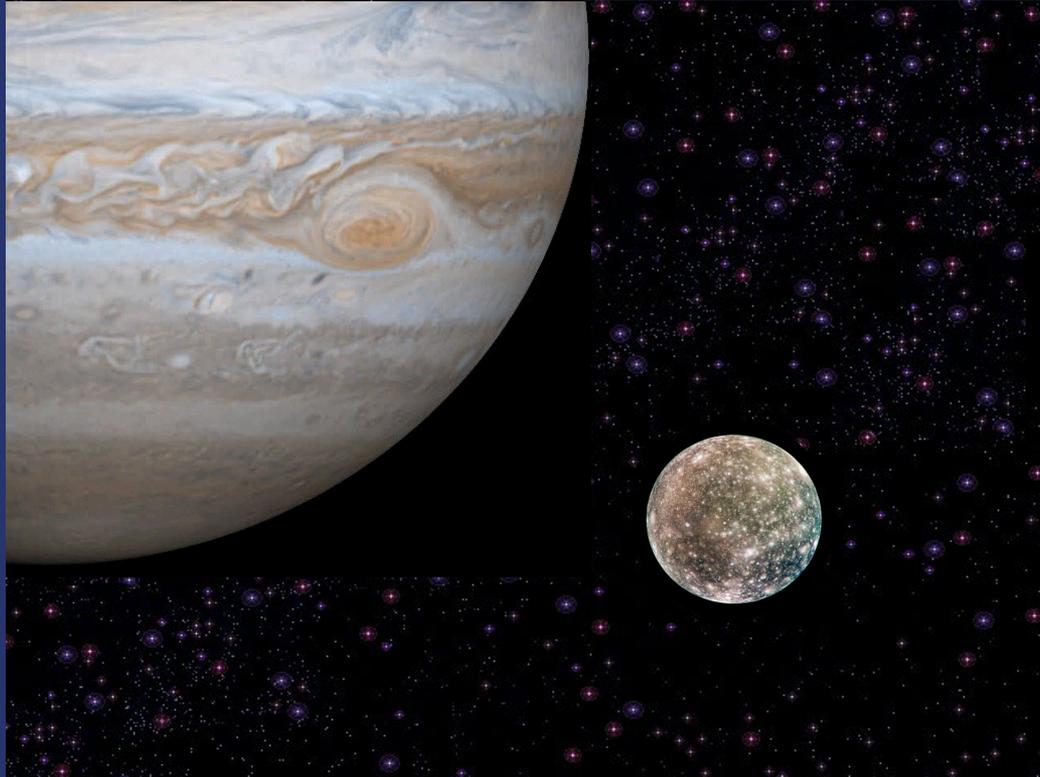


# Nuclear and the Media



**Dr. James Conca**  
Washington State University

**Trustee of the Herbert M. Parker Foundation**  
Richland, WA

<https://tricity.wsu.edu/parkerfoundation/>  
<https://www.forbes.com/sites/jamesconca>

<b>Energy Source</b>	<b>Mortality Rate (deaths per trillion kWh)</b>	
Coal – global average	100,000	(50% of global electricity)
Coal – China	170,000	(75% of China’s electricity)
Coal – U.S.	10,000	(19% of U.S. electricity)
Oil	36,000	(36% of global energy, 8% of global electricity)
Natural Gas	4,000	(25% of global electricity)
Biofuel/Biomass	24,000	(21% of global energy)
Solar	440	(< 1% of global electricity)
Wind	150	(~ 2% of global electricity)
Hydro – global average	1,400	(15% of global electricity, 171,000 Banqiao dead)
Hydro – U.S.	0.1	(7% of U.S. electricity)
Nuclear – global average	40	(11% of global electricity w/Chernobyl&Fukushima)
Nuclear – U.S.	0.1	(20% of U.S. electricity)



Beijing, China > 80% coal



Beijing, China

## **Social – some risks facing Americans over the past 5 years**

**alcohol consumption**

**automobile driving**

**coal industry**

**construction**

**food poisoning**

**iatrogenic**

**murder**

**mining**

**nuclear industry**

**opioid deaths**

**police work**

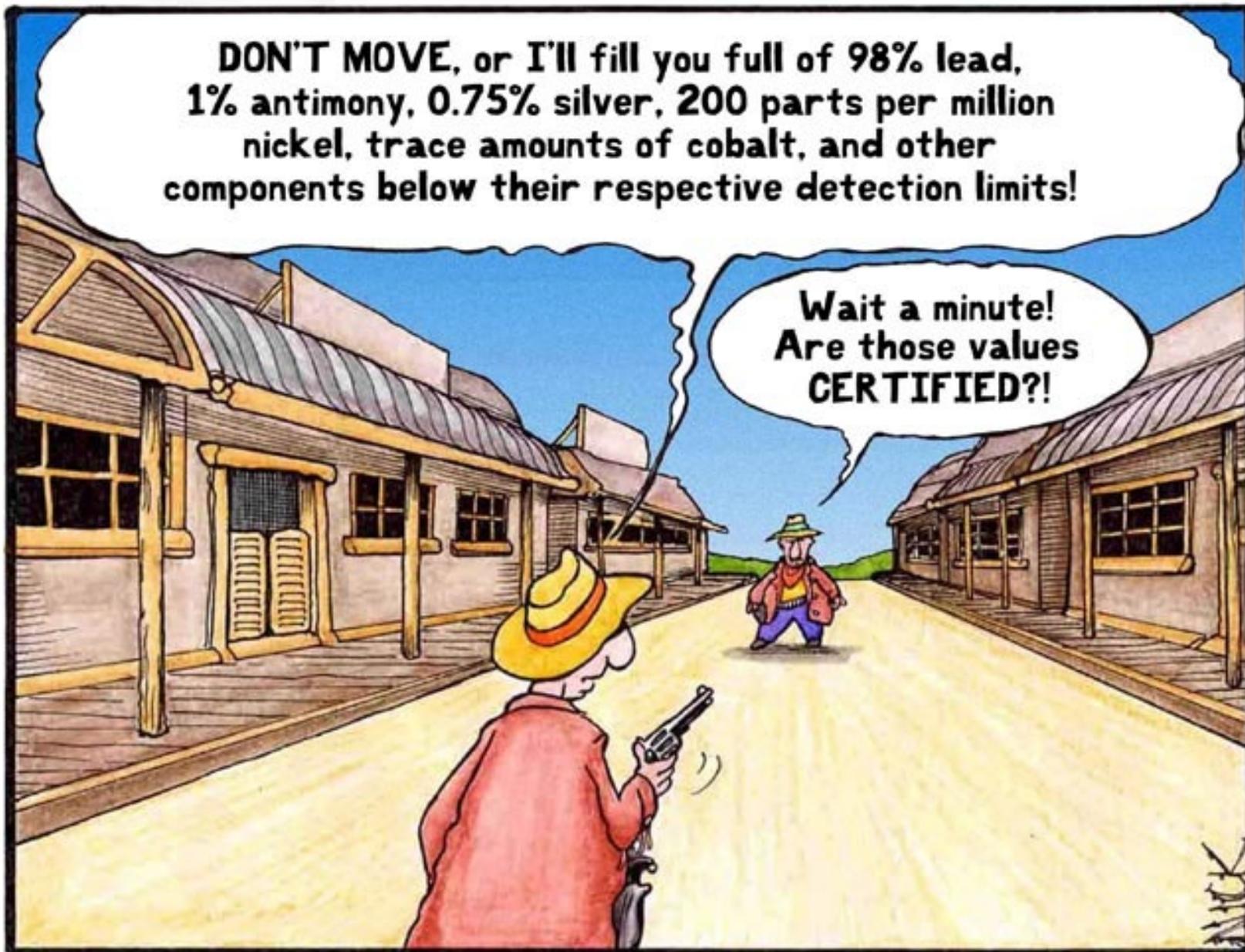
**smoking tobacco**

**accidental falls (> 65 yrs old)**

<b>Activity</b>	<b>Number of Deaths in U.S. Normalized to Sub-Population</b>	<b>Relative Danger Index</b>
<b>1) smoking (43.4 million smokers)</b>	<b>2,400,000</b>	<b>0.07059</b>
<b>2) alcohol (60 million impacted Americans)</b>	<b>500,000</b>	<b>0.00833</b>
<b>3) iatrogenic (180 million receive medical treatment)</b>	<b>950,000</b>	<b>0.00527</b>
<b>4) accidental falls (46 million over 65 yrs)</b>	<b>140,000</b>	<b>0.00304</b>
<b>5) police work (720,000 police officers)</b>	<b>800</b>	<b>0.00111</b>
<b>6) mining (350,000 miners)</b>	<b>360</b>	<b>0.00103</b>
<b>7) automobile accidents (190 million drivers)</b>	<b>180,000</b>	<b>0.00094</b>
<b>8) construction (7.7 million workers)</b>	<b>5,000</b>	<b>0.00065</b>
<b>9) opioid deaths (100 million prescribed)</b>	<b>170,000</b>	<b>0.00043</b>
<b>10) murder (300 million impacted)</b>	<b>80,000</b>	<b>0.00027</b>
<b>11) coal use (240 million impacted)</b>	<b>60,000</b>	<b>0.00025</b>
<b>12) food poisoning (304 million eat every day)</b>	<b>25,000</b>	<b>0.00008</b>
<b>13) nuclear industry (60 million)</b>	<b>1</b>	<b>0.0000001</b>

**DON'T MOVE, or I'll fill you full of 98% lead,  
1% antimony, 0.75% silver, 200 parts per million  
nickel, trace amounts of cobalt, and other  
components below their respective detection limits!**

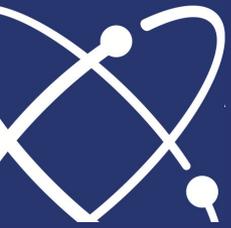
**Wait a minute!  
Are those values  
CERTIFIED?!**



Analytical Chemists in the Wild West



**When radiologists take a selfie**



# The Trouble with Tritium



**Dr. James Conca**

**Trustee of the Herbert M. Parker Foundation**

**Washington State University, Richland, WA**

**Citizen's Advisory Panel Meeting**

**Plymouth, MA**

**September 26 2022**

<https://tricity.wsu.edu/parkerfoundation/>

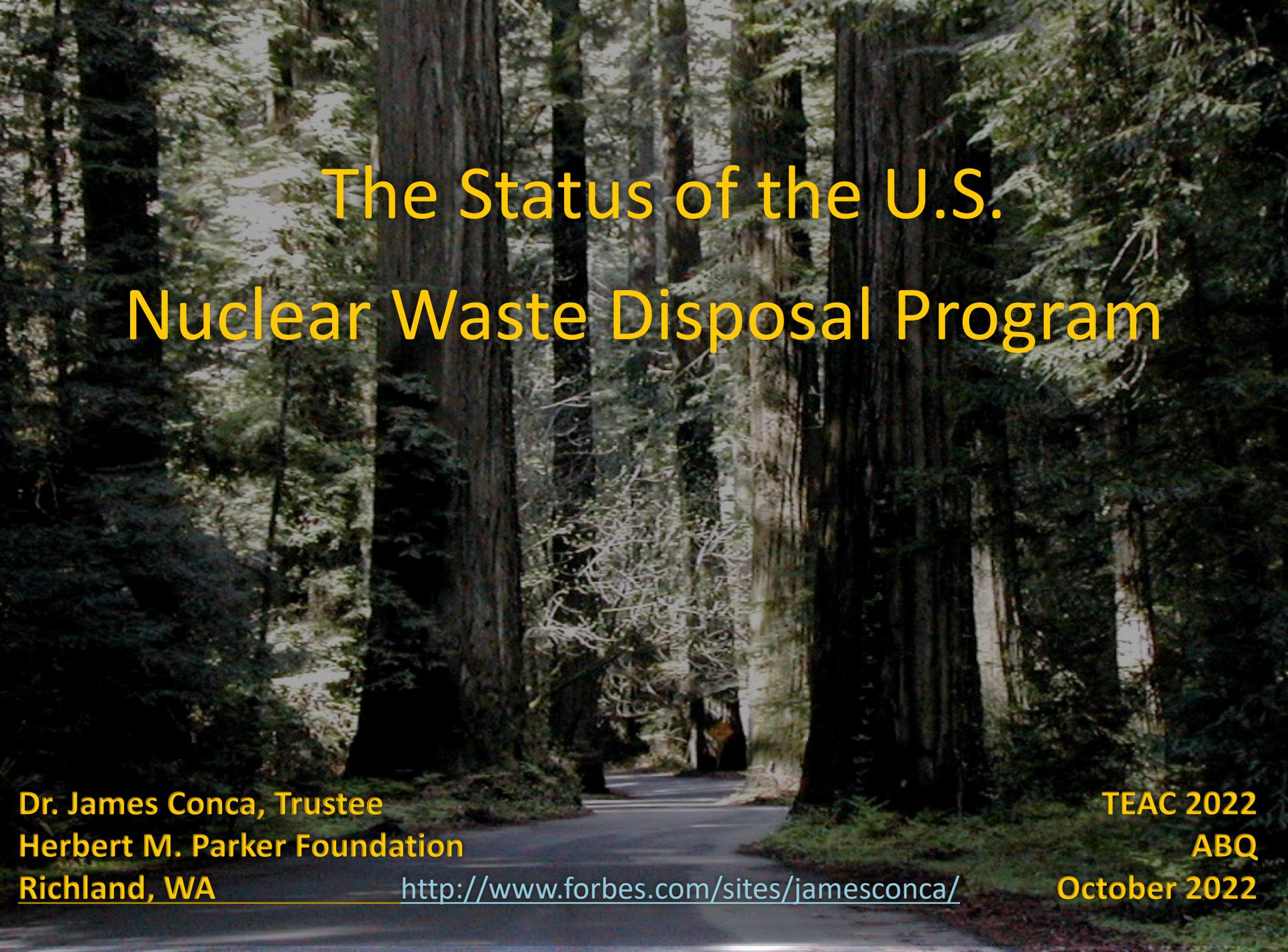
<https://www.forbes.com/sites/jamesconca>





