

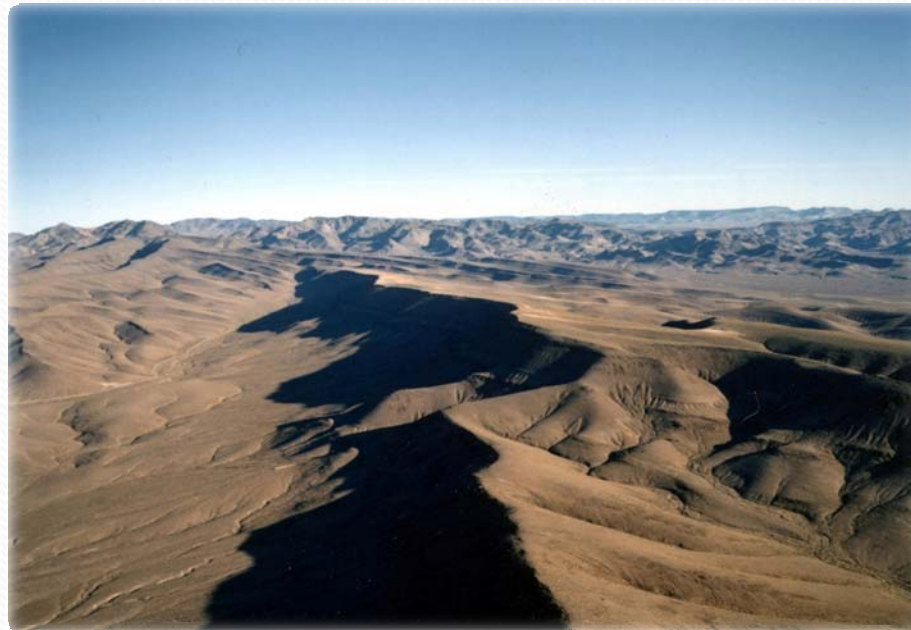
# Radioactive Waste Management & Yucca Mountain



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# Outline

1. How Nuclear Power works
2. How Nuclear Power is currently stored
3. The proposed repository at Yucca Mountain



# How Nuclear Power Works

- Nuclear power plants are similar to a typical coal-burning power plant.
- Both heat water into pressurized steam, which drives a turbine generator.
- The key difference is the method used to heat the water. Whereas coal plants burn fossil fuels, nuclear plants use nuclear fission to create heat.

- Coal power plant

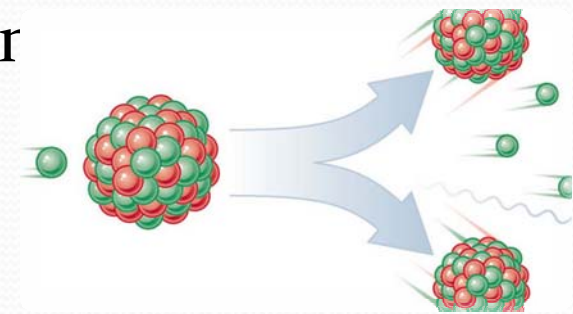


- Nuclear power plant



# Nuclear Fission

- Nuclear fission occurs when one atom splits into two.
- When the atom splits it releases an incredible amount of heat and gamma radiation.
- The two atoms that result from the split will later release beta radiation, as well as gamma radiation.
- Uranium is used in nuclear power plants. It undergoes spontaneous nuclear fission naturally, so it is a good choice for induced fission.
- Plutonium could also be used.



# How much energy does nuclear fission produce?

- Splitting one U-235 Uranium atom releases approximately 200 MeV (million electron volts).
- There are A LOT of atoms in a pound of Uranium.
- A pound of highly enriched Uranium can power a nuclear submarine.
- It would take millions of gallons of gasoline to fuel the same submarine.

