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E. Tosoni , A. Salo , J. Govaerts , E. Zio

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Article Title

Definition of the data for comprehensiveness in scenario analysis of near-surface nuclear waste repositories

Authors

E. Tosoni[1,2], A. Salo[1], J. Govaerts[3], E. Zio[2,4,5]

Affiliations

1. Department of Mathematics and Systems Analysis, Aalto University, Finland
2. Energy Department, Politecnico di Milano, Italy
3. SCK·CEN, Studiecentrum voor Kernenergie - Centre d'Étude de l'Énergie Nucléaire, Belgium
4. MINES ParisTech/PSL Université Paris, Centre de Recherche sur les Risques et les Crises (CRC), Sophia Antipolis, France
5. Eminent Scholar, Department of Nuclear Engineering, Kyung Hee University, South Korea

Corresponding author(s)

edoardo.tosoni@aalto.fi

Abstract

This article provides data on the near-surface repository for nuclear waste in the associated Research article “Comprehensiveness of scenarios in the safety assessment of nuclear waste repositories” [1].We illustrate i) the parameters of the COMSOL Multiphysics model for calculating the radiological impact of the repository, ii) the set of scenarios analyzed following a pluralistic approach, and iii) nodes, experts’ beliefs and prior probabilities for the scenario analysis based on Bayesian networks.

Keywords

Safety Assessment, Scenario Analysis, Comprehensiveness, Uncertainty, Bayesian networks.

Specifications Table

Subject	Engineering
Specific subject area	Risk and reliability analysis
Type of data	Tables Figure
How data were acquired	Authors' assumptions and computational simulations
Data format	Raw
Parameters for data collection	Data are part of the modelling of a near-surface nuclear waste repository
Description of data collection	The figure with the schematization of the repository, the simulation-model parameters and most probabilities for the Bayesian network were supplied by the authors based on their assumptions. The prior values of the conditional probabilities for the dose rate were derived from the results of computer simulations.
Data source location	Aalto University, Espoo, Finland - 60°11'11.9"N 24°49'41.9"E Politecnico di Milano, Milan, Italy - 45°30'10.6"N 9°09'21.8"E SCK·CEN, Studiecentrum voor Kernenergie - Centre d'Étude de l'Énergie Nucléaire, Mol, Belgium - 51°13'07.7"N 5°05'40.9"E
Data accessibility	With the article
Related research article	E Tosoni, A Salo, J Govaerts, E Zio, Comprehensiveness of scenarios in the safety assessment of nuclear waste repositories. Reliability Engineering & System Safety, 188 (2019) 561-573.

Value of the Data

- This data makes it possible to reproduce the results in the associated Research article.
- Data provides a benchmark for researchers who plan to investigate alternative assumptions concerning, for instance, the probabilities in the Bayesian network or prior probabilities in computational simulations.
- Data supports further developments outlined in the associated Research article, including the calculation of risk importance measures

Data Description

Table 1 lists the model parameters of COMSOL Multiphysics [2]. This software was used for calculating the radiation dose to the public due to exposure to radionuclides leaked from the repository studied in Tosoni et al. (2019) [1], as represented in Figure 1. Table 2 reports the COMSOL parameter values for the characterization of scenarios which were formulated following a pluralistic approach.

Table 3 illustrates the Features, Events and Processes (FEPs) and the safety target of the Bayesian network for the probabilistic scenario analysis (second column), the corresponding consistent model parameters (third column), and their discrete states (fourth to sixth columns). Specifically, the earthquake can be either a beyond-design-basis (*BDBE*, return period of 20,000 y) or a *major* one. The other FEPs are associated with continuous ranges whose bounds characterize opposite pluralistic scenarios (e.g., “low” versus “high”).

Table 4 -

Table 12 present illustrative assignments to the probabilities for the FEPs of the BN. Lastly, Table 13 reports the prior probabilities of the violation state at the safety target (columns 9 and 18), conditioned on subscenarios (columns 1 through 8, and 10 through 17) associated with the states of the FEPs *Water flux*, *Crack aperture*, *Diffusion coefficient*, *Distribution coefficient*, *Chemical degradation*, *Barrier degradation*, *Monolith degradation* and *Hydraulic conductivity*.

Figure 1. Conceptual representation of near-surface disposal, and flowchart of the human dose-exposure model in COMSOL (white boxes).

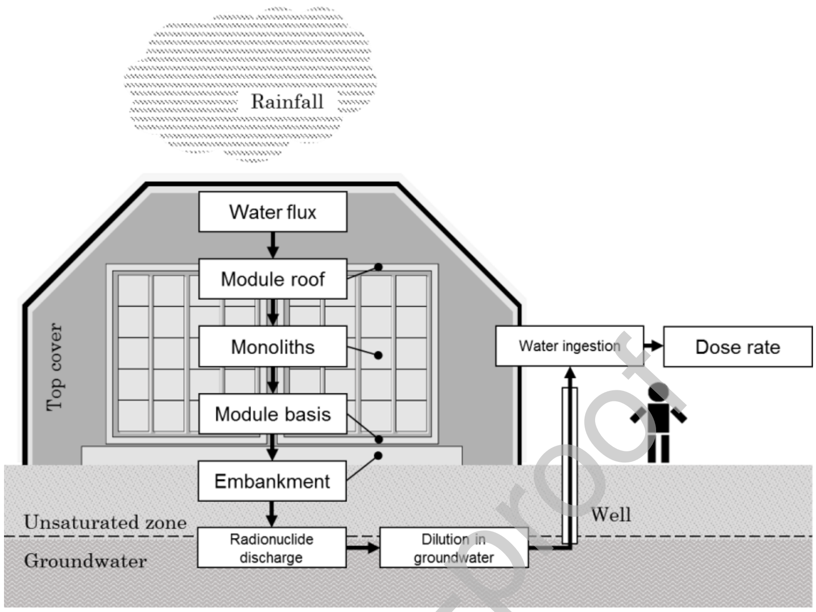

Table 1. Parameters of COMSOL Multiphysics and their units of measurements.

Parameter	u.m.	Parameter	u.m.
Initial water flux	m s^{-1}	Diffusion coefficient of embankment	m^2 s^{-1}
Degraded water flux	m s^{-1}	Diffusion coefficient of cracks	m^2 s^{-1}
Initial hydraulic conductivity of module	m s^{-1}	Initial longitudinal dispersivity of concrete	m
Degraded hydraulic conductivity of module	m s^{-1}	Degraded longitudinal dispersivity of concrete	m
Initial hydraulic conductivity of monolith	m s^{-1}	Initial transverse dispersivity of concrete	m
Degraded hydraulic conductivity of monolith	m s^{-1}	Degraded transverse dispersivity of concrete	m
Hydraulic conductivity of embankment	m s^{-1}	Longitudinal dispersivity of concrete	m
Hydraulic conductivity of cracks	m s^{-1}	Transverse dispersivity of concrete	m
Initial crack aperture	μm	Barrier degradation	y
Degraded crack aperture	μm	Monolith degradation	y
Initial porosity of concrete	-	Distribution coeff. in concrete, State I (*)	l kg^{-1}
Degraded porosity of concrete	-	Distribution coeff. in concrete, State II (*)	l kg^{-1}
Initial porosity of mortar (grout in monolith)	-	Distribution coeff. in concrete, State IV (*)	l kg^{-1}
Degraded porosity of mortar	-	Distribution coeff. in embankment, State I (*)	l kg^{-1}
Porosity of embankment	-	Distribution coeff. in embankment, State II (*)	l kg^{-1}
Initial bulk density of concrete	kg m^{-3}	Distribution coeff. in embankment, State IV (*)	l kg^{-1}
Degraded bulk density of concrete	kg m^{-3}	t_i	y
Initial bulk density of mortar	kg m^{-3}	t_{ii}	y
Degraded bulk density of mortar	kg m^{-3}	t_{ii1}	y
Bulk density of embankment	kg m^{-3}	t_{ii2}	y
Initial diffusion coefficient of concrete	m^2 s^{-1}	t_{iii}	y
Degraded diffusion coefficient of concrete	m^2 s^{-1}	Geotransfer factor	-
Initial diffusion coefficient of mortar	m^2 s^{-1}	Bioconversion factor (*)	Sv Bq^{-1}
Degraded diffusion coefficient of mortar	m^2 s^{-1}	(*) Radionuclide-specific	

Table 2. Values of COMSOL parameters (rows, units of measurement from Table 1) in the pluralistic scenarios (columns).