Neil Sheehan





# The Status of the U.S. Nuclear Waste Disposal Program

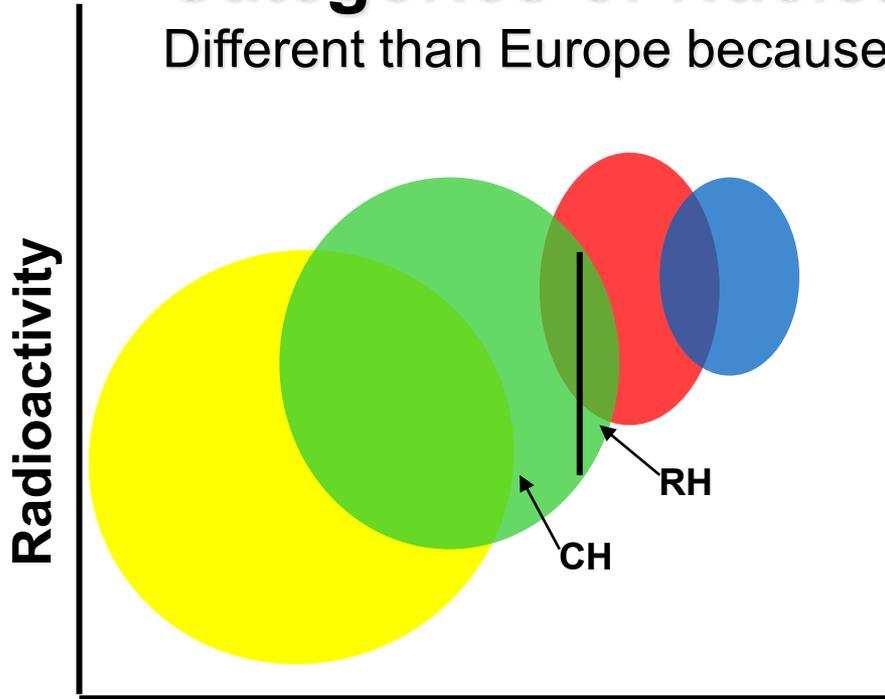
**Dr. James Conca, Trustee  
Herbert M. Parker Foundation  
Richland, WA**

<http://www.forbes.com/sites/jamesconca/>

**TEAC 2022  
ABQ  
October 2022**

# Categories of Nuclear Waste In the U.S.

Different than Europe because of the larger amount of defense waste

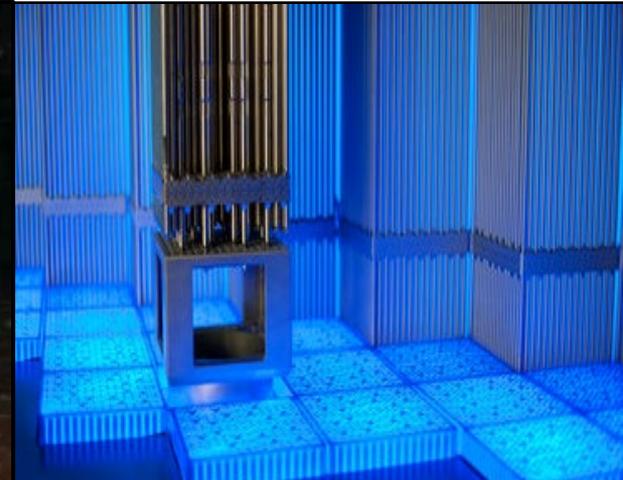


- ◆ Spent Nuclear Fuel (SNF)
- ◆ High Level Waste (HLW)
- ◆ Transuranic Waste (TRU-CH&RH)
- ◆ Low Level Waste (LLW)

**Dose Rate**

Contact Handled (CH) < 200 mrem/hr < Remote Handled (RH)

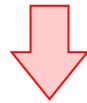
***Deep Geologic Disposal is required for SNF, HLW and TRU***





**FUEL ASSEMBLIES**  
from a weapon's reactor

- 57 million gallons at Hanford
- most is now TRU or LLW
- ~ 600k gallons are HLW



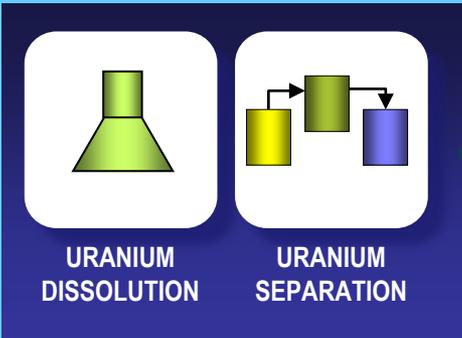
**CLADDING REMOVAL**  
(Coating Dissolution)

COATING  
REMOVAL  
WASTE

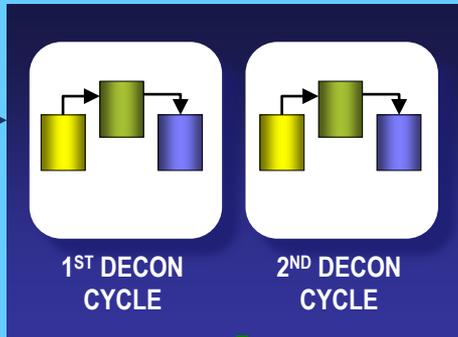
IRRADIATED FUEL



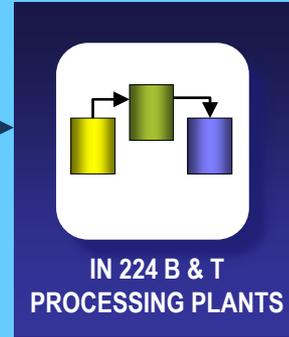
**REPROCESSING**



**PLUTONIUM  
DECONTAMINATION**



**PLUTONIUM  
CONCENTRATION**



PLUTONIUM  
PRODUCT

METAL WASTE



Other SSTs

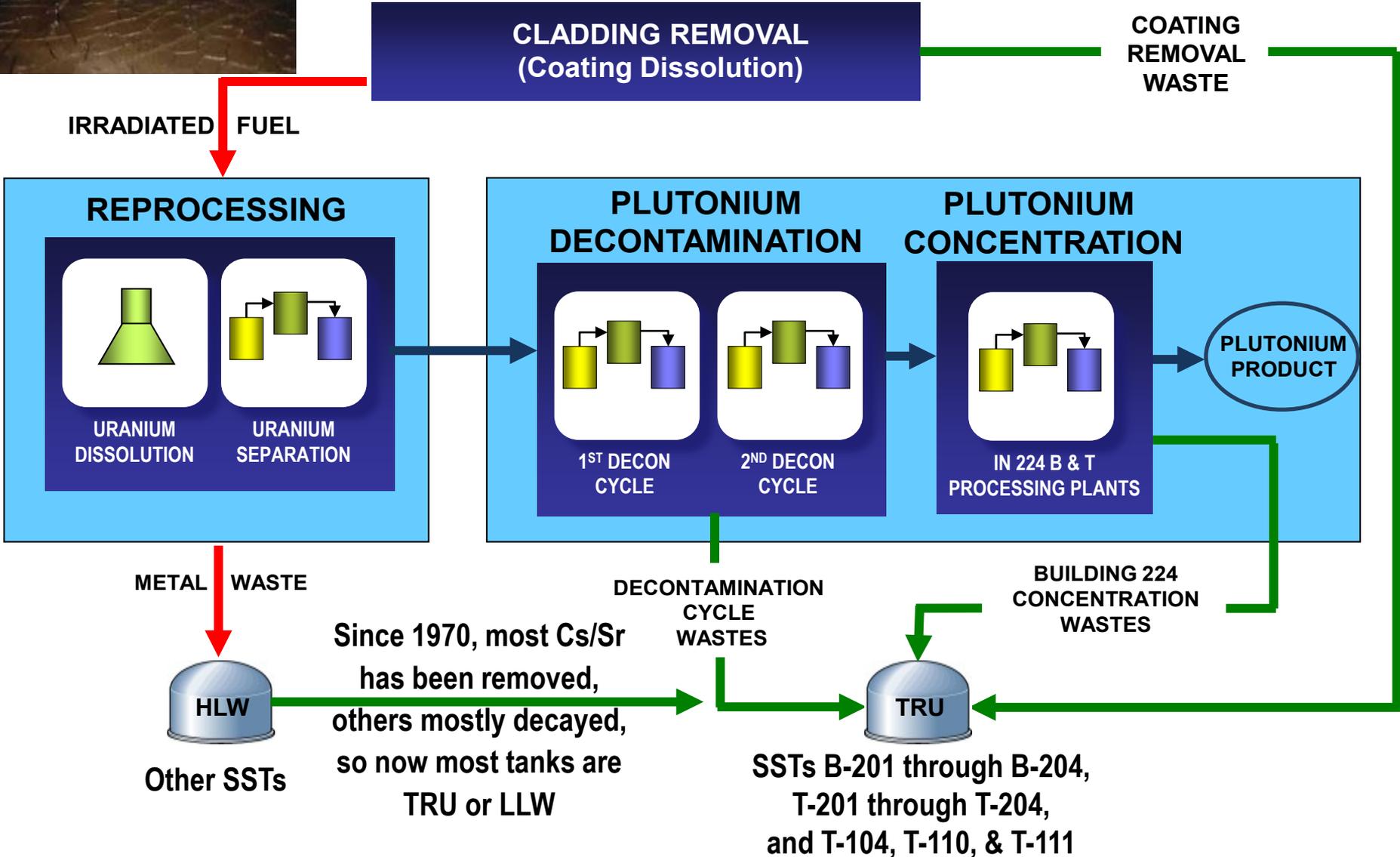
Since 1970, most Cs/Sr  
has been removed,  
others mostly decayed,  
so now most tanks are  
TRU or LLW

DECONTAMINATION  
CYCLE  
WASTES



SSTs B-201 through B-204,  
T-201 through T-204,  
and T-104, T-110, & T-111

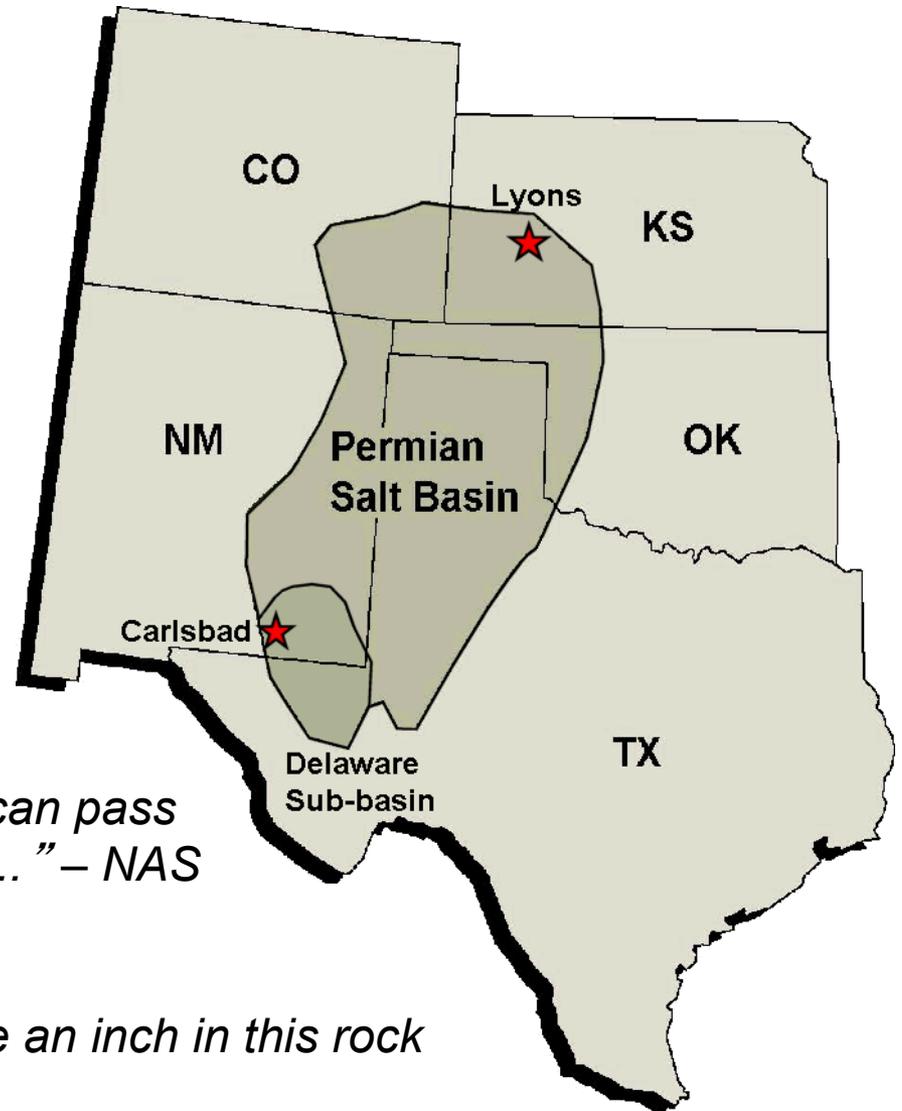
BUILDING 224  
CONCENTRATION  
WASTES



National Academy of Sciences (NAS) concludes in 1957 that the most promising disposal option for all radioactive waste is in massive salt deposits

**1957**

*“Salt at great depth flows.’ It will encapsulate any waste placed at depth and isolate it from the surface environment for eons.” - NAS*



*“The great advantage is that no water can pass through salt. Fractures are self healing..” – NAS*

