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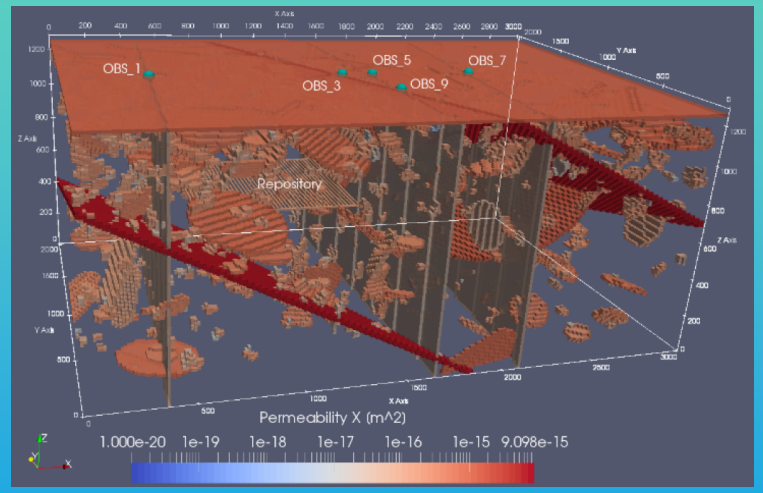


# Methodology for Design and Performance Assessment of Engineered Barrier Systems in a Salt Repository for HLW/SNF

Waste Management 2021 Virtual Symposium

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# RANGERS Team

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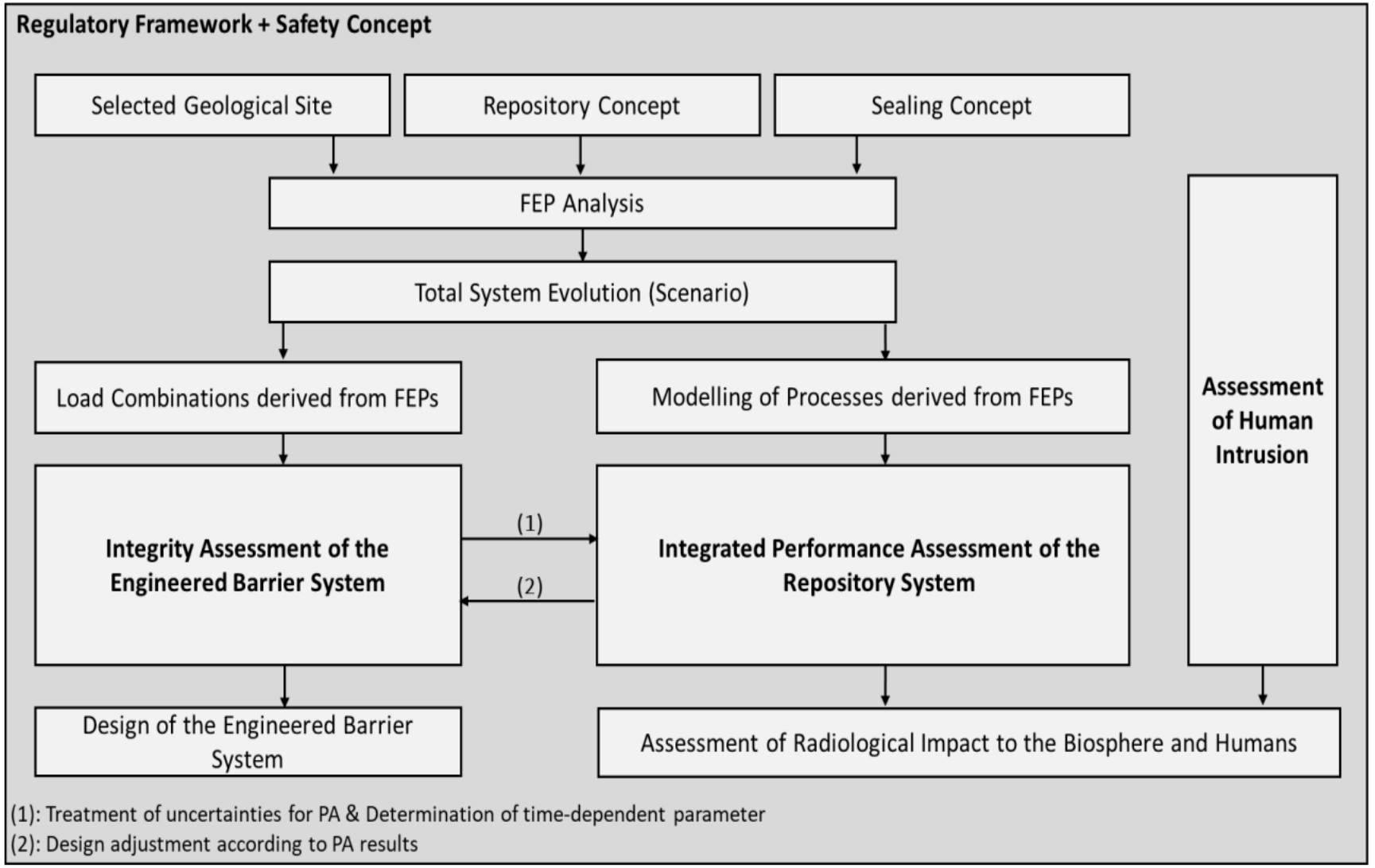
# RANGERS Overview

