WIPP Lessons Learned from Experience in Operations and Heater Testing

Nuclear Waste Technical Review Board
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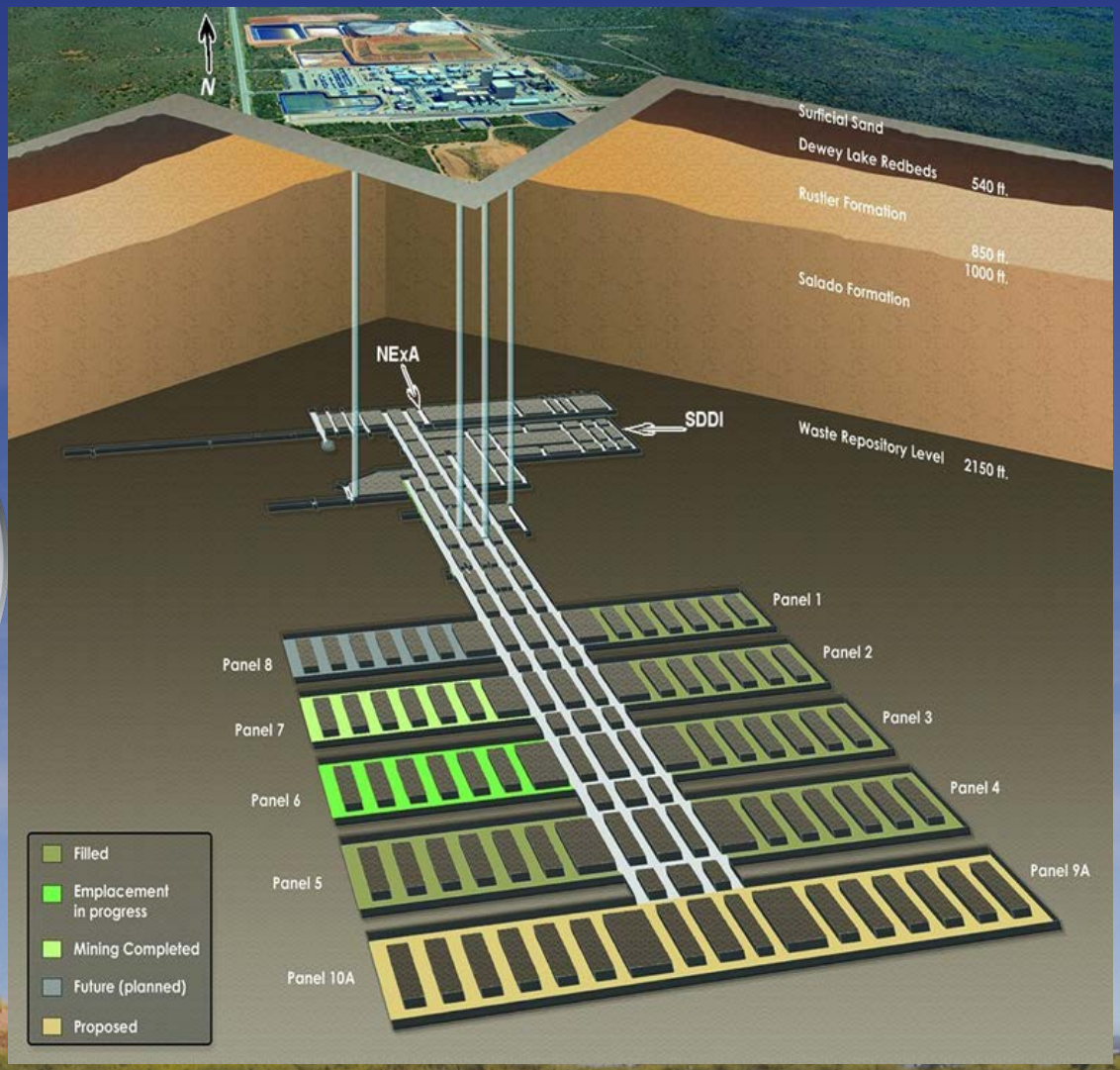
WIPP: A national solution



