U.S. Department of Energy
Office of Civilian Radioactive Waste Management

YUCCA MOUNTAIN PROJECT

Flexible Repository Design and Thermal Operating Conditions

Presented to:
Nuclear Waste Technical Review Board

Presented by:
Woody Stroupe
Special Projects
Bechtel SAIC Company, LLC.

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Outline

- **Need for Design Flexibility**
- **Flexible Design Approach**
- **Approach to Addressing Thermal Operating Conditions**
- **Summary**

Need for Flexible Repository Design

- **Design flexibility is needed to be prepared for**
  - **Variability in the characteristics of the incoming waste stream**
  - **Variability in the waste receipt schedule**
  - ***Selection of the repository thermal load***
  - **Variability in natural system processes**
  - **Variability in funding profiles**

Flexible Repository Design Approach

- **Repository design includes**
  - **Fixed engineering parameters**
    - **Drift spacing and drift diameter**
  - **Thermal design criteria**
  - **Variable operating parameters**
    - **Ventilation duration**
    - **Ventilation flow rate**
    - **Waste package spacing**
    - **Aging quantity and duration**
    - **Waste package loading**
- **Achieve design flexibility by varying operating parameters**

Approach to Addressing Thermal Operating Conditions

- **Initially select operating parameters assuming that the Total System Performance Assessment for License Application will analyze a higher temperature repository**
- **This approach will not preclude closing in a cold mode by adjusting only the amount of fuel aged, the aging duration, and/or the ventilation rate and/or duration**
- **Subsequent decisions will be informed by results of ongoing tests, analyses, and modeling**

Events that are Decision Points for Thermal Operating Conditions

Decision	License Application (Note 1)	Construction Authorization	Construct Aging Pad 1	Construct Aging Pad N (Note 2)	Receive & Possess	Construct Panel 1 (Note 3)	Emplace Panel 1	Construct Panel N	Emplace Panel N	Timing for Closure (Note 4)
Target Thermal Operating Mode (TOM)	Half pillar<96° C	Reevaluation Opportunity	Reevaluation Opportunity	Reevaluation Required	Reevaluation Required for aging (Note 5)	Reevaluation Opportunity	Reevaluation Required (Note 5)	Reevaluation Opportunity	Reevaluation Required (Note 5)	Reevaluation Required
Engineering Parameters Drift Spacing Drift Diameter	 81 meter 5.5 meter	Reevaluation Opportunity	Reevaluation Opportunity	Reevaluation Opportunity	Reevaluation Opportunity	Reevaluation Opportunity	Done	Reevaluation Opportunity	Done	Done
Operating Parameters WP Spacing, average Ventilation Rate Ventilation Duration Aging Duration and Amount	 2 meter 15 CMS Sufficient to achieve TOM Sufficient to achieve TOM Based on estimated waste stream	Reevaluation Opportunity			Decisions now based on actual waste stream and selected TOM		WP spacing and drift thermal load based on actual waste stream and selected TOMs for post closure simulation testing		Aging and WP spacing, based on actual waste stream and selected TOM	Ventilation duration based on actual loading and selected TOM; all other variables now fixed

Key:

	Target for License Application (preliminary)
	Decision does not affect construction or operation yet
	Decision affects construction and/or operation
	Decision is made either consciously or by default at the time this event occurs

