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NRC Recommended Approach for Performance Assessment Methodology for Low-Level Radioactive Waste Disposal

WM2011 Session 101

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Topics

- 10 CFR Part 61 disposal concepts and performance objectives
- Performance assessment (PA) overview
- PA LLW recommended approach & methodology – NUREG-1573
- Summary of PA approach related to DOE Waste Determination – NUREG-1854
- Current PA issues
- Concluding remarks and path forward

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PA Overview
NRC Guidance on PA Approaches

- **NUREG-1573** ***(A Performance Assessment Methodology for Low-Level Radioactive Waste Disposal Facilities)***
- **NUREG-1854** ***(NRC Staff Guidance for Activities Related to U.S. DOE Waste Determinations)***
- **Comprehensive PA review guidance reflecting updated methods & approaches (planned)**

10 CFR Part 61 LLW Disposal Concept

Near-surface (<30 m depth) land disposal with specific technical requirements, performance objectives, and procedural requirements

- Cornerstone of safe disposal is stability:
  - Stable wastes, design
  - Reliance natural system isolation
  - Reduced exposure to intruders
  - Stability of waste form & packaging

Graded stability requirements using waste classes A, B, and C

Limit on maximum inventory for mobile long half-life radionuclides to limit potential radiation exposure

10 CFR Part 61 LLW Disposal Concept (Cont'd)

Inadvertent intruder dose limit not to exceed 5 mSv/yr

Greater than class C waste unsuitable for near- surface disposal

Site closure and stabilization (a 5-year post-closure period for observation, monitoring, and maintenance)

Monitoring, access restrictions, and custodial activities after license transferred to the State or Federal agency for 100 year of institutional control period

State or federal government ownership of land assuring custodial care during institutional control period

10 CFR Part 61 Subpart C Performance Objectives

- **Protection of the general public *(annual doses not to exceed 0.25 mSV/yr to the whole body, 0.75 mSv/yr to the thyroid, and 0.25 mSv/yr to any other organ and maintain effluent releases ALARA)***
- **Protection of individuals from inadvertent intrusion *(< 5 mSv/yr)***
- **Protection of individuals during operations**
- **Stability of disposal site after closure (the LLW facility must be sited, designed, operated, and closed to achieve long-term stability)**
- **Only surveillance, monitoring, or minor custodial care are required**

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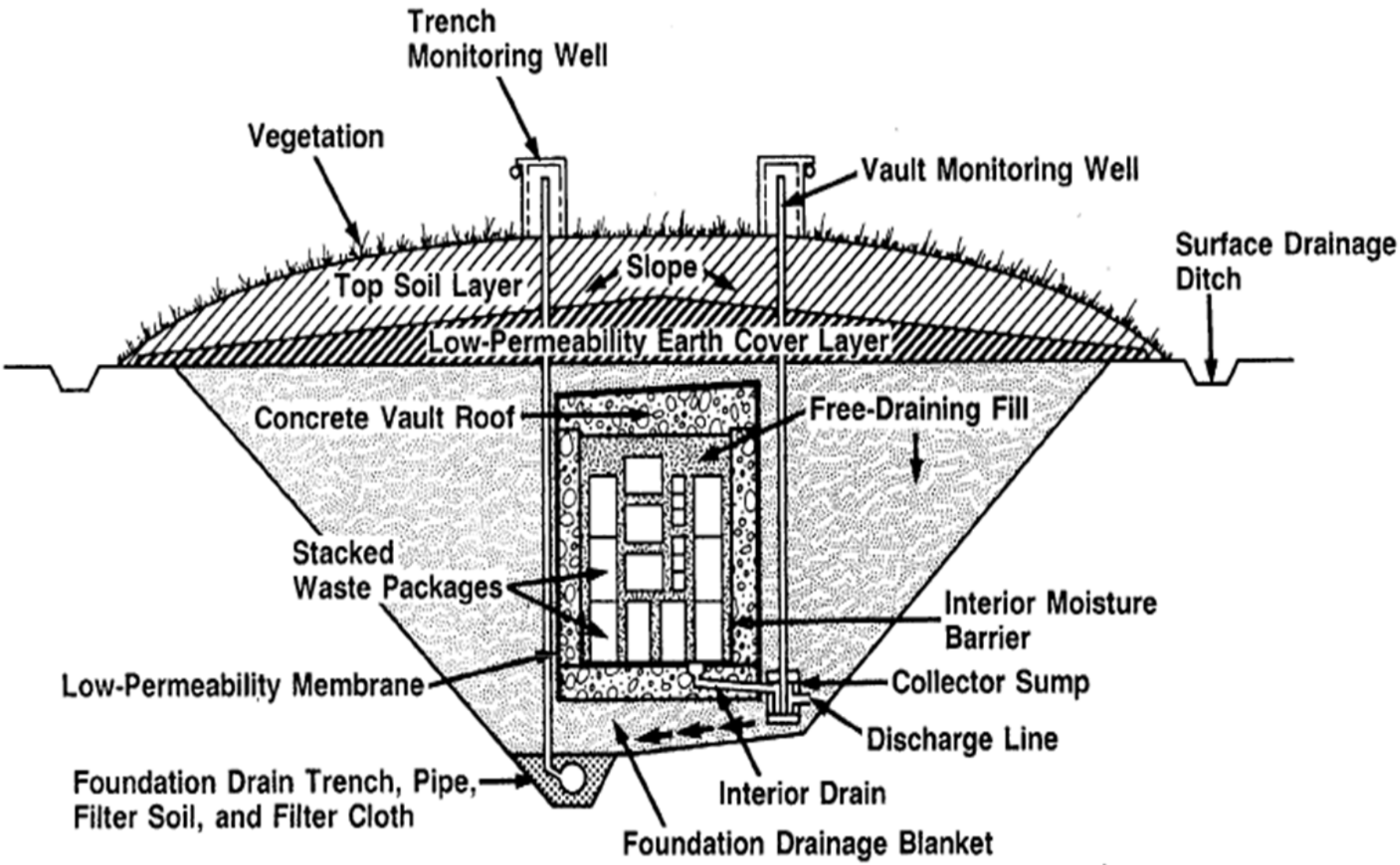
A LLW Disposal Design Concept



