Safety case for Loviisa LILW repository 2018

Focus on scenarios in the safety case context

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Safety case

- "*Documentation for demonstrating compliance with the long-term safety requirements*" (STUK 2018a)
- Scope defined in international guidance (e.g. IAEA 2011, 2012), STUK's requirements (STUK 2018a,b)
- Safety case methodologies by Posiva (2012) & SKB (2015) were followed

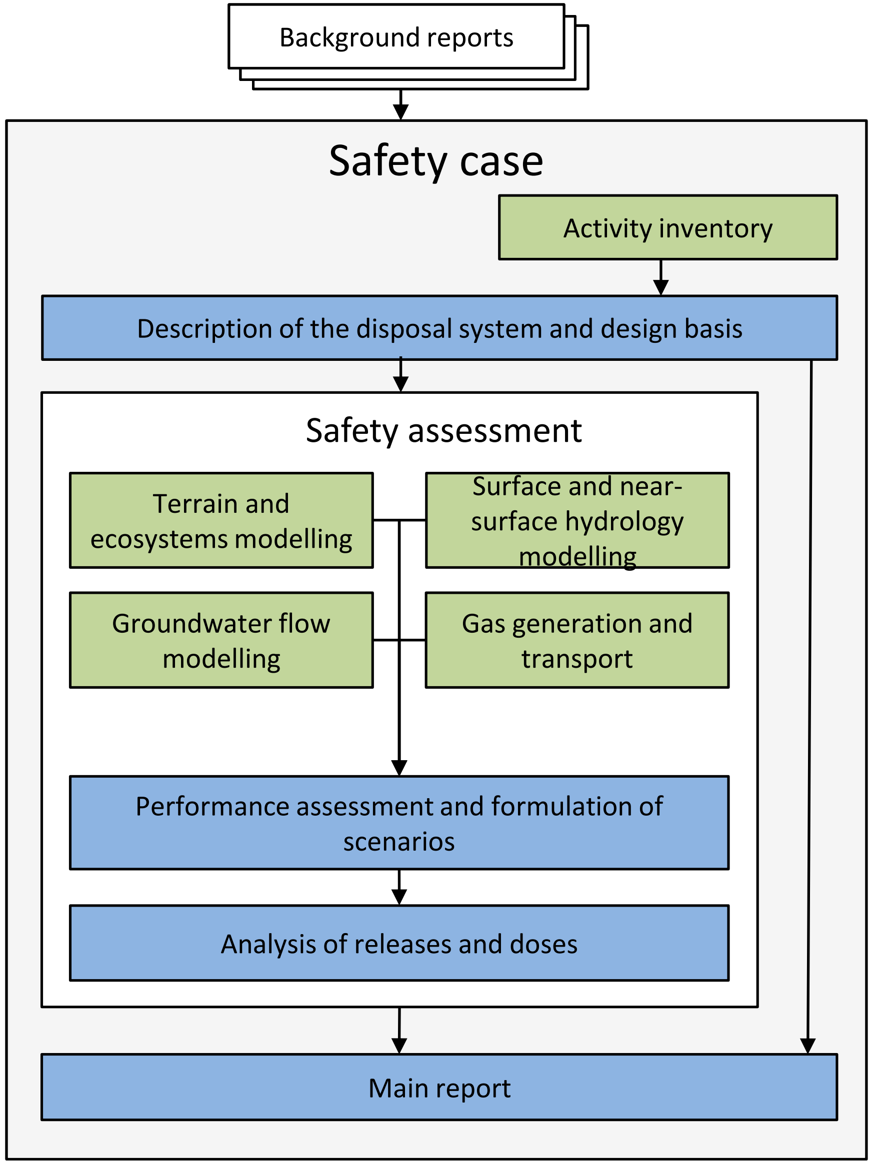

Figure: Nummi 2019a

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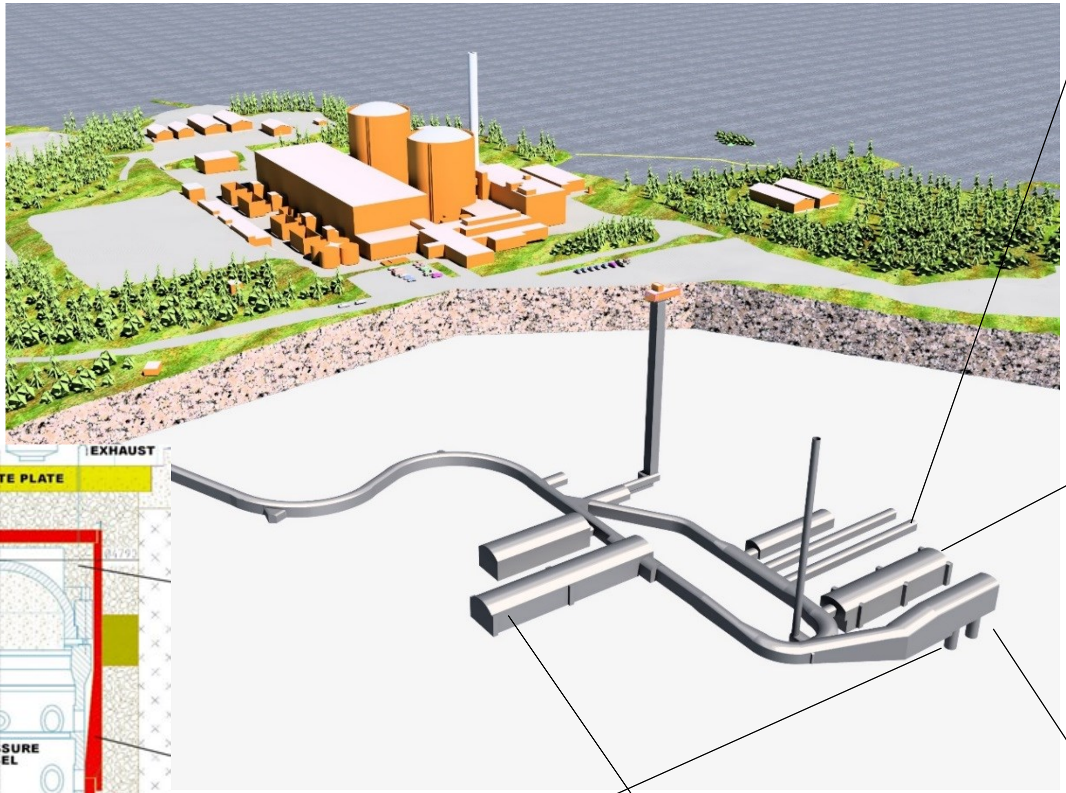
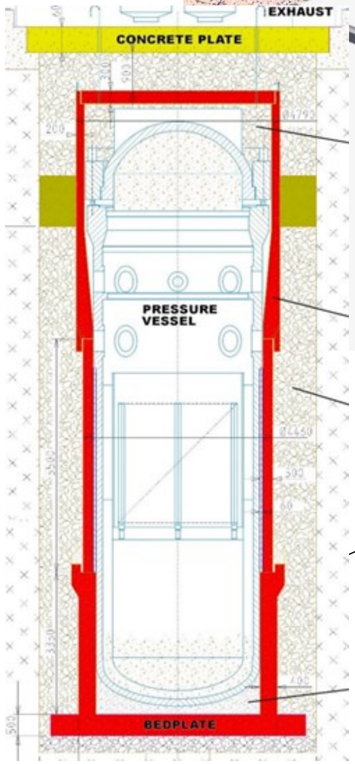
Disposal site