# Cherbourg of Le Terrible, France's newest nuclear submarine



# Advantages of Nuclear Fuel

- Does not depend on fossil fuels
- CO<sub>2</sub> emissions are minimal
- The cost is not affected by fluctuations in oil and gas prices
- A properly functioning nuclear power plant will release less radioactivity into the atmosphere than a coal power plant



# Disadvantages of Nuclear Fuel

- Historically, mining and purifying uranium is not a very clean process
- The transportation of nuclear fuel poses contamination risks
- After nuclear fuel is spent, it is still radioactive and potentially deadly
- An average nuclear plant generates 20 metric tons annually of high-level radioactive waste. Eventually this waste will decay to safe radioactive levels, but this will take tens of thousands of years. In the meantime, it will emit radiation and heat, which means it will eventually corrode any container it is kept in.

# More Disadvantages...

- Currently, the nuclear energy industry lets waste cool for many years, then mixes it with glass and stores it in massive cooled, concrete structures.
- These structures must be maintained, monitored, and guarded at all times, which is costly.



Savannah River Site, where waste is temporarily stored in South Carolina.

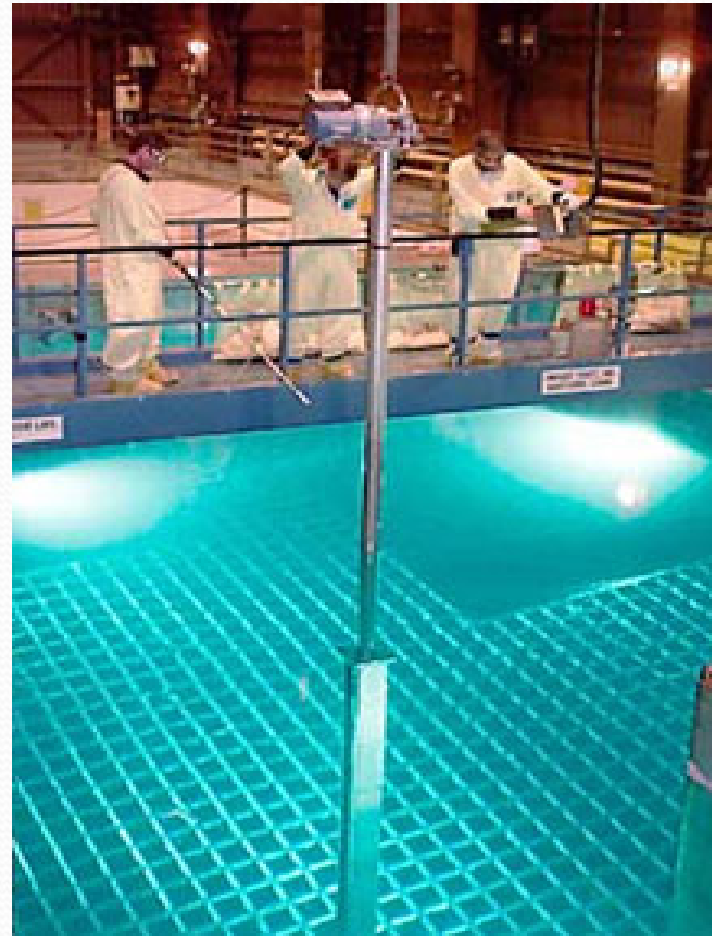
...these disadvantages highlight an important issue for the future of nuclear fuel...

- How should radioactive waste be stored and managed?



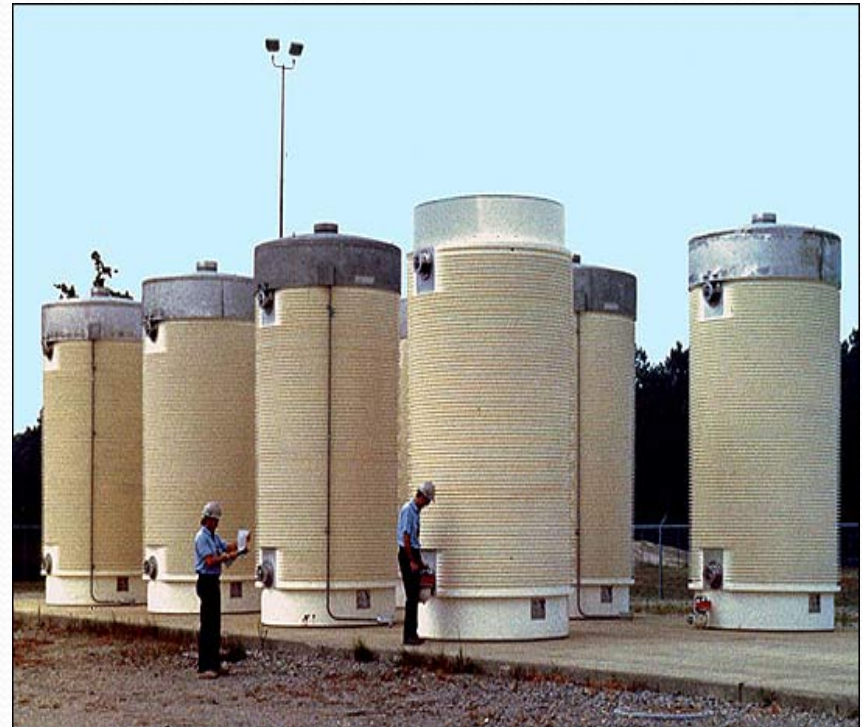
# Currently, there are 2 acceptable storage methods...