<table>
<tr><th>Parameter</th><th>Base</th><th>Low sorption</th><th>High sorption</th><th>Fast chemical degradation</th><th>Slow chemical degradation</th><th>High conductivity</th><th>Low infiltration</th><th>High diffusion</th><th>Uncracked basis</th><th>Bathtubbing</th><th>Fast monolith degradation</th><th>Major earthquake</th><th>Major earthquake also affecting monolith</th><th>Cover disappearance</th></tr>
<tr><td>Initial water flux</td><td colspan="5">3.4E-12</td><td>4.58E-11</td><td colspan="3">3.4E-12</td><td>4.73E-12</td><td colspan="4">3.4E-12</td></tr>
<tr><td>Degraded water flux</td><td colspan="6">1.31E-08</td><td>3.17E-09</td><td colspan="6">1.31E-08</td><td>3.00E-08</td></tr>
<tr><td>Init. hyd. cond. mod.</td><td colspan="5">1.75E-12</td><td>4.58E-11</td><td colspan="8">1.75E-12</td></tr>
<tr><td>Init. hyd. cond. mon.</td><td colspan="5">1.42E-13</td><td>2.91E-11</td><td colspan="8">1.42E-13</td></tr>
<tr><td>Degr. crack aperture</td><td colspan="8">300</td><td>1</td><td colspan="5">300</td></tr>
<tr><td>Init. diff. coeff. con.</td><td colspan="7">3.83E-11</td><td>2.03E-10</td><td>3.83E-11</td><td>7.01E-11</td><td colspan="4">3.83E-11</td></tr>
<tr><td>Init. diff. coeff. mor.</td><td colspan="7">8.46E-12</td><td>1.75E-10</td><td>8.46E-12</td><td>1.56E-11</td><td colspan="4">8.46E-12</td></tr>
<tr><td>Barrier degradation</td><td colspan="11">466</td><td colspan="2">50</td><td>466</td></tr>
<tr><td>Monolith degradation</td><td colspan="10">1,350</td><td>1</td><td>1,350</td><td>50</td><td>1,350</td></tr>
<tr><td>Distr. coeff. con. St. I 129I</td><td>1.50E-01</td><td>0</td><td>4.50E01</td><td colspan="11">1.50E-01</td></tr>
<tr><td>Distr. coeff. con. St. II 129I</td><td>1.50E00</td><td>0</td><td>1.50E02</td><td colspan="11">1.50E00</td></tr>
<tr><td>Distr. coeff. con. St. IV 129I</td><td>1.50E-01</td><td>0</td><td>4.00E00</td><td colspan="11">1.50E-01</td></tr>
<tr><td>Distr. coeff. emb. St. I 129I</td><td>5.00E-02</td><td>0</td><td>1.50E01</td><td colspan="11">5.00E-02</td></tr>
<tr><td>Distr. coeff. emb. St. II 129I</td><td>5.00E-01</td><td>0</td><td>5.00E01</td><td colspan="11">5.00E-01</td></tr>
<tr><td>Distr. coeff. con. St. I 239Pu</td><td>3.00E02</td><td>1.50E02</td><td>1.50E05</td><td colspan="11">3.00E02</td></tr>
<tr><td>Distr. coeff. con. St. II 239Pu</td><td>4.50E03</td><td>1.50E02</td><td>1.50E05</td><td colspan="11">4.50E03</td></tr>
<tr><td>Distr. coeff. con. St. IV 239Pu</td><td>5.00E01</td><td>3.00E01</td><td>1.50E05</td><td colspan="11">5.00E01</td></tr>
<tr><td>Distr. coeff. emb. St. I 239Pu</td><td>1.00E02</td><td>5.00E01</td><td>5.00E04</td><td colspan="11">1.00E02</td></tr>
<tr><td>Distr. coeff. emb. St. II 239Pu</td><td>1.50E03</td><td>5.00E01</td><td>5.00E04</td><td colspan="11">1.50E03</td></tr>
<tr><td>t_i</td><td colspan="3">10</td><td>5</td><td>20</td><td colspan="9">10</td></tr>
<tr><td>t_{ii}</td><td colspan="3">2,061</td><td>1,030</td><td>4,122</td><td colspan="9">2,061</td></tr>
<tr><td>t_{ii1}</td><td colspan="3">6,100</td><td>3,050</td><td>12,200</td><td colspan="9">6,100</td></tr>
<tr><td>t_{ii2}</td><td colspan="3">19,400</td><td>9,700</td><td>38,800</td><td colspan="9">19,400</td></tr>
<tr><td>t_{iii}</td><td colspan="3">34,339</td><td>17,170</td><td>68,678</td><td colspan="9">34,339</td></tr>
</table>

Table 3. FEPs and safety target of the Bayesian network with their consistent COMSOL parameters (if any) and states, possibly derived from discretization of continuous ranges (units of measurement from Table 1; *Dose rate* is normalized, hence dimensionless).

	Node	Parameter	States			Discretization		
FEPs	Earthquake	-	BDBE	Major		-		
	Water flux	Initial water flux	Low	High		$[\ a^{IWF}, m^{IWF}\ )$	$[\ m^{IWF}, K_{eff}^{stack}\ ]$	
		Degraded water flux				[3.17E-09, 1.31E-08)	[1.31E-08, 3.00E-08]	
	Crack aperture	Degr. crack aperture	Micro	Macro		[1,100)	[100,300]	
	Diffusion coefficient	Init. diff. coeff. con.	Low	High		[3.83E-11, 8.82E-11)	[8.82E-11, 2.03E-10]	
		Init. diff. coeff. mor.				[8.46E-12, 3.85E-11)	[3.85E-11, 1.75E-10]	
	Distribution coefficient	Distr. coeff. con. St. I 129I	Low	High		[0, 2.12E-01)	[2.12E-01, 4.50E01]	
		Distr. coeff. con. St. II 129I				[0, 3.87E-01)	[3.87E-01, 1.50E02]	
		Distr. coeff. con. St. IV 129I				[0, 6.32E-02)	[6.32E-02, 4.00E00]	
		Distr. coeff. emb. St. I 129I				[0, 1.22E-01)	[1.22E-01, 1.50E01]	
		Distr. coeff. emb. St. II 129I				[0, 2.24E-01)	[2.24E-01, 5.00E01]	
		Distr. coeff. con. St. I 239Pu				[1.50E02, 4.74E03)	[4.74E03, 1.50E05]	
		Distr. coeff. con. St. II 239Pu				[1.50E02, 4.74E03)	[4.74E03, 1.50E05]	
		Distr. coeff. con. St. IV 239Pu				[3.00E01, 2.12E03)	[2.12E03, 1.50E05]	
		Distr. coeff. emb. St. I 239Pu				[5.00E01, 1.58E03)	[1.58E03, 5.00E04]	
		Distr. coeff. emb. St. II 239Pu				[5.00E01, 1.58E03)	[1.58E03, 5.00E04]	
	Chemical degradation	t_i	Fast	Slow		[5, 10)	[10, 20]	
		t_{ii}				[1,030, 2,061)	[2,061, 4,122]	
		t_{ii1}				[3,050, 6,100)	[6,100, 12,200]	
		t_{ii2}				[9,700, 19,400)	[19,400, 38,800]	
		t_{iii}				[17,170, 34,339)	[34,339, 68,678]	
	Barrier degradation	itself	Fast	Slow		[50, 150)	[150, 466]	
	Monolith degradation	itself	Very fast	Fast	Slow	[0, 50)	[50, 250)	[250, 1,350]
	Hydraulic conductivity	Init. hyd. cond. mod.	Low	Medium	High	[1.75E-12, 2.12E-12)	[2.12E-12, 1.00E-11)	[1.00E-11, 4.58E-11]
		Init. hyd. cond. mon.				[1.42E-13, 1.94E-13)	[1.94E-13, 2.43E-12)	[2.43E-12, 2.91E-11]
Safety target	Dose rate	-	Respect	Violation		[0, 1)	[1, +∞)	

Table 4. Assumptions on the probabilities for the FEP *Earthquake*

Earthquake		
State	Assumption 1	Assumption 2
BDBE	9.954E-01	9.908E-01
Major	4.600E-03	9.200E-03

Table 5. Assumptions on the probabilities for the FEP *Water flux*

Water flux		
State	Assumption 1	Assumption 2
Low	0.631	0.864
High	0.369	0.136

Table 6. Assumptions on the probabilities for the FEP *Crack aperture*

Crack aperture		
State	Assumption 1	Assumption 2
Micro	0.807	0.869
Macro	0.193	0.104

Table 7. Assumptions on the probabilities for the FEP *Diffusion coefficient*

Diffusion coefficient		
State	Assumption 1	Assumption 2
Low	0.500	0.750
High	0.500	0.250

Table 8. Assumptions on the probabilities for the FEP *Distribution coefficient*

Distribution coefficient		
State	Assumption 1	Assumption 2
Low	0.500	0.750
High	0.500	0.250

Table 9. Assumptions on the probabilities for the FEP Chemical degradation

Chemical degradation			
State	Expert 1	Assumption 2	Assumption 3
Fast	0.500	0.750	0.550
Slow	0.500	0.250	0.450

Table 10. Assumptions on the probabilities for the FEP *Barrier degradation*

Barrier degradation			
Subscenario			
Earthquake	State	Assumption 1	Assumption 2
BDBE	Fast	0.250	0.058
	Slow	0.750	0.942
Major	Fast	0.490	0.360
	Slow	0.510	0.640

Table 11. Assumptions on the probabilities for the FEP *Monolith degradation*

Monolith degradation			
Subscenario			
Earthquake	State	Assumption 1	Assumption 2
BDBE	Very fast	0.295	0.001
	Fast	0.292	0.033
	Slow	0.413	0.966
Major	Very fast	0.295	0.001
	Fast	0.425	0.345
	Slow	0.280	0.654

Table 12. Assumptions on the probabilities for the FEP *Hydraulic conductivity*

Hydraulic conductivity			
Subscenario			
Crack aperture	State	Assumption 1	Assumption 2
Micro	Low	0.814	0.667
	Medium	0.109	0.189
	High	0.077	0.144
Macro	Low	0.109	0.189
	Medium	0.814	0.667
	High	0.077	0.144

Table 13. Prior probabilities of the violation state conditioned on the subscenarios of the safety target.