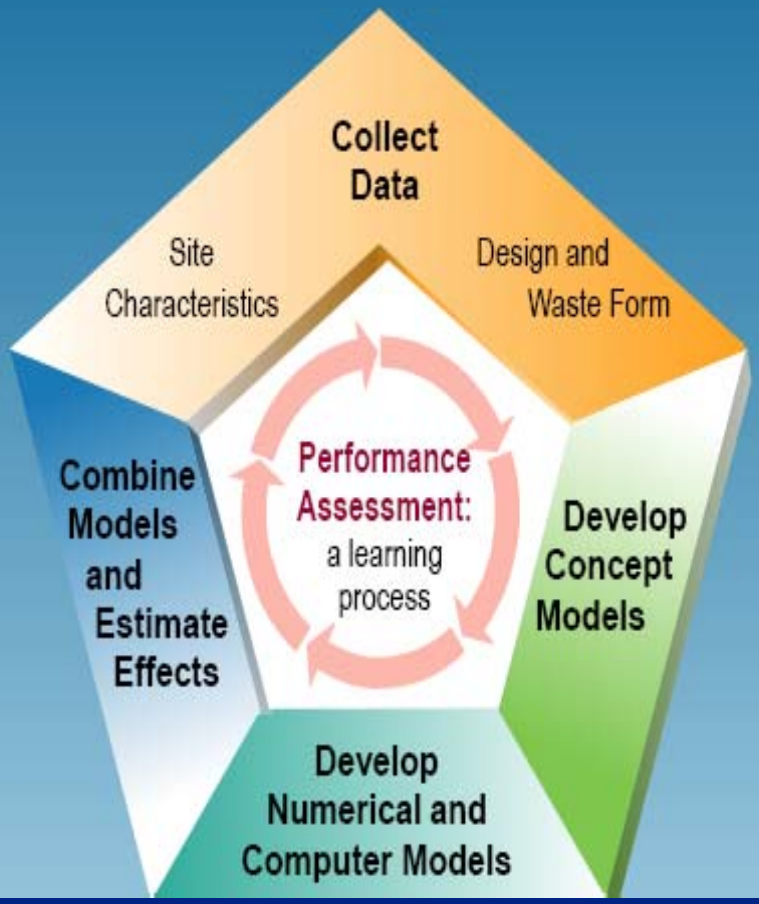
Overview of Performance Assessment

What is Performance Assessment?

- Systematic analysis of what could happen at a site

What is assessed?

- What can happen?
- How likely is it?
- What can result?



Why use it?

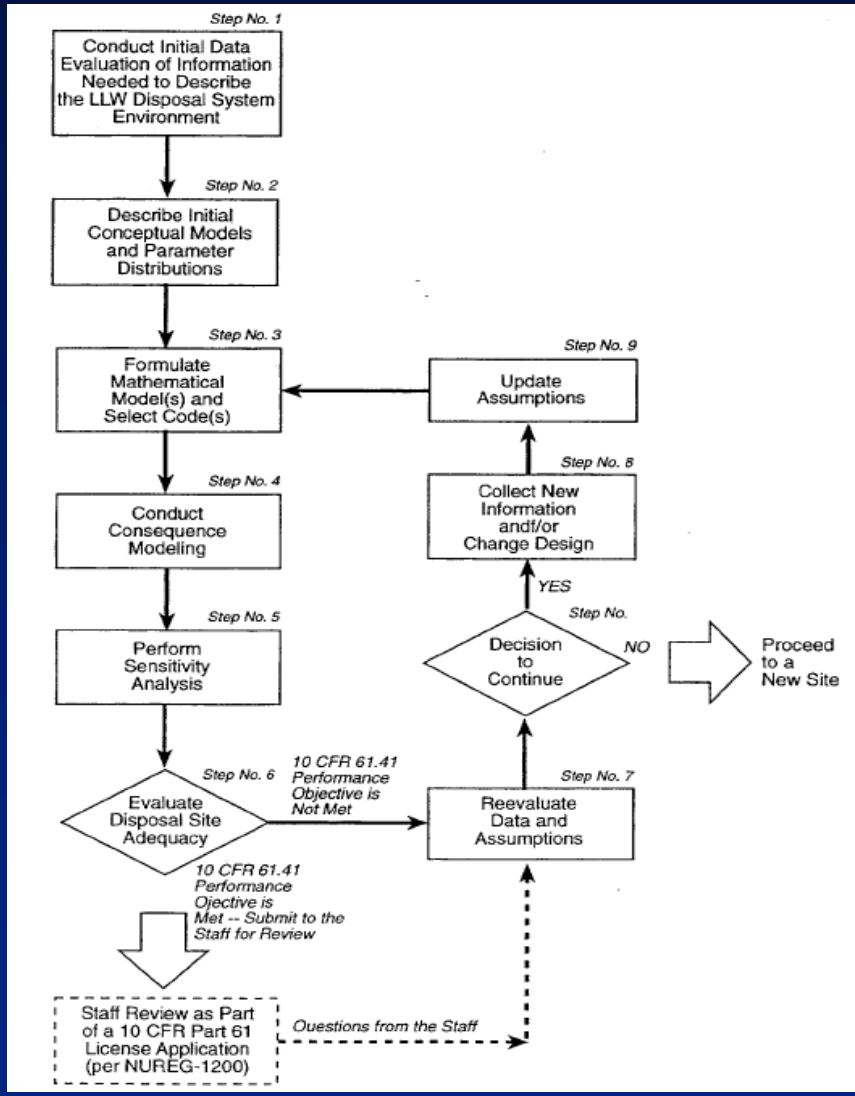
- Complex system
- Systematic way to evaluate data
- Internationally accepted approach

How is it conducted?