*It takes a billion years for water to move an inch in this rock*

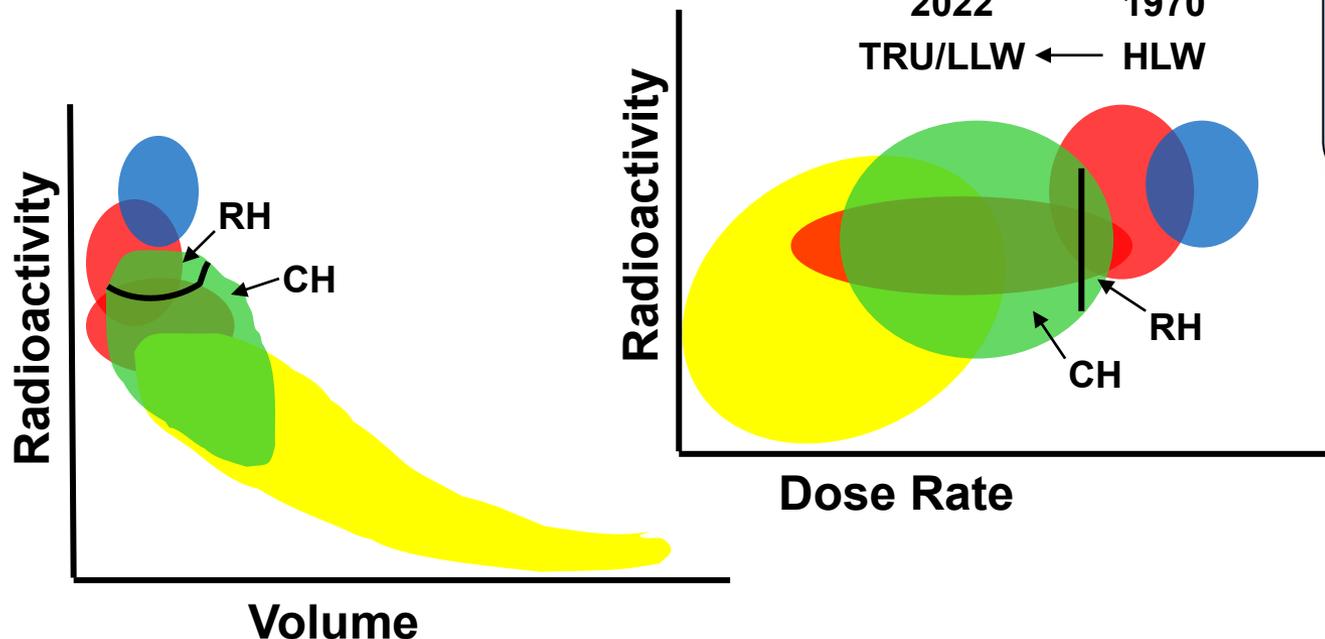
# Disposal options for different waste streams begins to diverge in the 1970s

1957 - deep geologic disposal adopted; salt chosen as best

1970 - AEC establishes new category for transuranic waste, distinct from low- and high-level radioactive waste but with significant overlap in radioactivity. EPA formed.

1976 – reprocessing of commercial spent fuel put on hold; separate retrievable disposal concept born for SNF/HLW not to go into salt; TRU still to go into salt.

1982 – Nuclear Waste Policy Act...



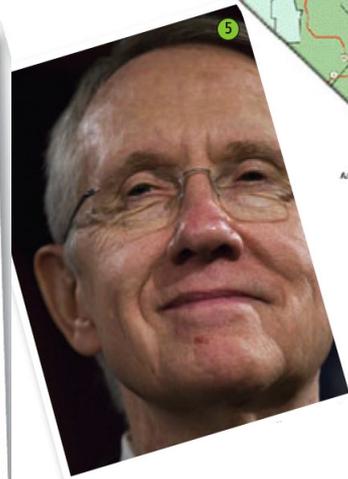
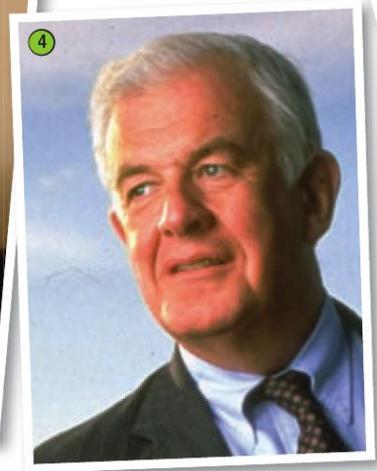
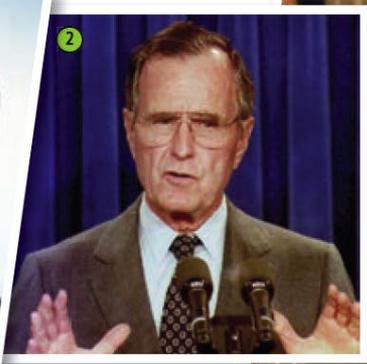
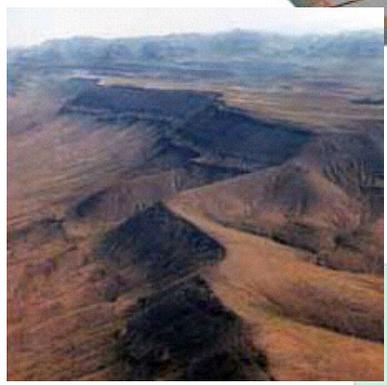
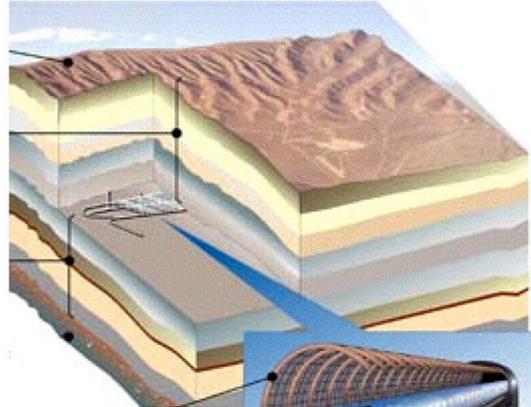
Contact Handled (CH) < 200 mrem/hr < Remote Handled (RH, up to 23 Ci/L)



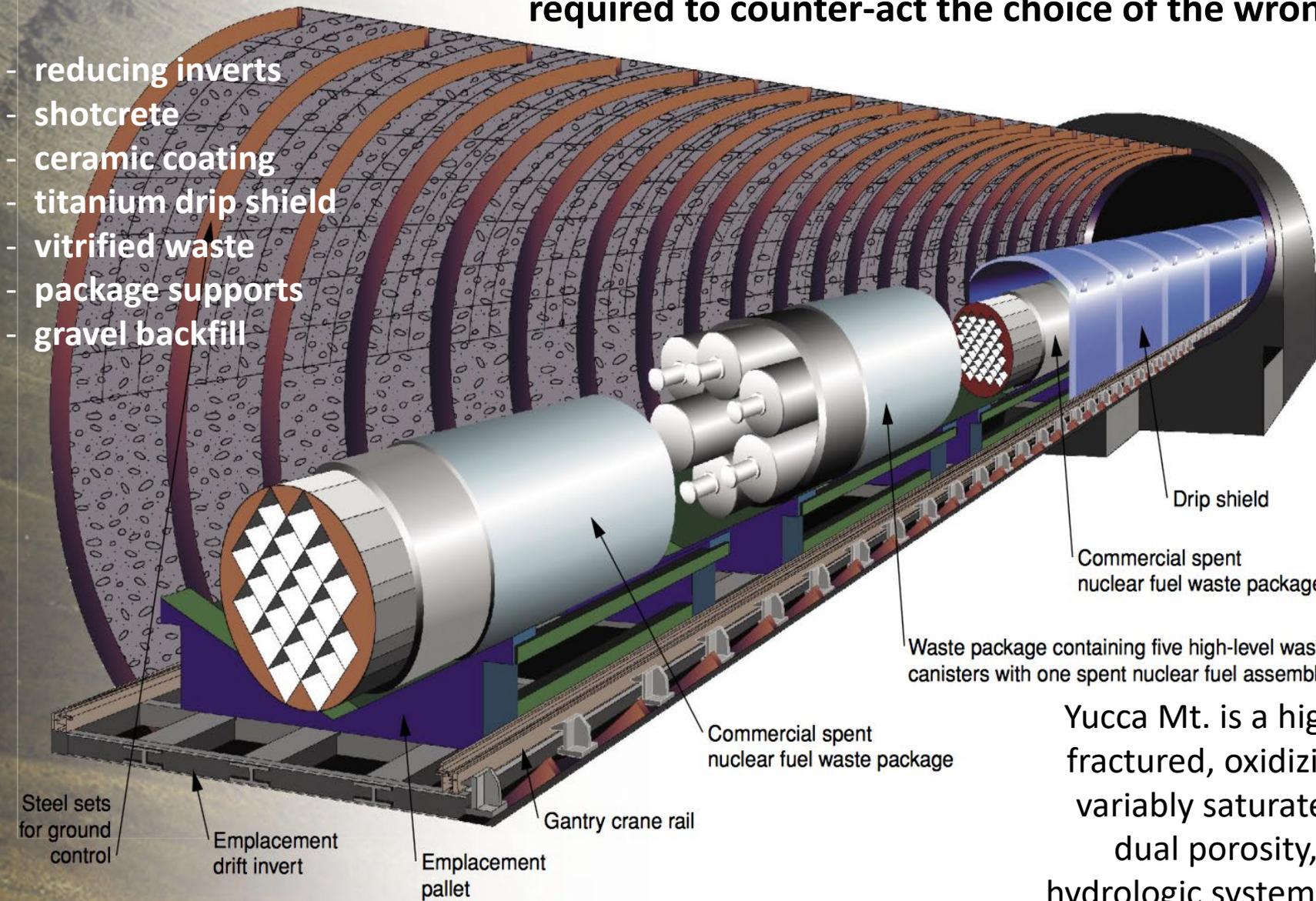
But the idea of retrieving SNF in the future took hold, killing salt as the host rock and by 1987 the candidate sites were narrowed from 17 to 3:

- Yucca Mt, Nevada
- Hanford, Washington State
- Deaf Smith, Texas

In 1987, Speaker of the House was Jim Wright from *Texas*, House majority lead was Tom Foley from *Washington State*. A new junior, Harry Reid, was from *Nevada*. So Nevada was chosen. Harry Reid became Senate Majority Leader and led the effort to shut down the Yucca Mountain project. In 2008, the YM license application submitted. In 2009, YMP was halted and President Obama put a Blue Ribbon Commission together to develop a new strategy.



**Extreme re-engineering, and great cost (~\$200 billion extra) is required to counter-act the choice of the wrong rock**



Yucca Mt. is a highly fractured, oxidizing, variably saturated, dual porosity, hydrologic system that sits on the edge of the Las Vegas Shear Zone

Unknown to most, transuranic waste (bomb waste) continued on into the salt as planned, leading to the Waste Isolation Pilot Plant.

WIPP has shown it can handle and isolate nuclear waste is safe and cost-effective

Only defense-generated TRU waste presently permitted: 100 nCi/g to 23 Ci/L of alpha-emitting <sup>239</sup>Pu equivalents but WIPP was originally designed to handle all nuclear waste

