2019 Regional Nuclear Decommissioning Forum

Hendrick Hudson Free Library

Montrose, NY

Thursday, October 10, 1:00 – 4:30 p.m..

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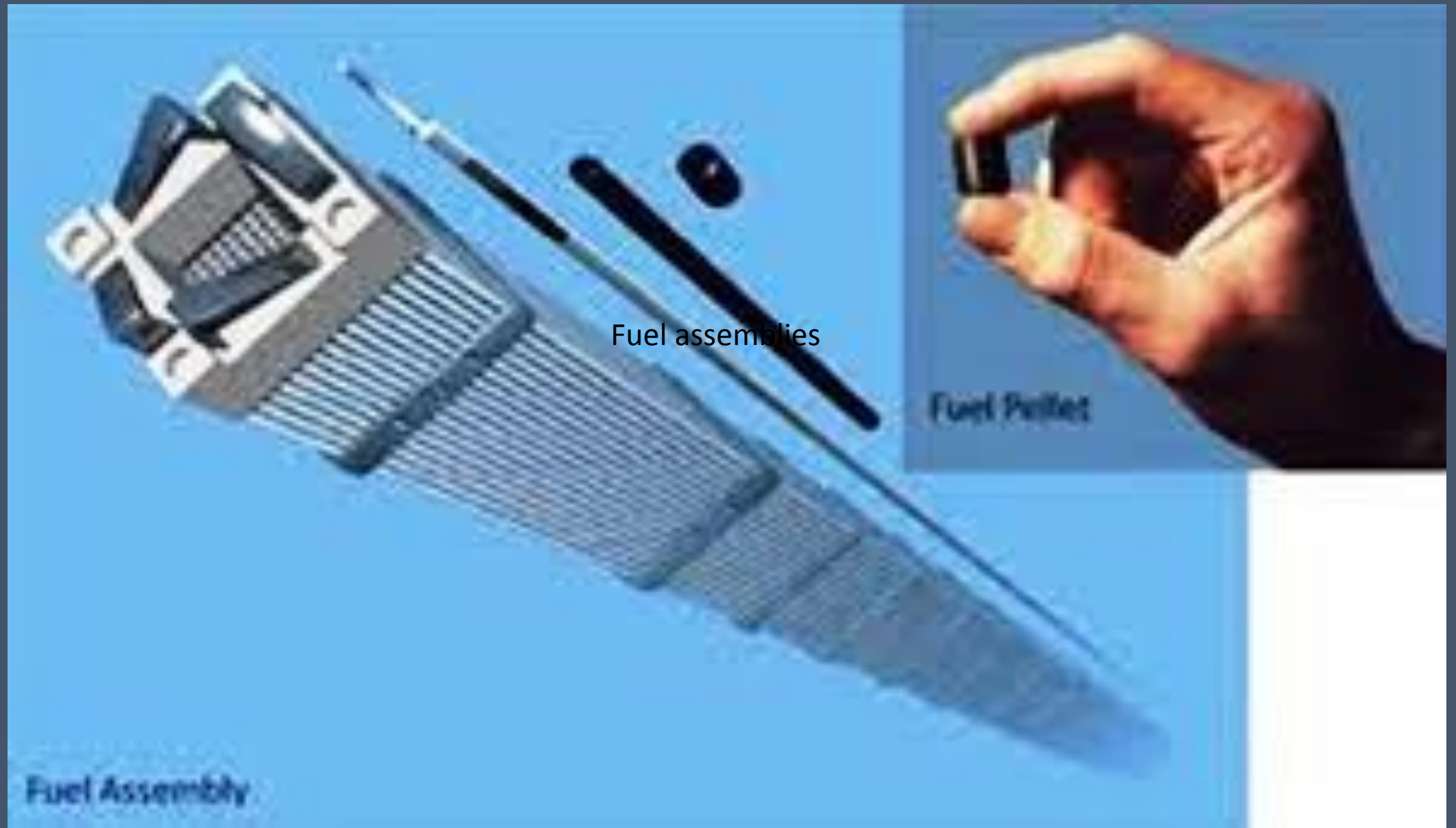
Radioactive Waste Management Associates

Transportation Requirements

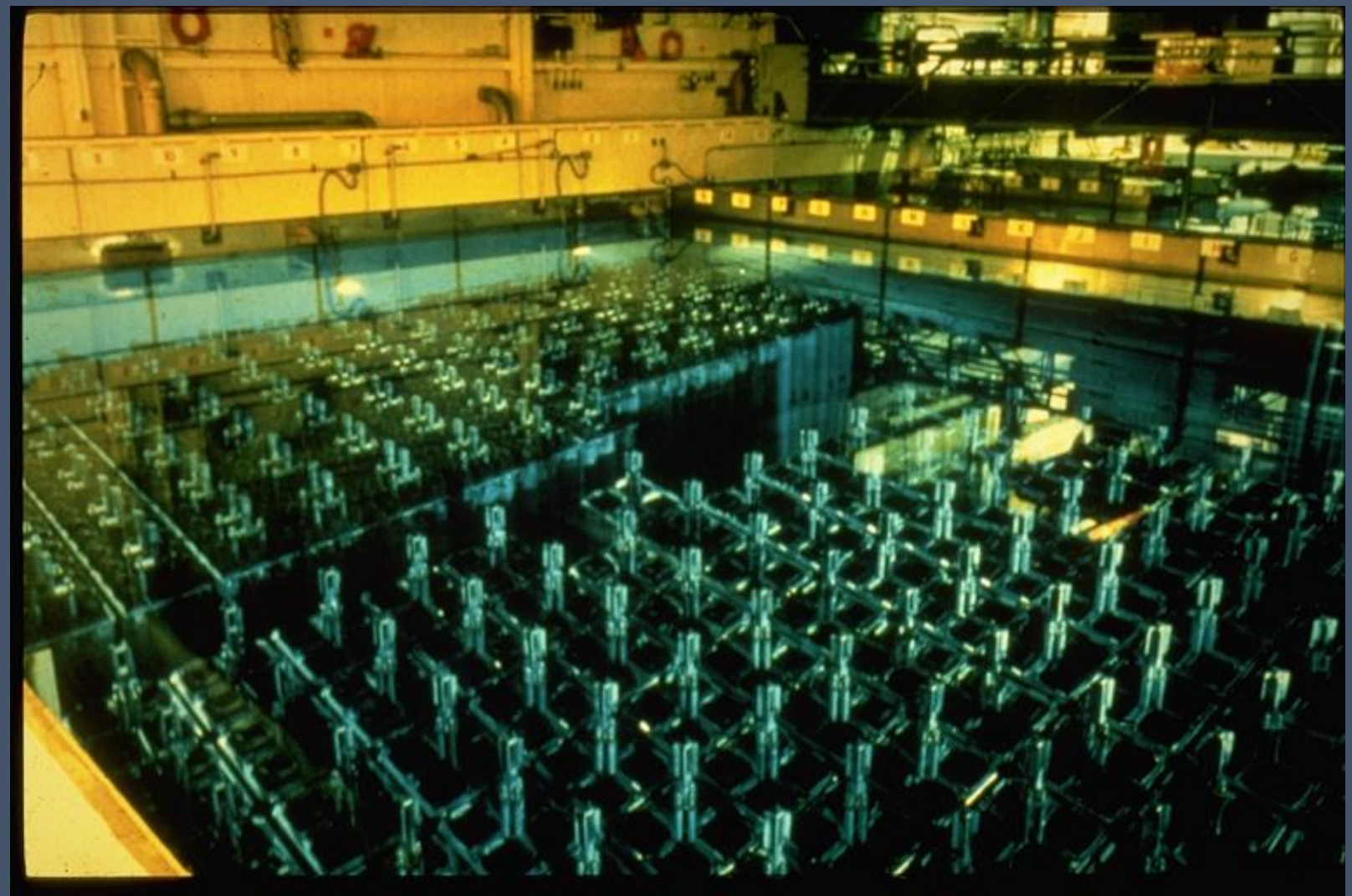
To transport irradiated fuel from a reactor to a storage site or final repository, you need:

- NRC licensed transportation cask (10 CFR Part 71)
- DOT approved means of conveyance (rail, highway, waterway), accessible to reactor (49 CFR parts 170 through 189)
- NRC licensed storage site or final repository (10 CFR Part 72)

PWR Fuel Assembly

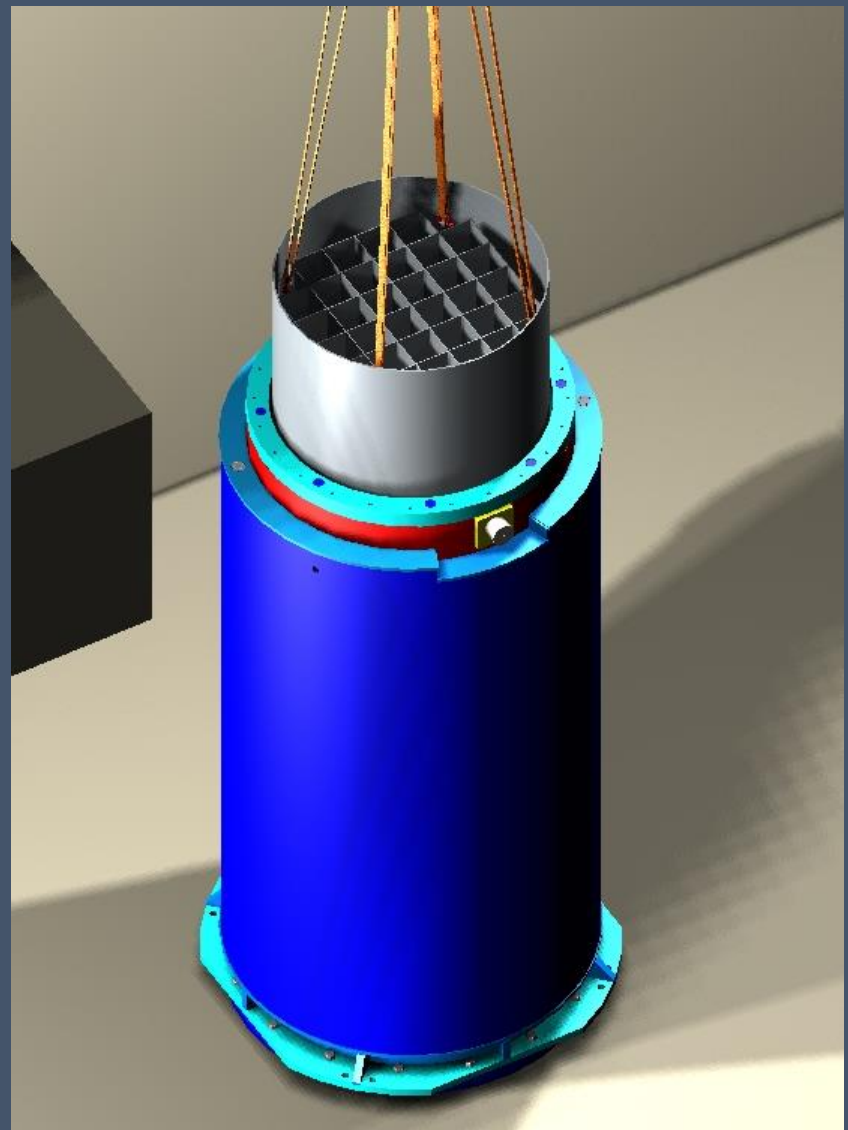


Spent Fuel Pool