WIPP is *currently* the world's only *operating* deep geologic repository for permanent isolation of radioactive waste

Lessons Learned re: Disposal of Remote Handled Waste

- In-wall borehole disposal is not efficient
  - One canister is emplaced in an operation that takes ten to twelve hours from receipt to emplacement
  - Equipment size dictates excavation size
  - Slowness of emplacement operations and size of equipment blocks access to drift for contact-handled waste disposal purposes, causing boreholes to be passed over and go unused
- On the floor disposal in dedicated rooms enhances operational simplicity and efficiency

Emplacement Experience at WIPP

Remote Handled waste shipping casks are received in a horizontal position at WIPP

Rotation

Waste canisters pulled from shipping cask behind shield doors and placed into shielded facility cask for handling

Rotation

In the underground, the facility cask is removed from the hoist and transported to a disposal room by a 41-ton fork lift

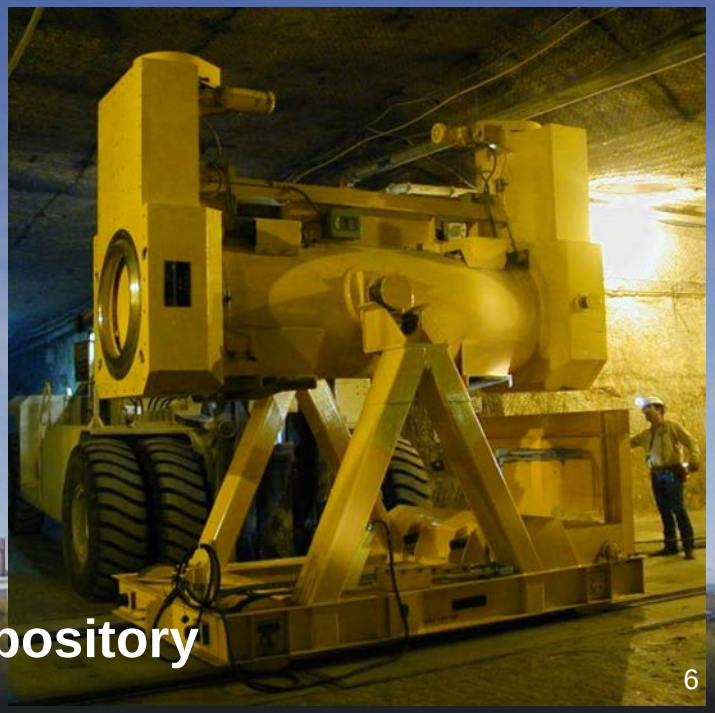
Large, complex, heavy and hard to maintain equipment

RH waste in the canister is emplaced in pre-drilled boreholes in disposal room walls, and a concrete shield plug is inserted afterwards

