

*The Beginning of “Forevermore”*  
High-Level Radioactive Waste  
Management Risks:  
Pools & Dry  
Cask Storage

Kevin Kamps, Beyond Nuclear

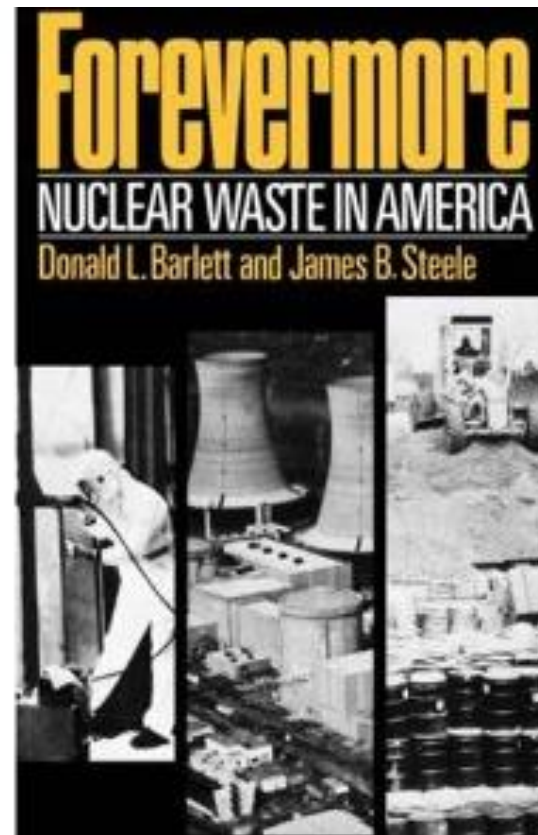
Stony Point, NY

May 3, 2015

# Beginnings...

“Electricity is but the fleeting byproduct from atomic reactors. The actual product is forever deadly radioactive waste.”

---Michael Keegan, Coalition for a Nuclear-Free Great Lakes and Don't Waste Michigan (*Dr. Judith H. Johnsrud Unsung Hero Award Winner 2015*)



And we don't even know what to do with the first cupful...



# Risks of long-term irradiated MOX fuel storage in pools on-site at nuclear power plants

Kevin Kamps

Radioactive Waste Watchdog

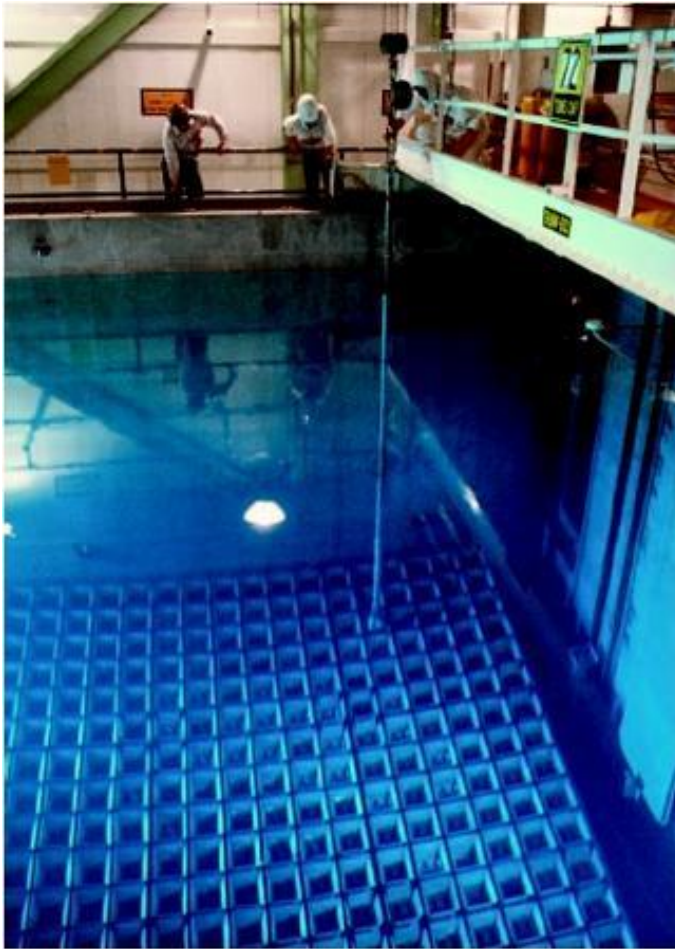
Beyond Nuclear

August, 2010 [Saga City, Japan]