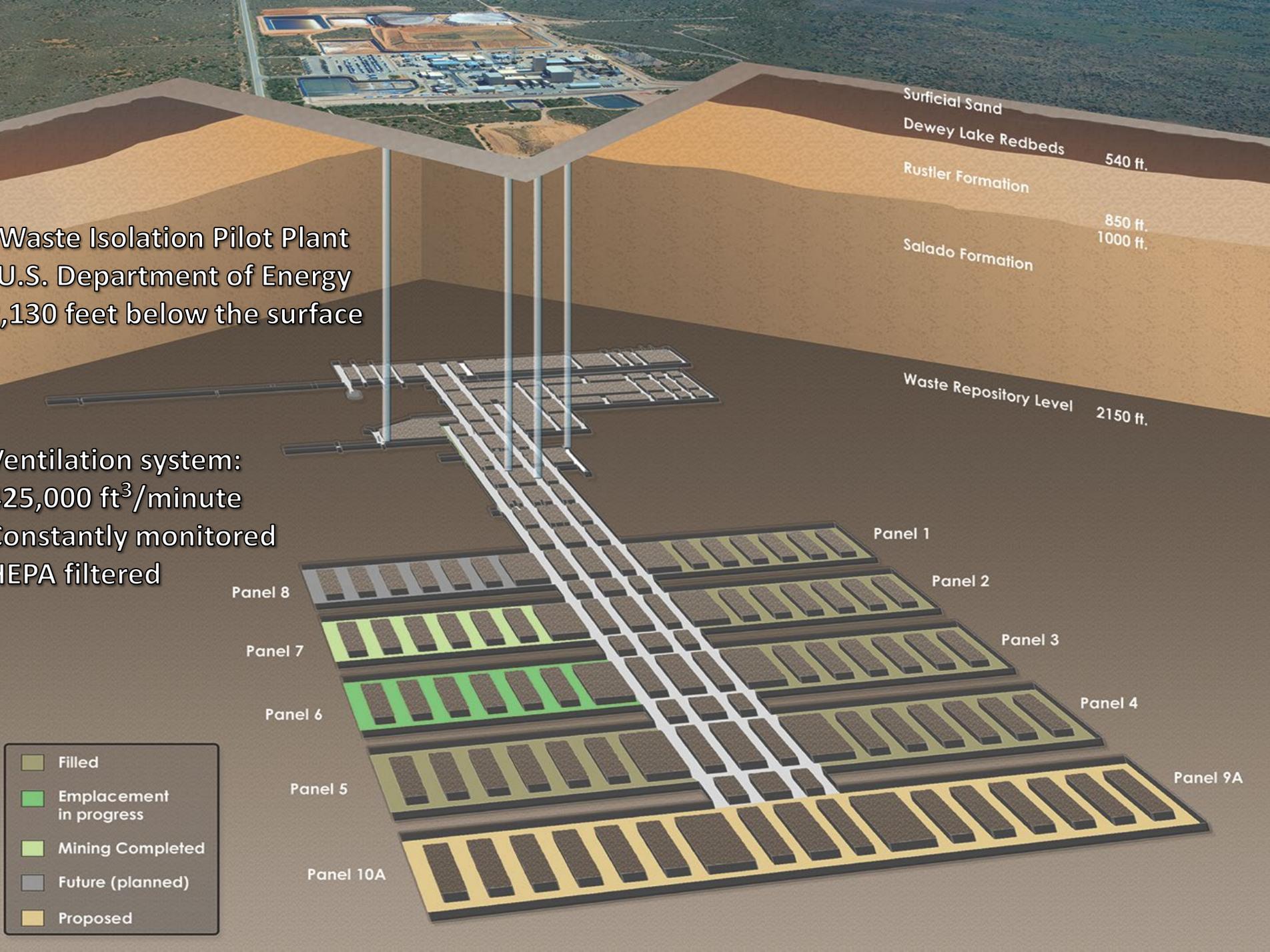
### Location of WIPP

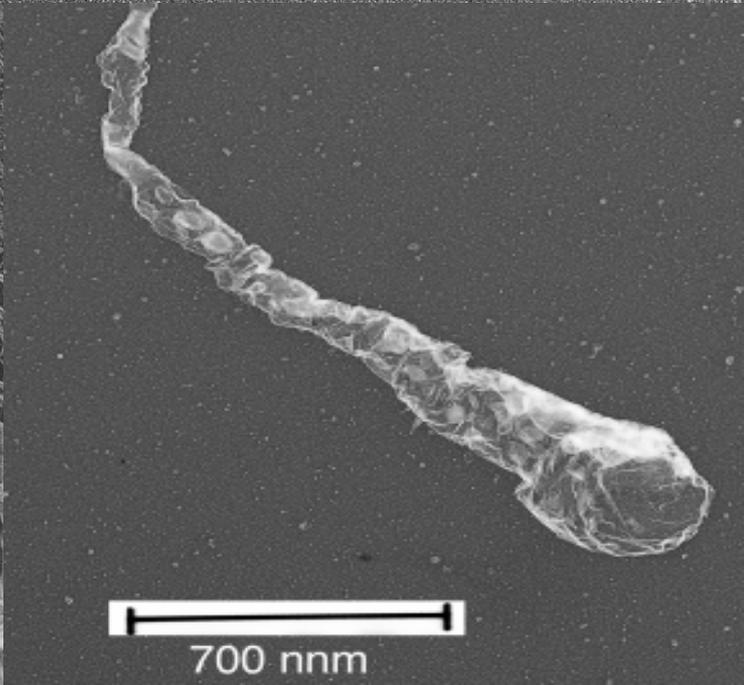
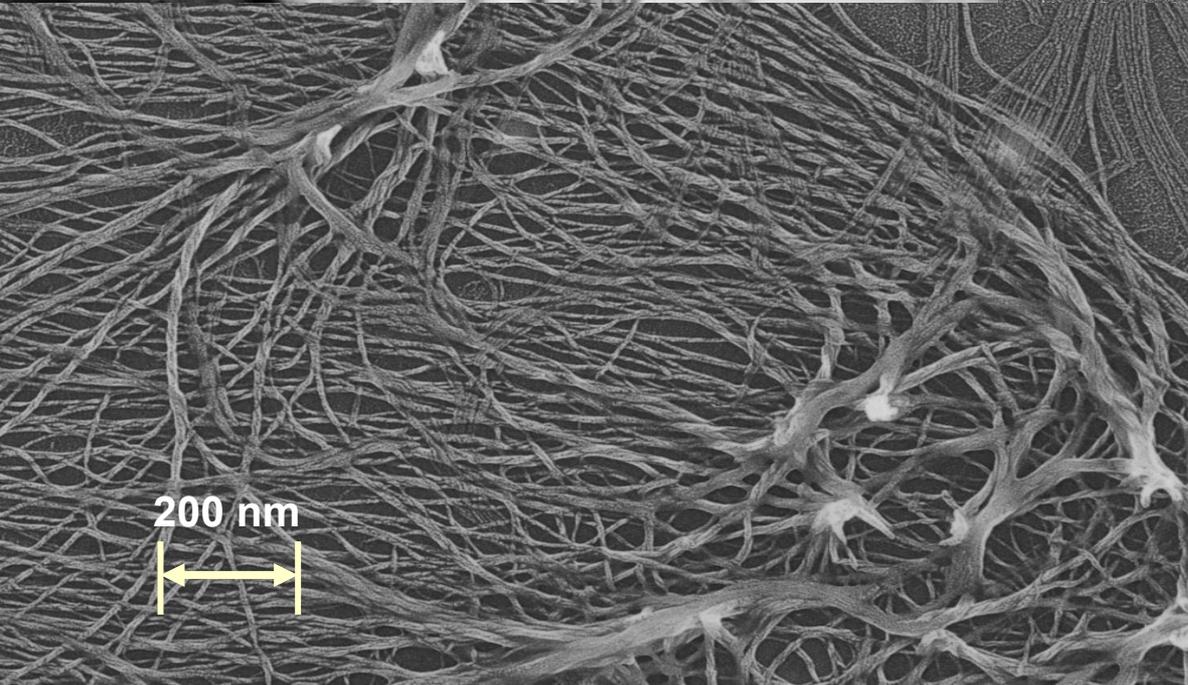
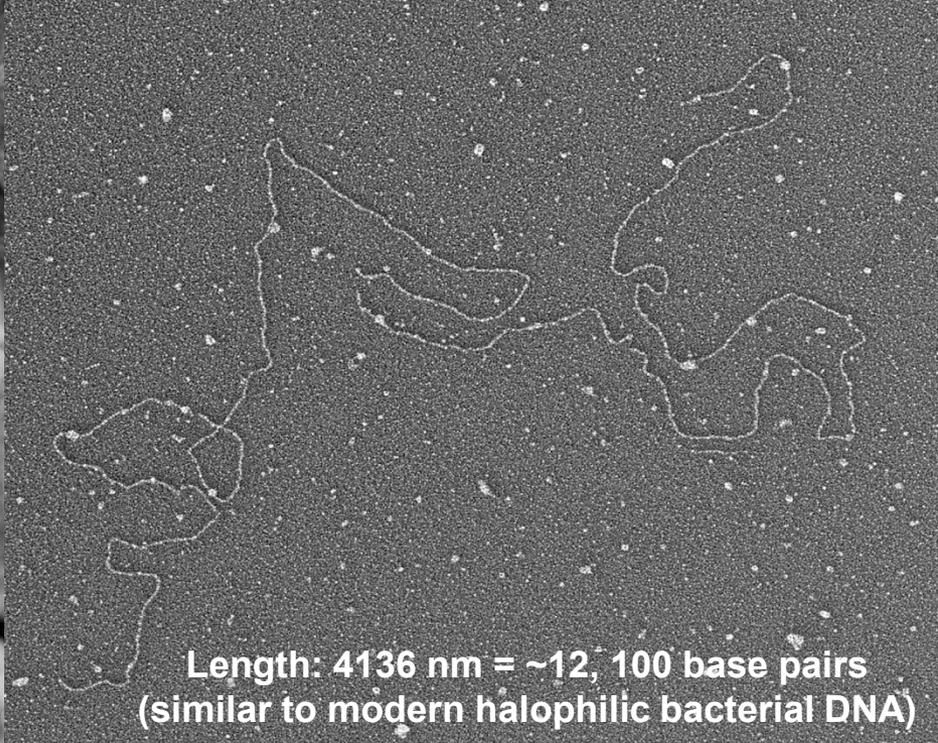
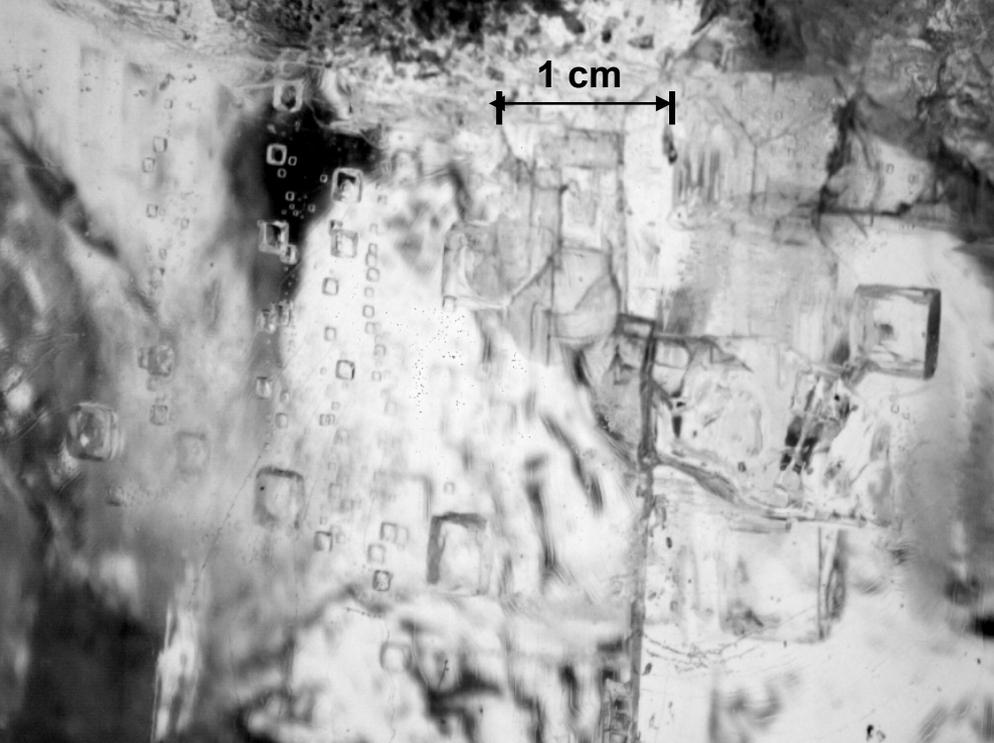


16 miles<sup>2</sup> set aside in the 1992 Land Withdrawal Act - when WIPP is full, only 1/2 mile<sup>2</sup> will have been used

Waste Isolation Pilot Plant  
U.S. Department of Energy  
2,130 feet below the surface

Ventilation system:  
425,000 ft<sup>3</sup>/minute  
Constantly monitored  
HEPA filtered





# **Mining the Salado is the easiest and safest mining operation in the world**





**January 2007, high activity waste began shipping to WIPP;  
up to 1000 R/hr surface and 23 Curies/liter (87 Curies/gallon)**



**The high activity waste is remotely handled in shielded transport casks**



**High activity waste is remotely plunged into boreholes in the room walls prior to filling with the lower activity waste**

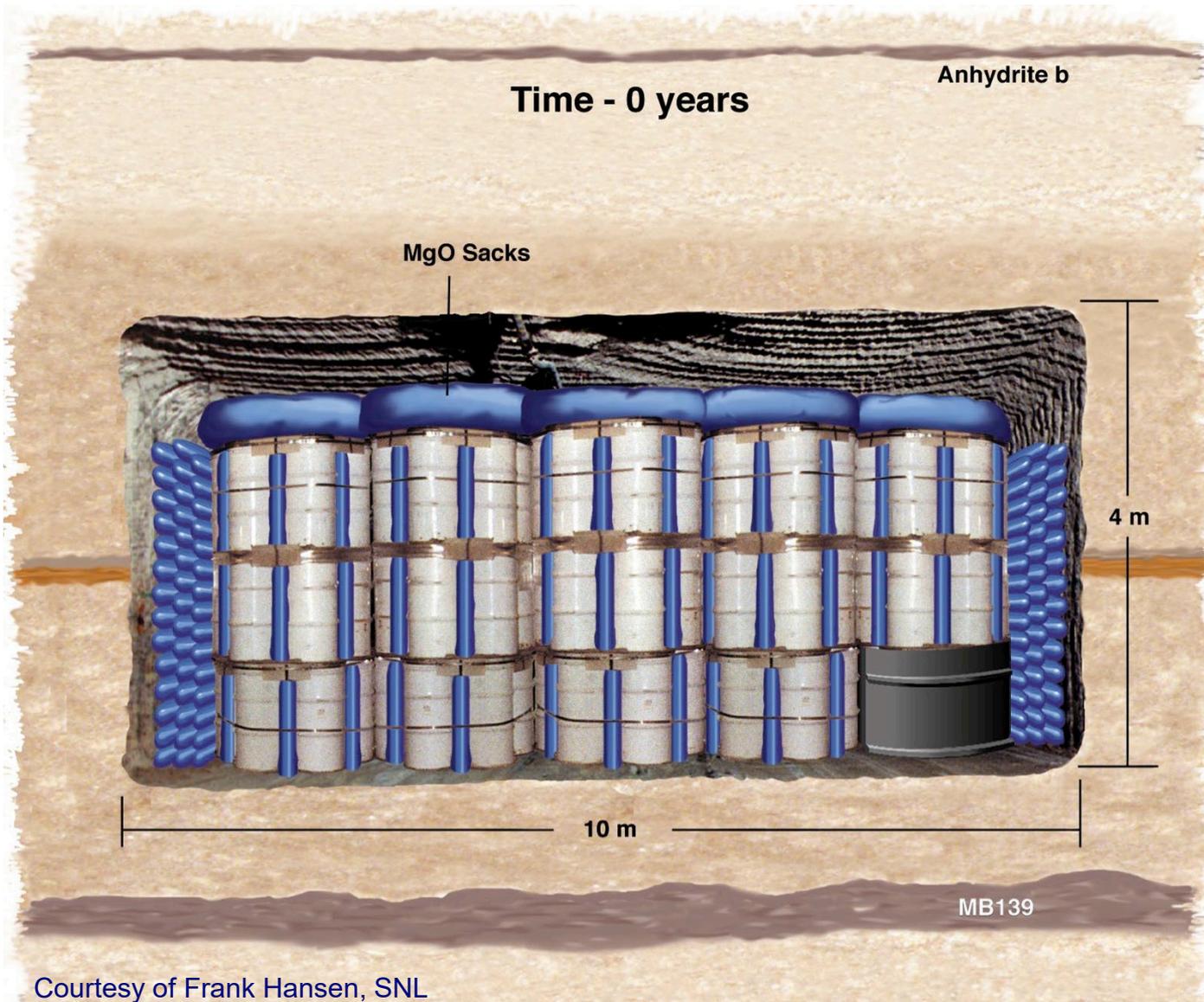


**At the 2000 lbs/inch<sup>2</sup> pressure at this depth, the salt exhibits significant creep closure, i.e., the salt completely closes all fractures and openings, even micropores, making the salt extremely tight, such that water cannot move even an inch in a billion years**



