SKI Report 02:41

Research

# Comparison of SKB's RES Matrix FEPs with SKI's PID FEPs

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## SKI perspective

### Background

As part of the license for SFR 1 a renewed safety assessment should be carried out at least every ten years for the continued operation of the SFR 1 repository. SKB has at mid-year 2001 finalised their renewed safety assessment (project SAFE) which evaluates the performance of the SFR 1 repository system.

As part of scenario development for SFR 1, SKI has in a previous work identified and assembled a list of features, events and processes (FEPs), representing the Process System (near-field and far-field), with interactions/influences between FEPs incorporated in a Process Influence Diagram (PID).

### Purpose of the project

The purpose of this project is to compare SKB's RES matrix FEPs and their interactions, with SKI's PID FEPs (for the near-field and far-field/geosphere) and their interactions. The reversed order comparison is also investigated. For the biosphere, SSI's FEP-list is compared with SKB's RES matrix FEPs. Furthermore, the transparency of the links to the assessment calculations is investigated.

### Results

As far as the comparison between SKI's and SKB's FEPs for the near-field and far-field is concerned, no major discrepancies are found. It is not fully transparent what considerations SKB have made to include which FEPs in the assessment calculations.

### Effect on SKI's work

This project forms an important part of the SKI's review of SKB's project SAFE for SFR 1.

SKI's PID FEPs for SFR 1, especially the near-field FEPs, is a good starting-point when SKI develops near-field FEPs for the deep repository for long-lived low- and intermediate-level waste in Sweden (SFL 3-5).

### Project information

Responsible at SKI has been Benny Sundström.

SKI ref.: 14.9-020220/02088

*Relevant SKI report:* Stenhouse M.J., Miller W.M., Chapman N.A., System Studies in PA: Development of Process Influence Diagram (PID) for SFR-1 Repository Near-Field + Far-Field, SKI report 01:30, Swedish Nuclear Power Inspectorate, Stockholm, Sweden, 2001.

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Research

# Comparison of SKB's RES Matrix FEPs with SKI's PID FEPs

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SKI Project Number 02088

# Summary

This report provides a comparison of the features, events and processes (FEPs) identified by the Swedish Nuclear Fuel and Waste Management Company, SKB, with those of the Swedish Nuclear Power Inspectorate (SKI) and the Swedish Radiation Protection Authority (SSI), the latter identified as the basis for SKI/SSI's independent assessment calculations relating to the SFR 1 repository. Both SKB and SKI use the systems analysis approach as the framework for carrying out performance assessment (PA) calculations, although the specific details of their assessment methodologies vary.

The review was conducted on two levels of detail:

- Top-level review, where FEP titles and Influences were compared between SKB and SKI/SSI documents, and
- A more in-depth review, where attention was paid to how a particular FEP was treated within the SKB assessment, by reference to SKB's Information Flow Network diagrams.

With regard to findings of the review, in the near-field, a few SKB FEPs were not included in SKI's assessment: "Osmosis", "Heat-generating reactions", "Heat conduction", "Water pressure (influence on stress conditions)", "Advection (advective transport of microbes)" and "Capillary suction". Of these, "Heat-generating reactions", "Heat conduction" and "Water pressure" were not considered further in the SKB assessment. Similarly, the two-phase flow aspects of saturation were ignored. Of the remaining FEPs, it is not clear to what extent osmosis and the advective transport of microbes were taken into account in SKB's assessment.

A few SKB FEP titles were not identified explicitly in SKI's FEP titles, although these may be considered as part of the description under existing SKI FEPs, *i.e.* at a different level of detail (e.g. "Ion exchange", considered under SKI's "Degradation and alteration of bentonite backfill"). Finally, the SKB FEP "Methylation/transformation" was not included in SKI's near-field FEP list, although degradation of organic waste to radioactively-contaminated methane was considered by SKI in the assessment calculations involving gas.

Of the far-field FEPs, important processes (interactions) involving seals were not identified in the SKI assessment. Only the possibility of the degradation of a shaft or tunnel seal was considered. However, SKB also did not analyse in detail processes associated with seals or plugs because the material(s) to be used had not been selected.

Some SKB FEPs were not included explicitly, owing to the level of detail provided in the SKI FEPs, similar to the near-field FEPs. Finally, Microbial degradation, Water pressure, Radon generation, and Methylation/transformation were not included in SKI's FEP list:

Comparison of FEPs within the biosphere is more complicated than within the near-field or geosphere, because only general FEP titles are given as section headings in

SSI's FEPs. Based on the review conducted here, SKB's biosphere appears to be more detailed in terms of the number of different species identified.

For completeness, SKI's FEPs were compared with SKB's FEPs to identify whether or not any SKI FEPs had been omitted by SKB. In fact, there are no major omissions.

Of the FEPs that were designated by SKB as important and, therefore, to be included in the assessment, the text indicates that certain FEPs were *not* considered in the quantitative analysis and these are discussed in this report. For example, there is no evidence of any coupling between gas and water pathways (e.g. the impact of gas pressure on water movement) although processes affecting gas generation and transport are discussed elsewhere (separate report).

The general conclusion from this part of the review is that the level of detail provided in the Information Flow Diagrams is not sufficient to identify how every FEP is treated in SKB's assessment.

Overall, the level of documentation on FEPs contained in the SKB report is detailed, providing thorough documentation of the nature of each FEP, which ones were included in the assessment, which ones were not, and why not. What is lacking, however, is a clear indication of how each FEP considered initially by SKB as being important and, therefore, included as part of the assessment, is actually treated or carried forward, *i.e.* mapped to the assessment calculations.

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# 1 Introduction

## 1.1 Objective of Review

The objective of the review work reported here is to compare the features, events and processes (FEPs) identified by the Swedish Nuclear Fuel and Waste Management Company, SKB, with those of the Swedish Nuclear Power Inspectorate (SKI) and the Swedish Radiation Protection Authority (SSI), the latter identified as the basis for SKI/SSI's independent assessment calculations relating to the SFR 1 repository. Both SKB and SKI use the systems analysis approach as the framework for carrying out performance assessment (PA) calculations, although the specific details of their assessment methodologies vary, as discussed below. The principal components of this methodology, which are reviewed here, are:

- Primarily, identification of FEPs relating to the SFR 1 repository system (near-field, far-field and biosphere) and to a lesser extent, identification of Influences (interactions between pairs of FEPs);

- The link between FEPs/FEP interactions and safety assessment calculations.

Owing to time constraints, the latter step - how the FEPs and interactions between them are addressed in safety assessment calculations - has been evaluated in a qualitative way. Thus, this review is not a full audit. In addition, EFEPs – scenario-generating FEPs – were not reviewed as scenarios have been reviewed by SKI and SSI.

The review was conducted on two levels of detail:

- Top-level review, where FEP titles and Influences were compared between SKB and SKI/SSI documents, and
- A more in-depth review, where attention was paid to how a particular FEP was treated within the SKB assessment, by reference to SKB's Information Flow Network diagrams.

## 1.2 Review Documents

In order to perform the comparison, three key documents have been reviewed, *viz.*

- Project SAFE: Scenario and system analysis [SKB 2001] – principally Chapters 4, 5.
- System Studies in PA: Development of Process Influence Diagram (PID) for SFR 1 repository: near-field + far-field [Stenhouse et al., 2001].
- Work in support of biosphere assessments for solid and radioactive waste disposal [Egan et al., 2001].

Other SKB documents have been consulted for supporting information, when appropriate.

# 2 Top-Level Review: Comparison of FEPs (and Certain Influences)

## 2.1 Brief Discussion of Methodologies – Key Differences

Assessment context and system definition aside, SKB and SKI develop the system analysis methodology starting from FEPs. A key difference between SKB and SKI approaches is how the FEPs are treated.

In the SKB approach, key components of the system (typically about 10 to 12 each for the near-field, geosphere[1] and biosphere) are identified as the diagonal elements of a RES[2] matrix (the RES matrix is discussed in detail by Eng et al. [1994]). Interactions between these elements are then identified as off-diagonal elements in this matrix, and normally these off-diagonal elements are themselves processes.

In the SKI approach, FEPs and Influences - interactions between pairs of FEPs, are shown in a Process Influence Diagram (PID); FEPs are represented as boxes and Influences by lines connecting boxes. To accommodate the different sections (Silo, BMA, BTF, BLA) and barriers of each section of the repository, sub-sections of the complete PID, often with similar FEPs and Influences, represent these sections and barriers, with some similarity to the diagonal elements of the RES matrix.

The slightly different ways of representing FEPs and Influences means that it is not always straightforward to compare "like" with "like". For example, the off-diagonal elements of the SKB RES matrix are usually processes which can be compared with either FEPs or Influences in the SKI methodology. This is why the comparison has not been restricted to FEPs alone, but has addressed, where necessary, certain Influences.

## 2.2 Results of Top-Level Review

The results of the comparison of FEPs in SKB's RES matrix with SKI FEPs (and Influences) are summarised in the spreadsheets shown in Appendix A, Tables A-1 (near-field) and A-2 (geosphere/far-field). Similarly, comparison with SSI FEPs for the biosphere is shown in Table A-3. The contents of these tables need some supporting explanation, as provided below.

- *Column 1*: The entries in the left-hand column of the spreadsheets are generally headings taken from Chapter 4 of SKB [2001]. These headings match various FEP entries in the corresponding RES matrix (near-field and geosphere).
- *Columns 2-4* are relevant to the off-diagonal elements of the RES matrix for near-field and geosphere, and identify where in the RES matrix these FEPs can be found.

[1] To all extents and purposes, the geosphere defined by SKB is the same as the far-field as used in Stenhouse et al. [2001].

[2] Rock Engineering Systems.

Furthermore, Columns 2-4 give an indication of whether these FEPs have been treated by SKB in the PA, viz.

- Entries under Column 2 ("Treated") correspond to FEPs which are specified by SKB as "important interactions", red or pink[3] colour coding, and treated in the PA (supporting text in Appendix F in SKB [2001]);
- Entries under Column 3 ("Possibly") are designated by SKB as "probably part of the assessment", yellow colour coding;
- Entries under Column 4 ("NOT") are designated by SKB as having "negligible influence on other parts of the process system", green colour coding, and were not considered in the PA.

Thus, Columns 2 and 3 are useful in the more in-depth review discussed in Section 3.

- Column 5: contains the page number reference for the FEP heading in SKB [2001].
- Column 6 (COMMENT): various brief comments are provided to indicate how a FEP was treated by SKB in the assessment, based on the text discussion in SKB [2001]. In this column, the coding for the abbreviations is:
  - *IND ($K_d$, $D_e$)*: indirectly considered via pessimistic choice of data ($K_d$, $D_e$);
  - *IND (DS)* = indirectly considered via selection of input data;
  - *IND (CC)* = indirectly considered via selection of calculational cases;
  - *NOT specific* = not specifically included in quantitative analysis, i.e. ignored.
- Column 7: the right-hand column of Tables A-1, A-2 and A-3 indicates which SKI FEPs (or Influences) correspond to the SKB FEP, and includes the diagram reference level in the SKI report [Stenhouse et al., 2001]. SKI FEPs and Influences are provided in a series of drawings as output from SPARTA, the software tool used to develop the PID [Jack and Hillier, 1999]. The layout of the individual drawings is given on pages Annex II-2 and III-3 of Stenhouse et al. [2001]. Here, in Tables A-1 and A-2, the coding L2, L3 etc. refers to the hierarchical level of the drawing in which a FEP or Influence can be found – Level 2, Level 3 etc.

## 2.3 Summary of Top-Level Review

### 2.3.1 Near-Field

In the near-field, a few SKB FEPs were not included in SKI's assessment, *viz.*

- Osmosis
- Heat-generating reactions
- Heat conduction
- Water pressure (influence on stress conditions)
- Advection (advective transport of microbes)

[3] A pink colour was used by SKB to describe important interactions "only in the water saturation phase".

- Capillary suction.

Of these, "Heat-generating reactions", "Heat conduction" and Water pressure" were not considered further in the SKB assessment. Similarly, the two-phase flow aspects of saturation were ignored. Of the remaining FEPs, it is not clear from the text in SKB [2001] to what extent osmosis and the advective transport of microbes were taken into account in SKB's assessment.

A few SKB FEP titles were not identified explicitly in SKI's FEP titles, although these may be considered as part of the description under existing SKI FEPs, *i.e.* at a different level of detail, *viz.*

- Ion exchange (considered under SKI's "Degradation and alteration of bentonite backfill")
- Dispersion of clay particles (bentonite barriers) (considered under "Degradation and alteration of bentonite backfill").

Finally, the SKB FEP "Methylation/transformation" was not included in SKI's near-field FEP list, although degradation of organic waste to radioactively-contaminated methane was considered by SKI in the assessment calculations involving gas.

### 2.3.2 Far-Field/Geosphere

Of the far-field FEPs, important processes (interactions) involving seals were not identified in the SKI assessment. Only the possibility of the degradation of a shaft or tunnel seal was considered. However, SKB also did not analyse in detail processes associated with seals or plugs because the material(s) to be used had not been selected.

