Remote Handled LLW Performance Assessment at the Idaho National Laboratory: Overview and Update

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DOE Community of Practice Workshop
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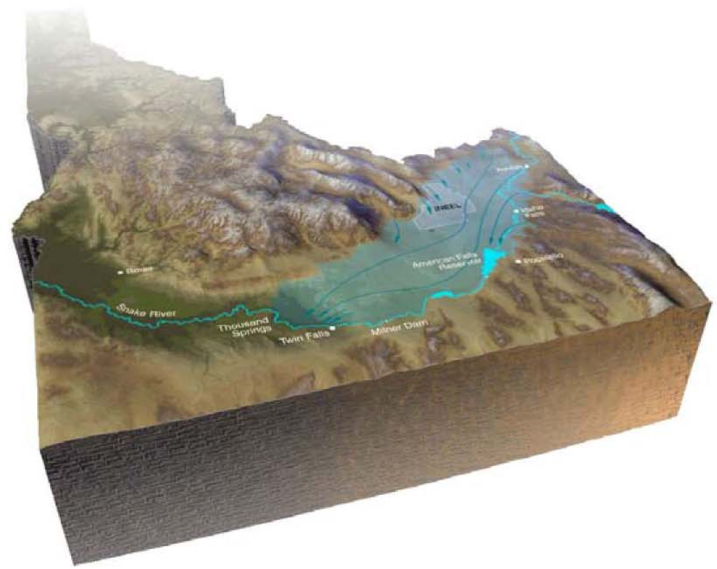

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Outline

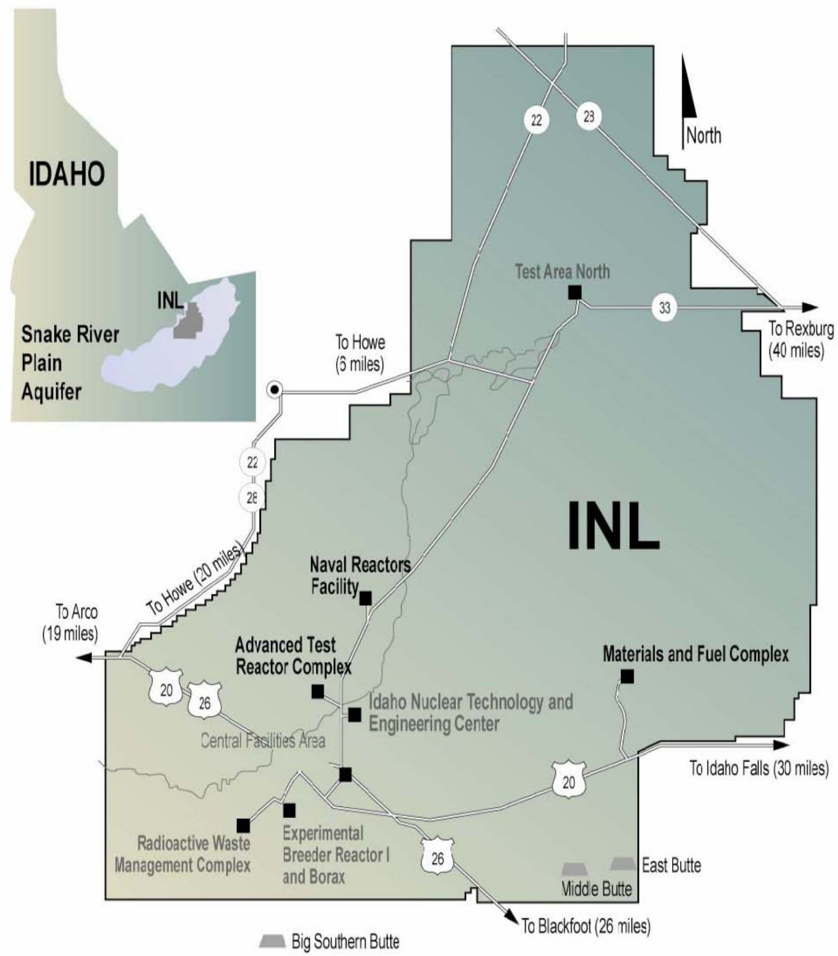
- Introduction and Background
- Facility Design
- Source Term
- Performance Assessment
  - Conceptual Model
  - Screening
  - Source Term Model
  - Dose Assessment Model
  - Uncertainty Assessment
- Additional Studies
  - Liner Analysis
  - NEPA Environmental Assessment

NOTE

- Work on the performance assessment is ongoing and all results are preliminary. Some modifications are expected before the performance assessment is submitted

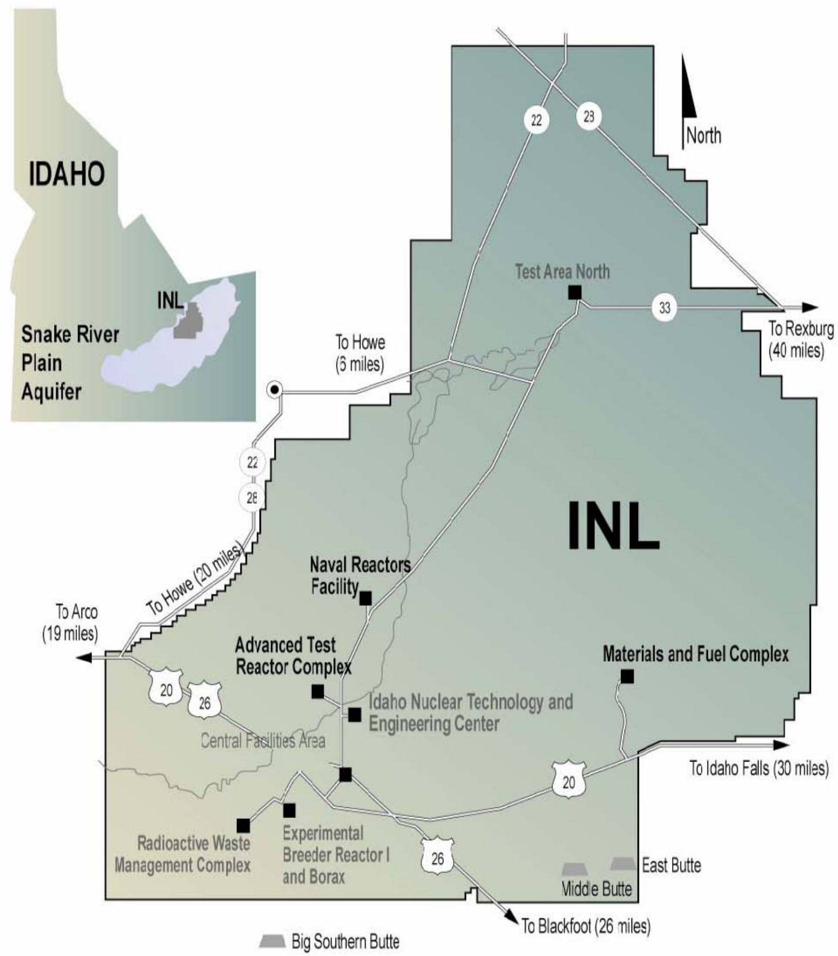
Introduction and Background

- Current disposal of Remote Handled Low-Level Waste (RWLLW) is performed onsite in concrete vaults at the Radioactive Waste Management Complex (RWMC)
- Operations at the RWMC are to terminate in 2017, and therefore, a new disposal facility is needed



Introduction and Background

- Site selection process considered 34 potential sites across the INL
- The two highest ranked sites were consider in the NEPA Environmental Assessment
- Site ranking process included evaluation of
  - Geology
  - Hydrology
  - Land use
  - Natural resources