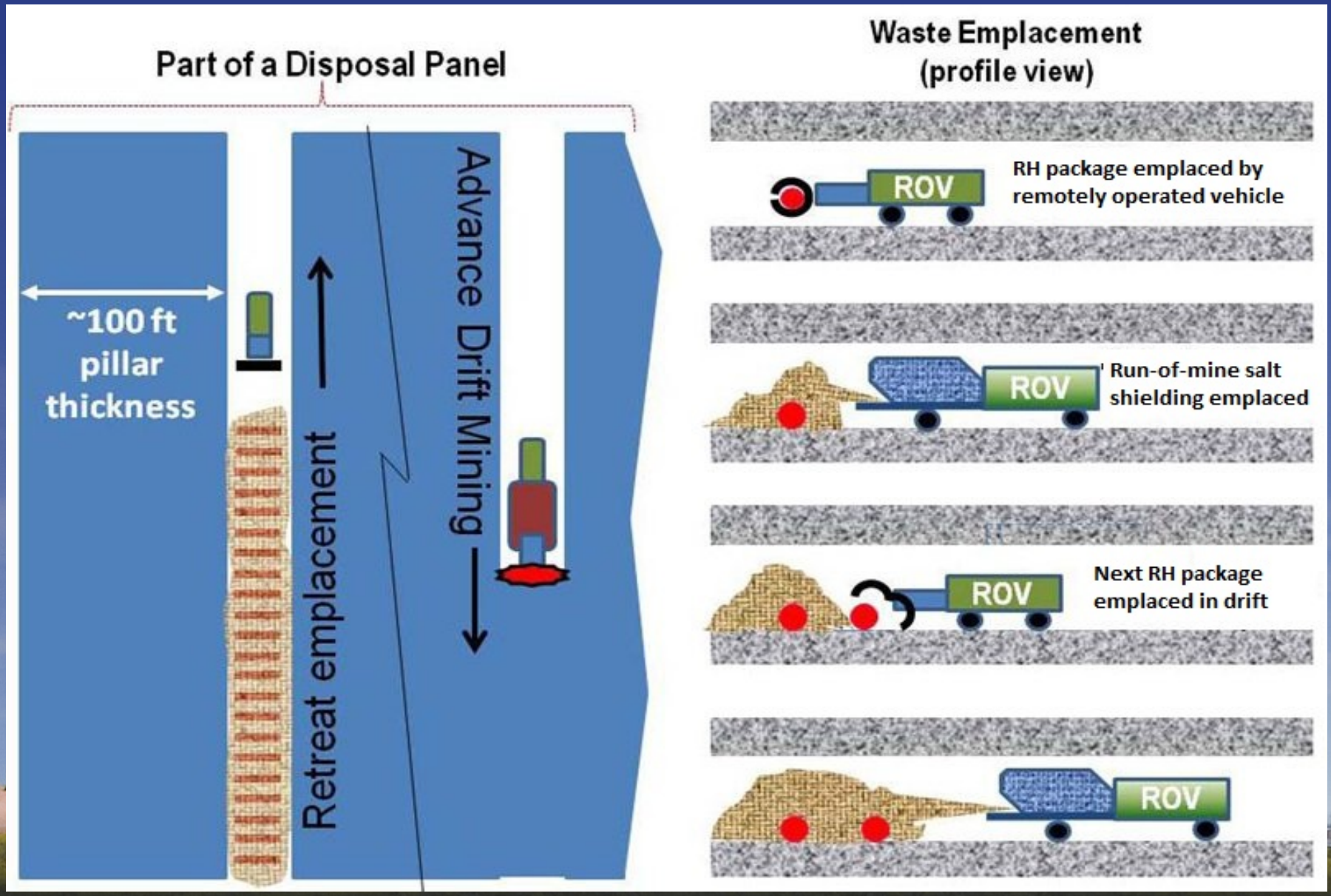
RH & CH Waste Compete for Disposal Resources