- Collect data
- Develop scientific models
- Develop computer code
- Analyze results

Steps in NRC NUREG-1573 PA Methodology Reviews

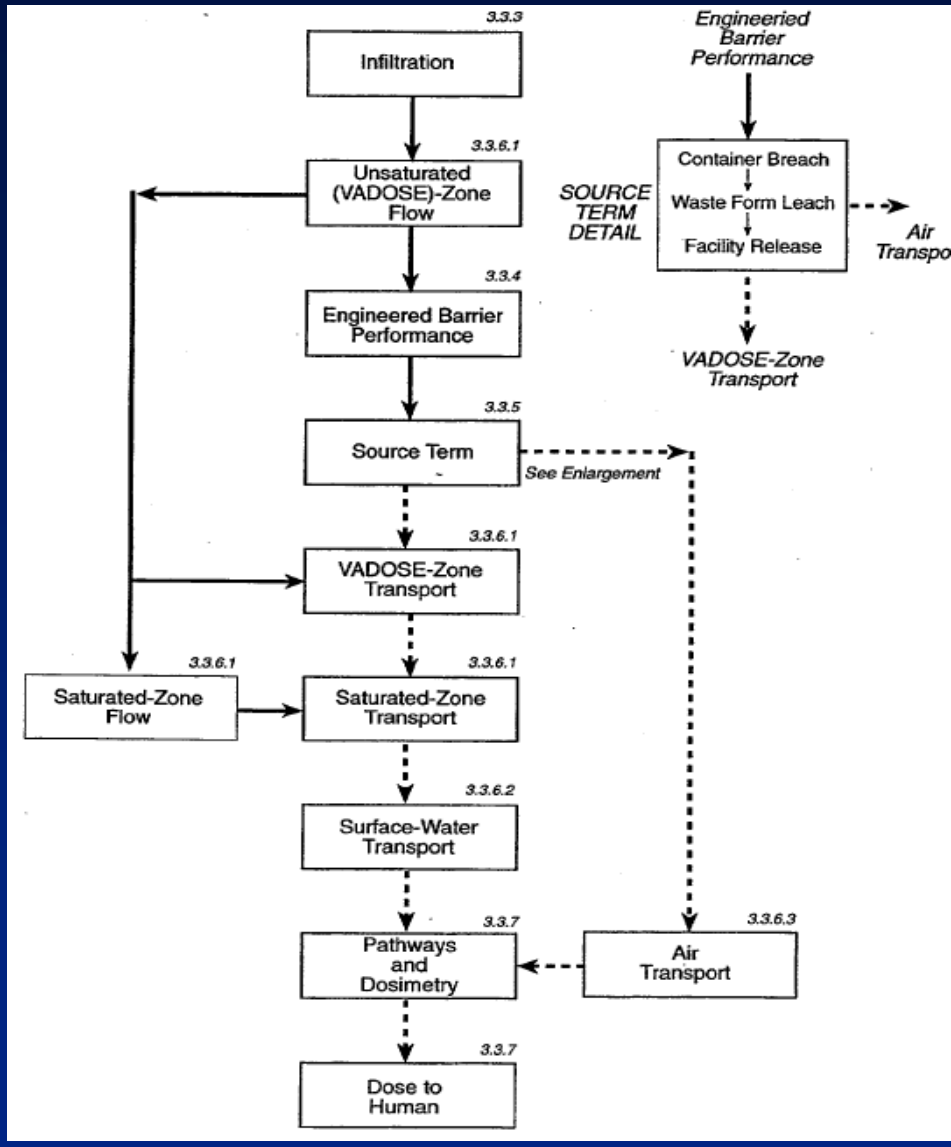
- Data evaluation
- Conceptual models
- Parameter distributions
- Mathematical models & codes
- Consequence modeling & analysis
- Sensitivity & uncertainty analysis
- Initial evaluation of site performance
- R-evaluation of data & assumptions
- Assessment of compliance with 10 CFR 61.41



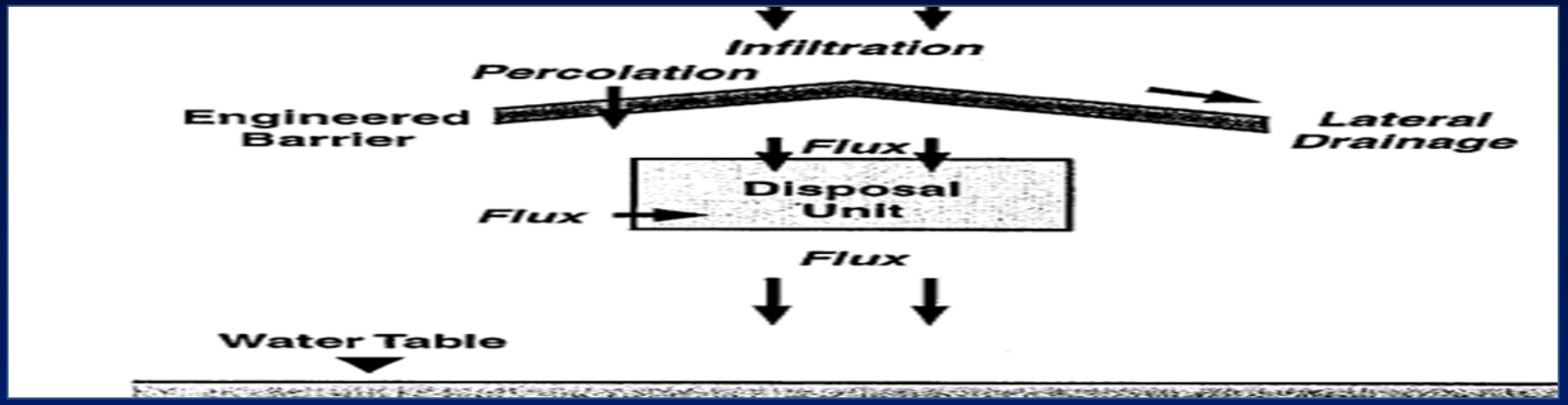
Specific Processes Considered in NRC LLW PA

