SAND2008-7942P

Geologic Disposal of Transuranic and Mixed Waste at the Waste Isolation Pilot Plant

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Sandia National Laboratories

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IAEA Workshop
Gyeongju City, Republic of Korea

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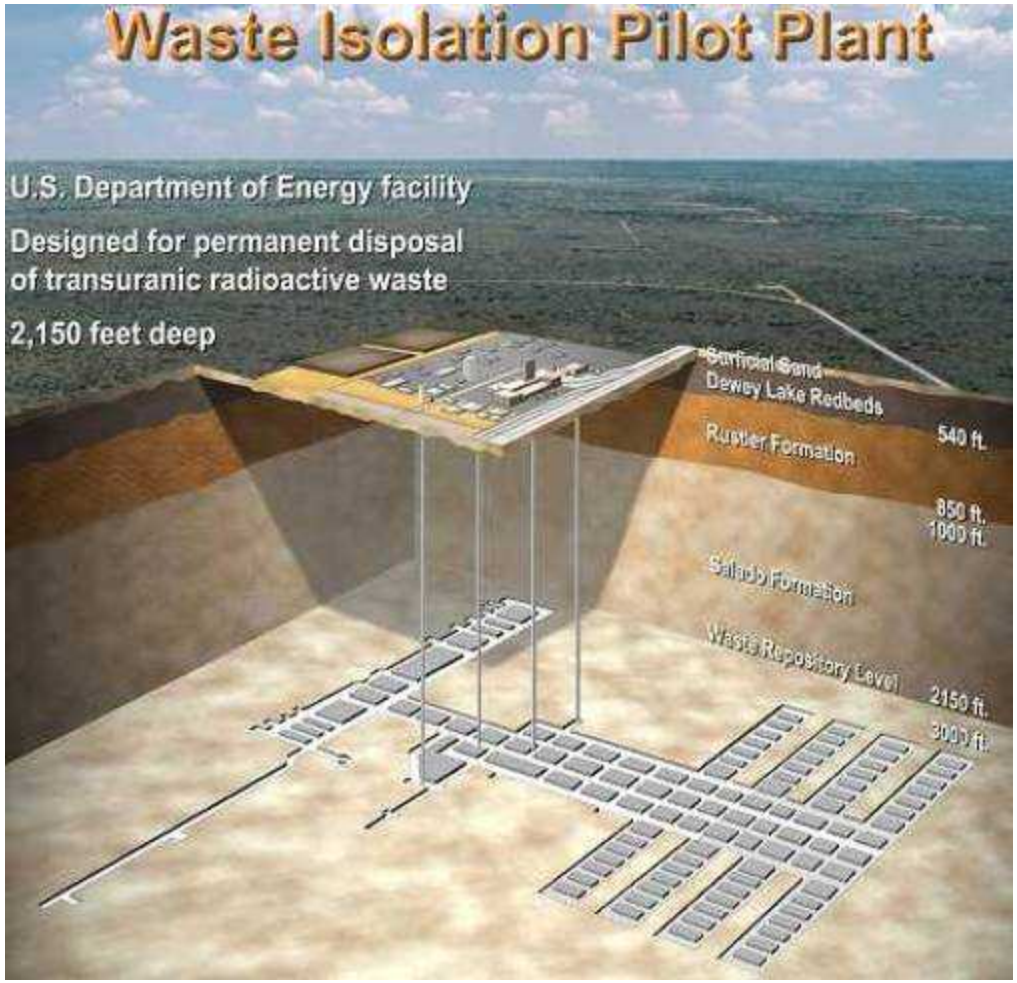
WIPP – First Underground Repository for Disposal of Transuranic Waste



On March 26, 1999, WIPP became the world's first underground repository certified to safely and permanently dispose of TRU wastes left from U.S. research and production of nuclear weapons. The facility is operated by the U.S. Department of Energy.

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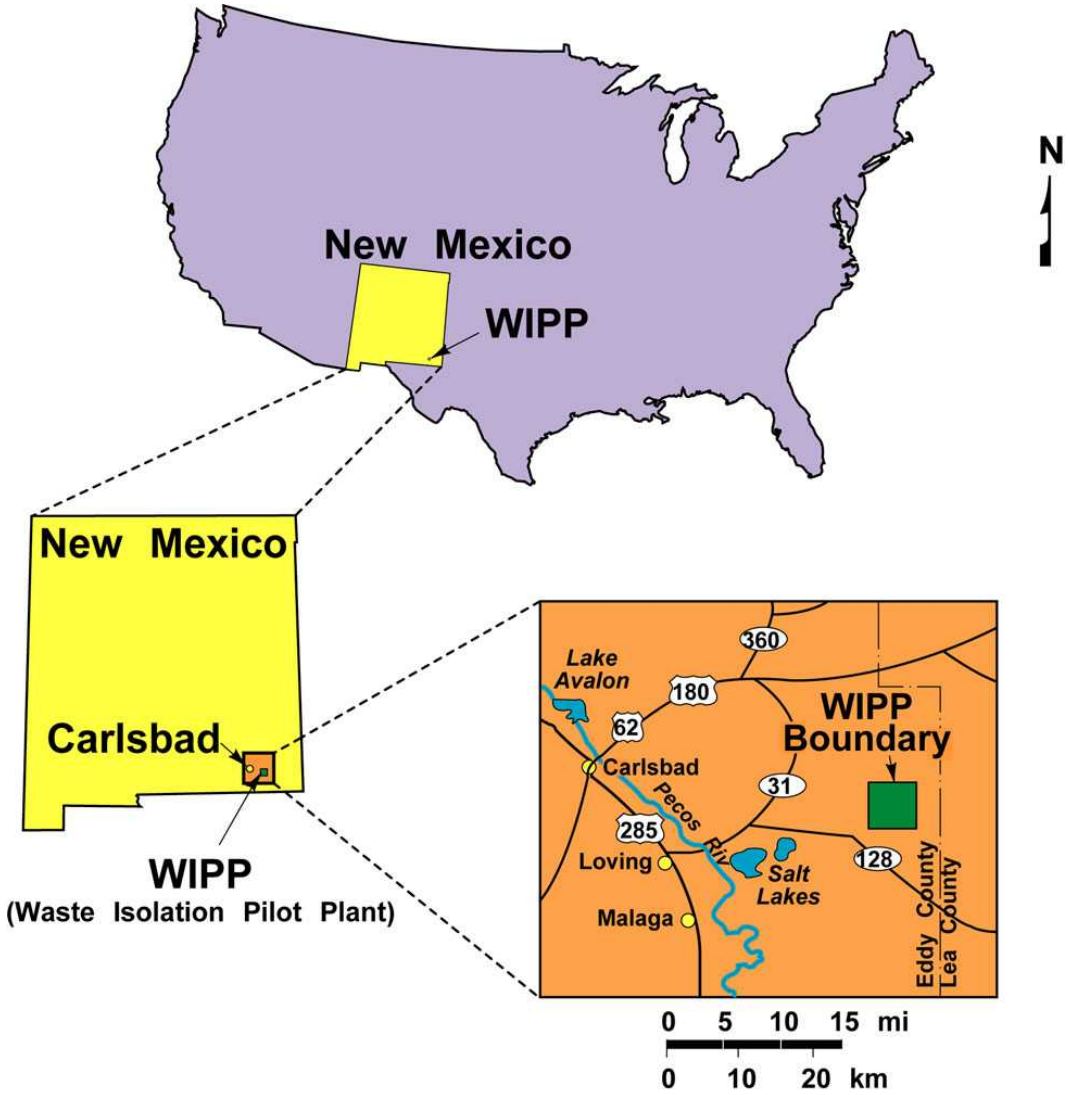
WIPP Site Location



