Practical Considerations for Development and Selection of Scenarios

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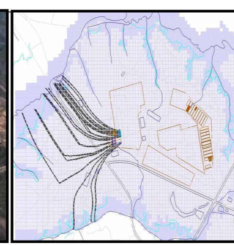
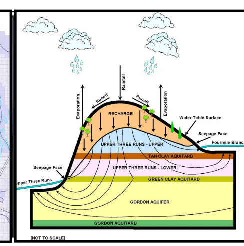
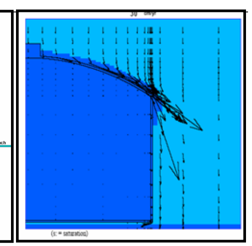
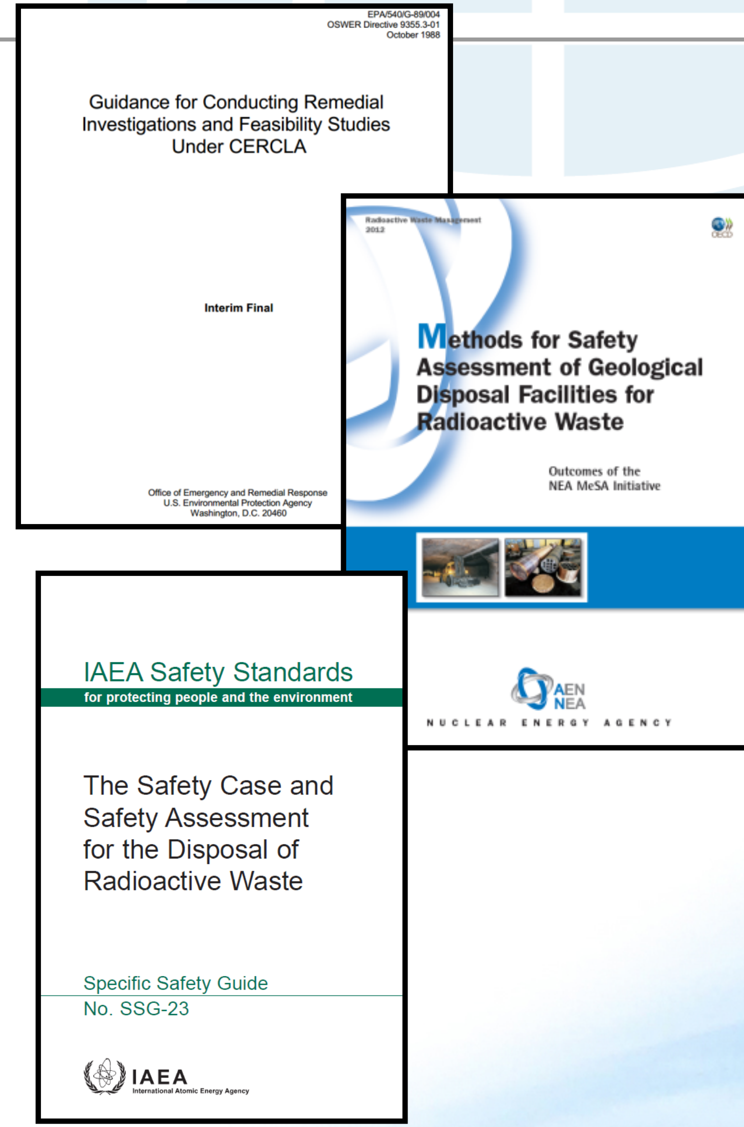