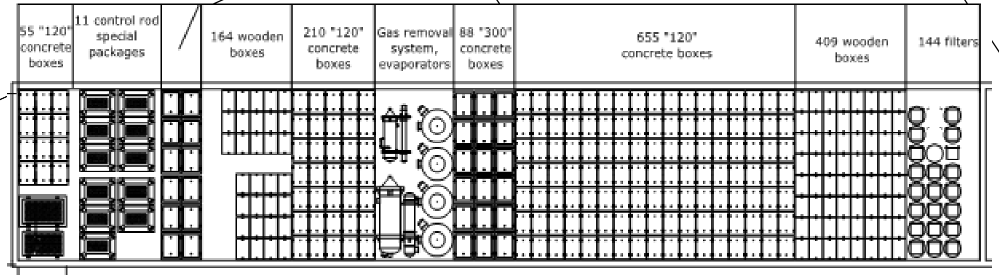
Picture: Fortum Power and Heat Oy

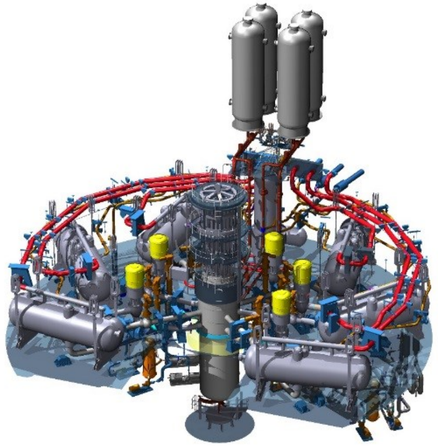
Waste caverns

Figures: Fortum Power and Heat Oy









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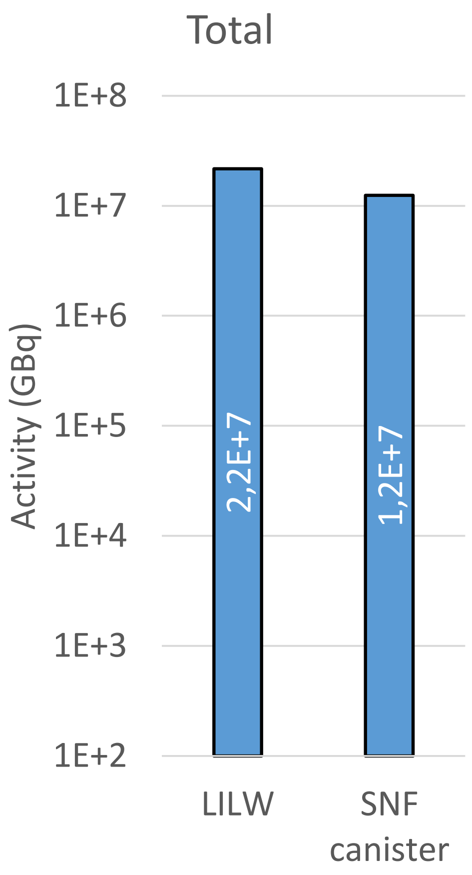
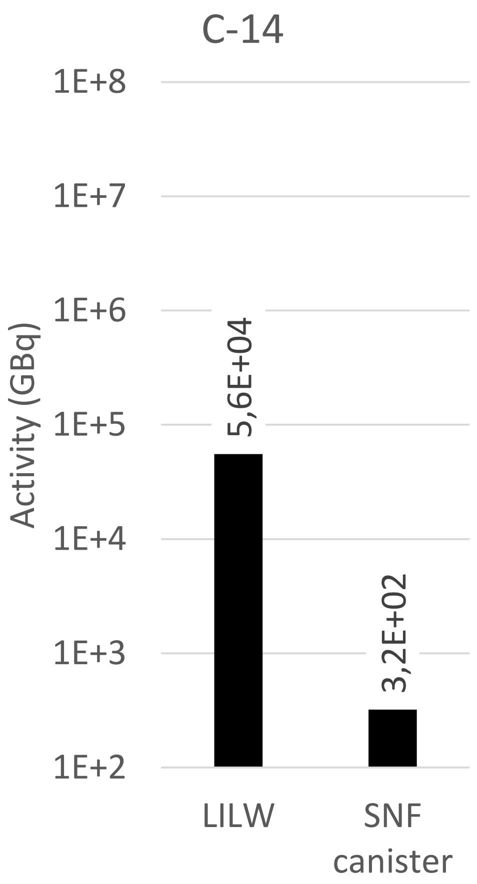
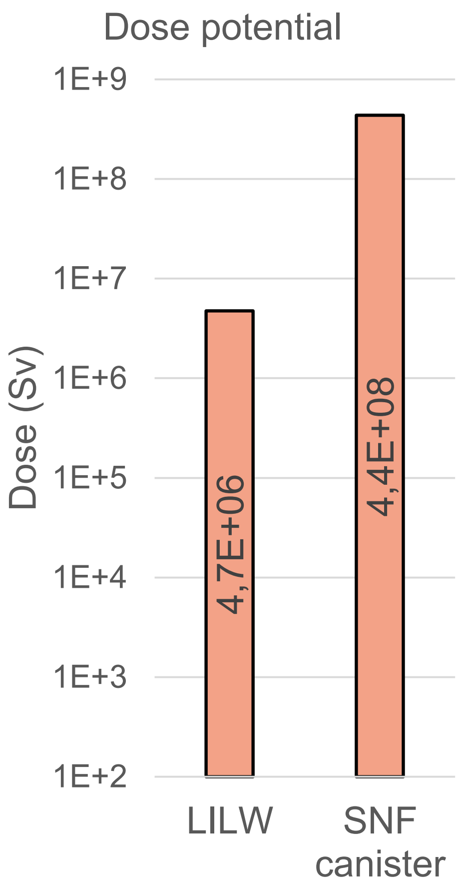
Activity in comparison to spent nuclear fuel