- Southeastern New Mexico, USA
- ~ 50 km east of Carlsbad, New Mexico

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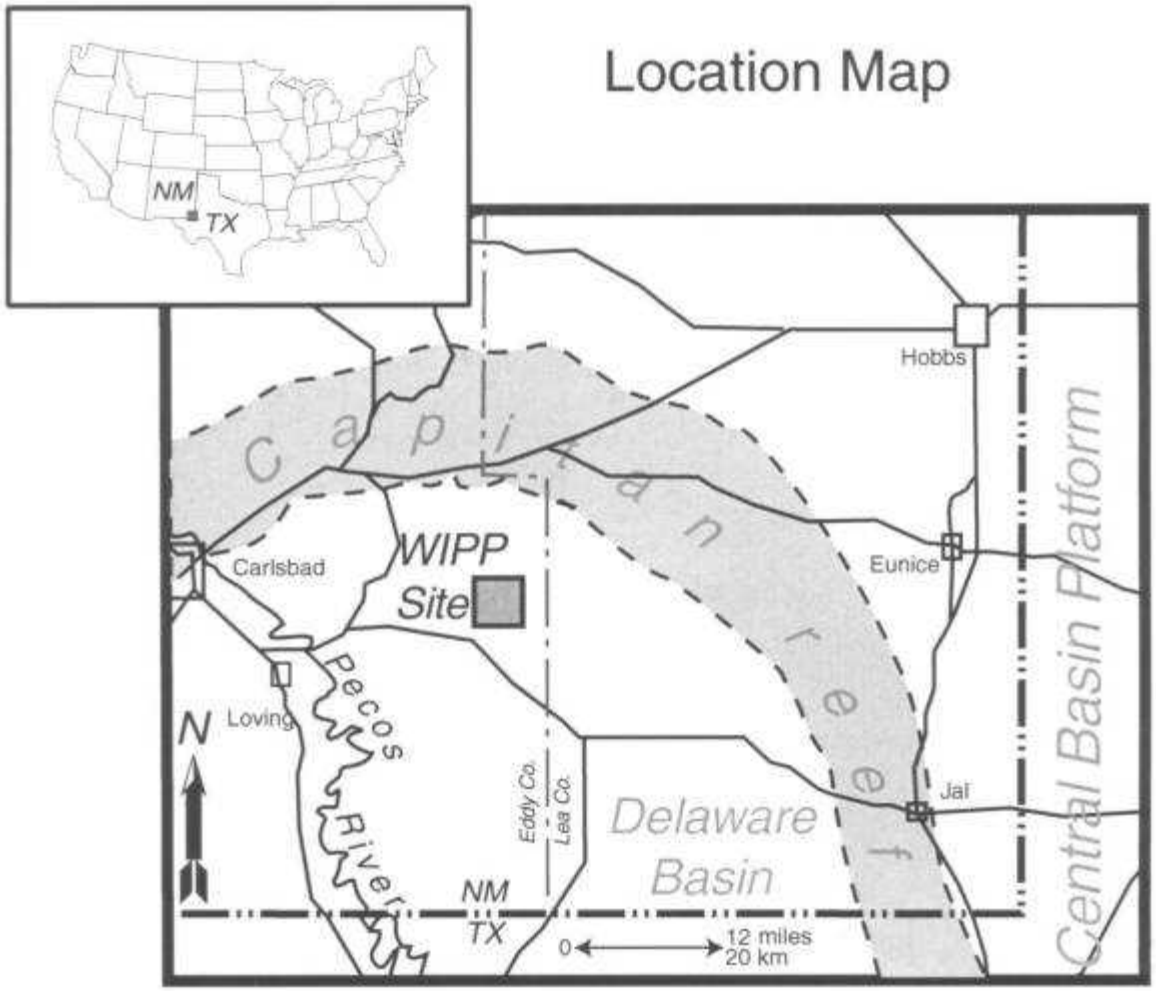
Delaware Basin & Capitan Reef



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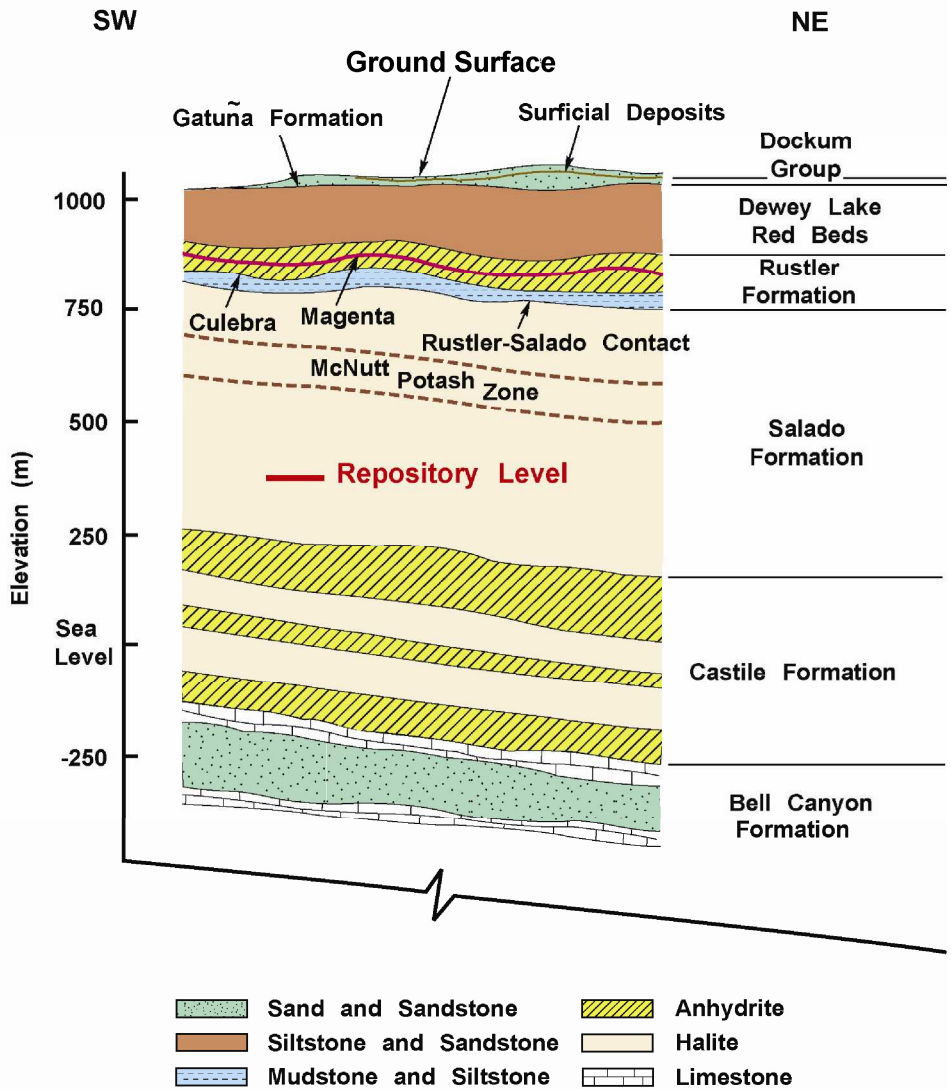
Generalized WIPP Stratigraphy



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Surface Facilities

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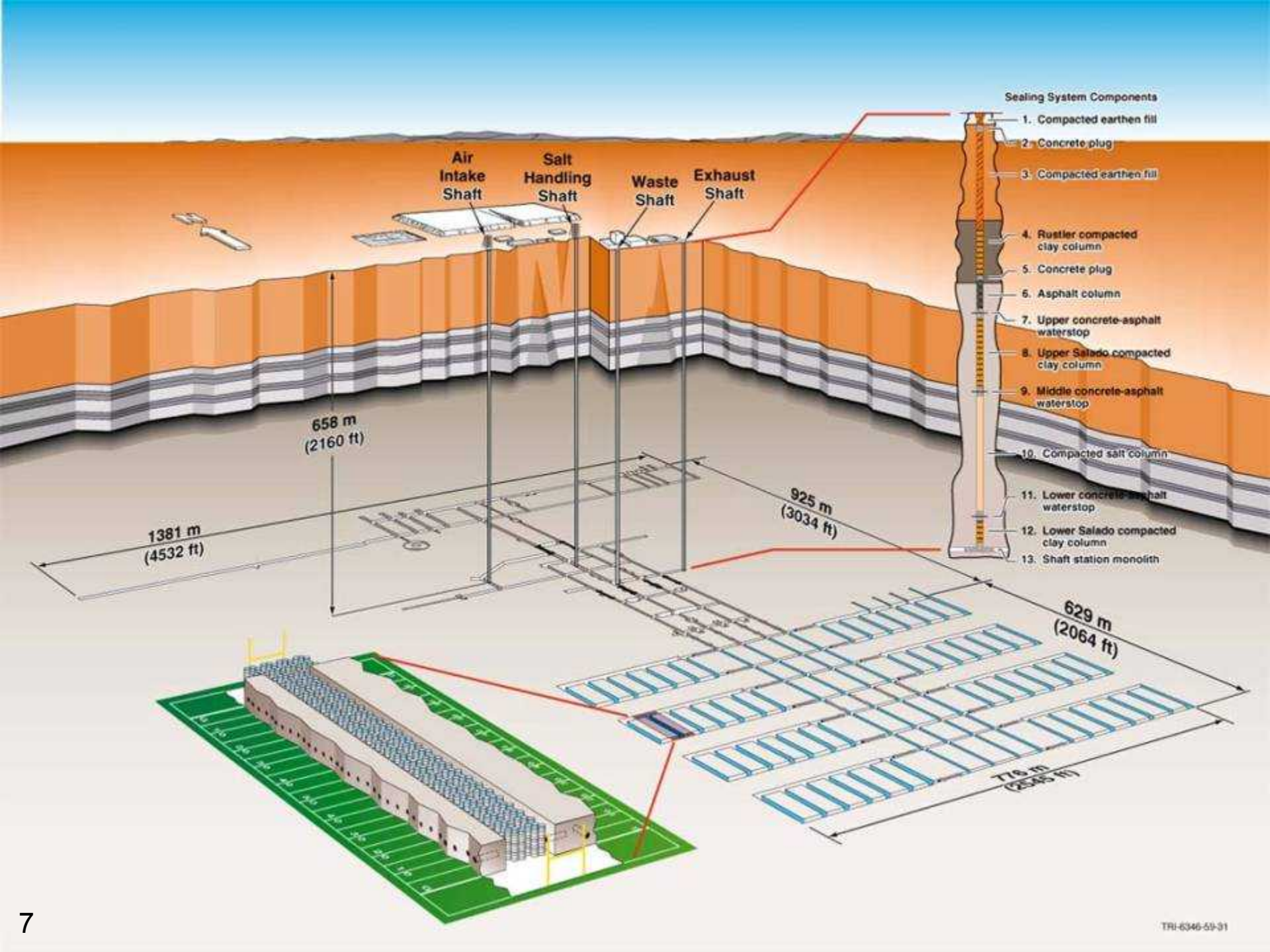

