YUCCA MOUNTAIN PROJECT

Studies

High Temperature Enhanced Design Alternatives

Presented to:
Nuclear Waste Technical Review Board
Panel for the Repository

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Waste Management

High Temperature EDA Goals

- **Drive water away from the EBS/WP for as long as practicable**
  - **Water must shed, be removed in ventilation, or be imbibed in rock matrix**
- **Avoid extended periods of warm, moist conditions (80°C < TWP < 100°C, RHWP > 90%)**
- **Have long term performance even if one or two barriers are compromised**
- **Have capacity within the primary area for all waste**
- **Limit cost**

High Temperature Design Approach

- **Limit drift wall temperature to limit ground support loads**
  - **Preclosure ventilate to just below limit (200°C in CDA, 225°C probably viable)**
  - **Blending and line loading produce more uniform temperatures along the drifts**

High Temperature Design Approach - 2

- **Remove water from the system**
  - **Drive near field > 100°C to mobilize water**
  - **Extend superheat and/or reflux region several to many drift diameters, creating a large dry volume**
  - **Limit temperatures such that mobilized water can shed before pillars reach above-boiling temperatures**
  - **Use postclosure ventilation to move additional or new water to the footprint periphery**

High Temperature Design Approach - 3

- **Avoid seepage of new percolation flux while WPs are hot by:**
  - **Designing such that pillars cool below boiling before the flux integral exceeds mobilized water volume, or**
  - **Designing such that the repository footprint sheds water around its overall periphery**

High Temperature Design Approach - 4

- **Limit WP temperature to not exceed cladding limit of 350°C for extended periods**
  - **Preclosure ventilate to just below limit for design basis WPs**
  - **If backfilling, delay closure until WP thermal power has decayed**