Some SKB FEPs were not included explicitly, owing to the level of detail provided in the SKI FEPs, *viz.*

- "Ionic strength effects" (Access tunnels and boreholes) (= Influences on "Water chemistry").
- "Redistribution of particles in flowing water" (= "Degradation and alteration of backfill").

Finally, the following SKB FEPs were not included in SKI's FEP list:

- Microbial degradation.
- Water pressure.
- Radon generation.
- Methylation/transformation.

### 2.3.3 Biosphere

Comparison of FEPs within the Biosphere is more complicated than within the near-field or geosphere, because only general FEP titles are given as section headings in Egan *et al.* [2001]. The discussion under each heading normally provides a good indication of the detail considered under each of these FEP titles. For example, an off-diagonal element in SKB's RES matrix such as "Change in water content (Quaternary deposits)" can be matched with the text "soil water content" under the heading **Soils and sediments** in Egan et al. [2001]. Inevitably, because of the different approaches to FEP identification, many of the entries in the SSI column in Table A-3 contain "NOT included explicitly" although it is likely that the FEP was addressed in some way in the biosphere assessment.

Certainly, based on a review of Egan et al. [2001], individual components of the ecosystem do not appear to have been identified explicitly in the SSI study, although involvement of different species in the transfer of radioactive contaminants through the food chain is considered in SSI's biosphere assessment. The general conclusion is that a more detailed review of how SKB FEPs are treated would be necessary in order to establish the level of agreement between SSI and SKB. Based on the review conducted here, SKB's biosphere appears to be more detailed in terms of the number of different species identified.

## 2.4 Comparison of SKI FEPs with SKB FEPs

For completeness, the SKI FEPs listed in Appendices C (Near-Field) and E (Far-Field) in Stenhouse et al. [2001] were compared with SKB's FEPs to identify whether or not any SKI FEPs had been omitted by SKB. This comparison is shown in Table A-4. In fact, there are no major omissions. "Gas generation" does not appear in SKB's RES Matrix for the geosphere (apart from "Radon generation"), but this is in line with SKI's revised FEP list in which this FEP title was renamed "Bulk gas".

# 3 Mapping of SKB FEPs/Interactions to Information Flow Diagrams

The final stage in the review process involved examination of the FEPs identified by SKB as important and part of the PA calculations, to see if these FEPs had been treated in the assessment. In this case, the examination was confined to the near-field and geosphere. The more detailed examination involved an attempt to map these important FEPs to the corresponding Information Flow Diagrams developed by SKB, *i.e.* Figures 5-2 and 5-3 in SKB [2001]. These diagrams are intended to show the information exchange between different analyses; repository performance (Figure 5-2) and geosphere performance (Figure 5-3).

Tables A-1 and A-2 were checked to see if each process or interaction identified as being included in the PA (Column 2 /"Treated" and Column 3/"Possibly" in Tables A-1 and A-2) had in fact been treated, according to the information provided in Figures 5-2 and 5-3. It should be noted that this check should not be regarded as a full audit. However, it was felt that the review should at least identify any major omissions.

The results of the review are shown in Tables A-5 (near-field) and A-6 (geosphere). The three left-hand columns of Tables A-1 and A-2 have been retained for reference purposes. An entry in the fourth column (Figure 5-2 or 5-3) notes whether the FEP has been considered in the corresponding Information Flow Diagram and the right-hand column contains additional input from SKB [2001] that has some bearing on the treatment of FEPs in the subsequent assessment calculations.

Of the FEPs that were designated by SKB as important and, therefore, to be included in the assessment, the text indicates that in certain cases the FEPs were *not* considered in the quantitative analysis.

- Examples for the near-field are:
  - the impact of "Rock fallout/redistribution" on the concrete backfill and concrete structures;
  - the impact of "Diffusion" on water composition;
  - the impacts of "Colloids" (colloid transport judged to be negligible for Silo, BMA and BTF vaults due to the filtering effect of the barriers); and
  - the impact of "Osmosis" on hydrology.

- Examples for the geosphere are:
  - the impact of "Dissolution/precipitation on the function of shotcrete and backfill in tunnels and boreholes;
  - the impact of "Redistribution of stress" on the rock matrix and fractures;
  - the impact of "Gas flow and saturation" on hydrology;
  - any impacts of "Gas pressure";
  - the impact of "Water pressure" on gas distribution and movement;
  - the impact of "Dissolution/precipitation" on radionuclide distribution (precipitation of radionuclides and toxicants is not expected due to low concentrations).

Generally, as discussed in SKB [2001], potential impacts of "Microbial activity/growth" throughout the near-field and geosphere were ignored in the quantitative assessment, although values selected for corrosion and degradation rates were intended to reflect the influence of microbially-catalysed chemical reactions.

Finally, there is no evidence in either Figures 5-1, 5-2 or 5-3 of any coupling between gas and water pathways (e.g. the impact of gas pressure on water movement) although processes affecting gas generation and transport are discussed in a separate report (Moreno *et al.* [2001]).

Clearly from the findings presented in Tables A-5 and A-6, however, the level of detail provided in the Information Flow Diagrams is not sufficient to identify how every FEP is treated in SKB's assessment.

# 4 Summary Comments

SKB [2001] provided the main source of information in the review of FEPs. This report was not reviewed in detail[4] – only those sections discussing FEPs or elements within SKB's interaction matrices for near-field, geosphere and biosphere. As such, the level of documentation is considered to be relatively detailed, providing thorough documentation of the nature of each FEP, which ones were included in the assessment, which ones were not, and why not.

What is lacking in SKB [2001], however, is a clear indication of how each FEP considered initially by SKB as being important and, therefore, included as part of the assessment, is actually treated or carried forward, *i.e.* mapped to the assessment calculations. This report (SKB [2001]) appears to be the ideal medium for reporting this information.

[4] The report has been reviewed elsewhere.

# References

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Jack, J.P. and Hillier, J.E. (1999). Sparta User Guide, Sparta Version 2, QuantiSci Report SKI-6145A-1, Version 1.1.

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Stenhouse M.J., Chapman, N.A. and Miller, W.M. (2001). System Studies in PA: Development of Process Influence Diagram (PID) for SFR- Repository: Near-Field + Far-Field. *SKI Report* 01:30. Swedish Nuclear Power Inspectorate, Stockholm, Sweden.

# Appendix: Tables Summarising FEP Comparison and Review

Table A-1: Comparison of SKB FEPs with SKI FEPs (and Influences): Near-Field.

Table A-2: Comparison of SKB FEPs with SKI FEPs (and Influences): Geosphere.

Table A-3: Comparison of SKB FEPs with SKI FEPs (and Influences): Biosphere.

Table A-4: Comparison of SKI FEPs with SKB FEPs.

Table A-5: Review of SKB RES Matrix FEPs with SKB's Information Flow Diagram: Near-field (Figure 5-2, SKB Report R-01-13[5]).

Table A-6: Review of SKB RES Matrix FEPs with SKB's Information Flow Diagram: Geosphere (Figure 5-3, SKB Report R-01-13).

[5] SKB Report R-01-13, Swedish Nuclear Fuel and Waste Management Co, Stockholm, 2001.

# Table A-1: Comparison of SKB FEPs with SKI FEPs (and Influences): Near-Field

| NEAR-FIELD FEPs SKB FEP Name | <===== RES MATRIX =====> | | | SKB Report R-01-13 on Page | COMMENT | EQUIVALENT OR CORRESPONDING SKI FEP TITLES |
|---|---|---|---|---|---|---|
| **DIAGONAL ELEMENTS** | | | | | | |
| Waste/cement matrix | | **1.1** | | 41, 42 | | Waste package [L2], Properties of waste package [L3] |
| Waste/bitumen matrix | | **2.2** | | 41, 42 | | Waste package [L2], Properties of waste package [L3] |
| Waste/non-solidified | | **3.3** | | 41, 42 | | Waste package [L2], Properties of waste package [L3] |
| Concrete packaging | | **4.4** | | 41 | | Waste package [L2], Properties of waste package [L3] |
| Steel packaging | | **5.5** | | 41 | | Waste package [L2], Properties of waste package [L3] |
| Concrete backfill | | **6.6** | | 41 | | Porous concrete(grout) [L2), Properties of porous concrete FEPs [L3] |
| Concrete structure | | **7.7** | | 41 | | Reinfirced concrete shell [L2], Properties of reinforced concrete shell [L3] |
| Bentonite barriers | | **8.8** | | 41 | | Bentonite backfill [L3], Properties of bentonite backfill [L4], Sand-bentonite backfill [L3], Properties of sand-bentonite backfill [L4] |
| Vaults and backfill | | **9.9** | | 41 | | Silo secton [L2], BLA Section [L2], BTF Section [L2], BMA Section [L2], Sand backfill [L3], Properties of sand backfill [L4] |
| Water composition | | **10.10** | | 41 | | Groundwater composition [L4], Porewater composition [L4], Water chemistry [L4], Colloid generation [L4] |
| Hydrology | | **11.11** | | 41 | | Groundwater flow [L3], Water movement in and through waste package [L3] |
| Gas | | **12.12** | | 41 | | Gas FEPs [L3], Gas generation [L4], Gas pressure and flow [L3, L4] |
| Temperature | | **13.13** | | 41 | | Temperature and heat transfer [L3] |
| Stress conditions | | **14.14** | | 41 | | Mechanical properties (including stress distribution) [L4] |
| Biological state | | **15.15** | | 41 | | Microbial activity [L4] |
| Radionuclide and toxicants | | **16.16** | | 41 | | Transport and release of radionuclides [L3], Composition of waste, waste matrix and container [L4] |
| **OFF-DIAGONAL ELEMENTS** | **Treated** | **Possibly** | **NOT** | | | |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR DIFFERENT WASTE FORMS (CEMENT MATRIX, BITUMEN MATRIX, NON-SOLIDIFIED); 1.1, 2.2, 3.3** | | | | | | |
| Recrystallisation/mineralisation | 1.1 | | | 42 | IND. (Kd, De) | Degradation of waste package [L4] (+ L5 FEPs); Influences on Properties of waste package [L3] |
| Expansion/contraction of waste | 1.14, 2.14 | 4.3,5.3 | 1.4,1.5,2.5 3.4,3.5,3.14 4.1,5.1,5.2 | 42/43 | | Properties of waste package [L3], Degradation of waste package [L4] (+ L5 FEPs), Influence of Microbial activity on Degradation of waste package [L4] |
| Water uptake (Water flow, capillary suction) | 1.10,2.11,3.11 10.1,10.2,11.1 11.2 | 10.3 | 11.3 | 43 | | Saturation of waste package [L4] |
| Chemical and microbial degradation | 1.10,2.10,3.10 10.1,10.2 11.1, 11.2 | 10.3 | 11.3 | 43 | Kd/De + Gas | Degradation of waste package [L4] (+ L5 FEPs), porous concrete [L4], concrete shell [L4]; Influences on Properties of waste package [L3], porous concrete [L3], concrete shell [L3] Degradation of waste package on Gas generation [L4] |
| Corrosion of metals | 1.12, 3.12 10.1,11.1 | 10.3 | 11.3 | 44 | Gas | Corrosion of metallic waste [L5], Corrosion and degradation of waste container [L5] |
| Dissolution/precipitation | 1.10,2.10,3.10 10.1, 10.2 | 10.3 | | 44 | Cement | Precipitation & dissolution [L4] |
| Cracking | 14.1, 14.2 | | 14.3 | 44/45 | IND. | Degradation of waste package [L4] (+ L5 FEPs); Influence on Mechanical stress distribution [L4] Influences on Properties of waste package [L3], porous concrete [L3], concrete shell [L3] |
| Microbial activity/growth | 1.15,2.15,3.15 | 15.1,15.2,15.3 | | 45 | Ignored | Microbial activity, waste package [L4] |
| Irradiation | | 16.1,16.2,16.3 | | 45 | Insignificant | Radiolysis in waste package - Silo only [L4] |