Water flux	Crack aperture	Diffusion coefficient	Distribution coefficient	Chemical degradation	Barrier degradation	Monolith degradation	Hydraulic conductivity	Prior conditional violation probability	Water flux	Crack aperture	Diffusion coefficient	Distribution coefficient	Chemical degradation	Barrier degradation	Monolith degradation	Hydraulic conductivity	Prior conditional violation probability
Low	Micro	Low	Low	Fast	Fast	Very fast	Low	0.000	Low	Micro	Low	Low	Fast	Slow	Fast	Medium	0.333
High	Micro	Low	Low	Fast	Fast	Very fast	Low	0.500	High	Micro	Low	Low	Fast	Slow	Fast	Medium	0.333
Low	Macro	Low	Low	Fast	Fast	Very fast	Low	0.250	Low	Macro	Low	Low	Fast	Slow	Fast	Medium	0.000
High	Macro	Low	Low	Fast	Fast	Very fast	Low	0.500	High	Macro	Low	Low	Fast	Slow	Fast	Medium	0.667
Low	Micro	High	Low	Fast	Fast	Very fast	Low	0.333	Low	Micro	High	Low	Fast	Slow	Fast	Medium	0.333
High	Micro	High	Low	Fast	Fast	Very fast	Low	0.667	High	Micro	High	Low	Fast	Slow	Fast	Medium	0.500
Low	Macro	High	Low	Fast	Fast	Very fast	Low	0.333	Low	Macro	High	Low	Fast	Slow	Fast	Medium	0.000
High	Macro	High	Low	Fast	Fast	Very fast	Low	0.500	High	Macro	High	Low	Fast	Slow	Fast	Medium	0.333
Low	Micro	Low	High	Fast	Fast	Very fast	Low	0.000	Low	Micro	Low	High	Fast	Slow	Fast	Medium	0.000
High	Micro	Low	High	Fast	Fast	Very fast	Low	0.000	High	Micro	Low	High	Fast	Slow	Fast	Medium	0.000
Low	Macro	Low	High	Fast	Fast	Very fast	Low	0.000	Low	Macro	Low	High	Fast	Slow	Fast	Medium	0.000
High	Macro	Low	High	Fast	Fast	Very fast	Low	0.000	High	Macro	Low	High	Fast	Slow	Fast	Medium	0.000
Low	Micro	High	High	Fast	Fast	Very fast	Low	0.000	Low	Micro	High	High	Fast	Slow	Fast	Medium	0.000
High	Micro	High	High	Fast	Fast	Very fast	Low	0.333	High	Micro	High	High	Fast	Slow	Fast	Medium	0.000
Low	Macro	High	High	Fast	Fast	Very fast	Low	0.000	Low	Macro	High	High	Fast	Slow	Fast	Medium	0.000
High	Macro	High	High	Fast	Fast	Very fast	Low	0.000	High	Macro	High	High	Fast	Slow	Fast	Medium	0.000
Low	Micro	Low	Low	Slow	Fast	Very fast	Low	0.000	Low	Micro	Low	Low	Slow	Slow	Fast	Medium	0.333
High	Micro	Low	Low	Slow	Fast	Very fast	Low	0.750	High	Micro	Low	Low	Slow	Slow	Fast	Medium	0.500
Low	Macro	Low	Low	Slow	Fast	Very fast	Low	0.000	Low	Macro	Low	Low	Slow	Slow	Fast	Medium	0.000
High	Macro	Low	Low	Slow	Fast	Very fast	Low	0.667	High	Macro	Low	Low	Slow	Slow	Fast	Medium	0.333
Low	Micro	High	Low	Slow	Fast	Very fast	Low	0.333	Low	Micro	High	Low	Slow	Slow	Fast	Medium	0.000
High	Micro	High	Low	Slow	Fast	Very fast	Low	0.500	High	Micro	High	Low	Slow	Slow	Fast	Medium	0.500
Low	Macro	High	Low	Slow	Fast	Very fast	Low	0.000	Low	Macro	High	Low	Slow	Slow	Fast	Medium	0.000
High	Macro	High	Low	Slow	Fast	Very fast	Low	0.667	High	Macro	High	Low	Slow	Slow	Fast	Medium	0.000
Low	Micro	Low	High	Slow	Fast	Very fast	Low	0.000	Low	Micro	Low	High	Slow	Slow	Fast	Medium	0.000
High	Micro	Low	High	Slow	Fast	Very fast	Low	0.500	High	Micro	Low	High	Slow	Slow	Fast	Medium	0.000
Low	Macro	Low	High	Slow	Fast	Very fast	Low	0.000	Low	Macro	Low	High	Slow	Slow	Fast	Medium	0.000
High	Macro	Low	High	Slow	Fast	Very fast	Low	0.000	High	Macro	Low	High	Slow	Slow	Fast	Medium	0.000
Low	Micro	High	High	Slow	Fast	Very fast	Low	0.000	Low	Micro	High	High	Slow	Slow	Fast	Medium	0.000
High	Micro	High	High	Slow	Fast	Very fast	Low	0.333	High	Micro	High	High	Slow	Slow	Fast	Medium	0.000
Low	Macro	High	High	Slow	Fast	Very fast	Low	0.000	Low	Macro	High	High	Slow	Slow	Fast	Medium	0.000
High	Macro	High	High	Slow	Fast	Very fast	Low	0.000	High	Macro	High	High	Slow	Slow	Fast	Medium	0.000
Low	Micro	Low	Low	Fast	Slow	Very fast	Low	0.500	Low	Micro	Low	Low	Fast	Fast	Slow	Medium	0.333
High	Micro	Low	Low	Fast	Slow	Very fast	Low	0.333	High	Micro	Low	Low	Fast	Fast	Slow	Medium	0.750
Low	Macro	Low	Low	Fast	Slow	Very fast	Low	0.000	Low	Macro	Low	Low	Fast	Fast	Slow	Medium	0.000
High	Macro	Low	Low	Fast	Slow	Very fast	Low	0.000	High	Macro	Low	Low	Fast	Fast	Slow	Medium	0.333