Figures: Fortum Power and Heat Oy

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Safety functions

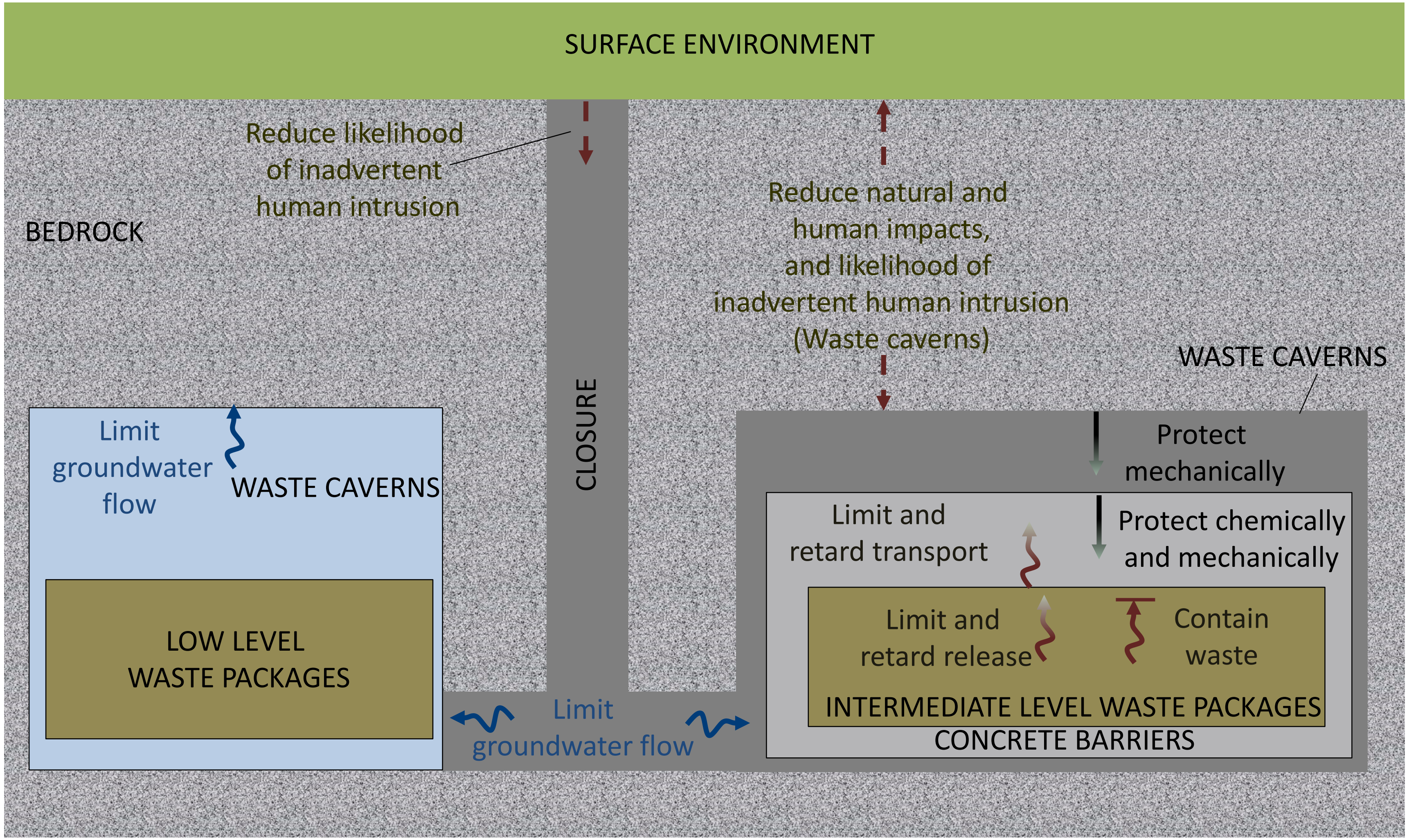

Figure: Nummi 2019a

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Concept of scenario

- **Uncertainty** in future evolution is managed by scenarios
- **Scenario** describes a potential evolution of the entire disposal system during the assessment period (100,000 years) associated with fulfilment of or deviation from safety functions and performance targets
  - Scenarios are based on performance assessment results and uncertainties therein
- Principles adopted:
  - *Plausibility*
  - *Consistency*
  - *Small number & distinctness*
  - *Transparency & traceability*

Phases of scenario formulation (after Kosow and Gaßner 2008)

- **Phase 1: Scenario field identification**
  - What do we want study?
  - What is included / excluded?
- **Phase 2: Key factor identification**
  - What are the factors driving the system evolution
  - Key characteristics of barriers providing safety functions identified with uncertainty
- **Phase 3: Key factor analysis**
  - Define *states* (evolutions) for the key factors

Key factors and key factor states

	Key factor	Key factor states			
Intermediate level waste packages	Concrete container evolution	*Reference evolution*	*Accelerated concrete degradation*	*Mechanical damage*	
	Areas with zero wall thickness in reactor pressure vessels and steam generators	*Reference evolution*	*Initial defect in welds*		
	Reactor pressure vessel and steam generator wall thicknesses	*Reference evolution*	*Early loss of alkaline conditions and microbiological corrosion*	*Initial defect and microbiological corrosion*	*Early loss of alkaline conditions, initial defect and microbiological corrosion*
Concrete barriers	Concrete barrier evolution	*Reference evolution*	*Accelerated concrete degradation*	*Mechanical damage*	
Waste caverns	Groundwater flow through the waste caverns	*Reference evolution*	*No plugs*		
Closure	Hydraulic conductivity of the concrete plugs	*Reference evolution*	*Gap between concrete and rock*	*Mechanical damage*	

