Strålsäkerhetsmyndigheten
Att: Georg Lindgren
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Svar till SSM på begäran om förtydligande komplettering av data för konsekvensanalysberäkningar

Strålsäkerhetsmyndigheten, SSM, har till Svensk Kärnbränslehantering AB, SKB, skickat en begäran om komplettering av ansökan om utökad verksamhet vid SFR. Begäran om komplettering som är daterad 2016-07-01 avser data som används inom ramen för konsekvensanalysen i SR-PSU.

SKB översänder härmed begärda data, resultat och beräkningsexempel. Leveransen består av detta brev, tillhörande datafiler och tre PM tillhörande fråga 10 (bilaga 1), fråga 11 (bilaga 2) och fråga 12 (bilaga 3). Följande text förtydligar leveransen för respektive fråga. Beskrivningarna är på engelska eftersom begäran om komplettering var framtagen med hjälp av SSM:s externa experter. Vid behov bistår SKB gärna med ytterligare förtydliganden, förslagsvis genom möten där genomgång av data sker.

The requested material is delivered in a separate folder for each request (fråga#). There are two exceptions to this rule, namely:

- Files associated with request 1 and 2 are delivered in one common folder (fråga1_2).
- Information requested in #5 is provided in folder fråga_8 (as specified below)

1. The 20 m DEM describing land surface, lake bottoms, and lake sediment surfaces (Figure 3-1 of R-12-03). Initial DEM + perturbed DEM as a results of landscape evolution (if possible).

The 20 m DEM is delivered in the folder ‘DEM_SR-PSU’.

The perturbed DEM is given in the folder ‘Dyn_jorddjupsmodell_GW_SR_PSU’, which holds a subfolder for each time step (named -8500AD, -8000AD, … 40 000 AD). The file ‘[X]ADpdem.asc’ (in each subfolder) describes the perturbed DEM for the specified time step X.

2. R-13-22 calculated updates the regolith model at 500 year intervals. To match the documented MIKE-SHE hydrology DEM at 3000, 5000 and 11000 CE the regolith depth model (RDM) results for each layer in the landscape at each of these times should be provided.

The regolith lake development model (RLDM) gives the depth of different regolith layers over time. In the folder Dyn_jorddjupsmodell__GW_SR_PSU, SKB provides files that describes the upper and lower surface for each regolith layers for 500 year time step from -8500 AD to 40 000 AD (in subfolders with the name of the time step). For each time step files are given which represents the upper surface for each layer respectively (Table 1).

Table 1. Files with different regolith layers. [X] denotes the time step.

File name	Regolith type
[X]ADpdem.asc	Organic sediments (peat) (DEM)
[X]ADlpgd.asc	Lacustrine postglacial fine-grained sediments
[X]ADmpgd.asc	Marine postglacial fine-grained sediments
[X]ADgkl.asc	Glacial clay
[X]ADglfl.asc	Glaciofluvial sediment
[X]ADfill.asc	Artificial fill from the RDM
[X]ADtill.asc	Till
[X]ADbedr.asc	Bedrock adjusted for the shoreline displacement, i.e. height coordinate is given relative to the sea level of the time step

3. Biosphere object boundaries as depicted in Appendix 1 of TR-14-06 in GIS format.

The biosphere objects are delivered in GIS format in the file 'BiosfarsObjekt_SR_PSU.shp'.

4. Exit point locations for radionuclides into the biosphere at each of the six "time slices" (as discussed during the meeting). The reference is Figure 4-15 of R-13-25.

The delivery contains trajectory statistics and particle exit locations for 17 bedrock cases and 6 selected time steps.

The data in the folder reflect particles uniformly released in INDIVIDUAL waste vaults of SFR 1 and SFR 3. Trajectory statistics are only calculated inside the bedrock (not inside tunnels, not inside Hydraulic Soil domain (HSD)).

The delivery is organised according to the following file-name convention:
[Bedrock case]_[Extension layout]_[Time step]_[Release location]_[File type].dat

The delivery is further described in the file 'Td11_Exit locations__READ_ME'.