Lessons Learned from WIPP

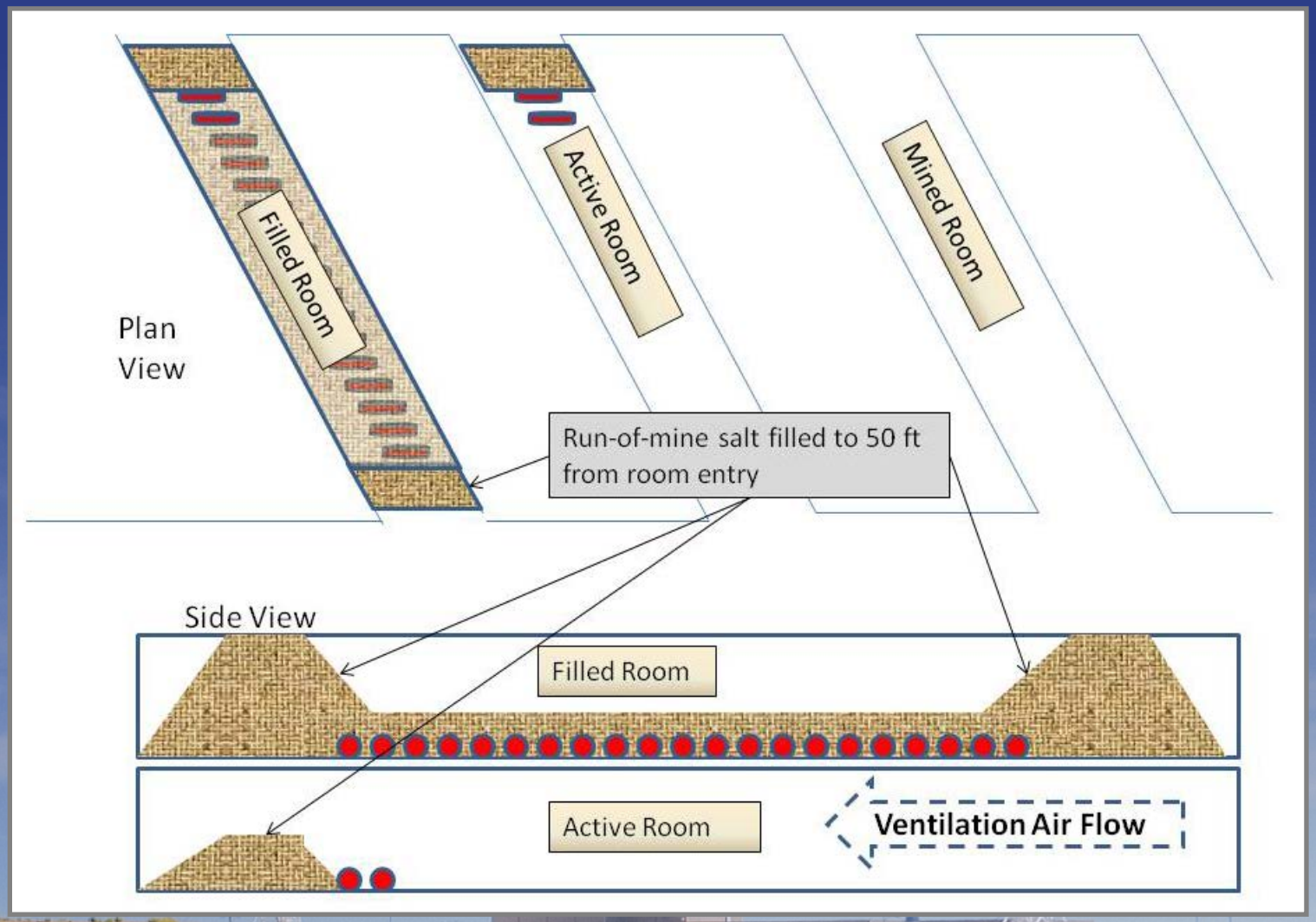
- **Preferable to have a basic waste handling concept**
  - Unload/transport shielded waste in single (horizontal) orientation
  - Eliminate RH placement in walls or vertically in floor
  - Emplace RH on floor unshielded, backfill with run-of-mine salt
  - Accept that “retrieval” of thermally hot and highly radioactive waste would be possible, but difficult
- **Basic mining approach**
  - Minimal mining
    - Single pass when possible
    - Angled entries
    - Narrow disposal rooms
  - Minimum roof support
    - Just-in-time mining
    - Maintain mains
  - Mine and emplace in same portion of repository