Introduction

- **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**

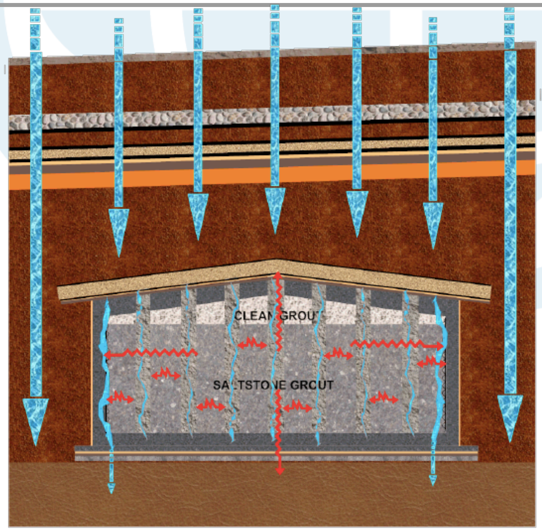


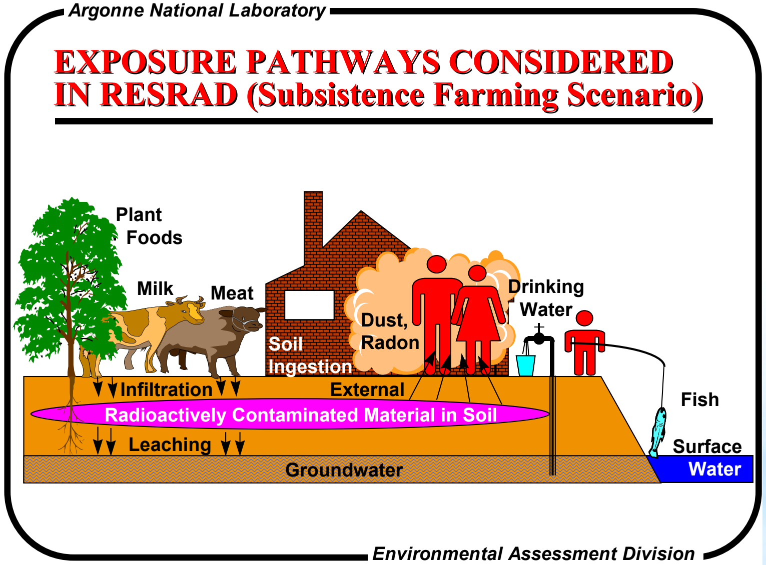
Scenarios

"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





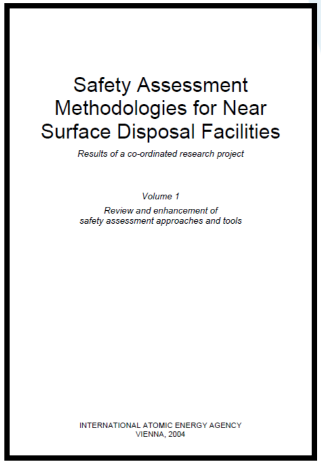
Contents

- 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