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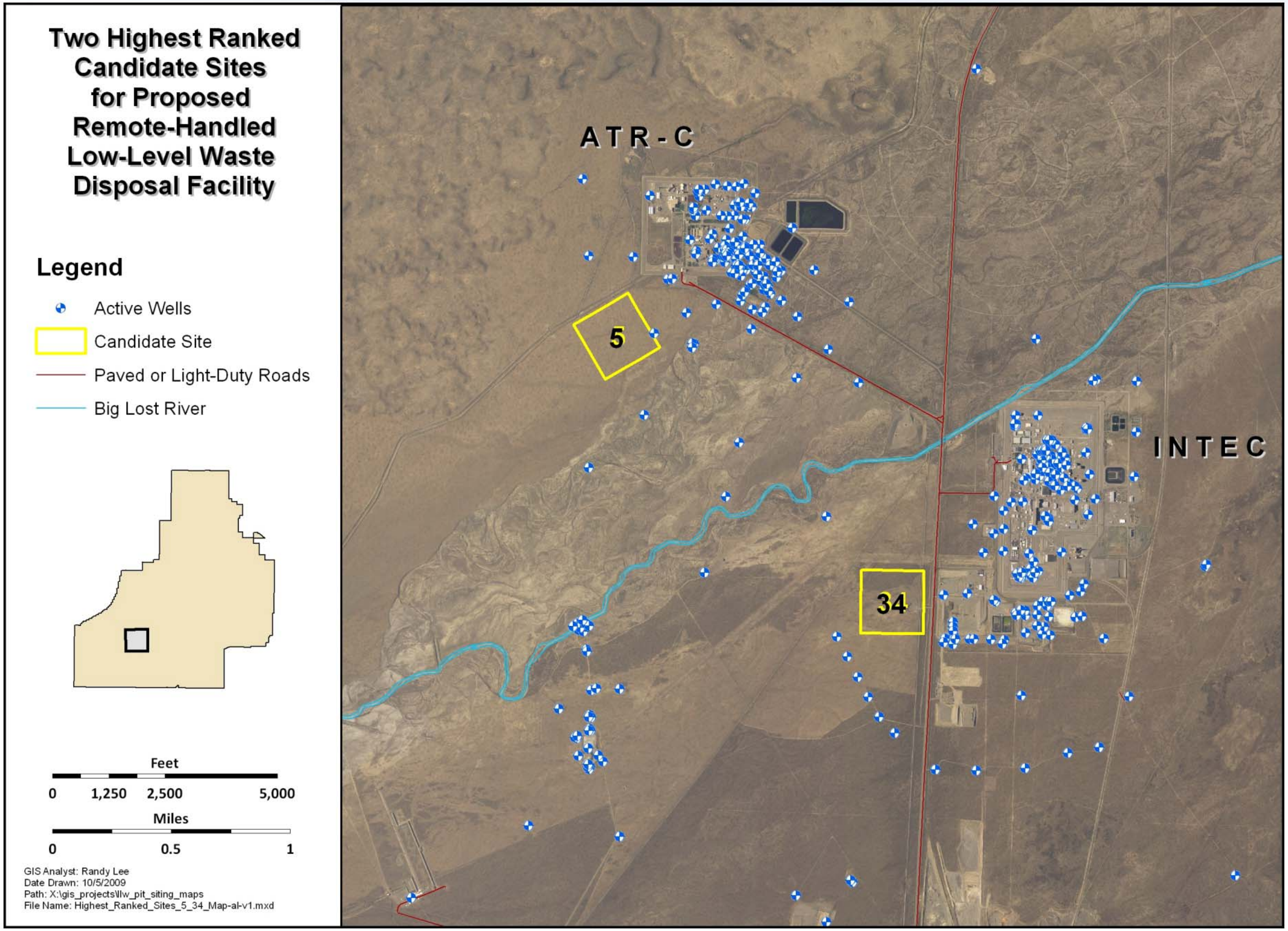
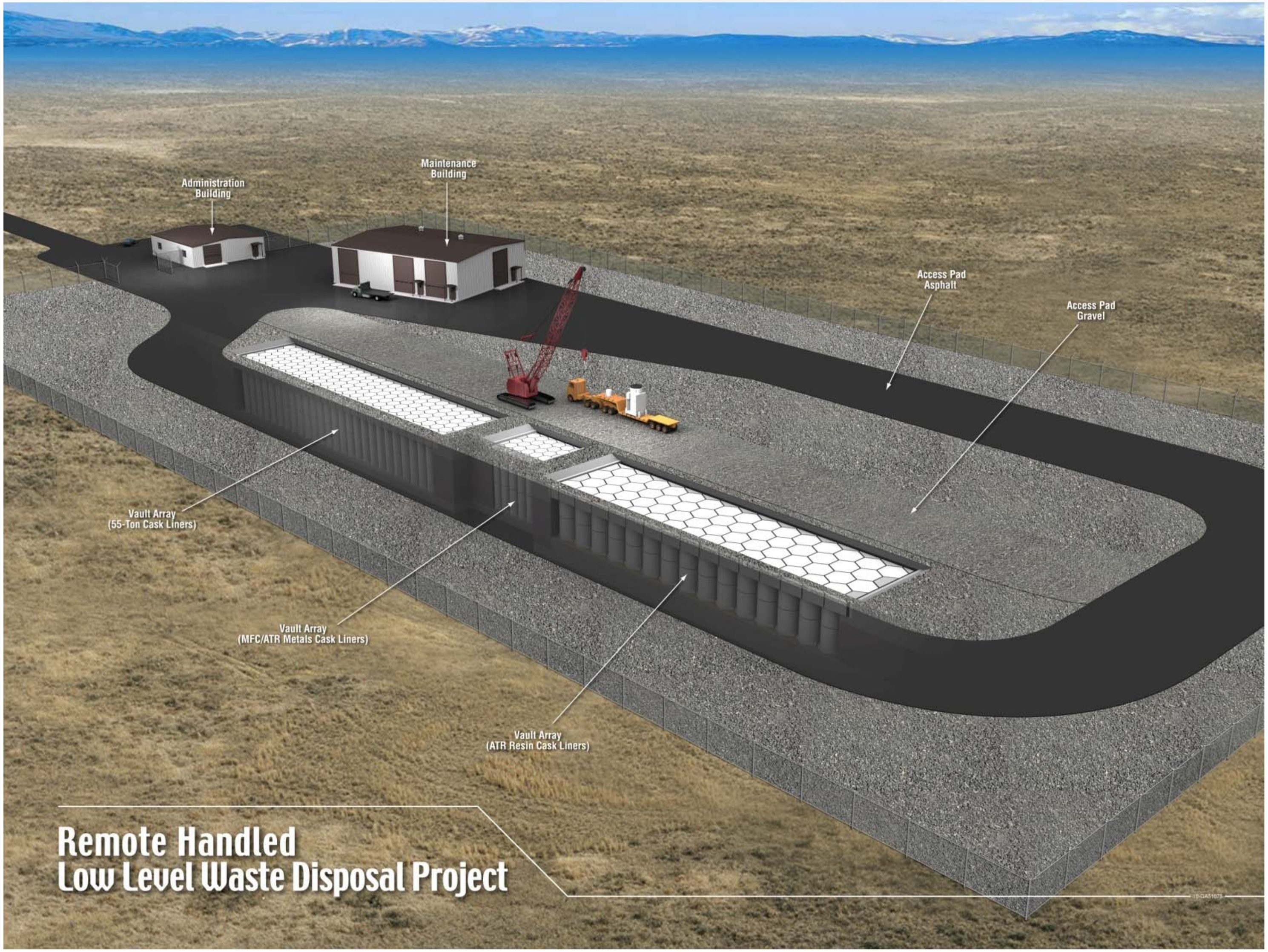
Two Locations Considered

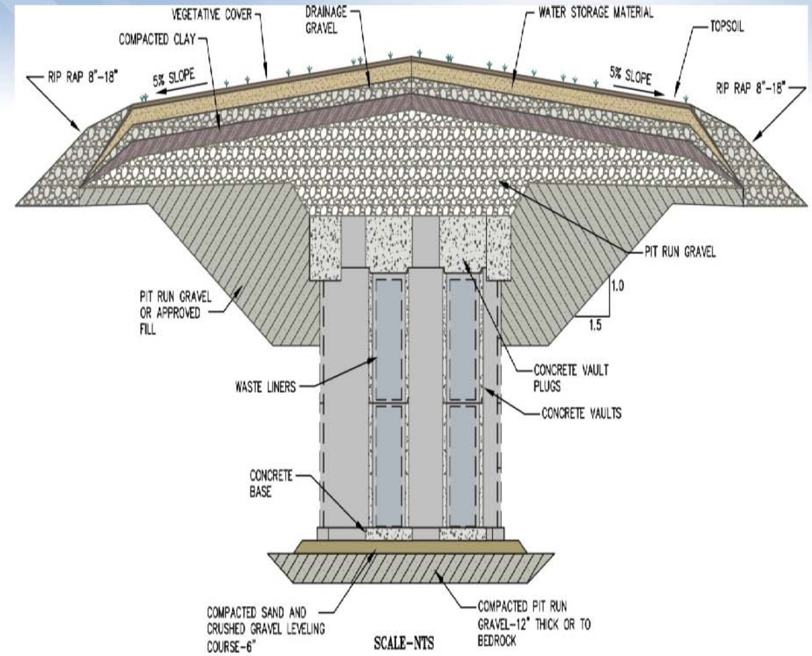


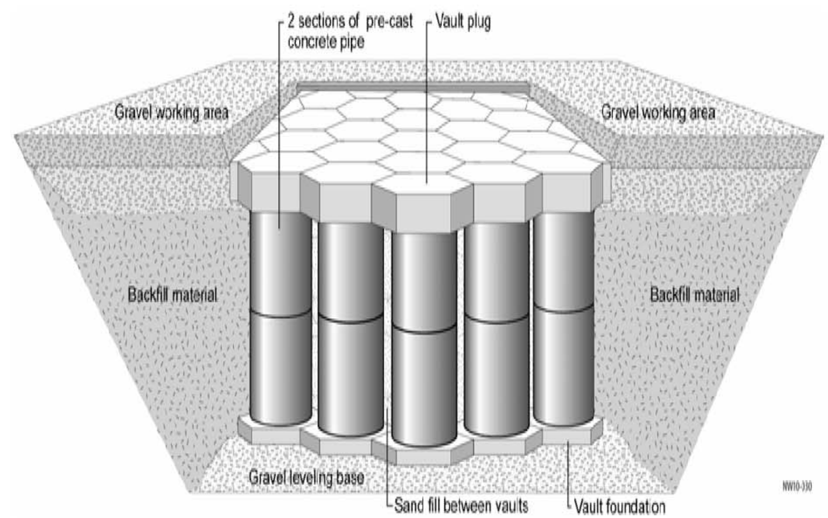
Facility Design



Facility Design

- Cover designed to limit infiltration to 1/10th the background infiltration rate of 1 cm/yr
- Width of cover is to be large enough to create infiltration shadow in the facility and underlying alluvium
- Cover assumed to last 500 years