Air Intake Shaft
Salt Handling Shaft
Waste Shaft
Exhaust Shaft
Sealing System Components
1. Compacted earthen fill
2. Concrete plug
3. Compacted earthen fill
4. Rustler compacted clay column
5. Concrete plug
6. Asphalt column
7. Upper concrete-asphalt waterstop
8. Upper Salado compacted clay column
9. Middle concrete-asphalt waterstop
10. Compacted salt column
11. Lower concrete-asphalt waterstop
12. Lower Salado compacted clay column
13. Shaft station monolith
658 m (2160 ft)
1381 m (4532 ft)
925 m (3034 ft)
629 m (2064 ft)
TRI-6346-59-31

Repository Excavations

Unmined

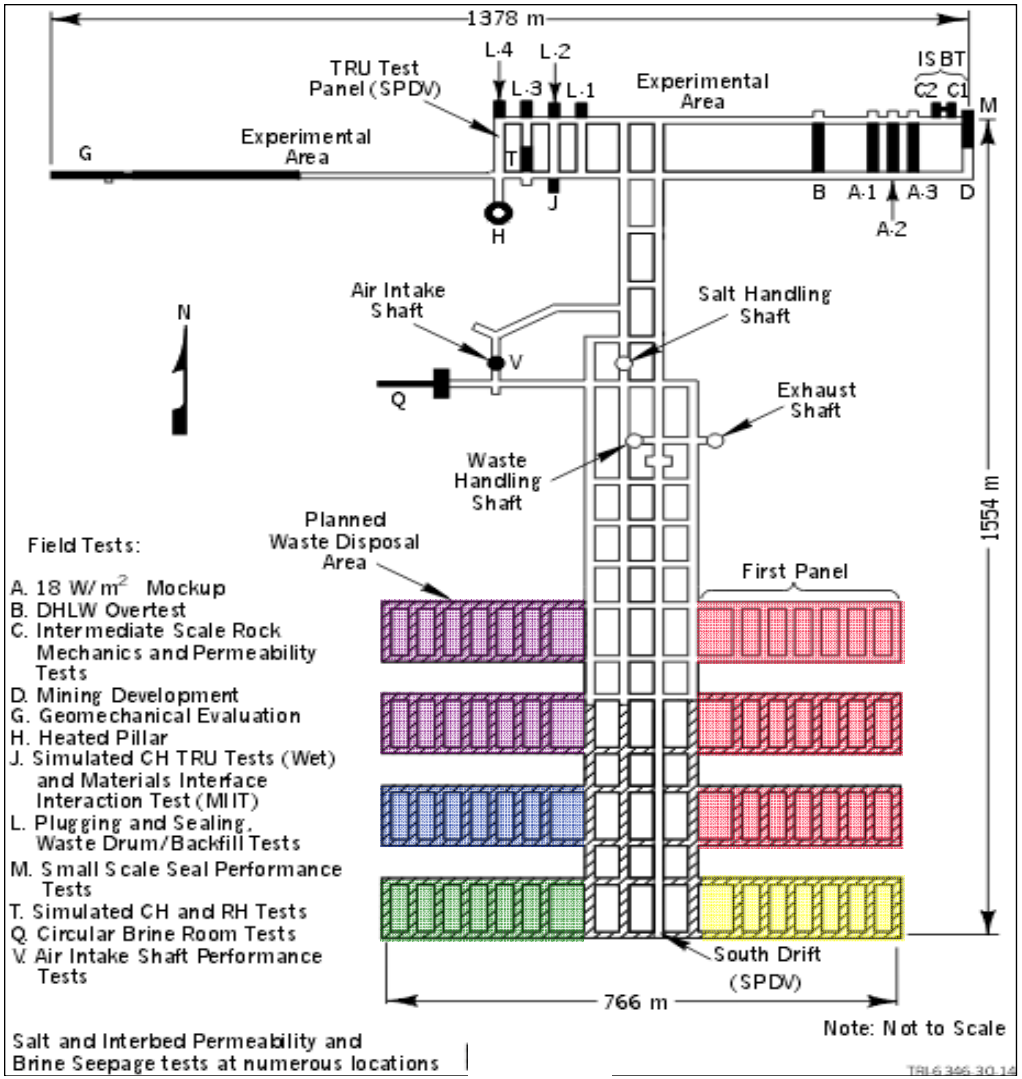
Mining

Mined

Filling

Filled

As of 26 Nov 2008



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Salt Excavation

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Excavated Access Drifts

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WIPP TRU Waste

- Waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes, with half-lives greater than twenty years, per gram of waste, excluding high-level waste
- Waste emitting ≤ 200 mrem/hr at the surface of the container is considered contact-handled (CH) waste
- Waste emitting > 200 mrem/hr at the surface of the container is considered remote-handled (RH) waste
- The total capacity of WIPP by volume is ~175,000 m^3 of TRU waste. RH waste is limited to ~7000 m^3.

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WIPP RH TRU Waste

(1) Rem limits for RH waste

(A) No transuranic waste received at WIPP may have a surface dose rate in excess of 1,000 rem/hr.

(B) No more than 5 percent by volume of the RH waste received at WIPP may have a surface dose rate in excess of 100 rem/hr.

(2) Curie limits for RH waste

(A) RH waste received at WIPP shall not exceed 23 curies per liter maximum activity level (average over the volume of the canister).

(B) The total curies of RH waste received at WIPP shall not exceed 5,100,000 curies.

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CH TRU Waste Drum Contents

WIPP waste is termed “mixed” waste because it contains both radioactive and hazardous components

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Emplaced Contact-Handled Waste