## Table A-1 (continued): Comparison of SKB FEPs with SKI FEPs (and Influences): Near-Field

| NEAR-FIELD FEPs (continued) SKB FEP Name | <===== RES MATRIX =====> Treated | Possibly | NOT | SKB Report R-01-13 on Page | COMMENT | SKI FEP Title |
|---|---|---|---|---|---|---|
| **OFF-DIAGONAL ELEMENTS** | **Treated** | **Possibly** | **NOT** | | | |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR CONCRETE AND STEEL PACKAGING; 4.4, 5.5** | | | | | | |
| Recrystallisation | 4.4 | | | 46 | IND. (Kd, De | Corrosion and degradation of waste container [L5]; Influence on Properties of waste package [L3] |
| Expansion/contraction of packaging | 4.14, 5.14 | 4.9, 5.9 | 4.6,5.6,6.4 6.5,9.4,9.5 | | | Properties of waste package [L3], Degradation of waste package [L4] (+ L5 FEPs), |
| Water uptake (Water flow, capillary suction) | 4.11, 5.11 | | | --- | | Saturation of waste package [L4] |
| Corrosion | 4.12,5.12 | | 11.4, 11.5 | 46 | Rebar | Corrosion and degradation of waste container [L5]; Influence on Properties of waste package [L3] |
| Cracking/deformation | 14.4 | 14.5 | | 46 | IND. | Corrosion and degradation of waste container[L5];Influence on Mechanical properties of waste package[L4] |
| Microbial growth | | 4.15,15.4,15.5 | 5.15 | 47 | Ignored | Microbial activity, waste package [L4] |
| Irradiation | | | 16.4, 16.5 | --- | | Influence of Radioactive decay in waste on Degradation of waste form [L5] |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR CONCRETE BACKFILL AND CONCRETE STRUCTURES; 6.6, 7.7** | | | | | | |
| Recrystallisation/mineralisation | 6.6, 7.7 | | | 47 | IND. (Kd, De | Degradation and alteration of porous concrete [L4], reinforced concrete structure [L4]; Influences on Properties of porous concrete [L3], reinforced concrete shell [L3] |
| Expansion/contraction | 6.14, 6.15 | | 6.5, 7.5 | | | Degradation of shell, concrete base [L4] |
| Water uptake (Water flow, capillary suction) | 6.11, 7.11 | | | | | |
| Corrosion | | | | 47 | IND. (k) | Degradation and alteration of porous concrete [L4], reinforced concrete structure [L4]; Influences on Hydrogeological properties of porous concrete [L4], reinforced concrete shell [L4] |
| Dissolution/precipitation | 6.10, 7.10 | | 11.6, 11.7 | 48 | | Precipitation & dissolution, porous concrete [L4], reinforced concrete shell [L4] |
| Cracking | 14.6, 14.7 | | | 48 | DS, CC | Degradation and alteration of porous concrete [L4], reinforced concrete structure [L4]; Influences on Hydrogeological properties of porous concrete [L4], reinforced concrete shell [L4] |
| Rock fallout/redistribution | 14.7 | | | 48 | NOT specifi | Mechanical properties (including stress distribution) of porous concrete [L4], Mechanical properties (including stress distribution) of reinforced concrete shell [L4]; Influences on Properties of porous concrete [L4], reinforced concrete shell [L4] |
| Microbial growth | | 6.15, 7.15 15.6, 15.7 | | 48 | Ignored | Microbial activity, porous concrete [L4], reinforced concrete shell [L4] |
| **OFF-DIAGONAL ELEMENTS** | **Treated** | **Possibly** | **NOT** | | | |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR BENTONITE BARRIERS; 8.8** | | | | | | Applicable to bentonite backfill and bentonite-sand backfill |
| Bentonite expansion and contraction | 9.8 | 7.8, 8.9 | 13.8 | 48/49 | IND. (CC) | Swelling of bentonite in backfill [L5]; Influences on Degradation and alteration of backfill [L5], and Properties of near-field rock [L4]; NOT on Degradation and alteration of reinforced concrete shell [L4] |
| Expansion/contraction | 8.14 | | | | | Selling of bentonite [L4] |
| Water uptake (Water flow, capillary suction) | 8.11 | | | 49 | Simplified | Resaturation of backfill [L5]; Influences on Properties of backfill [L4] |
| Montmorillonite transformation | 10.8 | | | 49/50 | IND. (k) | Degradation and alteration of backfill [L5]; Influences on Properties of backfill [L4] |
| Dissolution/precipitation | 8.10, 10.8 | | | 50 | IND. (k) | Precipitation & dissolution of backfill [L5]; Influence on Properties of backfill [L4] |
| Ion exchange | 8.10, 10.8 | | | 50 | IND. (DS, CC | NOT explicitly; Degradation and alteration of backfill [L5], Influences on Mineralogy [L5] and on Properties of backfill [L4] |
| Dispersion of clay particles | 18.8 | | | 50/51 | CC | NOT included explicitly; Degradation and alteration of backfill [L5], Influence on Properties of backfill [L4] |
| Microbial growth | 8.15 | 15.8 | | 51 | Ignored | Microbial activity, backfill [L5] |
| Colloid filtering | 8.16 | | | | | Colloid filtration [L5] |

# Table A-1 (continued): Comparison of SKB FEPs with SKI FEPs (and Influences): Near-Field

| NEAR-FIELD FEPs (continued) SKB FEP Name | <===== RES MATRIX =====> Treated | Possibly | NOT | SKB Report R-01-13 on Page | COMMENT | SKI FEP Title |
|---|---|---|---|---|---|---|
| **OFF-DIAGONAL ELEMENTS** | | | | | | |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR VAULTS AND BACKFILL (INCLUDES SAND LAYER ABOVE CONCRETE LID, SILO, AND GAS VENTS); 9.9** | | | | | | |
| Expansion/contraction | | | 9.14, 13.9 | 51 | Ignored | Structural geomtery properties, sand backfill [L5], reinforced concrete shell [L4], concrete base [L4] |
| Redistribution of backfill | | 14.8 | | 51/52 | | Degradation and alteration of crushed rock [L4]; Influence on Advective & dispersive transport of radionuclides in groundwater [L4] |
| Bentonite intrusion | | 8.9 | | 52 | Ignored | NOT considered with regard to sand layer |
| Dissolution/precipitation | 9.10, 10.9 | | | 52 | IND. (porosi | Precipitation & dissolution [L5]; Influences on Properties of crushed rock (mineralogy, hydrogeological properties) |
| Microbial growth | | 9.15, 15.9 | | 52 | Ignored | Microbial activity, crushed rock [L4]; Influence on Colloid generation and transport [L4] |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR WATER COMPOSITION (INCLUDING COLLOIDS/PARTICLES AND DISSOLVED GAS); 10.10** | | | | | | |
| Dissolution/precipitation | 10.16,10.1,10.4,10.5,10.6 10.7,10.8,10.9 | 10.3 | | 52/53 | IND. (DS, CC | Precipitation & dissolution, various compartments [L4, L5] |
| Degradation of organics | 10.12, 10.16 | | | 53 | | Degradation of organic waste [L5]; Influences to Water chemistry [L4], Colloid generation [L4] |
| Corrosion | 10.12 | | | 54 | | Corrosion of metallic waste [L5], Corrosion and degradation of waste container [L5]; Influences on Redox heterogeneity [L4], Water chemistry[L4] |
| Sorption | 10.16 | | | 54 | IND. (DS, CC | Radionuclide sorption [L4]; Influence on Water chemistry [L4]; I nfluence of Degradation of waste package [L4] on Radionuclide sorption |
| Diffusion | 10.16 | | | 54 | | Diffusion of radionuclides [L4]; Influence on Water chemistry [L4] |
| Advection and mixing | 10.11 | | | 54 | | NOT included explicitly; Influence of Groundwater flow [L4] on Water chemistry [L4] |
| Erosion/colloid formation/colloid transport | 10.10, 10.10 | | | 55 | IND. (DS, CC | NOT considered explicitly for bentonite erosion; Colloid generation, bentonite backfill [L4]; Influence on Colloid transport [L4]; Influences on Filtration [L5] |
| Microbial activity | 10.15, 15.10 | | | 55 | Ignored | Microbial activity [L4] |
| Gas dissolution/degassing | 10.12 | | | 56 | IND. (DS, CC | NOT included explicitly; incorporated in Gas pressure and flow [L4] |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR HYDROLOGY (MAGNITUDE, DIRECTION AND DISTRIBUTION OF WATER FLOW; 11.11** | | | | | | |
| Two phase flow and saturation | 11.12 | | | 56 | | NOT included explicitly; Gas pressure and flow [L4], Gas-mediated radionuclide transport [L4], and Advective & dispersive transport of radionuclides in groundwater [L4] |
| Osmosis | 10.11 | | | 57 | | NOT considered |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR GAS FORMATION AND MOVEMENT; 12.12** | | | | | | |
| Gas generation through degradation of organic material | 1.12, 3.12 | 2.12 | | 57 | | Influence of Degradation of organic waste [L5] on Gas generation, waste package [L4] |
| Gas generation through metal corrosion | 1.12,3.12,5.12 | | | 57/59 | | Influences of Corrosion of metallic waste [L5], Corrosion and degradation of waste container [L5] on Gas generation, waste package [L4] |
| Gas generation through radiolysis | | 16.12 | | 58 | Bitumen | Influence of Radiolysis in waste package (Silo) [L4] on Gas generation, waste package [L4]; neglected |
| Gas flow | 1.12,3.12,4.12 5.12,6.12,7.12 8.12,9.12 | | | 58/59 | | Gas pressure and flow, various compartments [L4] |
| Expansion/contraction | | | 13.12 | 59 | | Influence of Gas pressure and flow [L4] on Water movement, waste package [L3], Groundwater flow [L3] |

## Table A-1 (continued): Comparison of SKB FEPs with SKI FEPs (and Influences): Near-Field

| NEAR-FIELD FEPs (continued) SKB FEP Name | <===== RES MATRIX =====> | | | SKB Report R-01-13 on Page | COMMENT | SKI FEP Title |
|---|---|---|---|---|---|---|
| **OFF-DIAGONAL ELEMENTS** | **Treated** | **Possibly** | **NOT** | | | |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR TEMPERATURE; 14.14** | | | | | | |
| Heat-generating reactions | | 16.13 | | 59 | Al only | NOT considered |
| Heat conduction | | Column 13 | | 59 | | NOT considered |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR MECHANICS - STRESS CONDITIONS; 14.14** | | | | | | |
| Expansion/contraction | Column 14 | | | 60 | DS, CC | Influence of Degradation of Waste package on Mechanical properties of waste package [L4] |
| Water pressure | | | 14.11 | 60 | | NOT considered |
| Gas pressure | 12.14 | | | 61 | | Influence of Gas pressure on Mechanical properties of waste package [L4] |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR BIOLOGICAL STATE; 15.15** | | | | | | |
| Microbial activity | Column 15 | | | 61 | | Microbial activity, various compartments [L4] |
| Advection | 11.15 | | | 61/62 | | NOT considered |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR RADIONUCLIDES AND TOXICANTS; 16.16** | | | | | | |
| Dissolution/precipitation | 1.16, 2.16 3.16, 10.16 | | | 62 | | Precipitation & dissolution, various compartments [L4] [L5] |
| Degradation of organic matter | 1.16, 2.16 3.16, 10.16 | | | 62 | | Influence of Degradation of waste packae on Water chemistry of waste package [L4] |
| Advection | 11.16 | | | 62 | | Influence of Groundwater-mediated transport of radionuclides on Distribution&release |
| Dispersion | 11.16 | | | 62 | | Influence of Groundwater-mediated transport of radionuclides on Distribution&release |
| Diffusion | 11.16 | | | 63 | DS, CC | Influence of Diffusion on Distribution and release of radionuclides [L4] |
| Sorption | 11.16 | | | 63 | | Influence of Sorption on Distribution and release of radionuclides [L4] |
| Colloid transport and filtering | 9.16 | | | 64 | | Influence of Colloid transport on Distribution and release of radionuclides [L4] |
| Advection of radioactive gas | 12.16 | | | 64 | | Influence of Gas-mediated radionuclide transport on Distribution and release of radionuclides [L4] |
| Methylation/transformation | 15.16 | | | 64 | | NOT considered explicitly but conservative assumptions about radioactive methane generation |
| Radioactive decay | 16.16 | | | 65 | | Influence of radioactive decay and ingrowth on Distribution and release of radionuclides [L4] |