Figure: Nummi 2019b

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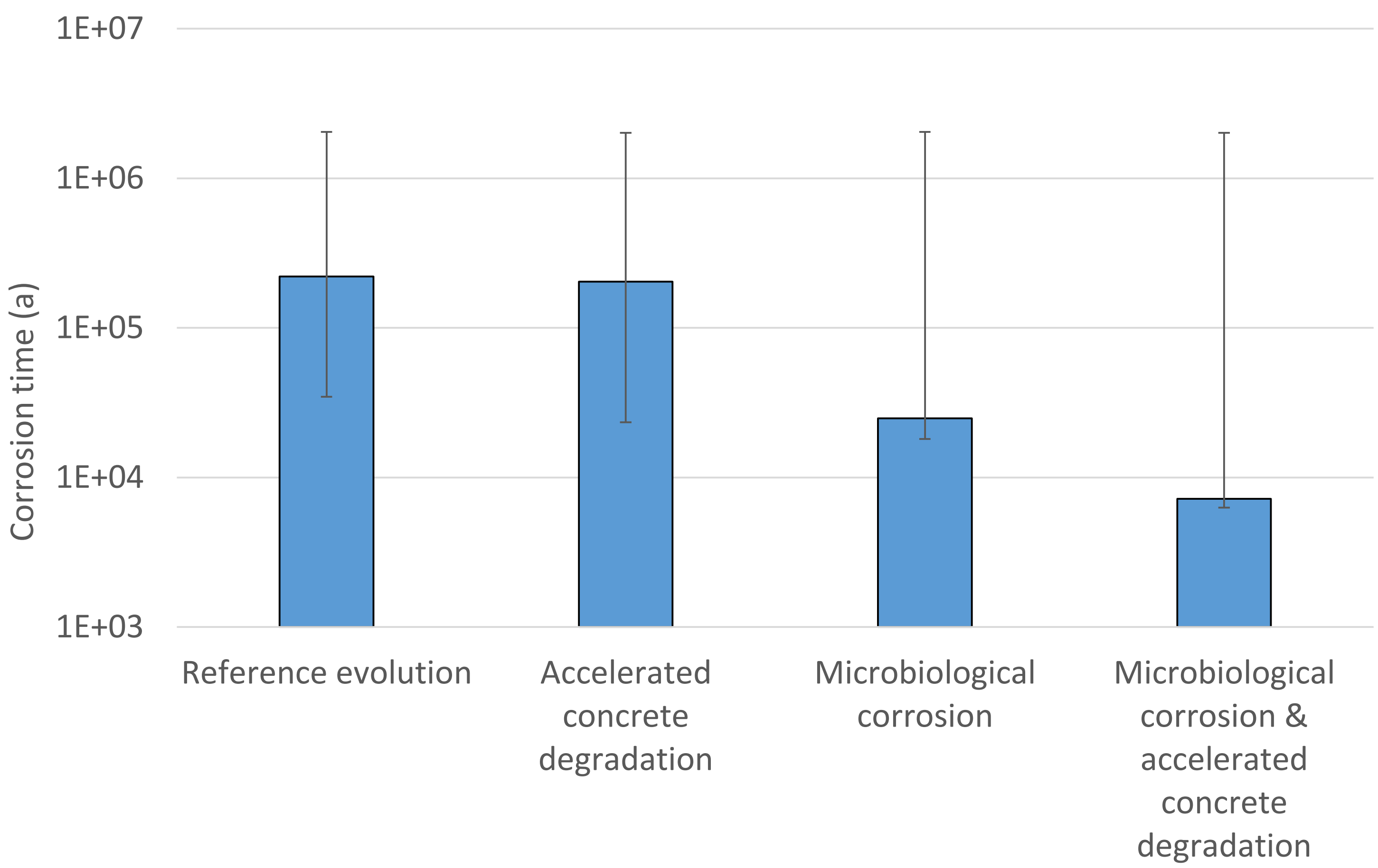
Example of evolution – reactor pressure vessel corrosion time



Phase 4: Scenario formulation

- Combination of key factor states into scenarios
  - 3×2×4×3×2×3 = 432 possible combinations
- Morphological analysis
  - Consider dependencies between key factor states and scenario distinctness

Hydraulic conductivity of the concrete plugs	Groundwater flow through the waste caverns	Concrete barrier evolution	Concrete container evolution	Areas with zero wall thickness in reactor pressure vessels and steam generators	Reactor pressure vessel and steam generator wall thicknesses
Reference evolution	*Reference evolution*	*Reference evolution*	*Reference evolution*	*Reference evolution*	*Reference evolution*
Gap between concrete and rock	*No plugs*	*Accelerated concrete degradation*	*Accelerated concrete degradation*	*Initial defect in welds*	*Early loss of alkaline conditions and microbiological corrosion*
Mechanical damage		*Mechanical damage*	*Mechanical damage*		*Initial defect and microbiological corrosion*
					Early loss of alkaline conditions, initial defect and microbiological corrosion