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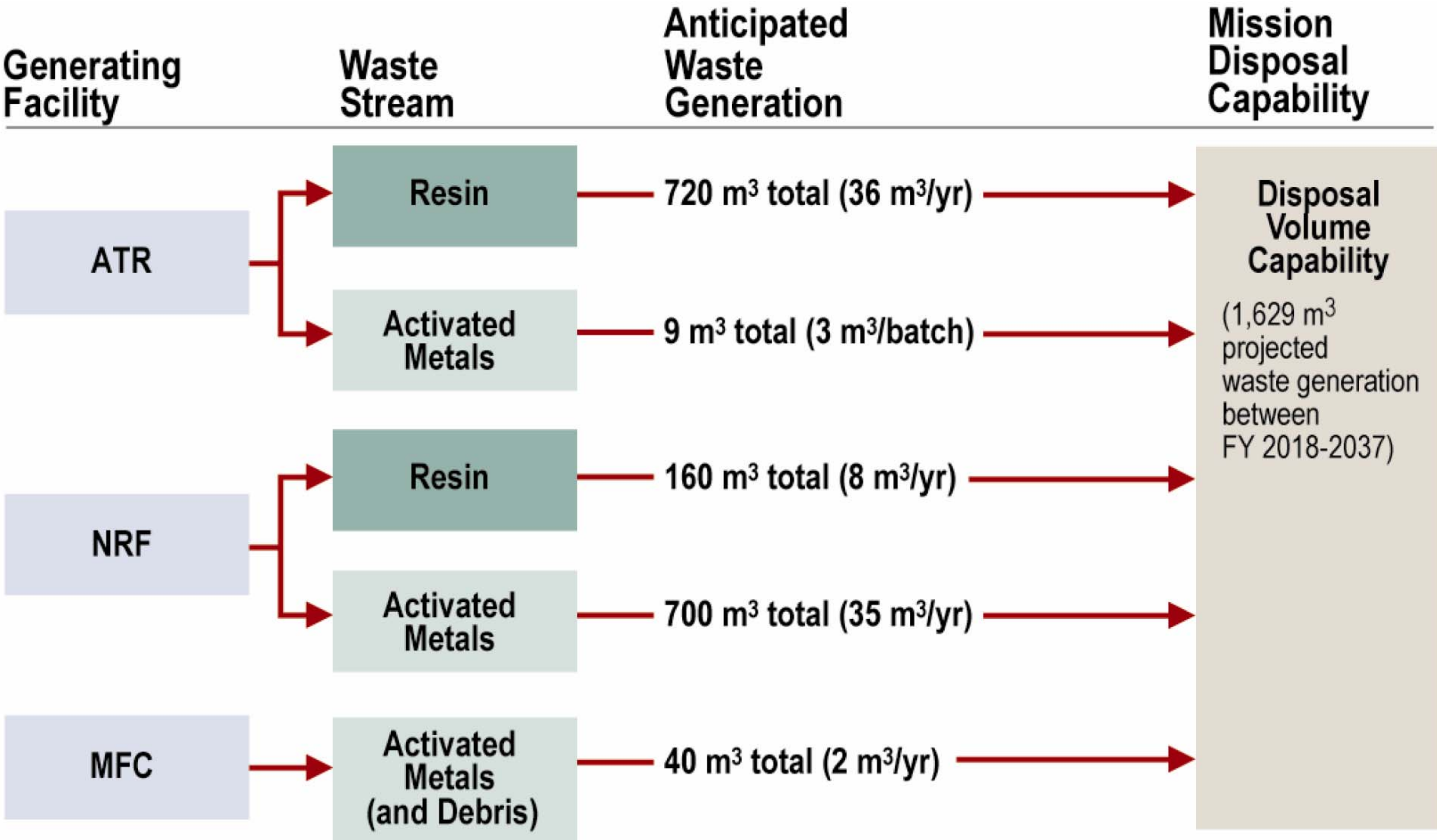
Source Term



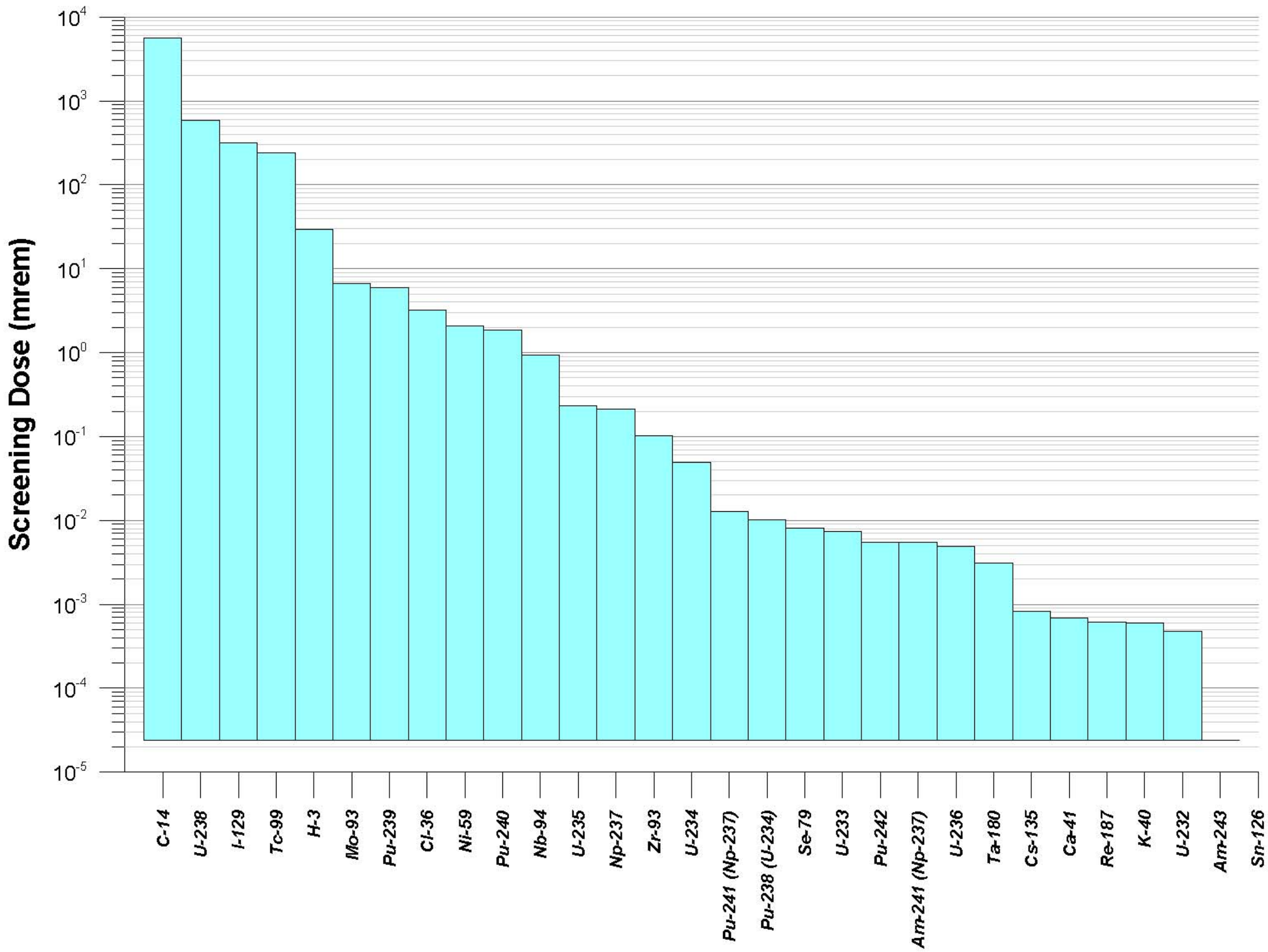
20-year inventory estimates. PA done for 50-year inventory

Performance Assessment

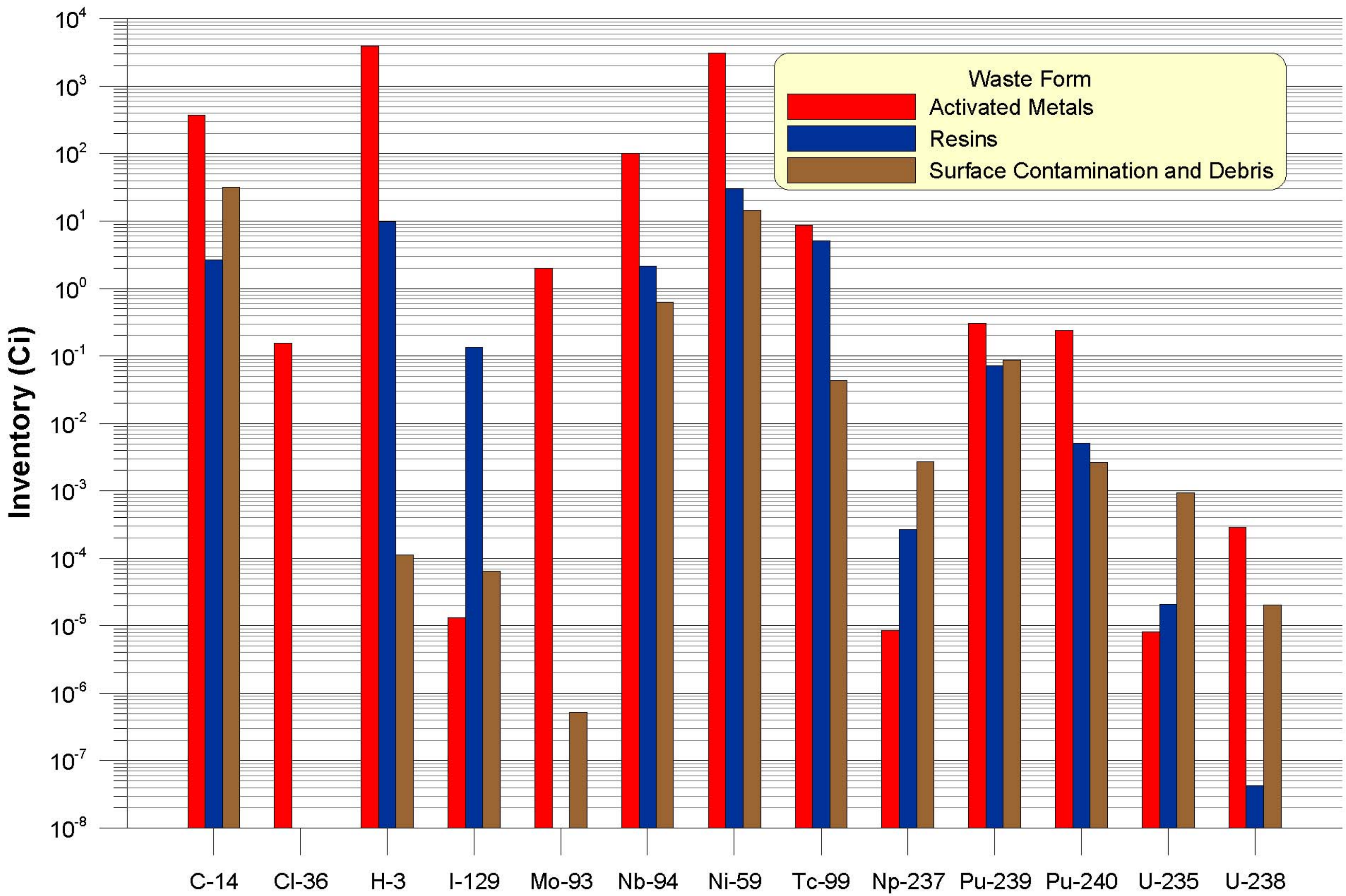
- Radionuclide screening for groundwater pathway
- Conceptual model
- Mathematical model
- All-pathways dose model
- Deterministic results
- Uncertainty/sensitivity analysis (probabilistic approach)
- Intruder dose assessment
- Atmospheric dose assessment