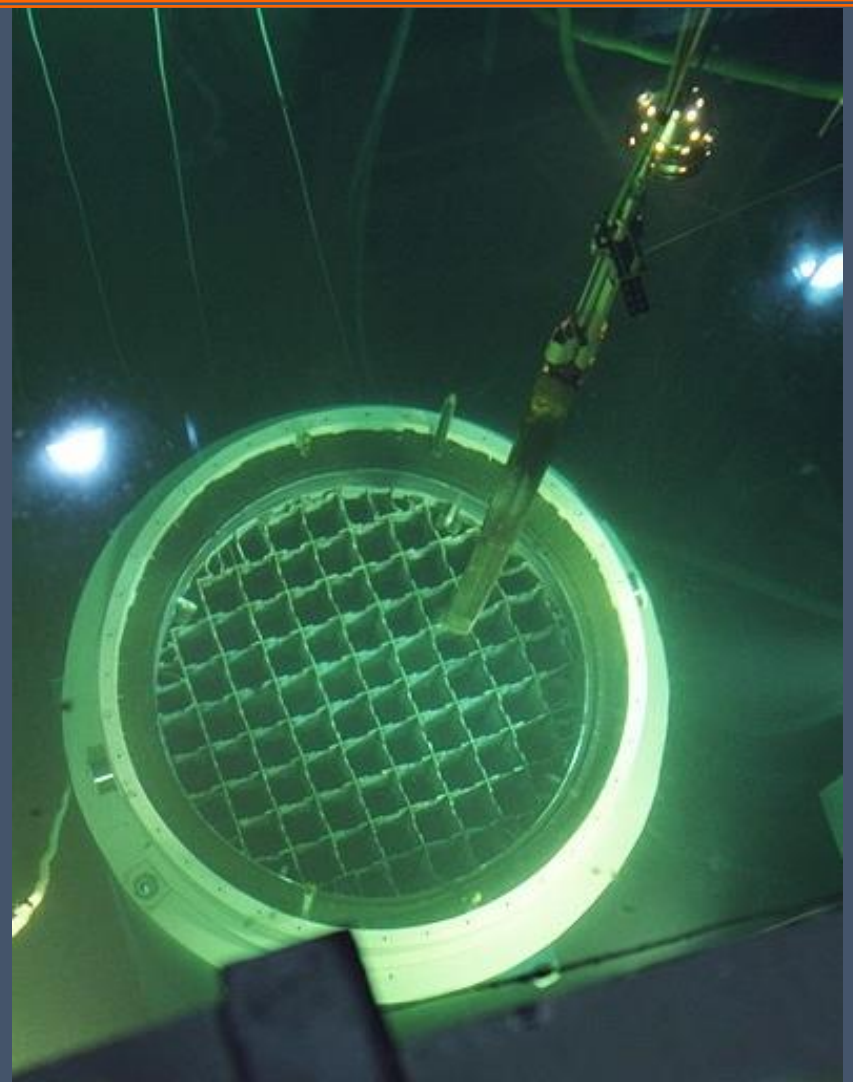


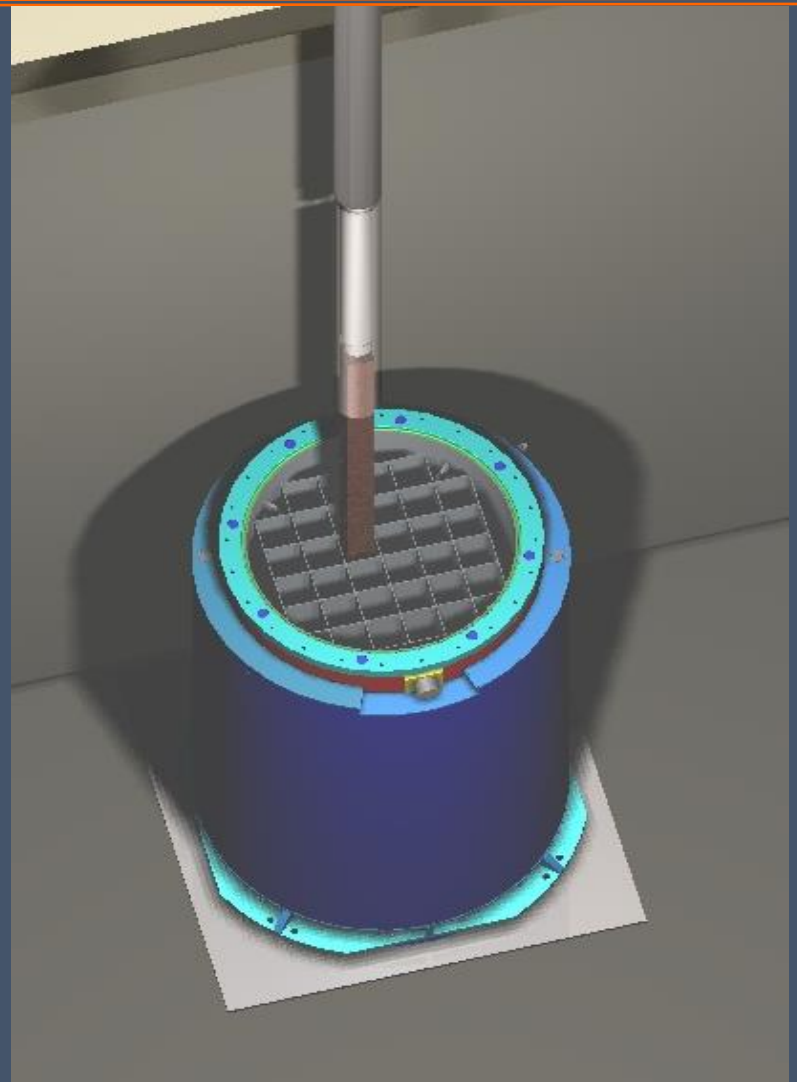
CT Yankee Dry Storage

Empty Canister Installed in HI-TRAC

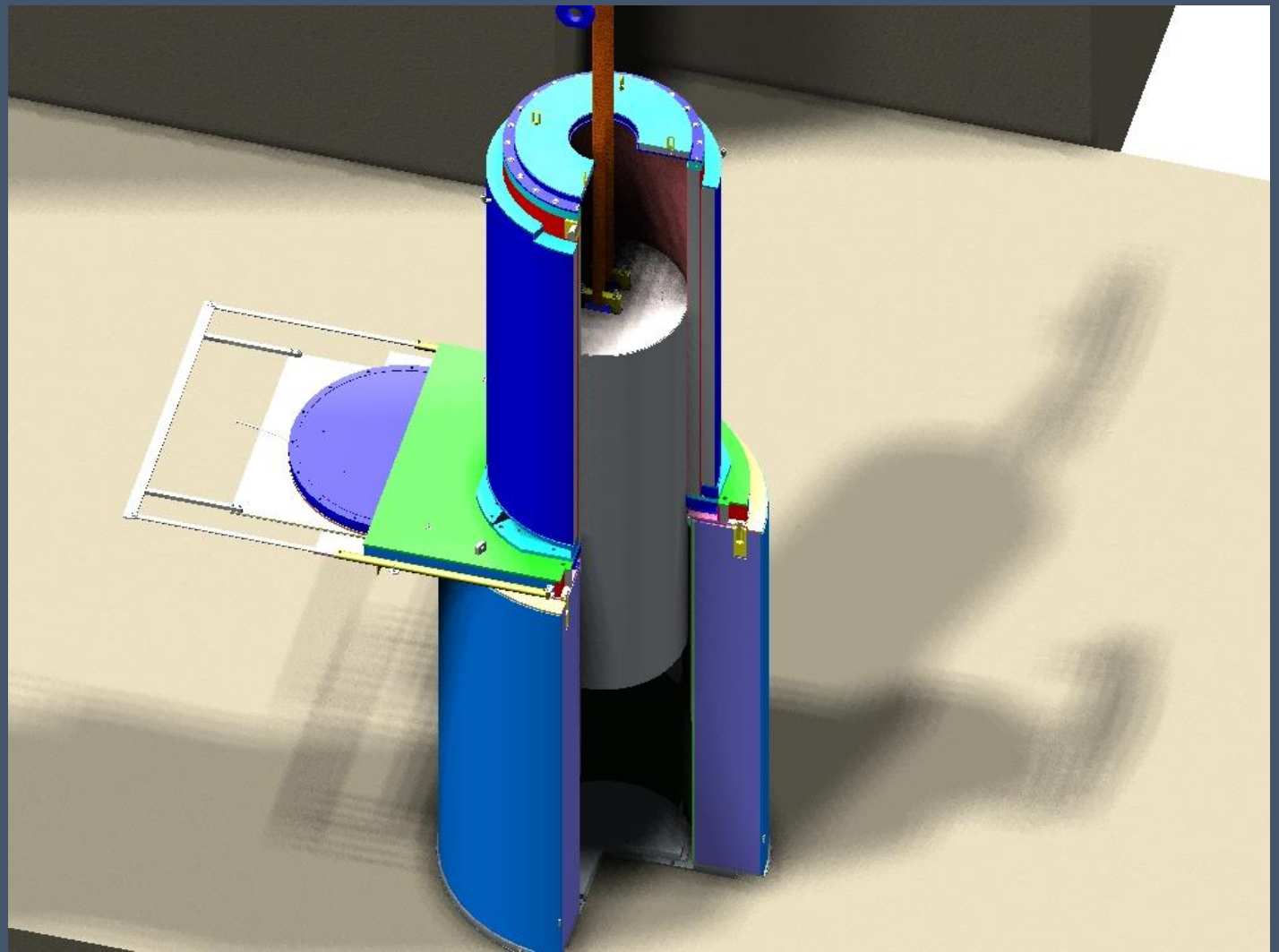


Canister Fuel Loading





LOWER THE CANISTER INTO CONCRETE CASK



MOVE CONCRETE CASK ONTO PAD

Figure II.10: HI-STORM Lifted from the top using the Vertical Cask Crawler