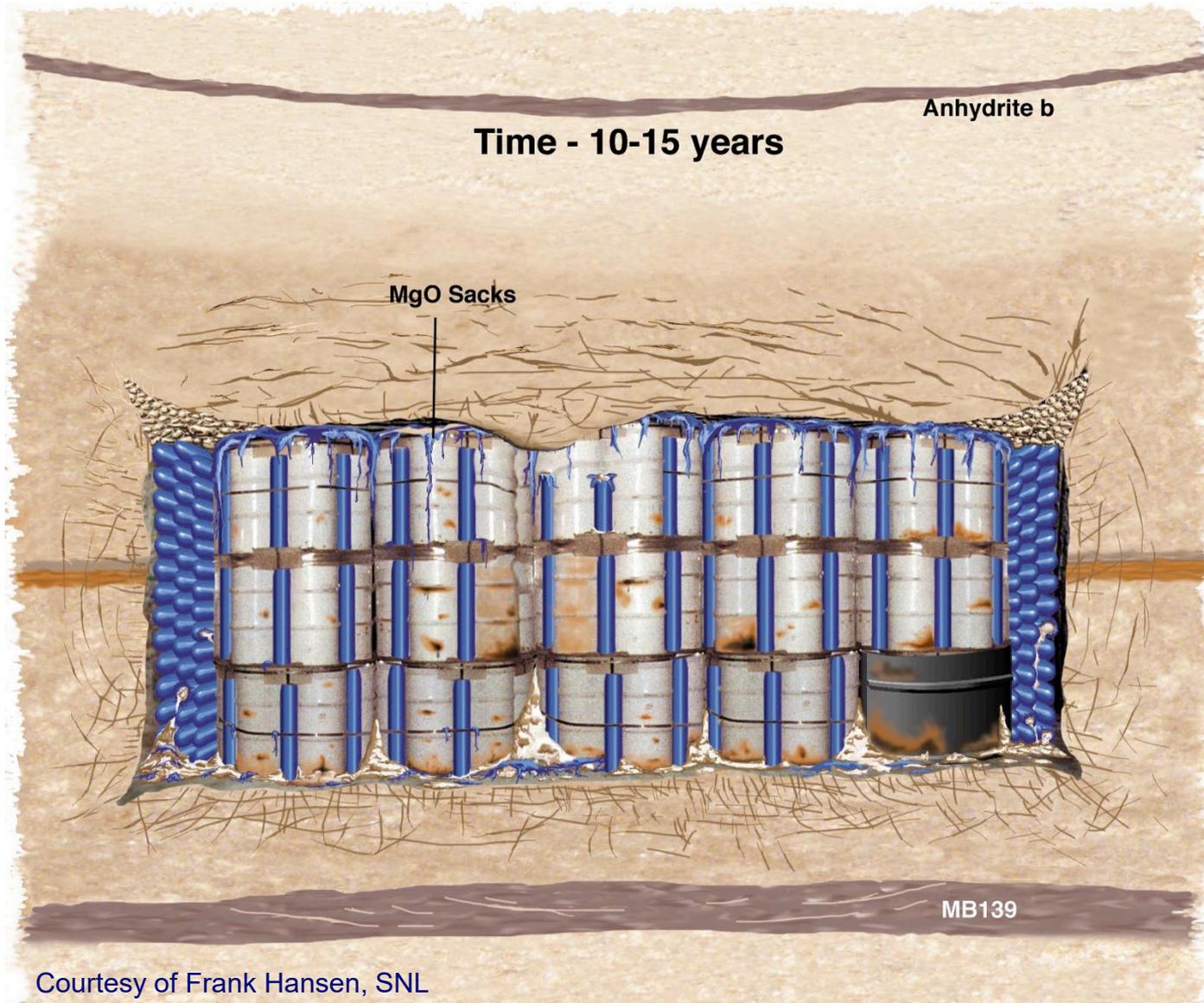
**23 years of operation – 150,000 cubic meters of TRU waste disposed  
700,000 fifty-five gallon drum equivalents  
22 storage sites cleaned of legacy waste  
1 minor release to the environment  
0 deaths 0 people contaminated**

# Evolution of the WIPP Disposal Rooms (t = 0 yrs)



Courtesy of Frank Hansen, SNL

# Evolution of the WIPP Disposal Rooms (10-15 yrs)



Courtesy of Frank Hansen, SNL

# Evolution of the WIPP Disposal Rooms (1000 yrs)

Time - 1000 years +

$$K \leq 10^{-14} \text{ m/s}$$

$$D \sim 10^{-15} \text{ m}^2/\text{s}$$

(water and contaminants move less than an inch in a billion years)

Anhydrite b

1% - 1.5% porosity

pH = 8.6 - 9.2

Eh < -500 mV

$$K_{\tau\text{salt}} \sim 15 \text{ kcal/m/hr/deg @ } 200^\circ\text{C} = 5 \times K_{\tau\text{crystalline}}$$

annealing of disturbed salt  $\sim f(T^x)$  where  $6 < x < 9 \Rightarrow$  closes in < 3 years for HLW



performance period - 200,000,000 years, not 10,000 or 100,000 years

MB139

no engineered barriers needed, waste form irrelevant  
no persistence of cladding or canister needed  
no adverse temperature effects, fluid inclusion migration irrelevant

# Waste Disposal Footprint in Salt

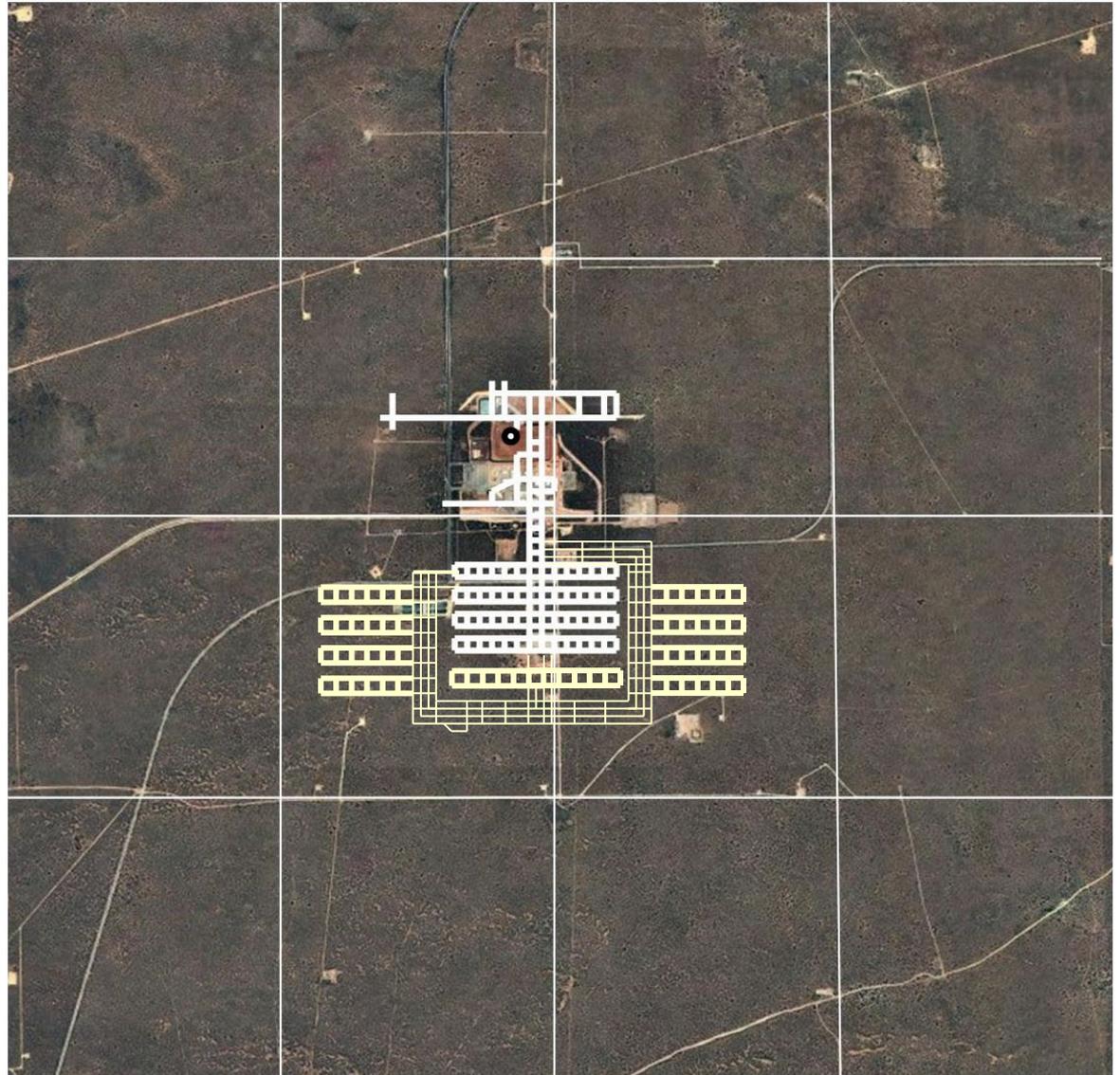
Final footprint of WIPP will be only 1 mile<sup>2</sup> out of 16 set aside for nuclear waste disposal by the the 1992 Land Withdrawal Act.

WIPP is still 10 yrs ahead of schedule and \$1 billion under budget.



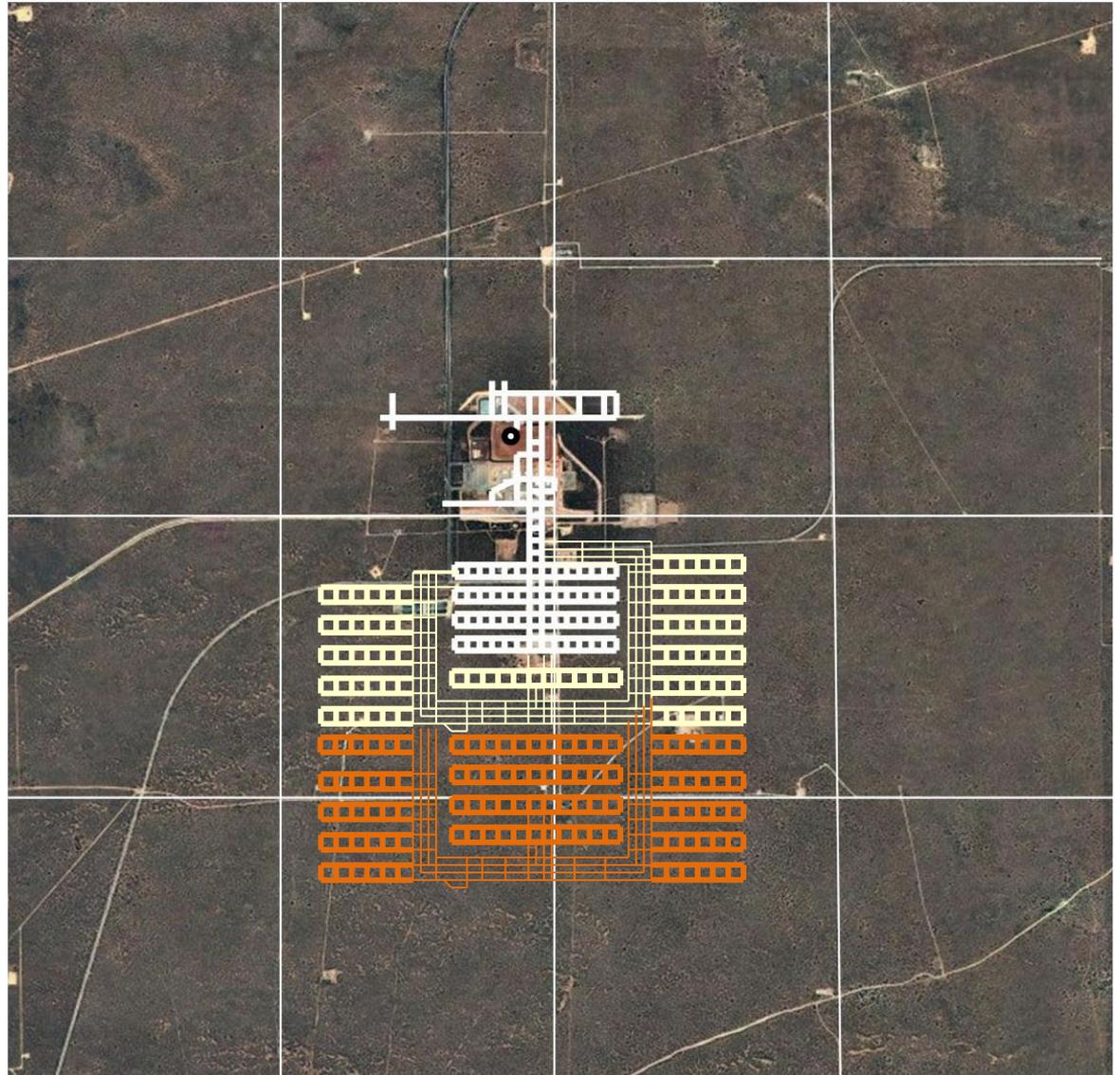
# Waste Disposal Footprint in Salt

New footprint of an expanded WIPP to include HLW that has become TRU, with interim storage for SNF, would be less than 3 mile<sup>2</sup> out of the 16 set aside for nuclear waste disposal by the the 1992 Land Withdrawal Act

