expected to be minor.		See process "Reactions groundwater/rock matrix" (Ge14).
A 2.54 Rock properties	Site-specific rock types.		
S 064 Properties of far-field rock	Changes in rock properties due to dissolution-precipitation reactions are described.		See process "Reactions groundwater/rock matrix" (Ge14).
S 065 Properties of near-field rock	Changes in rock properties due to dissolution-precipitation reactions are described.		See process "Reactions groundwater/rock matrix" (Ge14).
S 048 Groundwater chemistry	The effect of minerals on groundwater chemistry through dissolution and precipitation is described.		See processes "Reactions groundwater/rock matrix" (Ge14).
K 5.07 Mineralogy	The effect of mineralogy on groundwater chemistry is discussed.		See process "Reactions groundwater/rock matrix" (Ge14).
K 6.07 Mineralogy	The effect of mineralogy on groundwater chemistry is discussed.		See process "Reactions groundwater/rock matrix" (Ge14).

Recorded by: Kristina Skagius **Date:** Sept 2006
Checked and revised by: **Date:**

SR-Can FEP VarGe09 Fracture minerals

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 001 Alteration/weathering of flow paths	Changes in fracture minerals are discussed.		See process "Dissolution/precipitation of fracture-filling minerals" (Ge15).
A 2.35 Hydraulic properties - evolution	Impact of dissolution/precipitation is addressed but is expected to be minor.		See process "Dissolution/precipitation of fracture-filling minerals" (Ge15).
A 2.54 Rock properties	Site-specific fracture characteristics including fracture minerals,		
J 4.1.05 Matrix diffusion	Matrix diffusion and implications of fracture fillings and the rock mass (porosity and mineralogy) is addressed.		Se process "Diffusion and matrix diffusion" (Ge12).
S 054 Matrix diffusion	Impact of fracture minerals is discussed.		See process "Diffusion and matrix diffusion" (Ge12).
S 064 Properties of far-field rock	Changes in rock properties due to dissolution-precipitation reactions are described.		See process "Dissolution/precipitation of fracture-filling minerals" (Ge15).
S 065 Properties of near-field rock	Changes in rock properties due to dissolution-precipitation reactions are described.		See process "Dissolution/precipitation of fracture-filling minerals" (Ge15).

SR-Can FEP VarGe09 Fracture minerals

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
H 2.3.6 Far-field transport: Changes in sorptive surfaces	Impact of fracture minerals on sorption is discussed.		See process "Speciation and sorption" (Ge13).
S 048 Groundwater chemistry	The effect of minerals on groundwater chemistry through dissolution and precipitation is described.		See process "Dissolution/precipitation of fracture-filling minerals" (Ge15).
K 5.07 Mineralogy	The effect of minralogy on groundwater chemistry is discussed.		See process "Dissolution/precipitation of fracture-filling minerals" (Ge15).
K 6.07 Mineralogy	The effect of minralogy on groundwater chemistry is discussed.		See process "Dissolution/precipitation of fracture-filling minerals" (Ge15).
S 103 Water chemistry in near-field rock	The effect of minerals on groundwater chemistry through dissolution and precipitation is described.		See process "Dissolution/precipitation of fracture-filling minerals" (Ge15).
H 2.3.7 Far-field transport: Changes in groundwater chemistry and flow direction	Changes in mineralogy due to dissolution-precipitation reactions are described.		See process "Dissolution/precipitation of fracture-filling minerals" (Ge15).
K 5.08 Groundwater chemistry	The effect of minerals on groundwater chemistry through dissolution and precipitation is described.		See process "Dissolution/precipitation of fracture-filling minerals" (Ge15).
K 5.19 Influx of oxidising water	The possible effect of the influx of oxidizing surface waters during repository operation is described		See process "Dissolution/precipitation of fracture-filling minerals" (Ge15).
K 6.08 Groundwater chemistry	The effect of minerals on groundwater chemistry through dissolution and precipitation is described.		See process "Dissolution/precipitation of fracture-filling minerals" (Ge15).
K 6.19 Influx of oxidising water	The possible effect of the influx of oxidizing surface waters during repository operation is described		See process "Dissolution/precipitation of fracture-filling minerals" (Ge15).
K 7.08 Groundwater chemistry	The effect of minerals on groundwater chemistry through dissolution and precipitation is described.		See process "Dissolution/precipitation of fracture-filling minerals" (Ge15).
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarGe10 Groundwater composition

