Exceptional service in the national interest

Sandia National Laboratories

Reflections on the ISIBEL Project and Perspectives on Modeling Salt Reconsolidation

R. Chris Camphouse

Sandia National Laboratories

Sandia National Laboratories

Verantwortung für Generationen / Responsibility for Generations DBE TEC DBE TECHNOLOGY GmbH

PTKA Project Management Agency Karlsruhe Karlsruhe Institute of Technology

U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. SAND NO. 2014-16927PE

This research is funded by WIPP programs administered by the Office of Environmental Management (EM) of the U.S Department of Energy.

Outline

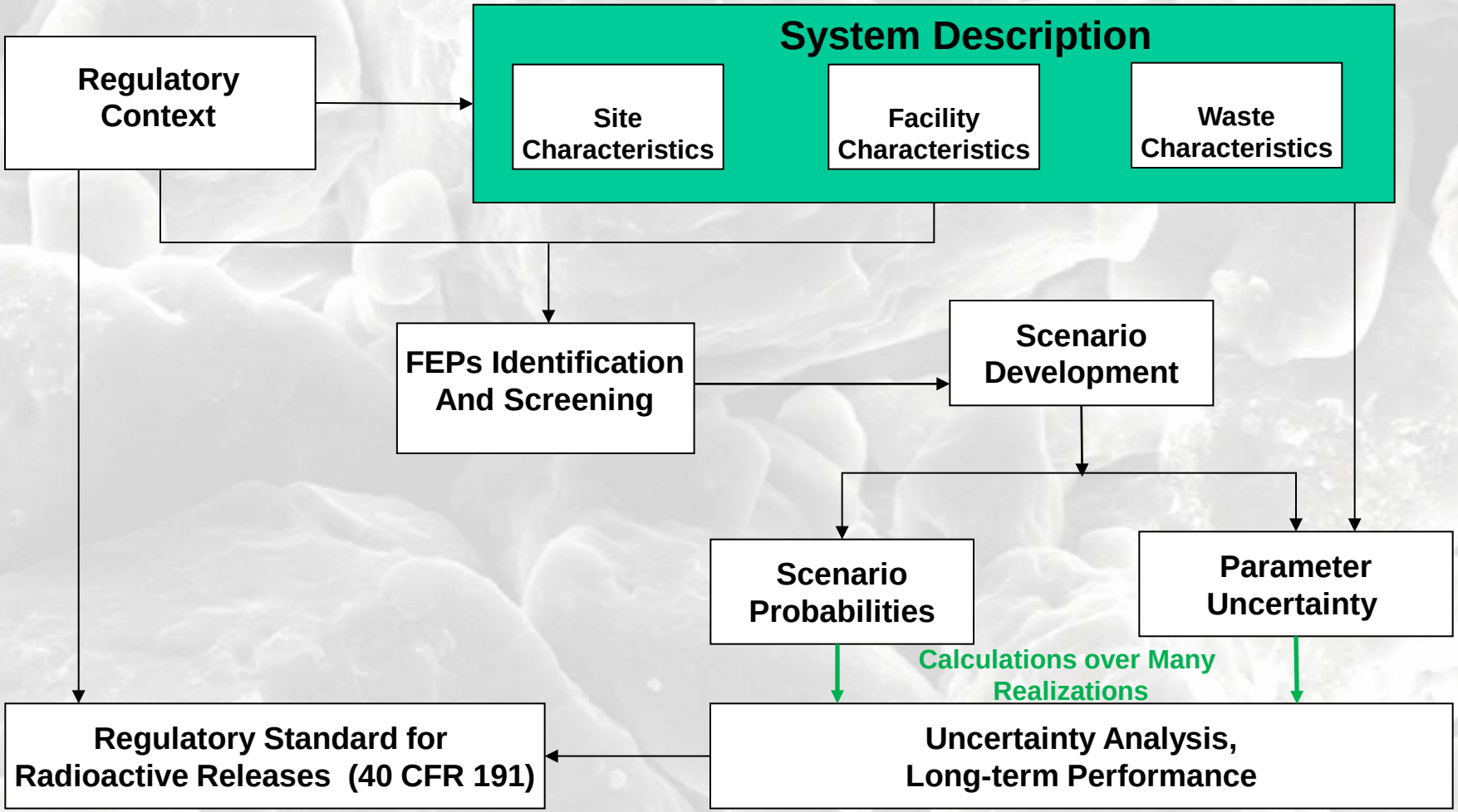
- ISIBEL and WIPP Common Ground
- Compare/Contrast the ISIBEL safety demonstration concept and WIPP PA – Methodologies, FEPs, Scenario Development, Uncertainty
- Discussion of the salt reconsolidation approach taken for a recent WIPP design change – Processes Modeled, Temporal Behavior, Regulator Interactions
- Conclusions

