Practical Considerations for Development and Selection of Scenarios

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Introduction

- Need set of cases to consider for quantitative assessments to evaluate effectiveness of disposal or remedial actions
- Emphasis on understanding roles and functions of "barriers" in context of system behavior rather than exact predictions (importance)
- Focus efforts where it matters
- Approaches have evolved to a top-down, bottom-up perspective for development of scenarios to consider for a given situation
Scenarios

“Scenarios” is used broadly for this presentation to represent the system and collection of cases (potential futures) that are considered in an assessment

- Sources
- Exposure Pathways
- Land Use/Receptors
- Conceptual Models
- Failure Assumptions
- “What-if”
- …

The challenge is how to efficiently and defensibly decide what is to be considered
Contents

- Top-Down and Bottom-Up Approaches
- Historical Perspective (Remediation and Disposal)
- Systems Approach and Safety Functions
- Example
- Practical Considerations
**Bottom-up and Top-down Perspectives**

**Bottom-up** – List of Features, Events and Processes (FEPs), screen FEPs, develop scenarios by piecing together individual FEPs that are relevant for a given system.

**Top-down** – develop system description, identify safety functions for different parts of the system, identify key aspects of the system, consider how functions could be compromised for key aspects.
Conceptual Site Model (Remediation)

- Integrate all available site information and identify potential gaps (iterative) – detailed description
- Sources, pathways, and receptors
- Means to identify remedial alternatives
- Help focus resources on primary concerns
- 3-D “picture” of system, communication tool to explain key factors
Historical Perspective – Disposal

- 80s – FEPs concept introduced
- 90s – Elaboration on FEPs methodologies, FEPs lists, structured bottom-up approaches
- Early 00s – Refinement of structured bottom-up approaches, detail added to FEPs lists, safety functions concept
- Late 00s – Safety functions emphasis, experience leads to top-down approach supplemented by FEPs input ("top-down, bottom-up")
Systems Approach and Safety Functions

- **Systems Approach** - Consider behavior of individual features in the context of overall system performance relative to the decision to be made.

- **Safety Functions** – Understanding of roles and functions of “barriers” in the context of total system performance.
  - Complements NRC barrier analysis concept.
  - Often counter-intuitive behavior with multiple “barriers” and/or functions.
  - Top-down, performance-based.

Examples of different scales of behavior.
Example Systems Perspective and Safety Functions

Water Balances

Cover – Limit infiltration, biointrusion and direct contact with waste, airborne releases

Waste Zone/Source – Limit subsidence, drainage, delay transport

Liner – Collect leachate for operations, limit water and contaminant releases from system

Vadose Zone – Delay and disperse radionuclides that may be released
### Functions

<table>
<thead>
<tr>
<th>Layer</th>
<th>Potential Subcomponents</th>
<th>Function</th>
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<tbody>
<tr>
<td>Vegetative Cover (Not Shown)</td>
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<td>Topsoil</td>
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<td>Upper Backfill</td>
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<td>Erosion Barrier</td>
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<td>Geotextile Fabric</td>
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<td>Middle Backfill</td>
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<td>Geotextile Filter Fabric</td>
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<td>Lateral Drainage Layer</td>
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<td>Geotextile Fabric</td>
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<td>Geosynthetic Clay Liner</td>
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<td>Upper Foundation Layer</td>
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### Processes, Events

- **Compacted Clay Layer (CCL)**
  - **Slope stability**: CCL slope stability should be appropriately addressed during the design process.
  - **Freeze-thaw cycles**: Freeze-thaw cycles should be precluded as a potential degradation mechanism during the design process by placing the CCL below the site-specific maximum frost depth.
  - **Natural weathering (dissolution)**: Natural weathering of the clay fraction of CCLs is dependent upon the clay mineralogy. However within the 1,000 year time frame of concern natural weathering of typical clays (i.e., kaolinite, illite, sodium bentonite) would not be a degradation mechanism of concern.
  - **Divalent cations (Ca²⁺, Mg²⁺, etc.)**: Saturated hydraulic conductivity increases due to cation exchange with divalent cations such as calcium and magnesium is dependent upon the clay mineralogy. The presence of divalent cations has little impact upon kaolinite or illite, however as outlined above the presence of divalent cations has a significant impact upon the saturated hydraulic conductivity of sodium bentonite.
  - **Desiccation (wet-dry cycles)**: Unprotected CCLs are vulnerable to desiccation; however an overlying HDPE geomembrane can be utilized to preclude this degradation mechanism for as long as the geomembrane remains essentially intact. This assumes that the region beneath the CCL remains relatively moist. The potential for material beneath the CCL to dry and create suction pressure that could dry the CCL should be addressed, however, this is considered relatively unlikely.
  - **Root penetration**: Unprotected CCLs are potentially vulnerable to root penetration; however an overlying HDPE geomembrane can be utilized to preclude this degradation mechanism for as long as the geomembrane remains essentially intact.
  - **Burrowing animals**: Unprotected CCLs are potentially vulnerable to burrowing animals; however an overlying bioinvasion layer can be utilized to preclude this degradation mechanism.
Recent Observations

“In all programmes, the starting point for the identification of safety-relevant phenomena and uncertainties is the development of a detailed description of the initial state of the system and its subsequent evolution. This description provides the basis for a main scenario, also termed normal evolution, base or reference scenario.”

“It could be contended that the “top-down” approach described in recent safety assessments is in fact a more accurate representation of the approach that was in reality adopted (though not documented) in earlier safety assessments.”

“It could further be contended that “top-down” approaches … are, in fact, better described … as “top-down/bottom-up”.”
Summary

- Practical experience reflects a performance-based perspective – gather existing information and develop initial concept, refine as needed

- Need system perspective when identifying potentially important safety functions and FEPs to help focus efforts where it matters – also, difficult to *a priori* recognize all important interactions

- Emphasize the need to integrate efforts and role of the process to help communications
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