# Peekskill, NY, Sept. 2011 (Photo by David M. Grossman)

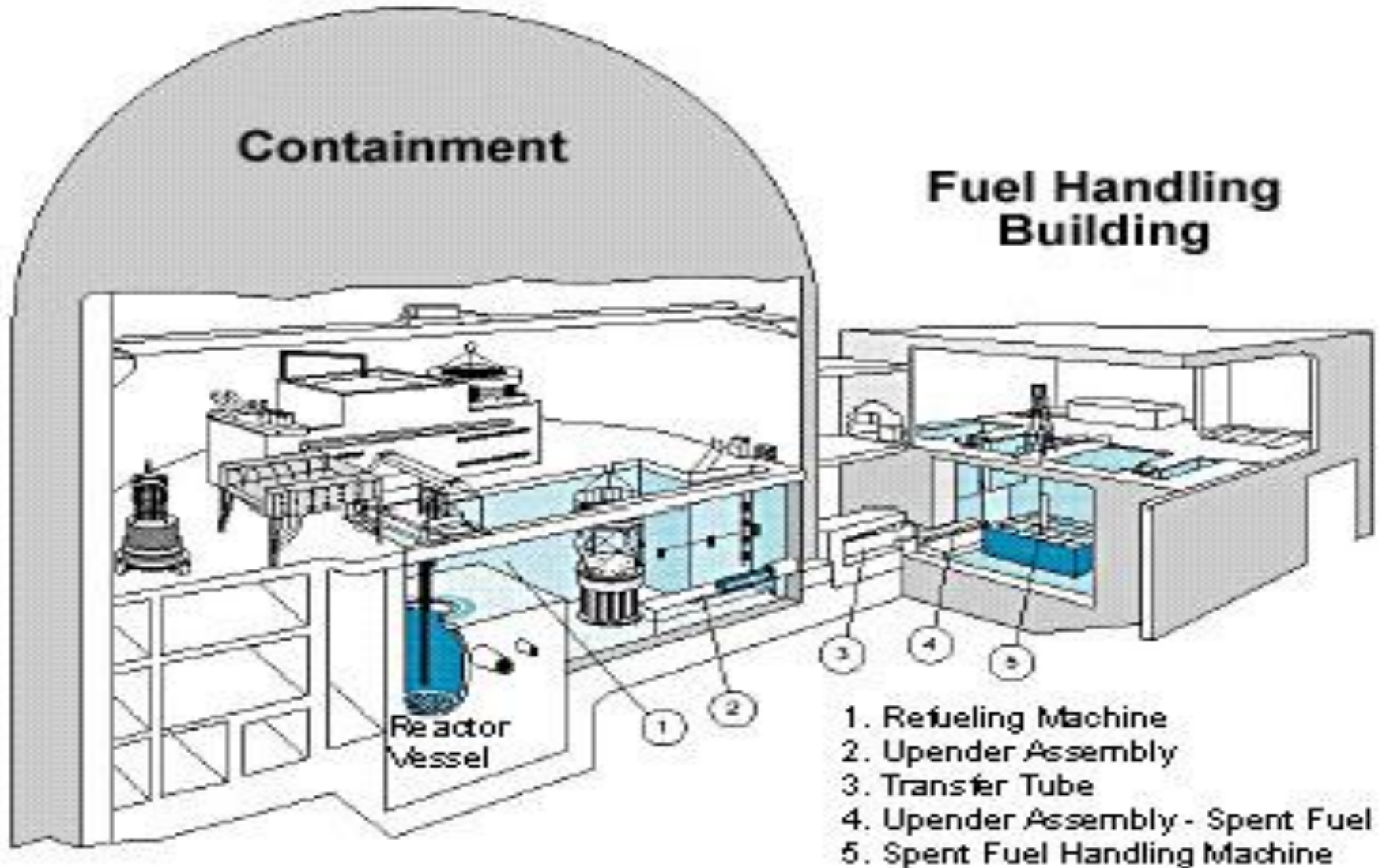


# Irradiated nuclear fuel pool storage in the U.S.



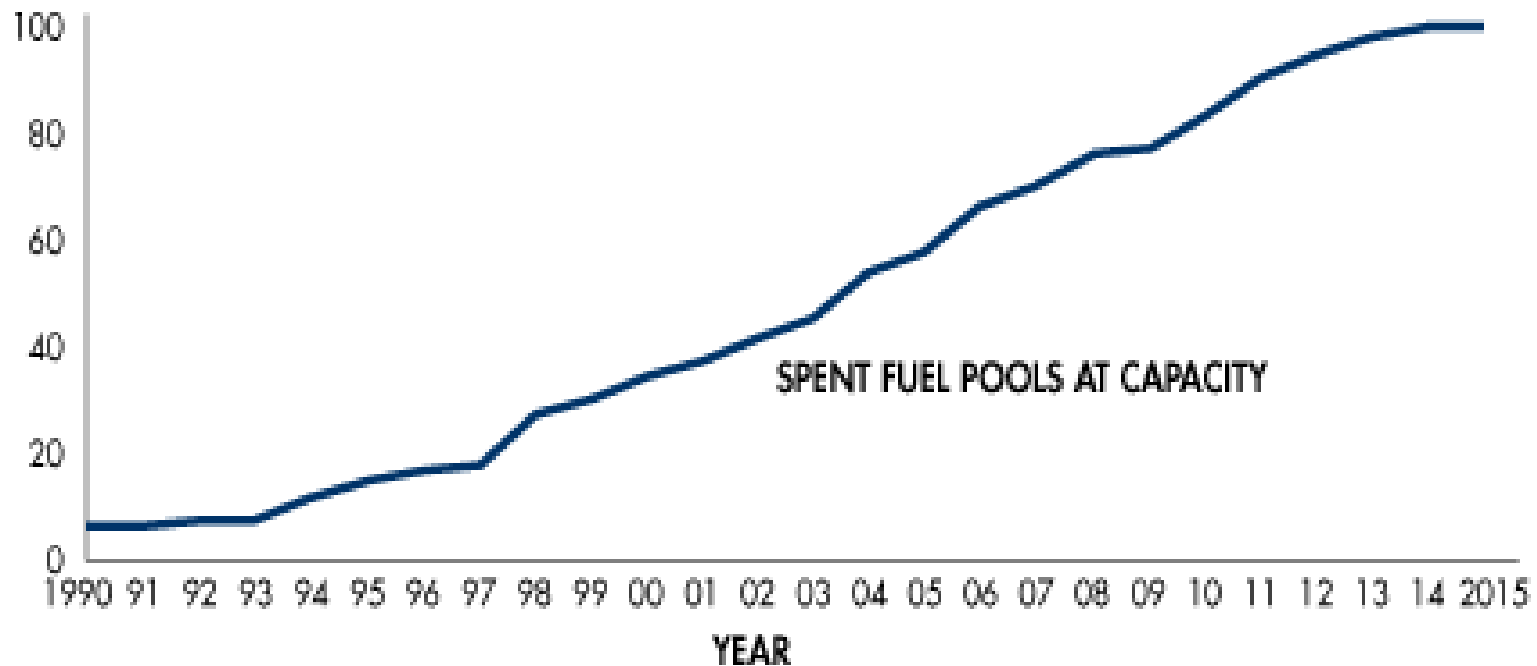
- Pools not within radiological containment
- By 2015, almost all pools full
- Pools vulnerable to accidents, attacks/sabotage, leakage
- No away-from-reactor waste plans in sight

# Pools outside containment



# By 2015, most pools full

NUMBER OF FILLED POOLS (CUMULATIVE)

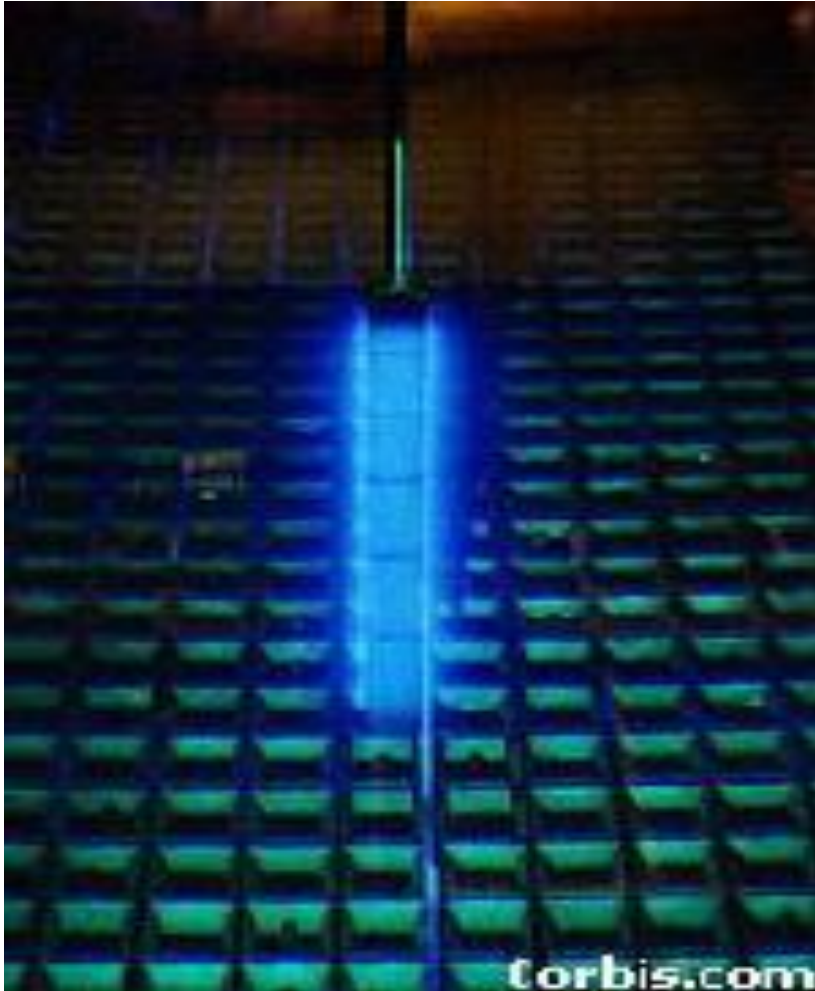


Note: All operating nuclear power reactors are storing used fuel under NRC license in spent fuel pools. Some operating nuclear reactors are using dry cask storage. Information is based on loss of full-core reserve in the spent fuel pools.

Source: Energy Resources International and DOE/RW-0431 – Revision 1



# Safety risks: accidents



- Loss of off-site power
- Natural disasters
- Pool drain downs
- Heavy load drops
- Inadvertent nuclear criticality

# Loss of Off-Site Power



- Continuous electricity supply is needed to continuously run pool circulation pumps.
- In the event of loss of off-site power, emergency diesel generators *must be connected to pools*, and must work, or pool boiling could begin within hours.

