YUCCA MOUNTAIN PROJECT

Studies

# Engineered Barrier Design

Presented to:
Nuclear Waste Technical Review Board

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Office of Civilian Radioactive
Waste Management

# Design Goals for the Engineered Barrier System

- **Engineered Barriers**
  - **Work in concert with natural site features**
  - **Not adversely impact natural barriers**
  - **Consist of multiple barriers to**
    - » **Delay failure of the waste package**
    - » **Delay release of radionuclides from waste package**
    - » **Mitigate effects of radionuclide release**

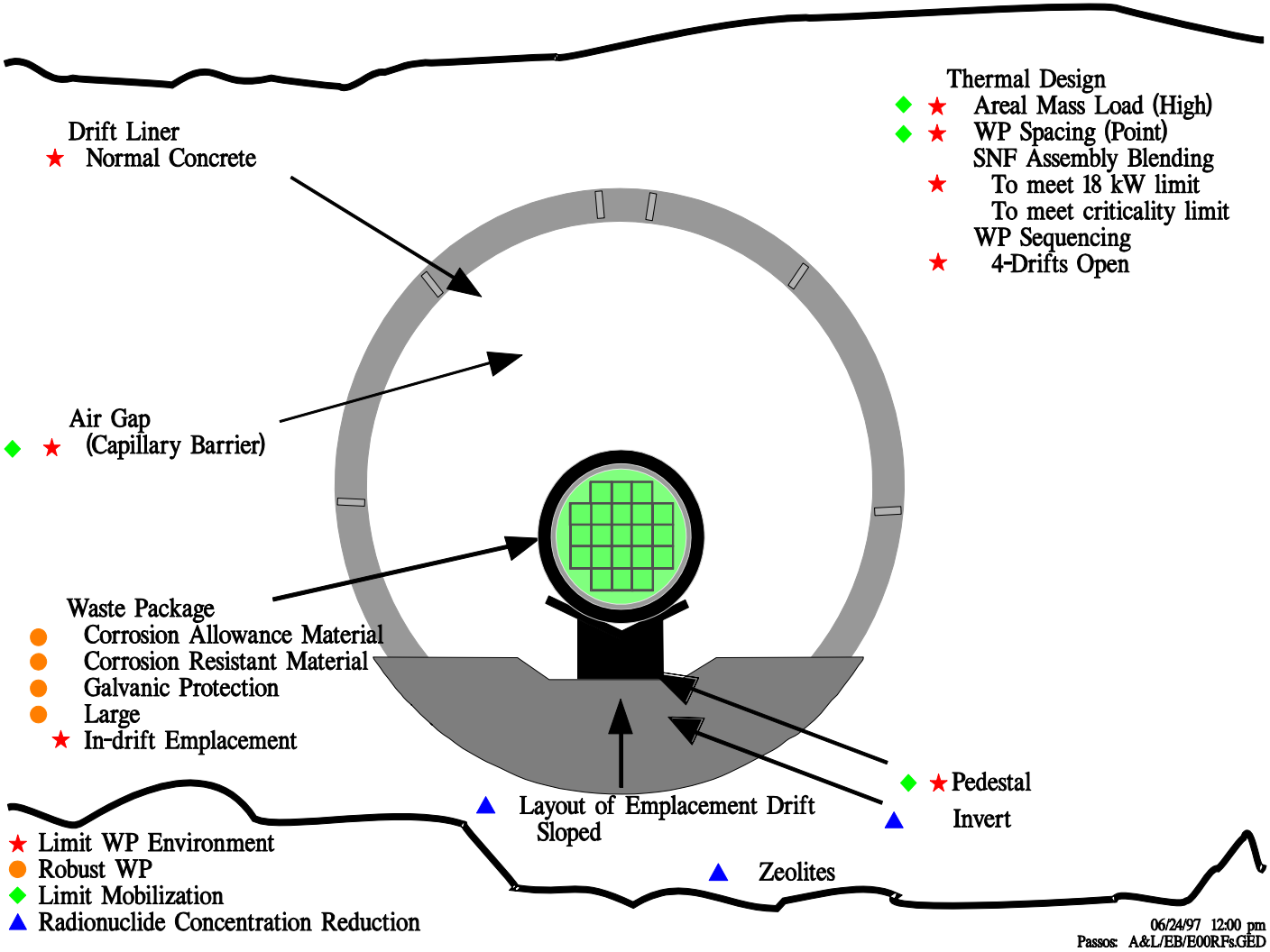
# Engineering Goals for the EBS

- **Meet Preclosure Requirements**
  - **Packaging**
  - **Handling**
  - **Storage**
  - **Closure**