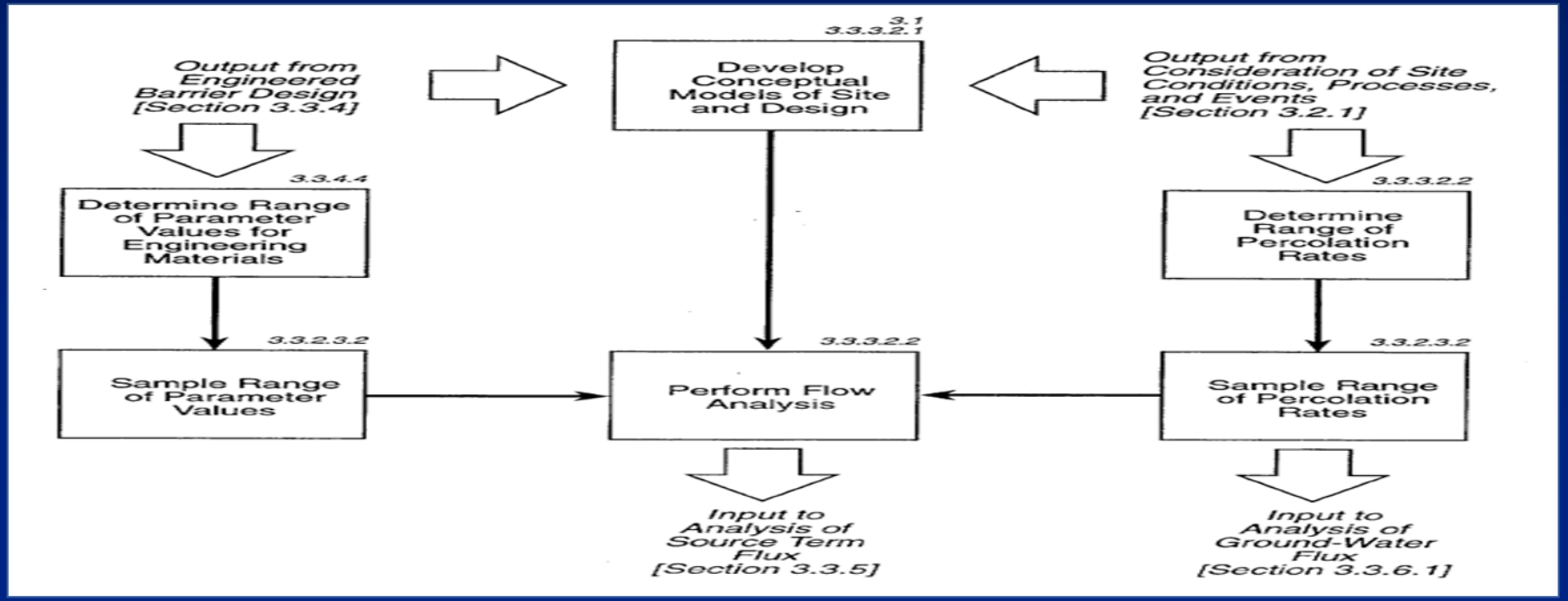
- Infiltration
- UZ Flow
- Eng. Barrier Performance
  - Container Breach
  - Waste Form Leach
  - Source term releases
- VZ Transport
- SZ flow & Transport
- Surface water transport
- Exposure pathways transport
- Dose to human