# Tornadoes



# Hurricanes



# Earthquakes



# Tsunamis



# Flooding



# “Port” Calhoun: 2011



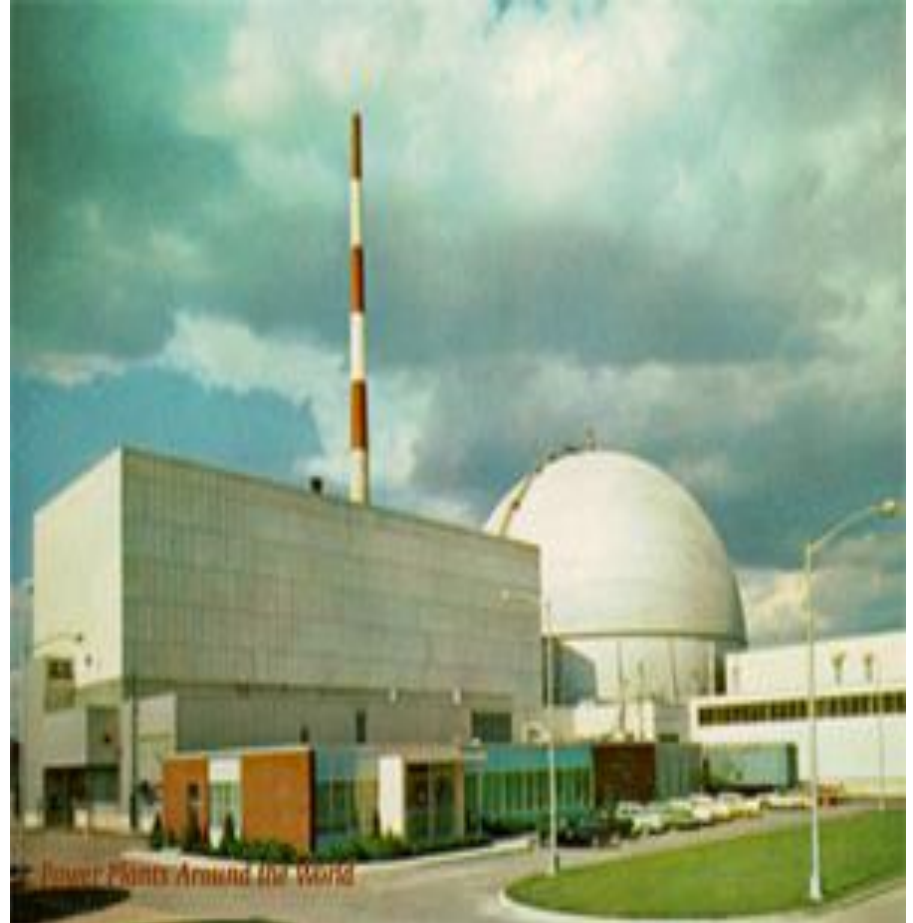


# Pool Drain Downs

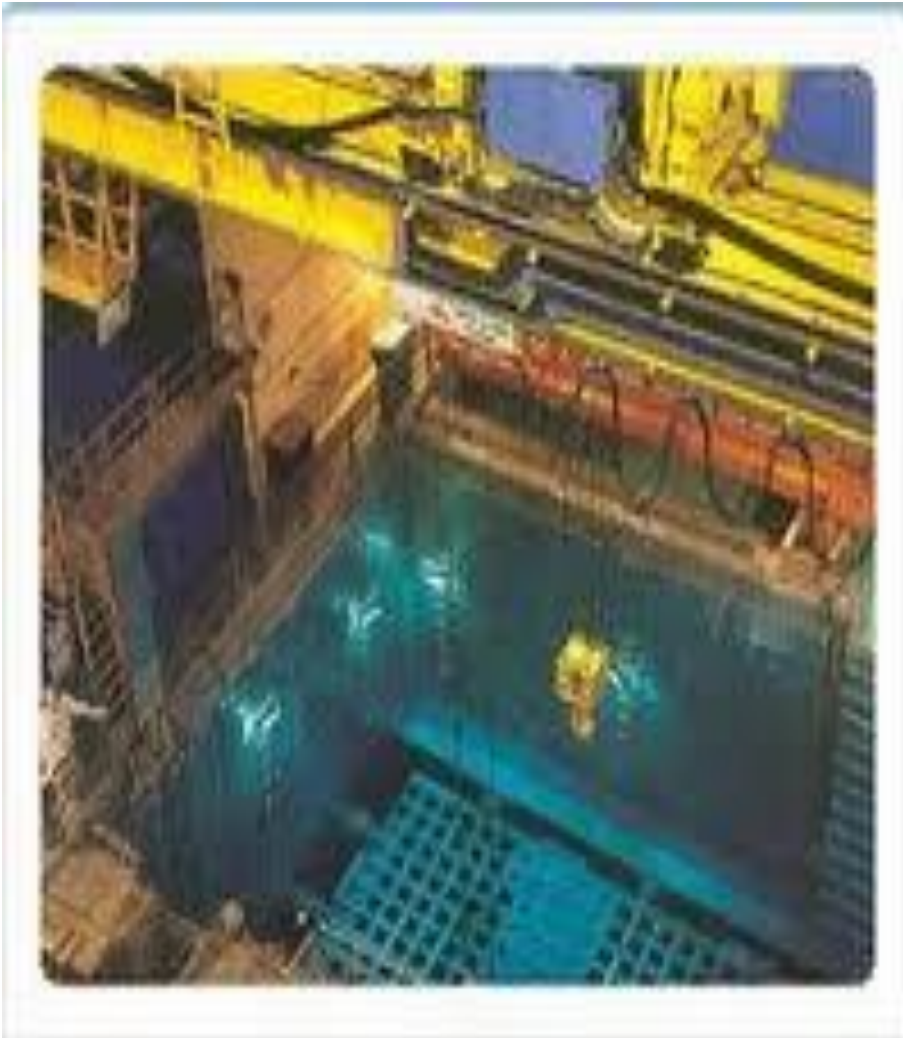
**I can fix anything**



**Where's the duct tape?**



# Heavy Load Drops



- *Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants (NRC, NUREG-1738, 2001)*
- Cask drops, dangles, explosions

# Security risks: attacks/sabotage

THE  
9/11  
COMMISSION  
REPORT

FINAL REPORT OF THE NATIONAL COMMISSION ON  
TERRORIST ATTACKS UPON THE UNITED STATES



- Alvarez et al.,  
“Reducing the Hazards  
from Stored Spent  
Power-Reactor Fuel in  
the United States,”  
*Science and Global  
Security*, 2003
- NAS, “Safety and  
Security of Commercial  
Spent Nuclear Fuel  
Storage,” 2005

# Security Risks: Attacks/Sabotage

- 1997 Brookhaven National Lab: pool fire could cause 1,500 to 143,000 cancer deaths, and \$800 million to \$566 billion in property damage, and render up to 2,790 sq. miles uninhabitable
- Institute for Resource and Security Studies has reported that a pool fire at either of Indian Point's reactors could render 75,000 to 95,000 sq. km uninhabitable (the area of New York State is 127,000 sq. km)

# Large waste inventories in pools



- Dresden nuclear power plant has 2,146 metric tons of irradiated nuclear fuel in storage pools
- The amount of nuclear fuel that exploded and burned at Chernobyl was “only” 200 tons

# BWR pools especially vulnerable



# Environmental risks: leakage from pools



# Pool Leaks: Haddam Neck, CT





# Pool Leaks: Indian Point, NY



# Pool Leaks: Salem Unit 1, NJ



# Pool Leaks: BWX Technologies, VA



# Pool Leaks: Brookhaven National Lab, NY



# Add'l SNF pool leaks, from NRC Nuke Waste Con Game EIS, App. E

## Internal leak to plant:

- Crystal River 3, FL, 2009
- Davis-Besse, OH, 2000
- Diablo Canyon 1 & 2, CA, 2010
- Duane Arnold, IA, 1994
- Hope Creek (Salem), NJ, 2009
- Kewaunee, WI, 2007
- Salem 2, NJ, 2010