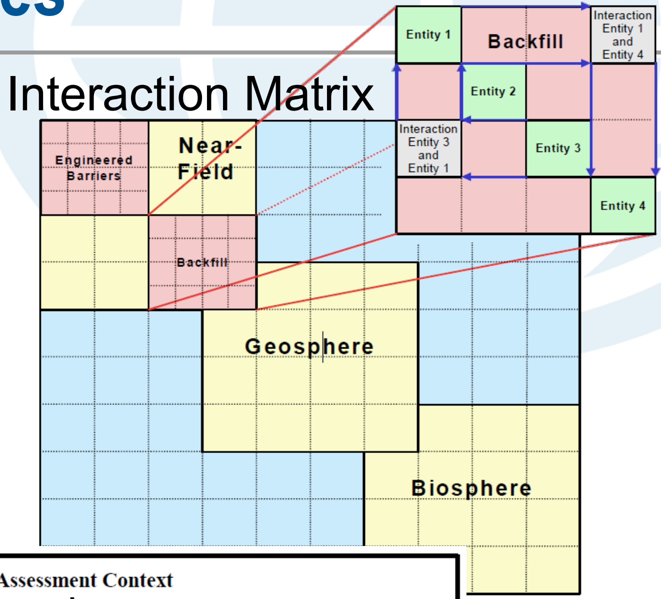

Safety Assessment Methodologies for Near Surface Disposal Facilities

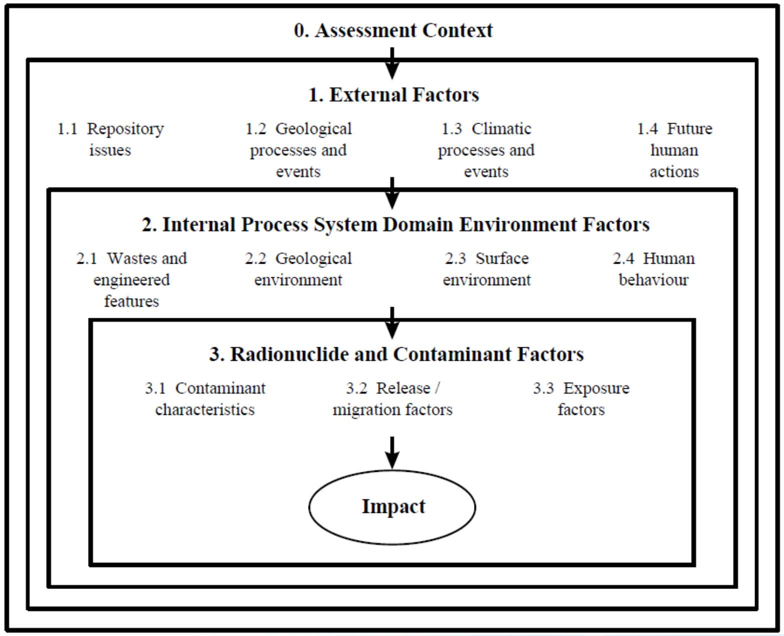
Results of a co-ordinated research project

Volume 1

Review and enhancement of safety assessment approaches and tools

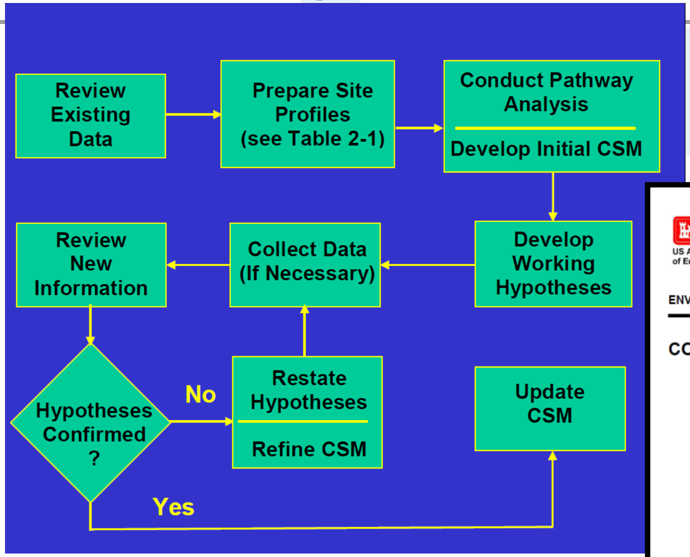
INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2004