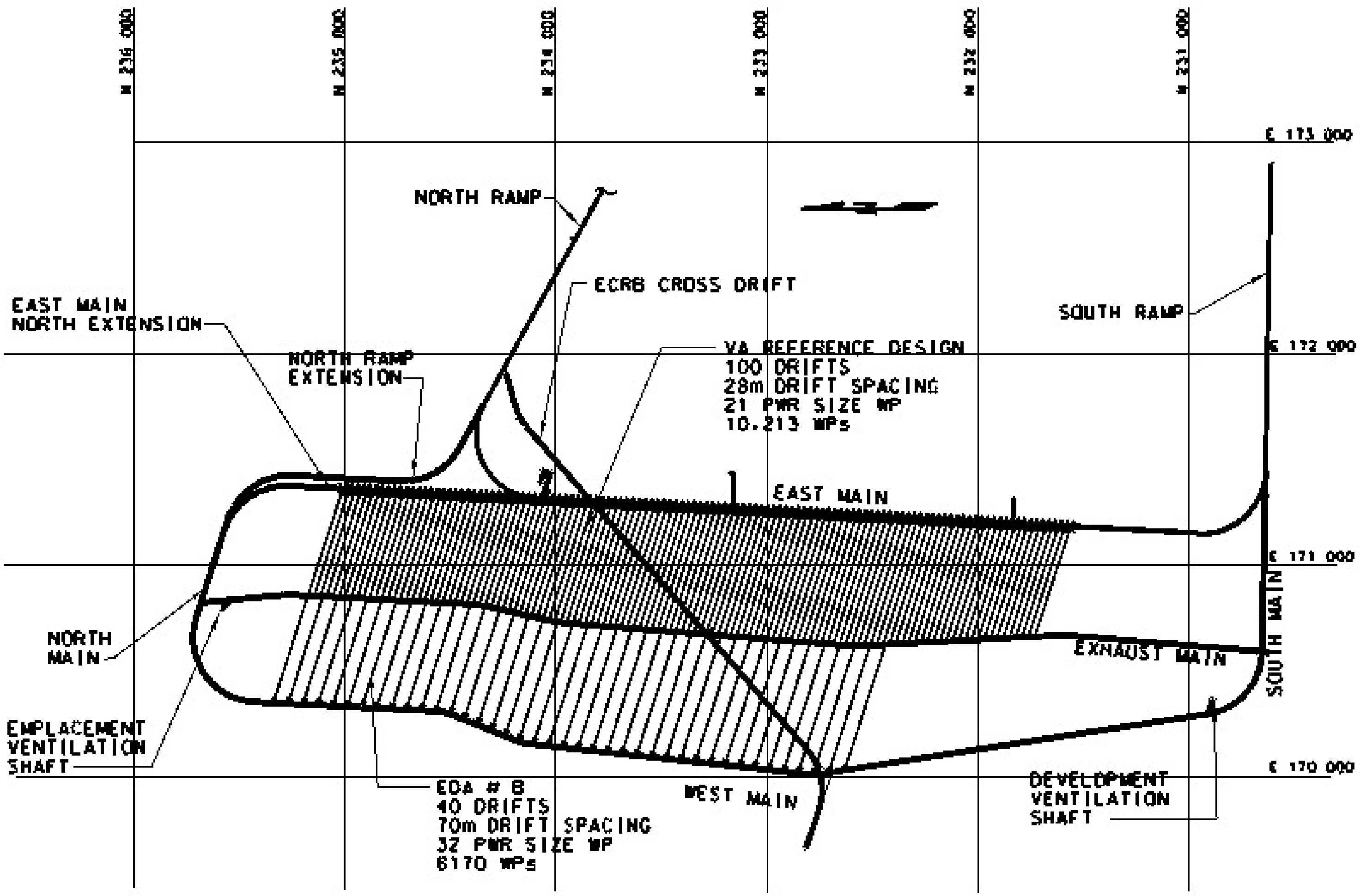
High Temperature Design Approach - 5

- **Allow zeolites to exceed 90°C for another 100 m of depth (to 270 m below repository horizon)**
  - **North end will lose zeolites, but will have a large remaining amount**
  - **South end's zeolites are largely below that depth**

High Temperature EDA Concept Summary

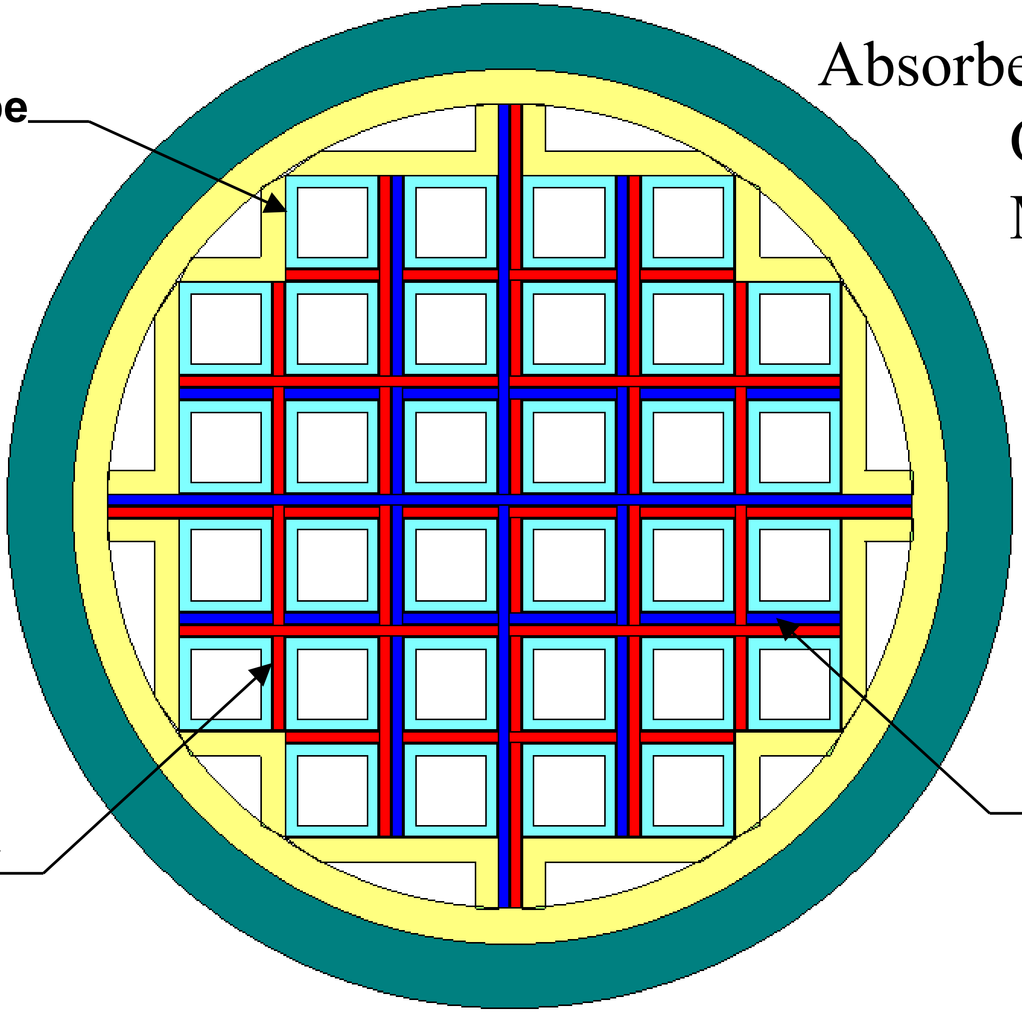
	85 MTU/ac Line Load	150 MTU/ac Line Load	170 MTU/ac Bowtie postclosure Ventilation
Area (acres)	~800	~400	~400 (WP region) ~800 in footprint
# of Drifts/WPs	40/8170	40/8170	66/6740
Drift Spacing (m)	70	40	42
WP Capacity (w/i VA diameter & weight envelope)	32 PWR SNFAs	32 PWR SNFAs	42 PWR SNFAs consolidated in 21 PWR size WP
Preclosure Ventilation	Low	Medium	High
WP Materials	5.5 cm A-22 over 2 cm Ti-7		
Sealed Ceramic Coated Drip Shields	All WPs	Edge WPs	Would add DID
Backfill	Yes	No	No