## Leaked to environment:

- Hatch, GA, 1986
- Turkey Pt., FL, 1988
- Palo Verde 1, AZ, 2005
- Seabrook, NH, 1999
- Watts Bar 1, TN, 2001
- San Onofre 1, CA, 1986
- Yankee Rowe, MA, 1979 and 1999

# GAO, April 2005



GAO

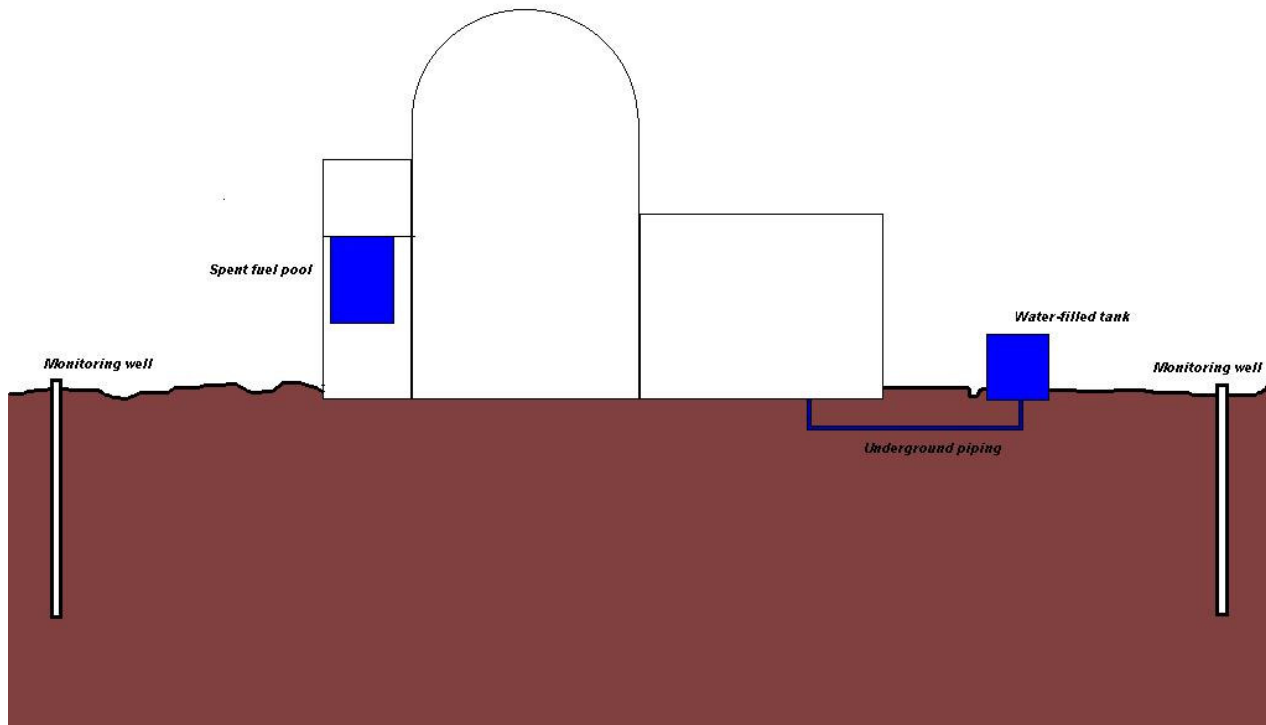
Accountability \* Integrity \* Reliability

- “NRC Needs to Do More to Ensure that Power Plants Are Effectively Controlling Spent Nuclear Fuel”
- Lost irradiated nuclear fuel at **Vermont Yankee**, Humboldt Bay, CA, and **Millstone, CT** in past decade

# Other Pool Risks



# Leaks from pools or pipes





# Leakage of radioactive pool water from Salem Unit 1, Artificial Island, NJ on the bank of the Delaware River

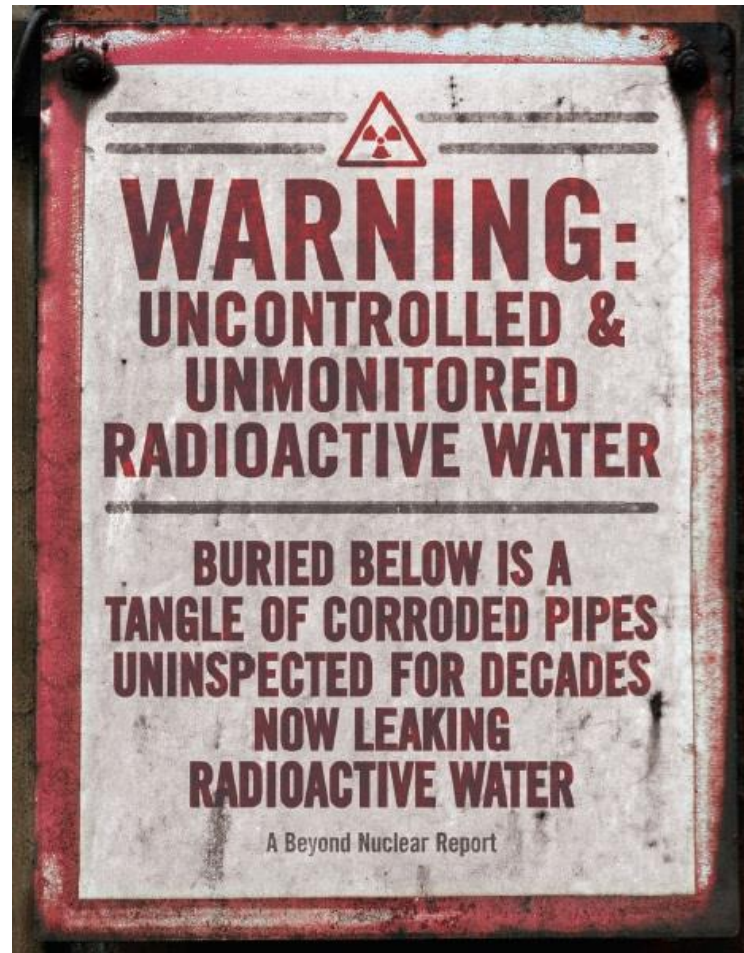


# Other leaks at nuclear power plants



- Other Entergy plants, such as Vermont Yankee & Palisades
- 102 leaking reactors between 1963 and 2009
- From March 2009 to April 2010, 13 nuclear plants reported 15 leaks (including VY)
- Individual leaks of several million gallons
- Some leaks undetected/unannounced for over a decade
- Contamination of groundwater, drinking water, and surface water supplies
- As high as over 10 million picocuries per liter – 500 times EPA SDWA standard (at Dresden, IL, 2004)

# “Leak First, Fix Later,” Paul Gunter, April 2010



# Dave Lochbaum, UCS



- Jan. 2006 public health emergency enforcement petition based on NRC regulations limiting radiation doses to members of the public, as well as requirement for control and monitoring of radioactive releases to the environment

# No Waste Solution: Yucca Mountain, Nevada



# Yucca zombie?!



# Shimkus, Upton, etc.



# No Waste Solution: Parking Lot Dumps





# No Waste Solution: Reprocessing



# MOX fuel higher risk



- Thermally hotter than irradiated uranium fuel
- Larger radioactive source term than U fuel
- Greater risk of accidents
- Worse consequences of accidents

# MOX lead test assemblies defective



- In June 2008, after only 3 years of a 4.5 year trial, Duke Energy was forced to discontinue testing Areva MOX fuel in its Catawba reactor due to risky elongation of the fuel rods.
- In November 2009, Duke terminated its MOX partnership with DOE.