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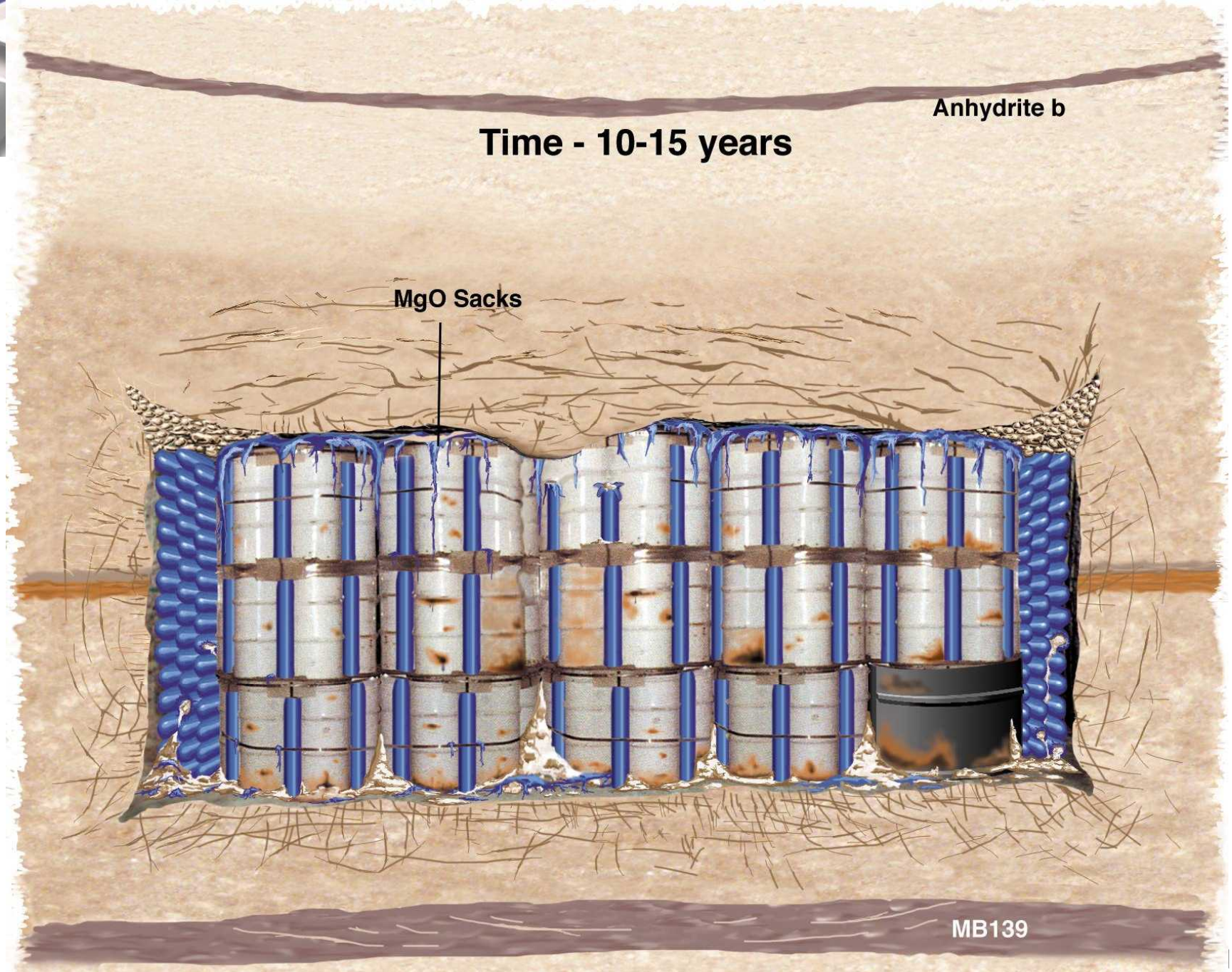
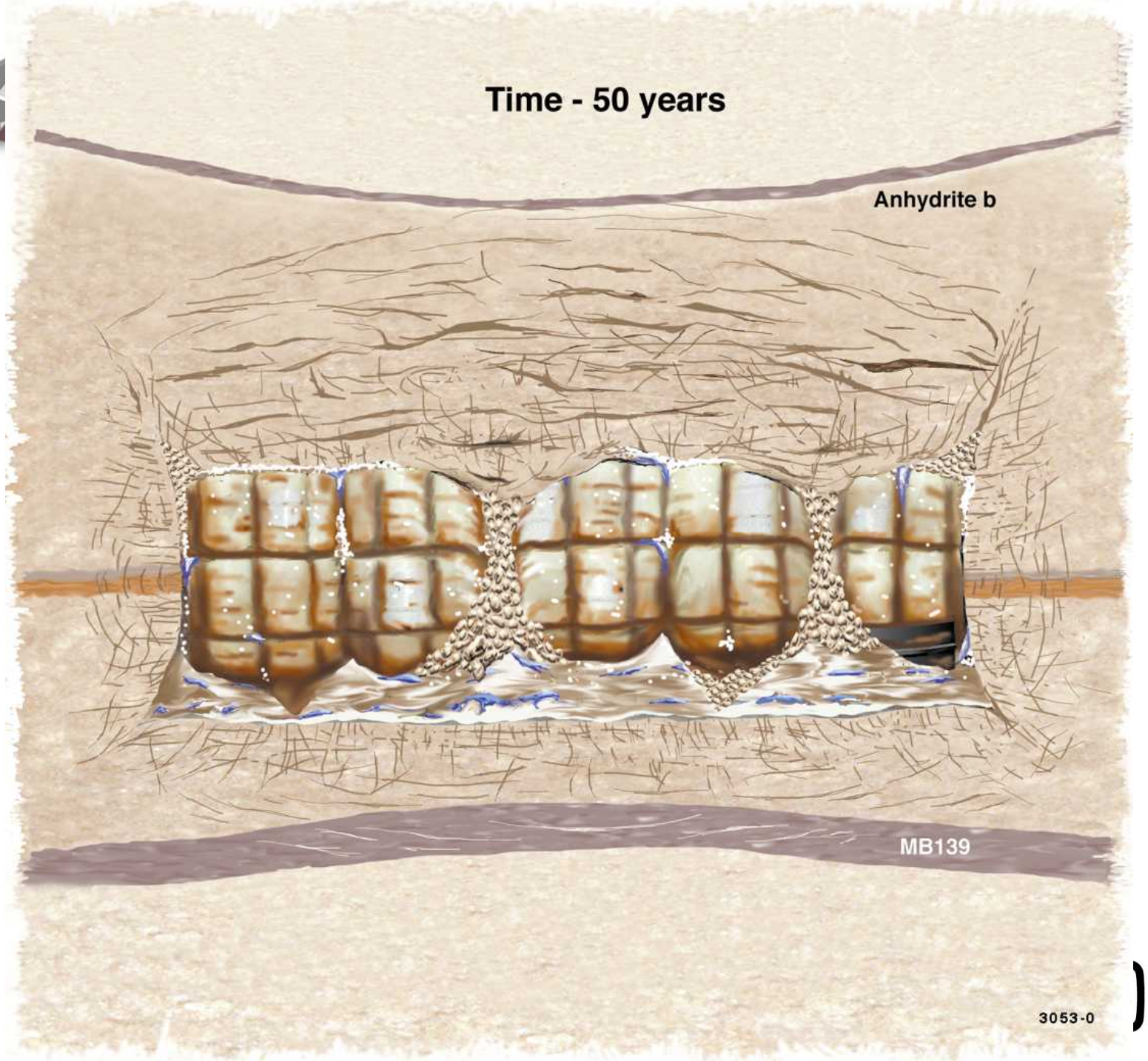

Anhydrite b
Time - 10-15 years
MgO Sacks
MB139



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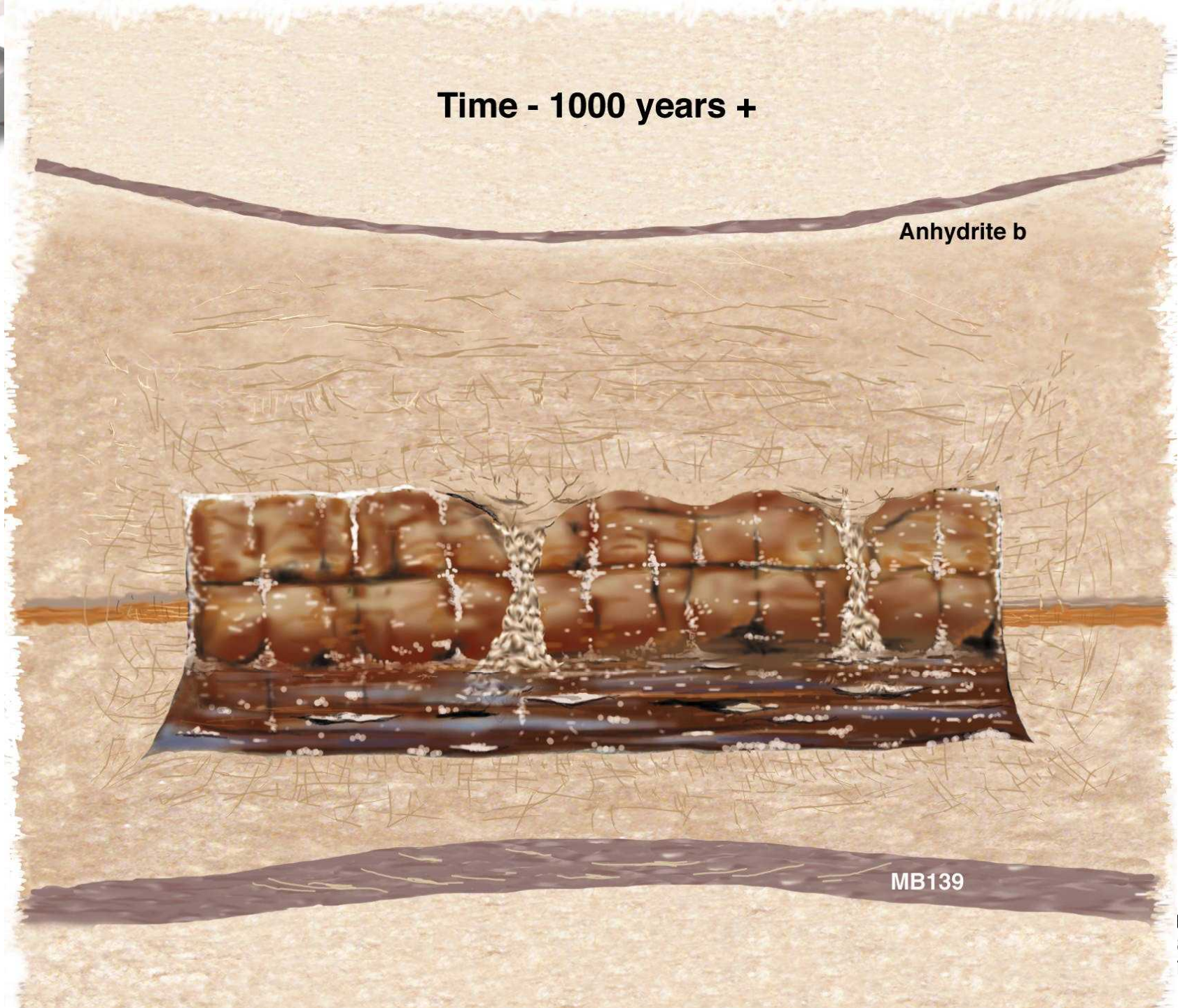