Overall goal: Develop methodological design approach of engineered barrier systems (EBS) in salt with preliminary representation in performance assessments (PA)

- Sub-goals:
  - Compile existing and new knowledge, experience, and concepts of geotechnical barrier design
  - Optimize methodology from state of the art science and technology for the design and verification
  - Preliminary design and verification of geotechnical barrier system for selected repository system
  - Compare design results from new methodology with previous designs and assessments

# Methodology

- Perform modified-FEPs analysis early on
- Improve representation of EBS in PA
- Reduce material and model uncertainties



# Regulatory Framework

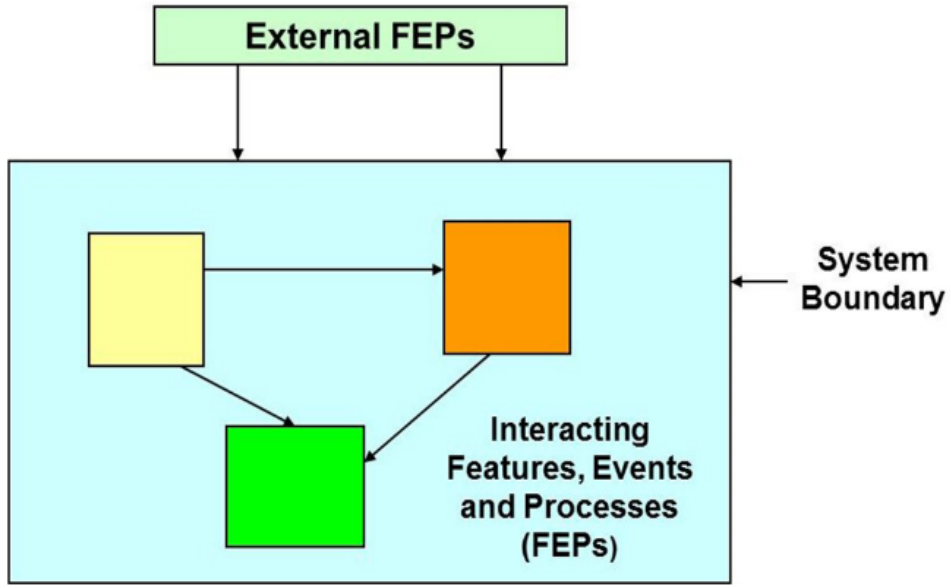
- Germany → Site Selection Act with Ordinance for Safety Requirements
  - EBS not compromised by any hydraulic, mechanical, thermal, and chemical processes
  - Specifications of EBS defined in safety concept

- US → Nuclear Waste Policy Act, 10 CFR 60 (NRC), 40 CFR 191 (EPA)
  - While there are aspects of the regulatory framework that will need to be updated, relevant portions can be for the preliminary design and preliminary PA associated with RANGERS

# Preliminary Repository Concept

- Salt as host rock
  - Define depth, dimensions, and thickness of formation
  - Design locations of emplacement areas, access drifts, etc.
- Emplaced waste
  - Define type, waste package design, and emplacement concept (vertical, horizontal, etc)
  - Shielded or unshielded
  - Design drift geometry and lengths
- Possibility of waste retrieval
- EBS of shafts, boreholes, and drifts for short-term; crushed salt backfill long-term