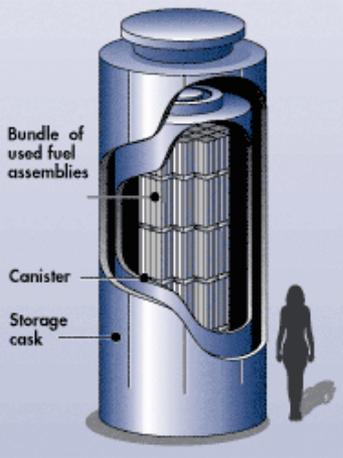


# Waste Disposal Footprint in Salt

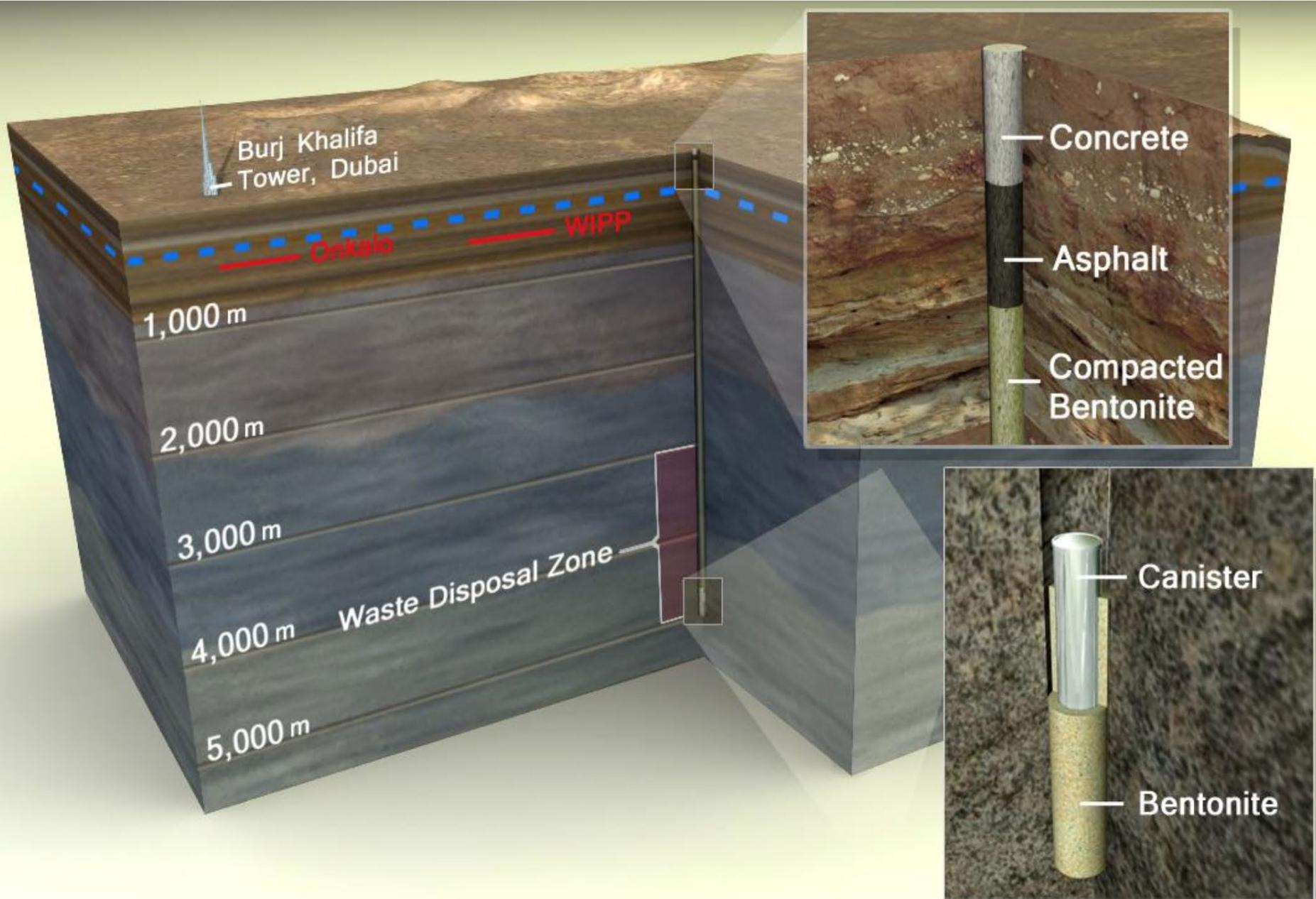
Footprint of an expanded WIPP to include advanced reactor waste, re-purposed SNF burned in fast reactors, and SNF just cooled off for some decades, all after supplying 40% of our energy needs from 2040 to 2100



# Interim Storage for Commercial Spent Fuel ideal for >120 years, enough time for SNF to cool significantly, and hopefully burned in fast reactors in the near-future



# Deep Borehole Injection of Nuclear Waste



# Deep Isolation UC Berkeley

**DEEP.  
SAFE.  
ISOLATED.**

Secure under more than 1 mile of sedimentary rock. The sealed canisters are retrievable at any time.

Aquifer  
Recharge Areas

Temporary  
emplacement rig, 160-feet high

Aquifer casing

Aquifers

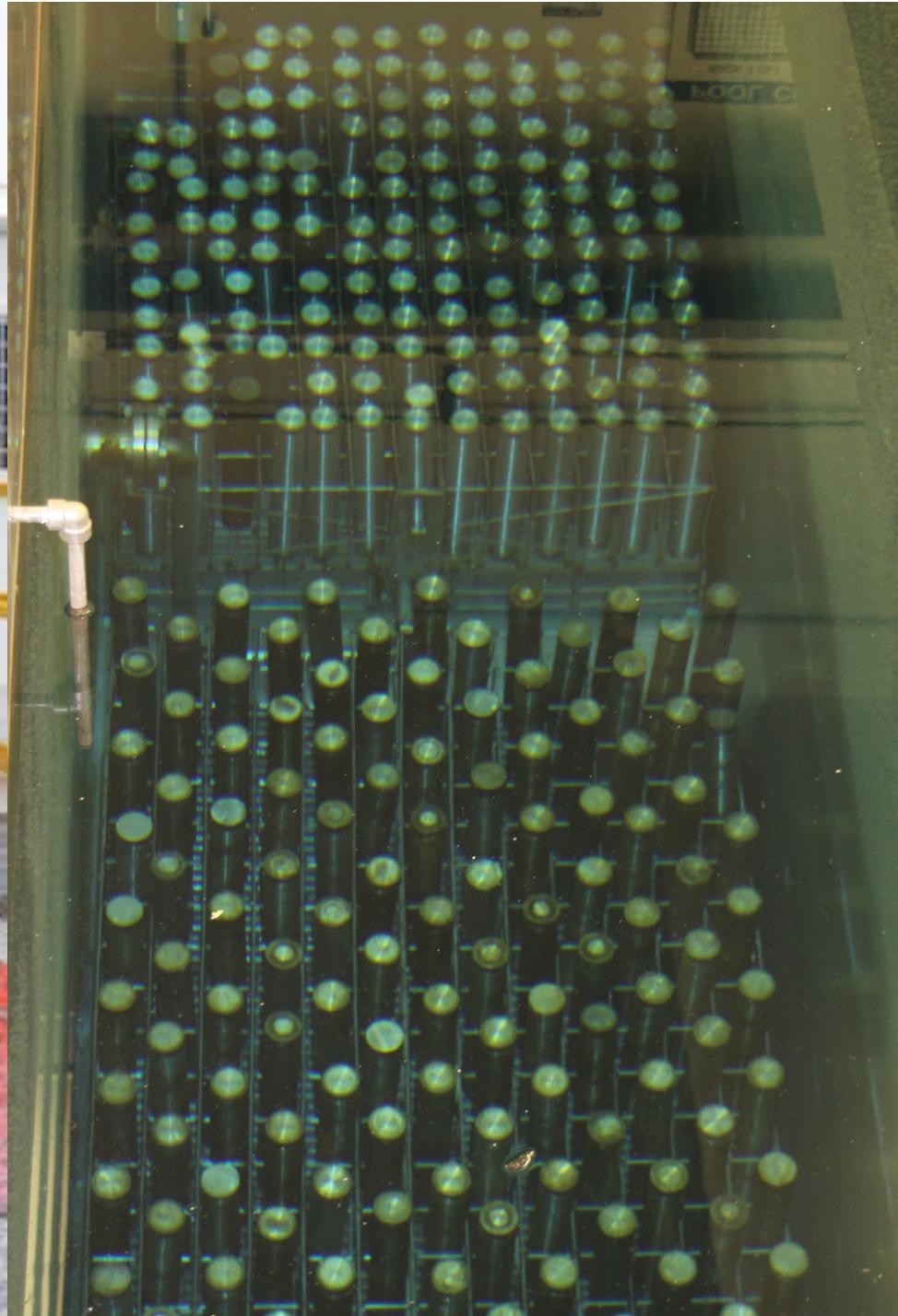
Plugged vertical  
access drill hole  
(with steel casing  
and concrete)

Pipe diameter isn't  
much wider than a  
regulation football

Dead end trap

Spent nuclear fuel  
canister storage

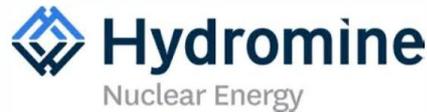
Plumbers trap



# Alternative Water and Non-Water Cooled Reactors

- various waste forms and geometries
- some able to be molded to a specific geometry for deep borehole

## Advanced Reactor Developers



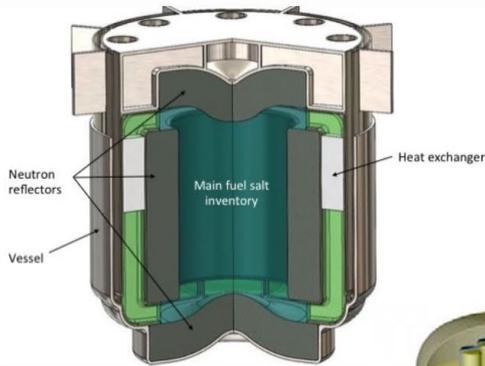
BSCE

ADNA

# Alternative Water and Non-Water Cooled Reactors

## - various waste forms and geometries

### Molten Salt Reactors

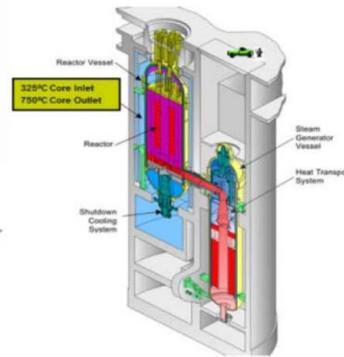


TerraPower



Terrestrial Energy

### High Temperature Gas Reactors



Framatome



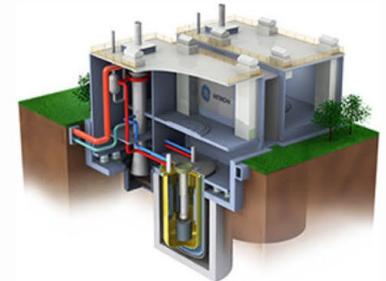
The Xe-100  
A Different Kind of Nuclear Reactor  
X-energy

### Micro Reactors

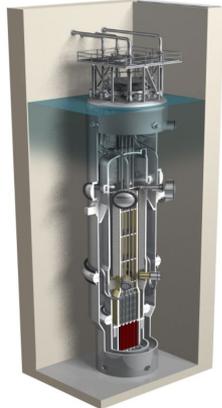


Westinghouse eVinci

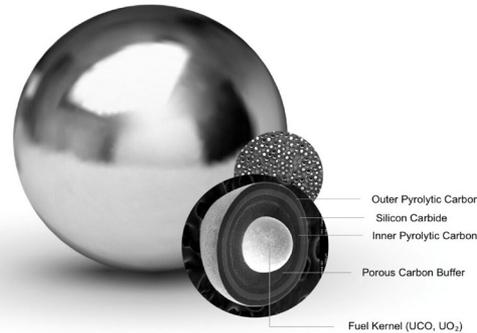
### Liquid Metal Reactors



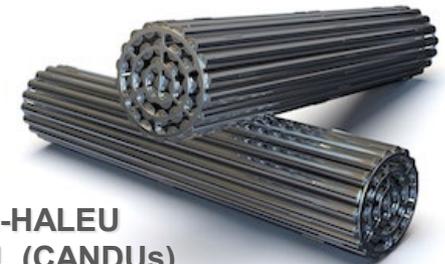
GE PRISM



NuScale Power Module



Th-HALEU  
ANEEL (CANDUs)  
Clean Core Thorium





# Probable Outcomes for U.S. Nuclear Waste (also supported by BRC)

## Defense Waste (TRU and HLW)

stays right where it is  
(EISs show no problem)