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
I 061 Concrete (influence on vault chemistry)	Impact of degradation of concrete grout in fractures is discussed.		See process "Degradation of grout" (GE17).
S 001 Alteration/weathering of flow paths	Impact of groundwater composition on dissolution/precipitation reactions is discussed.		See process "Dissolution/precipitation of fracture-filling minerals" (Ge15).
W 1.034 Saline intrusion	Effects on groundwater composition are described.		See process "Advection/mixing" (Ge11).
W 3.035 Borehole-induced mineralization		See process "Advection/mixing" (Ge11).	Existing boreholes are not specifically described in SR-Can, but location is part of the SDM. For impact of drilling of future boreholes, see SKB FHA FEPs.
W 3.036 Borehole-induced geochemical changes		See process "Advection/mixing" (Ge11).	Existing boreholes are not specifically described in SR-Can, but location is part of the SDM (see SKB FEP VarGe05). For impact of drilling of future boreholes, see SKB FHA FEPs.
J 3.2.06 Diffusion - surface diffusion	Impact of groundwater composition on diffusion is discussed.		See process "Diffusion and matrix diffusion" (Ge12).
S 023 Diffusion	Impact of groundwater composition on diffusion is discussed.		See process "Diffusion and matrix diffusion" (Ge12).
S 054 Matrix diffusion	Impact of groundwater composition is discussed.		See process "Diffusion and matrix diffusion" (Ge12).
S 048 Groundwater chemistry	The impact of various geosphere processes on groundwater chemistry is described.		See e.g. processes "Dissolution/precipitation of fracture-filling minerals" (Ge15), "Advection" (Ge11), "Microbial processes" (Ge16).
K 5.07 Mineralogy	The effect of mineralogy on groundwater chemistry is discussed.		See processes "Reactions groundwater/rock matrix" (Ge14) and "Dissolution/ precipitation of fracture-filling minerals" (Ge15).
K 6.07 Mineralogy	The effect of mineralogy on groundwater chemistry is discussed.		See processes "Reactions groundwater/rock matrix" (Ge14) and "Dissolution/ precipitation of fracture-filling minerals" (Ge15).
S 103 Water chemistry in near-field rock	The effect of minerals on groundwater chemistry through dissolution and precipitation is described.		See process "Dissolution/precipitation of fracture-filling minerals" (Ge15).
H 2.3.7 Far-field transport: Changes in groundwater chemistry and flow direction	Changes in groundwater composition, e.g. intrusion of oxygenated water, and effects of this are discussed.		See process "Dissolution/precipitation of fracture-filling minerals" (Ge15).
K 5.08 Groundwater chemistry	The effect of minerals on groundwater chemistry through dissolution and precipitation is described.		See process "Dissolution/precipitation of fracture-filling minerals" (Ge15).
K 5.19 Influx of oxidising water	The possible effect of the influx of oxidizing surface waters during repository operation is described		See process "Dissolution/precipitation of fracture-filling minerals" (Ge15).