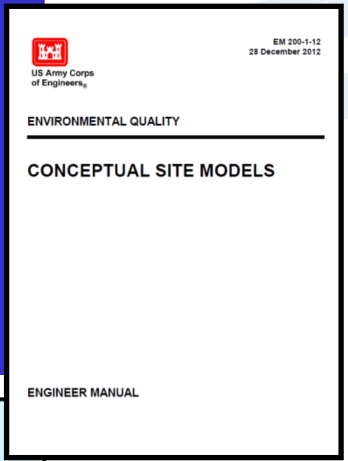


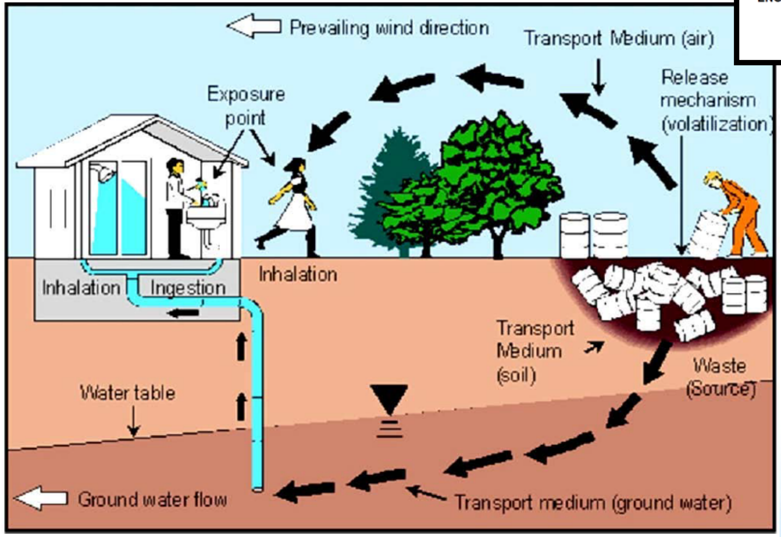


Conceptual Site Model (Remediation)

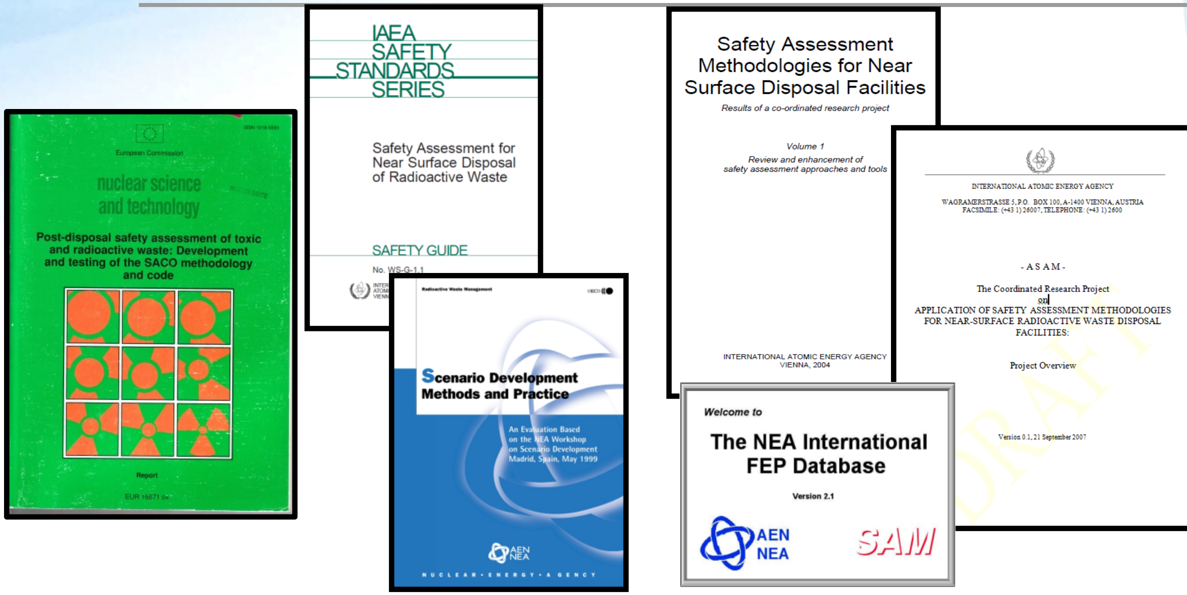
- Integrate all available site information and identify potential gaps (iterative) – detailed description
- Sources, pathways, and receptors
- Means to identify remedial alternatives
- Help focus resources on primary concerns
- 3-D "picture" of system, communication tool to explain key factors