85 MTU/acre Line Load



EDA # B - 85 MTU/ACRE, LINE LOAD, 32 PWR WPs

32 PWR SNFA WP



Absorber Plates Basket
OD = 1938 mm
Mass = 56 MT

Note: A 68 BWR SNFA WP is about the same diameter and weight

85 MTU/acre Line Load
Concept Description

- **Enhanced VA - Line Load , 85 MTU/acre**
  - Improved drip shield (ceramic coated)
  - Backfill
  - 32 PWR capacity dual CRM (Alloy-22/Ti-7) WPs (w/i VA thermal power, weight, and diameter envelopes), blending (to mean +50%)
  - Preclosure ventilation
  - Concrete invert and ground support

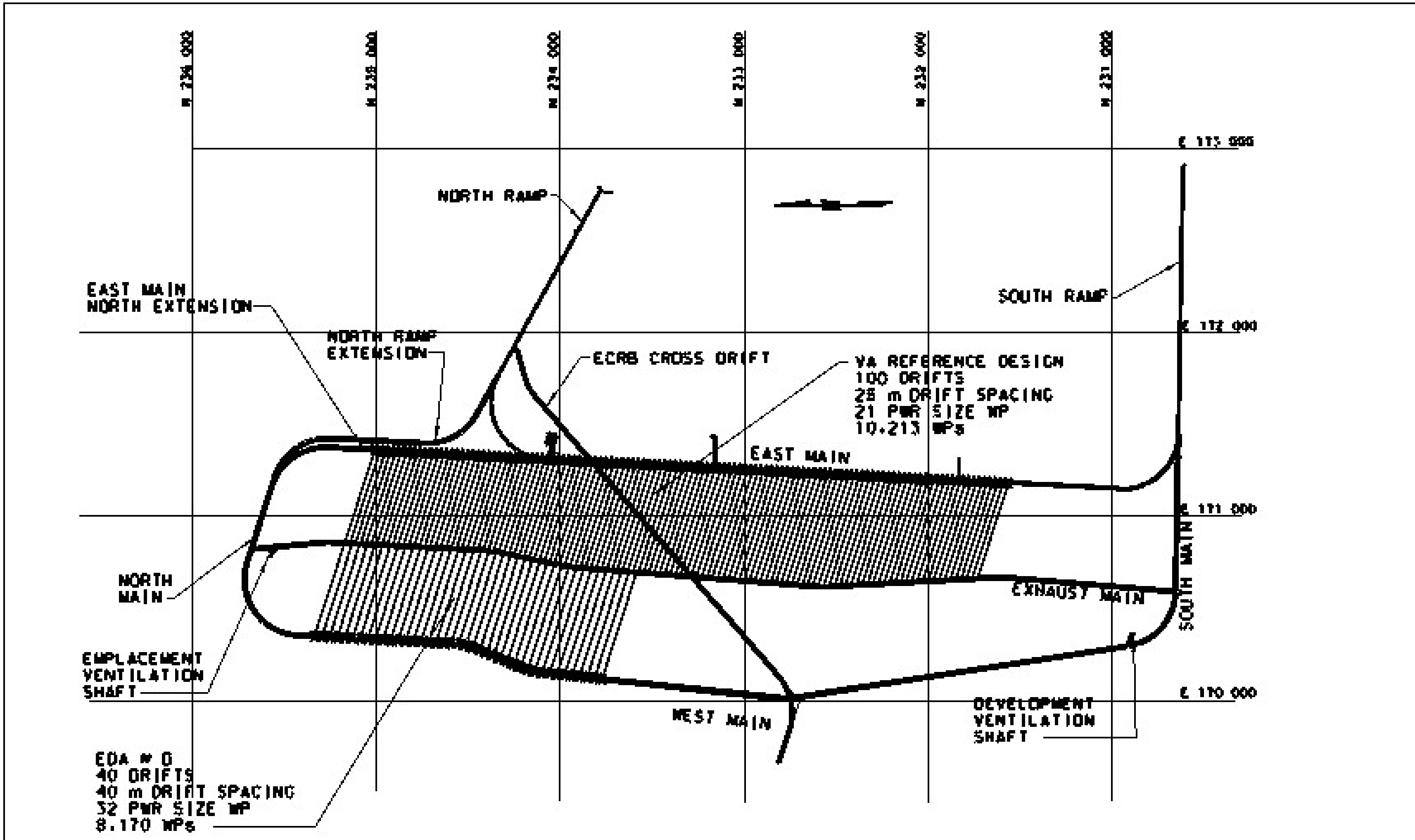
85 MTU/acre Line Load
50 yr closure approaches

- **Install backfill**
  - **Accept pinholes in cladding of highest thermal power WPs, or**
- **Do not install backfill**
  - **Make case that rock fall on drip shield, WP, or even ceramic coated component does not reduce performance as much as clad pinholes**

85 MTU/acre Line Load Implementing Feature Dependence

- **Integral**
  - **Preclosure ventilation to limit peak temperatures (DF7)**
  - **Line load to reduce cost and levelize temperatures (DF12)**
- **Other**
  - **Start with VA (DA6)**
  - **Improved drip shield (sealed ceramic on substrate) and backfill for DID (DFs1/2/3)**
  - **Blend to preserve thermal goals (DF4)**
  - **Delay closure beyond 50 yr to improve performance (DFs9/10)**
  - **Improved WP for DID (DF14)**
  - **Concrete invert for sorption (DF17)**
  - **Higher capacity WP to reduce WP cost w/o increasing subsurface costs**