SR-Can FEP VarGe10 Groundwater composition

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 6.08 Groundwater chemistry	The effect of minerals on groundwater chemistry through dissolution and precipitation is described.		See process "Dissolution/precipitation of fracture-filling minerals" (Ge15).
K 6.19 Influx of oxidising water	The possible effect of the influx of oxidizing surface waters during repository operation is described		See process "Dissolution/precipitation of fracture-filling minerals" (Ge15).
K 7.08 Groundwater chemistry	The effect of minerals on groundwater chemistry through dissolution and precipitation is described.		See process "Dissolution/precipitation of fracture-filling minerals" (Ge15).
A 2.53 Recharge groundwater	Recharge waters with different composition are considered.		See process "Advection/mixing" (Ge11).
J 1.1.02 Radioactive decay; heat	The impact of heat on water composition through tempe-rature and various chemical reactions is discussed.		See e.g. process "Dissolution/precipitation of fracture-filling minerals" (Ge15).
J 3.1.07 Reactions with cement pore water	The processes and consequences of concrete degradation on groundwater composition are discussed.		See process "Degradation of grout" (Ge17).
J 3.1.11 Redox front	Consumption of oxygen during resaturation phase and intrusion of oxygenated water in connection with glaciation are addressed		See process "Reactions groundwater/rock matrix" (Ge14).
J 4.1.01 Oxidizing conditions	Consumption of oxygen during resaturation phase and intrusion of oxygenated water in connection with glaciation are addressed		See processes "Reactions groundwater/rock matrix" (Ge14) and "Dissolution/ precipitation of fracture-filling minerals" (Ge15).
J 4.1.02 pH-deviations	pH-deviations and consequences on dissolution and precipitation is discussed.		See processes "Reactions groundwater/rock matrix" (Ge14) and "Dissolution/ precipitation of fracture-filling minerals" (Ge15).
J 4.1.09 Complexing agents	The effect of humic and fulvic acids on sorption characteris-tics are addressed.		See process "Speciation and sorption" (Ge13).
S 018 Deep saline water intrusion	Impact of saline water on geochemical conditions is discussed.		See e.g. processes "Advection /mixing" (Ge11) and "Specia-tion and sorption" (Ge13).
S 074 Redox front	Consumption of oxygen during resaturation phase and intrusion of oxygenated water in connection with glaciation are addressed		See process "Reactions groundwater/rock matrix" (Ge14).
H 2.1.9 Effects of natural gases.	Dissolved natural gases are addressed		See processes "Gas flow/dissolution" (Ge04) and "Formation/dissolution/reaction of gaseous species" (Ge19).
H 2.3.13 Far-field transport: Biogeo-chemical changes	Changes in water chemistry as a result of climate change are discussed.		See process "Advection/mixing" (Ge11).

SR-Can FEP VarGe10 Groundwater composition

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K 4.06 Groundwater chemistry		In case of de-saturation of the EDZ during excavation and backfilling it is to be expected a change to oxidizing conditions in the matrix porewater. The conditions will however return to reducing after re-saturation of the backfill. This effect may be neglected when considering the large amount of air entrapped in the backfill.	See processes "Reactions groundwater/rock matrix" (Ge14) and "Dissolution/precipitation of fracture-filling minerals" (Ge15).
K 5.11 Intrusion of saline groundwater	Site-specific groundwater compositions, including salinity. Prevailing salinity for different time periods assessed through hydrogeochemical modelling in SR-Can.		See e.g. processes "Advection/mixing" (Ge11) and "Dissolution/precipitation of fracture-filling minerals" (Ge15).
K 5.24 Geogas	Dissolved natural gases.		See e.g. process "Gas flow/dissolution" (Ge04).
K 6.11 Intrusion of saline groundwater	Site-specific groundwater compositions, including salinity. Prevailing salinity for different time periods assessed through hydrogeochemical modelling in SR-Can.		See e.g. processes "Advection/mixing" (Ge11) and "Dissolution/precipitation of fracture-filling minerals" (Ge15).
K 6.24 Geogas	Dissolved natural gases.		See e.g. process "Gas flow/dissolution" (Ge04).
W 1.035 Freshwater intrusion	The effect of changes in recharge waters is mentioned.		See process "Advection/mixing" (Ge11).
W 1.036 Changes in groundwater Eh	Site-specific groundwater compositions including Eh. Evolution for different time periods assessed through hydrogeochemical modelling in SR-Can.		See e.g. processes "Advection/mixing" (Ge11) and "Dissolution/precipitation of fracture-filling minerals" (Ge15).
W 1.037 Changes in groundwater pH	Site-specific groundwater compositions, including pH. Evolution for different time periods assessed through hydrogeochemical modelling in SR-Can.		See e.g. processes "Advection/mixing" (Ge11) and "Dissolution/precipitation of fracture-filling minerals" (Ge15).
W 1.038 Effects of dissolution	Evolution of water composition for different time periods assessed through hydrogeochemical modelling in SR-Can.		See process "Dissolution/precipitation of fracture-filling minerals" (Ge15).
W 2.074 Chemical degradation of seals	Impact of groundwater composition and effects on groundwater composition of degradation of concrete (grout) are discussed.	Impact of and on water composition from degradation of other seals in the repository (plugs, borehole seals etc) is not specifically addressed in SR-Can.	See process "Degradation of grout" (Ge17).
W 2.097 Chemical gradients	Very general FEP. Chemical gradients are considered when evaluating the geochemical evolution in the geosphere.		See e.g. processes "Advection /mixing" (Ge11) and "Dissolution/precipitation of fracture-filling minerals" (Ge15).
I 040 Farfield chemical interactions	Site-specific groundwater compositions. Evolution for different time periods assessed through hydrogeochemical modelling in SR-Can.		See e.g. processes "Advection /mixing" (Ge11) and "Dissolution/precipitation of fracture-filling minerals" (Ge15).
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarGe11 Gas composition