# Table A-2: Comparison of SKB FEPs with SKI FEPs (and Influences): Geosphere

| GEOSPHERE FEPs SKB FEP Name | <===== RES MATRIX =====> | | | SKB Report R-01-13 on Page | COMMENT | SKI FEP Title |
|---|---|---|---|---|---|---|
| **DIAGONAL ELEMENTS** | | | | | | |
| Silo (Bounday condition) | 1.1 | | | 66 | | Silo; Layout/barriers incorporated in modeling |
| BMA (Boundary condition) | 2.2 | | | 66 | | BMA; Layout/barriers incorporated in modeling |
| BTF (Boundary condition) | 3.3 | | | 66 | | BTF; Layout/barriers incorporated in modeling |
| BLA (Boundary condition) | 4.4 | | | 66 | | BLA; Layout/barriers incorporated in modeling |
| Tunnels/boreholes/backfill | 5.5 | | | 66 | | Shafts and tunnels; Crushed rock backfill components of Repository zone |
| Plugs (concrete/bentonite) | 6.6 | | | 66 | | NOT included explicitly; Shaft and tunnel seal degradation in original PID |
| Repository rock matrix | 7.7 | | | 66 | | Near-field rock component [L2] of Repository zone [L1] |
| Repository rock fracture system | 8.8 | | | 66 | | NOT included explicitly; Near-field rock [L2] component of Repository zone [L1], plus Properties of near-field rock [L3] |
| Rock | 9.9 | | | 66 | | NOT included explicitly; Near-field rock [L2] component of Repository zone [L1], plus Properties of near-field rock [L3] |
| Water composition | 10.10 | | | 66 | | Groundwater chemistry [L4], Colloid generation [L4] |
| Hydrology | 11.11 | | | 66 | | Groundwater flow, near-field rock [L3], fa-field rock [L1] |
| Gas | 12.12 | | | 66 | | Gas flow and pressure, far field [L1], shafts and tunnels [L3] |
| Temperature | 13.13 | | | 66 | | Temperature and heat transfer, far field [L1], shafts and tunnels [L3] |
| Stress conditions | 14.14 | | | 66 | | Mechanical properties of rock (+ stress distribution), far field [L2], shafts and tunnels [L4] |
| Biological state | 15.15 | | | 66 | | Microbial activity, far field [L2], shafts and tunnels [L4] |
| Radionuclide and toxicants | 16.16 | | | 66 | | Transport and release of radionuclides, far field [L1], shafts and tunnels [L3] |
| Biosphere (Boundary condition) | 17.17 | | | 66 | | Geosphere-biosphere interface [L0] |
| External rock (Boundary condition) | 18.18 | | | 66 | | NOT included explicitly; presumably boundary condition in modelling |
| **OFF-DIAGONAL ELEMENTS** | **Treated** | **Possibly** | **NOT** | | | |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR ACCESS TUNNELS AND BOREHOLES (INCLUDING BACKFILL, SHOTCRETE AND ROCK BOLTS); 5.5** | | | | | | **Crushed rock backfill and Near-field rock are relevant for this section** |
| Dissolution/precipitation | 5,10, 11.5 | 10.5 | | 67 | Neglected | Precipitation &dissolution, shafts and tunnels [L4], crushed rock backfill [L4] |
| Ionic strength effects | | 10.5 | | 68 | Ignored | NOT included explicitly; Influence of Groundwater chemistry, far field [L3] and near-field rock [L4] on Groundwater chemistry, bentonite backfill [L5] |
| Redistribution of particles in flowing water | | | 6.5 | 68 | Discarded | NOT included |
| Microbial activity | | 5.15, 15.5 | | 68 | Ignored | Microbial activity, far field [L2], shafts and tunnels [L3] |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR PLUGS (BENTONITE/CONCRETE); NOTE - FINAL SELECTION OF MATERIALS TO BE MADE!; 6.6** | | | | | | **ONLY Shaft and tunnel seal degradation included in original PID; Rock properties, shafts and tunnels [L3]** |
| Water uptake in bentonite (capillary suction) | 6.11 | | | 68 | Not analysed | --- |
| Bentonite expansion/dispersion | 5.6,6.14,8.6 | | 6.8 | 68 | in detail | --- |
| Recrystallisation | 6.6 | | | 69 | Not analysed | --- |
| Cracking of concrete in plugs | 14.6 | | | 69 | in detail | --- |
| Corrosion (of reinforcement) | 6.12,10.6,11.5 | | | 69 | Not analysed | --- |
| Dissolution/precipitation | 6.10,10.6,11.6 | | | 69 | in detail | --- |
| Ion exchange and sorption | 6.10, 10.6 | | | 69 | Not analysed | --- |
| Microbial activity | | 15.6 | 6.15 | 69 | in detail | --- |

# Table A-2 (continued): Comparison of SKB FEPs with SKI FEPs (and Influences): Geosphere

| GEOSPHERE FEPs SKB FEP Name | <===== RES MATRIX =====> Treated | Possibly | NOT | SKB Report R-01-13 on Page | COMMENT | SKI FEP Title |
|---|---|---|---|---|---|---|
| **OFF-DIAGONAL ELEMENTS** | | | | | | |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR REPOSITORY AND ROCK ROCK MATRIX AND FRACTURES; 7.7, 8.8, 9.9** | | | | | | |
| Dissolution/precipitation | 7.10,8.10.9.10 | | 11.7,11.8, | 69/70 | | Precipitation & dissolution, far field [L3]; Influences on Mineralogy [L3], |
| | 10.7,10.8,10.9 | | 11.9 | | | Hydrogeological properties of rock [L3] |
| Redistribution of stress | 7.14, 8.14 | | | 70 | Ignored | Mechanical properties of rock (+ stress distribution) |
| Microbial growth | | 15.7,15.8,15.9 | 7.15 | 70 | Discarded | Microbial activity, rock [L2]; Influence on Groundwater composition [L2] |
| | | 14.7,14.8,14.9 | | | | |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR WATER COMPOSITION; 10.10** | | | | | | |
| Dissolution/precipitation | [5 to 9].10 | | | 69/70 | IND. (DS, CC) | Precipitation & dissolution, far field [L3]; Influences on Mineralogy [L3], |
| | 10.[6 to 9] | | | | | Hydrogeological properties of rock [L3] |
| Diffusion | 10.16 | | | 71 | No quantitative ma | Matrix diffusion of radionuclides [L2]; Influence from Hydrogeological properties of rock [L2] |
| | [5 to 9].10 | | | | | |
| Advection/dispersion | 11.1 | | | 71 | | Advective & dispersive transport of radionuclides in groundwater [L2]; |
| | | | | | | Influence on Groundwater composition [L2] |
| Colloid formation and transport | 10.10,10.16 | | | 71 | Conservative Ass | Colloid generation {l2], Colloid transport [L2] |
| Gas dissolution/degassing | 10.12, 12.10 | | | 71 | IND. | NOT included explicitly; Gas flow and pressure [L1] |
| Microbial degradation | 10.15, 15.10 | | | 72 | Ignored | NOT included explicitly; Influence of Microbial activity [L2] on Groundwater composition [L2] - |
| | | | | | | mainly Eh considered |
| Boundary conditions | | | | 72 | | Changing composition of groundwaters [L2]; Influence on Groundwater chemsitry [L2] |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR HYDROLOGY; 11.11** | | | | | | |
| Rock permeability and its distribution | Not explicit | | | 72 | | Hydrogeological properties of rock [L2] |
| Driving forces and salinity | 11.10 | | | 72 | SC - neglected | NOT included explicitly; Salt (or fresh) water intrusion included in External FEPs |
| Gas flow and saturation | 11.12 | | | 72/73 | Conservative ass | Gas flow and pressure [L1], Gas-mediated radionuclide transport [L2], Advective and dispersive trans- |
| | | | | | saturation time | port of radionuclides in groundwater [L2]; Influence of Gas flow and pressure on Groundwater flow[ L1] |
| Boundary conditions | | | | 73 | | NOT included explicitly; presumably similar boundary condition used for modelling |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR GAS (DISTRIBUTION AND MOVEMENT);INCLUDING NATURALLY OCCURRING RADIONUCLIDES; 12.12** | | | | | | |
| Gas permeability | 8.12, 9.12 | | | 73 | | Influence of Hydrogeological properties of rock [L2] on Gas flow and pressure [L1] |
| Gas pressure | | | 12.14 | 73 | | Gas flow and pressure [L1] |
| Water pressure | 12.11 | | | 73 | Neglected | NOT included explicitly; Influence of Groundwater flow on Gas flow and pressure [L1] |
| Radon generation | 8.12, 9.12 | | 7.12 | | | |
| Boundary conditions | | | | 74 | | Gas flow and pressure, various repository components [L3, L4] |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR ROCK MECHANICS; 14.14** | | | | | | |
| Properties affecting deformation and stability | 7.14, 8.14 | | 14.5 | 74 | | Influence of Mineralogy on Mechanical properties of rock (+ stress distribution) [L2] |
| Degradation of rock reinforcement | | | 14.5 | 74 | | Cave-in [L3]; Influence of Cave-in on Rock properties [L3] |
| Boundary conditions | | | | 74 | | NOT included explicitly; presumably similar boundary condition used for modelling |

## Table A-2 (continued): Comparison of SKB FEPs with SKI FEPs (and Influences): Geosphere

| GEOSPHERE FEPs SKB FEP Name | <===== RES MATRIX =====> Treated | Possibly | NOT | SKB Report R-01-13 on Page | COMMENT | SKI FEP Title |
|---|---|---|---|---|---|---|
| **OFF-DIAGONAL ELEMENTS** | | | | | | |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR BIOLOGICAL STATE; 15.15** | | | | | | |
| Microbial activity | Column 15 | | | 75 | Methylation | Microbial activity [L2]; Influence on Groundwater composition [L2] |
| Boundary conditions | | | | 75 | | NOT included explicitly; Microbial activity and Colloid transport in different secions of repository and far field |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR RADIONUCLIDES AND TOXICANTS (SOLID, LIQUID AND GAS PHASES); 16.16** | | | | | | |
| Advection/dispersion | 11.16 | | | 75 | | Advective & dispersive transport of radionuclides in groundwater [L2]; Influence from Groundwater flow [L1] |
| Diffusion and matrix diffusion | 7.16,8.16,9.16 | | | 75 | | Matrix diffusion of radionuclides [L2]; NOT Diffusion |
| Sorption | 5.16,7.16,8.16 9.16 | | 6.16 | 76 | | Radionuclide sorption [L2] |
| Dissolution/precipitation | 10.16 | | | 76 | Conserv. Ignored | Precipitation & dissolution [L2] |
| Transport with gas | 12.16 | | | 76 | | Gas-mediated radionuclide transport [L2] |
| Transport with colloids or microbes | 10.16 | | | 76 | CC | Colloid transport [L2] |
| Methylation/transformation | 15.16 | | | 77 | CC | NOT included in Far field; Influence of Degradation of organic waste [L5] on Gas generation, waste package [L4] |
| Radioactive decay | 16.16 | | | 77 | | Radioactive decay and ingrowth [L2] |
| Boundary conditions | | | | 77 | | Influences from Transport and release of radionuclides from different components of repository |

# Table A-3: Comparison of SKB FEPs with SKI FEPs (and Influences): Biosphere

| BIOSPHERE FEPs<br>SKB Report<br>FEP Name | <===== RES MATRIX =====> | | | SKB Report<br>R-01-13<br>on Page | SSI Report<br>FEP Title |
|---|---|---|---|---|---|
| **DIAGONAL ELEMENTS** | | | | | |
| Geosphere (Boundary condition) | **1.1** | | | 79 | Geosphere |
| Quaternary deposits | **2.2** | | | 79 | NOT included explicitly; Soils and sediments |
| Primary producers (of organic matter) | **3.3** | | | 79 | NOT included explicitly; Ecological communities (see text) |
| Decomposers | **4.4** | | | 79 | NOT included explicitly; Ecological communities (see text) |
| Filter feeders | **5.5** | | | 79 | NOT included explicitly; Ecological communities (see text) |
| Herbivores | **6.6** | | | 79 | NOT included explicitly; Ecological communities (see text) |
| Carnivores | **7.7** | | | 79 | NOT included explicitly; Ecological communities (see text) |
| Humans | **8.8** | | | 79 | Human community characteristics |
| NONE (foemerly Topography) | **9.9** | | | 79 | |
| Water in quaternary deposits | **10.10** | | | 79 | NOT explicitly included; Near-surface hydrogeology |
| Surface water | **11.11** | | | 79 | Surface Waters (fresh and marine) |
| Water composition | **12.12** | | | 79 | Not included explicitly |
| Gas/Atmosphere | **13.13** | | | 79 | Atmosphere |
| Temperature | **14.14** | | | 79 | Not included explicitly; Climate characteristics |
| Radionuclide and toxicants | **15.15** | | | 79 | Radionuclide contaminant factors ("other toxic species" included) |
| External conditions | **16.16** | | | 79 | Not included explicitly; presumably included in modelling |
| **OFF-DIAGONAL ELEMENTS** | **Treated** | **Possibly** | **NOT** | | |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR QUATERNARY DEPOSITS (2.2)** | | | | | |
| Relocation | 2.2 | | | 80 | Not mentioned explicitly; Topography and morphology; Natural cycling and distributi<br>Solid-phase transport phenomena |
| Bioturbation | 4.2 | 5.2 | 3.2, 6.2, 7.2 | 80 | Transport mediated by flora and fauna (redistribution and mixing of soils…..) |
| Change in water content | 10.2 | | | 80 | NOT mentioned explicitly; Soils and sediments "(soil water content") |
| Erosion | 10.2, 11.2 | | 13.2 | 80 | Environmental processes; Solid-phase transport phenomena |
| Sedimentation | 12.2 | | | 80 | Environmental processes; Solid-phase transport phenomena |
| External boundary - land rise | 16.2 | | | 81 | NOT mentioned explicitly; Topography and morphology ("time-dependent description…") |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR PRIMARY PRODUCERS OF ORGANIC MATTER (plants, algae, tress etc.) (3.3)** | | | | | **ECOLOGICAL COMMUNITIES NOT TREATED SEPARATELY** |
| Settlement, deposition | 2.3,<br>10.3 to 12.3 | | 13.3, 14.3 | 81 | Solid-phase transport phenomena |
| Feeding | 8.3 | | 6.3 | 81 | Transport mediated by flora and fauna ("consumption", "metabolism") |
| Stimulation/inhibition | 3.4, 3.6, 3.8,<br>5.3, 8.3 | | 3.5, 3.7<br>4.3, 6.3, 7.3 | 82 | NOT included explicitly; Ecological communities ("population dynamics");<br>presumably assumptions made in modelling re. specific populations |
| Water uptake | 10.3, 11.3 | | | 82 | NOT included explicitly; Ecological communities ("population dynamics");<br>presumably assumptions made in modelling re. specific populations |
| Light attenuation | 12.3 | | | 82 | NOT included explicitly; Ecological communities ("population dynamics");<br>presumably assumptions made in modelling re. specific populations |
| Insolation | 16.3 | | 3.14 | 82 | Climate characteristics ("solar radiation"); not considered directly applicable |
| Exposure | 15.3 | | | 82 | Exposure modes (but emphasis on humans) |
| Import and export | 16.3 | | | 82 | NOT included explicitly; closest of relevance is Changes to natural phenomena associated with<br>human actions ("modification of plant and animal communities…..") |