# What are the risks?



- Health, safety, security, environment
- Property damage
- Loss of property values
- Radioactive stigma impacts on diverse economic sectors, from agriculture to fisheries, tourism to real estate

# Updates: The Beginning of “Forevermore”

High-Level Radioactive Waste  
Management Risks: Pools & Dry Cask  
Storage, the Big Picture

# Ongoing Fukushima Daiichi Nuclear Catastrophe



# HLRW Storage Pool “Near-Misses” (?!)

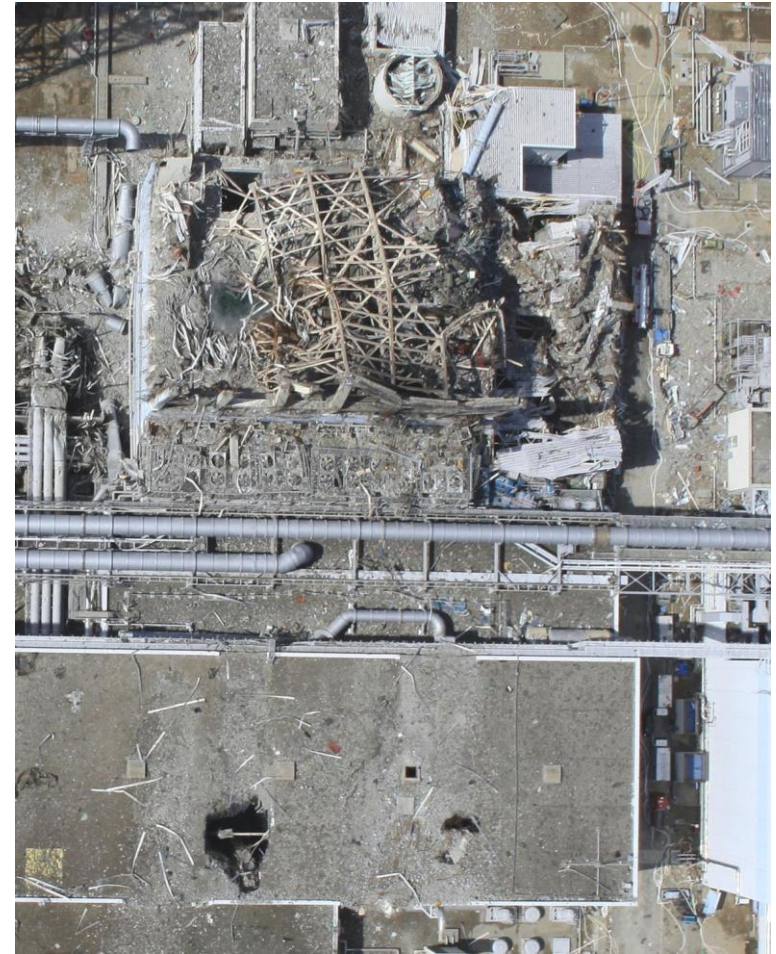


# Unit 4: “Close-Calls” (?!)





# Unit 3: Close-Calls (?!)



# Unit 3: Close-Calls (?!) Debris in Pool!/Status of Fuel?!



# Warning to Americans in Japan

## NRC Chairman Greg Jaczko



- Evacuation to more than 50 miles from Fukushima Daiichi
- NRC
- State Department
- White House
- U.S. military shelter in place orders at Yokohama (250 miles from Fukushima)

# Contingency planning to evacuate 30-50 million people

**Prime Minister Naoto Kan**



## **Worst case scenario:**

Reactor meltdowns and pool fires at Fukushima Daiichi (3 operating reactors, 7 pools), plus:

- 4 meltdowns and 4 pool fires at Fukushima Daini
- 1 meltdown and 1 pool fire at Tokai
- Evacuation of Metro Tokyo region

# National Diet of Japan Fukushima Nuclear Accident Independent Investigation Commission

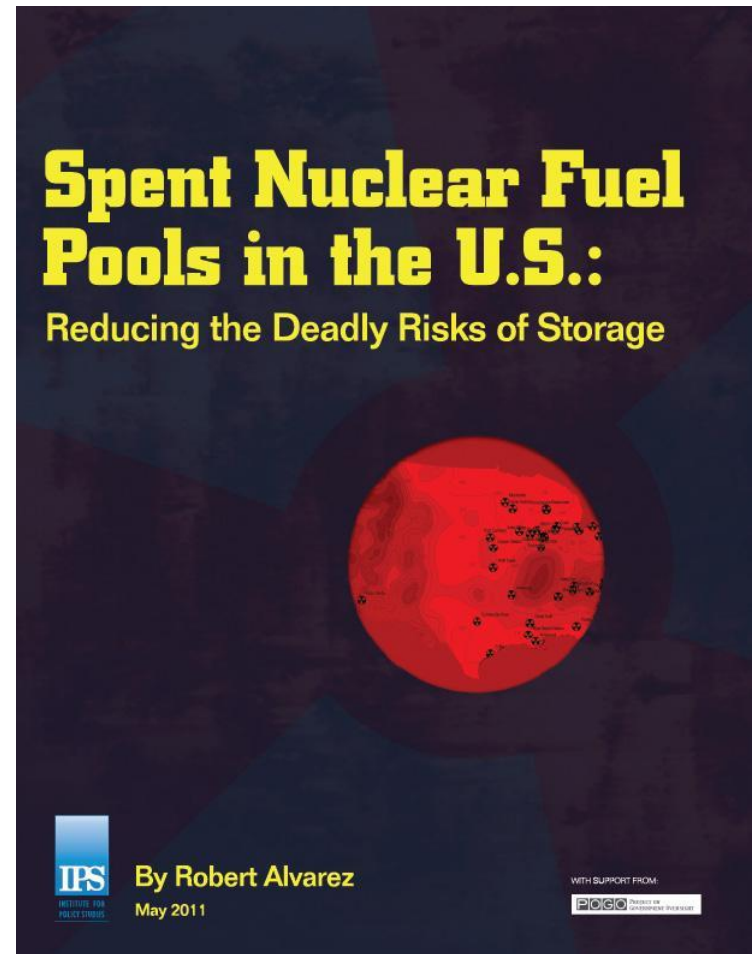
**Kiyoshi Kurokawa, Chairman**



**Key Findings**

- “Profoundly man-made” catastrophe
- Collusion between so-called safety regulatory agencies, nuclear power industry, and government (elected officials, ministries)
- “They effectively betrayed the nation's right to be safe from nuclear accidents.”

# Alvarez 2011



# Alvarez: Chernobyl & IP

Chernobyl:

Radiation-controlled zone of 6,000 square miles, about 2/3rds the land area of the State of NJ

“...a spent fuel pool fire in the United States could render an area uninhabitable that would be as much as **60 times larger** than that created by the Chernobyl accident. If this were to happen at one of the Indian Point nuclear reactors located 25 miles from New York City, it could result in as many as **5,600 cancer deaths and \$461 billion in damages.**”

# Comparison

## **Fukushima Daiichi Units**

- Unit 1: 40 tons
- Unit 2: 97 tons
- Unit 3: 63 tons
- Unit 4: 219 tons; 1,331 SNF assemblies

## **Indian Pt. 1, 2, and 3**

- 1,164 MTHM , more than 2,649 equivalent assemblies (per DOE 2002 figures, as of spring 2010).
- In last 5 years, this has grown by about 40 MTHM/year, so now 1,365 MTHM (3,100 equivalent assemblies)
- Approaching 250 million curies (per Alvarez, 2011)