Common Ground

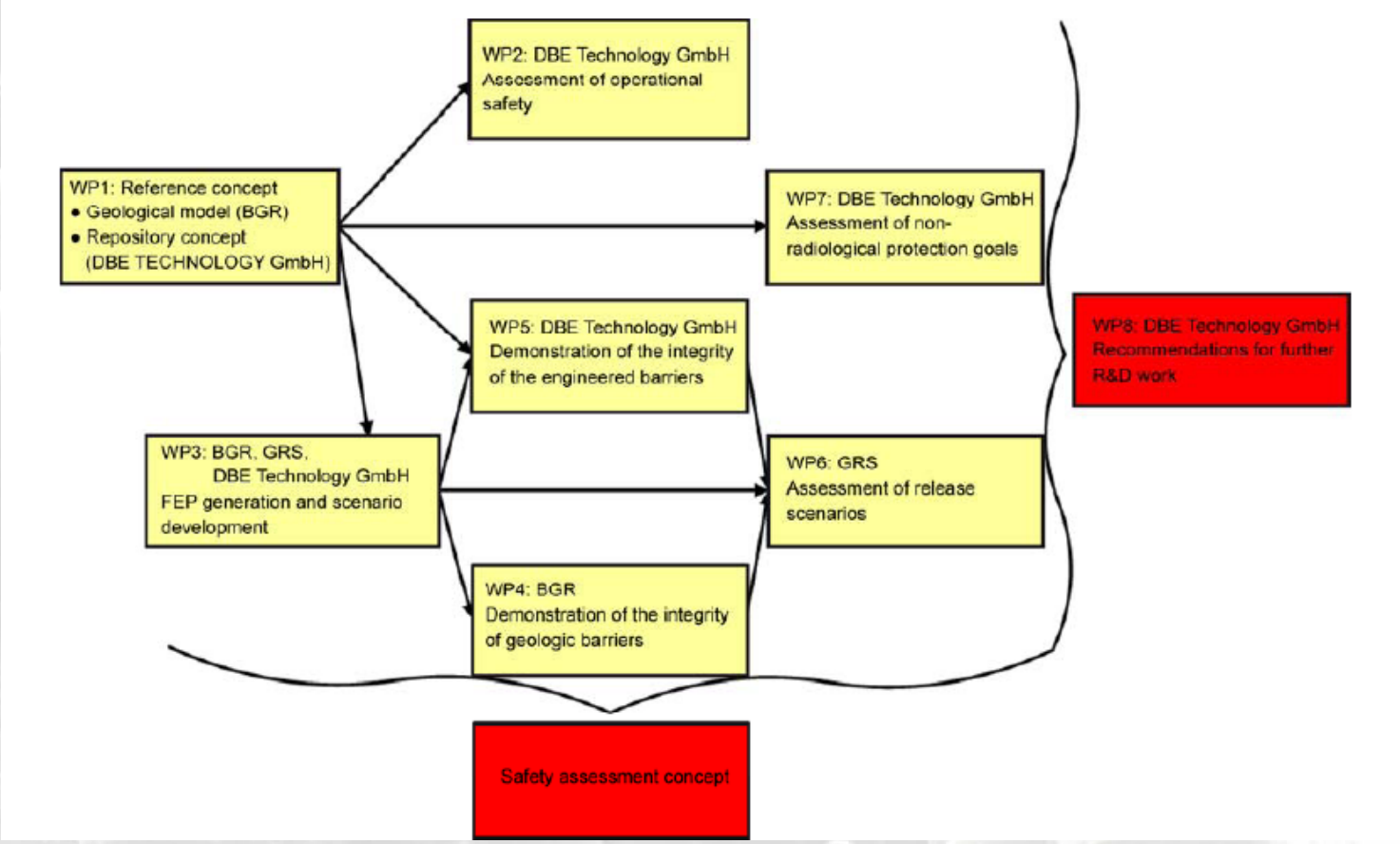
The ISIBEL repository concept and the WIPP have many common aspects.

- Both are underground waste disposal facilities in salt
- Both repositories have been designed to take advantage of salt properties
- Salt reconsolidation processes are important in ISIBEL (backfilled mine workings) and the WIPP (panel closures)
- WIPP PA is established and in use. ISIBEL safety demonstration capability is drafted with future work defined

WIPP Performance Assessment



ISIBEL Safety Demonstration Concept



Bedrock of WIPP PA and ISIBEL

Fundamental to WIPP PA and the ISIBEL safety demonstration concept are:

- A catalog of the features, events, and processes (FEPs) that must be considered
  - screening process → what needs to be considered and what doesn't
- Repository scenarios, informed by the set of FEPs, that capture future states of the repository
  - undisturbed and disturbed conditions
- Proper consideration of uncertainty
  - parameters, models, facility futures

ISIBEL FEPs

The Gorleben site was used to develop a generic FEP catalog for salt formations.