CHIMNEY EFFECT COOLING

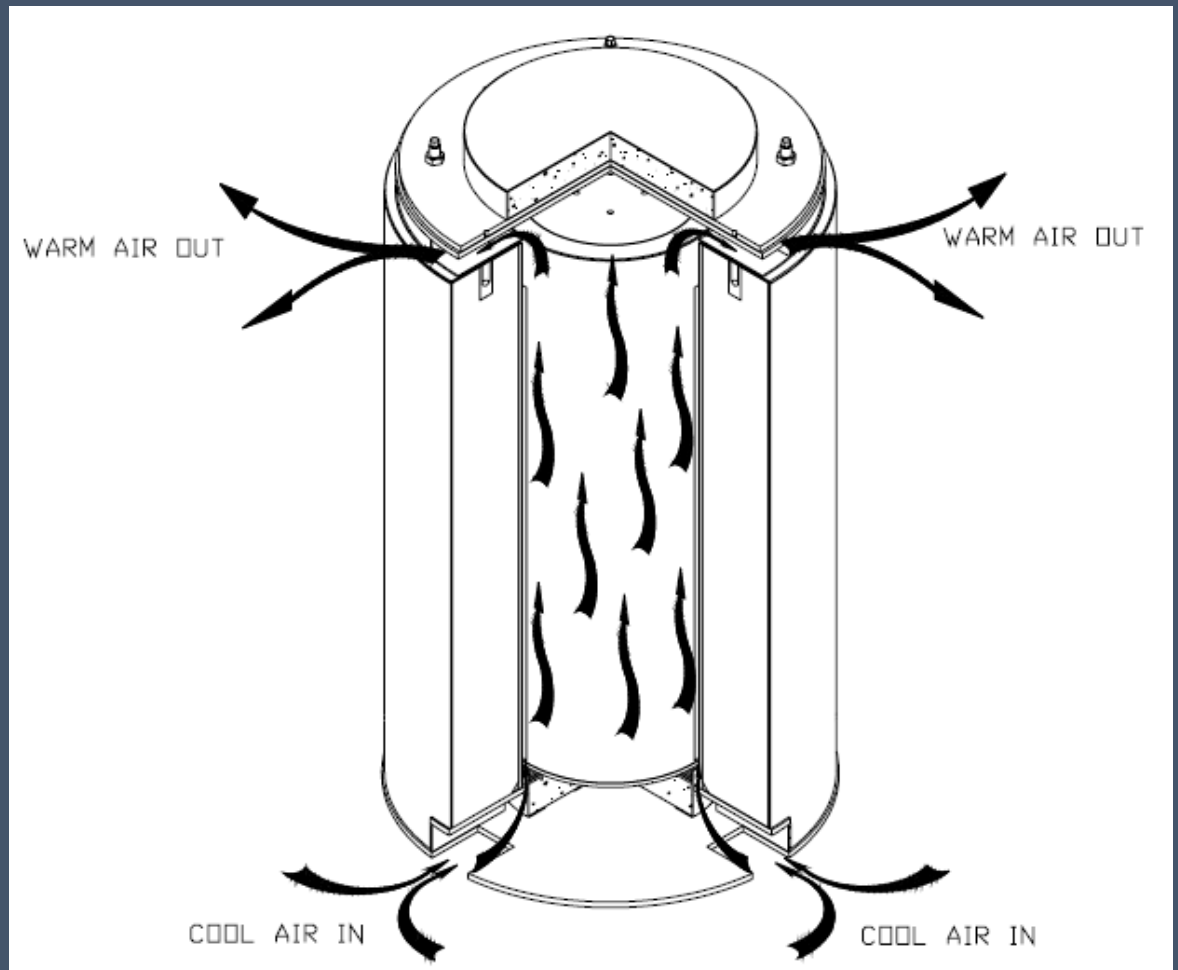


Figure II.9: Cooling by Natural Convection in the HI-STORM 100S

Hi-Star 100 Cask

Cooling Time MPC-32

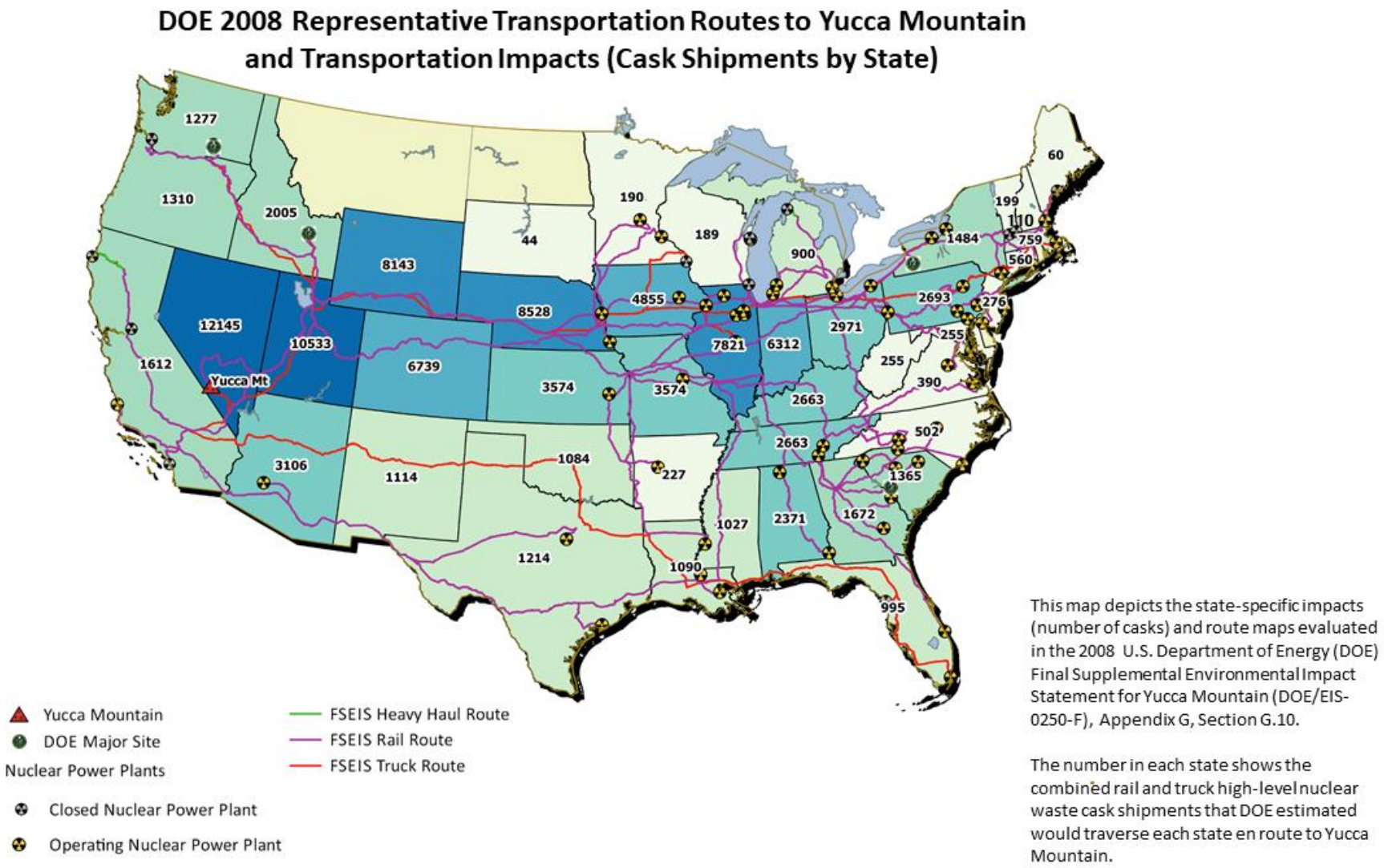
	Burnup	Time	NRC Docket
HI-STORM 100	44.5 GWd/MTU	20 yrs	72-1008
HI-STAR 100	45.0 GWd/MTU	24 yrs	71-9261