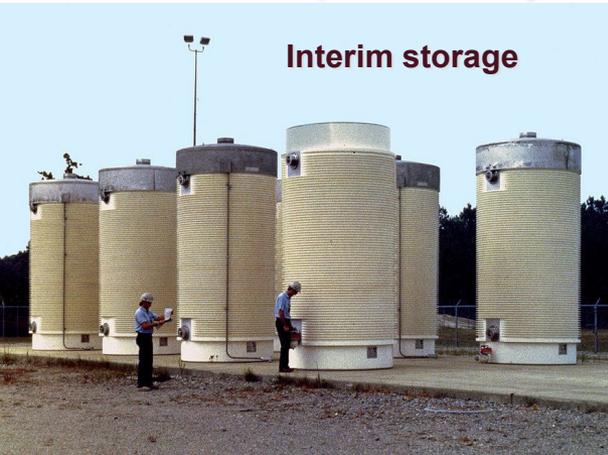
HLW redefined as TRU

2<sup>nd</sup> salt repository - cheap

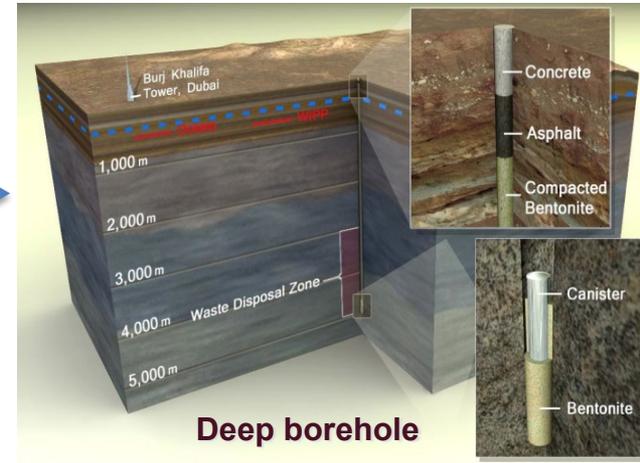
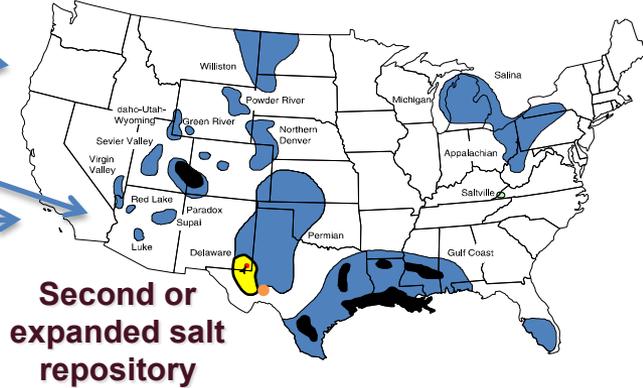
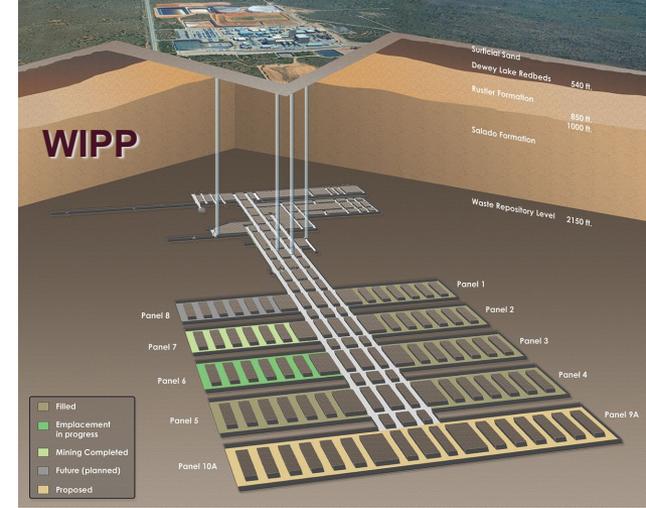
HLW redefined as LLW to TX, UT

## Commercial nuclear fuel

### Interim storage

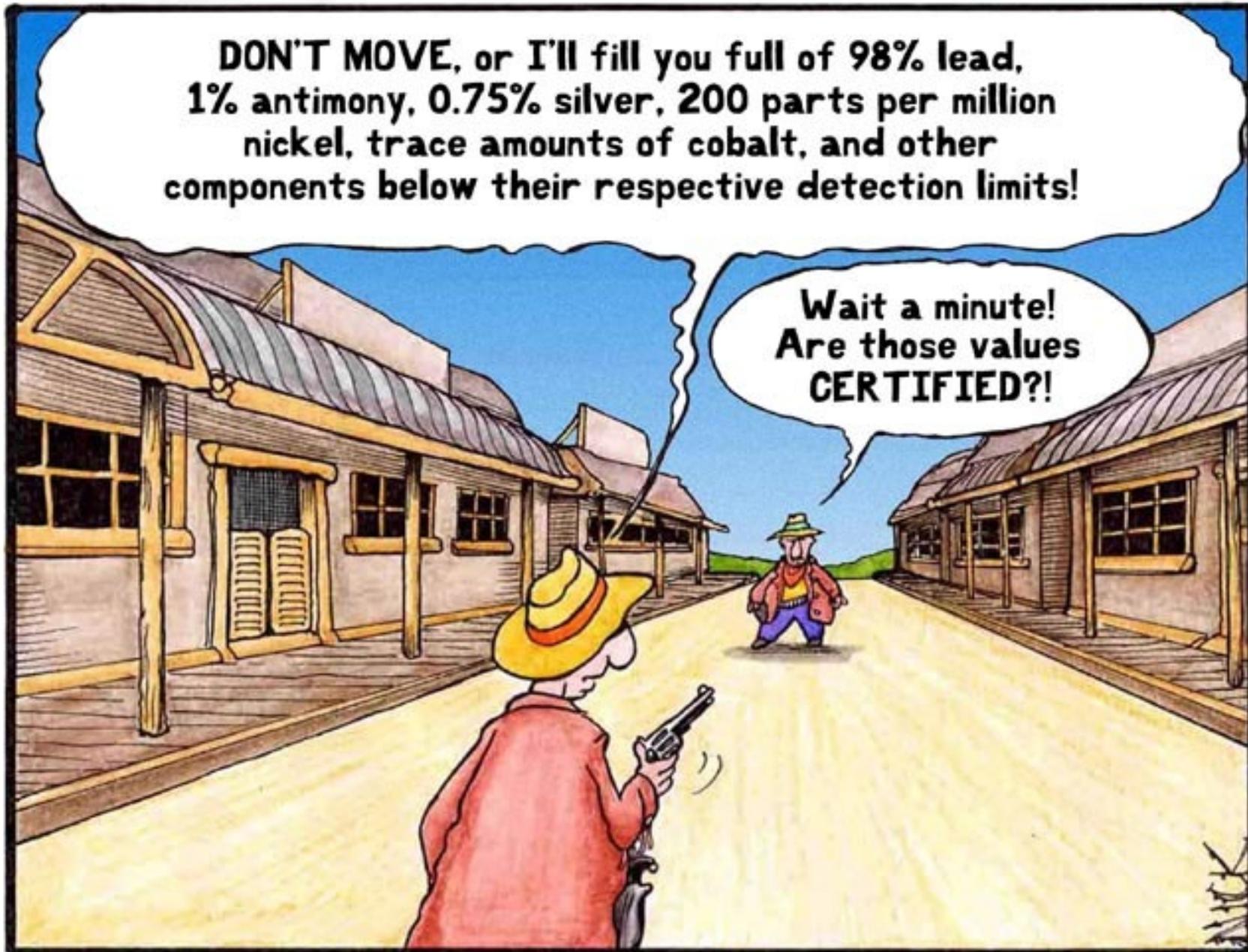


New reactor designs

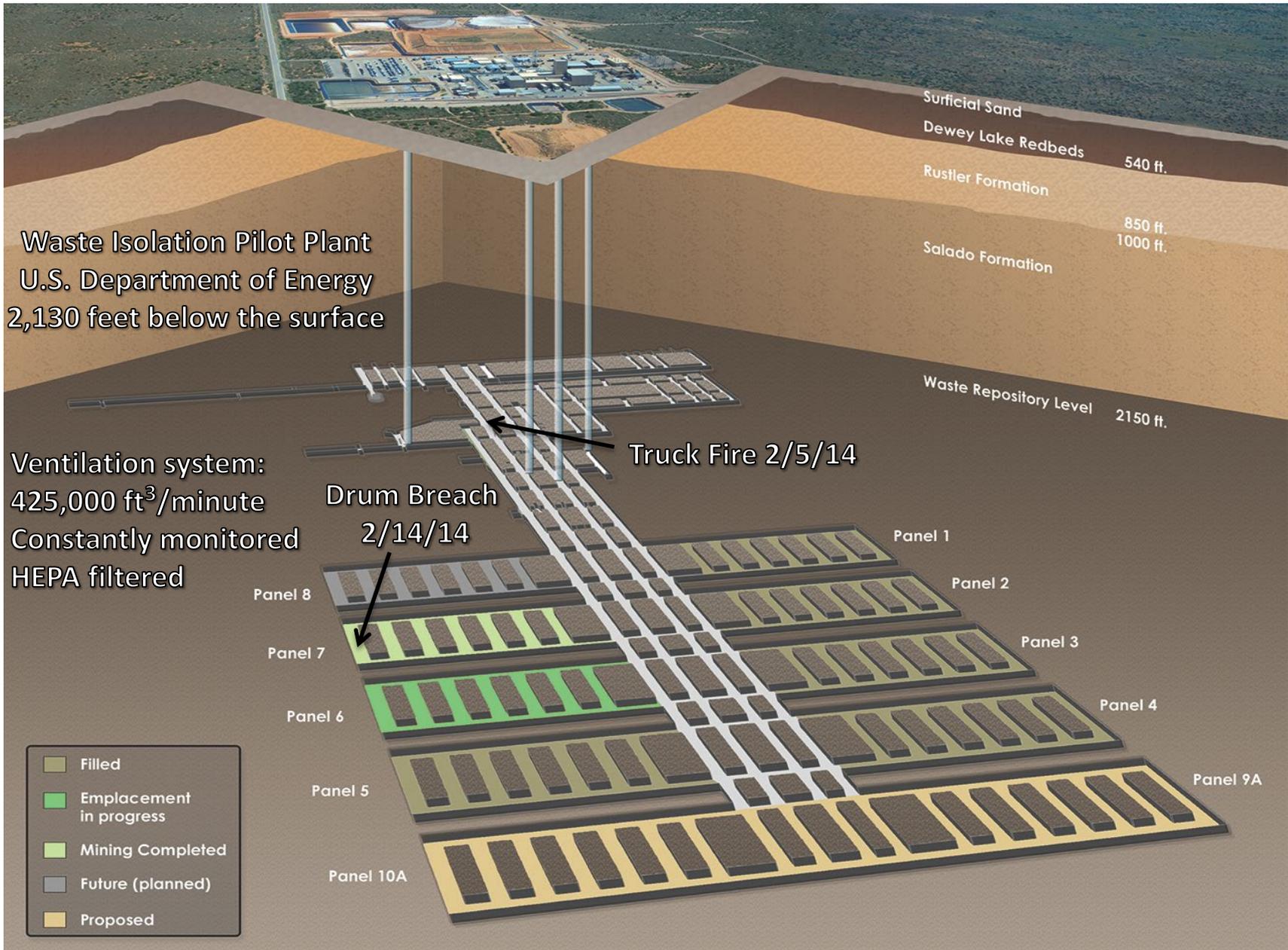


**DON'T MOVE, or I'll fill you full of 98% lead,  
1% antimony, 0.75% silver, 200 parts per million  
nickel, trace amounts of cobalt, and other  
components below their respective detection limits!**

**Wait a minute!  
Are those values  
CERTIFIED?!**



Analytical Chemists in the Wild West



**On Valentine's Day 2014, a puff of airborne radioactivity was detected in the WIPP underground. Immediately, ventilation went to HEPA. The amount released was 1.8 Bq/m<sup>3</sup> of air (not even reportable as per EPA) that quickly dropped to hundredths of a Bq/m<sup>3</sup>, measureable but a thousand times less than background doses. 21 Workers had detectable amounts that quickly disappeared, also well below human background.**