150 MTU/acre Line Load



EDA # D - 150 MTU/ACRE, LINE LOAD, 32 PWR WPs

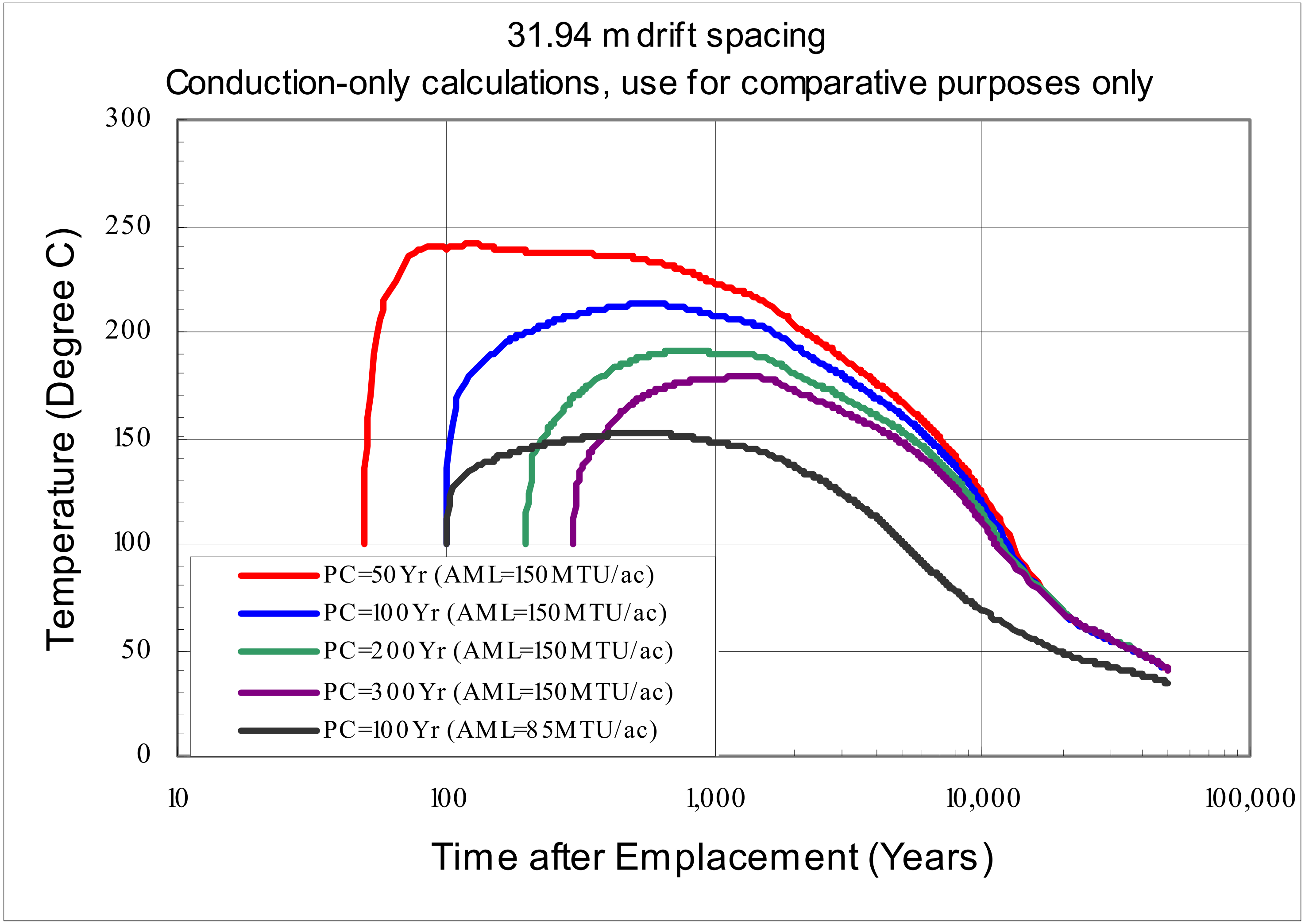
150 MTU/acre Line Load Concept Description

- High AML (120-170 MTU/acre, 150 is shown) line load
  - Preclosure ventilation (keep pillars below boiling for centuries, maintain clad < 350°C forever)
  - Increase edge load/protection (e.g., closer drift spacing on N & S edges and/or ceramic-coated drip shields on edge WPs)
  - Dual CRM (Alloy-22 over Ti-7) WP
  - 32 PWR capacity WPs (w/i VA thermal power, weight, and diameter envelopes), blending
  - Concrete invert and ground support