Cask Capacity

	Capacity (# PWR's)	Loaded Weight (tons)
HI-STAR 60	12	82
HI-STAR 100	24/32	140
HI-STAR 190	37	208

Nuclear Power Plants in the United States

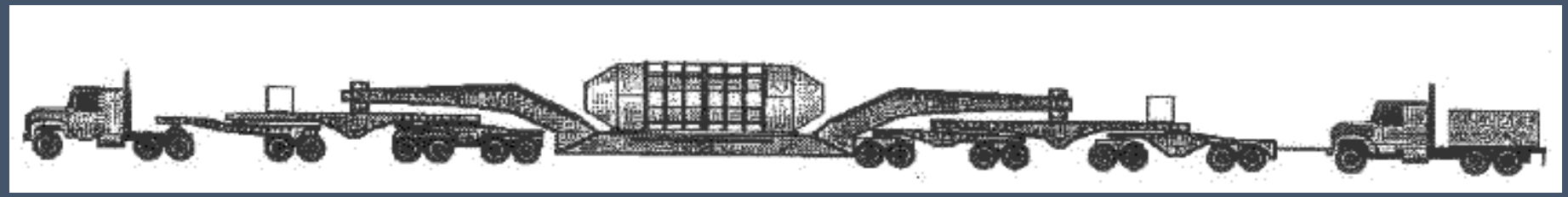
Representative Transportation Routes



This map depicts the state-specific impacts (number of casks) and route maps evaluated in the 2008 U.S. Department of Energy (DOE) Final Supplemental Environmental Impact Statement for Yucca Mountain (DOE/EIS-0250-F), Appendix G, Section G.10.

The number in each state shows the combined rail and truck high-level nuclear waste cask shipments that DOE estimated would traverse each state en route to Yucca Mountain.

Heavy Haul Truck Configuration



220 feet

6 ft
bicycle

15 ft
car

20 ft
van

30-40 ft
bus

70 ft
Legal-Weight Truck Cask

M-290 Rail Car

TransportationSystem (2008 SEIS)

- 21,909 rail casks (about 6,700 trains) & 5,025 truck casks [p.8-41]
- Average 1-3 trains (3-5 casks per train) & 1-2 trucks (1 cask per truck) per week for 50 years
- Every day, for 50 years, one or more loaded casks on rail or road, from 76 shipping sites to a single national repository or storage site

Transportation Issues

- Heavy casks, bridge capacity
- 12 axle cars - speed on turns
- Fire temperature
- Fire trends

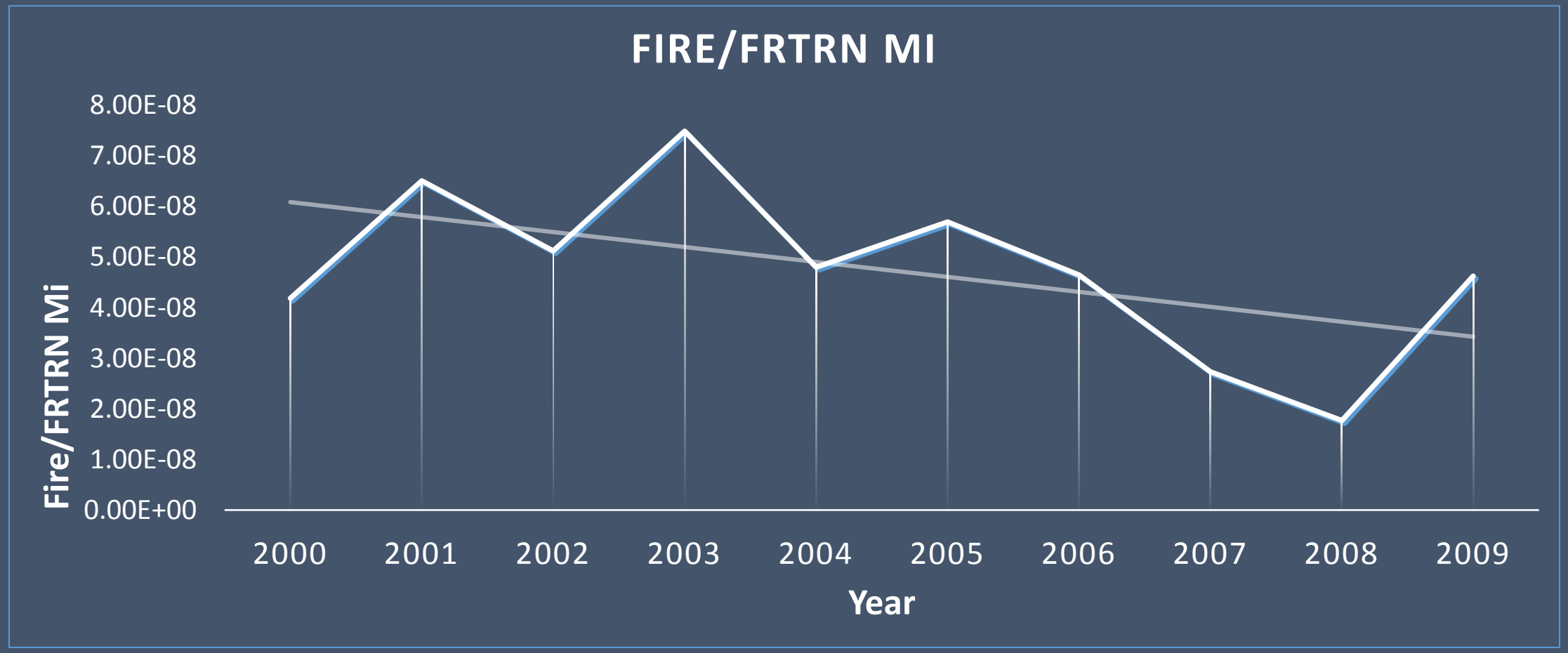
TRANSPORTATION ISSUES

- NRC hypothetical accident conditions (impact, fire)
- Cask tested by computer simulation, not physical
- Changed rail conditions (tank cars from North Dakota vs. oil pipeline)
- DOE EIS (size cask: 21 vs. 37 PWR fuel assemblies)
- Rail preferred, but Indian Point, CT Yankee, Yankee Rowe and others may require heavy haul transport or barge