Figure: Nummi 2019b

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Phase 5: Scenario transfer

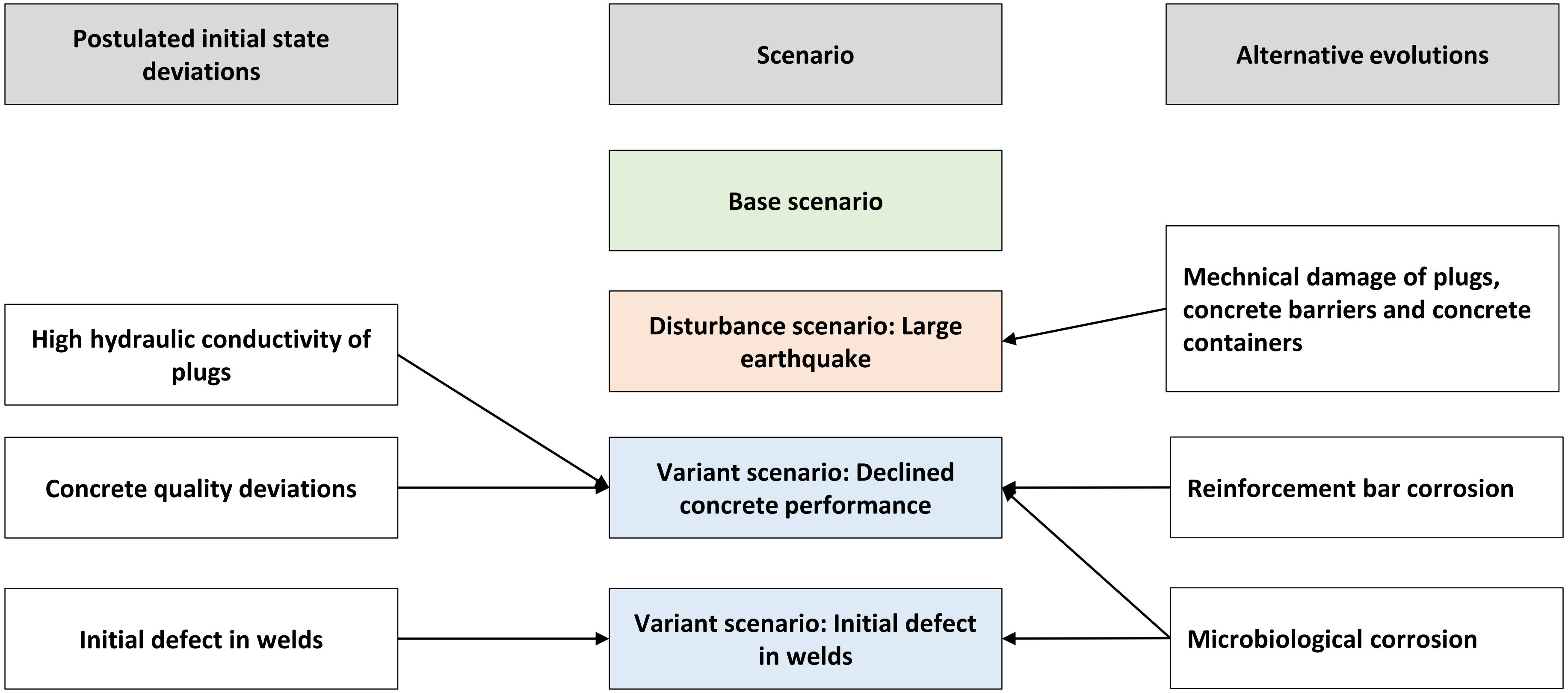