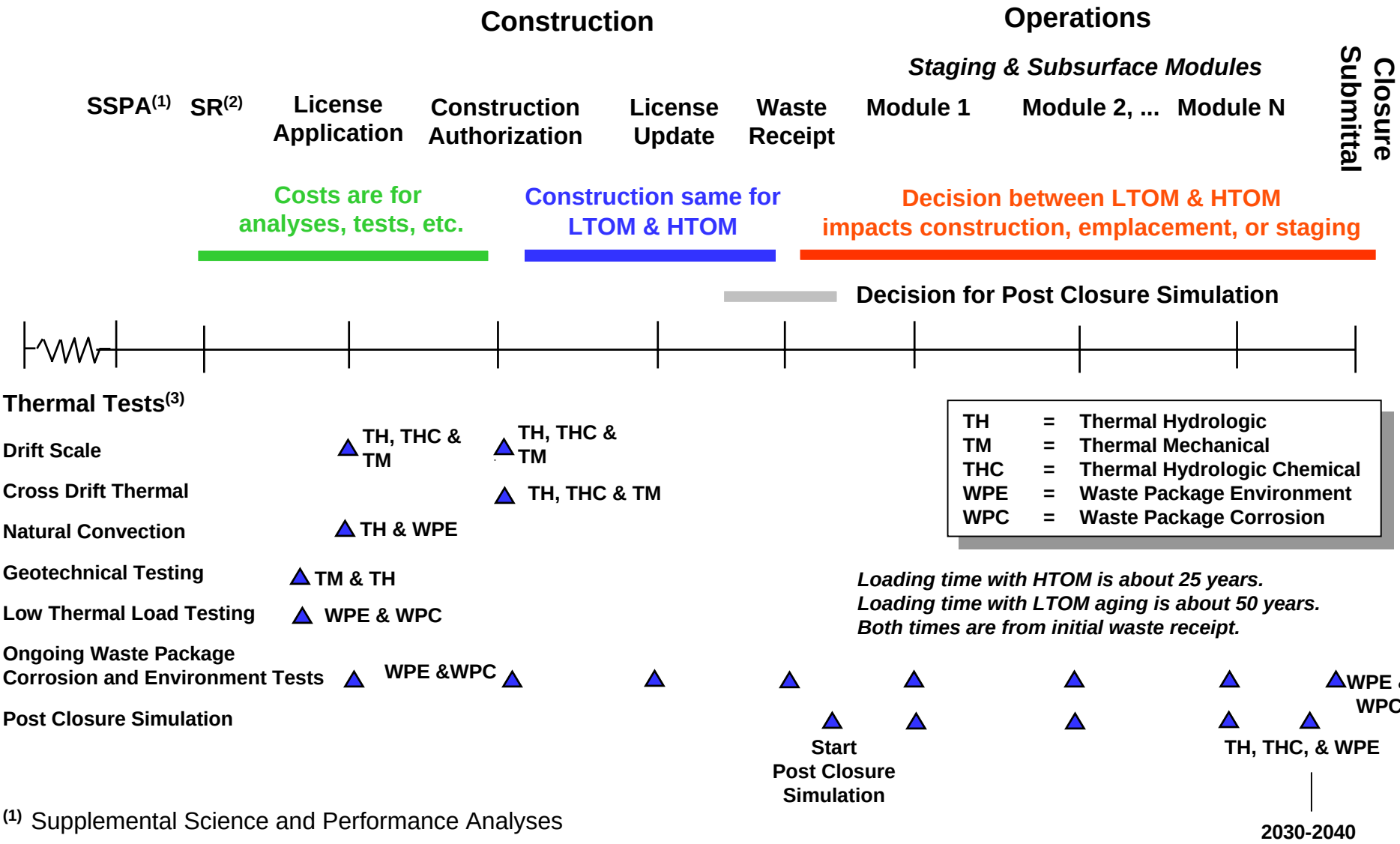
Notes:

1) These preliminary parameters subject to change when conceptual design studies complete.
2) Table assumes that some aging will be also required for a high TOM.
3) Panel I includes a postclosure simulation test.
4) Physically loading hot "precludes" reasonable cold operations (> 300 years of ventilation).
5) Must decide on aging.

Testing to Support Decisions on Thermal Operating Conditions

- **The following tests will provide a stronger technical basis for decisions on thermal operating conditions**
  - **Drift-Scale Thermal Test**
  - **Cross-Drift Thermal Test**
  - **Natural Convection Test**
  - **Geotechnical Tests**
  - **Low Thermal Load Testing**
  - **Waste Package Corrosion and Environmental Tests**
  - **Postclosure Simulation Test**

Availability of Thermal Test Results



(1) Supplemental Science and Performance Analyses

(2) Site Recommendation

(3) Times shown are for completion of tests, not completion of analyses

Thermal Operating Conditions for License Application Update Submittal

- **Thermal operating mode will be selected, considering test results from**
  - **Final data from the cool-down phase of Drift-Scale Heater Test and the Cross Drift Thermal Test**
  - **Natural Convection Tests that support validation of natural convection models used to predict environmental conditions in the near-field environment**
  - **Geotechnical Testing to provide enhanced understanding of the behavior of lithophysal rocks**
    - **Thermomechanical and time-dependent behavior**
    - **Thermal conductivity**
    - **Preclosure ground support specifications**
    - **Postclosure drift degradation and rockfall estimates**

Thermal Operating Conditions for License Application Submittal

(Continued)

- **Thermal operating mode will be selected, considering test results from**
  - **Low Thermal Load Testing**
    - **Improved technical understanding and analytical tools to model postclosure behavior of the Engineered Barrier System**
      - » **Replace the 85° Celsius value with a temperature range and corresponding uncertainties**
  - **Waste Package Environment Tests**
    - **Enhanced understanding of the range of anticipated environments and associated uncertainties**
  - **Waste Package Corrosion Tests**
    - **Enhanced experimental data on passive dissolution, localized corrosion, and environmentally assisted cracking**