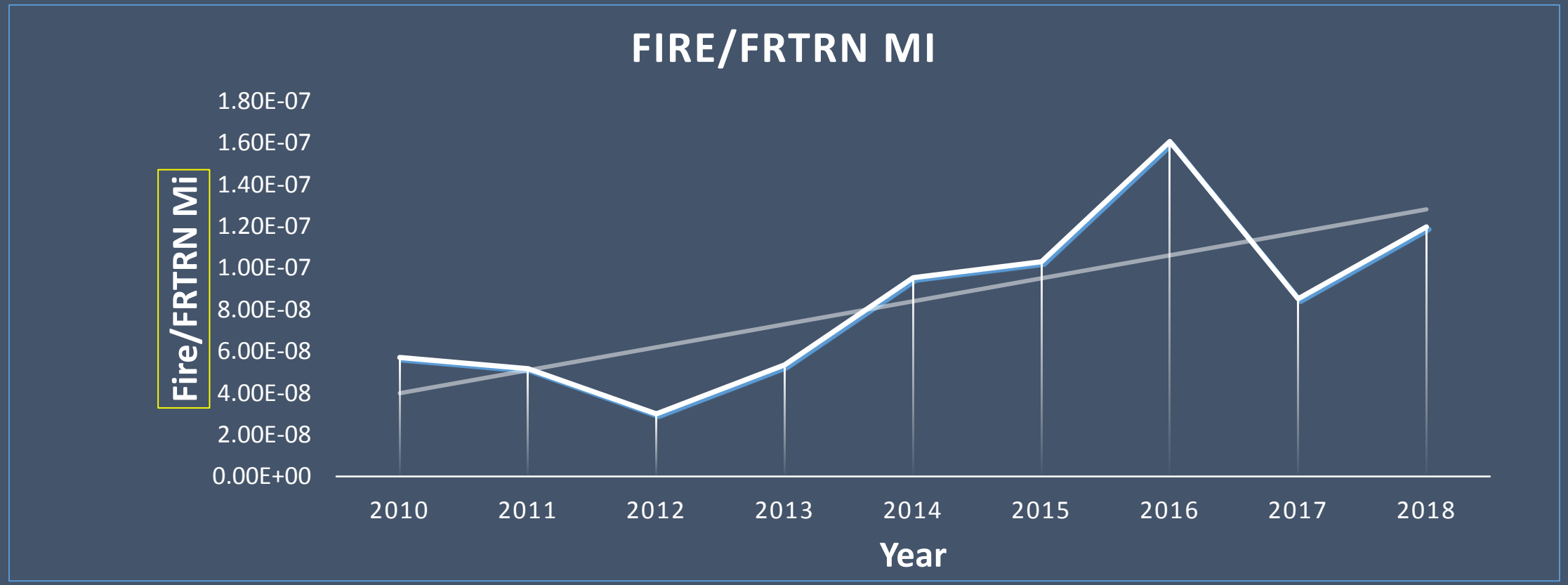
Flame Temperatures

Chemical	Flame Temperature (°F)
Acetone	2160-7072
Diesel	1740-1839
Propane	2242-6487
Vinyl Chloride	2552-11,142

Rail Fires 2000 - 2009

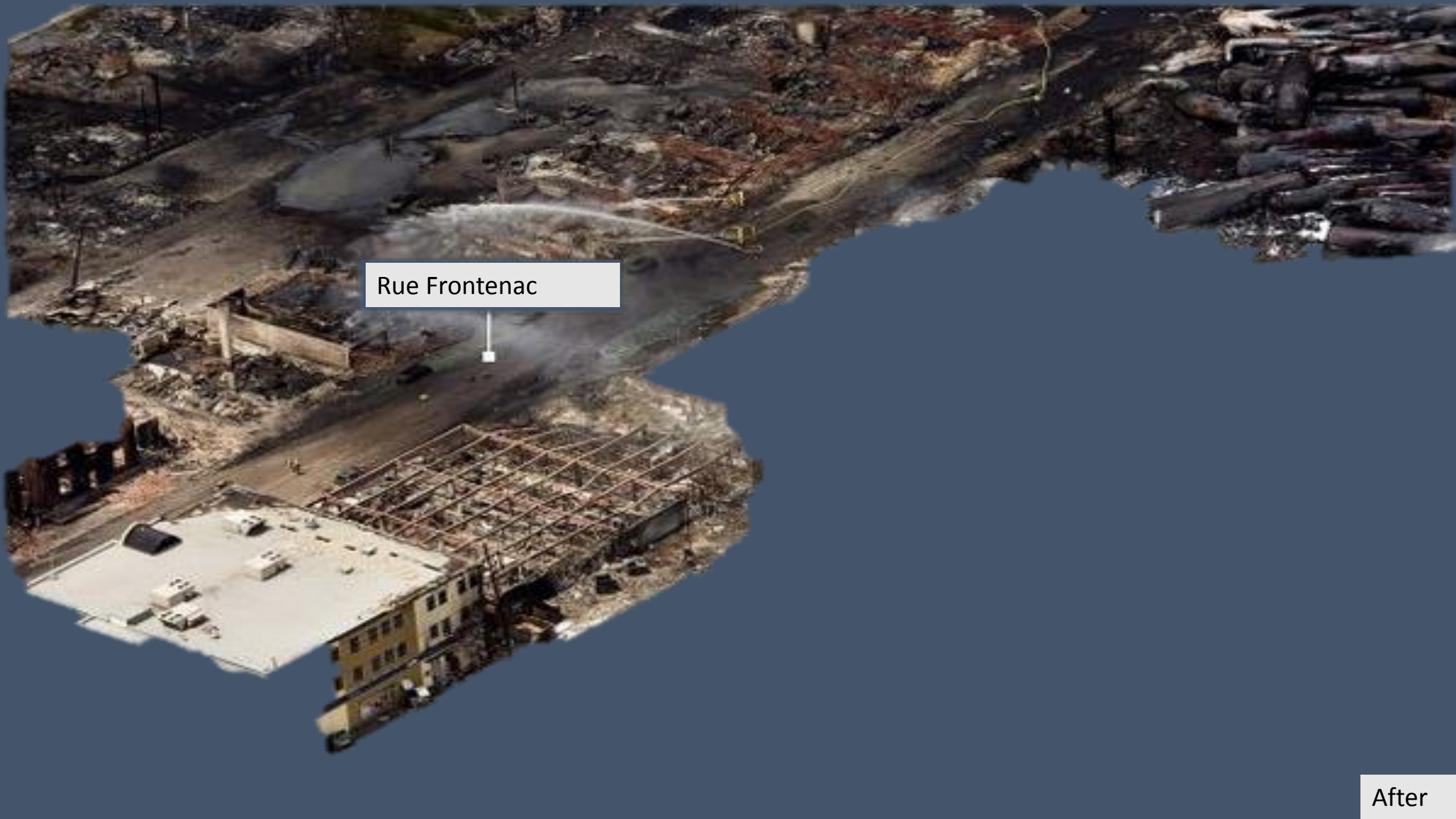


Rail Fires 2010 - 2018



Rue Frontenac
YVES TREMBLAY PHOTOHELICO.COM
Before

The train rolled downhill for seven miles (11km) before derailing at Lac-Megantic

