PRE-CLOSURE SAFETY ANALYSIS: SENSITIVITY STUDIES AND PRELIMINARY DOSE RESULTS

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DISCLAIMER

The NRC staff views expressed herein are preliminary and do not constitute a final judgment or determination of the matters addressed or of the acceptability of a license application for a geologic repository at Yucca Mountain.

OUTLINE

- **Purpose**
- **Background**
- **Event Sequences**
- **Work Description**
- **Results**
- **Conclusions**

PURPOSE

Present NRC's scoping pre-closure safety analysis of operations at the potential Yucca Mountain (YM) repository surface facilities

- **Present a preliminary evaluation of the potential source term from spent nuclear fuel (SNF) under normal and accident conditions**
- **Present a consequence analysis of the evaluated source term in terms of preliminary dose to the worker and the public**
- **Present sensitivity study results of the preliminary dose calculations**

BACKGROUND

- **The U.S. Department of Energy's (DOE's) design, construction, and operation of a permanent high-level waste (HLW) repository at the potential YM site:**

  - construction and operation (pre-closure period)
  - long-term waste isolation (post-closure period)

- **Present an assessment of radionuclide releases from a dry transfer building during the pre-closure period**

- **Note: NRC's scoping analyses were conducted prior to DOE's announcement to implement a canister-based approach**

EVENT SEQUENCES

- **Event sequences potentially leading to radioactive release from the dry transfer building: Normal Operations, Category 1 (Cat 1), or Category 2 (Cat 2)**

- **Analyze radionuclide releases from the event sequences**

EVENT SEQUENCES (Continued)

(Uncanistered SNF)

- **During Normal Operations**

  - **some SNF rods may arrive at YM with breached cladding**
  - **SNF pellets in rods with breached cladding may oxidize in air**

- **Cat 1 - in a dry transfer building, bare spent fuel assembly (SFA) may be damaged from drops or collisions**

- **Cat 2 - seismic event, mechanical impacts on SFAs and no credit for building containment of radionuclides**

WORK DESCRIPTION

- **The Pre-closure Safety Analysis (PCSA) Tool**

- **Consequence Analysis:**

  - an atmospheric radionuclide release (RSAC)
  - building discharge fractions (MELCOR)

WORK DESCRIPTION (Continued)

- *Generating the Source Term*

  - The materials at risk
  - Damage ratio: one
  - Release fraction (RF)
  - Leak path factor (LPF)
  - SNF conditions: PWR, 0.429 MTU [0.473 tons], 49 GWd/MTU [3.565×10^{12} Btu/ton], 4% enrichment, and 25 years decay

- *Materials at Risk Assumptions*

  - Oxidation: maximum 1% of rods arrive at YM with breached cladding
  - SFA or collision: two SFAs
  - Cat 2 mechanical impact: 100 PWR SFAs vulnerable at the time of the seismic event

WORK DESCRIPTION (Continued)

- ***Release Fraction***

Material at Risk	Release Fraction		
	Drop	Oxidation	Seismic
Tritium	0.3	0.3	0.3
Noble Gases	0.3	0.3	0.3
Iodine	0.3	0.3	0.3
Crud	0.15	0.15	0.15
Ruthenium	0.0002	0.002	0.0002
Cesium	0.0002	0.002	0.0002
Strontium	2.0E-06	1.2E-03	8.5E-06
Fuel Fines	2.0E-06	1.2E-03	8.5E-06

WORK DESCRIPTION (Continued)

- ***Leak Path Factor***

  - Product of Building Discharge Fraction and HEPA Filter Mitigation Factor

  - Normal Operations and Cat 1*:* radionuclides leave the building through a filtered ventilation system