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
S 032 Excavation effects on nearby rock	Unsaturated conditions.		See process "Groundwater flow" (Ge03).
K 5.24 Geogas	Natural gas content.		See e.g. process "Gas flow/ dissolution" (Ge04).
K 6.24 Geogas	Natural gas content.		See e.g. process "Gas flow/ dissolution" (Ge04).
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarGe12 Structural and stray materials

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
K S1.2 Waste Emplacement and Repository	Amount and composition of injection grout in rock fractures around deposition tunnels and other caverns.		
W 2.008 Seal chemical composition	Amount and composition of injection grout in rock fractures around deposition tunnels and other caverns.		
I 061 Concrete (influence on vault chemistry)	Amount and composition of injection grout in rock fractures around deposition tunnels and other caverns.		
J 3.1.07 Reactions with cement pore water	Amount and composition of injection grout in rock fractures around deposition tunnels and other caverns.		
A 1.15 Concrete	Amount and composition of injection grout in rock fractures around deposition tunnels and other caverns.		
K 4.17 Shaft and tunnel seals	Amount and composition of injection grout in rock fractures around deposition tunnels and other caverns.		
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

SR-Can FEP VarGe13 Saturation

NEA FEP	Aspects of the FEP addressed:	Aspects of the FEP not addressed because:	Comments
A 2.15 Dewatering	Saturation conditions are discussed.		See processes "Groundwater flow" (Ge03) and "Gas flow/dissolution" (Ge04)
H 1.5.1 Desaturation (pumping) effects	Desaturation and resaturation discussed.		See processes "Groundwater flow" (Ge03) and "Gas flow/dissolution" (Ge04)
K 4.03 Desaturation /resaturation of EDZ	Desaturation and resaturation discussed.		See processes "Groundwater flow" (Ge03) and "Gas flow/dissolution" (Ge04)
Recorded by: Kristina Skagius			**Date:** Sept 2006
Checked and revised by:			**Date:**

Appendix 11

List of provisional process FEPs for the system components “bottom plate in deposition holes”, “backfill in other repository cavities”, “plugs”, “borehole seals”

SR-Can FEP Bottom plate in deposition holes

BP01	Heat transport
BP02	Water transport under saturated conditions
BP03	Mechanical degradation of inorganic engineering materials
BP04	Decomposition of inorganic engineering material
BP05	Diffusion
BP06	Sorption (including ion-exchange)
BP07	Radiation effects
BP08	Microbial processes
BP09	Transport of radionuclides in water phase

SR-Can FEP Backfill of other repository cavities

BfO01	Heat transport
BfO02	Freezing
BfO03	Water uptake and transport under unsaturated conditions
BfO04	Water transport under saturated conditions
BfO05	Gas transport/dissolution
BfO06	Piping/erosion
BfO07	Swelling/Mass redistribution
BfO08	Liquefaction
BfO09	Advection
BfO10	Diffusion
BfO11	Sorption (including ion-exchange)
BfO12	Alterations of impurities
BfO13	Pore water speciation
BfO14	Osmosis
BfO15	Montmorillonite transformation
BfO16	Colloid release
BfO17	Microbial processes
BfO18	Colloid formation and transport
BfO19	Speciation of radionuclides
BfO20	Transport of radionuclides in the water phase
BfO21	Transport of radionuclides in the gas phase

SR-Can FEP Plugs

Pg01	Heat transport
Pg02	Water transport under saturated conditions
Pg03	Gas transport/dissolution
Pg04	Mechanical degradation
Pg05	Decomposition of inorganic engineering material
Pg06	Diffusion
Pg07	Sorption (including ion-exchange)
Pg08	Microbial processes

SR-Can FEP Borehole seals

BhS01	Heat transport
BhS02	Freezing
BhS03	Water transport under saturated conditions
BhS04	Gas transport/dissolution
BhS05	Mechanical degradation of inorganic engineering materials
BhS06	Advection
BhS07	Decomposition of inorganic engineering material
BhS08	Diffusion
BhS09	Sorption (including ion-exchange)
BhS10	Alterations of impurities
BhS11	Montmorillonite transformation
BhS12	Microbial processes
BhS13	Transport of radionuclides in the water phase
BhS14	Transport of radionuclides in the gas phase