Figure: Nummi 2019b

Scenarios and calculation cases

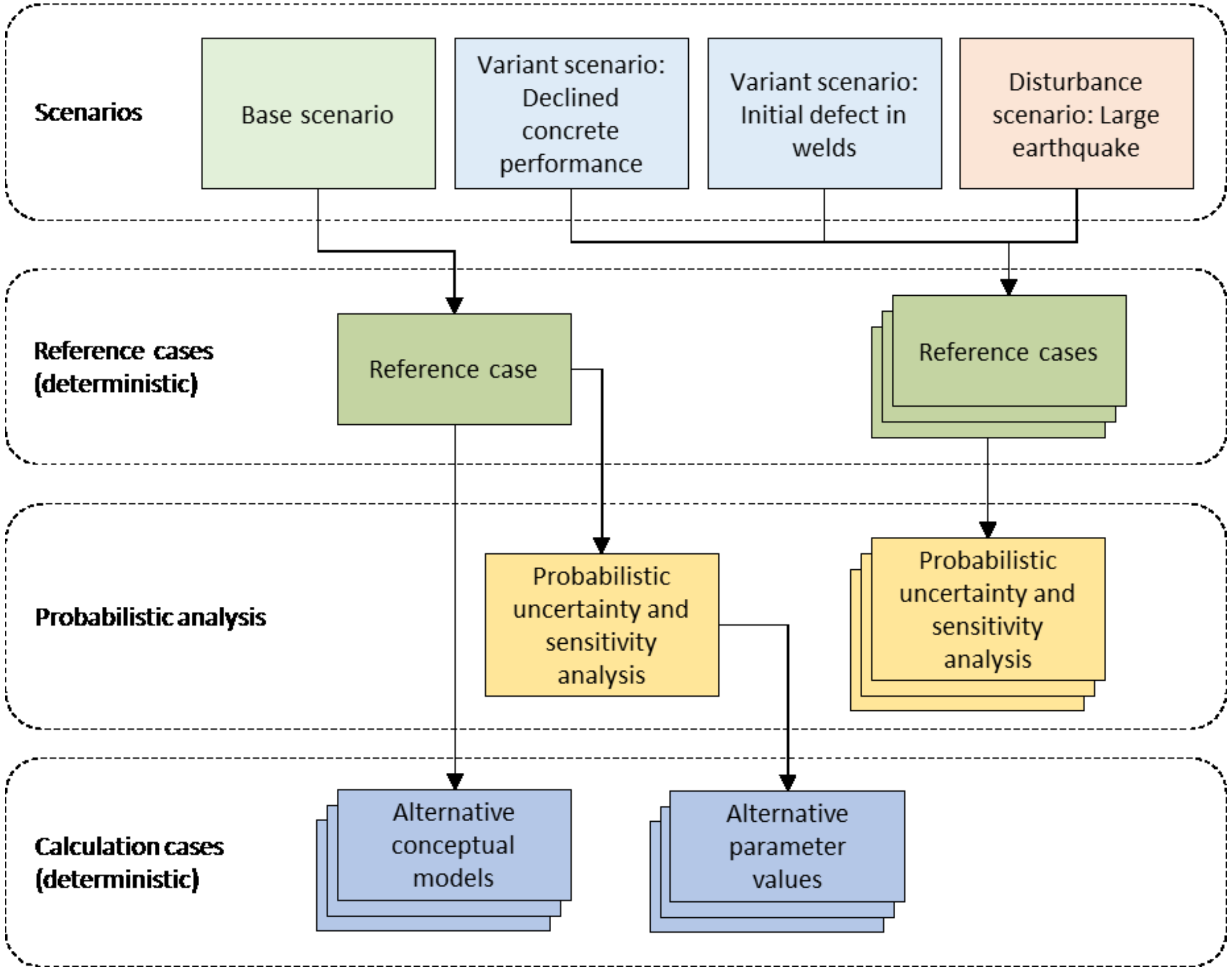

Figure: Jansson et al. 2019

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