Three-Phase Inventory Screening for Groundwater Pathway

- Phase 1 – Half-life < 1 year
- Phase 2 – NCRP screening factors (0.4 mrem/yr screening criteria)
- Phase 3 – GWSCREEN with conservative assumptions and 0.1 mrem/yr criteria



Radionuclide Inventories by Waste Form



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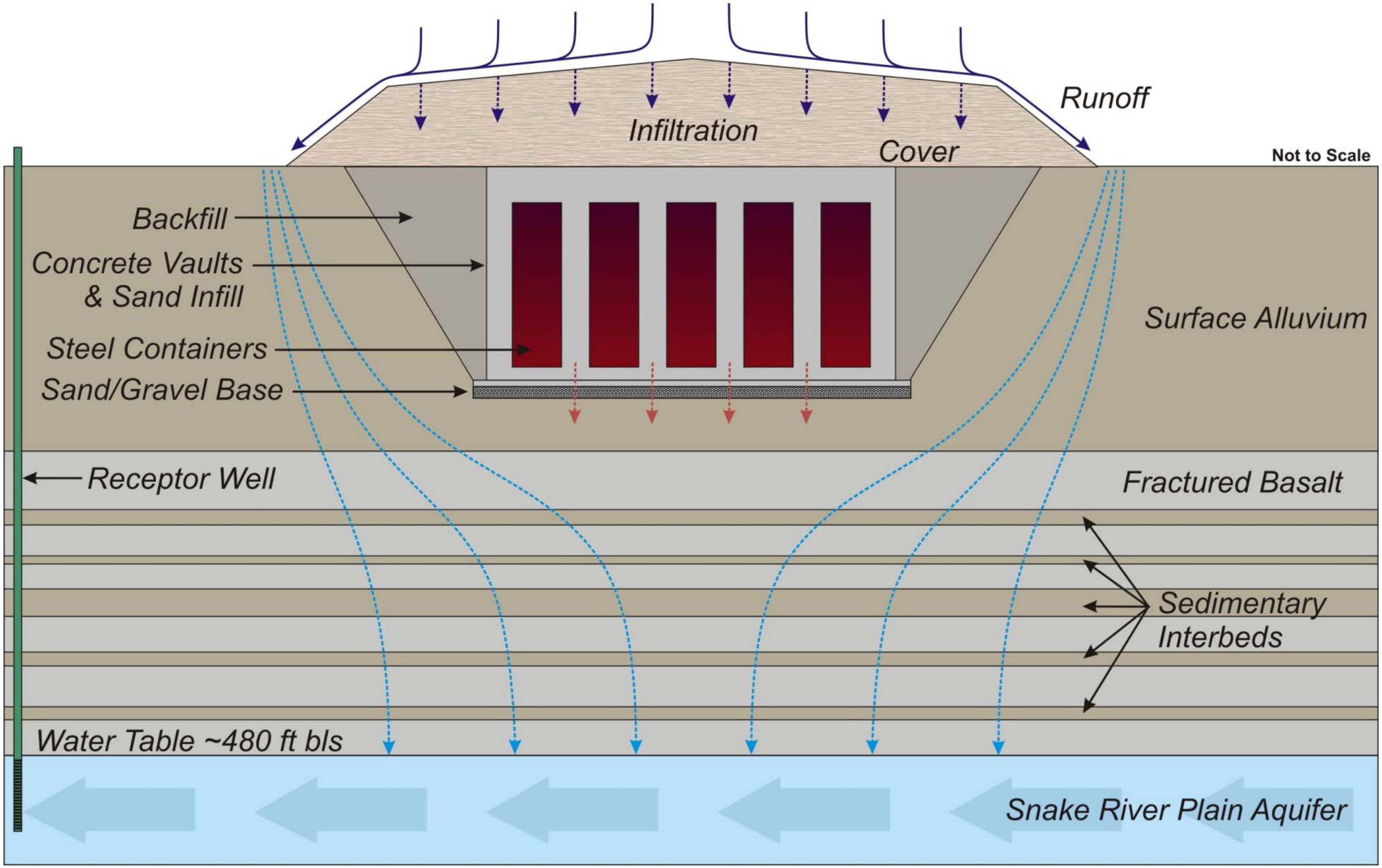
Waste Form Release Mechanisms

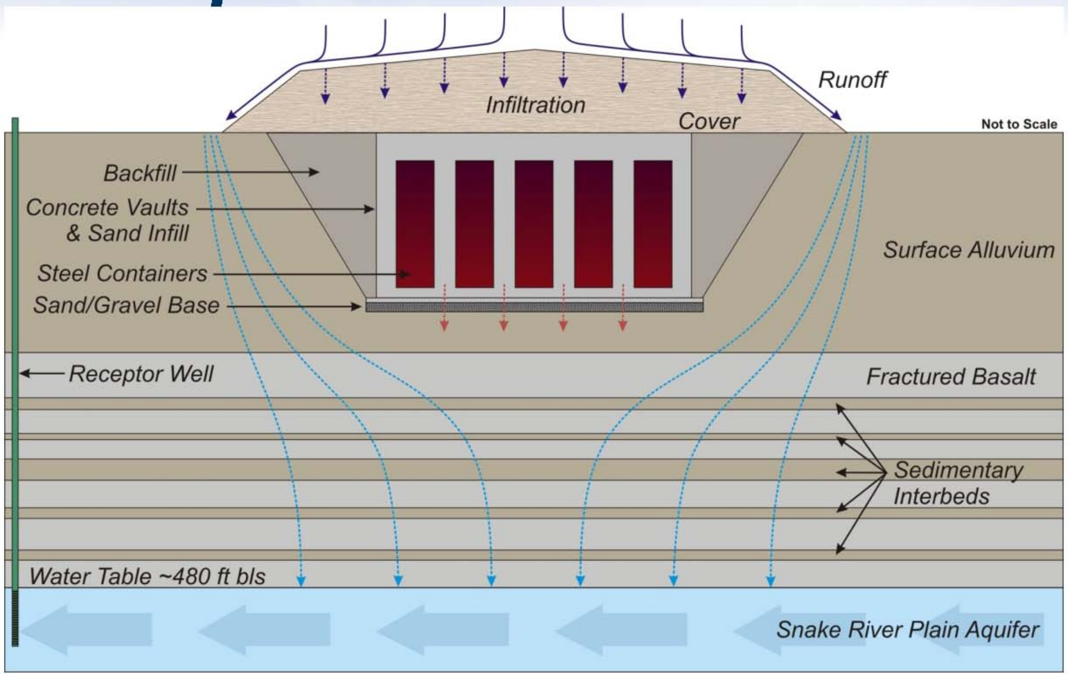
- Activated metals
  - Corrosion release to container, surface wash after container failure
- Resins
  - Surface wash after container failure
- Surface contamination and debris
  - Surface wash after container failure

Conceptual Model



Conceptual Model Assumptions

- One-dimensional flow through vault system and underlying alluvium and controlled by infiltration through engineered cap
- Cement-altered geochemistry in vault water and underlying alluvium
- No water flow through intact containers