- **Develop a design that provides acceptable performance for the expected postclosure case**
- **Use multiple barriers to improve confidence in the engineered system performance considering**
  - **Uncertainties in natural processes**
  - **Uncertainties in response of design features**

# Design Inputs for TSPA Evaluation

- **Subsurface Layout**
  - **Drift size and spacing**
  - **Thermal load**
  - **Support and ventilation system**
- **Engineered Barrier System**
  - **Invert materials**
  - **Packing and backfill materials**
  - **Flow diversion**
- **Waste Package**
  - **Size and thermal load**
  - **Materials and fabrication technique**

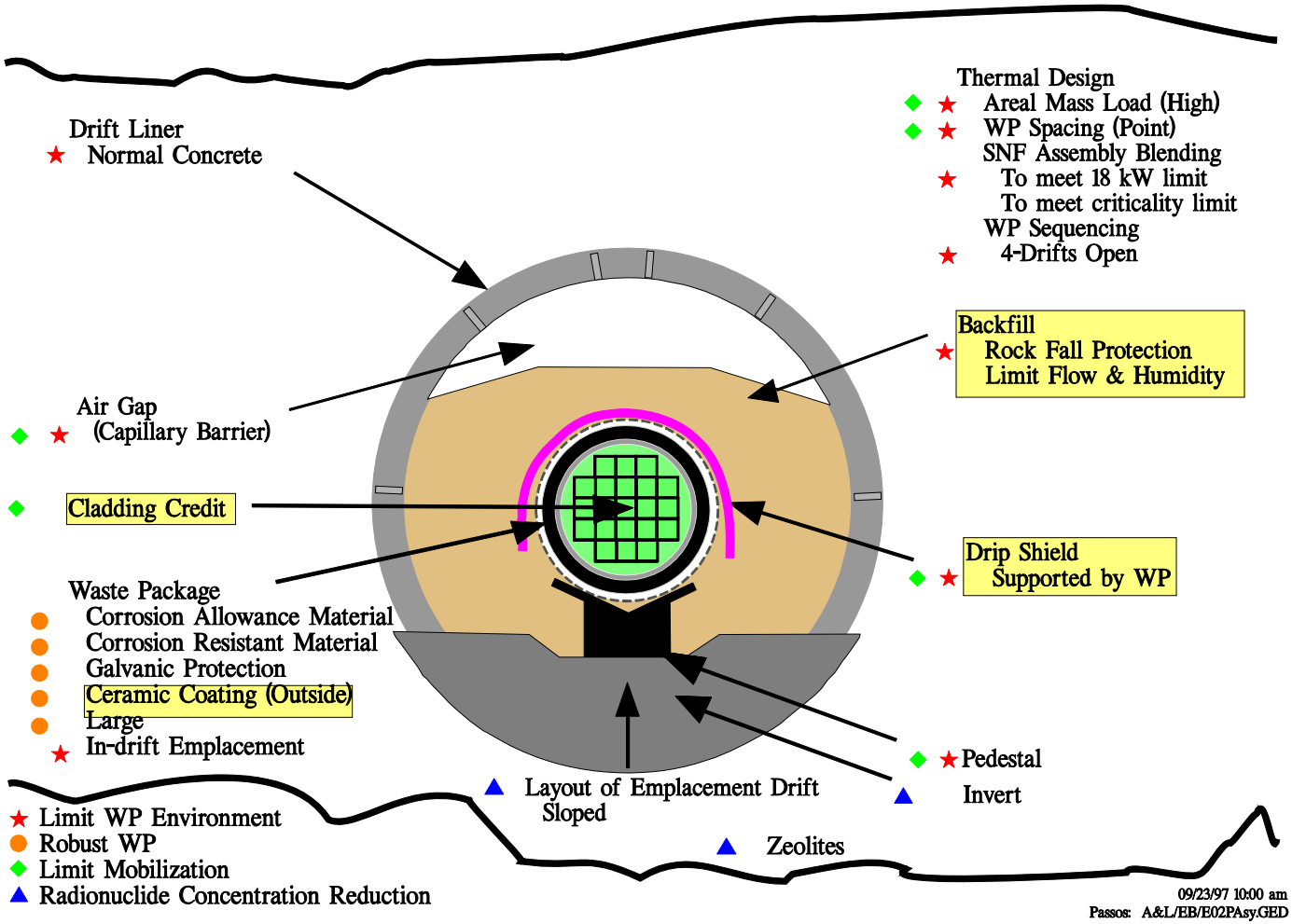
# Design Options for Waste Isolation (Reference Design)