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")**

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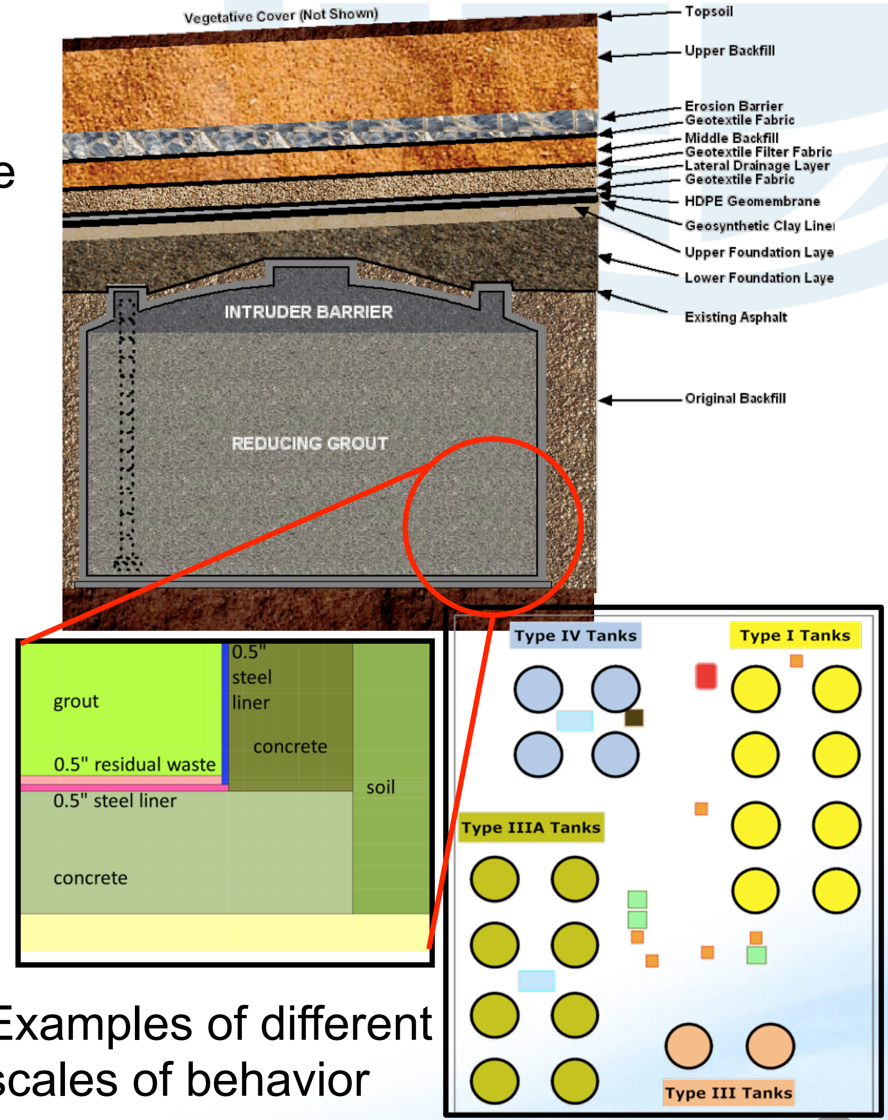
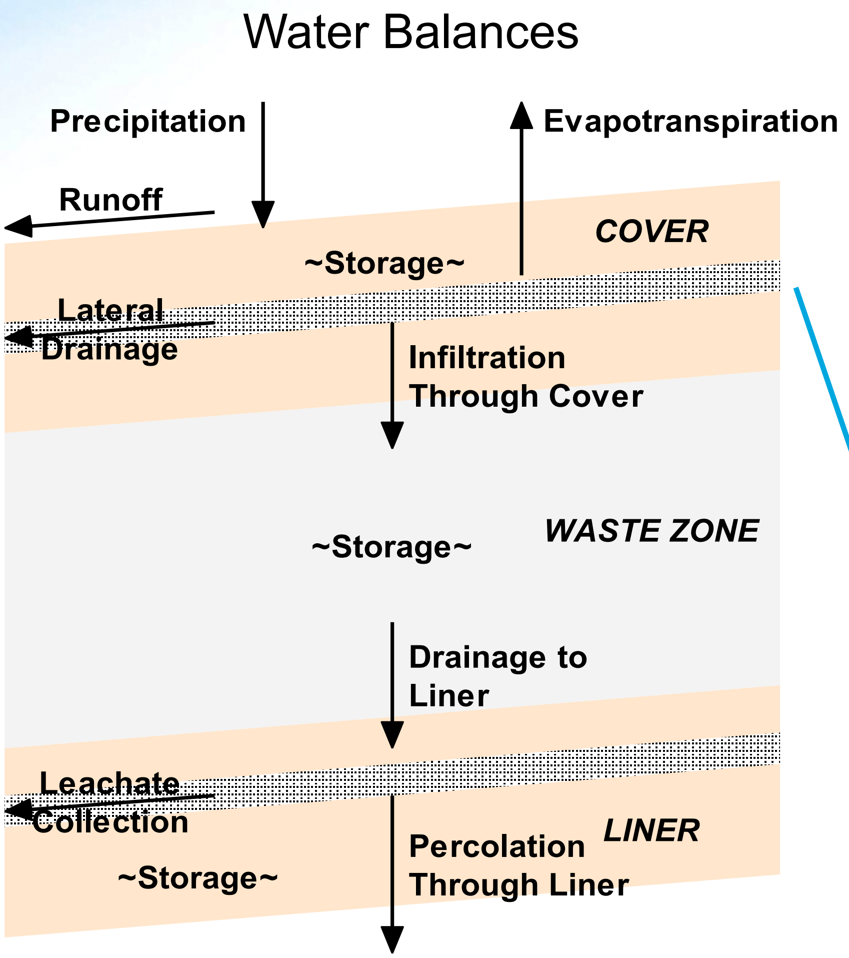
Systems Approach and Safety Functions