Low	Micro	High	Low	Fast	Slow	Very fast	Low	0.000	Low	Micro	High	Low	Fast	Fast	Slow	Medium	0.500
High	Micro	High	Low	Fast	Slow	Very fast	Low	0.333	High	Micro	High	Low	Fast	Fast	Slow	Medium	0.667
Low	Macro	High	Low	Fast	Slow	Very fast	Low	0.333	Low	Macro	High	Low	Fast	Fast	Slow	Medium	0.333
High	Macro	High	Low	Fast	Slow	Very fast	Low	0.000	High	Macro	High	Low	Fast	Fast	Slow	Medium	0.500
Low	Micro	Low	High	Fast	Slow	Very fast	Low	0.000	Low	Micro	Low	High	Fast	Fast	Slow	Medium	0.000
High	Micro	Low	High	Fast	Slow	Very fast	Low	0.000	High	Micro	Low	High	Fast	Fast	Slow	Medium	0.000
Low	Macro	Low	High	Fast	Slow	Very fast	Low	0.000	Low	Macro	Low	High	Fast	Fast	Slow	Medium	0.000
High	Macro	Low	High	Fast	Slow	Very fast	Low	0.000	High	Macro	Low	High	Fast	Fast	Slow	Medium	0.000
Low	Micro	High	High	Fast	Slow	Very fast	Low	0.000	Low	Micro	High	High	Fast	Fast	Slow	Medium	0.000
High	Micro	High	High	Fast	Slow	Very fast	Low	0.000	High	Micro	High	High	Fast	Fast	Slow	Medium	0.000
Low	Macro	High	High	Fast	Slow	Very fast	Low	0.000	Low	Macro	High	High	Fast	Fast	Slow	Medium	0.000
High	Macro	High	High	Fast	Slow	Very fast	Low	0.000	High	Macro	High	High	Fast	Fast	Slow	Medium	0.000
Low	Micro	Low	Low	Slow	Slow	Very fast	Low	0.000	Low	Micro	Low	Low	Slow	Fast	Slow	Medium	0.667
High	Micro	Low	Low	Slow	Slow	Very fast	Low	0.333	High	Micro	Low	Low	Slow	Fast	Slow	Medium	0.667
Low	Macro	Low	Low	Slow	Slow	Very fast	Low	0.000	Low	Macro	Low	Low	Slow	Fast	Slow	Medium	0.000
High	Macro	Low	Low	Slow	Slow	Very fast	Low	0.333	High	Macro	Low	Low	Slow	Fast	Slow	Medium	0.333
Low	Micro	High	Low	Slow	Slow	Very fast	Low	0.000	Low	Micro	High	Low	Slow	Fast	Slow	Medium	0.333
High	Micro	High	Low	Slow	Slow	Very fast	Low	0.667	High	Micro	High	Low	Slow	Fast	Slow	Medium	0.667
Low	Macro	High	Low	Slow	Slow	Very fast	Low	0.000	Low	Macro	High	Low	Slow	Fast	Slow	Medium	0.000
High	Macro	High	Low	Slow	Slow	Very fast	Low	0.000	High	Macro	High	Low	Slow	Fast	Slow	Medium	0.667
Low	Micro	Low	High	Slow	Slow	Very fast	Low	0.000	Low	Micro	Low	High	Slow	Fast	Slow	Medium	0.000
High	Micro	Low	High	Slow	Slow	Very fast	Low	0.000	High	Micro	Low	High	Slow	Fast	Slow	Medium	0.333
Low	Macro	Low	High	Slow	Slow	Very fast	Low	0.000	Low	Macro	Low	High	Slow	Fast	Slow	Medium	0.000
High	Macro	Low	High	Slow	Slow	Very fast	Low	0.000	High	Macro	Low	High	Slow	Fast	Slow	Medium	0.000
Low	Micro	High	High	Slow	Slow	Very fast	Low	0.000	Low	Micro	High	High	Slow	Fast	Slow	Medium	0.000
High	Micro	High	High	Slow	Slow	Very fast	Low	0.000	High	Micro	High	High	Slow	Fast	Slow	Medium	0.333
Low	Macro	High	High	Slow	Slow	Very fast	Low	0.000	Low	Macro	High	High	Slow	Fast	Slow	Medium	0.000
High	Macro	High	High	Slow	Slow	Very fast	Low	0.000	High	Macro	High	High	Slow	Fast	Slow	Medium	0.000
Low	Micro	Low	Low	Fast	Fast	Fast	Low	0.667	Low	Micro	Low	Low	Fast	Slow	Slow	Medium	0.500
High	Micro	Low	Low	Fast	Fast	Fast	Low	0.667	High	Micro	Low	Low	Fast	Slow	Slow	Medium	0.667
Low	Macro	Low	Low	Fast	Fast	Fast	Low	0.000	Low	Macro	Low	Low	Fast	Slow	Slow	Medium	0.000
High	Macro	Low	Low	Fast	Fast	Fast	Low	0.000	High	Macro	Low	Low	Fast	Slow	Slow	Medium	0.333
Low	Micro	High	Low	Fast	Fast	Fast	Low	0.500	Low	Micro	High	Low	Fast	Slow	Slow	Medium	0.500
High	Micro	High	Low	Fast	Fast	Fast	Low	0.750	High	Micro	High	Low	Fast	Slow	Slow	Medium	0.667
Low	Macro	High	Low	Fast	Fast	Fast	Low	0.500	Low	Macro	High	Low	Fast	Slow	Slow	Medium	0.000
High	Macro	High	Low	Fast	Fast	Fast	Low	0.333	High	Macro	High	Low	Fast	Slow	Slow	Medium	0.333
Low	Micro	Low	High	Fast	Fast	Fast	Low	0.000	Low	Micro	Low	High	Fast	Slow	Slow	Medium	0.000
High	Micro	Low	High	Fast	Fast	Fast	Low	0.500	High	Micro	Low	High	Fast	Slow	Slow	Medium	0.000
Low	Macro	Low	High	Fast	Fast	Fast	Low	0.000	Low	Macro	Low	High	Fast	Slow	Slow	Medium	0.000
High	Macro	Low	High	Fast	Fast	Fast	Low	0.000	High	Macro	Low	High	Fast	Slow	Slow	Medium	0.000
Low	Micro	High	High	Fast	Fast	Fast	Low	0.000	Low	Micro	High	High	Fast	Slow	Slow	Medium	0.000
High	Micro	High	High	Fast	Fast	Fast	Low	0.000	High	Micro	High	High	Fast	Slow	Slow	Medium	0.000
Low	Macro	High	High	Fast	Fast	Fast	Low	0.000	Low	Macro	High	High	Fast	Slow	Slow	Medium	0.000
High	Macro	High	High	Fast	Fast	Fast	Low	0.000	High	Macro	High	High	Fast	Slow	Slow	Medium	0.000
Low	Micro	Low	Low	Slow	Fast	Fast	Low	0.333	Low	Micro	Low	Low	Slow	Slow	Slow	Medium	0.500

High	Micro	Low	Low	Slow	Fast	Fast	Low	0.500	High	Micro	Low	Low	Slow	Slow	Slow	Medium	0.667
Low	Macro	Low	Low	Slow	Fast	Fast	Low	0.333	Low	Macro	Low	Low	Slow	Slow	Slow	Medium	0.000
High	Macro	Low	Low	Slow	Fast	Fast	Low	0.667	High	Macro	Low	Low	Slow	Slow	Slow	Medium	0.000
Low	Micro	High	Low	Slow	Fast	Fast	Low	0.667	Low	Micro	High	Low	Slow	Slow	Slow	Medium	0.333
High	Micro	High	Low	Slow	Fast	Fast	Low	0.500	High	Micro	High	Low	Slow	Slow	Slow	Medium	0.500
Low	Macro	High	Low	Slow	Fast	Fast	Low	0.000	Low	Macro	High	Low	Slow	Slow	Slow	Medium	0.000
High	Macro	High	Low	Slow	Fast	Fast	Low	0.667	High	Macro	High	Low	Slow	Slow	Slow	Medium	0.000
Low	Micro	Low	High	Slow	Fast	Fast	Low	0.000	Low	Micro	Low	High	Slow	Slow	Slow	Medium	0.000
High	Micro	Low	High	Slow	Fast	Fast	Low	0.333	High	Micro	Low	High	Slow	Slow	Slow	Medium	0.000
Low	Macro	Low	High	Slow	Fast	Fast	Low	0.000	Low	Macro	Low	High	Slow	Slow	Slow	Medium	0.000
High	Macro	Low	High	Slow	Fast	Fast	Low	0.333	High	Macro	Low	High	Slow	Slow	Slow	Medium	0.000
Low	Micro	High	High	Slow	Fast	Fast	Low	0.000	Low	Micro	High	High	Slow	Slow	Slow	Medium	0.000
High	Micro	High	High	Slow	Fast	Fast	Low	0.000	High	Micro	High	High	Slow	Slow	Slow	Medium	0.000
Low	Macro	High	High	Slow	Fast	Fast	Low	0.000	Low	Macro	High	High	Slow	Slow	Slow	Medium	0.000
High	Macro	High	High	Slow	Fast	Fast	Low	0.000	High	Macro	High	High	Slow	Slow	Slow	Medium	0.000
Low	Micro	Low	Low	Fast	Slow	Fast	Low	0.000	Low	Micro	Low	Low	Fast	Fast	Very fast	High	0.000
High	Micro	Low	Low	Fast	Slow	Fast	Low	0.000	High	Micro	Low	Low	Fast	Fast	Very fast	High	0.667
Low	Macro	Low	Low	Fast	Slow	Fast	Low	0.000	Low	Macro	Low	Low	Fast	Fast	Very fast	High	0.667
High	Macro	Low	Low	Fast	Slow	Fast	Low	0.500	High	Macro	Low	Low	Fast	Fast	Very fast	High	0.500
Low	Micro	High	Low	Fast	Slow	Fast	Low	0.000	Low	Micro	High	Low	Fast	Fast	Very fast	High	0.333
High	Micro	High	Low	Fast	Slow	Fast	Low	0.500	High	Micro	High	Low	Fast	Fast	Very fast	High	0.667
Low	Macro	High	Low	Fast	Slow	Fast	Low	0.000	Low	Macro	High	Low	Fast	Fast	Very fast	High	0.000
High	Macro	High	Low	Fast	Slow	Fast	Low	0.500	High	Macro	High	Low	Fast	Fast	Very fast	High	0.333
Low	Micro	Low	High	Fast	Slow	Fast	Low	0.000	Low	Micro	Low	High	Fast	Fast	Very fast	High	0.000
High	Micro	Low	High	Fast	Slow	Fast	Low	0.000	High	Micro	Low	High	Fast	Fast	Very fast	High	0.667
Low	Macro	Low	High	Fast	Slow	Fast	Low	0.000	Low	Macro	Low	High	Fast	Fast	Very fast	High	0.000
High	Macro	Low	High	Fast	Slow	Fast	Low	0.000	High	Macro	Low	High	Fast	Fast	Very fast	High	0.333
Low	Micro	High	High	Fast	Slow	Fast	Low	0.000	Low	Micro	High	High	Fast	Fast	Very fast	High	0.000
High	Micro	High	High	Fast	Slow	Fast	Low	0.000	High	Micro	High	High	Fast	Fast	Very fast	High	0.000
Low	Macro	High	High	Fast	Slow	Fast	Low	0.000	Low	Macro	High	High	Fast	Fast	Very fast	High	0.000
High	Macro	High	High	Fast	Slow	Fast	Low	0.000	High	Macro	High	High	Fast	Fast	Very fast	High	0.000
Low	Micro	Low	Low	Slow	Slow	Fast	Low	0.000	Low	Micro	Low	Low	Slow	Fast	Very fast	High	0.333
High	Micro	Low	Low	Slow	Slow	Fast	Low	0.333	High	Micro	Low	Low	Slow	Fast	Very fast	High	0.667
Low	Macro	Low	Low	Slow	Slow	Fast	Low	0.000	Low	Macro	Low	Low	Slow	Fast	Very fast	High	0.667
High	Macro	Low	Low	Slow	Slow	Fast	Low	0.333	High	Macro	Low	Low	Slow	Fast	Very fast	High	0.500
Low	Micro	High	Low	Slow	Slow	Fast	Low	0.000	Low	Micro	High	Low	Slow	Fast	Very fast	High	0.000
High	Micro	High	Low	Slow	Slow	Fast	Low	0.333	High	Micro	High	Low	Slow	Fast	Very fast	High	0.667
Low	Macro	High	Low	Slow	Slow	Fast	Low	0.000	Low	Macro	High	Low	Slow	Fast	Very fast	High	0.000
High	Macro	High	Low	Slow	Slow	Fast	Low	0.000	High	Macro	High	Low	Slow	Fast	Very fast	High	0.333
Low	Micro	Low	High	Slow	Slow	Fast	Low	0.000	Low	Micro	Low	High	Slow	Fast	Very fast	High	0.000
High	Micro	Low	High	Slow	Slow	Fast	Low	0.000	High	Micro	Low	High	Slow	Fast	Very fast	High	0.000
Low	Macro	Low	High	Slow	Slow	Fast	Low	0.000	Low	Macro	Low	High	Slow	Fast	Very fast	High	0.000
High	Macro	Low	High	Slow	Slow	Fast	Low	0.333	High	Macro	Low	High	Slow	Fast	Very fast	High	0.000
Low	Micro	High	High	Slow	Slow	Fast	Low	0.000	Low	Micro	High	High	Slow	Fast	Very fast	High	0.000
High	Micro	High	High	Slow	Slow	Fast	Low	0.000	High	Micro	High	High	Slow	Fast	Very fast	High	0.000