NUREG-1573

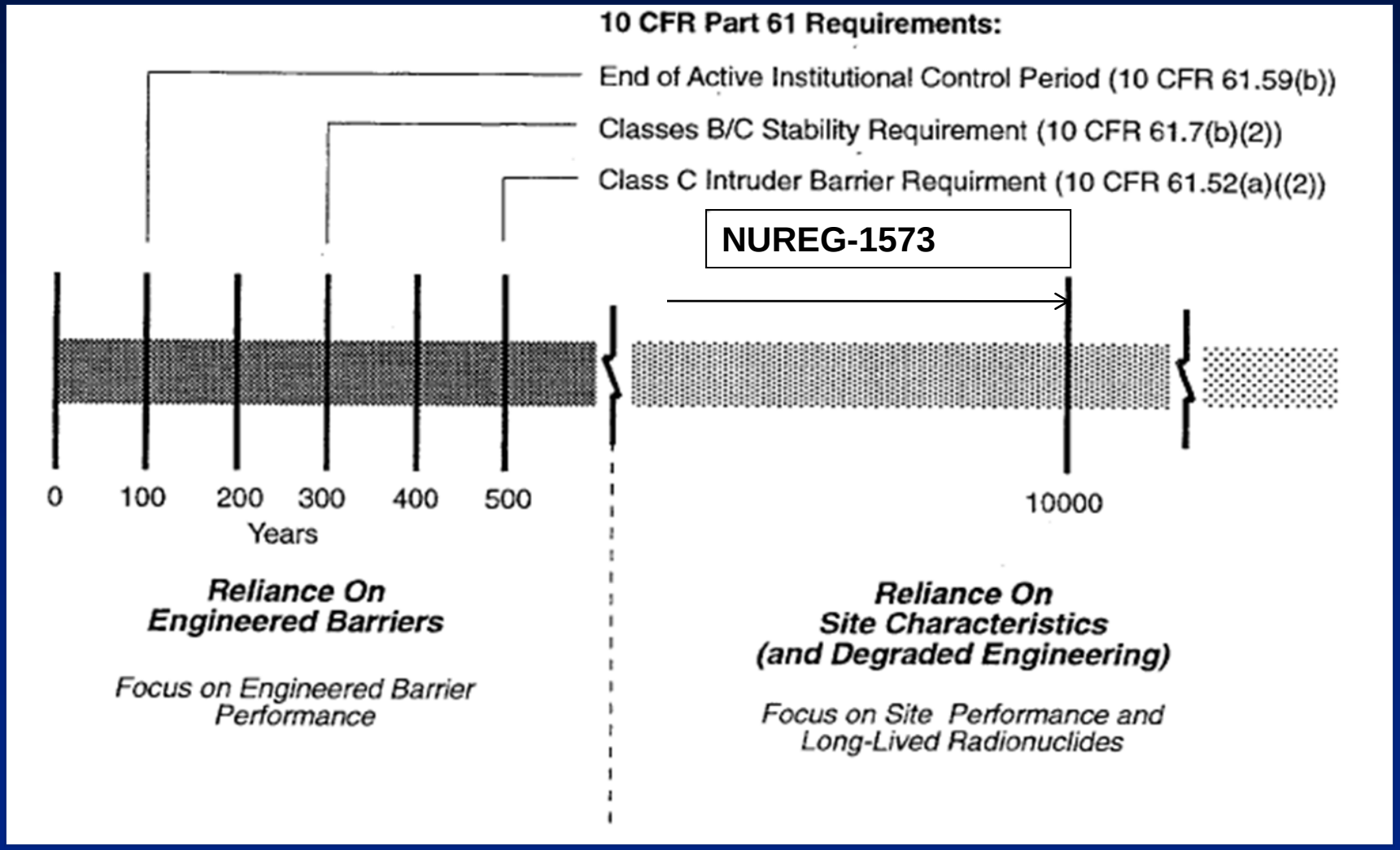


Infiltration Process and Recommended Approach for LLW PA Analysis





LLW Timeframe and Performance Period



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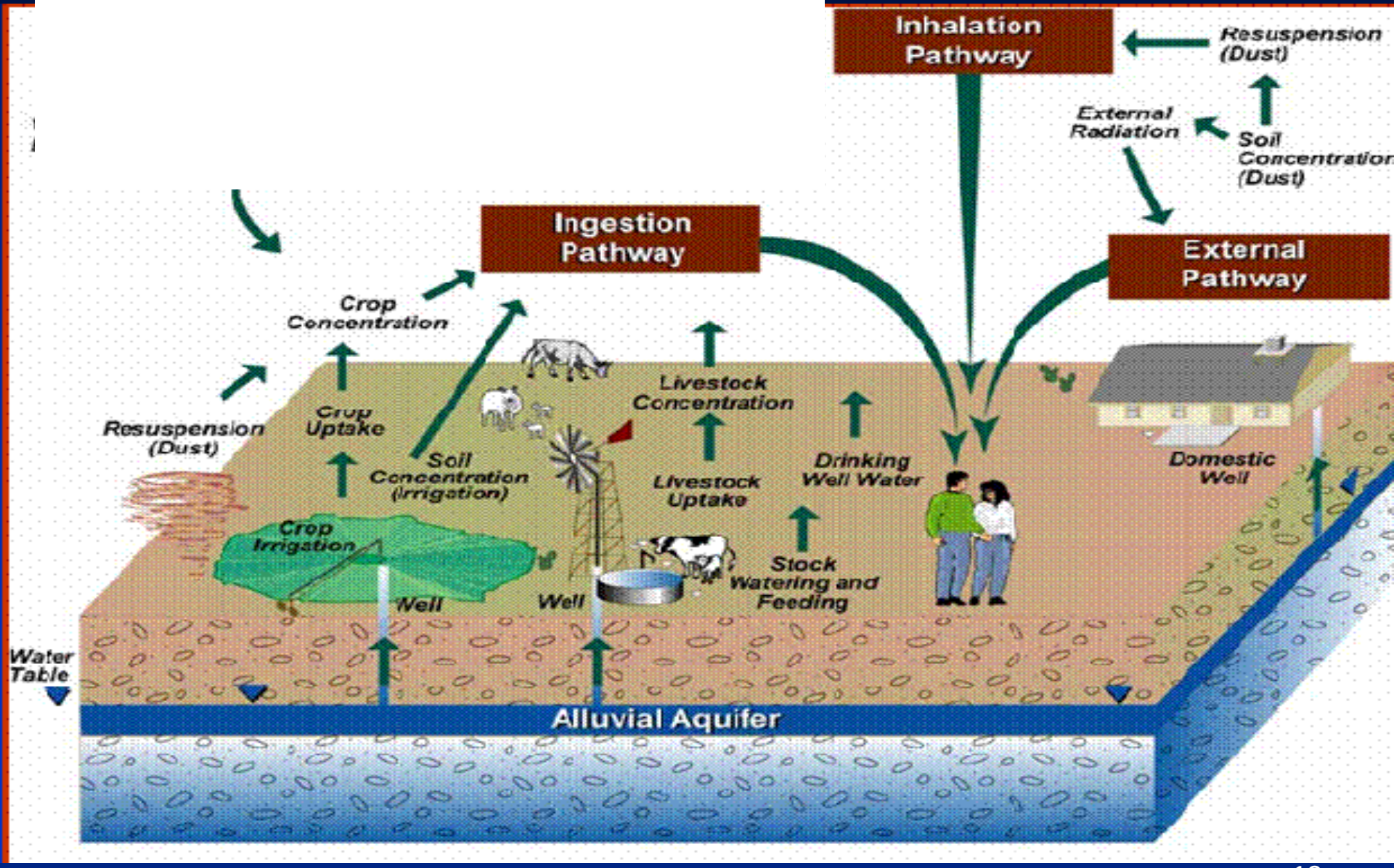
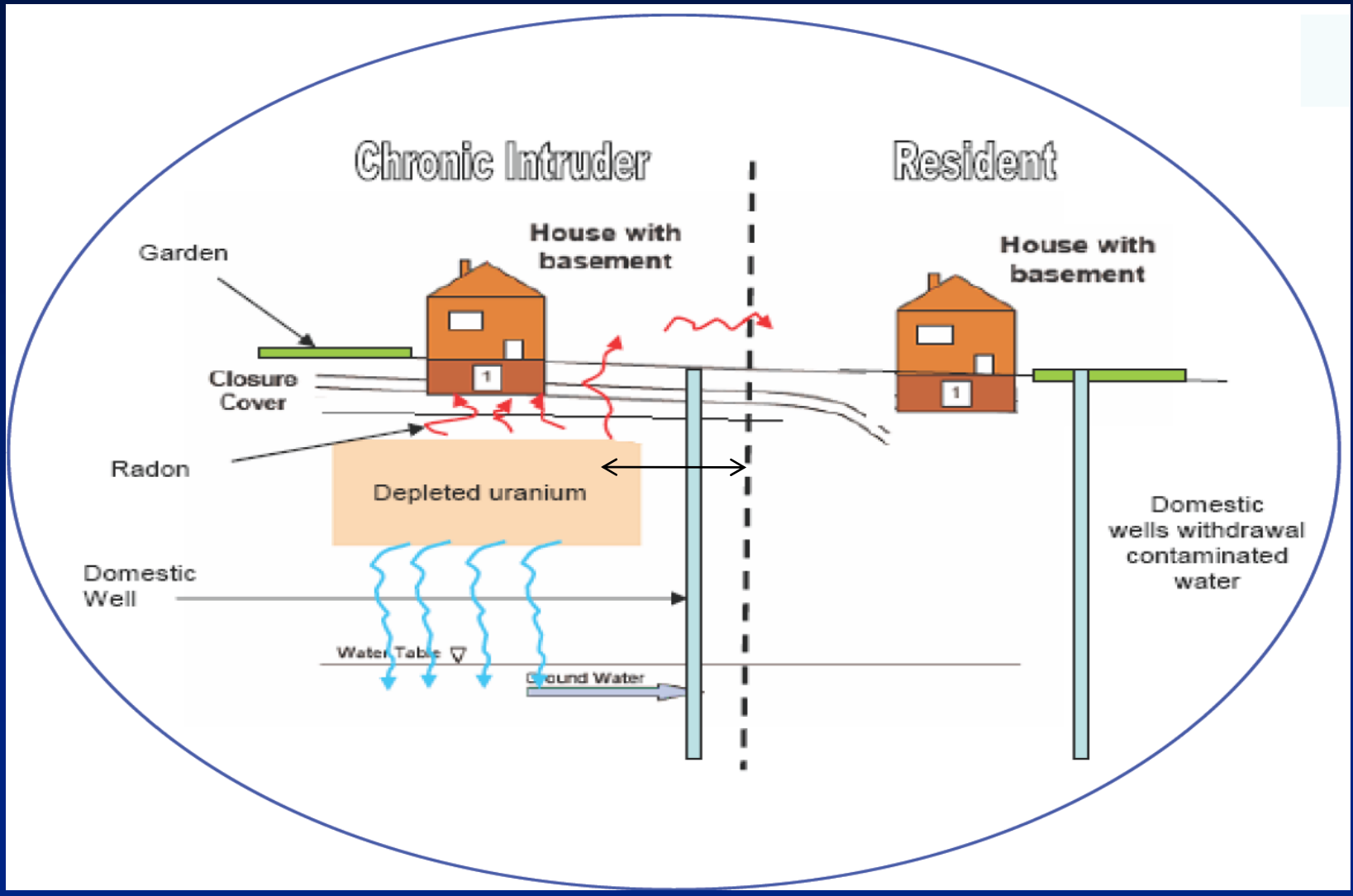
Schematic Illustration of Potential Exposure Pathways