Iterative approach:

- A comparison with the NEA-FEP database, with an emphasis on salt as the host rock
- A bottom-up approach identifying all FEPs relevant to the future evolution of the repository
- A top-down approach identifying FEPs that could play a role in conceivable scenarios
- FEPs added to represent interdependencies between FEPs found above

FEPs catalog evaluated in the course of a national peer review. Catalog consists of 92 probable and 4 less probable FEPs.

FEPs Screening for WIPP

WIPP FEPs are screened according to:

- Probability: If a FEP has a probability of occurring less than 10^{-4} in 10,000 years it does not have to be included in PA (e.g., meteorite impact)
- Consequence: If a FEP is beneficial to performance, is not relevant to WIPP, or has a insignificant consequence to the disposal system, it does not have to be included in PA (e.g. lakes, oceans, tides, floods). If a FEP is related to the WIPP disposal system and/or impacts the repository, it must be accounted for in PA (e.g., chemical effects of corrosion).
- Regulation: Certain FEPs are either screened in or out by regulation (e.g., mining, resource extraction following drilling).
- 245 FEPs were screened in for the most recent WIPP compliance calculation.

ISIBEL/VSG Scenario Development

Possible repository futures categorized as probable, less probable, and improbable.

- Binning of futures results in one reference scenario and 17 alternative scenarios
- Reference scenario represents probable repository futures
  - includes climate change (100,000 year cycle), waste heat generation, mobilization and transport, initial barrier integrity
- Alternative scenarios differ in only one aspect from the reference scenario
  - improvised barrier functionality, less probable mobilization and transport, etc.

WIPP Scenario Development

- All retained (screened-in) FEPs must be accounted for in WIPP PA in at least one scenario.
- FEPs can be included by explicit modeling or by parameter assignment.
- Expected FEPs are included in all scenarios
  - Creep closure
  - Brine flow, gas generation
- Disruptive FEPs are included in disturbed scenarios.
  - Drilling, mining, brine pocket

Uncertainty

Proper representation of uncertainty is vital to WIPP PA and the ISIBEL safety demonstration concept.

- Uncertainties reduced by information gained via site characterization
- Data generated by individual R&D programs can reduce uncertainty and inform parameter distribution assignments
- Uncertainties with regard to future events must be represented
- Uncertainty distributions used for parameter sampling may be iterated with or prescribed by the site regulator

WIPP Panel Closure Redesign

The waste panel closure implemented in WIPP has recently been redesigned.

- Current design based on Salado Mass Concrete was mandated by the EPA as part of their 1998 WIPP certification decision
- Redesigned panel closure consists of 100 feet run-of-mine (ROM) salt with barriers at each end – termed the ROMPCS
- Including the ROMPCS in WIPP PA required spatial and temporal modeling of ROM salt reconsolidation
- ROMPCS modeling in WIPP PA was a negotiated process with the EPA – federal rulemaking process

ROMPCS Processes

The representation of the ROMPCS in WIPP PA needed to account for several physical processes.

- Creep closure of the surrounding salt rock resulting in consolidation of ROM salt placed in panel entries
- ROM salt comprising the closures approaching a condition similar to intact salt
- Imposed back stress on the surrounding rock resulting in eventual healing of the surrounding salt rock

ROMPCS Evolution

The ROMPCS is modeled as having short-term and long-term characteristics in WIPP PA, with properties based on three time periods

- 0 to 100 years: Emplaced ROM salt undergoes some re-consolidation with no impact on surrounding salt rock
- 100 to 200 years: ROMPCS continues to re-consolidate with no impact on surrounding salt rock
- 200 to 10000 years: ROMPCS is re-consolidated and the surrounding salt rock is healed

Regulator Interaction

The approval of the ROMPCS design by the EPA regulator is slated to appear in the Federal Register soon.

- Federal rulemaking aspect of design change invoked a lengthy and involved process for the regulator
- Good communication with the EPA was critical in gaining their approval of the new design
- Representation of spatial and temporal ROMPCS behaviors was an iterative process – consensus between EPA and DOE
- Extensive support of EPA verification calculations increased regulator comfort with the new design
- Regulatory comfort in the new design → stakeholder defense

Conclusions

- The ISIBEL repository concept and the WIPP have many aspects in common.

  - repositories in salt rock, taking advantage of physical and temporal salt characteristics
- FEPs, repository scenarios, and consideration of uncertainty are fundamental to the WIPP and ISIBEL safety demonstrations.
- The spatial and temporal behaviors of “loose” salt are important to ISIBEL and the WIPP

  - Backfill of mine workings for ISIBEL

  - WIPP panel closures
- Modeling of ROM salt has recently been undertaken, with consensus by the EPA, for a WIPP design change