In-Drift Emplacement Concept



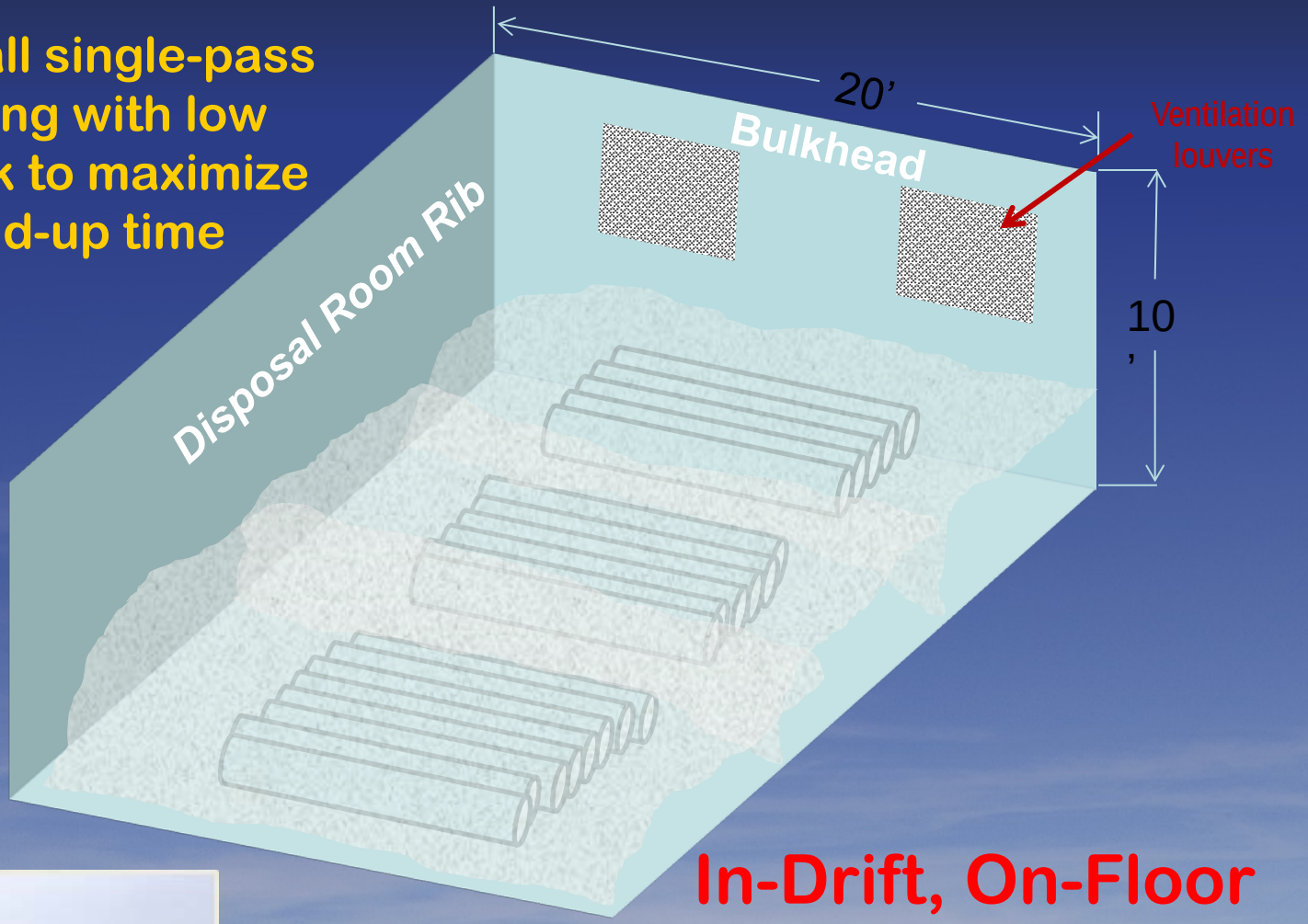
Emplacement and Closure Concept



Emplacement concept adapted from Carter, J.T., C. Redmell, B. Robinson, and E. Kehrman. 2012. *Defense Waste Salt Repository Study*. DOE Office of Nuclear Energy Report FCRD-UFD-2012-000116.