- 1. Spent Fuel Pools:  
most spent fuel is safely stored in pools specifically designed and located at reactor sites around the country.

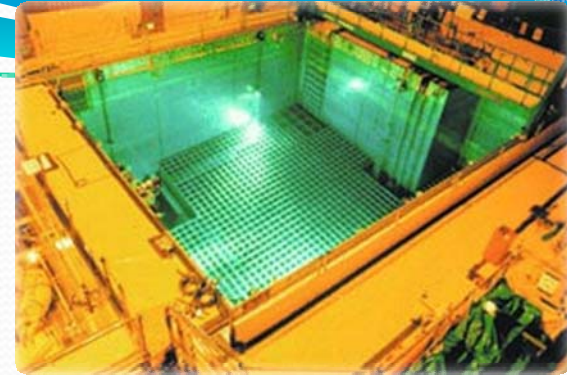


# Acceptable storage methods...

- 2. Dry Cask Storage: If the pool storage capacity is reached, storage sites may move toward the use of above-ground dry storage casks.



# Spent Fuel Pools



- The “water pool” option
- This method stores rods of spent fuel under at least 20 feet of water.
- This method shields the radiation from anyone near the pool.
- The rods are moved into the pools from the reactor along the bottom of water canals, so workers are always shielded.

# Spent Fuel Pools

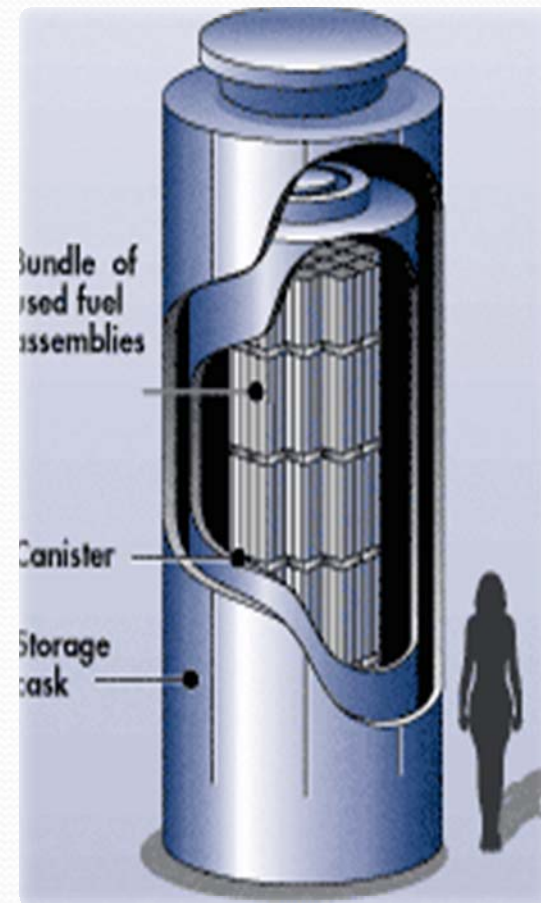
- One-fourth to one-third of total fuel load from the pools is spent and removed from the reactor every 12 to 18 months and replaced with fresh fuel.
- Current regulations permit re-racking of the spent fuel grid and fuel rod consolidation, subject to Nuclear Regulatory Commission (NRC) review and approval, to increase the amount of spent fuel that can be stored in the pool.
- Both of these methods are constrained by the size of the pool