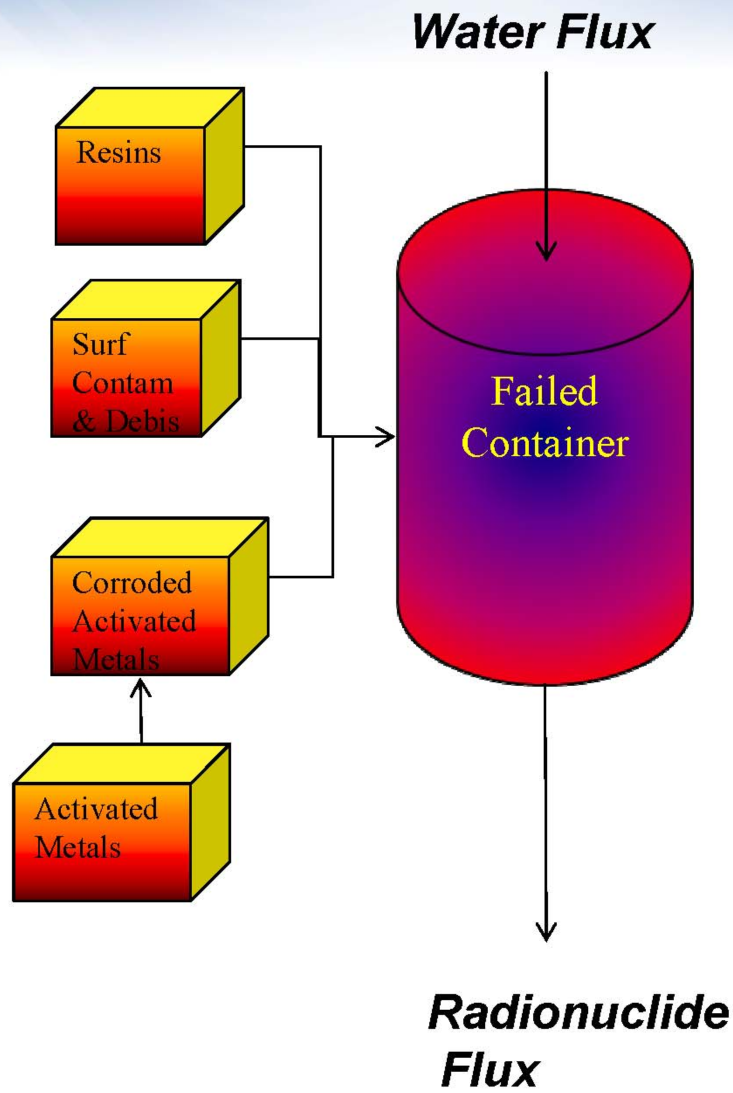
- Failure of waste container occurs by corrosion. Once failed, water may flow free through container leaching radionuclides
- Due to the high aspect ratio of facility, infiltration shadow does not extend below alluvium
- One-dimensional water flux in vadose zone based on background infiltration rates and enhanced infiltration during operations
- No geochemistry effects of cement in vadose zone

Implementation of Conceptual Model

- Separate models for source, alluvium, vadose zone, and aquifer
- Models are coupled through radionuclide and water fluxes across boundaries
- Different container types by waste generator
- Compartmental model for source term
- Time varying water fluxes based on assumed cover infiltration of 1 mm/yr and 500-year lifetime

Source Release Model

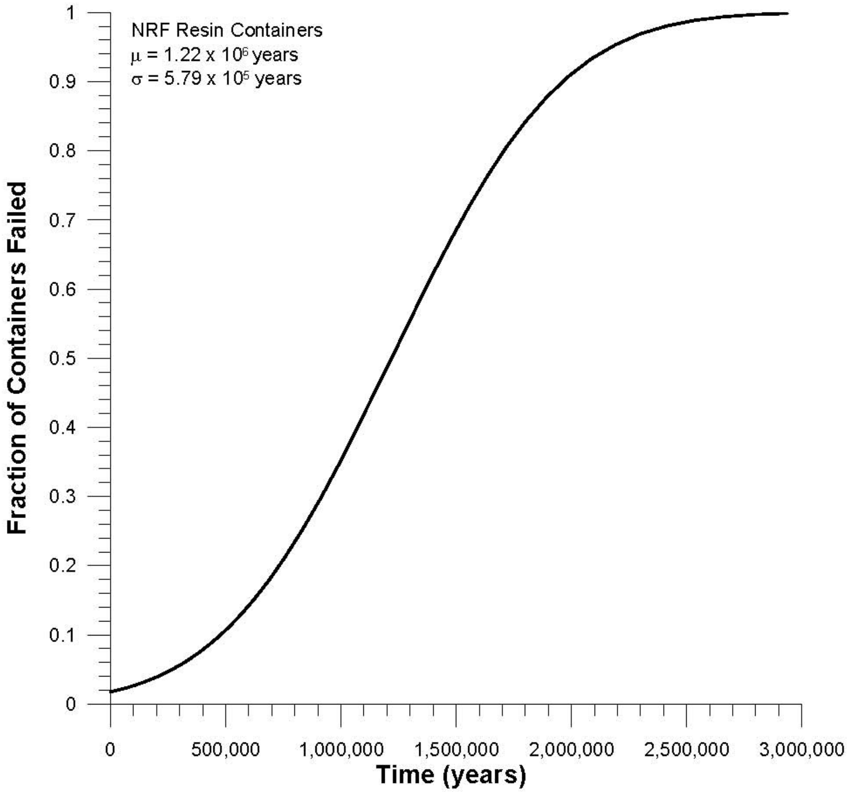
- Radionuclide inventories decay and ingrow in containers until failure
- Activated metals decay and ingrow in activated metal form and corroded form in container
- Upon failure, radionuclides in resin, surface contamination, and corroded metal release via surface wash

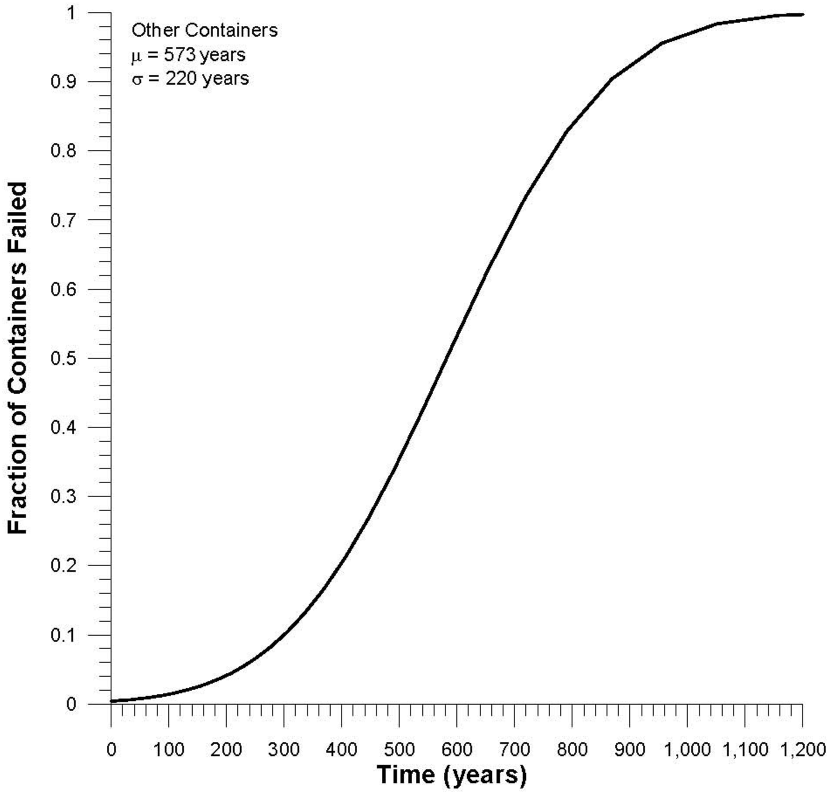


Mathematical Models

- Release from waste containers calculated with custom FORTRAN codes
- Flow and transport from the waste zone, alluvium, and remainder of the vadose zone calculated with the one-dimensional Mixing Cell Model (MCM)
- Transport in the aquifer calculated with GWSCREEN
- One-dimensional models were justified based on 3-dimensional modeling at INTEC and more recently the TOUGHREACT simulations for a study of liner alternatives

Container Failure Distributions





Sorption Coefficients

- No sorption assumed in waste containers
- Cement-altered Kd values in underlying alluvium
- Unaltered Kd values in interbeds
- No sorption in fractured basalt

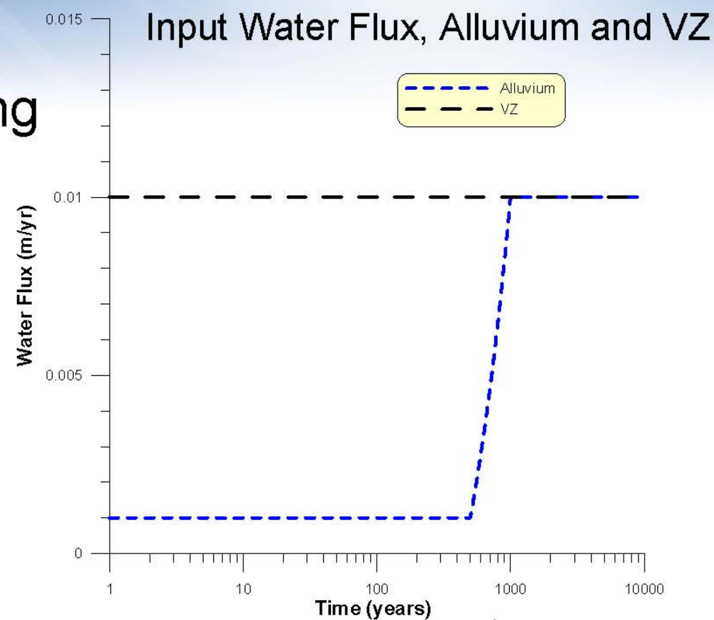
Element	Alluvium-Interbed Kd (mL/g)	Cement Adjustment Factor	Cement-Altered Kd (mL/g)
Ac	300	1.2	360
C	0.5	4	2
Cl	0	0.1	0
H	0	1	0
I	3	0.1	0.3
Mo	10	1.4	14
Nb	160	1.4	224
Ni	100	0.3	30
Np	17.5	1	17.5
Pa	550	1.5	825
Pb	270	0.2	54
Pu	1250	1.3	1625
Ra	500	0.5	250
Tc	0.1	0.1	0.01
Th	500	0.3	150
U	10	1	10