# Features, Events, and Processes (FEPs)



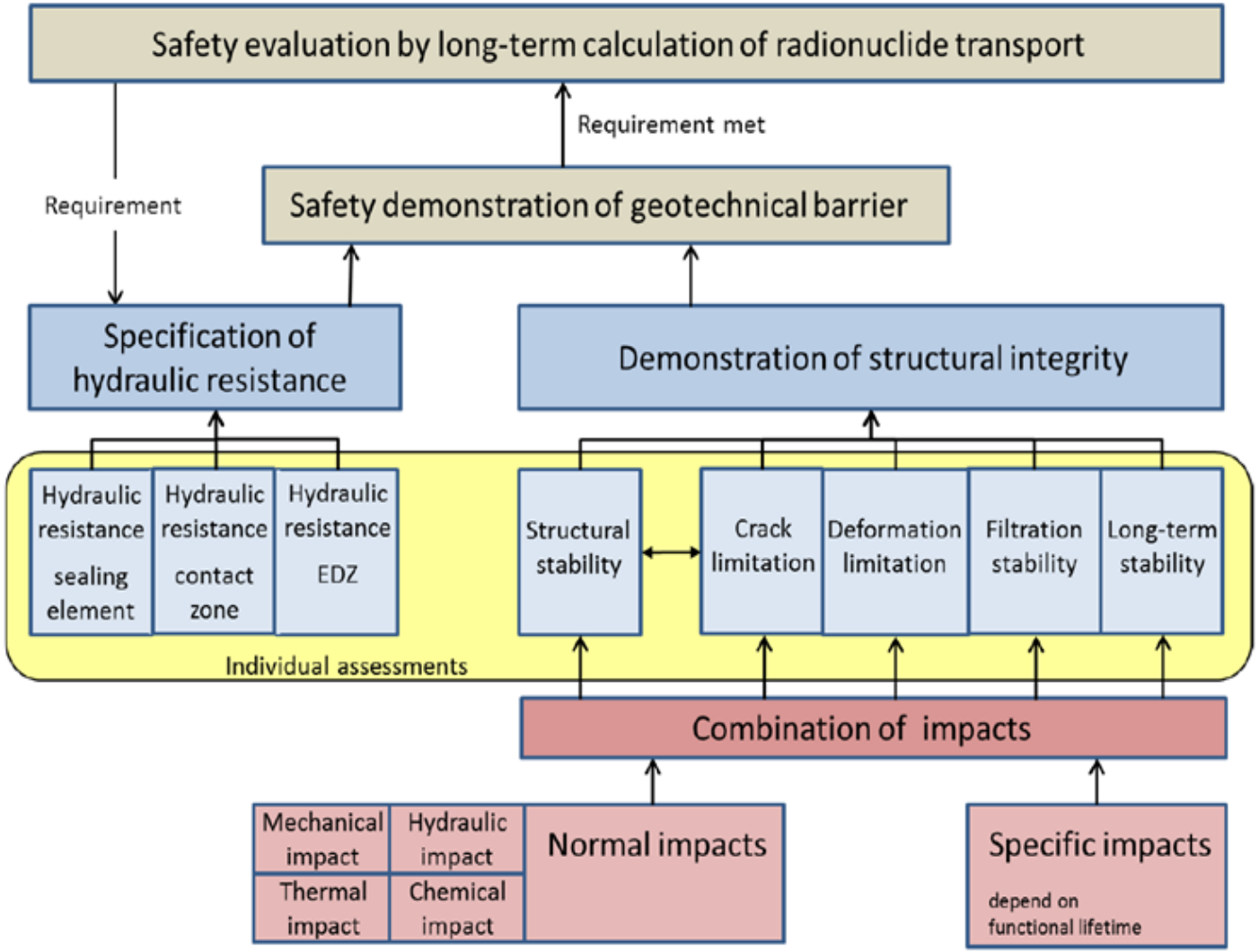

**(NEA, 2019)**

- NEA FEP Catalogue (NEA, 2019)
  - Descriptions of relevant components, events, and processes
  - Dependencies and likelihood of occurrence and characteristics
  - Impact of processes on geological and geotechnical barriers ("initial FEP")
  - Relevant processes for radionuclide mobilization and transport
  - Chronological restrictions of FEP occurrence and characteristics
  - Effects of FEP in subsystems
- Consider interactions between near-field and far-field
- For EBS, several models needed to account for all FEPs due to limitations of numerical codes & knowledge gaps