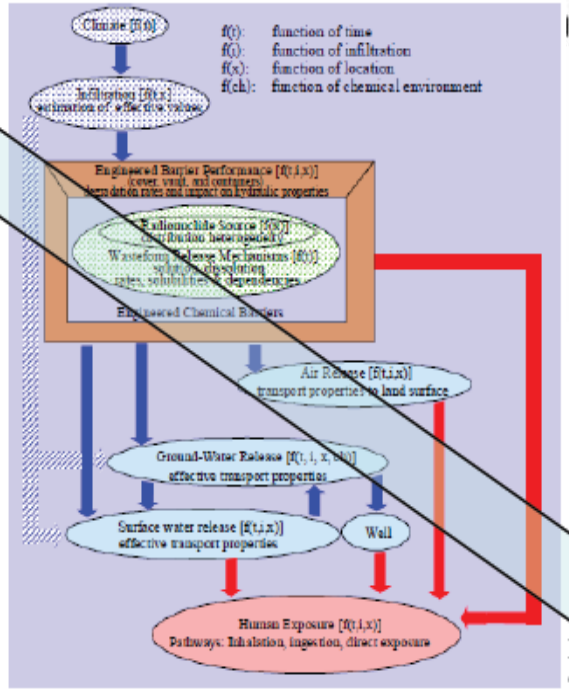


Schematic Illustration of Examples of Exposure Scenarios

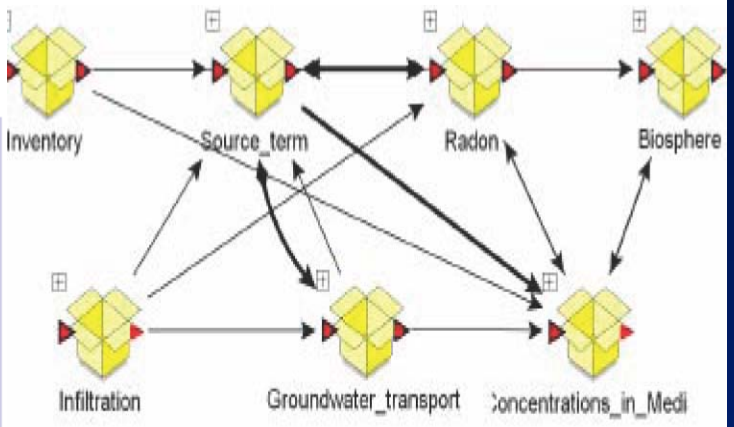


PA Approach: Representation of LLW System, Conceptual & Mathematical Models, and Estimated Performance