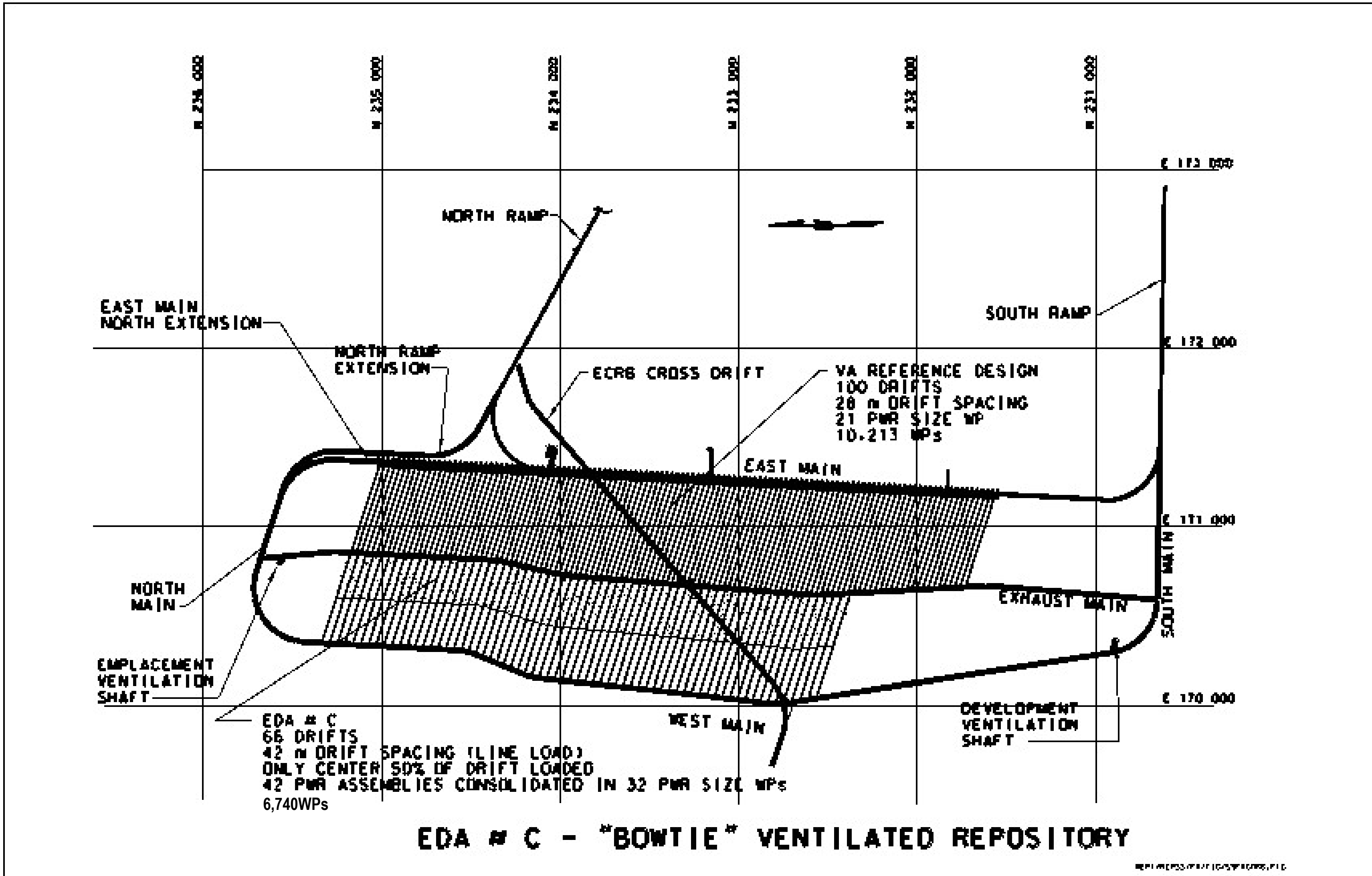
150 MTU/acre Line Load Implementing Feature Dependence

- **Integral**
  - Preclosure ventilation to limit peak temperatures and allow shedding of mobilized water (DF7)
  - Line load to maximize use of inventory heat and increase available repository capacity (DF12)
- **Other**
  - Improved drip shield (sealed ceramic on substrate) to protect edge WPs from seepage during the thermal pulse (DFs1/2)
  - Blend to preserve thermal goals and early shedding of mobilized water (DF4)
  - Delay closure beyond 50 yr improves performance (DFs9/10)
  - Improved WP for DID (DF14)
  - Concrete invert for sorption (DF17)
  - Higher capacity WP to reduce WP cost w/o increasing subsurface costs