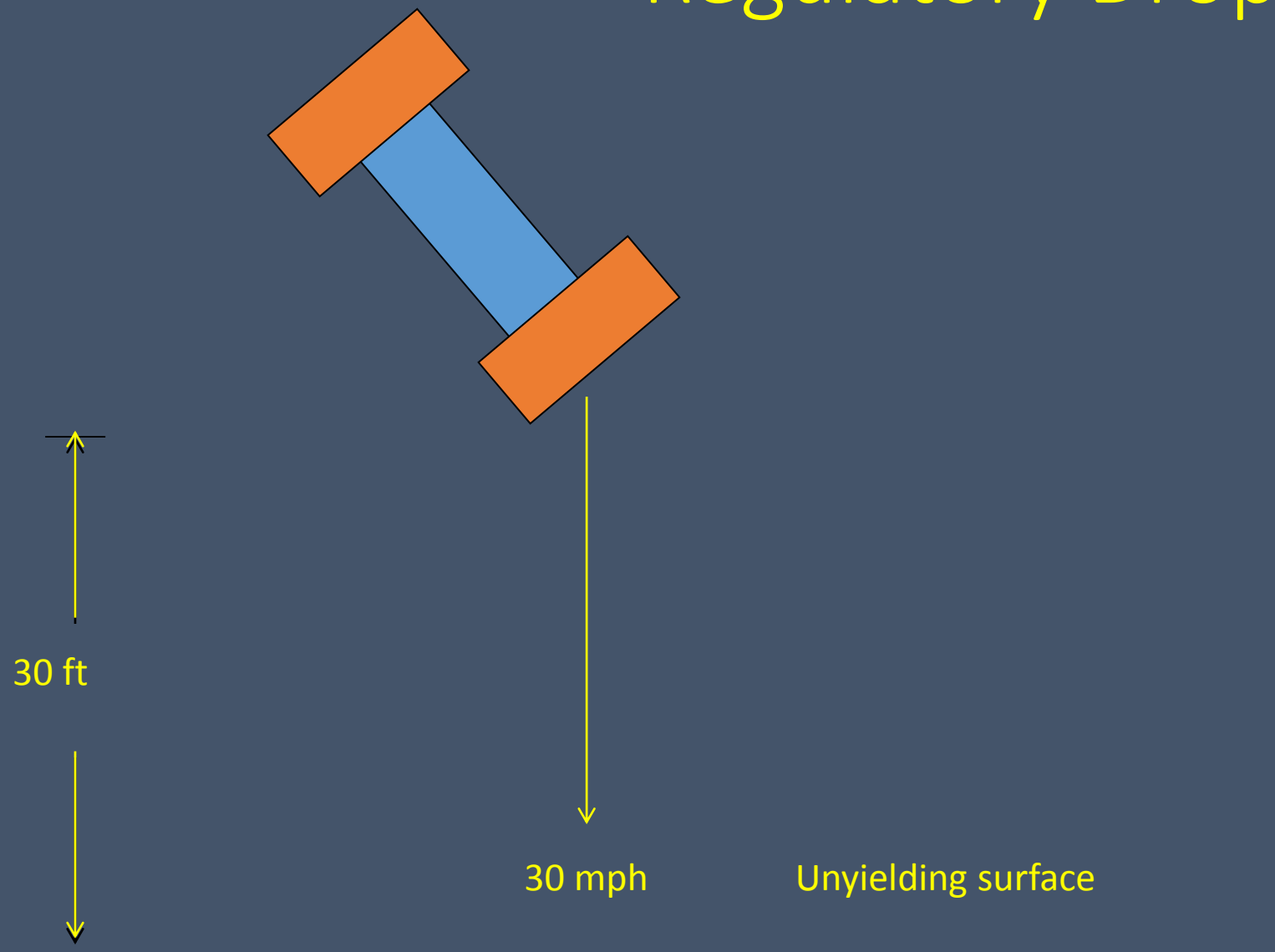


After

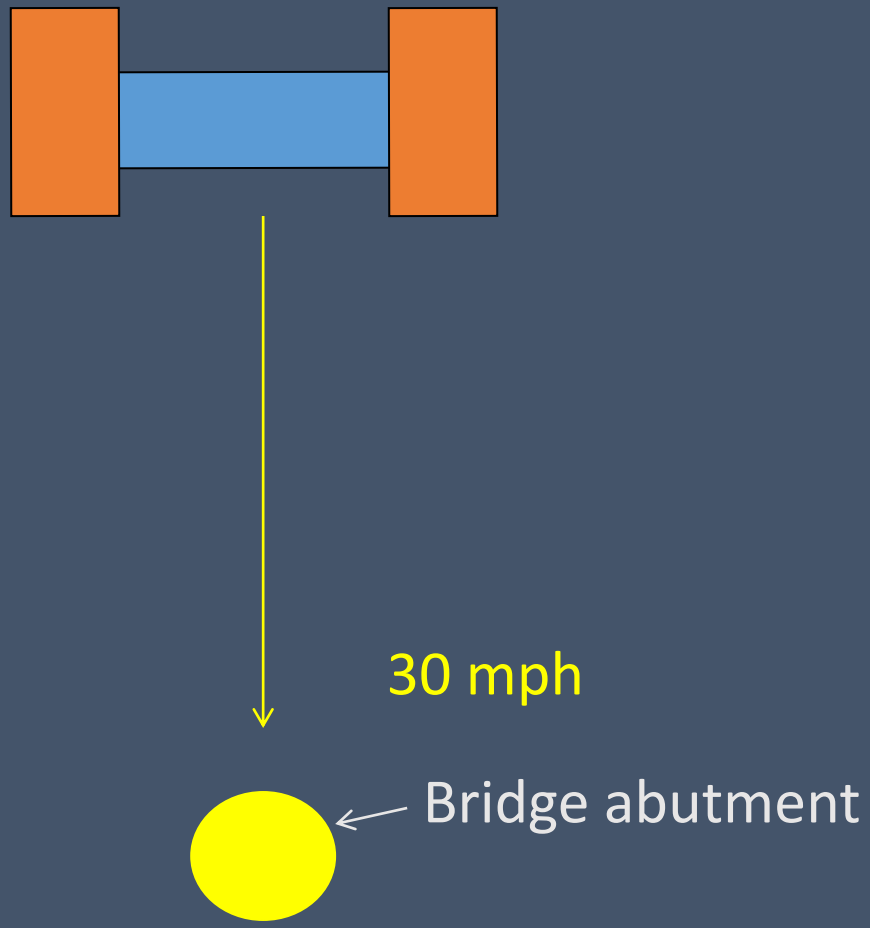
Irradiation/Storage Conditions for PWR Fuel

Category	Reactor	Pool	Dry Strge
ID Clad T	340-370	30-60	360
Water T	300-330	20-50	
In Rod Pressure	38-150		38-150
Coolant Pressure	140-160	2	1