## Table A-3 (continued): Comparison of SKB FEPs with SKI FEPs (and Influences): Biosphere

| BIOSPHERE FEPs<br>SKB Report<br>FEP Name | <===== RES MATRIX =====> | | | SKB Report<br>R-01-13<br>on Page | SSI Report<br>FEP Title |
|---|---|---|---|---|---|
| **OFF-DIAGONAL ELEMENTS** | **Treated** | **Possibly** | **NOT** | | |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR DECOMPOSERS OF ORGANIC MATTER (bacteria, worms, snails, fungi etc.) (4.4)** | | | | | |
| | | | | | **ECOLOGICAL COMMUNITIES NOT TREATED SEPARATELY** |
| Settlement | 2.4, 10.4, 12.4, 14.4 | | 11.4, 13.4 | 83 | Solid-phase transport phenomena |
| Bioturbation | 4.2 | | | | Transport mediated by flora and fauna (redistribution and mixing of soils…..) |
| Consumption | 2.4 | | | 83 | Transport mediated by flora and fauna ("consumption", "metabolism") |
| Food supply | 5.4, 6.4 | 7.4 | 8.4 | 83 | NOT included explicitly; Ecological communities ("population dynamics") |
| Feeding | 5.4, 6.4 | 7.4 | 4.4, 8.4 | 83 | Transport mediated by flora and fauna ("consumption", "metabolism") |
| Stimulation/inhibition | 4.7, 5.4, 6.4, 12.4 | 7.4 | 4.4, 4.5, 4.6, 4.8, 8.4, 13 | 84 | NOT included explicitly; Ecological communities ("population dynamics"); presumably assumptions made in modelling concerning specific populations |
| Water uptake | 10.4 | | 11.4 | 84 | NOT included explicitly; Ecological communities ("population dynamics"); presumably assumptions made in modelling concerning specific populations |
| Exposure | 15.4 | | | | Exposure modes (but emphasis on humans) |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR FILTER FEEDERS (mussels, hydroids, sponges, insect larvae etc - filter water) (5.5)** | | | | | |
| | | | | | **ECOLOGICAL COMMUNITIES NOT TREATED SEPARATELY** |
| Settlement | 2.5, 11.5, 12.5, 14.5 | | | 84 | Solid-phase transport phenomena |
| Bioturbation | | 5.2 | | | Transport mediated by flora and fauna (redistribution and mixing of soils…..) |
| Stimulation/inhibition | 5.3, 5.4, 5.7, 5.8, 12.5, 14.5 | | 3.5, 4.5, 5.6, 6.5, 7.5, 8.5 | 84 | NOT included explicitly; Ecological communities ("population dynamics"); presumably assumptions made in modelling concerning specific populations |
| Exposure | 15.5 | | | 84 | Exposure modes (but emphasis on humans) |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR HERBIVORES (snails, insects, cows and sheep) (6.6)** | | | | | |
| | | | | | **ECOLOGICAL COMMUNITIES NOT TREATED SEPARATELY** |
| Settlement | 2.6, 11.6, 12.6, 14.6 | | 10.6, 13.6 | 85 | Solid-phase transport phenomena |
| Bioturbation | | | 6.2 | | Transport mediated by flora and fauna (redistribution and mixing of soils…..) |
| Consumption | 2.6 | | | 85 | Transport mediated by flora and fauna ("consumption", "metabolism") |
| Food supply, feeding | 3.6, 6.7, 6.8, 6.4, 8.6 | | 4.6, 5.6, 6.3, 6.5, 7.6 | 85 | NOT included explicitly; Ecological communities ("population dynamics") |
| Stimulation/inhibition | 3.6, 6.7, 6.8, 8.6, 12.6, 14.6, 6.4 | | 4.6, 5.6, 6.6, 7.6, 13.6, 6.3, 6.5 | 85 | NOT included explicitly; Ecological communities ("population dynamics"); presumably assumptions made in modelling concerning specific populations |
| Water uptake | 11.6 | | 10.6 | 85 | NOT included explicitly; Ecological communities ("population dynamics"); presumably assumptions made in modelling concerning specific populations? |
| Exposure | 15.6 | | | 85 | Exposure modes (but emphasis on humans) |

# Table A-3 (continued): Comparison of SKB FEPs with SKI FEPs (and Influences): Biosphere

| BIOSPHERE FEPs<br>SKB Report<br>FEP Name | <===== RES MATRIX =====> | | | SKB Report<br>R-01-13<br>on Page | SSI Report<br>FEP Title |
|---|---|---|---|---|---|
| **OFF-DIAGONAL ELEMENTS** | **Treated** | **Possibly** | **NOT** | | |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR CARNIVORES (e.g. fish, eagle, seal, fox, bird) (7.7)** | | | | | |
| | | | | | **ECOLOGICAL COMMUNITIES NOT TREATED SEPARATELY** |
| Settlement | 2.7, 11.7, 12.7, 14.7 | | 10.7, 13.7 | 86 | Solid-phase transport phenomena |
| Bioturbation | | | 7.2 | | Transport mediated by flora and fauna (redistribution and mixing of soils…..) |
| Food supply and feeding | 4.7, 5.7, 6.7 7.7, 7.8 | 7.4 | 7.5, 7.6, 8.7 | 86 | Transport mediated by flora and fauna ("consumption", "metabolism") |
| Stimulation/inhibition | 4.7, 5.7, 6.7 7.8, 12.7, 14.7 | | 3.7, 7.7, 8. 13.7 7.3, 7.5, 7.6 | 86 | NOT included explicitly; Ecological communities ("population dynamics"); presumably assumptions made in modelling concerning specific populations |
| Water uptake | 11.7 | | 10.7 | | NOT included explicitly; Ecological communities ("population dynamics"); presumably assumptions made in modelling concerning specific populations |
| Exposure | 15.7 | | | 86 | Exposure modes (but emphasis on humans) |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR HUMANS (8.8)** | | | | | |
| Settlement - living and building | 2.8,10.8, 11.8 12.8, 14.8 | | 1.8,13.8,14. | 87 | NOT mentioned explicitly; Human characteristics; presumably assumptions made concerning critical group |
| Food supply and feeding | 3.8, 5.8, 6.8 7.8, 8.3, 8.6 | | 4.8, 8.4, 8.5, 8.7 | 87 | Foodchain transfer |
| Materials supply | 2.8, 3.8, 5.8 | | 1.8, 4.8 | 87 | Exposure modes ("external irradiation…..building materials…") |
| Water use | 10.8, 11.8 | 8.10 | | 87 | Exposure modes; Drinking water and foodstuffs |
| Stimulation/inhibition | 3.8, 5.8, 6.8 7.8, 8.3, 8.6 | | 4.8,13.8,14. 8.4, 8.5, 8.7 8.8 | 87 | NOT mentioned explicitly; Human characteristics |
| Exposure | 15.8 | | | 88 | Exposure modes |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR WATER IN QUATERNARY DEPOSITS (10.10)** | | | | | |
| Water transport | 2.10, 12.10, 13.1 | | | 88 | Water-borne transport phenomena |
| Water uptake | 10.3, 10.4 | | 10.6, 10.7 | --- | Water-borne transport phenomena |
| Recharge/discharge | 10.1, 11.10, 10.11 | | 1.10 | 88 | Water-borne transport phenomena |
| Evaporation/condensation | 13.10 | | 10.13 | 88 | Atmospheric transport phenomena ("evaporation"); NOT condensation |
| Water extraction, use | 10.8 | 8.10 | | 88 | Changes to natural phenomena associated with human actions |
| External boundary conditions - import | 16.10 | | 10.16 | 88 | Water-borne transport phenomena |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR SURFACE WATER (11.11)** | | | | | |
| Discharge/recharge | 10.11, 11.10 | | | 89 | Water-borne transport phenomena |
| Water transport and convection | 2.11, 12.11, 13.11 | | 5.11 | 89 | Water-borne transport phenomena |
| Water uptake | 11.3,11.5,11.6 11.7 | 8.11 | 11.4, 3. to 7.11 | --- | Water-borne transport phenomena |
| Water extraction, use | 11.8 | | | --- | Changes to natural phenomena associated with human actions |
| Wind stress and wave formation | 13.11 | | | 89 | NOT included; |
| Movement - human induced | | 8.11 | | 89 | Changes to natural phenomena associated with human actions |
| Evaporation/condensation | 13.11, 14.11 | | 11.13 | 90 | Atmospheric transport phenomena ("evaporation"); NOT condensation |
| Precipitation | 13.11 | | | 90 | Atmospheric transport phenomena ("precipitatation") |
| External boundary conditions - sea currents | 16.11 | | | 90 | NOT included explicitly; Surface waters (fresh and marine) |

# Table A-3 (continued): Comparison of SKB FEPs with SKI FEPs (and Influences): Biosphere

| BIOSPHERE FEPs<br>SKB Report<br>FEP Name | <===== RES MATRIX =====> | | | SKB Report<br>R-01-13<br>on Page | SSI Report<br>FEP Title |
|---|---|---|---|---|---|
| **OFF-DIAGONAL ELEMENTS** | **Treated** | **Possibly** | **NOT** | | |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR WATER COMPOSITION (12.12)** | | | | | |
| Boundary condition - mass flux | 12.1 | | | 90 | Presumably similar boundary condition for assessment |
| Re-suspension | 2.12 | | | 90 | |
| Uptake/excretion | 3.12, 4.12 | | 5.12 to 8.12 | 91 | |
| Particle production and trapping | 3.12, 4.12 | | 5.12 to 7.12 | 91 | |
| Mixing | 14.12 | | 10.12 | 91 | |
| Property changes | 14.12 | | | 91 | |
| External boundary conditions - import | 16.12 | | 12.16 | 91 | |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR GAS - ATMOSPHERE (13.13)** | | | | | **GAS TRANSPORT AND EXPOSURE PATHWAY CONSIDERED SEPARATELY** |
| Boundary condition - gas transport | 1.13 | | 13.1 | 91 | NOT mentioned explicitly; presumably gas transport - geosphere-biosphere interface |
| Re-suspension | 2.13 | | | 92 | Exposure modes |
| Particle production - trapping | | | 3.13, 4.13, 6.13, 7.13 | 92 | NOT mentioned explicitly; Exposure modes; presumably assumption incorporated in modelling |
| External boundary conditions - import | 16.13 | | 13.16 | 92 | NOT mentioned explicitly, but Solid-phase transport phenomena ("coastal erosion") |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR TEMPERATURE (14.14)** | | | | | |
| Heat storage | 11.14 | | 2.14,10.14, 13.14 | 92 | NOT included; closest is Water-borne transport processes |
| Heat convection | | | | 92 | NOT included; closest is Water-borne transport processes |
| Heat transport | 11.14 | | 1.14 to 10.14, 13.14 | | NOT included |
| Light absorption | 12.14 | | | 92 | NOT included |
| External boundaries - import of heat | 16.14 | | | 92 | NOT included |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR RADIONUCLIDES AND TOXICANTS (15.15)** | | | | | |
| Boundary condition - release from the | 1.15 | | | 93 | Geosphere-biosphere interface boundary condition |
| Sorption/desorption | 2.15, 12.15 | | | 93 | Sorption/desorption processes |
| Sorption/uptake and excretion | 3.15 to 8.15 | | | 93 | Foodchain transfer; Drinking water and foodstuffs |
| Degradation | 3.15 to 8.15 | | | 93 | NOT mentioned explicitly; Chemical/organic toxin stability |
| Growth | 3.15 to 8.15 | | | 93 | Not included explicitly; |
| Mixing | 10.15, 11.15, 14.12 | | 13.15 | 94 | Not mentioned explicitly; presumably included as part of Water-borne transport phenomena; Artifical mixing of water bodies |
| Phase transitions | | 14.15 | 15.13 | 94 | Not mentioned explicitly; Volatility and volatilisation |
| Decay | 15.15 | | | 94 | Radionuclide decay and ingrowth |
| External boundaries - export | 15.16 | | | 94 | Not included explicitly; Sinks included in modelling |