  - Cat 2: no credit for building deposition or HEPA filtration

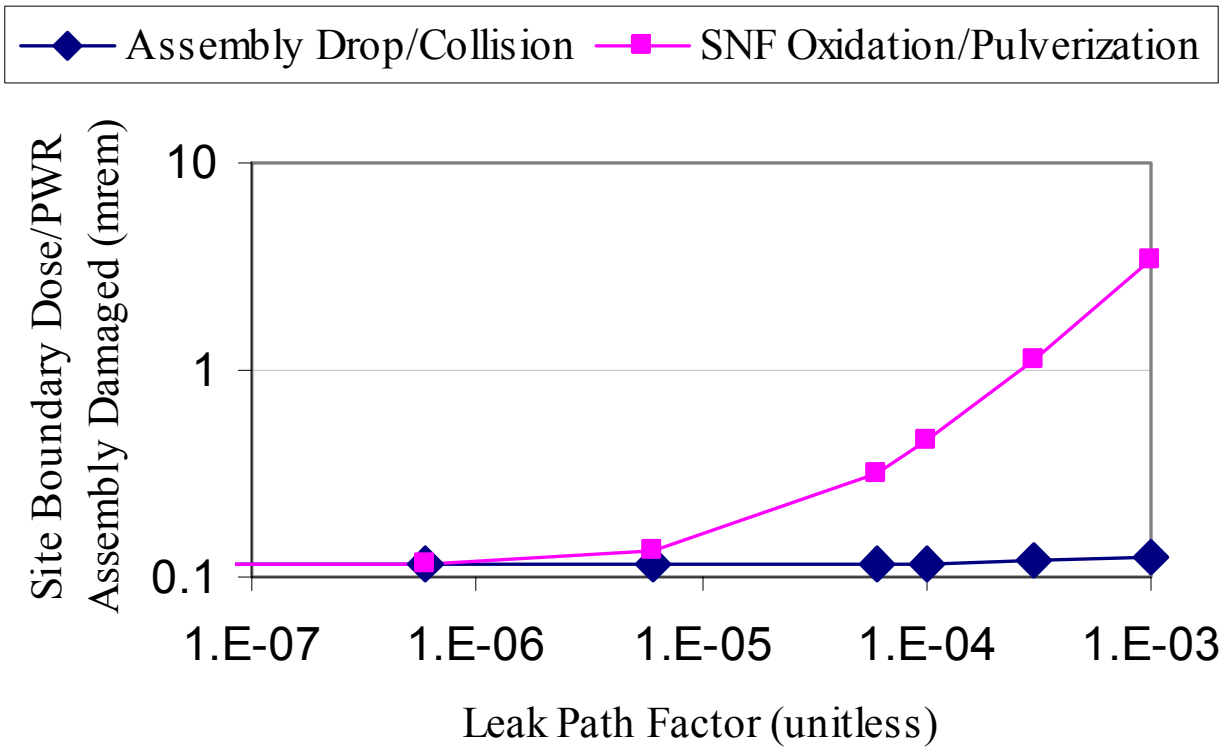
RESULTS

	Normal Operations	Cat 1	Cat 2
Release Height	30 m	30 m	Ground
Material at Risk	64 SFAs/yr	2 SFAs/yr	100 SFAs
Damage Ratio	1	1	1
RF_{Gas}	0.3	0.3	0.3
$RF_{Volatiles}$	2×10^{-3}	2×10^{-4}	2×10^{-4}
RF_{Crud}	0.15	0.15	0.15
RF_{Fines}	1.2×10^{-3}	2×10^{-6}	8.5×10^{-6}
LPF_{Gas}	1	1	1
LPF_{Crud}	3×10^{-6}	3×10^{-6}	1
LPF_{Others}	6×10^{-7}	6×10^{-7}	1

RESULTS (continued)

Dose results based on uncanistered SNF (100 mrem equals 1 mSv)