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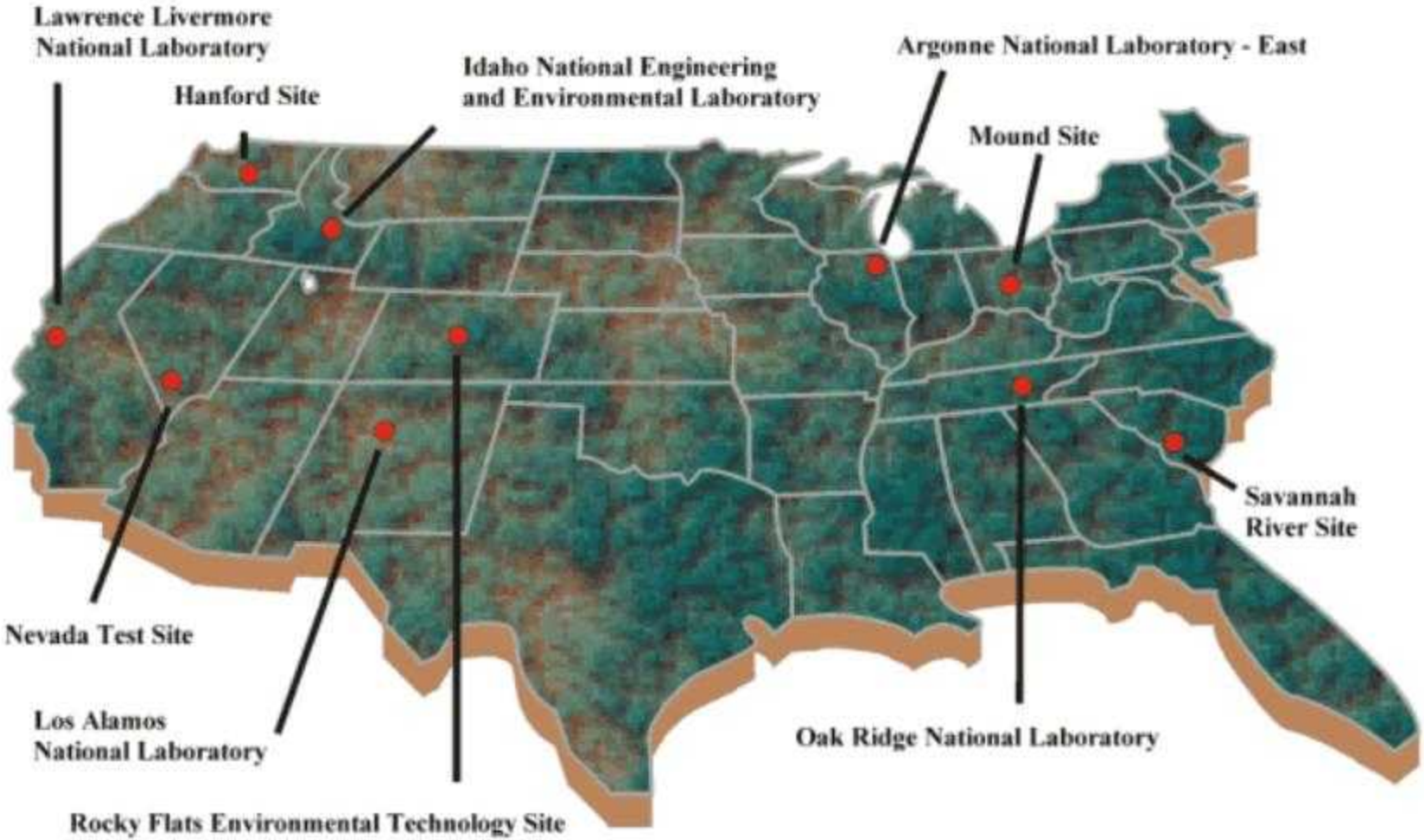
Waste Generator-Site Locations



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Transportation Routes

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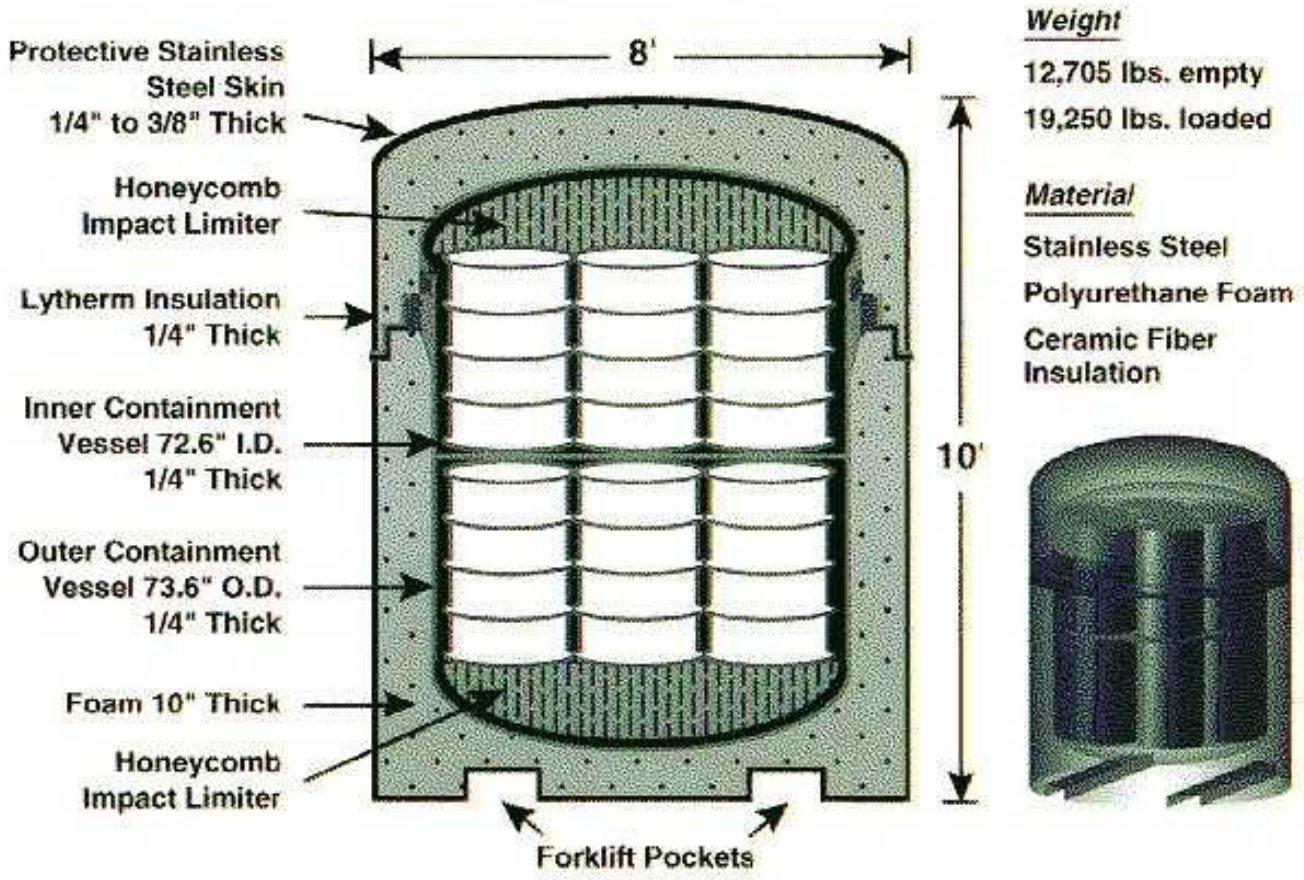
CH Waste Transportation Container