5. Details of release vs. time for all radionuclides and release locations for each of the climate scenarios. N.B. it is likely that these data are included with, or can be calculated from, the Ecolego models and data included in the request below. If this is the case SKB should indicate how to obtain the data for release rates.

Release vs. time for all radionuclides for each of the climate scenarios can be obtained from the Ecolego '.eas'-files for each waste vault. Table 2 lists all required folders in which models for each waste vaults are contained. All except the "Glacial and post-glacial conditions CC" (CCR_GC) use the same release to the biosphere listed as CC1 (also in question 8). For location in the landscape used in the calculations, SKB has assumed that all of the release will discharge in biosphere object 157_2 for all climate scenarios except during the cold period in CCM_EP in which the release is assumed to discharge in either biosphere object 157_1 or biosphere object 114.

Table 2. Folders containing Ecolego '.eas'-files sufficient to extract deterministic (D) and probabilistic (P) radionuclide release vs. time for all radionuclides and waste vaults for each of the climate scenarios.

Folder name	Calculation case	D/P	Original SVN-path (svn://svn.skb.se/kalkyl/SFR/SR-PSU/)
CC1	CCM_GW/CCM_EP/CCR_EX	D	/Indata/NearfieldAndFarfieldModels/
CCP1	CCM_GW/CCM_EP/CCR_EX	P	/Indata/NearfieldAndFarfieldModels/
CC19	CCR_GC	D	/Indata/NearfieldAndFarfieldModels/
CCP19	CCR_GC	P	/Indata/NearfieldAndFarfieldModels/

6. With reference to Figures 4-11 and 4-12 of R-13-25, the following data in GIS format:
Low-magnetic lineaments (black lines in Figs 4-11 and 4-12)
Boundaries of hydraulic domains (grey areas in Figs 4-11, 4-12)

The requested data is provided in the zip-file 'dz lineament.zip'.

'lineament forsmark.shp' contains a shapefile with low magnetic lineaments from Figure 4-11 and 4-12 in report R-13-25.

'forsmark_dz_0m.shp' contains a shapefile with boundaries of hydraulic domains from Figure 4-11 and 4-12 in report R-13-25.

7. The data file that allows the SFR1 and SFR3 repositories to be drawn in GIS format. See, for example, Appendix 1 of TR-14-06.

In the folder 'GIS-delivery Layout SFR' there are files that allows SFR 1 and SFR 3 to be drawn in GIS.

'Layout_SFR1-POS_FR_FJA_12641.shp ' is a shapefile with the layout of SFR 1 (existing repository). The data layer corresponds to the example figure in Appendix 1 TR-14-06. Coordinate system RT90 2.5 g V.

'Layout_SFR3_ver20-SWI_FR_INF_12881.shp' is a shapefile with the layout of SFR 3 (extension). The data layer corresponds to the example figure in Appendix 1 TR-14-06. Coordinate system RT90 2.5 g V.

8. The Ecolego 'EAS' files and associated inputs sufficient to reproduce deterministic and probabilistic results for the main scenario (global warming and early periglacial variants).

Table 3 lists all required files sufficient to reproduce both deterministic and probabilistic results for the main scenario. The Ecolego '.eas'-files are self-propelled with all sufficient input data correctly imported. Since the waste vaults together with attached geosphere models are separate Ecolego-models; the radionuclide discharge needs to be updated in the biosphere and dose-calculation models if any changes have been performed. In SR-PSU this was performed by exporting the radionuclide discharge from each waste vault after simulation to Ecolego '.ear'-files and then imported and the data was linked to discharge variable in the biosphere and dose calculation models. These steps might be cumbersome to do manually, but they are indeed doable. Similar

approach has been performed for probabilistic input parameter values since the same set of values was required between different calculation cases.