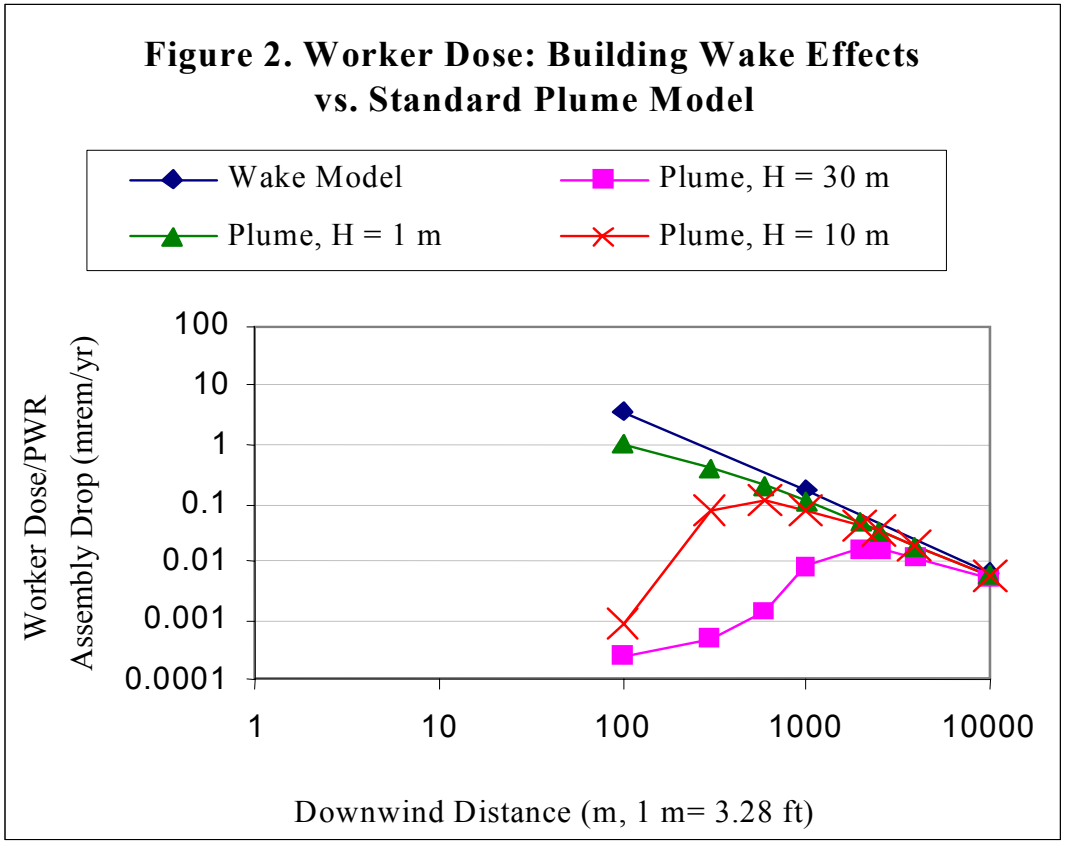
Figure 1- Dose at the Site Boundary
(11 km from release) (annual dose)



RESULTS (continued)

Dose results based on uncanistered SNF

Figure 2. Worker Dose: Building Wake Effects vs. Standard Plume Model



RESULTS (continued)