## The nitrate waste drums

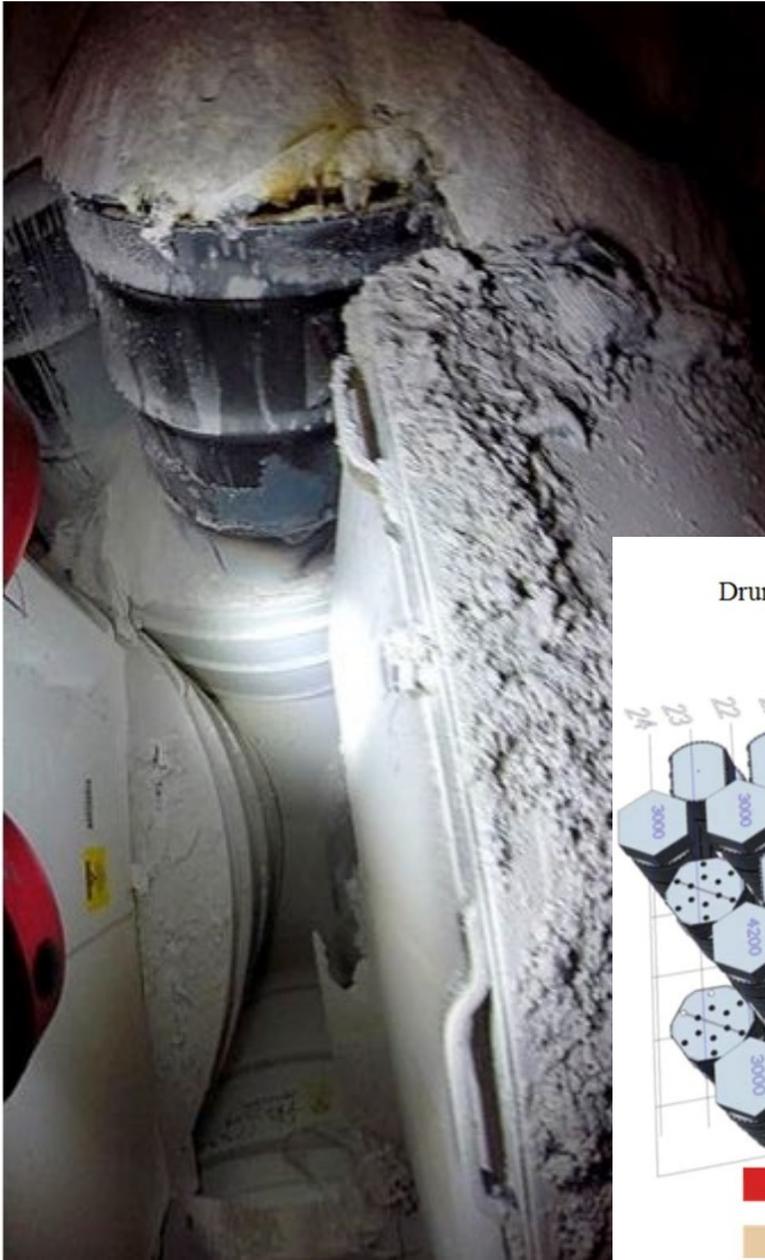
- 1970s-80s - metal-nitrate salts in nitric acid generated from experiments to remove Am from older weapons
- 1970s - experiments to remove Am from weapons materials; generated metal-nitrate salt waste
- 2011 - retrieved for packaging for WIPP, procedures altered to remove warnings about metal nitrates absorbents and neutralizer addition, some incompatible with waste, Pb
- 2013 - advised to add inorganic cat litter, someone switched to organic dustless litter, and shipped to WIPP
- 2014 - drum heats up, pops top, releases rad, WIPP closed
- May 19 NMED issues two Admin Orders
  - corral drums not in WIPP, make secure
  - seal WIPP Panel 6 and Panel 7 room 7



Clean-up could have taken 6 months and \$50 million

DOE took 3 years and \$500 million to clean-up

Lots of studies, redo all procedures, start from ground up, correct all issues which were mostly bureaucratic. New Ventilation, new shafts. But this leak was not a problem with the WIPP repository itself.



Neutralizers and sorbents included sodium carbonate, triethanolamine and polyacrylate. Anhydrous citric acid (a reducer) was used adjust pH. A strong acid should never be added to a strong oxidizer

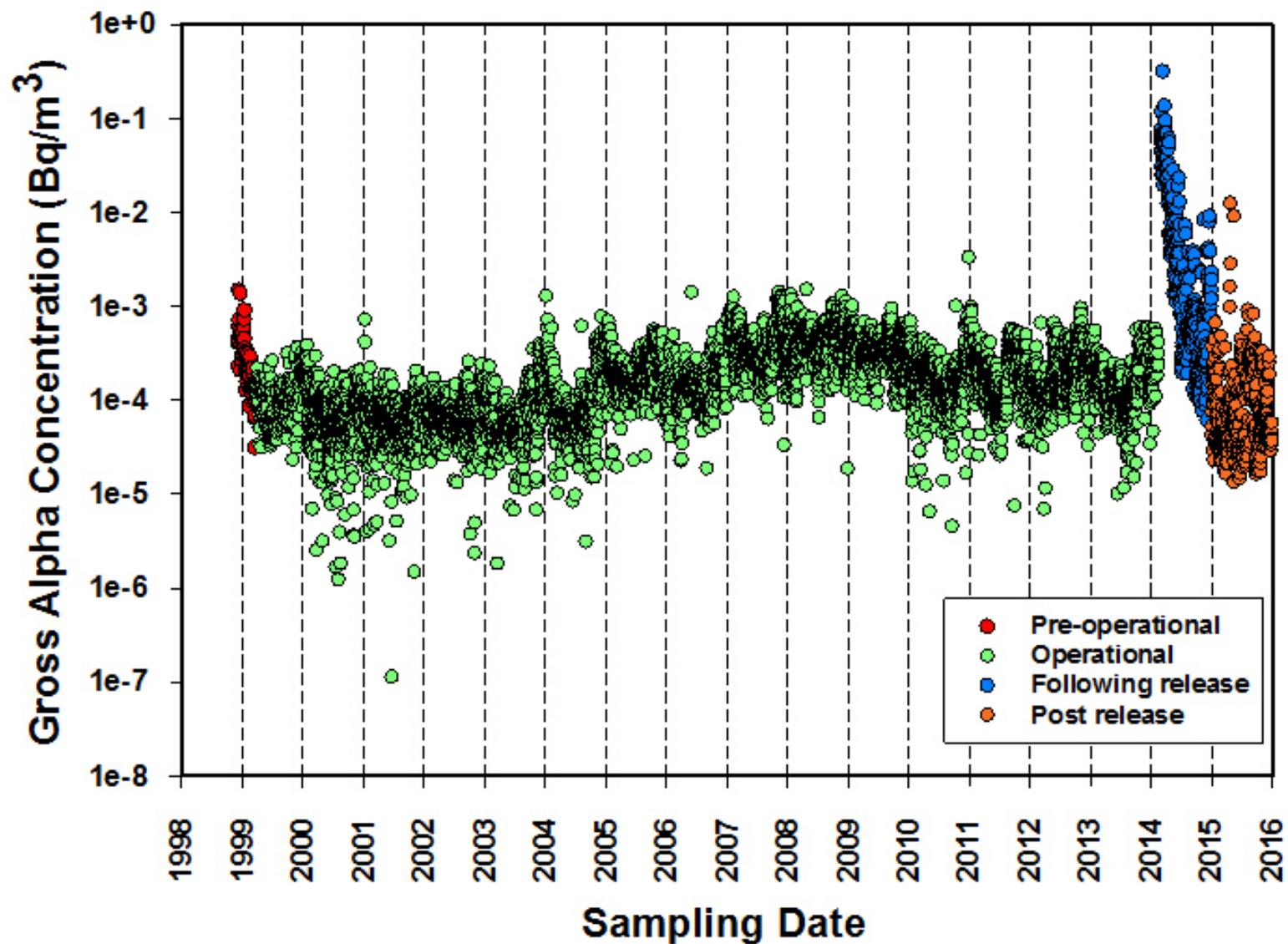
– this is a Chem 101 no-no

And citric acid should never be used with metal-nitrate salts, because of the rapid evolution of heat. Similarly for acrylates.

Drum 68660 at 16-4 in WIPP P7R7

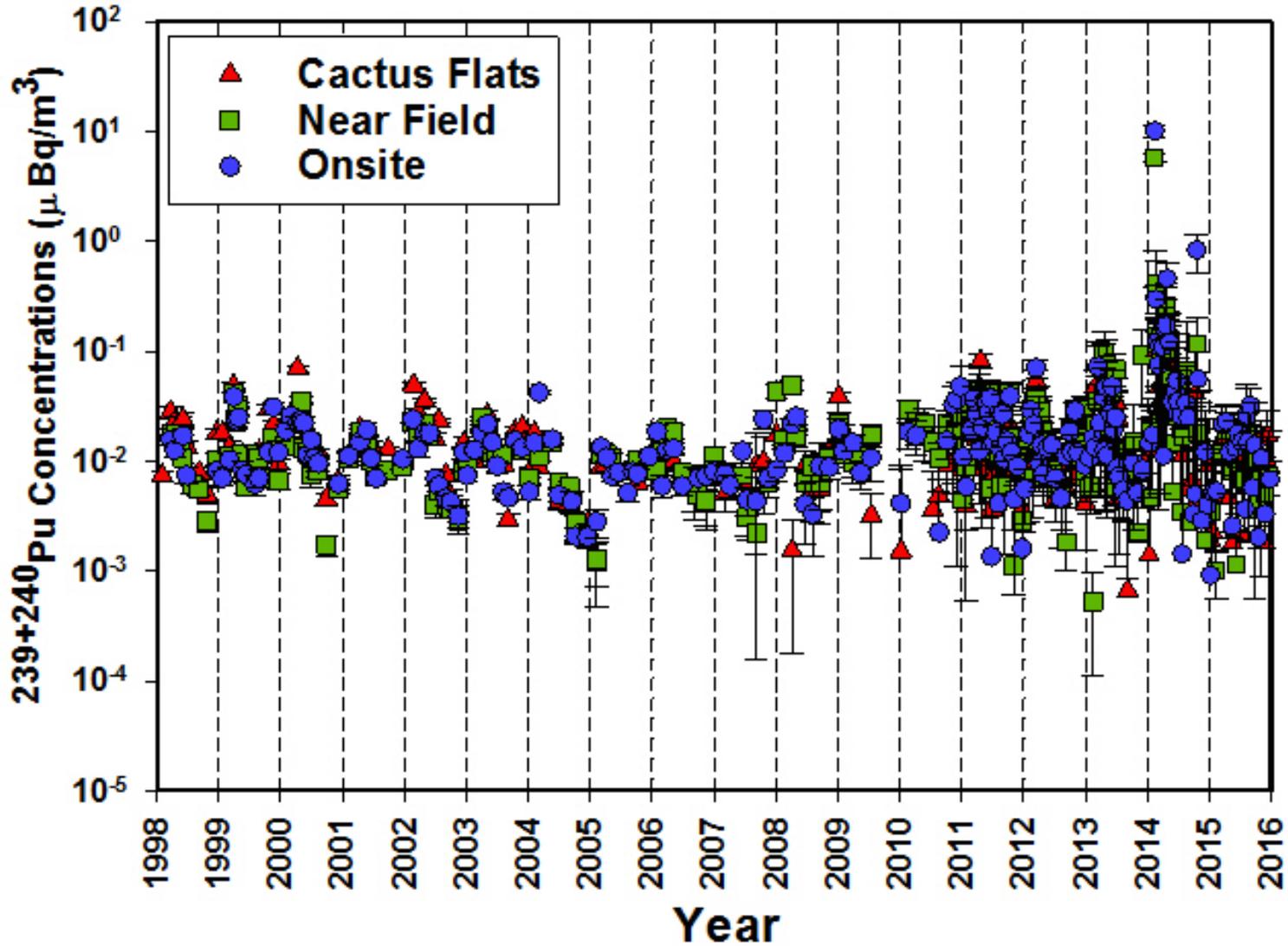


- Payload Assemblies from LANL MINO2 Waste Stream
- MgO SuperSacks with Indicated Burning/Melting of Polypropylene/Carboard Sack

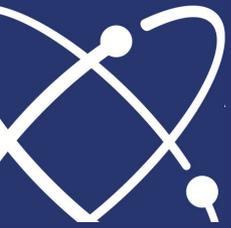


Pre- and Post-release Gross Alpha concentration in Station A (Pre-HEPA) filter

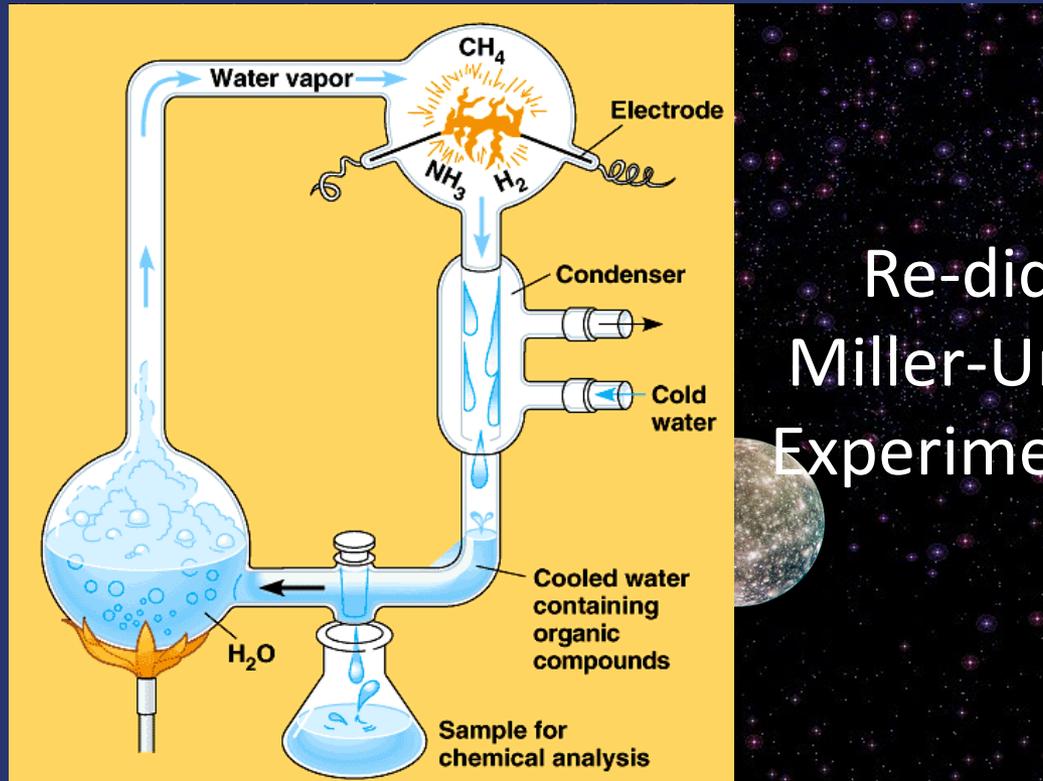
Figure 3-5: The Pre- and Post-radiological event  $^{239+240}\text{Pu}$  densities in ambient air at three stations in the vicinity of the WIPP site (Post-release dates are from July–December 2014)



The Pre- and Post-radiological event  $^{239+240}\text{Pu}$  concentrations in ambient air at three stations in the vicinity of WIPP (Post-release dates from July 2014 to December 2016)



# Nuclear and the Media



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