Table 3: Ecolego '.eas'-files sufficient to reproduce deterministic (D) and probabilistic (P) results for the main scenario; i.e. the global warming (CCM_GW and CCM_TR) and early periglacial (CCM_EP) variants. Files listed represent models for biosphere transport and dose calculations. Folders listed contain near-field/far-field models for each waste vault.

File/Folder name	Calculation case	D/P	Type	Original SVN-path (svn://svn.skb.se/kalkyl/SFR/SR-PSU/)
LandscapeMainChain_CC1.eas	CCM_GW	D	File	/Simulation/Assessments/
LandscapeMainChain_CCP1.eas	CCM_GW	P	File	/Simulation/Assessments/
LandscapeMainChain_CC6.eas	CCM_TR	D	File	/Simulation/Assessments/
LandscapeMainChain_CCP6.eas	CCM_TR	P	File	/Simulation/Assessments/
LandscapeMainChain_Cold_CC2.eas	CCM_EP	D	File	/Simulation/Assessments/
LandscapeMainChain_Cold_CCP2.eas	CCM_EP	P	File	/Simulation/Assessments/
CC1	CCM_GW/CCM_EP	D	Folder	/Indata/NearfieldAndFarfieldModels/
CCP1	CCM_GW/CCM_EP	P	Folder	/Indata/NearfieldAndFarfieldModels/
CC6	CCM_TR	D	Folder	/Indata/NearfieldAndFarfieldModels/
CCP6	CCM_TR	P	Folder	/Indata/NearfieldAndFarfieldModels/

9. Copies of the following figures from the Biosphere Synthesis Report (TR-14-06) at scale similar to that used in Figure 6-10 of the same report: Figures 3-2, 3-3, 3-4, 4-6, 5-4, 5-6, 5-7, 5-8 and 5-9.

In the three files 'Figures_Chapter_3_TR-14-06', 'Figure_Chapter_4_TR-14-06', and 'Figures_Chapter_5_TR-14-06' the requested figures are presented in a similar scale as the one used in Figure 6-10.

10. Results for a variant calculation that includes drainage of 157_2 into 157_1 via a stream together with an associated commentary.

SKB has answered this request by a PM (Saetre and Ekström 2016) which examines how the assumptions made on the surface water outlet from the main discharge area affects the calculated dose. The variant calculations show that the effects of adding a stream to the hydrological description of object 157_2 has a marginal effect on the accumulation of radionuclides and on the calculated dose, in the primary discharge area. A redirection of the inlet water to the down-stream object (157_1), from the wetland areas to the open water component of the recipient, will however affect both the accumulation of radionuclides and degassing of C-14 in the down-stream object. In addition, an upper boundary for the concentration of radio carbon in stream and lake water was calculated by allowing the geosphere release to reach a stream directly. None of the variant calculations results in a significantly higher dose than those calculated with the original model, and it is concluded that uncertainties with respect to the presence of a stream in object 157_2, do not have a significant effect on the overall assessment result in SR-PSU.

11. The raw databases used as a basis for the Kd and CR parameterisation.

In SR-PSU parameterisation workflow, two Access databases have been utilised as tools in order to manage the vast number of parameters, samples and data sources. In the first database, SKB_chemistry_SR_PSU.accdb, site-specific K_d and CR values are derived from site-specific concentration measurements and literature data is compiled. In the second database, SKB_Kd_CR.accdb, all available data are compiled and automated functions supports the selection process for each specific parameter case. The implementation of the entire parameterisation process in dynamic databases implicates that there is a traceable link between raw data and the final parameter values.

In addition to the original database files, one document (Grolander and Tröjbom 2016a - Guide to the implementation of the SR-PSU K_d and CR parameterisation in two Access databases) is provided where the implementation of the entire parameterisation process is described. This document assumes that the reader is familiar with both the contents of the report Tröjbom et al. 2013 (R-13-01), and Access database programming. The objective with the main part of this document is to illustrate the SR-PSU K_d and CR parameterisation process using three examples that in detail describe the process from beginning to end. The second part of the document is a technical appendix where database objects and code are further described. This latter part was compiled mainly in order to facilitate future updates of the parameterisation, but may also be useful when reviewing the databases and understanding the structures of the databases.