# Table A-4: Comparison of SKI FEPs with SKB FEPs

| SKI FEP TITLE [Appendix C SKI 01:30] | SKB FEP | SKB Reference page(s) | COMMENT |
|---|---|---|---|
| **WASTE PACKAGE** | | | |
| Colloid generation | Water composition | Section 4.2.7, p.52 | Waste package = 1.1 through 5.5 in SKB's RES matrix |
| Degradation of inorganic waste | Chemical and microbial degradation | Heading, p. 43 | |
| Degradation of metal waste | Corrosion of metals | Heading, p. 44 | |
| Degradation of organic waste | Chemical and microbial degradation | Heading, p. 43 | |
| | Degradation of organics | Heading, p. 53 | |
| Diffusion through and in | Diffusion, Radionuclides and toxicants | Heading, p. 63 | |
| Evolving properties of bitumen matrix | Expansion/contraction of the waste; Recrystallisation | Headings, p. 42 | Three considered together |
| Evolving properties of cement matrix | + Water uptake; | Heading, p. 43 | Three considered together |
| Evolving properties of container | + Cracking | Heading, p. 44 | Three considered together |
| Evolving radionuclide inventory | Waste inventory; treated as Boundary condition | Figure 5-1 | |
| Gas flow and transport | Gas, 12.12; Gas flow + Advection of radioactive gas | Headings, pp. 58, 64 | |
| Gas generation | Gas generation through degradation of organic material | Heading, p. 57 | |
| | Gas generation through metal corrosion | Heading, p. 57 | |
| | Gas generation through radiolysis | Heading, p. 58 | |
| Mechanical stress distribution | Mechanics - stress conditions, 14.14 | Section 4.2.11, p. 60 | SKB FEP covers Water pressure and Gas pressure |
| Microbial activity | Microbial activity/growth | Headings, pp. 45, 47 | |
| Precipitation/dissolution | Dissolution/precipitation | Headings, pp. 44, 46, 62 | |
| Radioactive decay in waste | Radioactive decay, Radionuclides and toxicants | Heading, p. 65 | |
| Radioactive decay and ingrowth | Radioactive decay, Radionuclides and toxicants | Heading, p. 65 | |
| Radiolysis | Irradiation | Heading, p. 45 | SILO ONLY |
| Release from I/LLW | Advection and Dispersion, Radionuclides and toxicants | Headings, pp. 62, 63 | |
| Resaturation/saturation state | Water uptake | Heading, p. 43 | |
| Sorption | Sorption, Radionuclides and toxicants | Heading, p. 63 | |
| Temperature | Temperature, 13.13 | Section 4.2.10 | SKB address heat-emitting aspects of waste |
| Transport and release of nuclides | Advection and Dispersion, Radionuclides and toxicants | Headings, pp. 62, 63 | |
| Water chemistry | Water composition | Section 4.2.7, p. 52 | |
| Water movement in and through | Hydrology, 11.11 | Section 4.2.8, p. 56 | |
| **MORTAR** | **CONCRETE BACKFILL, 6.6** | | Mortar = 6.6 (Concrete backfill) in SKB's RES matrix |
| Colloid generation and transport | Water composition + Colloid transport and filtering | Section 4.2.7, p.52; p. 55 | |
| Degradation/alteration | Recrystallisation, Dissolution/precipitation; | Headings, p. 46 | |
| | Cracking/deformation | Heading, p. 47 | |
| Degradation of cell walls | Recrystallisation, Dissolution/precipitation; | Headings, p. 46 | |
| | Cracking/deformation | Heading, p. 47 | |
| Diffusion in and through | Diffusion, Radionuclides and toxicants | Heading, p. 63 | |
| Gas flow and transport | Gas, 12.12; Gas flow + Advection of radioactive gas | Headings, pp. 58, 64 | |
| Gas generation | Gas generation through radiolysis | Heading, p. 58 | |
| Mechanical stress distribution | Mechanics - stress conditions, 14.14 | Section 4.2.11, p. 60 | |
| Microbial activity | Microbial growth | Heading, p. 48 | |
| Precipitation/dissolution | Dissolution/precipitation | Heading, p. 48 | |
| Properties of mortar | NOT SPECIFIC; Concrete backfill, 6.6 | Table 4-1 | |
| Radioactive decay and ingrowth | Radioactive decay, Radionuclides and toxicants | Heading, p. 65 | |
| Redox front/heterogeneity | Redox, Water composition | Table 4-1 | |
| Resaturation/saturation state | Hydrology (Degree of saturation) | Table 4-1 | |
| Sorption | Sorption, Radionuclides and toxicants | Heading, p. 63 | |
| Temperature | Temperature, 13.13 | Section 4.2.10, p. 59 | SKB address heat-emitting aspects of waste |
| Transport and release of nuclides | Advection and Dispersion, Radionuclides and toxicants | Headings, pp. 62, 63 | |
| Water chemistry | Water composition | Section 4.2.7, p. 52 | |
| Water movement in and through | Hydrology, 11.11 | Section 4.2.8, p. 56 | |

## Table A-4 (continued): Comparison of SKI FEPs with SKB FEPs

| SKI FEP TITLE [Appendix C SKI 01:30] | SKB FEP | SKB Reference page(s) | COMMENT |
|---|---|---|---|
| **SHELL (SILO) or CONCRETE SHELL** | **CONCRETE STRUCTURES, 7.7** | | Shell = 7.7 (Concrete structures) in SKB's RES matrix |
| Colloid generation and transport | Water composition + Colloid transport and filtering | Section 4.2.7, p. 52; p. 55 | |
| Degradation/alteration | Recrystallisation; Dissolution/precipitation | Heading, p. 47 | |
| Degradation of steel reinforcement | Corrosion | Heading, p. 47 | SILO ONLY |
| Diffusion in and through | Diffusion, Radionuclides and toxicants | Heading, p. 63 | |
| Gas flow and transport | Gas, 12.12; Gas flow + Advection of radioactive gas | Headings, pp. 58, 64 | |
| Gas generation | Gas generation through metal corrosion | Heading, p. 57 | SILO ONLY?? |
| Mechanical stress distribution | Mechanics - stress conditions, 14.14 | Section 4.2.11, p. 60 | |
| Microbial activity | Microbial growth | Heading, p. 48 | |
| Precipitation/dissolution | Dissolution/precipitation | Heading, p. 48 | |
| Properties of shell | NOT SPECIFIC; Concrete backfill, 6.6 | Table 4-1 | |
| Radioactive decay and ingrowth | Radioactive decay, Radionuclides and toxicants | Heading, p. 65 | |
| Redox front/heterogeneity | Redox, Water composition | Table 4-1 | |
| Resaturation/saturation state | Hydrology (Degree of saturation) | Table 4-1 | |
| Sorption | Sorption, Radionuclides and toxicants | Heading, p. 63 | |
| Temperature | Temperature, 13.13 | Section 4.2.10, p. 59 | SKB address heat-emitting aspects of waste |
| Transport and release of nuclides | Advection and Dispersion, Radionuclides and toxicants | Headings, pp. 62, 63 | |
| Water chemistry | Water composition | Section 4.2.7, p. 52 | |
| Water movement in and through | Hydrology, 11.11 | Section 4.2.8, p. 56 | |
| **BACKFILL (Bentonite; Sand-bentonite)** | **BENTONITE BARRIERS, 8.8** | | SILO ONLY; Backfill = 8.8 (Bentonite barriers |
| Bentonite swelling | Bentonite expansion and contraction | Heading, p. 48 | |
| Colloid generation and transport | Water composition + Colloid transport and filtering | Section 4.2.7, p. 52; p. 55 | and 9.9 (Vaults and backfill) in SKB's RES matrix |
| Degradation/alteration | Montmorillonite transformation; Ion exchange | Headings, pp. 49, 50 | |
| Diffusion in and through | Diffusion, Radionuclides and toxicants | Heading, p. 63 | |
| Filtration | Colloid filtering | RES Matrix, 8.10, 8.16 | SILO ONLY |
| Gas flow and transport | Gas, 12.12; Gas flow + Advection of radioactive gas | Headings, p. 58, 64 | |
| Gas generation | NOT SPECIFIC; Gas, 12.12 | Section 4.2.9, p. 57 | ?? |
| Mechanical stress distribution | Mechanics - stress conditions, 14.14 | Section 4.2.11, p. 60 | |
| Microbial activity | Microbial growth | Heading, p. 51 | |
| Precipitation/dissolution | Dissolution/precipitation | Heading, p. 50 | |
| Properties of backfill | NOT SPECIFIC; Bentonite barriers, 8.8 | Table 4-1 | |
| Radioactive decay and ingrowth | Radioactive decay, Radionuclides and toxicants | Heading, p. 65 | |
| Redox front/heterogeneity | Redox, Water composition | Table 4-1 | |
| Resaturation/saturation state | Water uptake | Heading, p. 49 | |
| Sorption | Sorption, Radionuclides and toxicants | Heading, p. 63 | |
| Temperature | Temperature, 13.13 | Section 4.2.10, p. 59 | SKB address heat-emitting aspects of waste |
| Transport and release of nuclides | Advection and Dispersion, Radionuclides and toxicants | Headings, pp. 62, 63 | |
| Water chemistry | Water composition | Section 4.2.7, p. 52 | |
| Water movement in and through | Hydrology, 11.11 | Section 4.2.8, p. 56 | |

# Table A-4 (continued): Comparison of SKI FEPs with SKB FEPs

| SKI FEP TITLE [Appendix C SKI 01:30] | SKB FEP | SKB Reference page(s) | COMMENT |
|---|---|---|---|
| **NEAR-FIELD ROCK** | **REPOSITORY ROCK, MATRIX AND FRACTURE SYSTEM, 7.7, 8.8** | | Near-field rock = 7.7, 8.8 (Repository rock) |
| Alteration/weathering of flowpaths | | | |
| Cave-in | Rock fallout/distribution | Heading, p. 48 | |
| Colloid generation and transport | Colloid formation and transport | Heading, p. 71 | |
| Degradation of rock reinforcement and grout | Degradation of rock reinforcement | Heading, p. 74 | |
| Diffusion | Diffusion and matrix diffusion, Radionuclides, toxicants | Heading, p. 75 | |
| Dispersion | Advection/dispersion | Heading, p. 75 | |
| Excavation effects | | | |
| Gas flow and transport | Gas permeability; Gas flow and saturation | Headings, pp. 73, 72 | |
| Gas generation | NOT CONSIDERED | | Subsequently renamed "Bulk gas, near-field rock" |
| Groundwater flow | Advection/dispersion | Heading, p. 75 | |
| Matrix diffusion | Diffusion and matrix diffusion, Radionuclides, toxicants | Heading, p. 75 | |
| Microbial activity | Microbial growth | Heading, p. 70 | |
| Precipitation/dissolution | Dissolution/precipitation | Headings, pp. 69, 70 | |
| Properties of | Rock matrix and rock fractures | Section 4.3.4, p. 69 | |
| | Properties affecting deformation and stability | Heading, p. 74 | |
| Radioactive decay and ingrowth | Radioactive decay, Radionuclides and toxicants | Heading, p. 77 | |
| Redox front/heterogeneity | Redox, Groundwater composition | Table 4-2 | |
| Resaturation/saturation state | Hydrology (Degree of saturation) | Table 4-2 | |
| Shaft and tunnel seal degradation | Cracking of concrete in plugs, Corrosion, | Headings, p. 69 | |
| | Dissolution/precipitation | Heading, p. 69 | |
| Sorption | Sorption, Radionuclides and toxicants | Heading, p. 76 | |
| Stress field | Rock mechanics; Stress conditions, 14.14 | Section 4.3.8, p. 7; Table 4-2 | |
| Temperature | Temperature, 13.13 | Table 4-2 | |
| Transport and release of nuclides | Advection/dispersion, Radionuclides, toxicants | Heading, p. 75 | |
| Water chemistry | Groundwater composition | Section 4.3.5, p. 70 | |
| **FAR-FIELD (= GEOSPHERE)** | | | |
| Alteration/weathering of flowpaths | NOT EXPLICIT; Dissolution/precipitation | Heading, p. 69 | |
| Colloid generation and transport | Colloid formation and transport | Heading, p. 71 | |
| Diffusion | Diffusion; Diffusion and matrix diffusion, Radionucl | Headings, p. 71; p. 75 | |
| Dispersion | Advection/dispersion | Heading, p. 75 | |
| Fault movement/activation | NOT INCLUDED; but Stress conditions, 14.14 | Table 4-2 | Subsequently renamed "Rock movement/collapse" |
| Gas flow and transport | Gas | Section 4.3.7, p. 73 | |
| Gas generation | NOT INCLUDED | | Subsequently renamed "Bulk gas, near-field rock" |
| Gas pressure | Gas pressure | Heading, p. 73 | |
| Geometry and driving force for flow | Driving forces and salinity | Heading, p. 72 | |
| Groundwater chemistry | Groundwater composition | Section 4.3.5, p. 70 | |
| Groundwater flow | Advection/dispersion | Heading, p. 75 | |
| Hydraulic saturation/unsaturation | Hydrology (Degree of saturation) | Table 4-2 | |
| Matrix diffusion | Diffusion and matrix diffusion, Radionuclides, toxicants | Heading, p. 75 | |
| Microbial activity | Microbial growth | Heading, p. 70 | |
| Precipitation/dissolution | Dissolution/precipitation | Headings, pp. 69, 70 | |
| Properties | Rock matrix and rock fractures | Section 4.3.4, p. 69 | |
| Radioactive decay and ingrowth | Radioactive decay, Radionuclides and toxicants | Heading, p. 77 | |
| Redox front/heterogeneity | Redox, Groundwater composition | Table 4-2 | |
| Saline (or fresh) water intrusion | Driving forces and salinity | Heading, p. 72 | |
| Seismic activity | NOT INCLUDED | | External FEP in SPARTA PID |
| Sorption | Sorption, Radionuclides and toxicants | Heading, p. 76 | |
| Stress field (in situ) | Rock mechanics; Stress conditions, 14.14 | Section 4.3.8, p. 7; Table 4-2 | |
| Thermal field | Temperature, 13.13 | Table 4-2 | |
| Transport and release of nuclides | Advection/dispersion, Radionuclides, toxicants | Heading, p. 75 | |
| Uplift/subsidence | NOT INCLUDED | | External FEP in SPARTA PID |