# Dry Cask Storage

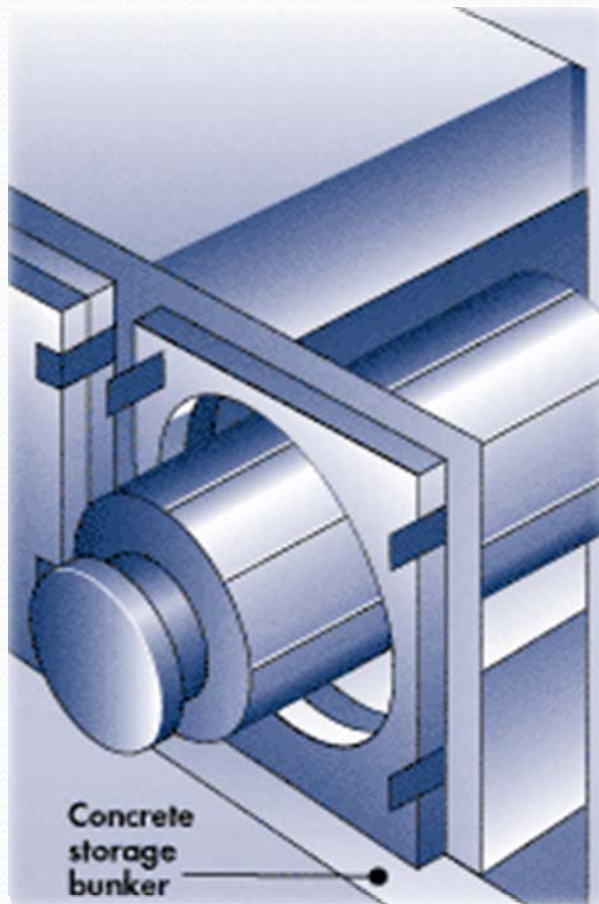
- In the late 1970s and early 1980s, the need for alternative storage grew as pools were filling up with spent fuel
- Waste must be cooled in the spent fuel pool for at least one year
- Then it can be surrounded by inert gas inside a container called a cask
- The casks are usually steel containers which are either welded or bolted to provide leak-tight containment
- Each cask is surrounded by additional steel, concrete, or other material to provide additional protection

# Typical Dry Cask Storage System

- Canisters like this one are designed to be placed vertically in steel or concrete structures above the ground



# Another typical system...

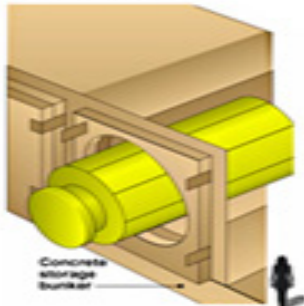
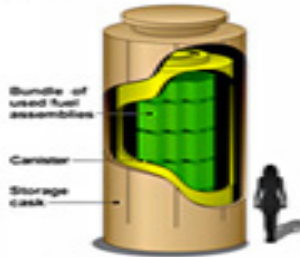


- Some dry casks are designed for horizontal storage
- Each above ground bunker is about the size of a one car garage

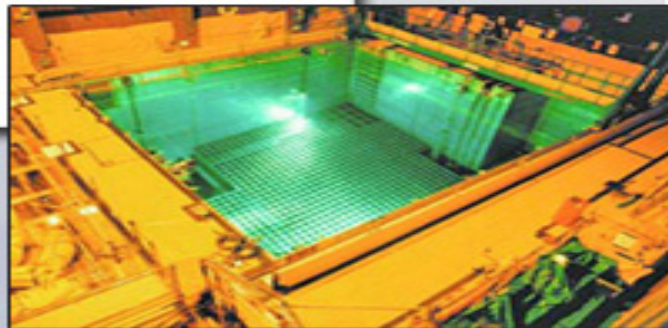
## Spent Fuel Dry Storage Single & Dual Purpose Cask

At some nuclear reactors across the country, spent fuel is kept on site, above ground, in systems basically similar to the ones shown here.