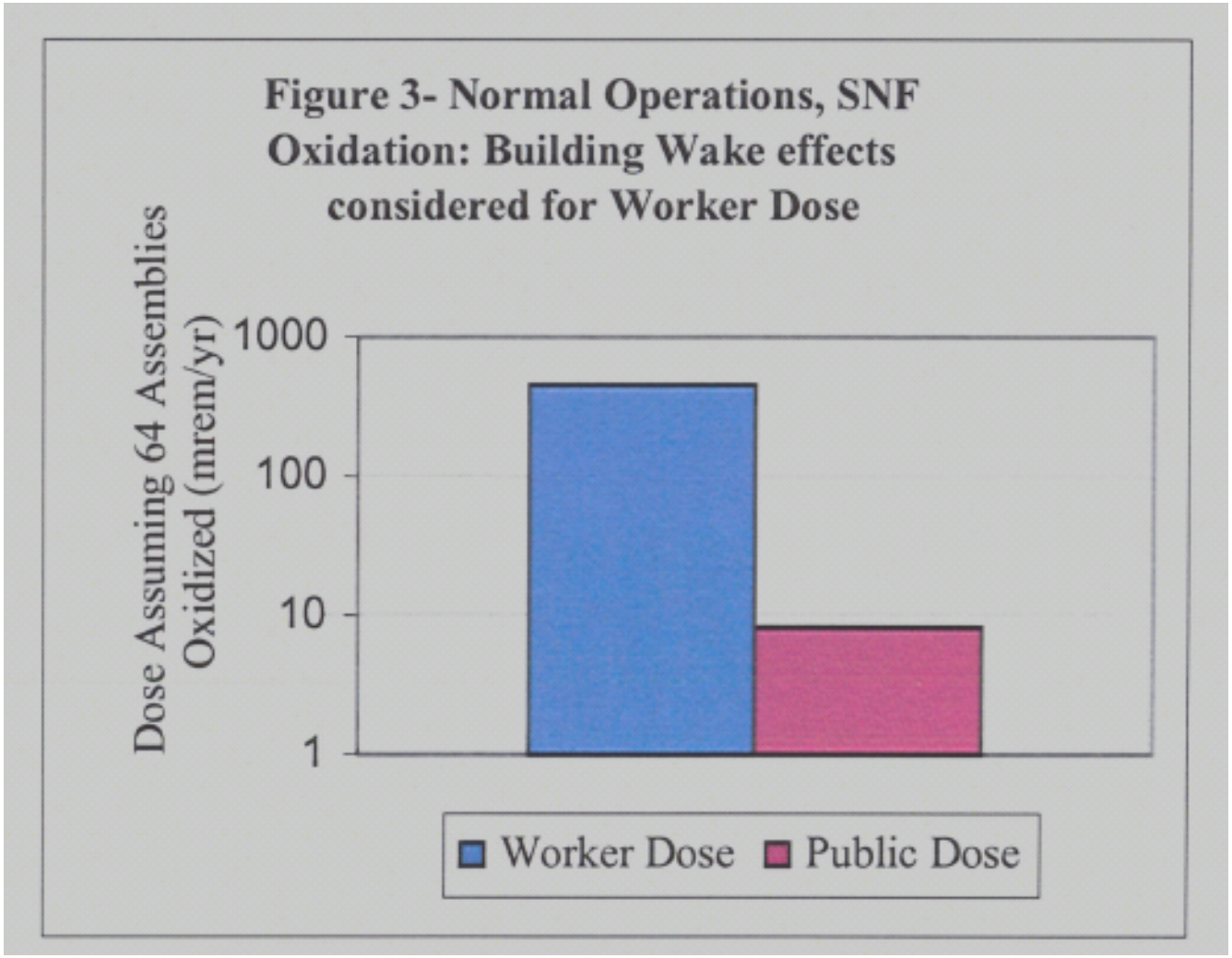
- **Cross-sectional building area: 60 m (196.85 ft) wide by 20 m (65.62 ft) high, perpendicular to wind flow**

- **The model for Wake effects (i.e., Wake Model) is under further evaluation and validation**