- **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

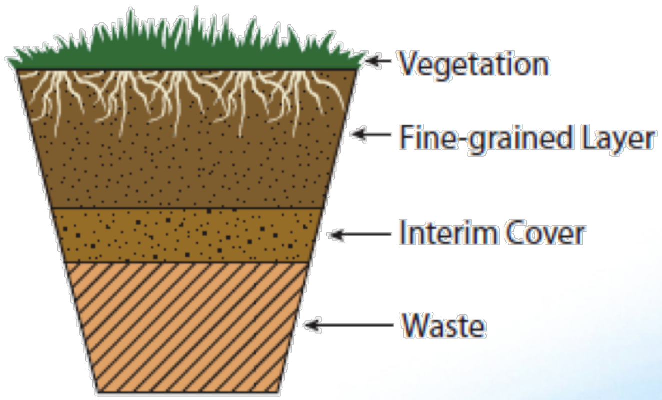


Cover – Limit infiltration, biointrusion and direct contact with waste, airborne releases

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

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

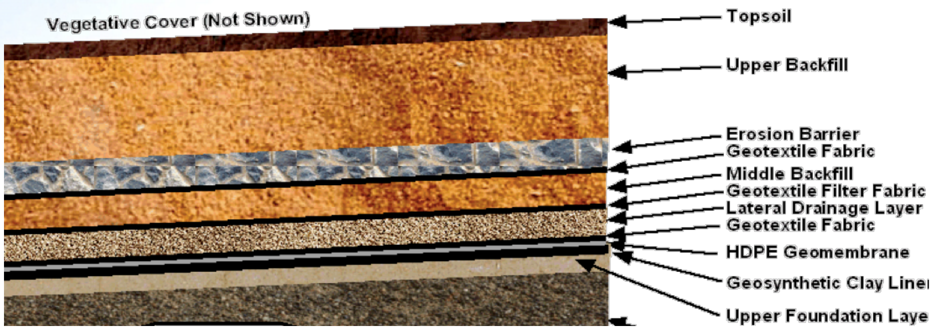
Vadose Zone – delay and disperse radionuclides that may be released