Click on the screen to start animation

Small single-pass mining with low back to maximize stand-up time



RH canisters emplaced by ROV and Run-Of-Mine Salt For Shielding

In-Drift, On-Floor Emplacement Concept in Dedicated RH-Only Panel

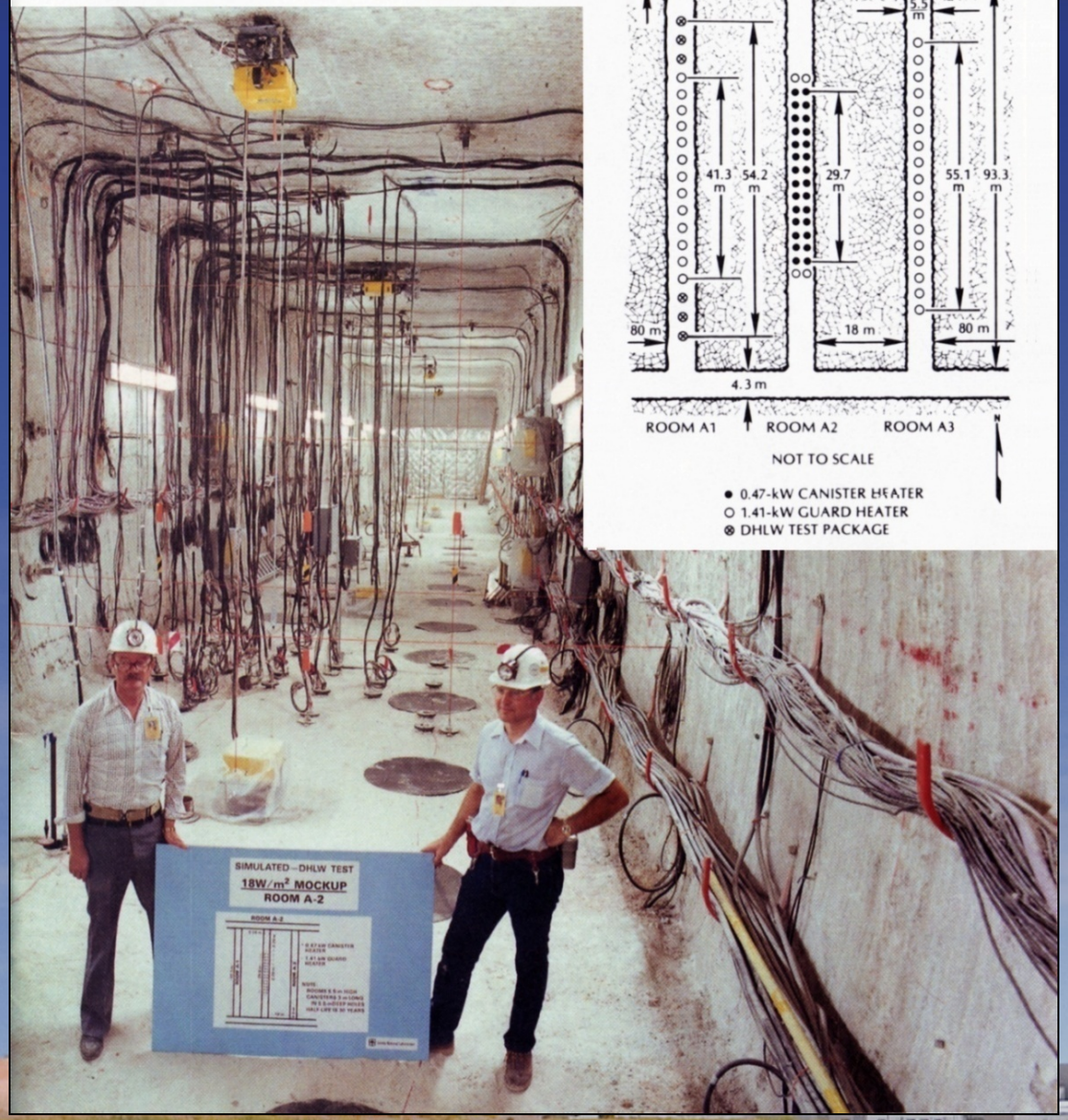
Experience Leads to Further Design Optimization Insights