Low	Macro	High	High	Slow	Slow	Fast	Low	0.000	Low	Macro	High	High	Slow	Fast	Very fast	High	0.000
High	Macro	High	High	Slow	Slow	Fast	Low	0.333	High	Macro	High	High	Slow	Fast	Very fast	High	0.250
Low	Micro	Low	Low	Fast	Fast	Slow	Low	0.667	Low	Micro	Low	Low	Fast	Slow	Very fast	High	0.000
High	Micro	Low	Low	Fast	Fast	Slow	Low	0.667	High	Micro	Low	Low	Fast	Slow	Very fast	High	0.500
Low	Macro	Low	Low	Fast	Fast	Slow	Low	0.000	Low	Macro	Low	Low	Fast	Slow	Very fast	High	0.000
High	Macro	Low	Low	Fast	Fast	Slow	Low	0.500	High	Macro	Low	Low	Fast	Slow	Very fast	High	0.000
Low	Micro	High	Low	Fast	Fast	Slow	Low	0.667	Low	Micro	High	Low	Fast	Slow	Very fast	High	0.333
High	Micro	High	Low	Fast	Fast	Slow	Low	0.667	High	Micro	High	Low	Fast	Slow	Very fast	High	0.500
Low	Macro	High	Low	Fast	Fast	Slow	Low	0.000	Low	Macro	High	Low	Fast	Slow	Very fast	High	0.250
High	Macro	High	Low	Fast	Fast	Slow	Low	0.667	High	Macro	High	Low	Fast	Slow	Very fast	High	0.000
Low	Micro	Low	High	Fast	Fast	Slow	Low	0.000	Low	Micro	Low	High	Fast	Slow	Very fast	High	0.000
High	Micro	Low	High	Fast	Fast	Slow	Low	0.000	High	Micro	Low	High	Fast	Slow	Very fast	High	0.333
Low	Macro	Low	High	Fast	Fast	Slow	Low	0.000	Low	Macro	Low	High	Fast	Slow	Very fast	High	0.000
High	Macro	Low	High	Fast	Fast	Slow	Low	0.000	High	Macro	Low	High	Fast	Slow	Very fast	High	0.000
Low	Micro	High	High	Fast	Fast	Slow	Low	0.000	Low	Micro	High	High	Fast	Slow	Very fast	High	0.000
High	Micro	High	High	Fast	Fast	Slow	Low	0.000	High	Micro	High	High	Fast	Slow	Very fast	High	0.000
Low	Macro	High	High	Fast	Fast	Slow	Low	0.000	Low	Macro	High	High	Fast	Slow	Very fast	High	0.000
High	Macro	High	High	Fast	Fast	Slow	Low	0.000	High	Macro	High	High	Fast	Slow	Very fast	High	0.000
Low	Micro	Low	Low	Slow	Fast	Slow	Low	0.667	Low	Micro	Low	Low	Slow	Slow	Very fast	High	0.000
High	Micro	Low	Low	Slow	Fast	Slow	Low	0.667	High	Micro	Low	Low	Slow	Slow	Very fast	High	0.000
Low	Macro	Low	Low	Slow	Fast	Slow	Low	0.000	Low	Macro	Low	Low	Slow	Slow	Very fast	High	0.000
High	Macro	Low	Low	Slow	Fast	Slow	Low	0.000	High	Macro	Low	Low	Slow	Slow	Very fast	High	0.000
Low	Micro	High	Low	Slow	Fast	Slow	Low	0.333	Low	Micro	High	Low	Slow	Slow	Very fast	High	0.000
High	Micro	High	Low	Slow	Fast	Slow	Low	0.667	High	Micro	High	Low	Slow	Slow	Very fast	High	0.333
Low	Macro	High	Low	Slow	Fast	Slow	Low	0.000	Low	Macro	High	Low	Slow	Slow	Very fast	High	0.000
High	Macro	High	Low	Slow	Fast	Slow	Low	0.333	High	Macro	High	Low	Slow	Slow	Very fast	High	0.333
Low	Micro	Low	High	Slow	Fast	Slow	Low	0.000	Low	Micro	Low	High	Slow	Slow	Very fast	High	0.000
High	Micro	Low	High	Slow	Fast	Slow	Low	0.333	High	Micro	Low	High	Slow	Slow	Very fast	High	0.000
Low	Macro	Low	High	Slow	Fast	Slow	Low	0.000	Low	Macro	Low	High	Slow	Slow	Very fast	High	0.000
High	Macro	Low	High	Slow	Fast	Slow	Low	0.000	High	Macro	Low	High	Slow	Slow	Very fast	High	0.000
Low	Micro	High	High	Slow	Fast	Slow	Low	0.000	Low	Micro	High	High	Slow	Slow	Very fast	High	0.000
High	Micro	High	High	Slow	Fast	Slow	Low	0.333	High	Micro	High	High	Slow	Slow	Very fast	High	0.000
Low	Macro	High	High	Slow	Fast	Slow	Low	0.000	Low	Macro	High	High	Slow	Slow	Very fast	High	0.000
High	Macro	High	High	Slow	Fast	Slow	Low	0.000	High	Macro	High	High	Slow	Slow	Very fast	High	0.000
Low	Micro	Low	Low	Fast	Slow	Slow	Low	0.500	Low	Micro	Low	Low	Fast	Fast	Fast	High	0.667
High	Micro	Low	Low	Fast	Slow	Slow	Low	0.667	High	Micro	Low	Low	Fast	Fast	Fast	High	0.500
Low	Macro	Low	Low	Fast	Slow	Slow	Low	0.000	Low	Macro	Low	Low	Fast	Fast	Fast	High	0.333
High	Macro	Low	Low	Fast	Slow	Slow	Low	0.333	High	Macro	Low	Low	Fast	Fast	Fast	High	0.667
Low	Micro	High	Low	Fast	Slow	Slow	Low	0.500	Low	Micro	High	Low	Fast	Fast	Fast	High	0.667
High	Micro	High	Low	Fast	Slow	Slow	Low	0.667	High	Micro	High	Low	Fast	Fast	Fast	High	0.667
Low	Macro	High	Low	Fast	Slow	Slow	Low	0.000	Low	Macro	High	Low	Fast	Fast	Fast	High	0.000
High	Macro	High	Low	Fast	Slow	Slow	Low	0.333	High	Macro	High	Low	Fast	Fast	Fast	High	0.500
Low	Micro	Low	High	Fast	Slow	Slow	Low	0.000	Low	Micro	Low	High	Fast	Fast	Fast	High	0.000
High	Micro	Low	High	Fast	Slow	Slow	Low	0.000	High	Micro	Low	High	Fast	Fast	Fast	High	0.000
Low	Macro	Low	High	Fast	Slow	Slow	Low	0.000	Low	Macro	Low	High	Fast	Fast	Fast	High	0.000