During the review it is recommended that the reader of the document also has access to the three Excel-files listed in Table 4.

Table 4. Files needed for reviewing the databases as described in 'Guide to the implementation of the SR-PSU Kd and CR parameterisation in two Access databases'

File name	Description
SKB_chemistry_SR_PSU.accdb	Access database where site specific K_d and CR values are derived
SKB_Kd_CR.accdb	Access database that compiles all available data and implements the data selection process
Coupling parameters to data_ver3.xlsx	Interface Excel-file where each parameter is coupled to appropriate site data.
ParamClass.xlsx	Interface Excel-file where parameters are associated to specific site data and literature data sources. Sources are also ranked in this table.
FinalTable_cond_fix_PLOTB.xlsx	Excel-file containing figures where Kd and CR are compared for elements across parameters. This supporting information is not included into the report.

12. Worked examples of the derivation of Kd and CR for the following radionuclides (identified as being important in the initial review of biosphere modelling for specific radionuclides): Ca-41, Ni-59, Mo-93, I-129, U-238

In the SR-PSU assessment for the biosphere, K_d parameters were derived for nine soils and particulate matter, 55 CR parameters were derived for terrestrial, limnic and marine biota and two transfer factors were derived for cow milk and meat. This gives in total 69 parameters and for each parameter 31 elements were parameterised, which sums up to 2,139 unique parameter cases handled. Worked examples for the five listed nuclides for all K_d and CR parameters correspond to 330 unique cases.

The parameters were not manually derived but automated functions in the Access database SKB_Kd_CR.accdb were used to achieve K_d and CR values. Nevertheless, manual reproduction of the parameters is doable. The document (Grolander and Tröjbom 2016b -Manual reproduction of parameter values) includes worked examples for two parameters (one K_d and one CR parameter) for the five requested nuclides. The examples in this document can be seen as instructions on how to manually reproduce and review any parameter case of interest based on the original data files provided and the information on data selections given in Tröjbom et al. 2013. This can be seen as one option to review and quality assure the K_d and CR data selection process and the resulting parameter values without the need to investigate the database tools in detail.

Files needed for manually reproduce and review the selected parameter values are listed below (Table 5).

Table 5. Files needed for manually reproduce and reviewing the databases as described in Manual reproduction of parameter values'

File name	Description
Matched_SNO.xlsx	Excel-file that specifies which sample pairs are combined for the calculation of K_d and CR.
SKB_Chemistry_SR_PSU.xlsx	Excel-file with site specific concentrations data.
Kd_CR.xls	Excel-file that compiles all available site-specific data and literature data.
ConversionFactors.xlxs	Excel-file with conversion factors derived from IAEA data on carbon and dry matter content.
Excluded_sampels.xlsx	Excel-file that lists site-specific samples excluded during the parameterisation process.
DMC & CC database.xlsx	Excel file that contains dry matter and carbon content data from IAEA.

Med vänlig hälsning

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Bilagor

1. *Saetre P, Ekström P-A, 2016. Drainage of runoff water from 157_2 into157_1 via a stream – Biosphere complementary information for SR-PSU,* SKBdoc 1554499, ver 1.0, Svensk Kärnbränslehantering AB
2. *Grolander S, Tröjbom M, 2016a. Guide to the SR-PSU parameterisation of Kd and CR*, SKBdoc 1555970, ver 1.0, Svensk Kärnbränslehantering AB
3. *Grolander S, Tröjbom M, 2016b. Manual reproduction of parameter values*, SKBdoc 1556279, ver 1.0, Svensk Kärnbränslehantering AB

Alla dokument och datafiler levereras till SSM på ett usb-minne. Dokumenten och datafilerna finns lagrade hos SKB på följande plats:
svn.skb.se/trac/PSU/browser/Tillståndsansökan/Komplettering_aug_2016