# Obama's Blue Ribbon Commission on America's Nuclear Future, 2010-12



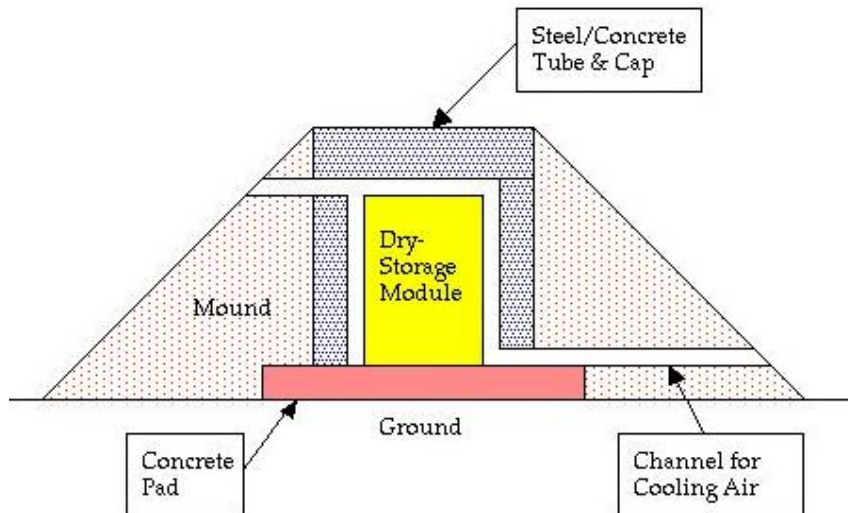
- Moniz, Macfarlane, Hagel, Rowe, *et al.*
- Ignored thousands of quality public comments
- Go through the motions exercise of public participation
- The ongoing revolving door between industry, government, academia

# Nuclear Guardianship Project



- *Despair and Personal Power in the Nuclear Age* (New Society Publishers, 1984), by Joanna Macy

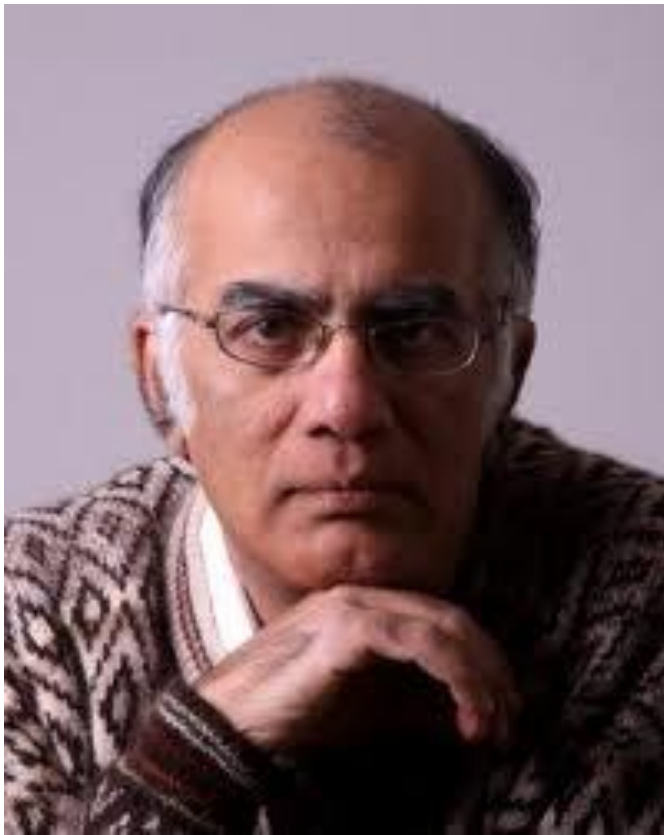
# HOSS



- Hardened On-Site Storage or Robust Storage
- Thin or even empty the pools
- Design and build dry casks well, to last centuries, not decades
- Real time radiation, heat, pressure monitoring
- Safeguard dry casks against leaks
- Secure dry casks against attacks

# HOSS/Robust Storage

**Arjun Makhijani, IEER**



**Gordon Thompson, IRSS**



# Dry casks as “Rust Buckets of Death”

**Mary Sinclair**



**Deb Katz**



# No “Nuclear Waste Confidence”

Diane Curran



NY AG Schneiderman



# No “Nuclear Waste Confidence”



# Nuke Waste Con Game





# Public Comment



# HOW much?!



- \$210-450 billion (yep, with a B!) for the first 200 years of HLRW management (assuming one repository opened)
- This effectively doubles the price of nuclear generated electricity (although it's not being accounted for)

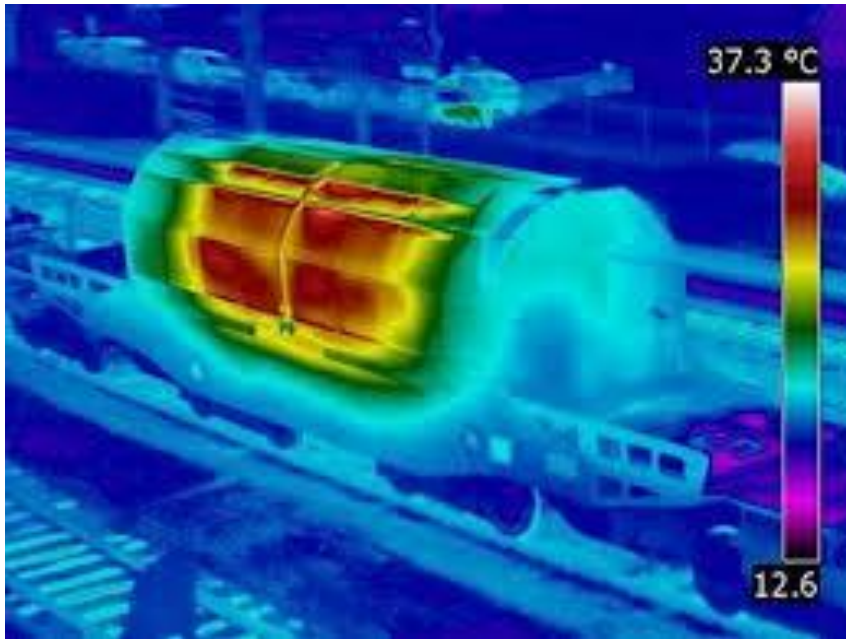
# Beware HOLTECs!

Oscar Shirani, Exelon/ComEd

Dr. Ross Landsman, NRC



# Beware CASTORs!



# “Accident Testing at Sandia National Lab”

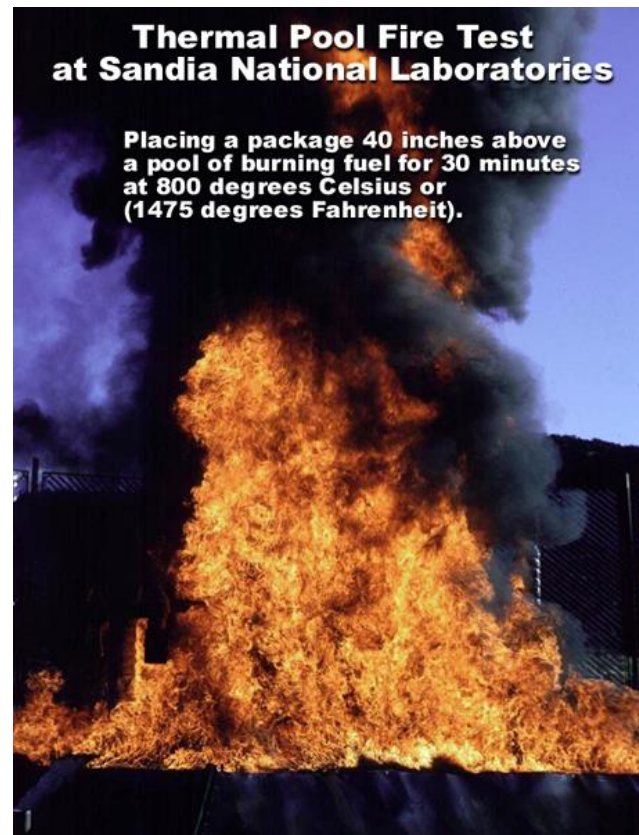
- “Broad sided a container by a 120-ton train locomotive traveling 80-miles per hour.” – J.P. Tarzia, RSCS
- Marvin Resnikoff, RWMA: cask was jacked up above main force of oncoming train (sill), glanced off nose



# “NRC Required Licensing Tests”

## “30-minute engulfing fire at 1,475 F”

- Other flammable and hazardous substances that share the roads, rails, and waterways burn at much hotter temperatures (diesel burns at 1,800 F).
- The July 2001 Baltimore train tunnel fire burned for more than 3 days, and reached temperatures above 1,500 F.