TRUPACT-II



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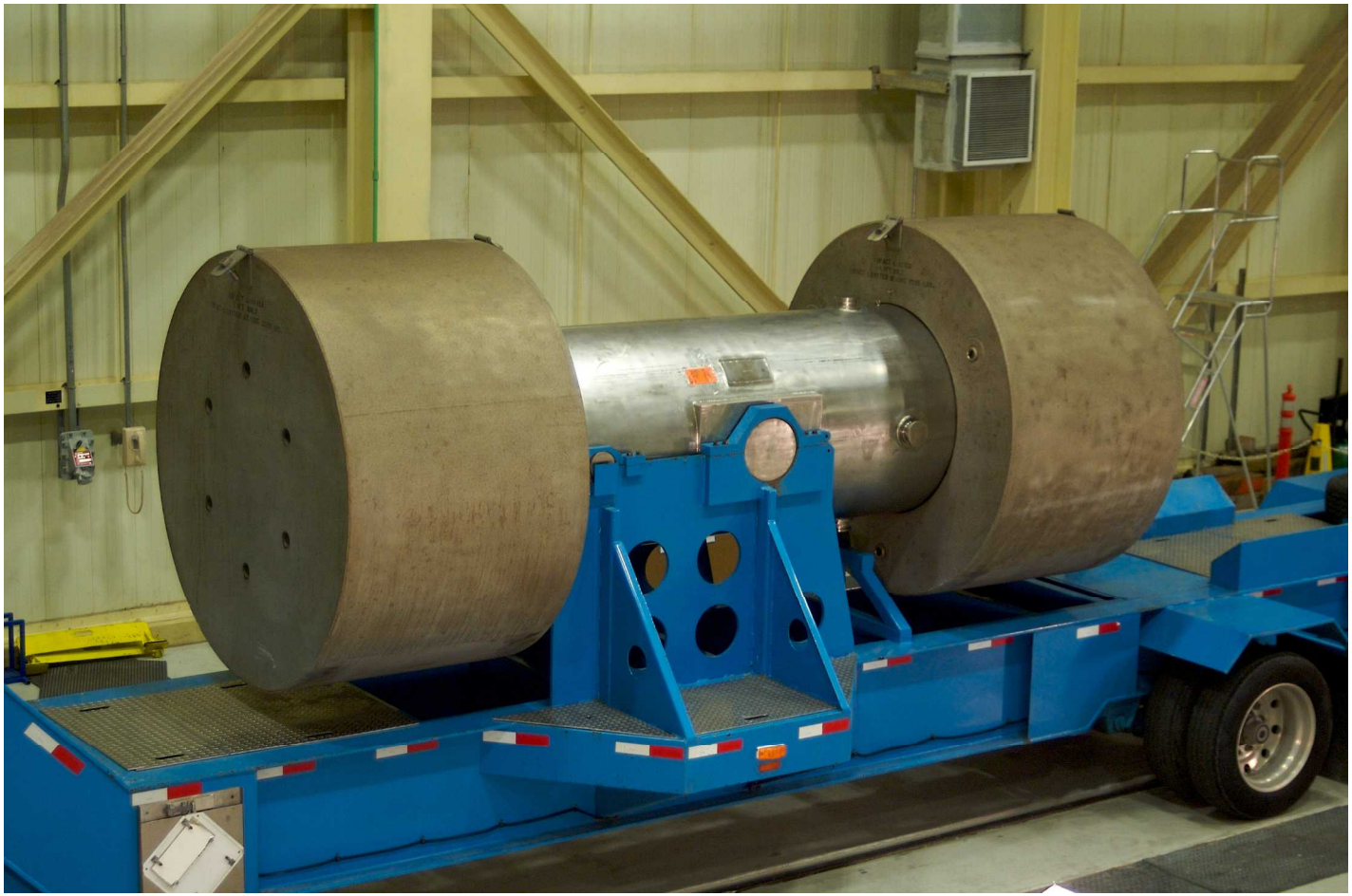
RH Waste Transportation Container



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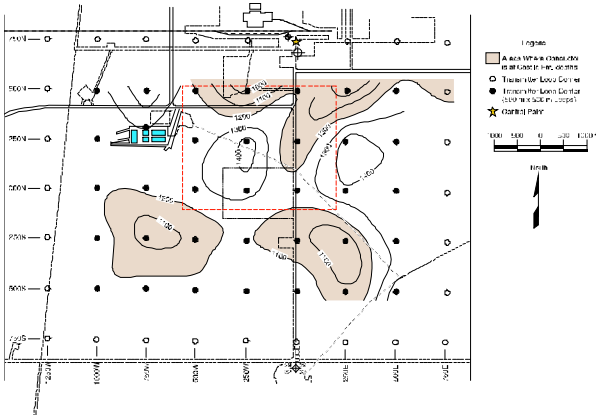
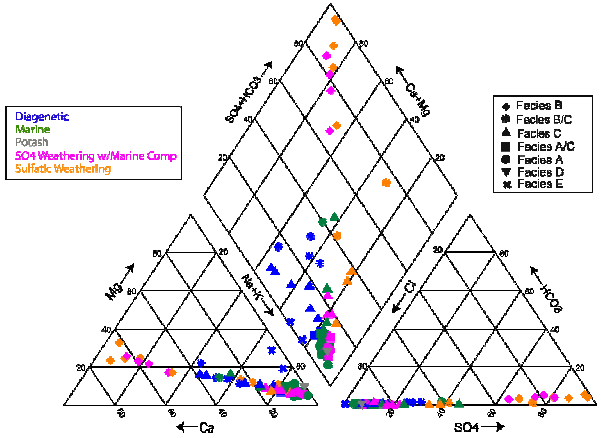
WIPP Site Characterization

Geologic studies



Geophysical surveys

Hydrologic testing

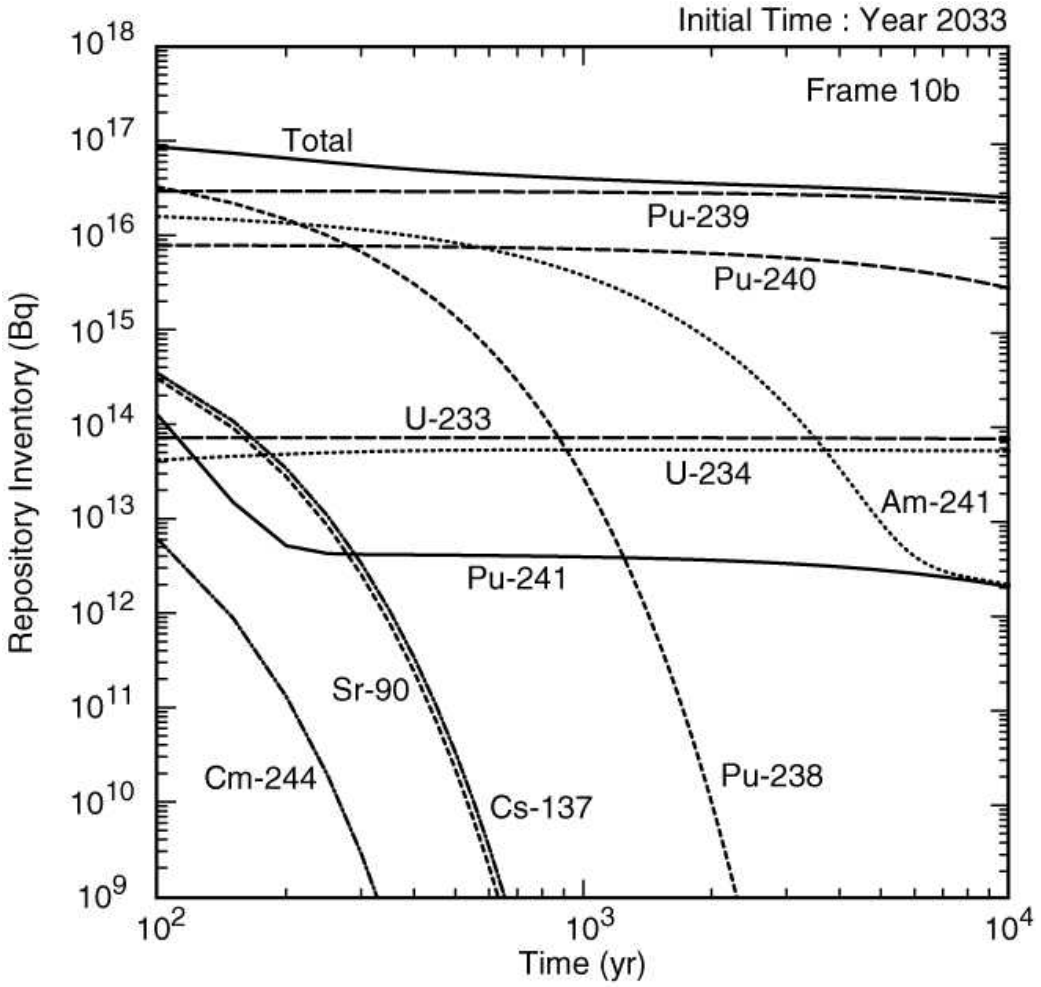


Geochemical sampling and analysis

Geomechanical testing

Surface-based geologic drilling, coring, & geophysical logging

WIPP Radionuclide Inventory as a Function of Time



TRI-6342-5228-0

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Regulatory Drivers (1 of 2)

- Radioactive Waste Component
  - U.S. Environmental Protection Agency (EPA) 40 Code of Federal Regulations Parts 191 & 194
    - 40 CFR 191 – "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes (1985)"
    - 40 CFR 194 – "Criteria for the Certification and Recertification of the Waste Isolation Pilot Plant's Compliance with the 40 CFR Part 191 Disposal Regulations (1996)"
    - WIPP certified in 1999 with recertification every 5 years

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Regulatory Drivers (2 of 2)

- **Hazardous Waste Component**
  - **Resource Conservation and Recovery Act (RCRA), (USC, 1976)**
    - **RCRA implemented through EPA 40 CFR Part 260 – 280**
    - **In New Mexico, EPA has delegated RCRA authority to the NM Environment Department (NMED). Applicable NM Administrative Code is NMAC 20.4.1.500 which incorporates 40 CFR 260 – 280.**
    - **WIPP issued a Hazardous Waste Facility Permit (HWFP) by NMED in 1999 with repermitting every 10 years.**

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Containment Requirements for the WIPP: 40 CFR § 191.13(a)

- **Disposal systems for spent nuclear fuel or high-level or transuranic radioactive wastes shall be designed to provide a reasonable expectation, based on performance assessments, that the cumulative releases of radionuclides to the accessible environment for 10,000 years after disposal from all significant processes and events that may affect the disposal system shall:**

  (1) Have a likelihood of less than one chance in 10 of exceeding the quantities calculated according to Table 1 (Appendix A); and

  (2) Have a likelihood of less than one chance in 1,000 of exceeding ten times the quantities calculated according to Table 1 (Appendix A).”