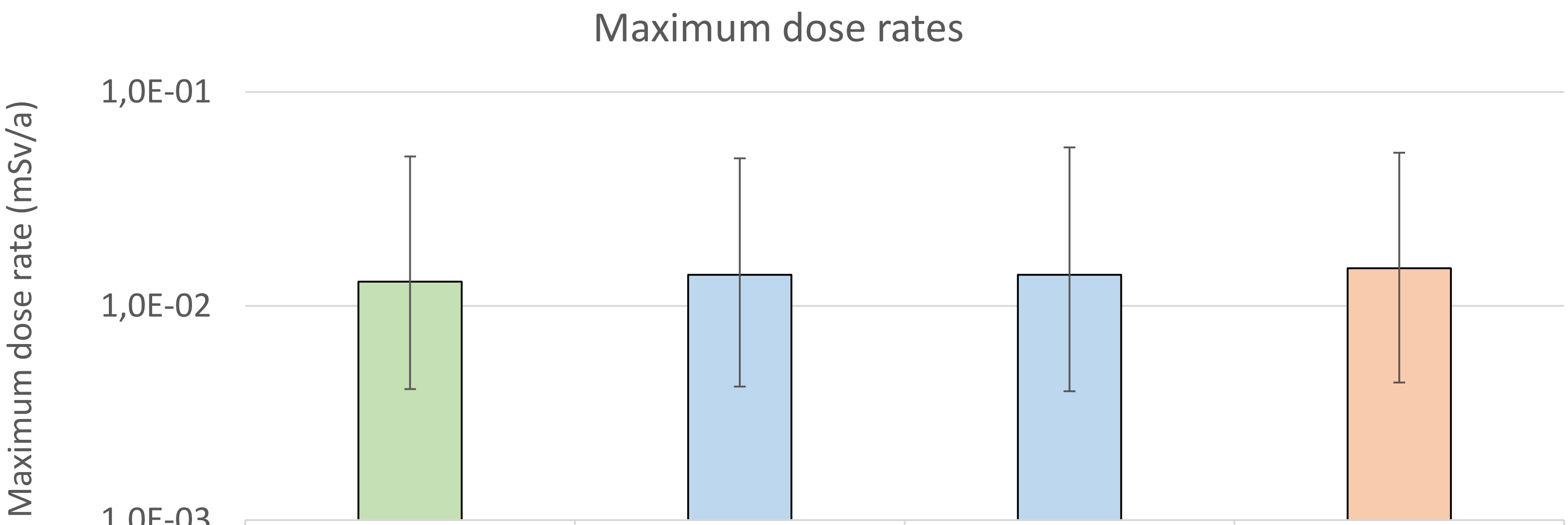
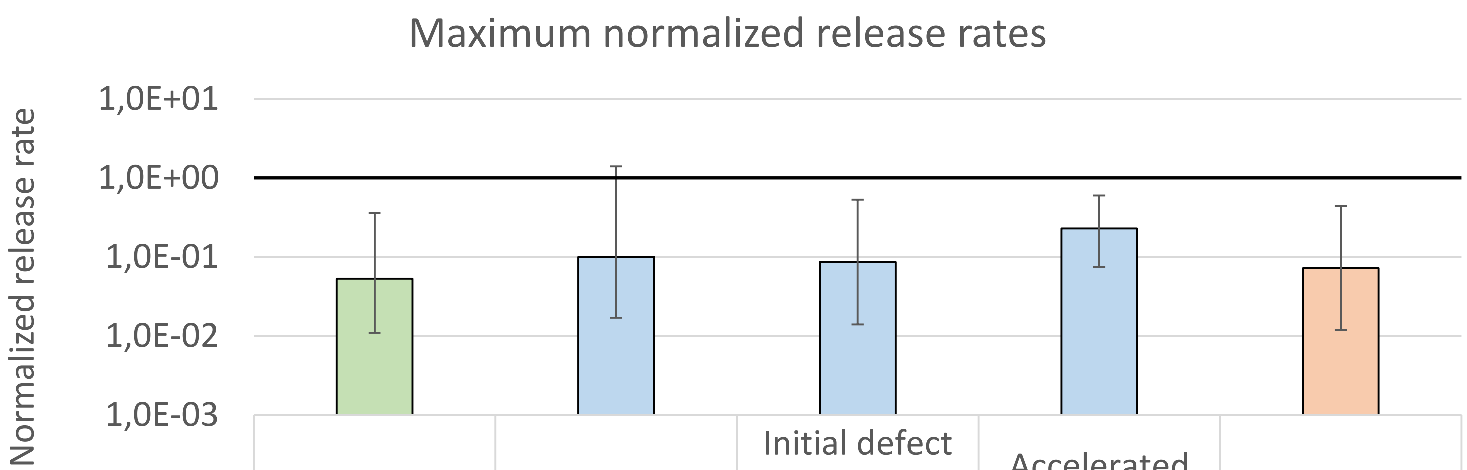
Resulting dose rates in each scenario