# Assumptions and Uncertainties For The Reference Case

- Seepage into drifts
- Seepage onto waste packages
- Waste package surface relative humidity/temperature time histories
- Waste package degradation
  - Corrosion allowance material
  - Galvanic protection
  - Corrosion resistant material
- Radionuclide solubility
- Transport through the waste package
- Transport through the invert

# Design Options for Waste Isolation (Reference Design)



# Uncertainties Addressed By Options

| Assumptions/Uncertainties | Options That Reduce Uncertainties |
|---|---|
| Seepage into Drifts | Ceramic Coating, Drip Shield Backfill |
| Seepage onto Packages | Ceramic Coating, Drip Shield Backfill |
| Drift Thermo-hydrologic Response | Ceramic Coating, Drip Shield Backfill |
| Waste Package Degradation | Ceramic Coating, Alternate Materials |
| Radionuclide Solubility | Cladding |
| Transport Through the Waste Package | Drip Shield |
| Transport Through the Invert | |

# Assumptions and Uncertainties for the Options

- **Cladding**
  - **Failure; pinhole, unzip, mechanical, corrosion**
  - **Initial conditions at emplacement**
- **Ceramic Coating**
  - **Long term permeability**
  - **Mechanical integrity**
  - **Failure modes**
- **Drip Shield**
  - **Waste package interaction**
  - **Ceramic issues**
- **Backfill**
  - **Thermal conductivity**
  - **Seepage and wicking**