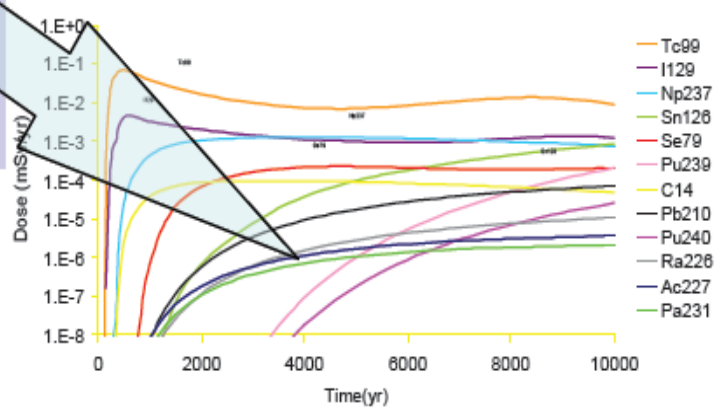
Real system



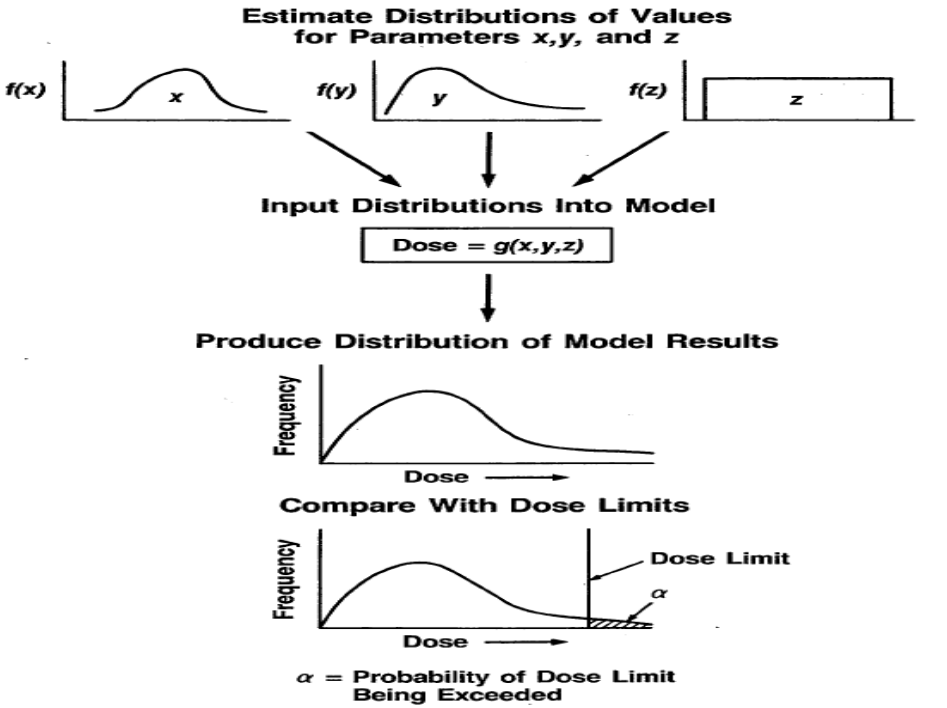
Mathematical model



Estimated future performance



An Approach to Uncertainty Analysis



$$\text{Max}[\text{Mean}(t)] \leq \textit{Regulatory Limit}$$

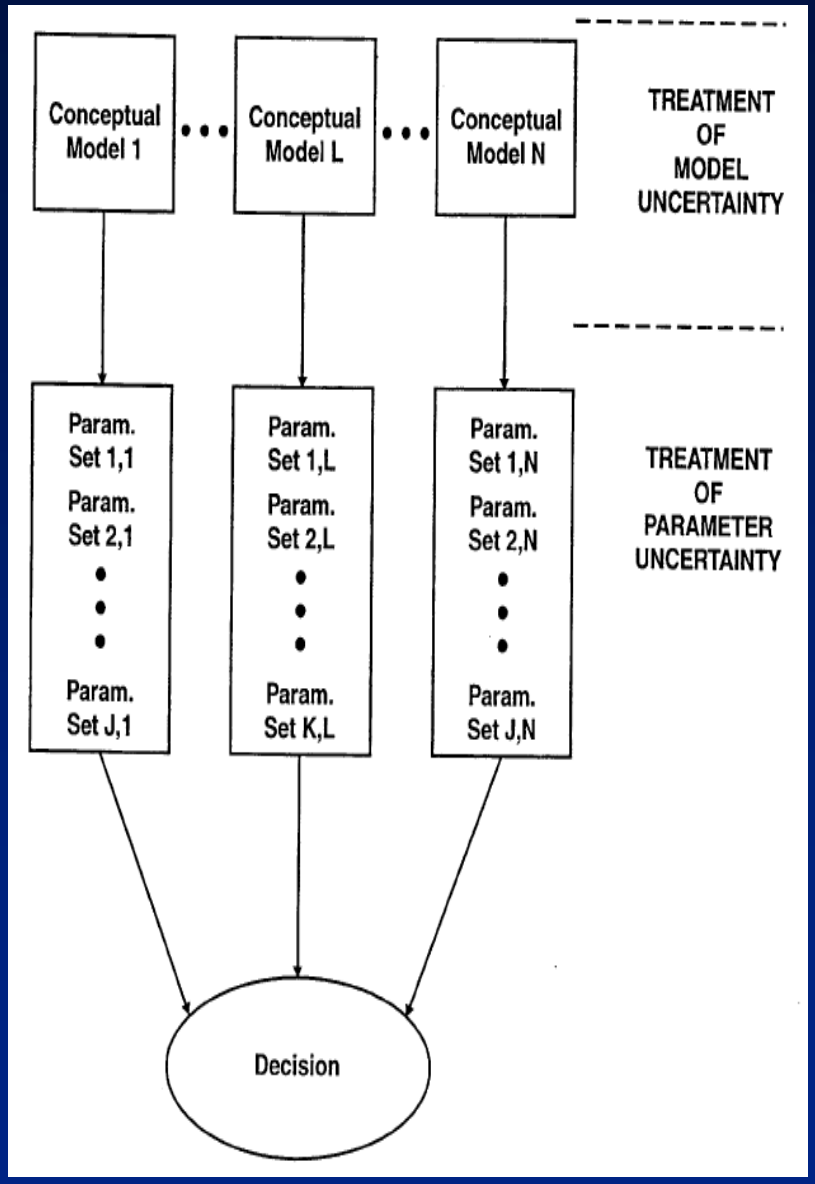
where:

$$\text{Mean}(t) = \frac{\sum_{k=1}^{N} \text{Dose}_k(t)}{N}$$

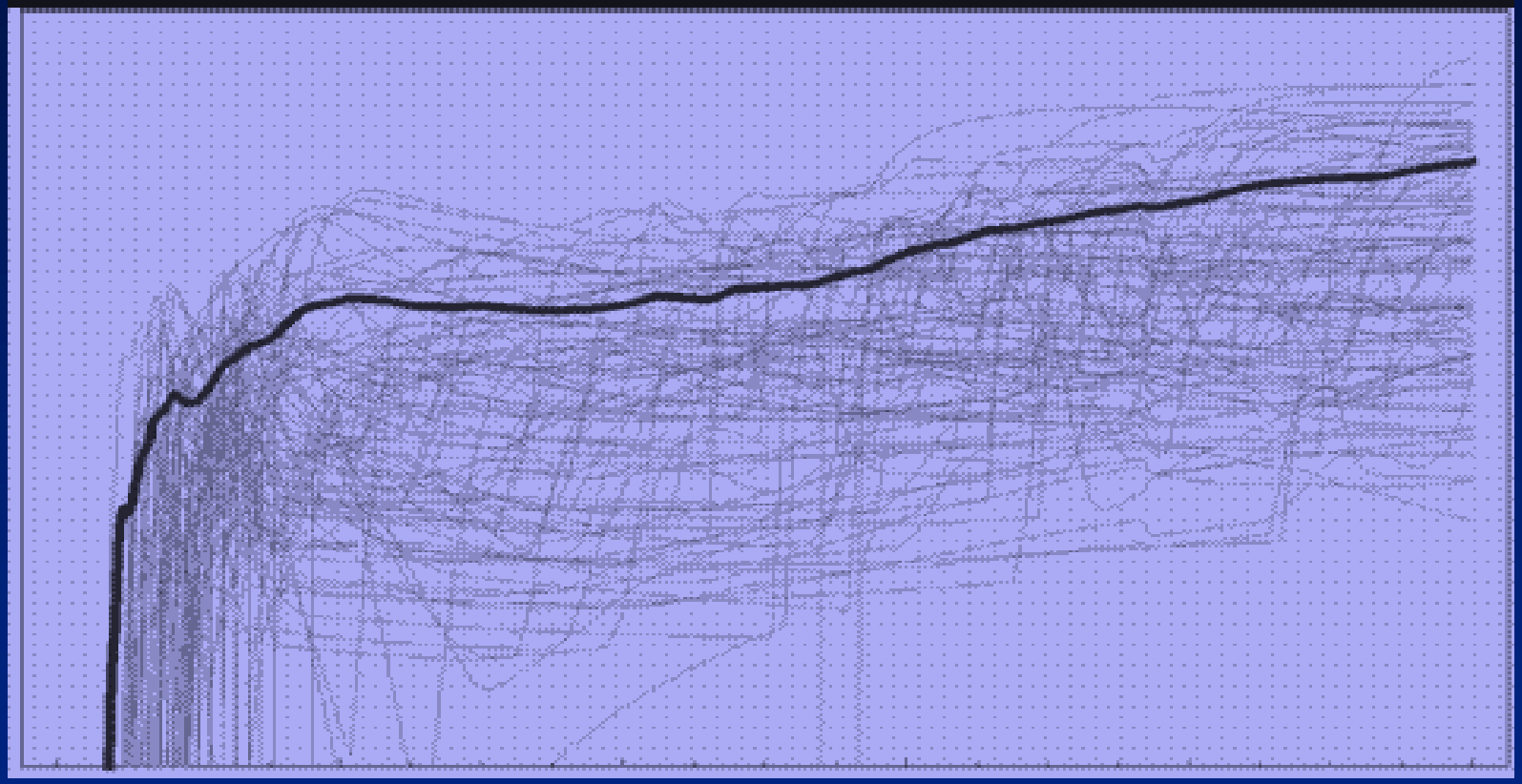
$\text{Dose}_k(t)$ = doses *at time t, for run k*

N = *number of Monte Carlo runs*

t = *time*



Dose - Time PA Outputs



NUREG-1854 - *PA Guidance for Activities Related to U.S. DOE Waste Determinations*

- **Discusses the main areas that should be addressed during a WIR review**
- **Applies to all four WIR sites (SRS, INL, Hanford, West Valley)**
- **Is risk-informed and performance-based**
- **Is based on existing NRC guidance (e.g., NUREG-1573, NUREG-1757) as well as staff experience**

NUREG-1854 Areas of PA Review Guidance

PA Review areas include:

- Scenario Selection and Receptors
- General Technical Review Procedures
- Specific Technical Review Procedures
  - Climate and Infiltration
  - Engineered Barriers
  - Source Term/Near Field Release
  - Radionuclide Transport
  - Biosphere Characteristics and Dose Assessment
- Models and Codes
- Uncertainty/Sensitivity Analyses
- Evaluating Model Results
- ALARA Analysis

NUREG-1854 PA Reviews Generic Approaches

- The guidance emphasizes the need for adequate model to support its stability
- The amount of model support is to be commensurate with the risk significance of the model
- Model support may entail multiple lines of evidence
- The guidance recognizes that traditional validation may not be possible for some PA models
- Technical basis is needed for the performance of intruder protection systems
- Types of scenarios envisioned: residential, agricultural, recreational, hunting & fishing, well-driller, construction, or others
- Site stability PA includes:
  - Natural stability of the site (e.g., effects of floods, erosion)
  - Stability of the waste (e.g., potential for differential settling)
  - Stability of the engineered facility (e.g., vault degradation)

Examples of Key Elements and Parameters in PA Analysis

- **Key PA Elements:**
  - **Period of performance, disposal depth, receptor scenario (pathways and location), correlation of parameters, integration and consistencies of sub-models particularly and transport and dose impact calculations, and bench-marking and QA/QC**
- **Examples of Parameters**
  - **Hydraulic: conductivity, gradient of aquifer, infiltration rate**
  - **Chemical & Geochemical: solubility, liquid saturation, retardation**
  - **Exposure Scenario: sources of exposure, and occupancy time, residence parameters, location of receptor, and intake parameters**

PA Regulatory Issues

- How to treat future site conditions, processes, events, and climate change
- Exposure scenarios & compliance dose criteria
- Performance of engineered barriers
- Timeframe for LLW performance assessment
- Treatment of sensitivity and uncertainty
- Role of performance assessment during operational and post-closure periods
- Overall integration of site characterization, facility design performance assessment, and safety analysis
- Bench-marking and QA/QC issues
- Stakeholders Inputs

Summary, Conclusion, and Path Forward

- Basic approaches and methodologies of generic NRC LLW PA, addressing 10 CFR Part 61 performance objectives, are well established in NUREG-1573
- PA analysis for LLW evaluation of specific sites, or specific waste streams, can be developed as necessary based on a case-by-case basis
- PA regulatory issues are typically addressed through coordination of PA analysts and decision-makers, as directed by the Commission and in consideration of stakeholders inputs
- PA analysis and management decisions will continue to be based on "Risk-Informed Performance Based Approach and Realistic Conservatism"
- NRC staff welcome international PA collaboration and exchange of information

Backup Slide

NRC's Recommended Approach to Dose Impact Analysis Calculations