	Base scenario	Initial defect in welds	Accelerated concrete degradation	Large earthquake
5th percentile	4,1E-03	4,2E-03	4,0E-03	4,4E-03
95th percentile	5,0E-02	4,9E-02	5,5E-02	5,2E-02
Median	1,3E-02	1,4E-02	1,4E-02	1,5E-02

Figure: Jansson et al. 2019

Resulting dose rates in each scenario



	Base scenario	Initial defect in welds	Initial defect in welds crushed concrete	Accelerated concrete degradation	Large earthquake
5th percentile	1,1E-02	1,7E-02	1,4E-02	7,5E-02	1,2E-02
95th percentile	3,6E-01	1,4E+00	5,3E-01	6,0E-01	4,4E-01
Median	5,3E-02	1,0E-01	8,6E-02	2,3E-01	7,2E-02

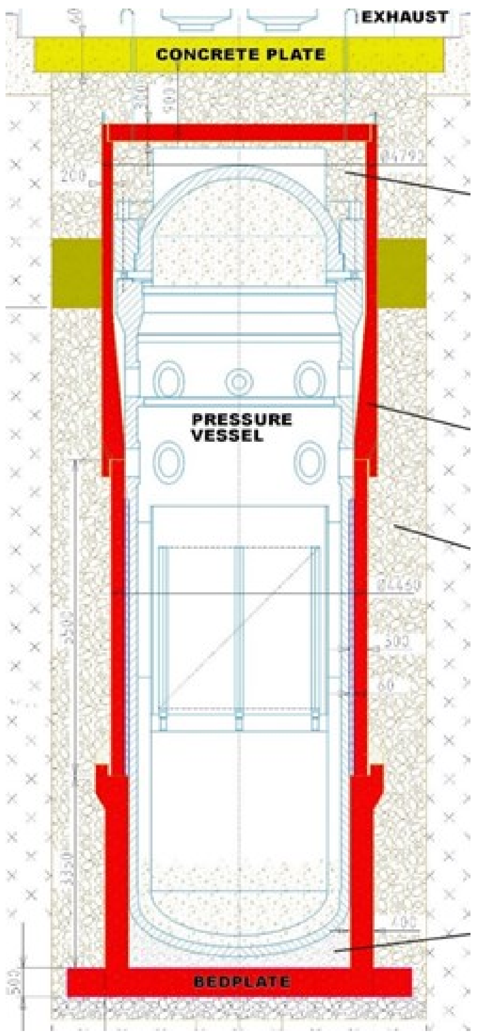


Figure: Jansson et al. 2019

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Literature

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Thank you!