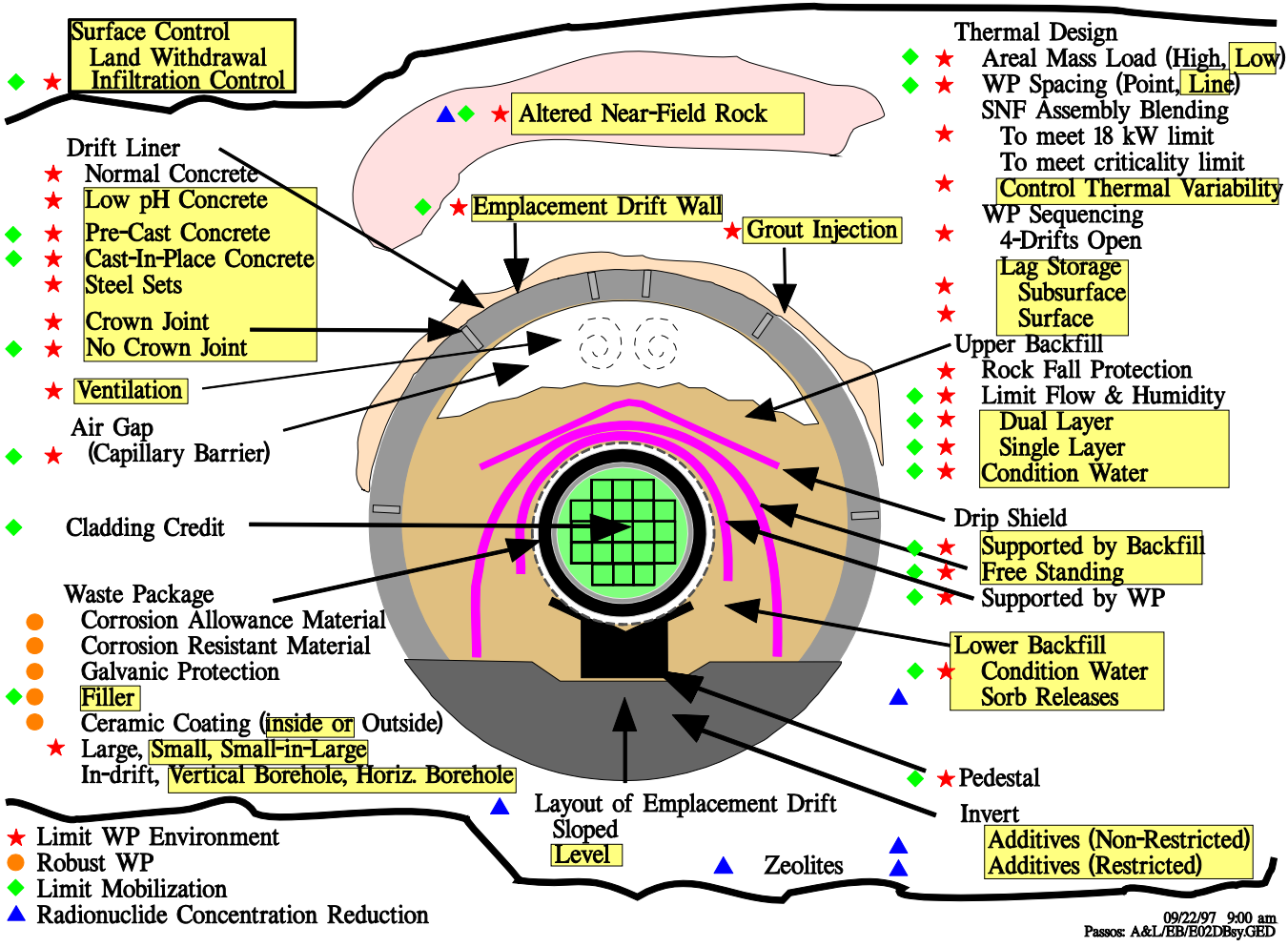
# Strategy for EBS Defense in Depth

- **Develop design features for the expected case to provide desired performance**
- **Systematically evaluate options for design features that could be used to improve performance**
  - **Use performance tools to analyze performance contributions**
  - **Evaluate sensitivities to low probability events/processes**
- **Systematically evaluate performance sensitivities to identify data uncertainties**
  - **Document design features/options with regard to the effects of data uncertainties**

# Strategy for EBS Defense in Depth
**(continued)**

- **Systematically evaluate performance sensitivities to identify uncertainties in design feature/options response**
  - **Document the design features/options with regard to the effects of uncertainties of their response**
- **Select appropriate design features to improve performance by desired amount and offset effects of major data uncertainties**