- Example design insight from WIPP experience
  - It may be useful to perform an engineering trade study on retreat emplacement on a whole-repository basis rather than just a panel basis, as done currently
    - Mains shorten with time
    - Panels can be permanently sealed as they are filled
    - But . . .
    - Initial extent of excavations may be a larger early investment
    - Flexibility for future expansion or major design changes may be reduced

Lesson Learned re: Past "Generic" Heater Tests

- In-floor borehole disposal invokes processes that can be mitigated
  - Sets up steep and very localized temperature and pressure gradients
  - Promotes migration of brine down pressure gradients
- In-floor borehole disposal for large, heavy packages is physically difficult and inefficient
  - Determines height and width of disposal rooms
  - Requires heavy, complex, shielded equipment to set containers upright and lower them into holes

1987



WIPP: surrogate for RW's Deaf Smith County site for high-level waste & used nuclear fuel

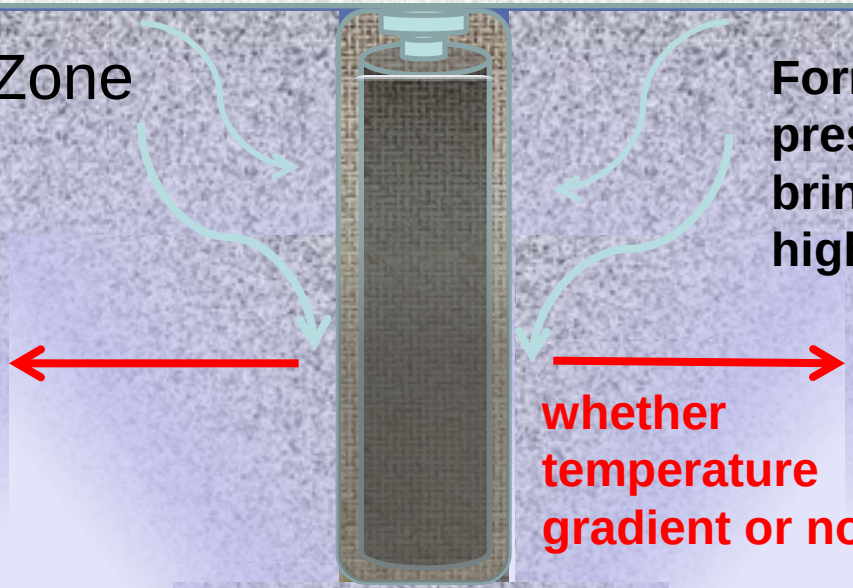
- Vertical borehole emplacement
- 18 W/m^2
- Coupons, brine, temperature monitored
- Peak temperatures never reached
- Tests terminated abruptly
- Limited post-test forensic examinations completed

1980's heater tests in WIPP focused on vertical borehole in-floor emplacement concept

Ventilation Air Flow

Through Open Drift

Disturbed Rock Zone



Formation pressure drives brine towards higher porosity

whether temperature gradient or not

Intact Salt

Intact Salt

Conclusions

- WIPP experience has two components:
  - Emplacement of remote handled waste in horizontal boreholes yielded direct insight into a potentially more efficient, simpler, and intrinsically safe emplacement scheme
  - Past experimental work has yielded insights into processes stimulated by high heat and pressure gradients, and how these gradients can be reduced
- Both experiences suggest that hot, higher radioactivity wastes can be disposed of safely and efficiently on a drift floor with run-of-mine salt and worker distance as shielding