- 1** Once the spent fuel has cooled, it is loaded into special canisters which are designed to hold Pressurized-Water Reactor and Boiling-Water Reactor assemblies. Water and air are removed. The canister is filled with inert gas, welded shut, and rigorously tested for leaks. It may then be placed in a "cask" for storage or transportation.

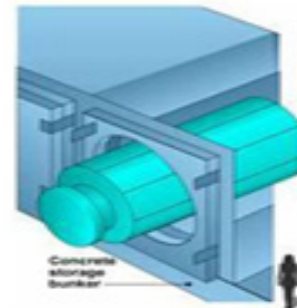
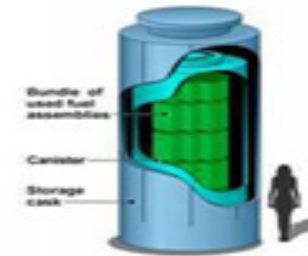


- 2** The canisters can also be stored in above-ground concrete bunkers, each of which is about the size of a one-car garage. Eventually they may be transported elsewhere for storage.



## Two Types of Spent Fuel Dry Storage Casks

### 1 Vertical

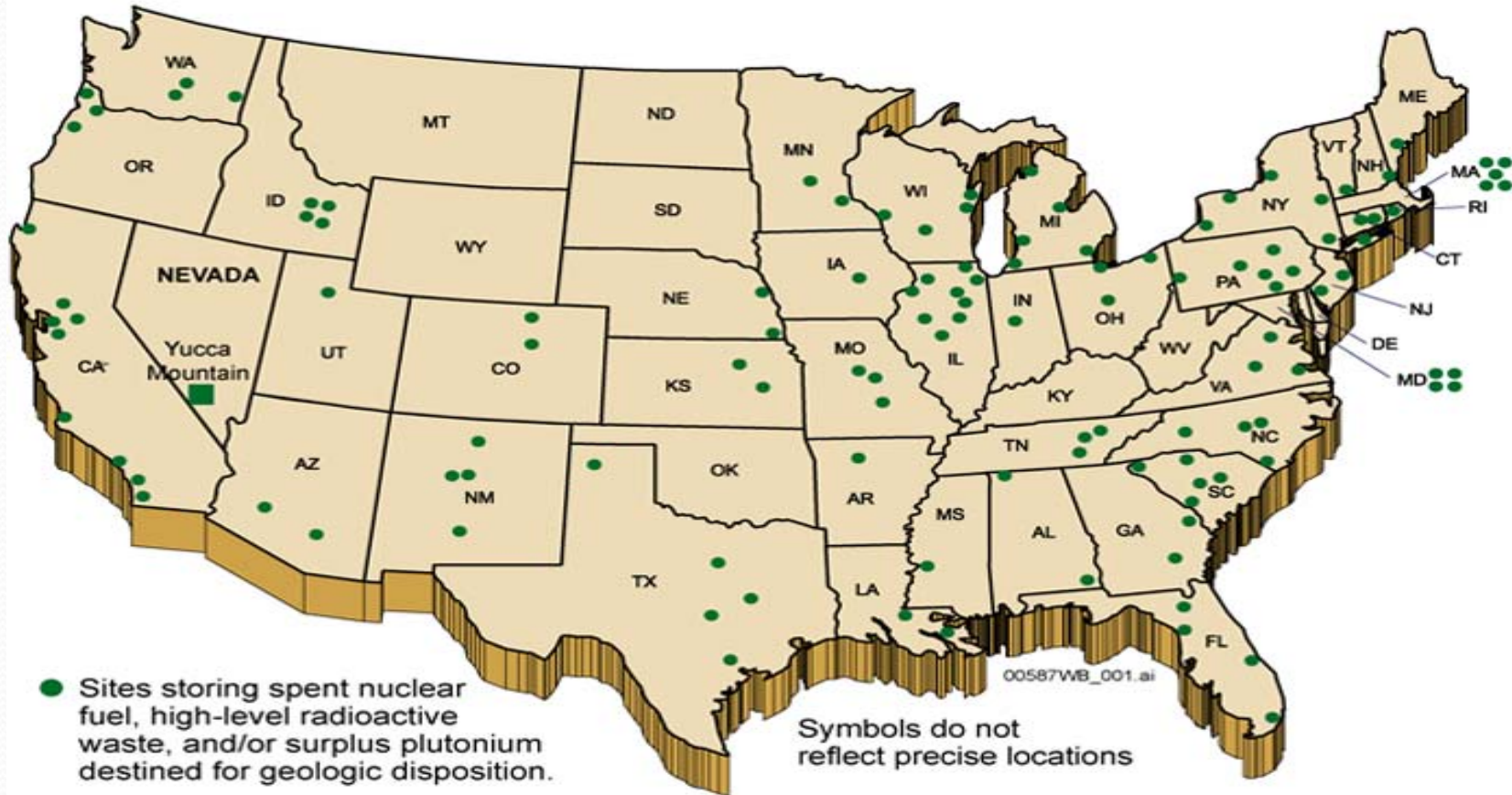


### 2 Horizontal

## Train Carrying Spent Nuclear Fuel

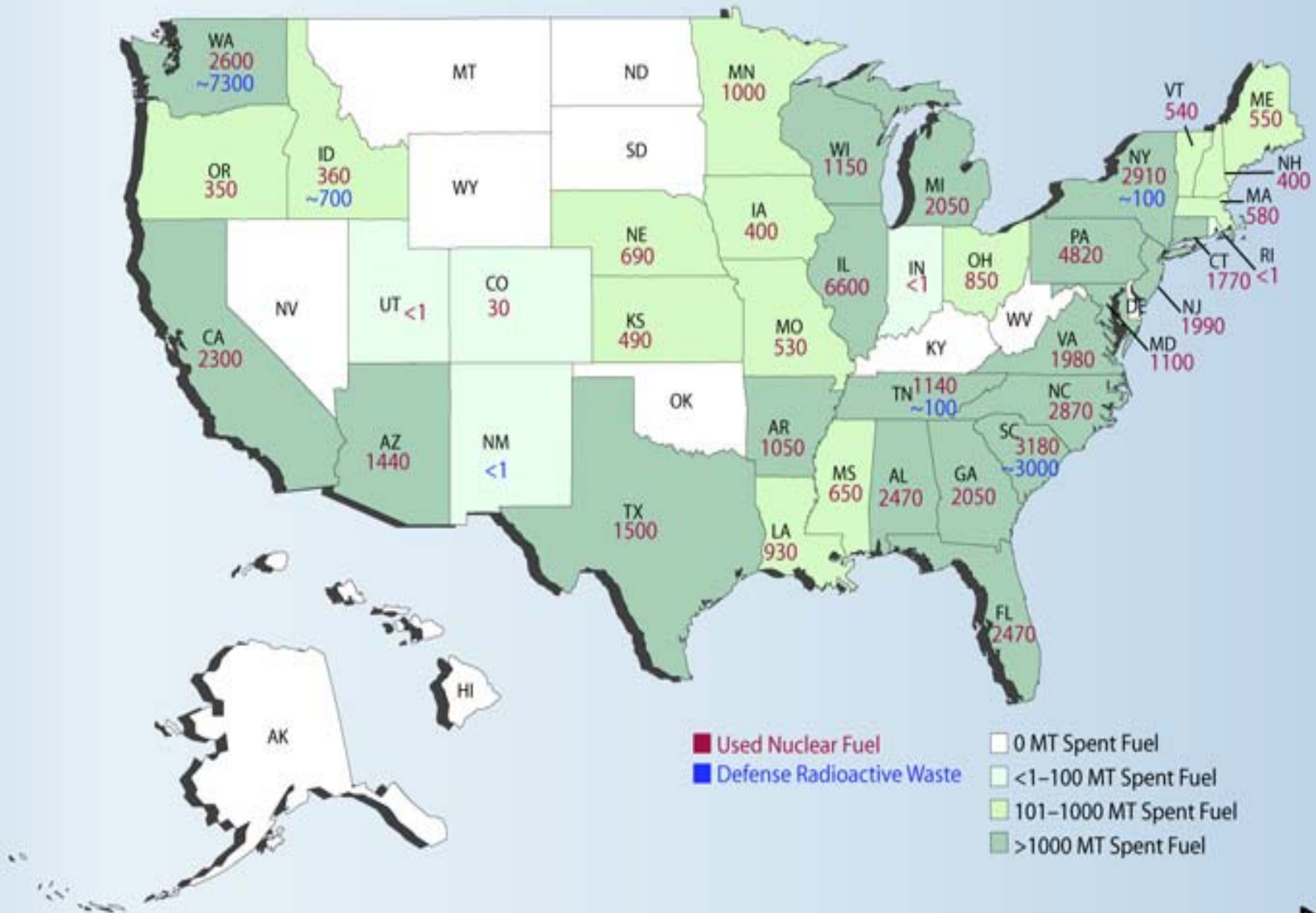


# There are 121 storage sites around the nation



# Used Nuclear Fuel & Defense Waste in Storage

(Metric Tons, End of 2005)





# What is wrong with the current radioactive waste storage sites?

- Each of the 121 sites in 39 states are temporary
- Over 161 million people live within 75 miles of these sites