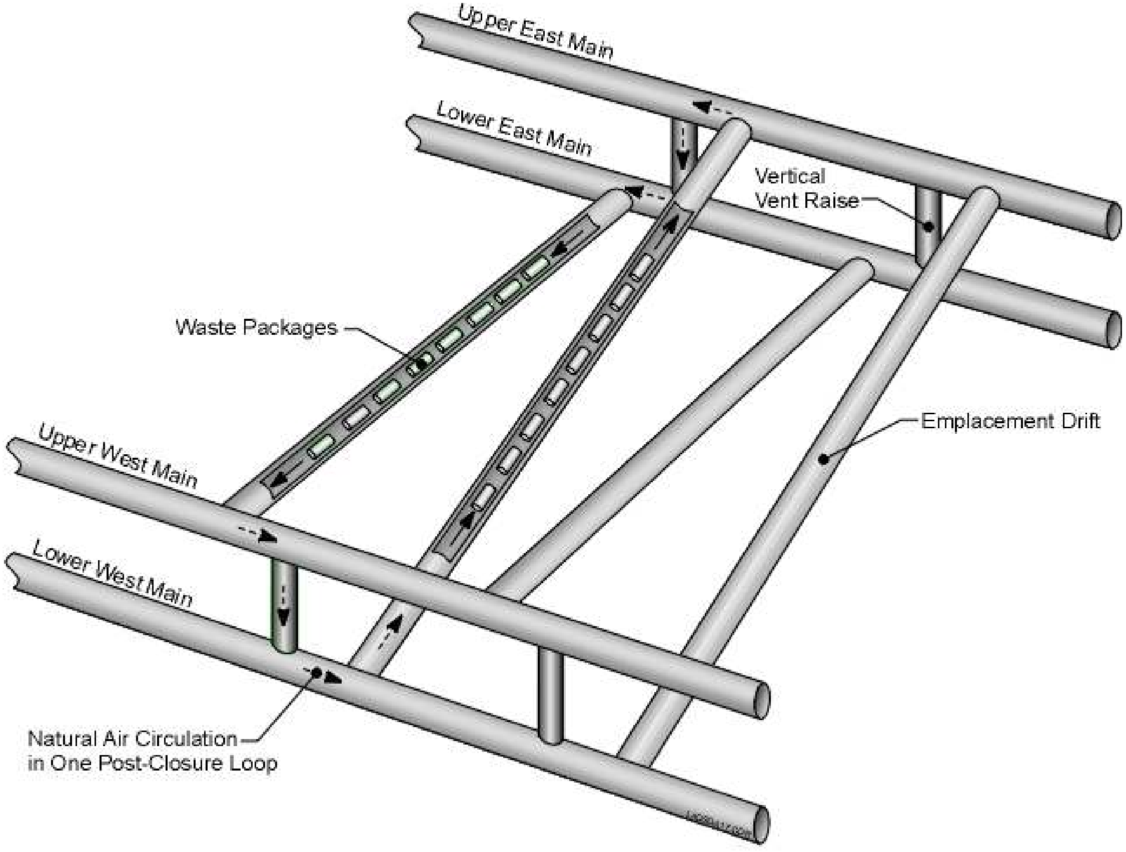
150 MTU/acre Line Load Drift Wall Temperatures