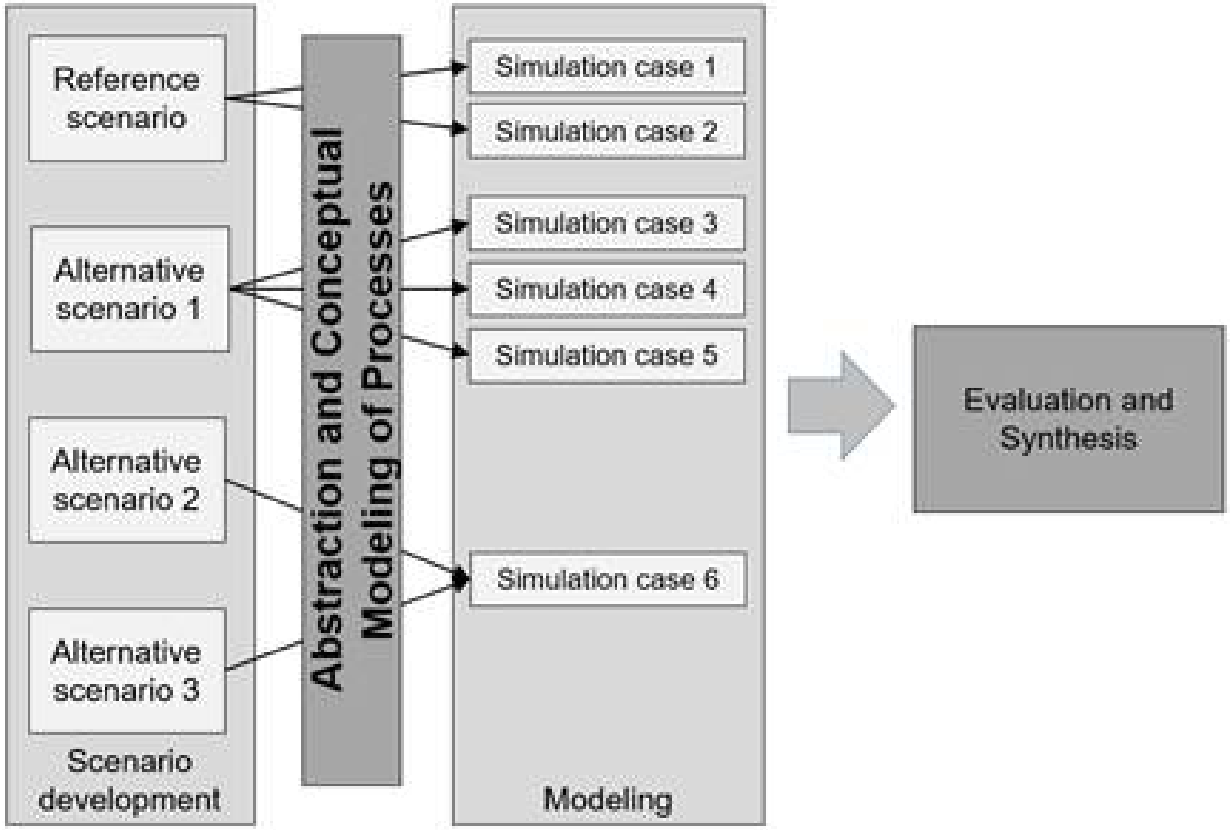
# Integrity Assessment of the EBS

## Combination of Impacts

- Chemical
  - Alteration by solutions and gases
  - Alterations induced by temperature changes
- Mechanical
  - Loads induced by forces and stresses
  - Dead load
  - Rock and fluid pressure
  - Abrasive forces
  - Restraint stresses
- Coupled effects
  - Thermal expansion and contractions
  - Swelling and shrinking
  - Creep and relaxation
  - Restraint strains from barrier-rock-interaction
- Biological degradation



# Conceptual Modeling Process for PA




- Breakdown scenarios and processes affecting EBS; examples include:
  - Advection & diffusion
  - Crushed salt compaction
  - Salt creep behavior
  - Heat propagation
- Modeling of specific processes as intermediary step to evaluate and integrate individually into PA

# Integrated Performance Assessment

- Current PA approach for US built upon previous reference cases
  - Bedded salt
  - Framework focused on EBS and natural barrier
  - Assumes undisturbed zone
- Processes include:
  - Waste package degradation
  - Waste form dissolution
  - Equilibrium controlled radionuclide sorption
  - Radioactive decay
  - Coupled heat and fluid flow
  - Radionuclide transport
- 200 probabilistic simulations for 7 uncertain parameters
- Use of sensitivity analysis to optimize design of EBS and its performance

# Assessment of Human Intrusion

- Scenarios are site-specific
- Example: Waste Isolation Pilot Plant (WIPP) in US
  - Human intrusion is the primary driver for WIPP PA
  - Includes 5 disturbed scenarios
  - Variables of Time and locations of intrusion (e.g. waste panels, brine pockets, etc.)
- Probability of intrusion reduced by siting at sufficient distances from known resources (e.g. aquifers, ore deposits, fossil fuels, etc.)
- Current generic reference case is undisturbed due to reliance of site-specific information for disturbed cases

# Summary

- RANGERS developed methodology for generic design and PA of EBS in salt repository
  - Describes workflow of integrity assessment of EBS
  - Incorporation of impacts within PA
- Brings an EBS-centric view on PA by focusing on process for each component of EB and evolution over time
- Optimatization of sealing concepts for salt repositories
- Additional development to apply design of EBS in a selected generic repository in Germany

# REFERENCES


- NEA: (2019): International Features, Events and Processes (IFEP) - List for disposal of Deep Geological Disposal of Radioactive Waste. Version 3.0.- Radioactive Waste Management and Decommissioning, NEA/RWM/R.1, Juli 2019, Paris