High	Macro	Low	High	Fast	Slow	Slow	Low	0.000	High	Macro	Low	High	Fast	Fast	Fast	High	0.000
Low	Micro	High	High	Fast	Slow	Slow	Low	0.000	Low	Micro	High	High	Fast	Fast	Fast	High	0.000
High	Micro	High	High	Fast	Slow	Slow	Low	0.000	High	Micro	High	High	Fast	Fast	Fast	High	0.333
Low	Macro	High	High	Fast	Slow	Slow	Low	0.000	Low	Macro	High	High	Fast	Fast	Fast	High	0.000
High	Macro	High	High	Fast	Slow	Slow	Low	0.000	High	Macro	High	High	Fast	Fast	Fast	High	0.000
Low	Micro	Low	Low	Slow	Slow	Slow	Low	0.500	Low	Micro	Low	Low	Slow	Fast	Fast	High	0.500
High	Micro	Low	Low	Slow	Slow	Slow	Low	0.750	High	Micro	Low	Low	Slow	Fast	Fast	High	0.667
Low	Macro	Low	Low	Slow	Slow	Slow	Low	0.000	Low	Macro	Low	Low	Slow	Fast	Fast	High	0.333
High	Macro	Low	Low	Slow	Slow	Slow	Low	0.000	High	Macro	Low	Low	Slow	Fast	Fast	High	0.500
Low	Micro	High	Low	Slow	Slow	Slow	Low	0.000	Low	Micro	High	Low	Slow	Fast	Fast	High	0.333
High	Micro	High	Low	Slow	Slow	Slow	Low	0.667	High	Micro	High	Low	Slow	Fast	Fast	High	0.667
Low	Macro	High	Low	Slow	Slow	Slow	Low	0.000	Low	Macro	High	Low	Slow	Fast	Fast	High	0.000
High	Macro	High	Low	Slow	Slow	Slow	Low	0.500	High	Macro	High	Low	Slow	Fast	Fast	High	0.333
Low	Micro	Low	High	Slow	Slow	Slow	Low	0.000	Low	Micro	Low	High	Slow	Fast	Fast	High	0.000
High	Micro	Low	High	Slow	Slow	Slow	Low	0.000	High	Micro	Low	High	Slow	Fast	Fast	High	0.000
Low	Macro	Low	High	Slow	Slow	Slow	Low	0.000	Low	Macro	Low	High	Slow	Fast	Fast	High	0.000
High	Macro	Low	High	Slow	Slow	Slow	Low	0.000	High	Macro	Low	High	Slow	Fast	Fast	High	0.000
Low	Micro	High	High	Slow	Slow	Slow	Low	0.333	Low	Micro	High	High	Slow	Fast	Fast	High	0.000
High	Micro	High	High	Slow	Slow	Slow	Low	0.667	High	Micro	High	High	Slow	Fast	Fast	High	0.333
Low	Macro	High	High	Slow	Slow	Slow	Low	0.000	Low	Macro	High	High	Slow	Fast	Fast	High	0.000
High	Macro	High	High	Slow	Slow	Slow	Low	0.000	High	Macro	High	High	Slow	Fast	Fast	High	0.000
Low	Micro	Low	Low	Fast	Fast	Very fast	Medium	0.333	Low	Micro	Low	Low	Fast	Slow	Fast	High	0.000
High	Micro	Low	Low	Fast	Fast	Very fast	Medium	0.667	High	Micro	Low	Low	Fast	Slow	Fast	High	0.667
Low	Macro	Low	Low	Fast	Fast	Very fast	Medium	0.000	Low	Macro	Low	Low	Fast	Slow	Fast	High	0.000
High	Macro	Low	Low	Fast	Fast	Very fast	Medium	0.667	High	Macro	Low	Low	Fast	Slow	Fast	High	0.333
Low	Micro	High	Low	Fast	Fast	Very fast	Medium	0.000	Low	Micro	High	Low	Fast	Slow	Fast	High	0.500
High	Micro	High	Low	Fast	Fast	Very fast	Medium	0.667	High	Micro	High	Low	Fast	Slow	Fast	High	0.667
Low	Macro	High	Low	Fast	Fast	Very fast	Medium	0.000	Low	Macro	High	Low	Fast	Slow	Fast	High	0.000
High	Macro	High	Low	Fast	Fast	Very fast	Medium	0.500	High	Macro	High	Low	Fast	Slow	Fast	High	0.333
Low	Micro	Low	High	Fast	Fast	Very fast	Medium	0.000	Low	Micro	Low	High	Fast	Slow	Fast	High	0.000
High	Micro	Low	High	Fast	Fast	Very fast	Medium	0.000	High	Micro	Low	High	Fast	Slow	Fast	High	0.000
Low	Macro	Low	High	Fast	Fast	Very fast	Medium	0.000	Low	Macro	Low	High	Fast	Slow	Fast	High	0.250
High	Macro	Low	High	Fast	Fast	Very fast	Medium	0.000	High	Macro	Low	High	Fast	Slow	Fast	High	0.000
Low	Micro	High	High	Fast	Fast	Very fast	Medium	0.000	Low	Micro	High	High	Fast	Slow	Fast	High	0.000
High	Micro	High	High	Fast	Fast	Very fast	Medium	0.500	High	Micro	High	High	Fast	Slow	Fast	High	0.000
Low	Macro	High	High	Fast	Fast	Very fast	Medium	0.000	Low	Macro	High	High	Fast	Slow	Fast	High	0.000
High	Macro	High	High	Fast	Fast	Very fast	Medium	0.000	High	Macro	High	High	Fast	Slow	Fast	High	0.000
Low	Micro	Low	Low	Slow	Fast	Very fast	Medium	0.000	Low	Micro	Low	Low	Slow	Slow	Fast	High	0.333
High	Micro	Low	Low	Slow	Fast	Very fast	Medium	0.667	High	Micro	Low	Low	Slow	Slow	Fast	High	0.333
Low	Macro	Low	Low	Slow	Fast	Very fast	Medium	0.333	Low	Macro	Low	Low	Slow	Slow	Fast	High	0.000
High	Macro	Low	Low	Slow	Fast	Very fast	Medium	0.500	High	Macro	Low	Low	Slow	Slow	Fast	High	0.333
Low	Micro	High	Low	Slow	Fast	Very fast	Medium	0.000	Low	Micro	High	Low	Slow	Slow	Fast	High	0.500
High	Micro	High	Low	Slow	Fast	Very fast	Medium	0.500	High	Micro	High	Low	Slow	Slow	Fast	High	0.250
Low	Macro	High	Low	Slow	Fast	Very fast	Medium	0.000	Low	Macro	High	Low	Slow	Slow	Fast	High	0.000
High	Macro	High	Low	Slow	Fast	Very fast	Medium	0.000	High	Macro	High	Low	Slow	Slow	Fast	High	0.000