# Table A-5: Review of SKB RES Matrix FEPs with SKB's Information Flow Diagram: Near-field (Figure 5-2, SKB Report R-01-13)

| SKB NEAR-FIELD FEPs<br>FEP Name<br>OFF-DIAGONAL ELEMENTS | RES MATRIX<br>Treated | <br>Possibly | FIGURE 5-2 | ADDITIONAL INPUT FROM SKB REPORT |
|---|---|---|---|---|
| **IMPORTANT INTERACTIONS (PROCESSES) FOR DIFFERENT WASTE FORMS** | | | | |
| Recrystallisation/mineralisation | 1.1 | | Alteration of waste and barriers,<br>Material composition, porosity; Solubility, sorption | May change internal physical structure of cement (SA - sorption, diffusion)<br>Effects not specifically addressed in quantitative analysis; should be covered by pessimistic selection of Kd and De values |
| Expansion/contraction of waste | 1.14, 2.14 | 4.3,5.3 | Alteration of waste and barriers<br>Dimensions. Geometries | Takes into account volume-expanding corrosion products<br>Process discarded from further analysis |
| Water uptake (Water flow, capillary suction) | 1.11, 2.11, 3.11<br>10.1,10.2,11.1<br>11.2 | 10.3 | Time for resaturation, silo; Alteration of waste and barriers<br>Dimensions. Geometries | Affects geometry, structure and volume of waste form;<br>considered for bitumenised waste form; results considered - REF |
| Chemical and microbial degradation | 1.10,2.10,3.10<br>10.1,10.2<br>11.1, 11.2 | 10.3 | Rate and yield for degradation products<br>Gas generation and transport within repository<br>Evolution of repository water<br>Material composition, porosity; Solubility, sorption | Impacts matrix properties; quantity of organic additives deemed too small<br>to impact sorption; porosity effects covered by pessimistic Kd/De values<br>Microbe effects on matrix deemed insignificant relative to water uptake<br>May cause gas generation and generate complexing agents |
| Corrosion of metals | 1.12, 3.12<br>10.1,11.1 | 10.3 | Corrosion rates, Amounts and dimensions of gas generating materials | Impacts gas generation; volume increase in matrix (=> porosity, cracking);<br>sorption on Fe corrosion products not considered |
| Dissolution/precipitation | 1.10,2.10,3.10<br>10.1, 10.2 | 10.3 | Alteration of waste and barriers; Dimensions, geometries | Cement phases; may cause volume increase in matrix (=> porosity/cracking)<br>Bitumen matrix; effects deemed small relative to water uptake |
| Cracking | 14.1, 14.2 | | Alteration of waste and barriers; Dimensions, geometries;<br>Voids, porosity | Affects geomtery, proosity, fracture apertures; not analysed in detail;<br>indirectly accounted for in selection of data and calculational cases<br>Changes in stress conditions; included in physical property changes from water uptake |
| Microbial activity/growth | 1.15,2.15,3.15 | 5.1,15.2,15.3 | NOT CONSIDERED EXPLICITLY<br>Selection of porosity values | => biofilms; affect porosity; effects ignored because conditions considered unfavourable for microbes |
| Irradiation | | 16.1,16.2,16.3 | NOT CONSIDERED | Radiation levels considered insignificant |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR CONCRETE AND STEEL PACKAGING** | | | | |
| Recrystallisation/mineralisation | 4.4 | | Alteration of waste and barriers,<br>Material composition, porosity; Solubility, sorption | May change internal physical structure of concrete (SA - sorption, diffusion)<br>Effects not specifically addressed in quantitative analysis; should be covered by pessimistic selection of Kd and De values |
| Expansion/contraction of packaging | 4.14, 5.14 | 4.9, 5.9 | Alteration of waste and barriers,<br>Dimensions, geometries | |
| Water uptake (Water flow, capillary suction) | 4.11, 5.11 | | Time for resaturation, silo; Alteration of waste and barriers | |
| Corrosion | 4.12,5.12 | | Alteration of waste and barriers,<br>Dimensions, geometries | Rebar - volume increase in concrete matrix (=> porosity, cracking);<br>change in hydraulic properties with time; GAS EFFECTS NOT MENTIONED<br>Effects of corrosion of steel packaging not specifically considered |
| Cracking/deformation | 14.4 | 14.5 | Alteration of waste and barriers,<br>Dimensions, geometries | Changes in stress conditions (con) not directly analysed; indirectly via data<br>No credit taken for steel packaging; SAFE assumption - packaging |
| Microbial growth | | 4.15,15.4,15.5 | NOT CONSIDERED | Possible effects ignored because conditions considered unfavourab |

# Table A-5 (continued): Review of SKB RES Matrix FEPs with SKB's Information Flow Diagram: Near-field (Figure 5-2, SKB Report R-01-13)

| SKB NEAR-FIELD FEPs<br>FEP Name<br>OFF-DIAGONAL ELEMENTS | RES MATRIX<br>Treated | <br>Possibly | FIGURE 5-2 | ADDITIONAL INPUT FROM SKB REPORT |
|---|---|---|---|---|
| **IMPORTANT INTERACTIONS (PROCESSES) FOR CONCRETE BACKFILL AND CONCRETE STRUCTURES** | | | | |
| Recrystallisation/mineralisation | 6.6, 7.7 | | Alteration of waste and barriers; Material composition, porosity; Solubility, speciation | Possible effects covered by pessimistic selection of Kd and De data |
| Expansion/contraction | 6.14, 6.15 | | Alteration of waste and barriers; Dimensions, geometries; | |
| Water uptake (Water flow, capillary suction) | 6.11, 7.11 | | Time for resaturation, silo; Alteration of waste and barriers | |
| Corrosion | | | Alteration of waste and barriers; Hydraulic conductivity distribution | Effects covered by assuming change in hydraulic properties with time |
| Dissolution/precipitation | 6.10, 7.10 | | Alteration of waste and barriers; Material composition, porosity; Solubility, speciation | Affects composition, dimensions and porosity of concrete, via H2O composition |
| Cracking | 14.6, 14.7 | | Alteration of waste and barriers; Material composition, porosity | Process considered in selection of data and calculational cases |
| Rock fallout/redistribution | 14.7 | | NOT CONSIDERED IN QUANTITATIVE ANALYSES | In absence of backfill; affects concrete structures; impacts not specifically considered in quantitative analyses |
| Microbial growth | | 6.15, 7.15<br>15.6, 15.7 | NOT CONSIDERED | Microbal activity deemed low; potential impacts ignored |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR BENTONITE BARRIERS** | | | | |
| Bentonite expansion and contraction | 9.8<br>8.14 | 7.8, 8.9 | Alteration of waste and barriers; Dimensions, geometries; Vault hydrology | Impact may depends on volume change of concrete which is small<br>Bentonite expansion discussed in SR97; effects considered to be small; impact indirectly considered as calculational case (less effective bentonite) |
| Water uptake (Water flow, capillary suction) | 6.11 | | Time for resaturation, silo; Vault hydrology<br>NOT ANALYSED IN DETAIL | Affects performance of bentonite barrier; discussed generally in SR97<br>Water uptake not analysed in detail within SAFE; simplified treatment included in estimate of resaturation time; Silo design can withstand uneven swelling P |
| Montmorillonite transformation | 10.8 | | Alteration of waste and barriers; Hydraulic conductivity distribution; Vault hydrology | Large uncertainties on impact of alkaline porewaters; indirectly treated by analysing consequences of deteriorating hydraulic properites |
| Dissolution/precipitation | 8.10, 10.8 | | Alteration of waste and barriers; Material composition, porosity; Solubility, speciation | Potentially important impacts on bentonite performance; small changes expected; indirectly treated by analysing consequences of deteriorating hydraulic properties |
| Ion exchange | 8.10, 10.8 | | Alteration of waste and barriers; Material composition, porosity; Solubility, speciation | Possible changes discussed generally in SR97 and in analysis of de<br>indirectly considered in selection of calculational cases and data |
| Dispersion of clay particles | 18.8 | | NOT CONSIDERED IN SHORT-TERM | Requires low ionic strength of water (SR97); not considered important in short-term perspective (saline groundwater); covered by calculational cases |
| Microbial growth | 8.15 | 15.8 | NOT CONSIDERED | Conditions unfavourable; not considered further |
| Colloid filtering | 8.16 | | NOT CONSIDERED? (Water phase transport of RN within repository | |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR VAULTS AND BACKFILL (INCLUDES SAND LAYER ABOVE CONCRETE LID, SILO, AND GAS VENTS)** | | | | |
| Expansion/contraction | | | NOT CONSIDERED | Processes leading to such expansion/contraction judged to be negligible |
| Redistribution of backfill | | 14.8 | Alteration of waste and barriers, Dimensions, geometries; Vault hydrology (conservativbely ignored?) | Possibility creation of permeable zones during saturation phase; smaller fraction of groundwater through the fill could lead to reduction in radionuclide release |
| Bentonite intrusion | | 8.9 | EFFECT IGNORED | May affect thin sand layer in Silo (above lid); possible effect ignored |
| Dissolution/precipitation | 9.10, 10.9 | | CONSIDERED INDIRECTLY (Material composition porosity) | Possible changes in porosity/sorptive properties; not analysed specifically but potential effects are considered via selection of data |
| Microbial growth | | 9.15, 15.9 | IGNORED | Stagnant hydraulic conditions; if any activity, could reduce porosity; ignored |

# Table A-5 (continued): Review of SKB RES Matrix FEPs with SKB's Information Flow Diagram: Near-field (Figure 5-2, SKB Report R-01-13)

| SKB NEAR-FIELD FEPs<br>FEP Name<br>OFF-DIAGONAL ELEMENTS | RES MATRIX<br>Treated | <br>Possibly | FIGURE 5-2 | ADDITIONAL INPUT FROM SKB REPORT |
|---|---|---|---|---|
| **IMPORTANT INTERACTIONS (PROCESSES) FOR WATER COMPOSITION (INCLDUING COLLOIDS/PARTICLES AND DISSOLVED GAS)** | | | | |
| Dissolution/precipitation | 10.16,10.1,10.<br>10.4,10.5,10.6<br>10.7,10.8,10.9 | 10.3 | Evolution of repository water<br>Complexing agents | Dissolution and leaching of cementitious phases => changes in pH and ionic strength<br>Generation of complexation agents; results of inventory study used<br><br>Salts from evaporator concentrates (bitumenised wastes); not specifically addressed in SAFE; considered indirectly in selection of calculational cases and data<br>Possible alteration of bentonite barriers; dispersion of high pH not specifically addressed within SAFE; selection of data and calculational cases |
| Degradation of organics | 10.12, 10.16 | | Complexing agents | Complexation wth radionuclides (ISA); formation of colloids |
| Corrosion | 10.12 | | NOT INCLUDED EXPLICITLY; Evolution of repository water | Metal corrosion affects redox conditions; possible galvanic corrosion (SFL3-5)<br>Within SAFE, assumption that corrosion contributes to anaerobic conditions |
| Sorption | 10.16 | | Complexing agents; Selection of migration data; Solubility, sorption | Process could be important for complexing agents such as ISA<br>Taken into consideration by careful selection of calculational cases and data<br>Ion exchange could affect montmorillonite's ability to buffer pH; studied as part of chemical alteration of barriers |
| Diffusion | 10.16 | | NO EVIDENCE OF CONSIDERATION IN FIGURE 5-2 | Considered when evaluating future water composition and alteration of concrete barriers |
| Advection and mixing | 10.11 | | Flow within and between vaults; Evolution of repository water | Evolution of water composition due to advective flow studied; results of this and change to fresh groundwater discussed in selection of data/calculational cases |
| Erosion/colloid formation/colloid transport | 10.10, 10.10 | | COLLOIDS IGNORED FOR SILO, BMA, BTF<br>INDIRECTLY CONSIDERED (DATA SELECTION; Sorption data) | Mechanical erosion => colloids (considered for SFL3-5); bentonite =>clay particles<br>Filtering of colloids (considered for SFL3-5); colloids attached to gas bubbles<br>Colloids ignored for Silo, BMA and BTF (due to filtering effects of barriers)<br>Colloids treated indirectly via selection of calculation cases |
| Microbial activity | 10.15, 15.10 | | IGNORED | Assessed to be low; no quantitative analysis; reducing conditions assumption OK |
| Gas dissolution/degassing | 10.12 | | NO EVIDENCE OF CONSIDERATION IN FIGURE 5-2 | Process not quantified; indirectly considered in selection of data/cases |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR HYDROLOGY (MAGNITUDE, DIRECTION AND DISTRIBUTION OF WATER FLOW** | | | | |
| Two phase flow and saturation | 11.12 | | Water expulsion; Water phase transport of RN within repository;<br>Flow within and between vaults | Important for saturation phase - timing; impact neglected; impact of gas pressure build-up on expulsion of contaminated water is considered |
| Osmosis | 10.11 | | NOT CONSIDERED | May affect saturation time; does not appear to be explicitly covered; uptake of water in bitumenised waste is studied |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR GAS FORMATION AND MOVEMENT** | | | | |
| Gas generation through degradation of organic material | 1.12, 3.12 | 2.12 | Rate and yield for degradation of organics<br>Amounts and dimensions of gas genrating materials | Alkaline hydrolysis of cellulose =>gas;<br>microbial degradation of IEX, but considered slow; other sources negligible<br>Gas generation is considered |
| Gas generation through metal corrosion | 1.12,3.12,5.12 | | Corrosion rates<br>Amounts and dimensions of gas generating materials | Considered in past SFR assessments, also SFL3-5; for SAFE. Gas formation is estimated as basis for analysis of pressure build-up and water expulsion |
| Gas generation through radiolysis | | 16.12 | NOT INCLUDED | Calculations indicate quantities of gas negligible; however radiolysis of bitumen may result in pressure build-up and cracking of matrix; considered in study of properties of bitumenised matrix |
| Gas flow | 1.12,3.12,4.12<br>5.12,6.12,7.12<br>8.12,9.12 | | Gas flux (t) from different release points | Dependent on uptake of water, size of voids, dimensions and properties of barriers; also degree of saturation, which is relatively fast |
| Expansion/contraction | | | Alteration of waste and barriers | Considered in analysis of gas generation and escape |