All Pathway Doses

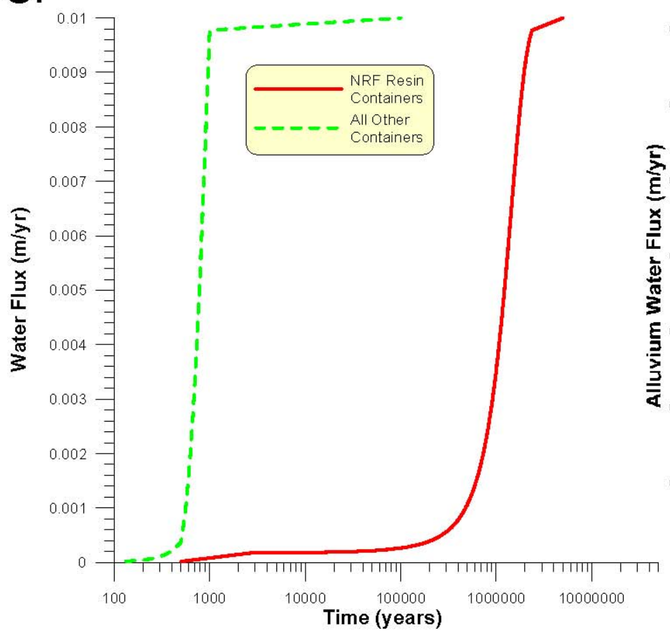
- All pathways doses calculated for a subsistence farmer with a water well 100 m downgradient from the facility
- Direct ingestion, milk, meat, vegetable ingestion
- Doses calculated for a unit concentration in groundwater and scaled for the modeled concentration

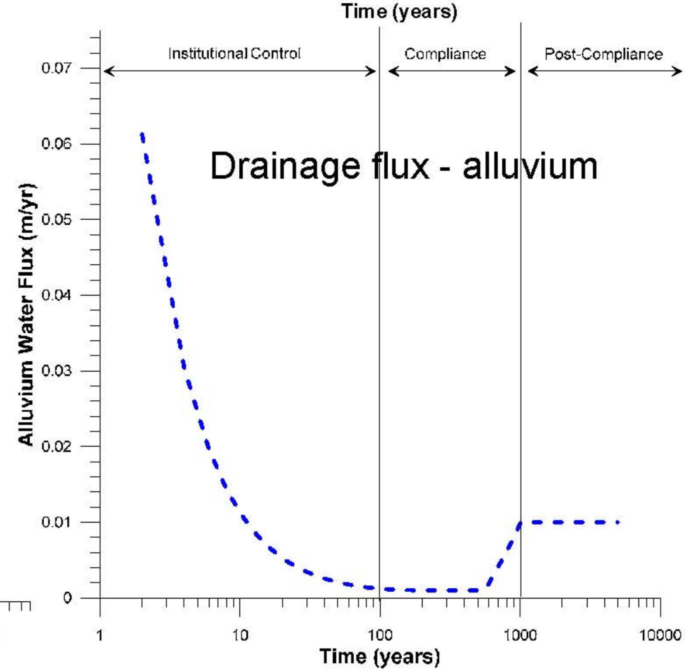
Water Input Rates

- 18 cm/yr in alluvium and vadose zone during operations (initial condition)
- 1 mm/yr in waste and alluvium after cover installation to 500 years, - linear failure to 1 cm/yr over next 500 years
- 1 cm/yr in vadose zone
- Water flux through waste accounts for container failure and infiltration through the engineered cover



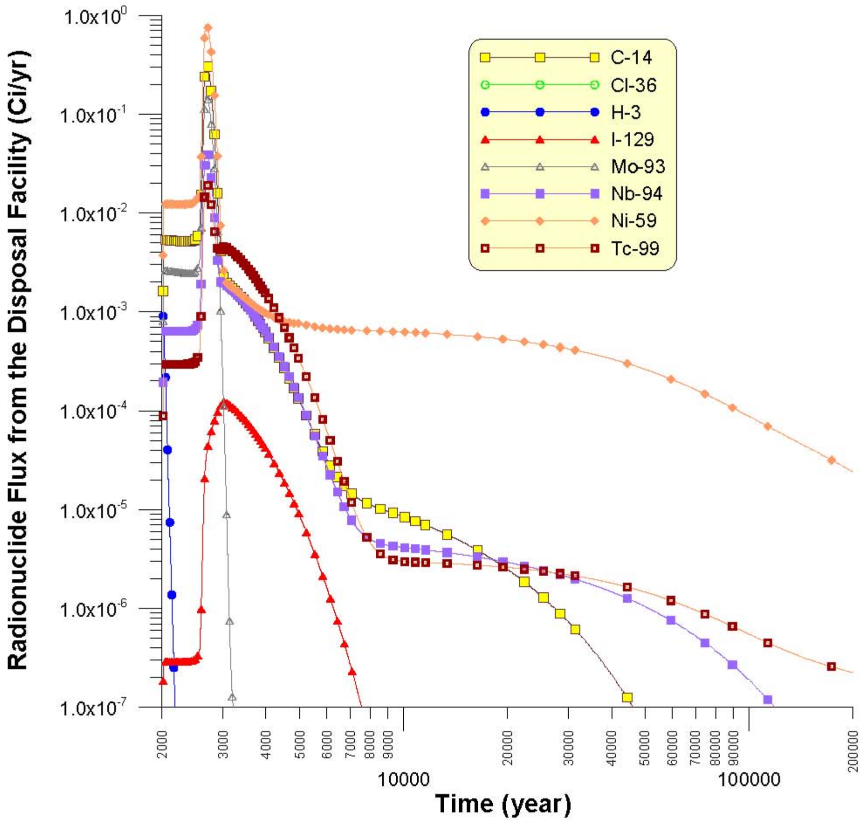
Input Water Flux through waste

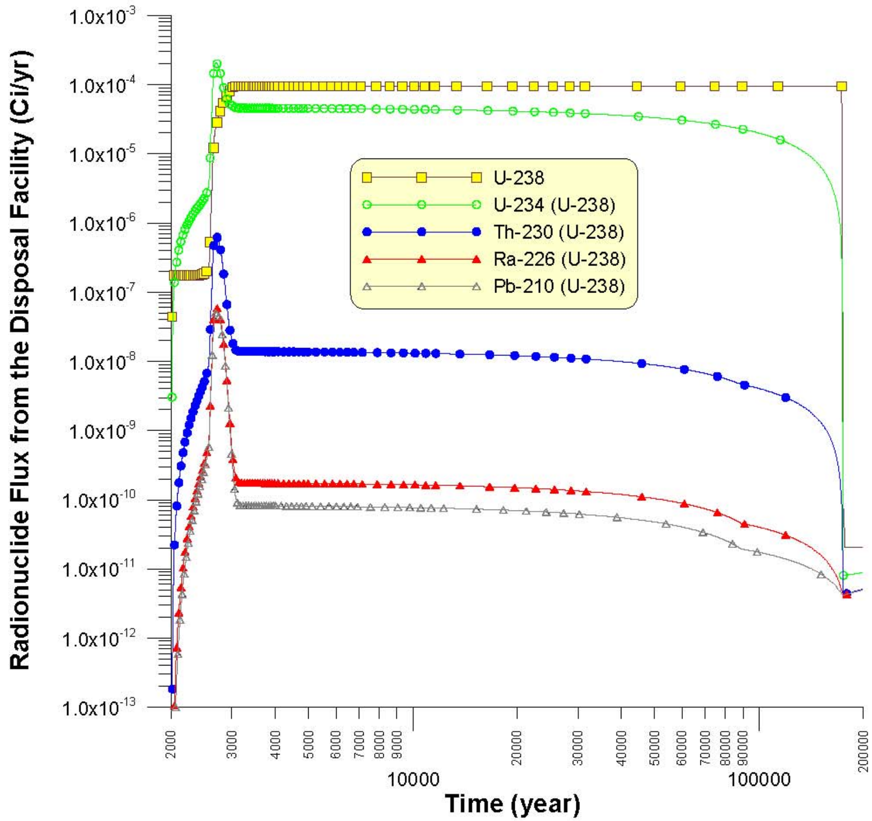




Radionuclide Fluxes from Source

- Radionuclide fluxes are complex and depend on the fraction of waste in different waste forms and containers