Low	Micro	Low	High	Slow	Fast	Very fast	Medium	0.000	Low	Micro	Low	High	Slow	Slow	Fast	High	0.000
High	Micro	Low	High	Slow	Fast	Very fast	Medium	0.000	High	Micro	Low	High	Slow	Slow	Fast	High	0.000
Low	Macro	Low	High	Slow	Fast	Very fast	Medium	0.000	Low	Macro	Low	High	Slow	Slow	Fast	High	0.000
High	Macro	Low	High	Slow	Fast	Very fast	Medium	0.500	High	Macro	Low	High	Slow	Slow	Fast	High	0.000
Low	Micro	High	High	Slow	Fast	Very fast	Medium	0.000	Low	Micro	High	High	Slow	Slow	Fast	High	0.000
High	Micro	High	High	Slow	Fast	Very fast	Medium	0.000	High	Micro	High	High	Slow	Slow	Fast	High	0.000
Low	Macro	High	High	Slow	Fast	Very fast	Medium	0.000	Low	Macro	High	High	Slow	Slow	Fast	High	0.000
High	Macro	High	High	Slow	Fast	Very fast	Medium	0.000	High	Macro	High	High	Slow	Slow	Fast	High	0.333
Low	Micro	Low	Low	Fast	Slow	Very fast	Medium	0.000	Low	Micro	Low	Low	Fast	Fast	Slow	High	0.500
High	Micro	Low	Low	Fast	Slow	Very fast	Medium	0.750	High	Micro	Low	Low	Fast	Fast	Slow	High	0.750
Low	Macro	Low	Low	Fast	Slow	Very fast	Medium	0.000	Low	Macro	Low	Low	Fast	Fast	Slow	High	0.000
High	Macro	Low	Low	Fast	Slow	Very fast	Medium	0.000	High	Macro	Low	Low	Fast	Fast	Slow	High	0.333
Low	Micro	High	Low	Fast	Slow	Very fast	Medium	0.000	Low	Micro	High	Low	Fast	Fast	Slow	High	0.500
High	Micro	High	Low	Fast	Slow	Very fast	Medium	0.000	High	Micro	High	Low	Fast	Fast	Slow	High	0.667
Low	Macro	High	Low	Fast	Slow	Very fast	Medium	0.333	Low	Macro	High	Low	Fast	Fast	Slow	High	0.000
High	Macro	High	Low	Fast	Slow	Very fast	Medium	0.000	High	Macro	High	Low	Fast	Fast	Slow	High	0.500
Low	Micro	Low	High	Fast	Slow	Very fast	Medium	0.000	Low	Micro	Low	High	Fast	Fast	Slow	High	0.000
High	Micro	Low	High	Fast	Slow	Very fast	Medium	0.000	High	Micro	Low	High	Fast	Fast	Slow	High	0.667
Low	Macro	Low	High	Fast	Slow	Very fast	Medium	0.000	Low	Macro	Low	High	Fast	Fast	Slow	High	0.000
High	Macro	Low	High	Fast	Slow	Very fast	Medium	0.000	High	Macro	Low	High	Fast	Fast	Slow	High	0.000
Low	Micro	High	High	Fast	Slow	Very fast	Medium	0.000	Low	Micro	High	High	Fast	Fast	Slow	High	0.333
High	Micro	High	High	Fast	Slow	Very fast	Medium	0.000	High	Micro	High	High	Fast	Fast	Slow	High	0.000
Low	Macro	High	High	Fast	Slow	Very fast	Medium	0.000	Low	Macro	High	High	Fast	Fast	Slow	High	0.000
High	Macro	High	High	Fast	Slow	Very fast	Medium	0.000	High	Macro	High	High	Fast	Fast	Slow	High	0.000
Low	Micro	Low	Low	Slow	Slow	Very fast	Medium	0.000	Low	Micro	Low	Low	Slow	Fast	Slow	High	0.667
High	Micro	Low	Low	Slow	Slow	Very fast	Medium	0.333	High	Micro	Low	Low	Slow	Fast	Slow	High	0.667
Low	Macro	Low	Low	Slow	Slow	Very fast	Medium	0.000	Low	Macro	Low	Low	Slow	Fast	Slow	High	0.000
High	Macro	Low	Low	Slow	Slow	Very fast	Medium	0.000	High	Macro	Low	Low	Slow	Fast	Slow	High	0.667
Low	Micro	High	Low	Slow	Slow	Very fast	Medium	0.333	Low	Micro	High	Low	Slow	Fast	Slow	High	0.500
High	Micro	High	Low	Slow	Slow	Very fast	Medium	0.000	High	Micro	High	Low	Slow	Fast	Slow	High	0.750
Low	Macro	High	Low	Slow	Slow	Very fast	Medium	0.000	Low	Macro	High	Low	Slow	Fast	Slow	High	0.000
High	Macro	High	Low	Slow	Slow	Very fast	Medium	0.333	High	Macro	High	Low	Slow	Fast	Slow	High	0.333
Low	Micro	Low	High	Slow	Slow	Very fast	Medium	0.000	Low	Micro	Low	High	Slow	Fast	Slow	High	0.000
High	Micro	Low	High	Slow	Slow	Very fast	Medium	0.000	High	Micro	Low	High	Slow	Fast	Slow	High	0.000
Low	Macro	Low	High	Slow	Slow	Very fast	Medium	0.000	Low	Macro	Low	High	Slow	Fast	Slow	High	0.000
High	Macro	Low	High	Slow	Slow	Very fast	Medium	0.000	High	Macro	Low	High	Slow	Fast	Slow	High	0.000
Low	Micro	High	High	Slow	Slow	Very fast	Medium	0.000	Low	Micro	High	High	Slow	Fast	Slow	High	0.500
High	Micro	High	High	Slow	Slow	Very fast	Medium	0.000	High	Micro	High	High	Slow	Fast	Slow	High	0.000
Low	Macro	High	High	Slow	Slow	Very fast	Medium	0.000	Low	Macro	High	High	Slow	Fast	Slow	High	0.000
High	Macro	High	High	Slow	Slow	Very fast	Medium	0.333	High	Macro	High	High	Slow	Fast	Slow	High	0.000
Low	Micro	Low	Low	Fast	Fast	Fast	Medium	0.333	Low	Micro	Low	Low	Fast	Slow	Slow	High	0.667
High	Micro	Low	Low	Fast	Fast	Fast	Medium	0.667	High	Micro	Low	Low	Fast	Slow	Slow	High	0.333
Low	Macro	Low	Low	Fast	Fast	Fast	Medium	0.000	Low	Macro	Low	Low	Fast	Slow	Slow	High	0.000
High	Macro	Low	Low	Fast	Fast	Fast	Medium	0.667	High	Macro	Low	Low	Fast	Slow	Slow	High	0.000
Low	Micro	High	Low	Fast	Fast	Fast	Medium	0.000	Low	Micro	High	Low	Fast	Slow	Slow	High	0.000

High	Micro	High	Low	Fast	Fast	Fast	Medium	0.667	High	Micro	High	Low	Fast	Slow	Slow	High	0.667
Low	Macro	High	Low	Fast	Fast	Fast	Medium	0.000	Low	Macro	High	Low	Fast	Slow	Slow	High	0.000
High	Macro	High	Low	Fast	Fast	Fast	Medium	0.667	High	Macro	High	Low	Fast	Slow	Slow	High	0.333
Low	Micro	Low	High	Fast	Fast	Fast	Medium	0.000	Low	Micro	Low	High	Fast	Slow	Slow	High	0.000
High	Micro	Low	High	Fast	Fast	Fast	Medium	0.000	High	Micro	Low	High	Fast	Slow	Slow	High	0.333
Low	Macro	Low	High	Fast	Fast	Fast	Medium	0.000	Low	Macro	Low	High	Fast	Slow	Slow	High	0.000
High	Macro	Low	High	Fast	Fast	Fast	Medium	0.667	High	Macro	Low	High	Fast	Slow	Slow	High	0.000
Low	Micro	High	High	Fast	Fast	Fast	Medium	0.333	Low	Micro	High	High	Fast	Slow	Slow	High	0.000
High	Micro	High	High	Fast	Fast	Fast	Medium	0.500	High	Micro	High	High	Fast	Slow	Slow	High	0.000
Low	Macro	High	High	Fast	Fast	Fast	Medium	0.000	Low	Macro	High	High	Fast	Slow	Slow	High	0.000
High	Macro	High	High	Fast	Fast	Fast	Medium	0.000	High	Macro	High	High	Fast	Slow	Slow	High	0.000
Low	Micro	Low	Low	Slow	Fast	Fast	Medium	0.000	Low	Micro	Low	Low	Slow	Slow	Slow	High	0.500
High	Micro	Low	Low	Slow	Fast	Fast	Medium	0.500	High	Micro	Low	Low	Slow	Slow	Slow	High	0.750
Low	Macro	Low	Low	Slow	Fast	Fast	Medium	0.000	Low	Macro	Low	Low	Slow	Slow	Slow	High	0.000
High	Macro	Low	Low	Slow	Fast	Fast	Medium	0.000	High	Macro	Low	Low	Slow	Slow	Slow	High	0.000
Low	Micro	High	Low	Slow	Fast	Fast	Medium	0.667	Low	Micro	High	Low	Slow	Slow	Slow	High	0.667
High	Micro	High	Low	Slow	Fast	Fast	Medium	0.667	High	Micro	High	Low	Slow	Slow	Slow	High	0.667
Low	Macro	High	Low	Slow	Fast	Fast	Medium	0.000	Low	Macro	High	Low	Slow	Slow	Slow	High	0.000
High	Macro	High	Low	Slow	Fast	Fast	Medium	0.750	High	Macro	High	Low	Slow	Slow	Slow	High	0.333
Low	Micro	Low	High	Slow	Fast	Fast	Medium	0.000	Low	Micro	Low	High	Slow	Slow	Slow	High	0.000
High	Micro	Low	High	Slow	Fast	Fast	Medium	0.333	High	Micro	Low	High	Slow	Slow	Slow	High	0.000
Low	Macro	Low	High	Slow	Fast	Fast	Medium	0.000	Low	Macro	Low	High	Slow	Slow	Slow	High	0.000
High	Macro	Low	High	Slow	Fast	Fast	Medium	0.000	High	Macro	Low	High	Slow	Slow	Slow	High	0.000
Low	Micro	High	High	Slow	Fast	Fast	Medium	0.000	Low	Micro	High	High	Slow	Slow	Slow	High	0.000
High	Micro	High	High	Slow	Fast	Fast	Medium	0.000	High	Micro	High	High	Slow	Slow	Slow	High	0.333
Low	Macro	High	High	Slow	Fast	Fast	Medium	0.000	Low	Macro	High	High	Slow	Slow	Slow	High	0.000
High	Macro	High	High	Slow	Fast	Fast	Medium	0.500	High	Macro	High	High	Slow	Slow	Slow	High	0.000

Experimental Design, Materials, and Methods

The associated research paper [1] presents a novel methodology for scenario analysis, which uses imprecise probability values obtained from expert judgments and computer simulations. Simulations have been utilized to derive the prior probabilities in Table 13 (following the procedure described at the end of the section). The probability assignments of TablesTable 4 - Table 12 are based on authors' assumptions rather than on a formal process of expert-judgment elicitation, which is outside the scope of the methodological work. The same is true for the rest of the data (Figure 1 and Table 1 - Table 3). The data, then, serve the purpose of illustrating the application of the scenario-analysis methodology through a case study which does not represent an actual safety assessment.