## Table A-5 (continued): Review of SKB RES Matrix FEPs with SKB's Information Flow Diagram: Near-field (Figure 5-2, SKB Report R-01-13)

| SKB NEAR-FIELD FEPs<br>FEP Name<br>OFF-DIAGONAL ELEMENTS | RES MATRIX<br>Treated | <br>Possibly | FIGURE 5-2 | ADDITIONAL INPUT FROM SKB REPORT |
|---|---|---|---|---|
| **IMPORTANT INTERACTIONS (PROCESSES) FOR TEMPERATURE** | | | | |
| Heat-generating reactions | | 16.13 | NOT INCLUDED | Only corrosion of aluminium considered important; effect on T studied |
| Heat conduction | | Column 13 | NOT INCLUDED | Depends on degree of water saturation and thermal properties of barriers |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR MECHANICS - STRESS CONDITIONS; 14.14** | | | | |
| Expansion/contraction | Column 14 | | Alteration of waste and barriers; dimensions, geometries | |
| Water pressure | | | NOT INCLUDED | NOT considered |
| Gas pressure | 12.14 | | Pressure build-up | |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR BIOLOGICAL STATE; 15.15** | | | | |
| Microbial activity | Column 15 | | IGNORED (other than Rate and yield of degradation of organcis) | |
| Advection | 11.15 | | NOT CONSIDERED | |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR RADIONUCLIDES AND TOXICANTS; 16.16** | | | | |
| Dissolution/precipitation | 1.16, 2.16<br>3.16, 10.16 | | Solubility data | |
| Degradation of organic matter | 1.16, 2.16<br>3.16, 10.16 | | Generation of RN in gaseous phase; Complexing agents | |
| Advection | 11.16 | | Water phase transport of RN within repository | |
| Dispersion | 11.16 | | Water phase transport of RN within repository | |
| Diffusion | 11.16 | | Diffusivity data | |
| Sorption | 11.16 | | Sorption data | |
| Colloid transport and filtering | 9.16 | | NOT CONSIDERED? (Water phase transport of RN within repository | |
| Advection of radioactive gas | 12.16 | | Rate of generation of RN in gas phase; Gas generation and transport within repository | |
| Methylation/transformation | 15.16 | | Generation of RN in gaseous phase | |
| Radioactive decay | 16.16 | | RN decay constants | |

# Table A-6: Review of SKB RES Matrix FEPs with SKB's Information Flow Diagram: Geosphere (Figure 5-3, SKB Report R-01-13)

| SKB GEOSPHERE FEPs<br>FEP Name<br>OFF-DIAGONAL ELEMENTS | RES MATRIX<br>Treated | <br>Possibly | INTERACTION FLOW DIAGRAM<br>FIGURE 5-3 | ADDITIONAL INPUT FROM SKB REPORT R-01-13 |
|---|---|---|---|---|
| **IMPORTANT INTERACTIONS (PROCESSES) FOR ACCESS TUNNELS AND BOREHOLES (INCLUDING BACKFILL, SHOTCRETE AND ROCK BOLTS)** | | | | |
| Dissolution/precipitation | 5,10, 11.5 | 10.5 | IMPACTS NEGLECTED | Considered to have negligible effect on function of shotcrete and backfill; for boreholes, effect is more uncertain; overall, any impacts are neglected |
| Ionic strength effects | | 10.5 | EFFECTS CONSIDERED SMALL; IGNORED | Primarily bentonite may be affected; resultant changes in properties are considered small enough to be ignored |
| Redistribution of particles in flowing water | | | NOT CONSIDERED | Flow rates expected to be too small for this to be important; discarded |
| Microbial activity | | 5.15, 15.5 | NOT CONSIDERED | Could affect composition and porosity of materials; any changes expected to be small, however; influence not considered in SAFE |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR PLUGS (BENTONITE/CONCRETE); NOTE - FINAL SELECTION OF MATERIALS TO BE MADE!** | | | | |
| Water uptake in bentonite | 6.11 | | Time for resaturation, silo (Fig. 5-2) | Nature of water effects on saturation time and resultant properties |
| Bentonite expansion/dispersion | 5.6,6.14,8.6 | | Plugs - dimensions, conditions | May affect density and homogeneity of bentonite |
| Recrystallisation | 6.6 | | Plugs - conditions | Cementitious phases; long-term properties may be affected |
| Cracking of concrete in plugs | 14.6 | | Plugs - conditions | Potential damage due to swelling pressure of bentonite |
| Corrosion (of reinforcement) | 6.12,10.6,11.6 | | Plugs - conditions | May cause volume changes and concrete properties |
| Dissolution/precipitation | 6.10,10.6,11.6 | | Plugs - conditions | Changes in primary minerals may affect properties |
| Ion exchange and sorption | 6.10, 10.6 | | | Primarily important for bentonite; possible changes in properties |
| Microbial activity | | 15.6 | NOT CONSIDERED | May affect composition and porosity; also surfaces of materials |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR ROCK MATRIX AND FRACTURES** | | | | |
| Dissolution/precipitation | 7.10,8.10.9.10<br>10.7,10.8,10.9 | | Mineralogy, matrix porosity; Hydraulic conductivity - fract | Mineral composition of fracture surfaces may be affected; secondary minerals in fractures and pores may affect porosity. Effects of alkaline plume may change mineralogy of rock; possible reduction in permeability (more conservative) |
| Redistribution of stress | 7.14, 8.14 | | NOT EVALUATED | Hydro-mechanical interaction may affect fracture apertures and rock porosity<br>Effects considered too small to be significant; no quantitative evaluation |
| Microbial growth | | 15.7,15.8,15.9<br>14.7,14.8,14.9 | IGNORED | Biofilms will affect rock surfaces, enhance mineral changes; change porosity; effects considered insignificant; discarded |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR GROUNDWATER COMPOSITION (INCLUDING DISSOLVED GAS, COLLOIDS AND PARTICLES)** | | | | |
| Dissolution/precipitation | [5 to 9].10<br>10.[6 to 9] | | Evolution of geosphere water; Selection of migration data; | Rock-water interactions generally slow; transient effect (buffering of pH, and dissolution of silica) can generate colloids; not specifically analysed in SAFE; covered indirectly by selection of calculational cases and data |
| Diffusion | 10.16<br>[5 to 9].10 | | Selection of migration data; diffusivity | Geometry, porosity and conectivity of backfill, plugs etc. can affect diffusion; not quantitatively analysed within SAFE |
| Advection/dispersion | 11.1 | | Fresh water/saline water interface; Evolution of geosphere water | Impact of advection on groundwater composition is considered in estimating time for saline-fresh water interface to reach repository |
| Colloid formation and transport | 10.10,10.16 | | ASSUMPTION; no RN retention in geosphere | Generally discussed in SR97; groundwaters at Forsmark expected to have low [Ca] and therefore low colloid concentration; colloids considered by assuming no radionuclide retention in geosphere |
| Gas dissolution/degassing | 10.12, 12.10 | | NOT EXPLICIT | Naturally dissolved gases considered indirectly in groundwater composition |
| Microbial degradation | 10.15, 15.10 | | IGNORED | Will affect water composition; ensure reducing conditions; no detrimental effects |
| Boundary conditions | | | | Interaction of different waters (vaults, external boundaries) will affect water composition; interactions considered via selection of geosphere water composition |

## Table A-6 (continued): Review of SKB RES Matrix FEPs with SKB's Information Flow Diagram: Geosphere (Figure 5-3, SKB Report R-01-13)

| SKB GEOSPHERE FEPs<br>FEP Name<br>OFF-DIAGONAL ELEMENTS | RES MATRIX<br>Treated | Possibly | INTERACTION FLOW DIAGRAM<br>FIGURE 5-3 | ADDITIONAL INPUT FROM SKB REPORT R-01-13 |
|---|---|---|---|---|
| **IMPORTANT INTERACTIONS (PROCESSES) FOR HYDROLOGY** | | | | |
| Rock permeability and its distribution | Not explicit | | Hydraulic conductivity (fractures, rock); Local hydrology (pa | Darcy's law, permeability distribution considered in updated HG modelling |
| Driving forces and salinity | 11.10 | | DENSITY-DEPENDENT FLOW NEGLECTED | Salinity/density gradients; fluid density (buoyancy effects); scoping calculations indicates density-dependent flow can be neglected |
| Gas flow and saturation | 11.12 | | TWO-PHASE FLOW DISCARDED | Two-phase flow aspects for saturation process is discarded in SAFE; saturation time approximated by time resulting from "saturated" analysis [??] |
| Boundary conditions | | | | Hydraulic head gradient originates from boundaries; rock/biosphere boundary important (Sea level, infiltration, recharge/discharge, wells); detailed hydraulic analysis. |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR GAS (DISTRIBUTION AND MOVEMENT); INCLUDING NATURALLY OCCURRING RADIONUCLIDES** | | | | |
| Gas permeability | 8.12, 9.12 | | Geometry: locations, fractures; Gas transport in far field | Significant for crystalline rock; scoping calculations indicate fast gas flow |
| Gas pressure | | | NO EVIDENCE OF CONSIDERATION IN FIGURE 5-3 | Gas pressure gradients one of the main driving forces for gas flow |
| Water pressure | 12.11 | | NO EVIDENCE OF CONSIDERATION IN FIGURE 5-3 | Pressure and pressure gradients can affect gas distribution; impact considered |
| | 8.12, 9.12 | | | of minor importance; effect on gas solubility also of minor importance |
| Boundary conditions | | | | Transport and release of gas from different sections of repository |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR ROCK MECHANICS** | | | | |
| Properties affecting deformation and stability | 7.14, 8.14 | | Mineralogy, matrix porosity | (rock type, mineralogy, microstructure); initial rock strength good<br>Effects of bentonite/cement plugs not addressed (final design not available) |
| Degradation of rock reinforcement | | | NOT EXPLICIT IN FIG. 5-3; Local hydrology (pathlines, flow) | Will affect rock strength; effects on rock fall in vaults assessed |
| Boundary conditions | | | | Changes in stress and strain at repository-geosphere boundary will have effect |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR BIOLOGICAL STATE** | | | | |
| Microbial activity | Column 15 | | IGNORED | Organic carbon in geosphere less than in repository; no detrimental effects apart from (possibly) methylation/transformation |
| Boundary conditions | | | | Biomass from vaults; exchange of biomass between biosphere and geosphere by recharging/discharging water |
| **IMPORTANT INTERACTIONS (PROCESSES) FOR RADIONUCLIDES AND TOXICANTS (SOLID, LIQUID AND GAS PHASES)** | | | | |
| Advection/dispersion | 11.16 | | Water phase transport of RN within far field | Groundwater flow characteristics used as input to selection of cases/data |
| Diffusion and matrix diffusion | 7.16,8.16,9.16 | | Matrix porosity; Selection of migration data (matrix diffusivity) | Results of HG modeling used as input to selection of transport resistance (F-parameter) |
| Sorption | 5.16,7.16,8.16<br>9.16 | | Mineralogy; Selection of migration data (sorption) | Impact of mineralogy and water composition reflected in selection of cases/data |
| Dissolution/precipitation | 10.16 | | NOT EXPLICIT IN FIG. 5-3; no far-field solubility data | Precipitation of RN or toxicants not expected because of low concentrations;<br>Co-precipitation with calcite + Fe hydroxides could retard transport |
| Transport with gas | 12.16 | | Gas transport in far field (RN not explicit) | Main transport mechanism for transport of gaseous radionuclides |
| Transport with colloids or microbes | 10.16 | | NOT EXPLICIT; Water phase transpor of RN within far field | Colloidal material expected to be low (low [Ca]); microbe transport considered not to be significant enough; fast transport IS considered however, via cases/data |
| Methylation/transformation | 15.16 | | NOT EXPLICIT IN FIG. 5-3; Gas flux from different release pathways | Will affect mobility of certain radionuclides (C14); selection of cases/data |
| Radioactive decay | 16.16 | | NOT EXPLICIT IN FIG. 5-3 | Will affect type and amount and distribution of radionuclides |
| Boundary conditions | | | | Release from other parts of the repository will have an effect; source term |