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Performance Assessment

- Regulatory requirements determine the structure of the performance assessment (PA)
  - For the WIPP, primary emphasis was on cumulative release, rather than dose
    - little need for exposure pathway analysis, essentially no dose assessment
    - large emphasis on human intrusion, need for models of drilling intrusion
  - For Yucca Mountain, emphasis on dose from undisturbed performance
    - emphasis on multiple barriers to contain radionuclides
      - engineered barrier performance (waste package)
      - unsaturated and saturated zone groundwater transport
    - dose calculations are important

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Release Limits for the WIPP (Table 1, Appendix A, 40 CFR part 191)

Radionuclide	Release limit L_i per 1000 MTHM* or other unit of waste (10^6 curies of TRU for WIPP)
Americium-241 or –243	100
Carbon-14	100
Cesium-135 or –137	1,000
Iodine-129	100
Neptunium-237	100
Plutonium-238, -239,-240, or –242	100
Radium-226	100
Strontium-90	1,000
Technetium-99	10,000
Thorium-230 or –232	10
Tin-126	1,000
Uranium-233, -234, -235, -236, or -238	100
Any other alpha-emitting radionuclide with a half-life greater than 20 years	100
Any other radionuclide with a half-live greater than 20 years that does not emit alpha particles	1,000

* Metric tons of heavy metal exposed to a burnup between 25,000 megawatt-days per metric ton of heavy metal (MWd/MTHM) and 40,000 MWd/MTHM.

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The EPA Normalized Release Unit

- **The "quantity calculated according to Table 1" is the "EPA normalized release," calculated as:**

$$nR = \sum \frac{Q_i}{L_i}\left(\frac{1\times 10^6\, curies}{C}\right)$$

where

Q_i = 10,000-year cumulative release (in curies) of radionuclide i

L_i = the Table 1 release limit (in curies) for radionuclide i

C = the total transuranic inventory (in curies)

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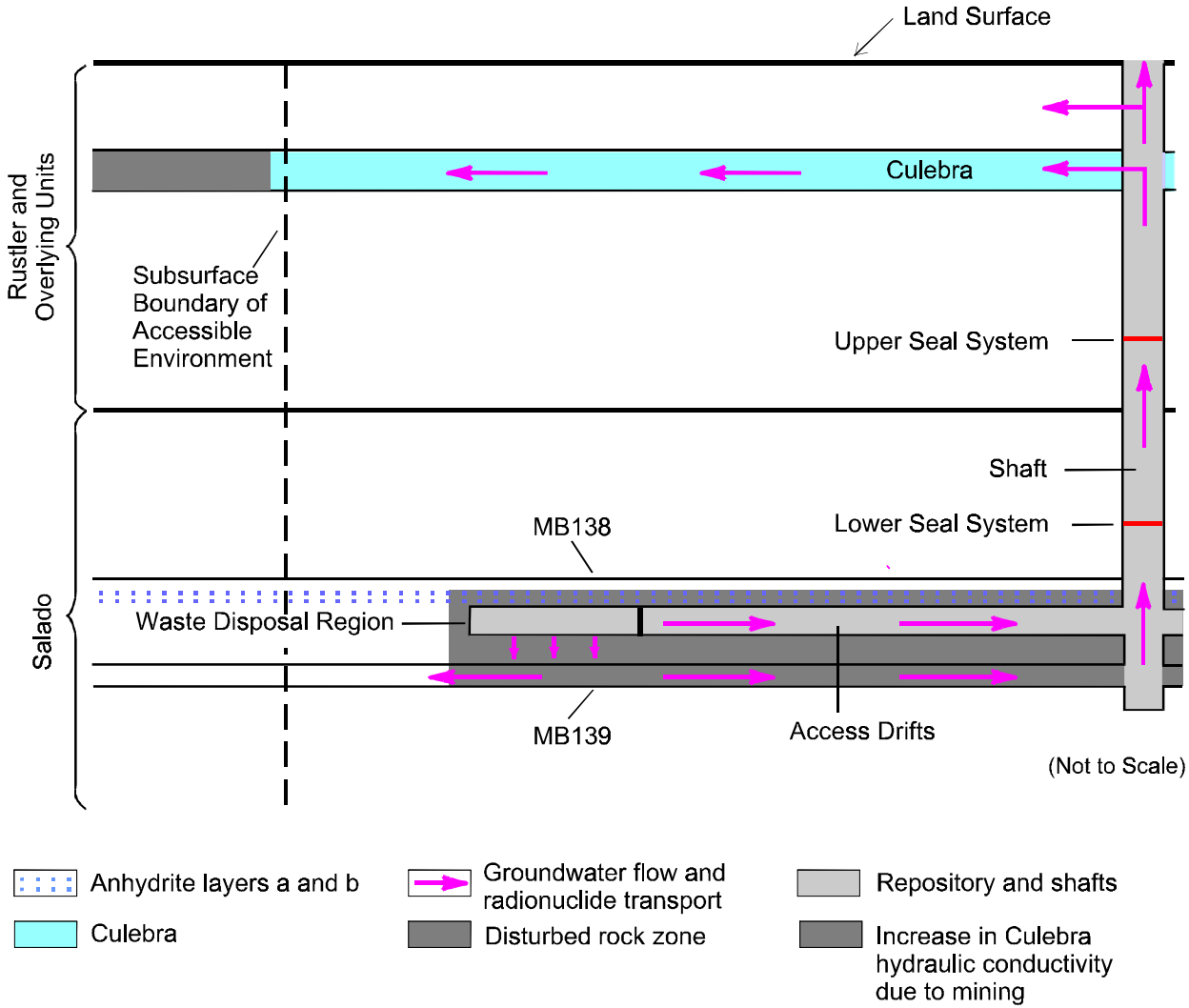
Undisturbed Scenario



Shaft seals effectively prevent any release of radionuclides

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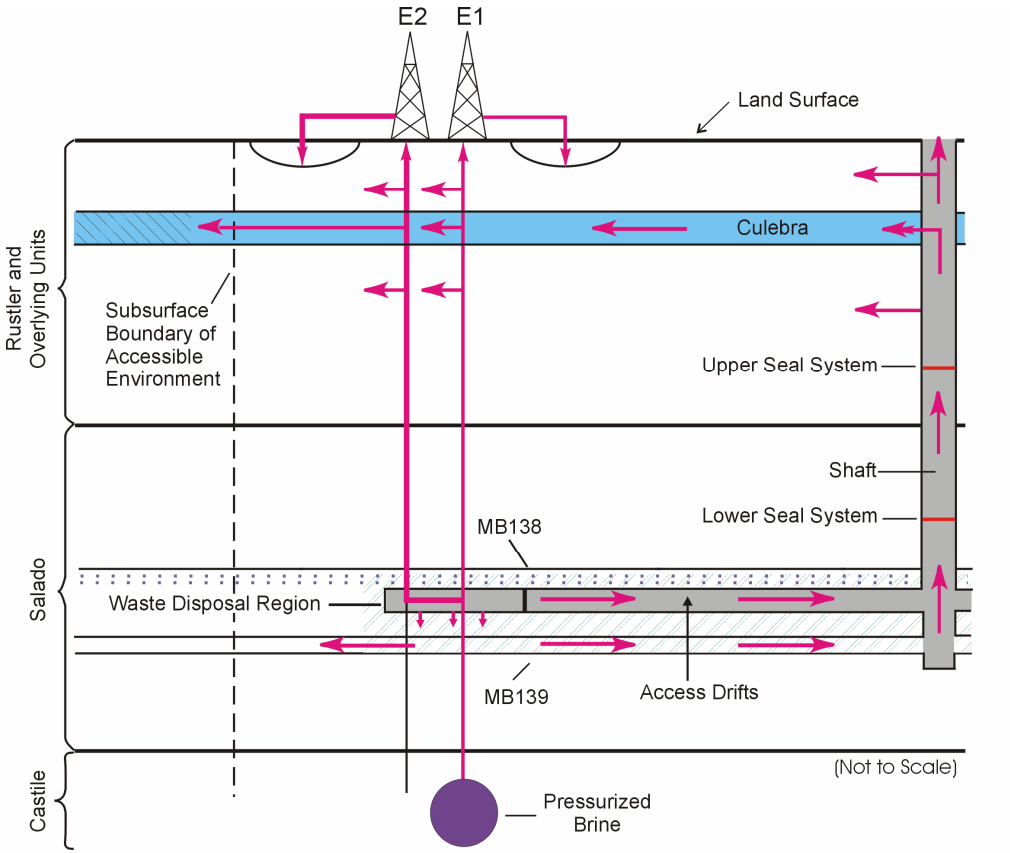
Intrusion Scenario



Note: Example shown includes only two boreholes, both of which penetrate waste and one of which penetrates pressurized brine in the underlying Castile Formation. Pathways are similar for examples containing multiple boreholes. Arrows indicate hypothetical direction of groundwater flow and radionuclide transport.