# Design Options for Waste Isolation



# Design Features Evaluation Matrix

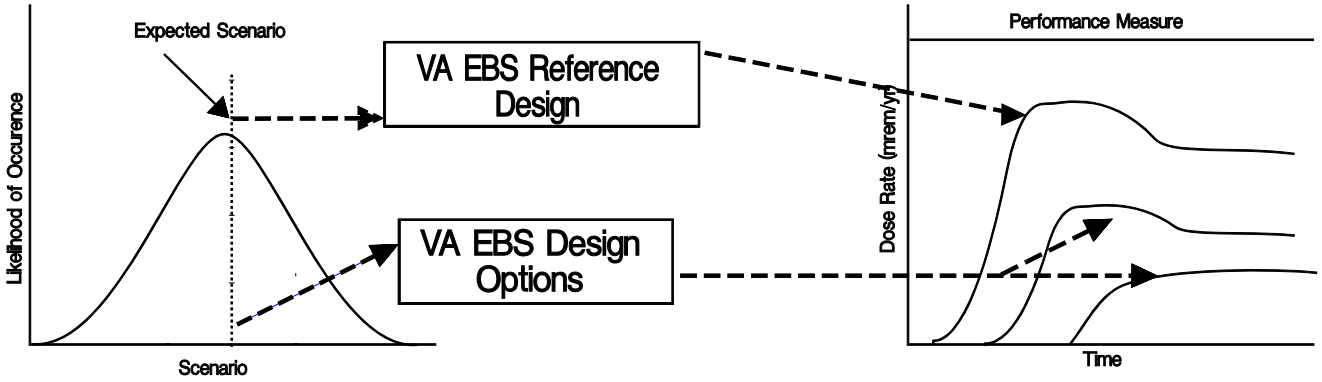
| | POST-CLOSURE GOALS | | | POST-CLOSURE ENVIRONMENTS | | | |
|---|---|---|---|---|---|---|---|
| **Engineered Features** | **Delay breach of WP** | **Prolong time from WP breach to waste release** | **Mitigate release from EBS** | **Waste Flux** | **Relative Humidity** | **Chemistry** | **Rockfall & Drift Collapse** |
| cladding credit | | X | | X | | X | X |
| corrosion resistant material | X | Y | | X | | X | X |
| corrosion allowance material | X | Y | Y | X | X | X | X |
| galvanic protection | X | | | X | Y | X | |
| ceramic coating | X | | | X | X | X | Y |
| filler | | X | | X | | X | Y |
| large package | X | | | | Y | | |
| small package | | | Y | | | | |
| small-in-large-package | | X | | | Y | | |
| pedestal | X | | | X | | | |
| invert additives (non-restricted) | | Y | X | | | X | |
| invert additives (restricted) | | Y | X | | | X | |
| backfill | X | Y | Y | X | X | Y | X |
| rock fall protection | X | Y | Y | X | X | Y | X |
| limit flow & humidity | X | Y | Y | X | X | Y | X |
| Dual Layer | X | Y | Y | X | X | Y | X |
| Single Layer | X | Y | Y | X | X | Y | X |
| condition water | X | Y | Y | X | X | Y | X |
| sorb releases | X | Y | Y | X | X | Y | X |
| drip shield | X | | | X | Y | | |
| supported by backfill | X | | | X | Y | | |
| free standing | X | | | X | Y | | |
| supported by WP | X | | | X | Y | | |
| air gap | X | | | X | | | |
| drift liner | Y | | | X | | | |
| crown joint | Y | | | X | | | X |
| no crown joint | Y | | | X | | | X |
| normal concrete | | Y | Y | | | Y | X |
| low PH concrete | Y | Y | Y | | | X | X |
| pre-cast concrete | Y | Y | Y | | | Y | X |
| cast-in-place concrete | Y | | Y | | | Y | X |

# Design Features Evaluation Matrix
## (continued)

| | POST-CLOSURE GOALS | | | POST-CLOSURE ENVIRONMENTS | | | |
|---|---|---|---|---|---|---|---|
| Engineered Features | Delay breach of WP | Prolong time from WP breach to waste release | Mitigate release from EBS | Waste Flux | Relative Humidity | Chemistry | Rockfall & Drift Collapse |
| ventilation | Y | | | Y | Y | | |
| grout injection | Y | Y | | X | | | X |
| areal mass load - high | X | | | X | X | | |
| areal mass load - low | X | | | Y | | | |
| WP spacing - point load | X | | | | Y | | |
| WP spacing - line load | X | Y | | Y | Y | | |
| SNF assembly blending | X | Y | | Y | X | | |
| to meet 18kW limit | X | Y | | Y | Y | | |
| to meet criticality limit | X | Y | | Y | Y | | |
| control thermal variability | X | Y | | Y | Y | | |
| WP sequencing | X | Y | | Y | Y | | |
| 4 drifts open | X | Y | | Y | Y | | |
| lag storage | X | Y | | Y | Y | | |
| subsurface | X | Y | | Y | Y | | |
| surface | X | Y | | Y | Y | | |
| surface control | X | | | X | | | |
| land withdrawal | | | | | | | |
| infiltration control | X | | | X | | | |
| emplacement drift | | | | | | | |
| sloped | | | | | | | |
| level | | | | | | | |
| zeolites | | | | | | | |
| in drift emplacement | Y | | | Y | Y | | |
| vertical borehole | | | | | | | |
| horizontal borehole | | Note: "X" indicates primary function of feature; | | | | | |
| | | "Y" indicates a secondary function of the feature | | | | | |
| | | | | | | | |

# EBS DESIGN DEVELOPMENT STRATEGY

## VA Design Focus




## LA Design Focus