# “NRC Required Licensing Tests”

## **Damaged cask, submerged under 3-feet of water for 8 hours**

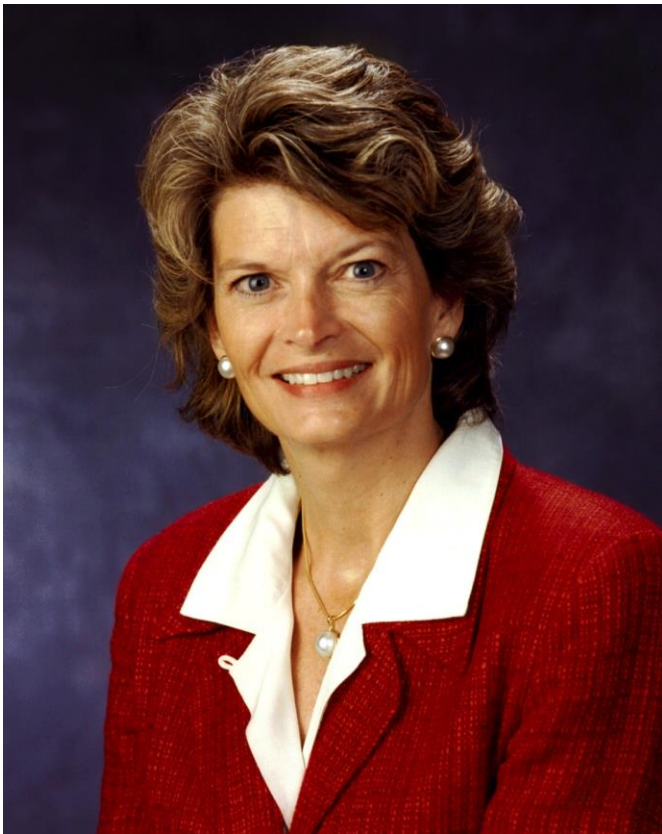
- A damaged cask could contaminate water supplies with radioactivity
- A critical mass, moderated by infiltrating water, could spark an inadvertent nuclear criticality, making emergency response extremely dangerous

## **Undamaged cask, submerged under 656-feet of water for 1 hour**

- Casks can weigh well over 100 tons, and would be very difficult to recover in an hour, especially in remote areas
- Water pressure over long periods could cause a radioactive release

# S. 854, Nuclear Waste Administration Act of 2015

**U.S. Sen. Lisa Murkowski (R-  
AK), Chair, ENR Ctte**



**U.S. Sen. Maria Cantwell (D-  
WA), ENR Ranking Member**





# S. 854, Nuclear Waste Administration Act of 2015

**U.S. Sen. Lamar Alexander (R-TN), Energy & Water Approps. Subctte Chairman**



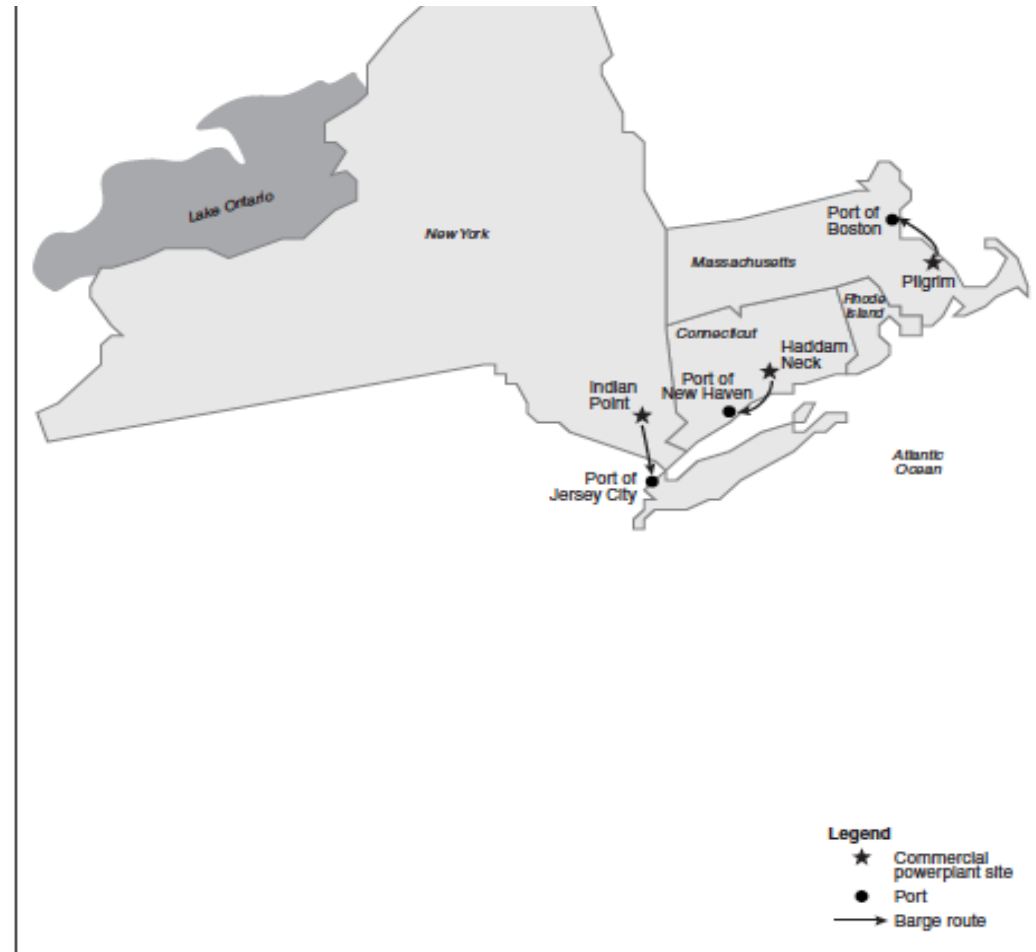
**U.S. Sen. Dianne Feinstein (D-CA), E&W Approps. Subctte Ranking Member**