- Anhydrite layers a and b
- Culebra
- Groundwater flow and radionuclide transport
- Disturbed rock zone
- Repository and shafts
- Increase in Culebra hydraulic conductivity due to mining

- E1 borehole penetrates repository and pressurized Castile brine reservoir, leading to immediate release of brine, cavings, cuttings, and spallings
- E2 borehole penetrates repository, creating flow pathway through waste rooms/panels and up to Culebra

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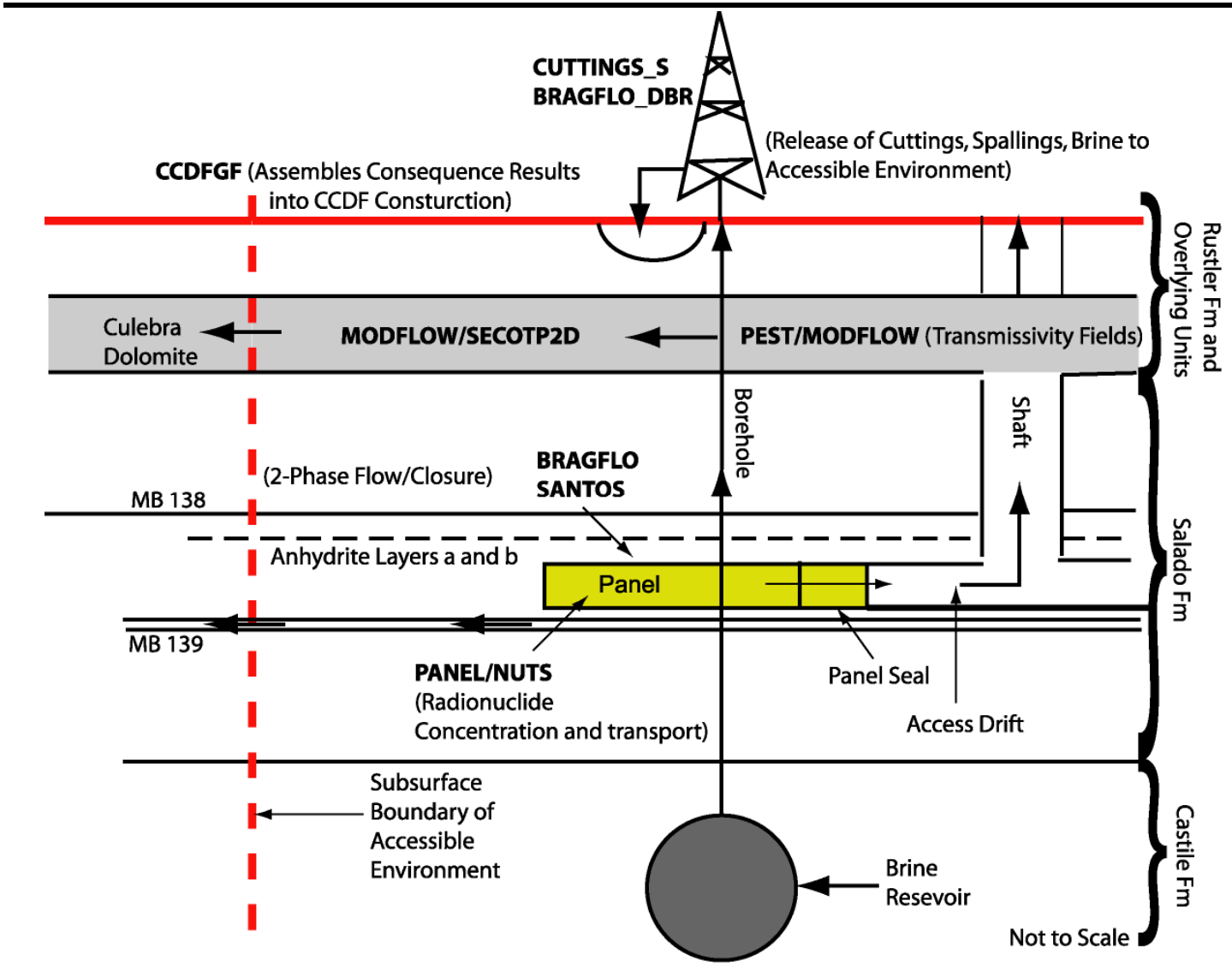
Scenario Consequence Estimation



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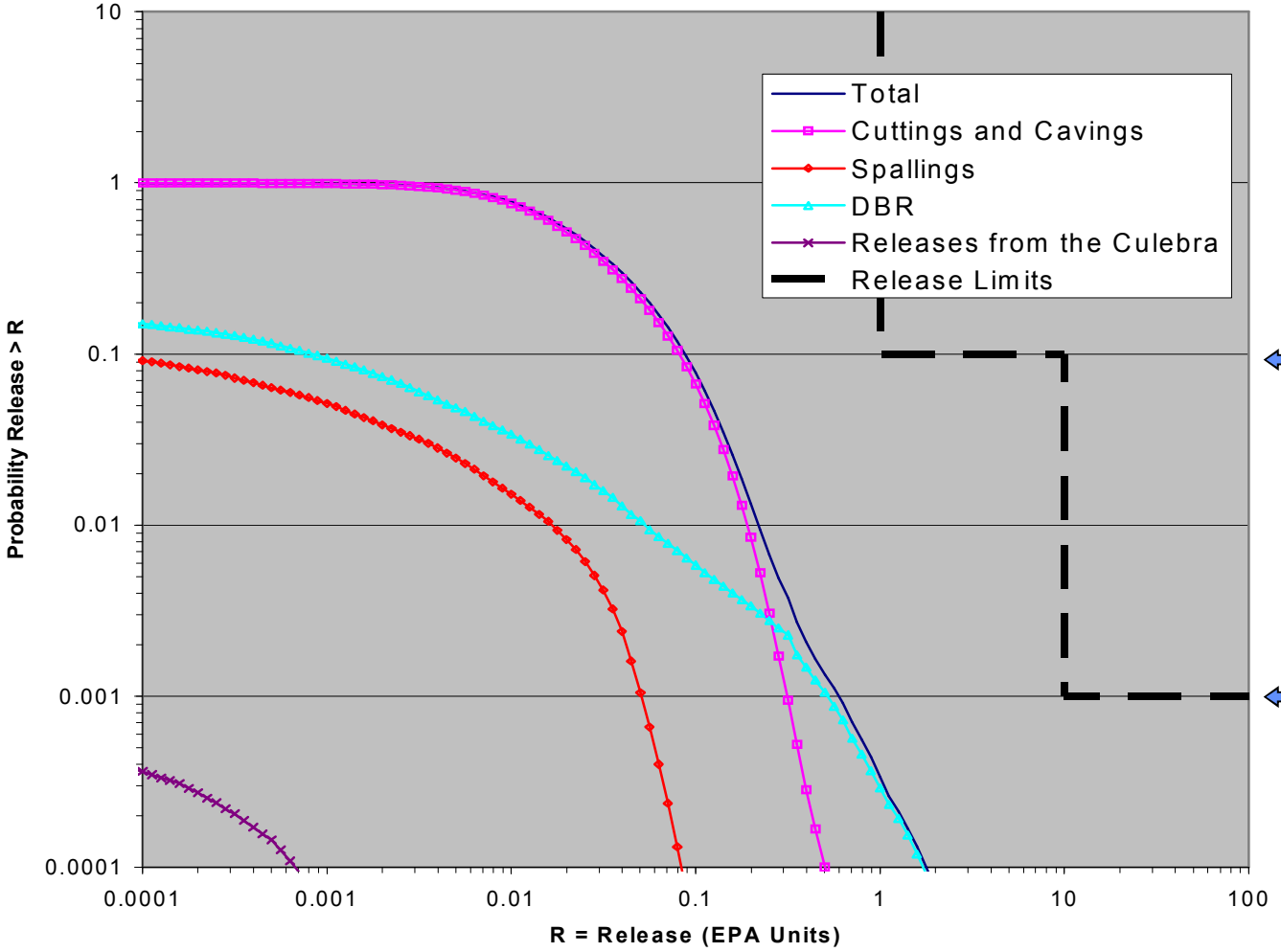
CCDF For WIPP Releases Calculated in Performance Assessment



Less than 1 chance in 10 of exceeding 1 EPA unit

Less than 1 chance in 1000 of exceeding 10 EPA units

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Current Status of WIPP

- WIPP was relicensed in March 2006 for the next five years
- License to receive remote-handled waste was obtained in October 2006
- ~7,100 shipments (~58,000 m^3) of waste have been received to date
- Next recertification application will be submitted in March 2009
- With no change in mission, WIPP will close before 2030

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