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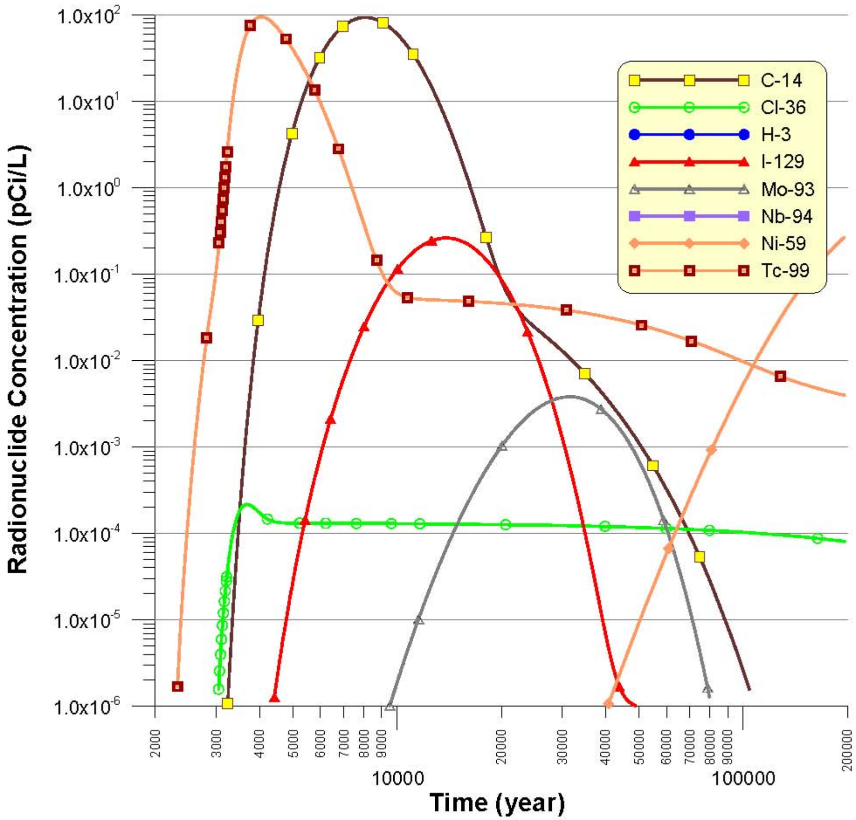
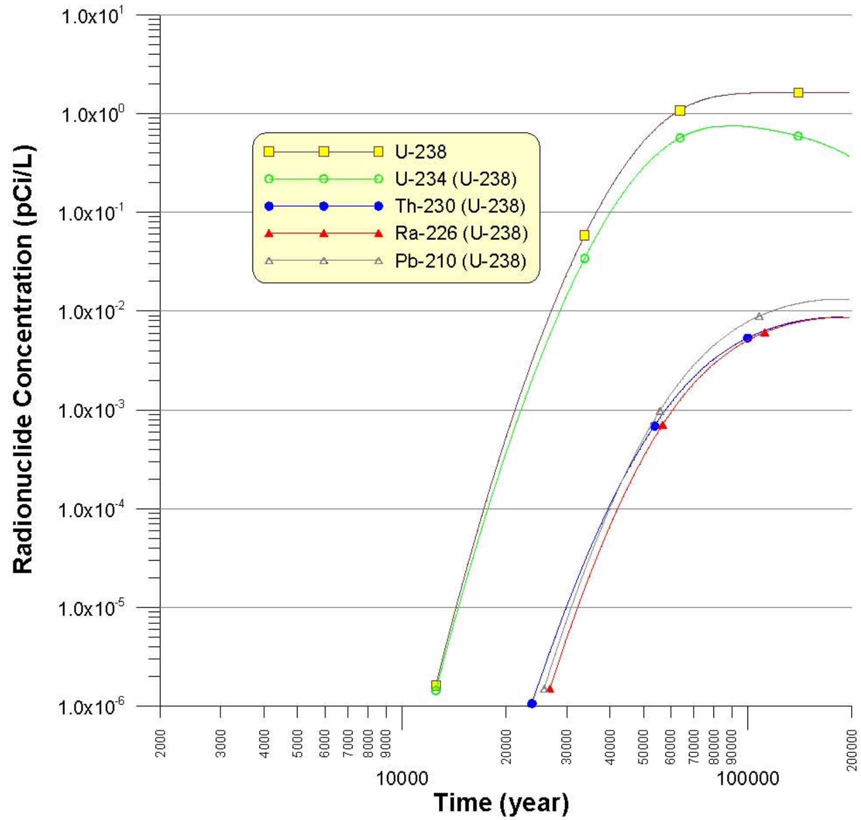
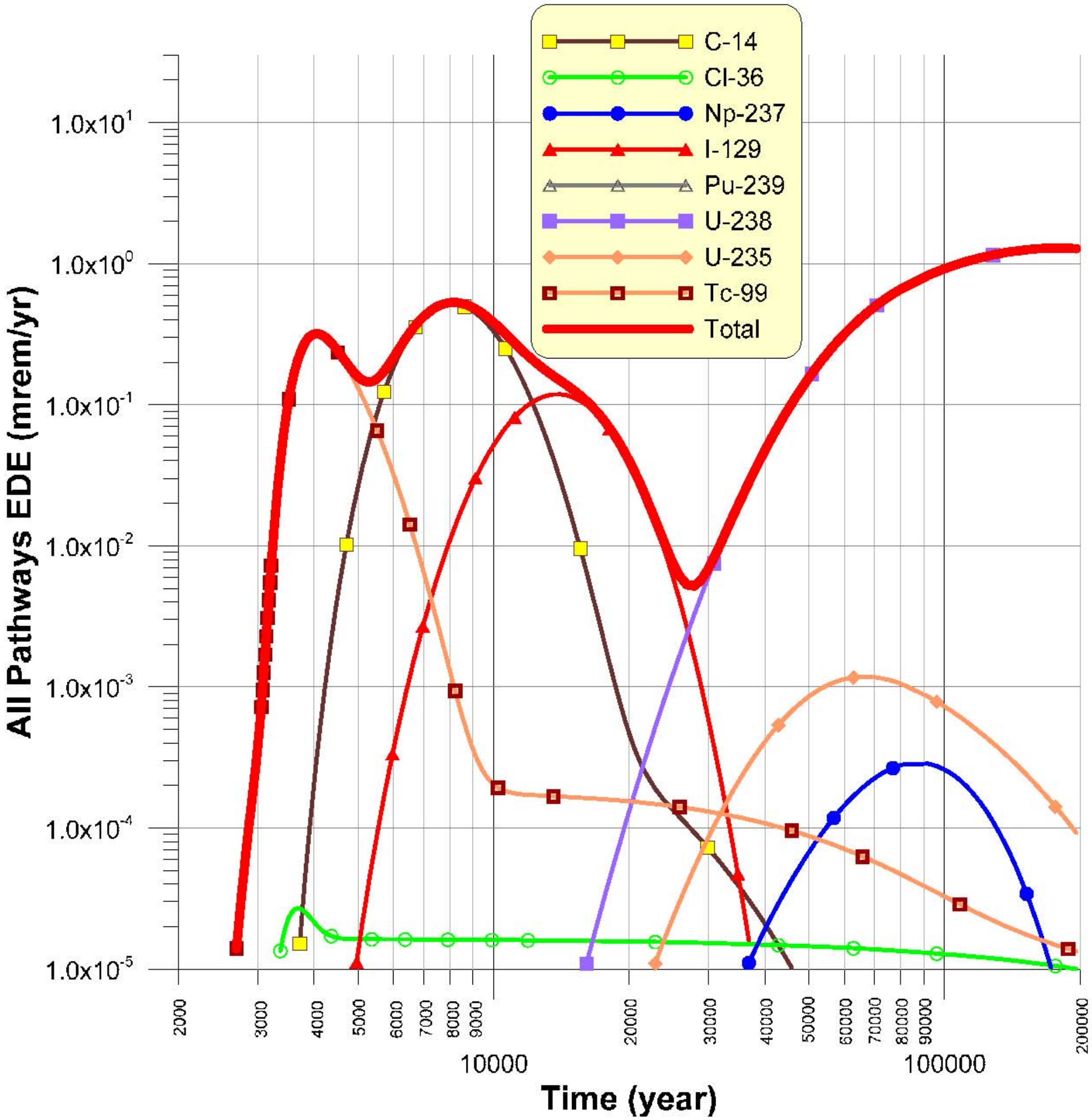
Radionuclide Concentrations in Groundwater





All Pathways Groundwater Dose

- Maximum EDE during compliance time: 8.7E-4 mrem/yr
  - Tc-99 major dose contributor
- Maximum EDE post-compliance period: 1.3 mrem/yr
  - U-238 and progeny



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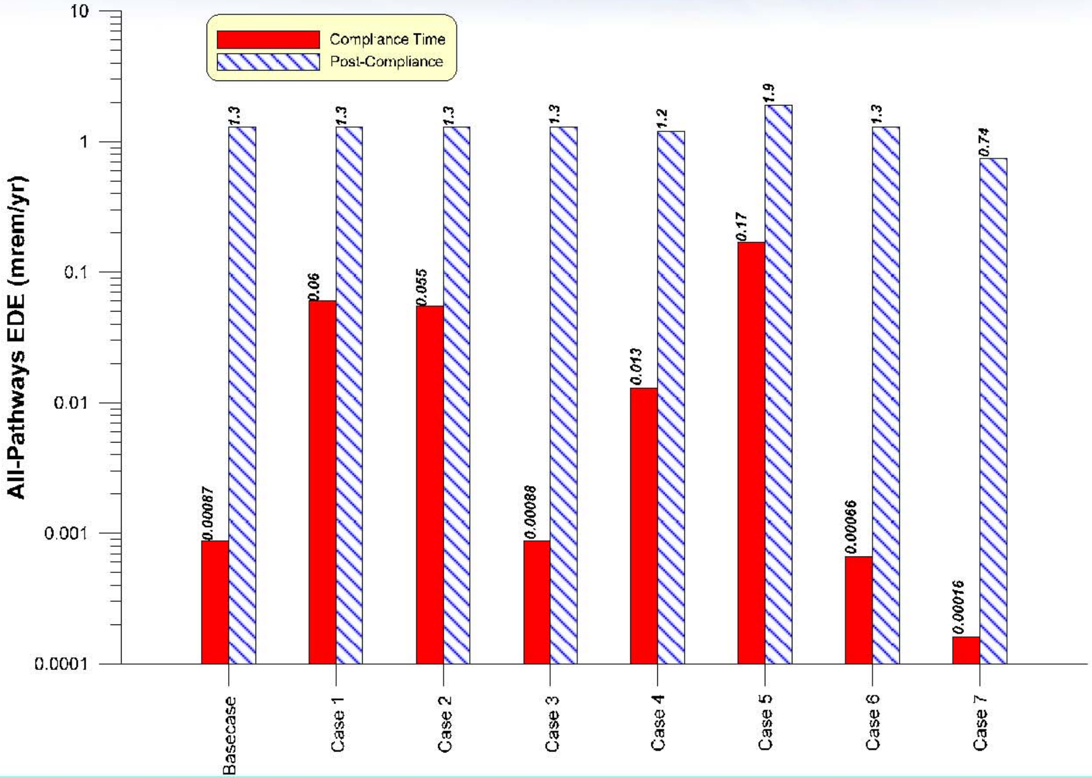
Uncertainty Analysis