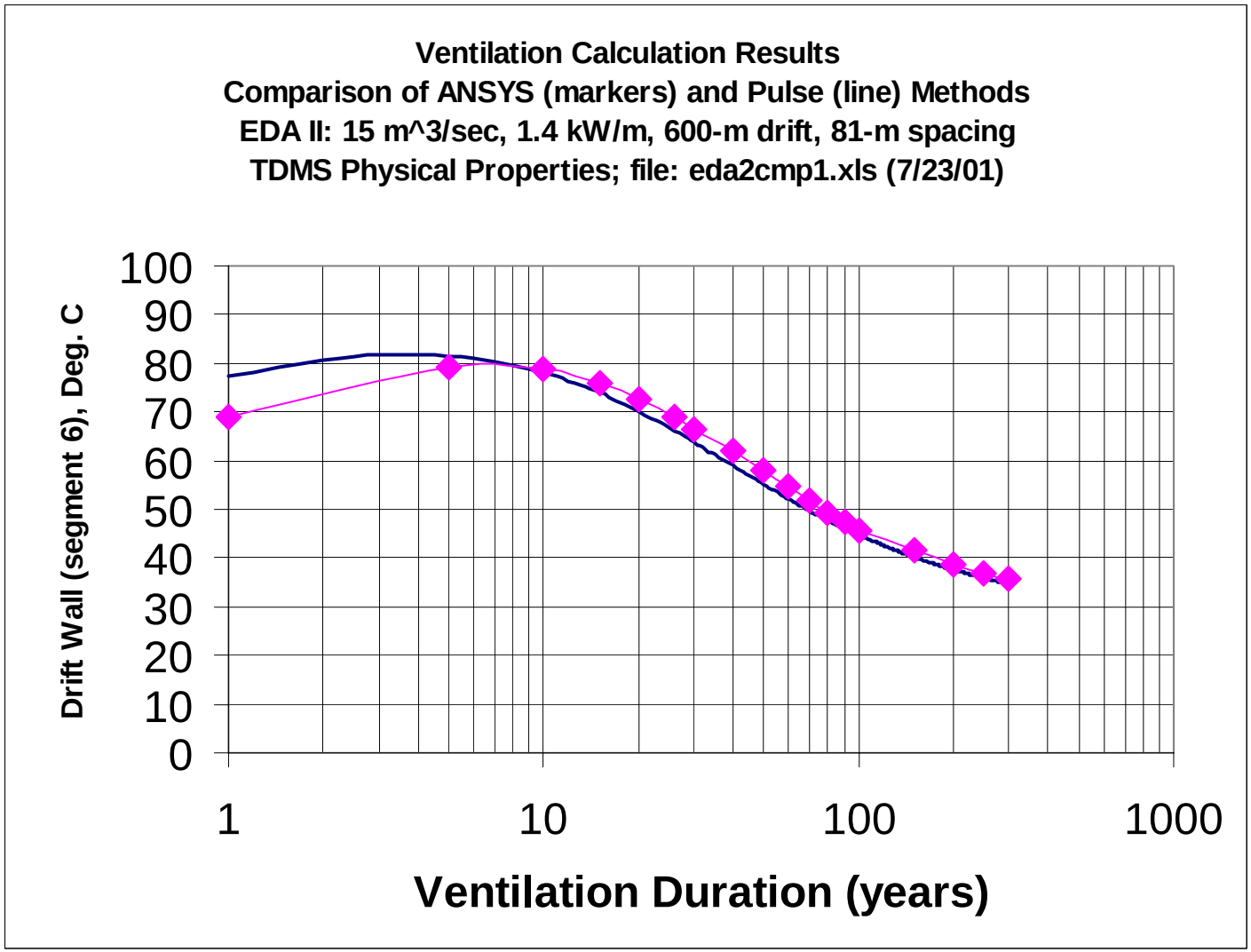
Summary

- **The repository design is flexible**
- **This approach preserves the ability to improve the design, using new information and evolving technology**
- **This approach also provides the opportunity to make informed decisions on postclosure thermal conditions at appropriate times during preclosure operations**

Backup

“Fast” Ventilation Calculation

- **The technical approach embodies *no new heat transfer equations/concepts*, essentially the same as existing Q work**
- ***The only things that have changed* are how the equations are solved, and how waste package power(s) are handled**
- **Work in progress on Q documentation**


Ventilation Calculation Results
Comparison of ANSYS (markers) and Pulse (line) Methods
EDA II: 15 m^3/sec, 1.4 kW/m, 600-m drift, 81-m spacing
TDMS Physical Properties; file: eda2cmp1.xls (7/23/01)
Drift Wall (segment 6), Deg. C
100
90
80
70
60
50
40
30
20
10
0
1
10
100
1000
Ventilation Duration (years)

“Fast” Ventilation Calculation

- **Applied mathematics and engineering resulted in improvements**
  - **Superposition greatly speeds up calculating the temperature response of the mountain (drift wall)**
  - **Use of the concept of a series of well-mixed volume elements from text-book literature**
  - **Linearization of radiant heat transfer**
  - **Fitting the waste-package power to a sum of three decaying exponentials (easy to “read” and interpret)**

“Fast” Ventilation Calculation
(Continued)

- “Runs” in seconds for forced/natural ventilation calculations
- Can run 6 segments (100 meters each), or 60 segments (10 meters each)
- Can investigate sensitivities quickly (heat transfer coefficients, air flow rates, emissivities)
- Can investigate rock-mass variability (thermal conductivities)