- These sites are safe right NOW, but they will not withstand environmental factors, such as wind and rain, for the tens of thousands of year during which the waste will remain hazardous.

# Potential solutions



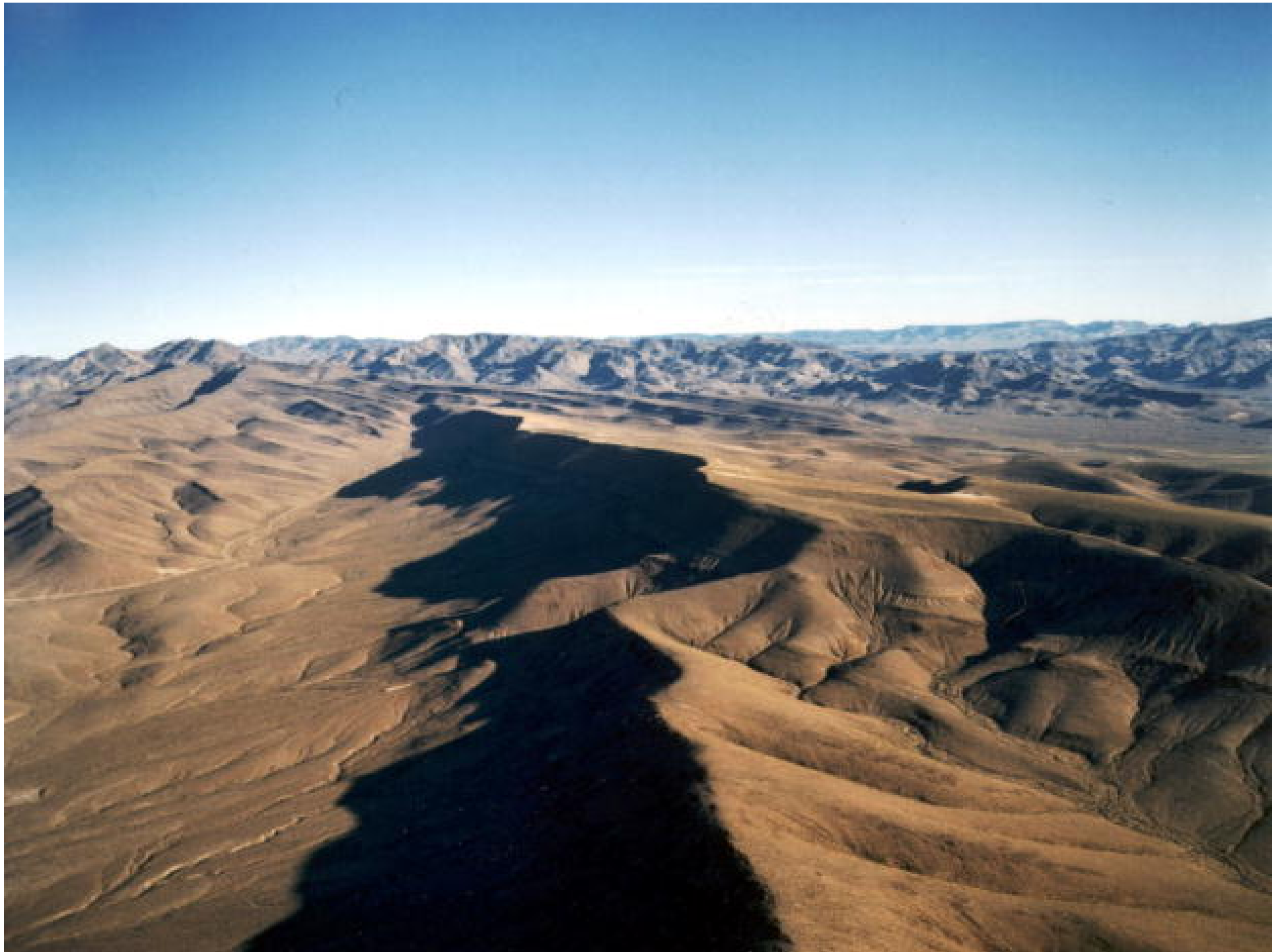
- Leaving the waste at the current storage sites
  - Burying waste in the ocean floor
  - Placing the waste in polar ice sheets
  - Sending the waste into outer space
  - Placing the waste deep underground in a geologic repository
- 
- Scientists agree... the best choice is the last...