Regulatory Drop Test

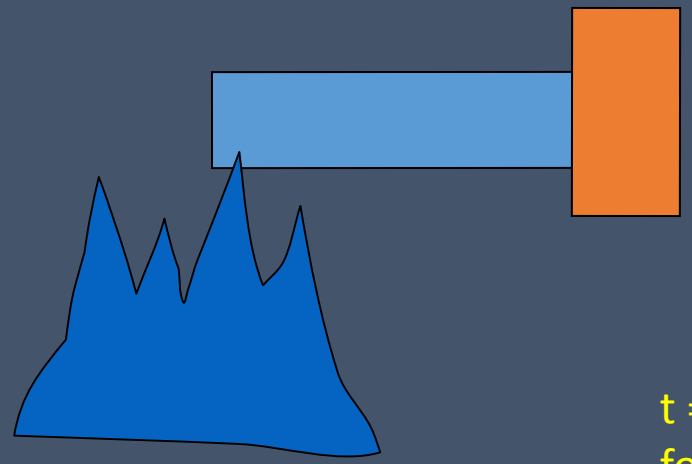


Potential Side Impact



Seals Damage in Fire

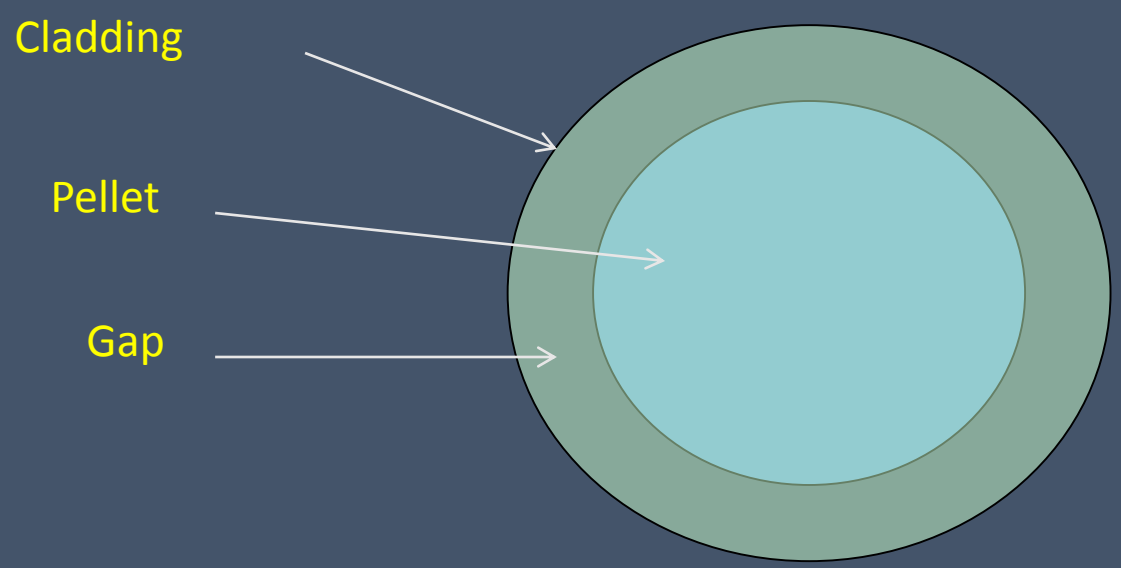
No Impact Limiter



Fire T = 1000 ^{o}C

t = 24 min
for seal failure

Cesium in Gap



Study	Cs in Gap
Modal	0.3%
Gray	9.9%

High Burnup Fuel

- Previously, every year 1/3 reactor core removed. Fuel burnup to 35 GWd/MTU
- More recently, fuel in reactor longer, now up to 72 GWd/MTU.
- For fission products like Cs-137 and Sr-90, transportation cask inventory is proportional, 72/35 = 2.06
- While buildup of fission products is roughly proportional to burnup, buildup of higher actinides like Pu, Am and Cm is greater. The subsequent decay of Pu-241 (14 yr half-life) with beta emission leads to buildup of Am-241 (432 year half-life) which has an alpha decay, accounting for greater heat production up to year 70 after fuel removal, then decline. This is not taken into account by the NRC.

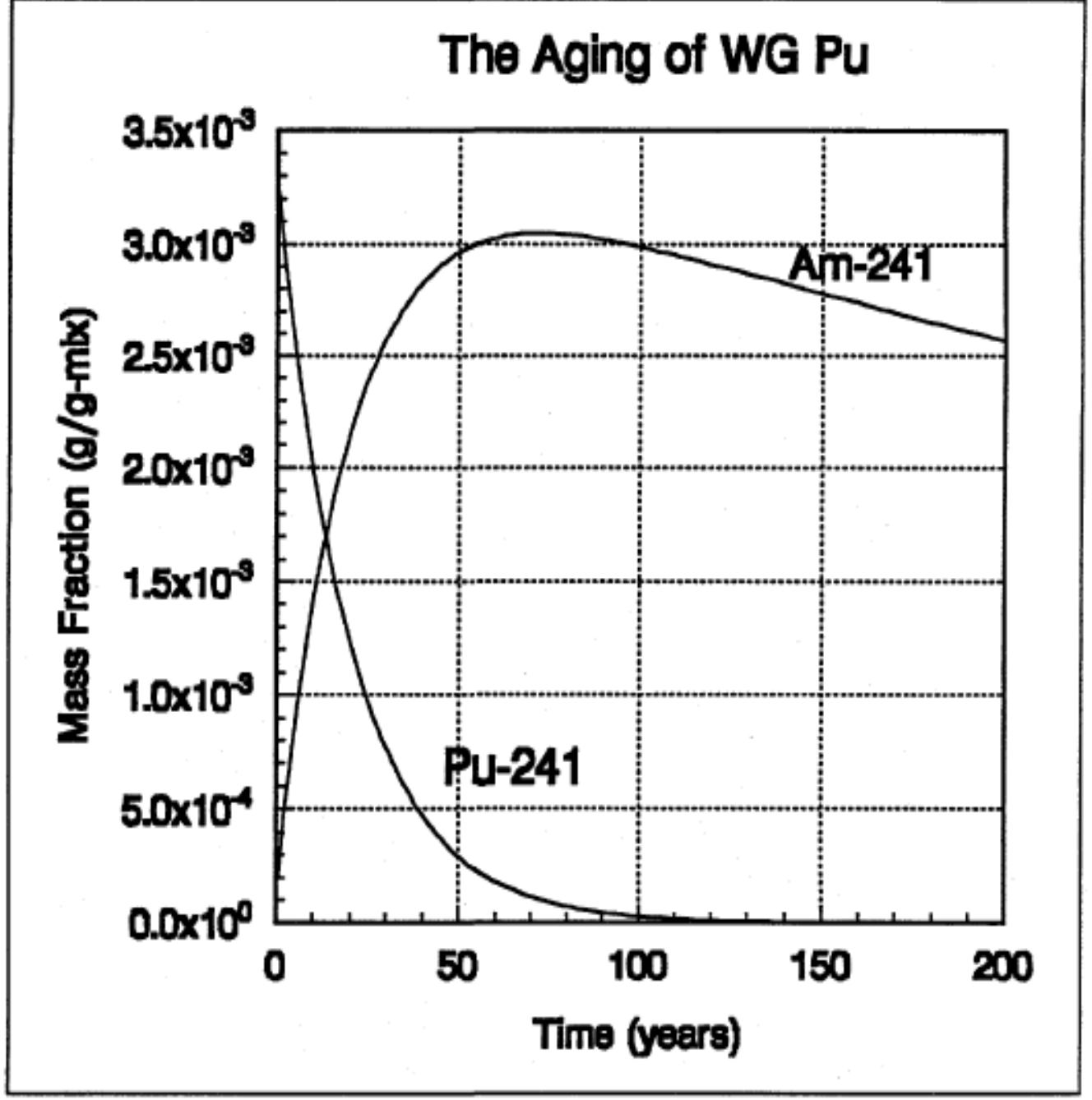


Figure 5-1. The time variation of ^{241}Pu and ^{241}Am over a 200 year time span.

San Onofre Dry Storage Cask System

High Burnup Fuel (continued)

- This increased heat production means cask must remain at reactor longer before shipping, at least 40 years (if CoC remains the same).
- In 2008 FSEIS for Yucca Mountain, cask contained 21 PWR fuel assemblies. Now Holtec's HI-STAR 190 contains 37 PWR fuel assemblies. With HBF, the new inventory of Cs-137 and Sr-90 can be 3.63 as much. This is important for accident analysis.
- Cladding can be more brittle and 15% thinner. Vibrations on rail may cause major degradation.