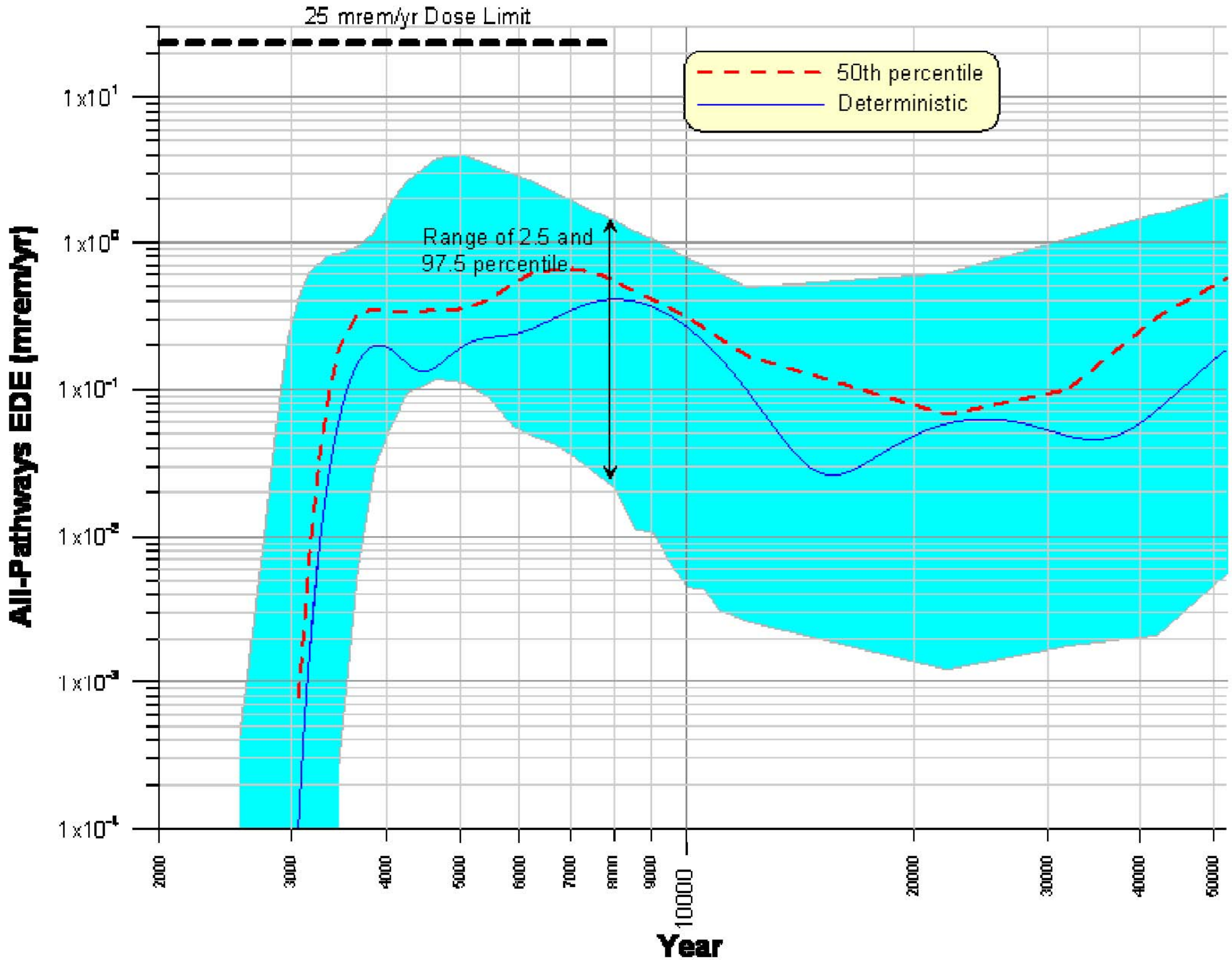
- One-Factor-at-a-Time
  - Seven separate cases
- Monte Carlo Simulation
  - Run for a limited set of radionuclides

Uncertainty Analysis – One-Factor-at-a-Time



Case Number	Description	Compliance Time All Pathway Dose (mrem/yr EDE)	Post Compliance Time All Pathway Dose (mrem/yr EDE)	I-129 Concentration Compliance (pCi/L)	I-129 Concentration Post Compliance (pCi/L)
0	Basecase	8.70E-04	1.3	<1e-10	0.26
1	Infiltration through cap 10x	6.00E-02	1.3	<1e-10	0.26
2	Corrosion rate 10X	5.50E-02	1.3	<1e-10	0.26
3	Iodine Kd 1/10	8.80E-04	1.3	5.50E-06	1.2
4	8-m less sedimentary interbeds	1.30E-02	1.2	<1e-10	0.34
5	Subsidence of 50% of facility (20 cm/yr over half of facility)	1.70E-01	1.9	<1e-10	n/a
6	1/4 in carbon steel containers (mean lifetime 1065 years)	6.60E-04	1.3	<1e-10	0.26
7	All stainless steel containers (mean lifetime 1.22E6 years)	1.60E-04	0.74	<1e-10	5.40E-04

Uncertainty Analysis – Monte Carlo Analysis



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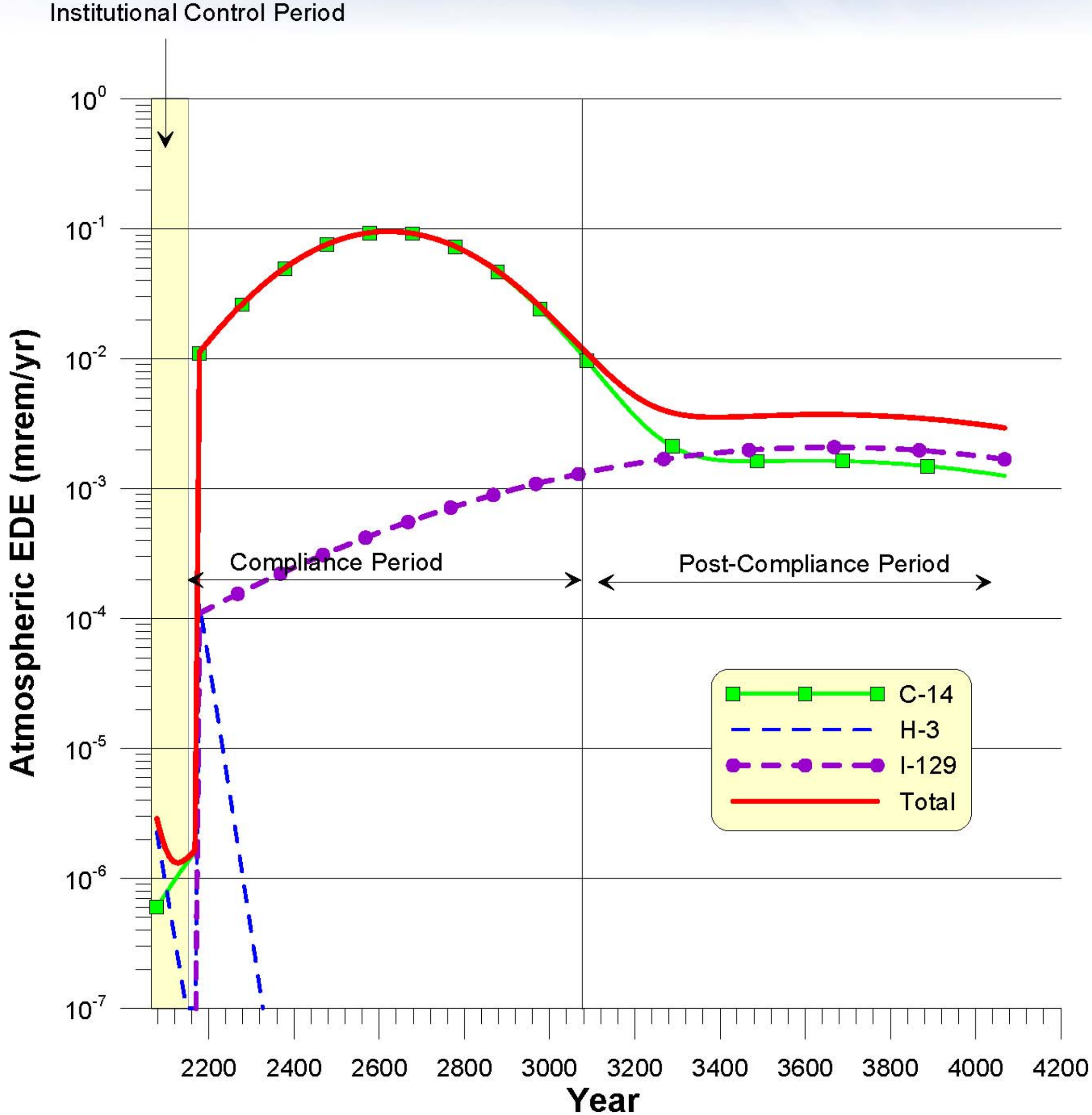
Atmospheric Doses



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Intruder Scenario Doses

Scenario	100-year	300-year	500-year	1000-year
Acute (mrem)	25.5	8.2	7.9	7.8
Chronic (mrem/yr)	16.7	4.2	3.9	3.8

Summary

- A one-dimensional model coupled with time-dependent water fluxes and container failure times was used to assess performance of the proposed RH-LLW facility
- All-pathways doses were less than the 25 mrem/yr EDE performance objective for all times
- Atmospheric doses were less than 10 mrem/yr for all time and intruder doses were less than 100 mrem EDE
- Monte Carlo uncertainty analysis followed by rank correlation indicated that infiltration rates through the cover (intact and failed), container lifetimes, and Tc-99 K_d were shown to be important parameters during the compliance time