Example – Humid Site (cover important and uncertain)

Functions →

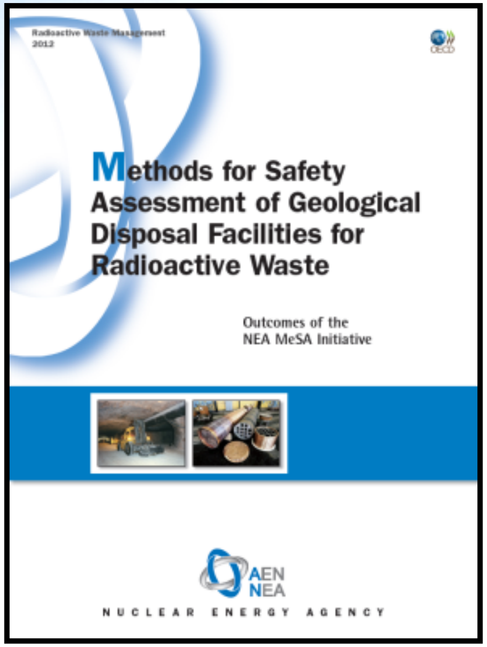
Layer	Potential Subcomponents	Function
Cover System Overall	-	The primary function of the cover system is to control infiltration into the waste, also limit biointrusion and direct contact with the waste.
Evapotranspiration Layer	• Vegetative Cover • Topsoil • Soil Water Storage Layer	The primary functions of the ET layer are to remove water from the cover system by promoting a combination of ET and soil-water storage in order to minimize infiltration, while minimizing erosion. In humid environments ET may be the primary means of removing water from the cover system, while in arid environments covers may consist of only an ET layer designed to remove essentially all water through adequate water storage and ET (i.e. ET covers). The promotion of runoff must be balanced versus the minimization of erosion. The ET layer materials are selected and the top of cover slopes (typically range from 2 to 5% slope) are designed to minimize erosion and prevent the initiation of gullying. The vegetative cover promotes runoff, minimizes erosion, and obviously promotes transpiration. The topsoil and underlying soil water storage layer support the vegetative cover, promote runoff, help minimize erosion, and provide water storage for the promotion of ET.
Biointrusion Layer	• Granular Filter • Geotextile Filter Fabric • Rip Rap or Cobbles	The primary functions of biointrusion layer are to prevent burrowing animals from damaging underlying components and creating continuous macropores into the waste, prevent exposure to burrowing animals, mitigate animals from bringing contamination to the surface, and potentially act as an intruder deterrent, and/or act as a deterrent to root penetration. The biointrusion layer can also act as a capillary break to maintain water storage in the overlying ET for the promotion of ET and runoff. The granular filter and geotextile filter fabric serve to minimize migration of overlying materials into the rip rap or cobbles thus maintaining the capillary break function, while the rip rap or cobbles serve to fulfill the primary functions of the biointrusion layer.
Lateral Drainage Layer	• Granular Filter • Geotextile Filter Fabric • Geonet and/or Gravel/Sand • Geotextile Protective Fabric	The primary function of the lateral drainage layer in conjunction with the underlying composite barrier is to divert infiltrating water away from the underlying waste and transport the water to the perimeter drainage system thus minimizing infiltration into the waste. When the underlying composite barrier also include a Geosynthetic Clay Liner (GCL), the lateral drainage layers serve to provide the necessary confining pressures to allow the underlying GCL to hydrate properly. The granular filter and geotextile filter fabric serve to minimize migration of overlying materials and penetration of the overlying rip rap or cobbles into the geonet and/or gravel/sand thus minimizing the potential for clogging. The geonet and/or gravel/sand serve the primary lateral drainage function. The geotextile protective fabric serves to protect the underlying geomembrane from puncture or tear during placement of the overlying geonet and/or gravel/sand.



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 (Ca^{+2}, Mg^{+2}, 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 very 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 a 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 biointrusion 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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