Figure 1 represents the conceptual flowchart of the human exposure to the radiation dose [3] as modeled in COMSOL Multiphysics. In particular, a two-dimensional column of monoliths is assumed to contain the entire radionuclide inventory. The migration of radionuclides across this physical domain is simulated to calculate the time-dependent radionuclide discharge beneath the embankment in [Bq y^{-1}]. The discharge is multiplied by a dimensionless geotransfer factor and a bioconversion factor in [Sv Bq^{-1}], to account for the dilution in groundwater and the radiation dose per unit activity ingested, respectively. The final output is the time-dependent dose rate to the public in [Sv y^{-1}]. Table 1 was built by listing the model parameters through which this conceptual flowchart is implemented quantitatively.

The scenarios in Table 2 were formulated according to the pluralistic approach described in Tosoni et al. [1]. The goal was to replicate the scenarios analyzed in a previous study on the same nuclear waste repository [4].

The nodes in Table 3 include the same parameters that characterize the scenarios of Table 2; they are, then, utilized in the probabilistic approach. The continuous ranges of corresponding parameter values were discretized into intervals (seventh to ninth columns) to capture *low*, *high*, *fast*, *slow*, etc., states of the consistent FEPs. Intervals were split at values for the *Base* scenario of Table 2, or at “milestone” percentages (e.g., 50%) using logarithmic scales for a balanced discretization of wide ranges. A flexible discretization (Table 3, third row) ensures that the *Initial water flux* does not exceed the initial effective hydraulic conductivity of the barriers, because this would cause numerical instability when very high water fluxes encounter very low hydraulic conductivities (details in the appendix). The normalized *Dose rate* was discretized at 1.

The probability assignments for the FEP states in TablesTable 4 -Table 12 were specified by the authors to produce illustrative values based on given assumptions. In a realistic application, these probabilities would need to be obtained by formal expert-judgment elicitation [5]. The assumptions underlying the FEP probabilities are summarized in Table 14.

For instance, the probability that a *major earthquake* occurs between 350 and 816 years from the present time (i.e., during the so-called isolation phase of the nuclear waste repository taken as the case study [4]) is

$$p_{major} = exp\left(-\frac{350y}{t_{ret}}\right) - exp\left(-\frac{816y}{t_{ret}}\right),$$

where t_{ret} is the return period of the underlying Poisson process. In Table 4, the probabilities of a *major earthquake* are obtained by assuming the return period to be 100,000 (Assumption 1) and 50,000 years (Assumption 2).

Table 5 - Table 12 refer instead to FEPs that overarch sets of consistent parameters in Table 3, such as the FEP *Water flux* and the parameter *Degraded water flux*. In these cases, alternative assumptions were made about the distribution over the ranges of parameter values in Table 3. Continuing with the example of *Degraded water flux* (Table 5), Assumption 1 consists in taking a log-uniform distribution over the range $\left[3.17 \cdot 10^{-9} \frac{m}{s}, 3.00 \cdot 10^{-8} \frac{m}{s}\right]$. Differently, Assumption 2 is a log-triangular probability density function, which has the maximum at $\ln(3.17 \cdot 10^{-9}\ m \cdot s^{-1})$ and linearly decreases until reaching 0 at $\ln(3.00 \cdot 10^{-8}\ m \cdot s^{-1})$. The rationale for using a log-uniform distribution is to spread the probability mass evenly over the orders of magnitude rather than over the values of a range. A log-triangular distribution serves to a similar purpose, except that more probability mass is assigned to either end of the range.

Then, the probabilities of the different states (e.g., *low* and *high*) are determined by how much probability mass gathers over the corresponding discretized ranges in Table 3 (note that the ranges of all parameters consistent with a given FEP are discretized so that the same distribution results in the same probabilities for the corresponding states).

Finally, the prior probabilities of Table 13 represent the frequencies with which the violation state of the safety target was observed as the result of multiple COMSOL Multiphysics simulations for each subscenario. For example, in the second subscenario of Table 13 *Water flux* is high, *Crack aperture* is micro, *Diffusion coefficient* is low, *Distribution coefficient* is low, *Chemical degradation* is fast, *Barrier degradation* is fast, *Monolith degradation* is very fast and *Hydraulic conductivity* is low. In order to simulate realizations of this subscenario, the parameter values were randomly and uniformly sampled from the corresponding intervals in Table 3 (in keeping with [1], Section 2.3.1). Here, as one of the two simulations leads to the violation state of the safety target, the retained prior probability is assigned a value of 0.5.

Table 14. Underlying assumptions of different beliefs (fifth to seventh columns) about the probabilities (Table 4 to Table 12) of FEP states (first and second columns) in different subscenarios (i.e., states of their respective parent FEPs, third to fourth columns).

FEP	FEP state	Parent	Subscenario	Assumption 1	Assumption 2	Assumption 3
Earthquake	BDBE	-	-	Complement to 1		-
	Major	-	-	Poisson process with return time of 100,000 years	Poisson process with return time of 50,000 years	-
Water flux	Low	-	-	Log uniform	Log triangular	-
	High	-	-			-
Crack aperture	Micro	-	-	Log uniform	Complement to 1	-
	Macro	-	-		-30% compared to Belief 1	-
Diffusion coefficient	Low	-	-	Log uniform	Log triangular	-
	High	-	-			-
Distribution coefficient	Low	-	-	Log uniform	Log triangular	-
	High	-	-			-
Chemical degradation	Fast	-	-	Log uniform	Log triangular	Triangular
	Slow	-	-			
Barrier degradation	Fast	Earthquake	BDBE	Log triangular	Triangular	-
	Slow					-
	Fast		Major	Log Uniform	LogLog Triangular	-
	Slow					-
Monolith degradation	Very fast	Earthquake	BDBE	Log Triangular	Triangular	-
	Fast					-
	Slow					-
	Very fast		Major	Same as in the BDBE subscenario		-
	Fast			Average between the probs. of Very fast and Fast in the BDBE subscenario (with 1/3 and 2/3 weights, respectively)		-
	Slow			Complement to 1		-
Hydraulic conductivity	Low	Crack aperture	Micro	Beta(0.1,1.8) distribution over a Log Triangular CFD	Beta(0.1,1.5) distribution over a Log Triangular CFD	-
	Medium					-
	High					-
	Low		Macro	Swap of the probabilities of Low and Medium		-
	Medium					-
	High			Same as in the Micro subscenario		-

Appendix. Range and discretization for the initial water flux

The initial effective hydraulic conductivity of the column made by the monoliths and the module basis can be calculated as

$$K_{eff}^{stack} = \left(\frac{h^{mon}}{h^{stack}} \cdot \frac{1}{K_{eff}^{mon}} + \frac{h^{base}}{h^{stack}} \cdot \frac{1}{x^{K^{mod}}}\right)^{-1},$$

where h^{mon}= 7.99 m is the height of the monolith column, h^{base}= 2.19 m is the height of the module basis, and $h^{stack} = h^{mon} + h^{base}$. These heights define the proportions between the conductivity of the module basis (the value $x^{K^{mod}}$ of the parameter *Initial hydraulic conductivity of module*) and the effective conductivity of the monoliths. Seeing the transversal section of the column as a monolith flanked by two void channels (assumed to have the same characteristics as the cracks in the module basis) separating it from the other columns, the latter is

$$K_{eff}^{mon} = \frac{2 \cdot x^{crack} \cdot K^{crack} + l^{mon} \cdot x^{K^{mon}}}{2 \cdot x^{crack} + l^{mon}},$$

where the indicative channel width x^{crack} is equal to the parameter *Degraded crack aperture*, l^{mon} = 1.94 m is the width of a monolith, $x^{K^{mon}}$ is the parameter *Initial hydraulic conductivity of monolith*, and the hydraulic conductivity of the channels is

$$K^{crack} = \frac{\rho_W \cdot g \cdot (x^{crack})^2}{24 \cdot \mu_W},$$

where ρ_W = 1,000 kg m^{-3} is water density, g = 9.81 m s^{-2} is gravitational acceleration and μ_W = 1.00E-03 kg m^{-1} s^{-1} is water dynamic viscosity (also remember to turn x^{crack} into meters).

The lower bound of the range for the *Initial water flux* could be set to the value 3.41E-12 m s^{-1} of the *Base* scenario, but because K_{eff}^{stack} could be lower than this, the lower bound is set to

$$a^{IWF} = min(3.41E - 12\ m\ s^{-1}, K_{eff}^{stack}).$$

Finally, in consistence with the discretization for the *Degraded water flux* in Table 3, the range $[a^{IWF}, K_{eff}^{stack}]$ is cut at m^{IWF}, that is, approximately 60% of this range on a logarithmic scale.

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Competing Interests

The authors declare that they have no known competing financial interests or personal relationships which have, or could be perceived to have, influenced the work reported in this article.

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