# A.K.A. The Mobile Chernobyl Bill

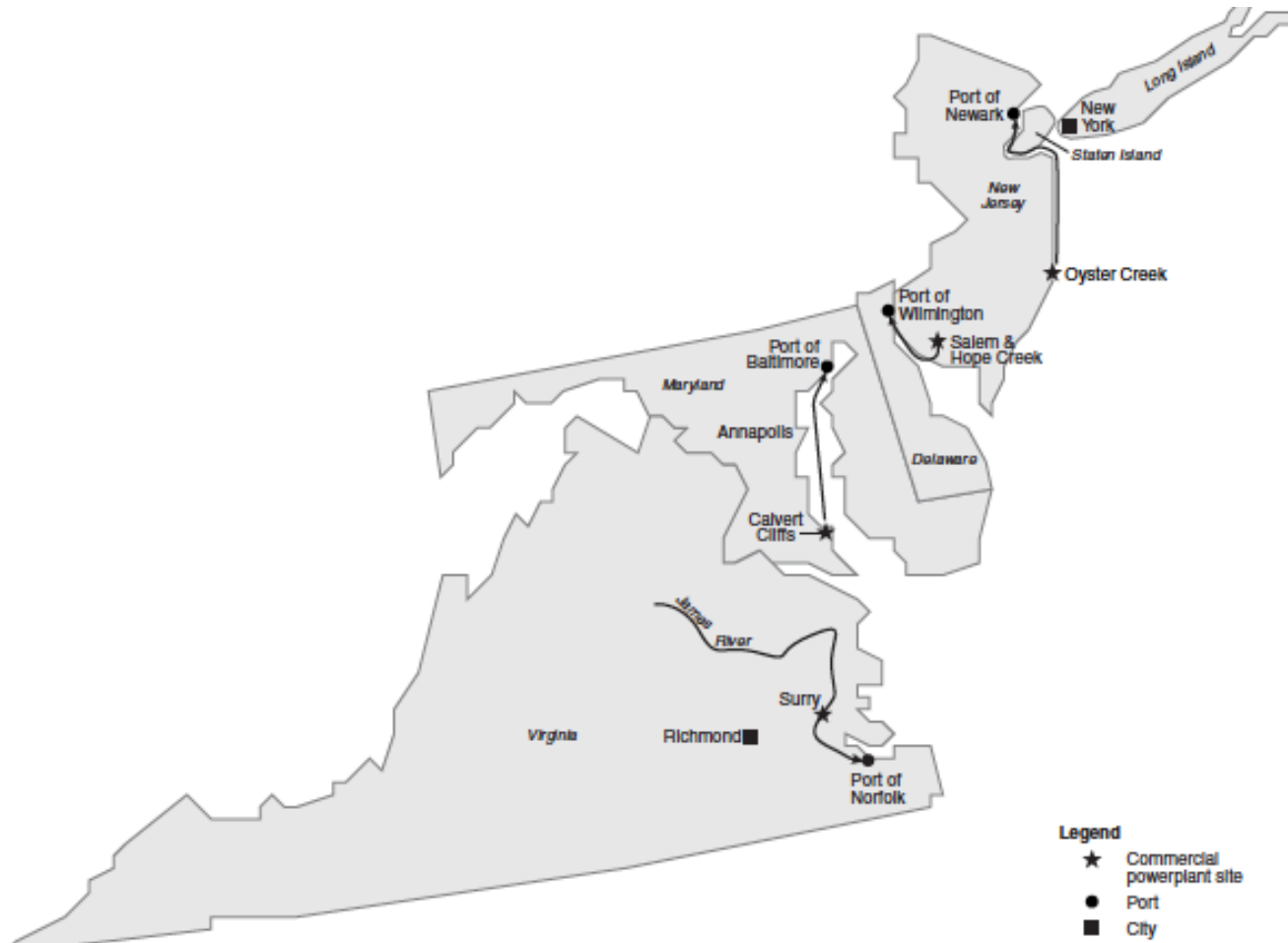


# DOE Yucca (etc.) barge routes



# DOE Yucca (etc.) barge routes

J-78

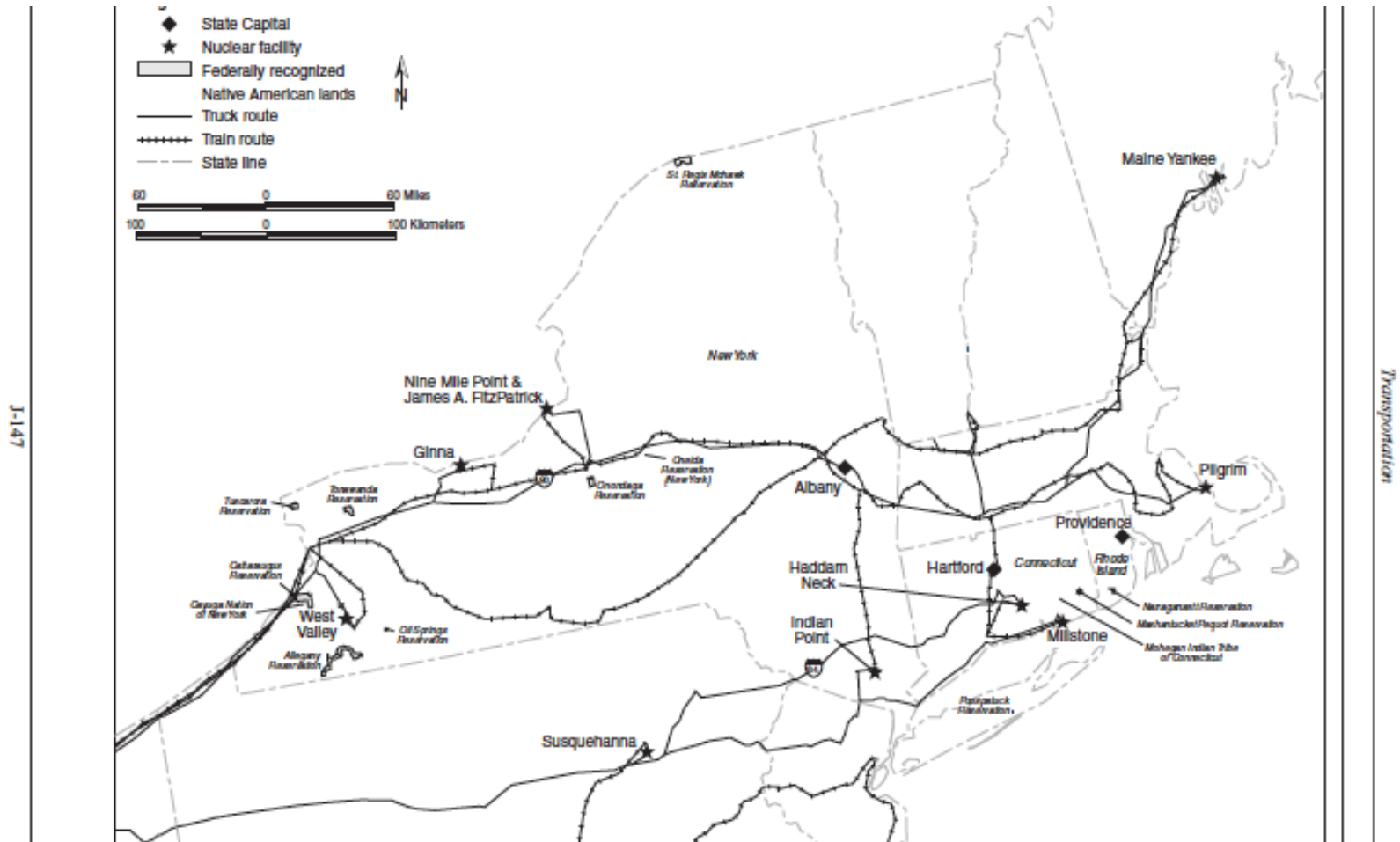


Transportation

# HLRW Barge Shipments: Up to 211 in this area

- Oyster Creek, NJ along NJ shore, to Newark, NJ: Up to 111 shipments
- Indian Point, NY down Hudson River, to Jersey City, NJ: Up to 58 shipments
- CT Yankee, down CT River & Long Island Sound, to New Haven, CT: Up to 42 shipments

# DOE Yucca (etc.) road & rail routes



# NYS road & rail casks to Yucca (etc.)

## Mostly Rail

Truck

426 originating/580 total

Rail

350 originating/861 total

## Mostly Legal-Weight Truck

2,571 originating/

5,287 total

From Table J-76, Page J-145

Feb. 2002 DOE Yucca FEIS

Forevermore begins today