- **Plume doses assume a Gaussian plume dispersion model**

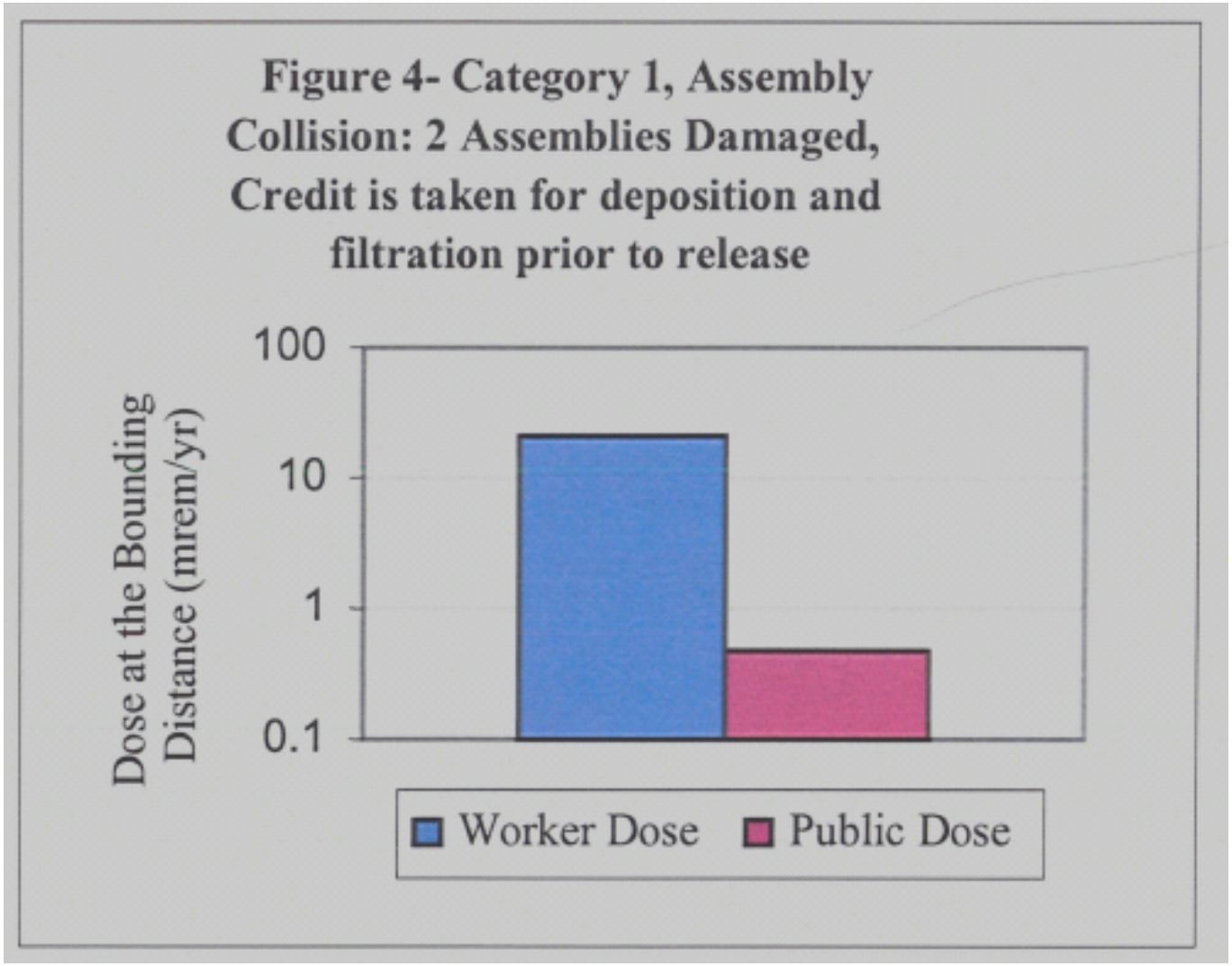
RESULTS (continued)

Dose results based on uncanistered SNF



RESULTS (continued)

Dose results based on uncanistered SNF



CONCLUSIONS

- **Small radionuclide release from a SFA drop or collision**
- **The dose consequence from SNF oxidation depends on rods with pinhole leaks or hairline cracks**
- **The deposition, agglomeration, and filtration of particulate radionuclides prior to atmospheric release may greatly reduce the downwind dose**
- **An example dose consequence from a Cat 2 impact event**
- **Work is ongoing systematically to develop more realistic source terms representative of Cat 1 and Cat 2 event sequences, and Normal Operations**

CONCLUSIONS (Continued)

- **Analysis conducted based on uncanistered rod SNF; canister-based approach could mitigate risk associated with drops and oxidation of SFA**

- **The assumptions in these analyses are likely to be conservative and the results upper bound**