170 MTU/acre Bowtie Postclosure Ventilation



170 MTU/acre
Bowtie Postclosure Ventilation



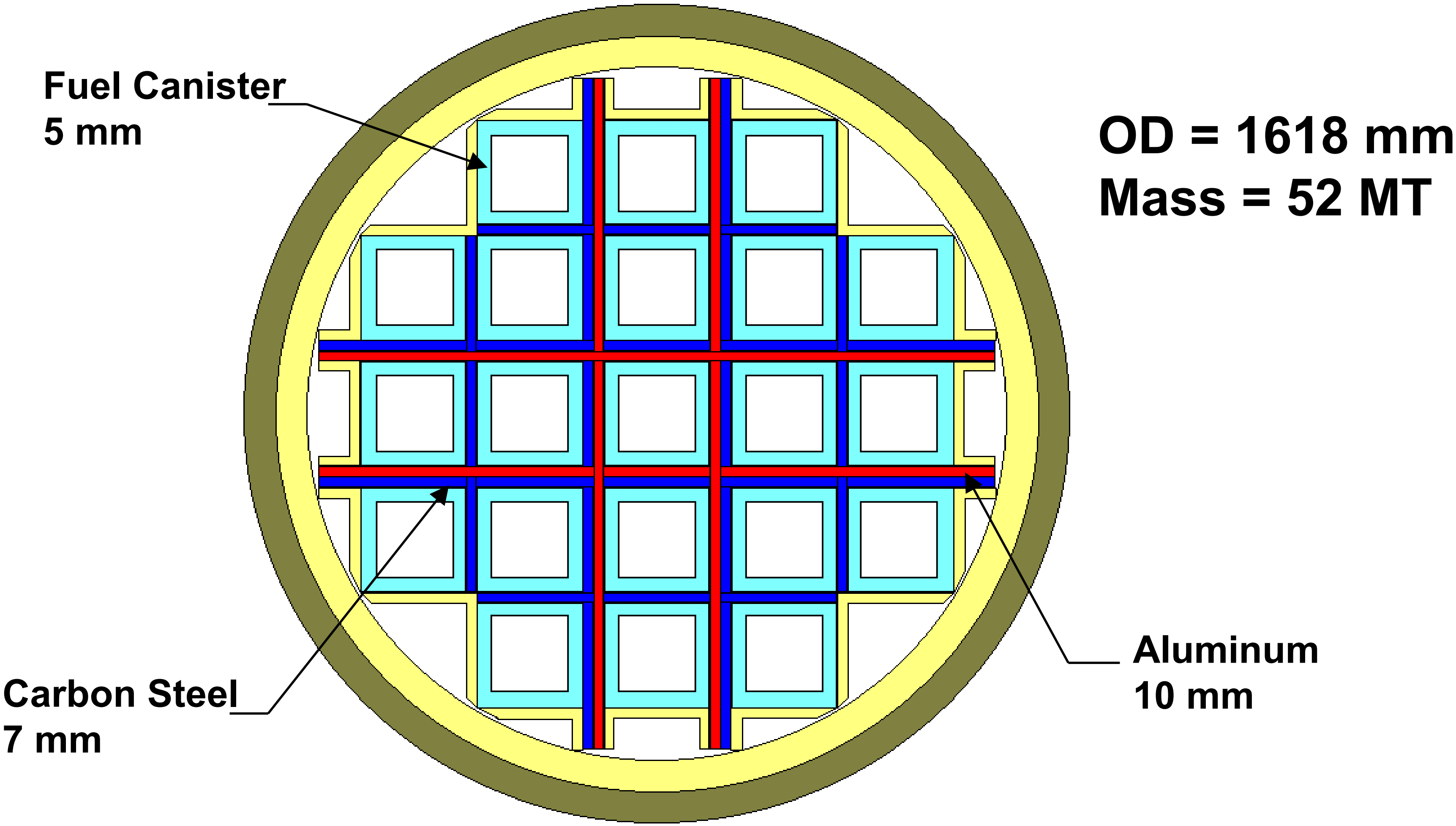
Vertical separation ~ 30 m

Drift slope ~ 3%

WPs and drifts are not to scale

Danko (Bow Tie) Concept

42 PWR SNFA Consolidated Fuel WP



Note: Each fuel canister holds rods from two PWR SNFAs

170 MTU/acre Bowtie Postclosure Ventilation Concept Description

- **Postclosure ventilation**
  - Bowtie layout (line load at >170 local MTU/acre, footprint average is 85 MTU/acre)
  - Preclosure ventilation
  - Rod consolidation at utilities (42 PWRs in 21 PWR-size WP - w/i VA size/weight envelope)
  - Dual CRM (Alloy-22/Ti-7) WP, blending at utilities
  - Concrete invert and ground support

170 MTU/acre Bowtie Postclosure Ventilation Implementing Feature Dependence

- **Integral**
  - **Postclosure ventilation to remove heat and water for a long time (DA3)**
  - **Preclosure ventilation to limit peak temperatures (DF7)**
  - **Line loading to increase thermal load (DF12)**
- **Other**
  - **Blending to preserve thermal goals (DF4)**
  - **Rod consolidation to increase heat source for ventilation (DF8)**
  - **Improved WP for DID (DF14)**
  - **Concrete invert for sorption (DF17)**
  - **Higher capacity WP to reduce WP cost w/o increasing subsurface costs**

Summary

- **Three high temperature designs have been developed as candidate EDAs**
- **Calculations to determine compliance with the high temperature design approach have begun**
  - **The 85 MTU/acre line load is based on VA calculations and LADS phase I calculations**
  - **Initial results for the 150 MTU/acre line load are promising**
  - **Initial results for the 170 MTU/acre Postclosure Ventilation case are promising (using 21 PWR WPs)**
- **Phase II calculations will be more comprehensive and evaluate each aspect of the design approach**