# Why do scientists think a geologic repository is the solution?

- there is “*a worldwide scientific consensus that deep geological disposal, the approach being followed by the United States, is the best option for disposing of highly radioactive waste.*”
  - National Research Council of the National Academy of Sciences, 1990 report
- “*Geologic disposal remains the only scientifically and technically credible long-term solution available to meet the need for safety without reliance on active management.*”
  - National Research Council of the National Academy of Sciences, 2001 report

# YUCCA MOUNTAIN





# Timeline

- 1978- DOE first studied Yucca Mountain
- 1982- The Nuclear Waste Policy Act gave DOE the responsibility to construct and operate a repository for radioactive waste. The NRC was given the responsibility to regulate the waste.
- 1987- Congress directed DOE to focus solely on Yucca Mountain as a repository site.
- 2002- DOE concluded that Yucca Mountain is a suitable site. President Bush and Congress accepted this conclusion and directed DOE to submit an application to the NRC.
- June 3, 2008- DOE submitted an application to the NRC.

# Timeline

- September 8, 2008- NRC staff formally docketed the application and adopted the EIS, subject to additional supplementation by DOE on groundwater analyses. This triggered a 3 year period in which the NRC must make a decision, although it may give notice to Congress that it needs an additional year.



# US Department of Energy – Office of Civilian Waste Management

- Purpose: “To safely manage & dispose of America’s spent nuclear fuel & high-level radioactive waste”
- Established in 1982 under the Nuclear Waste Policy Act of 1982, which is “an act to provide for the development of repositories for the disposal of high-level radioactive waste & spent nuclear fuel, to establish a program of research, development, and demonstration regarding the disposal of high-level radioactive waste and spent nuclear fuel, and for other purposes.”
- [www.ocrwm.doe.gov](http://www.ocrwm.doe.gov)



# U.S. Nuclear Regulatory Commission

- Mission: “To regulate the nation's civilian use of byproduct, source, and special nuclear materials to ensure adequate protection of public health and safety, to promote the common defense and security, and to protect the environment”
- [www.nrc.gov](http://www.nrc.gov)

# How much waste can Yucca Mountain hold?

- Yucca Mountain is said to be able to hold approximately 77,000 tons of waste
- Currently, approximately 57,000 tons of waste is held in temporary storage





# The License Application

- The general information portion provides overview of the repository's engineering design concept and describes the natural features of the site
- The safety analysis report will demonstrate how the repository can be constructed, operated, and closed in a manner that will protect the public, worker health and safety, and preserve the quality of the environment

# What the License Application Looks Like...



# Two Concurrent Application Review Processes

- 1. Technical Licensing Review:
  - Done by NRC staff
  - Assess technical merits
  - Decide whether to issue a construction authorization for the repository
- 2. Adjudicatory Hearings:
  - Before 1 or more of the NRC's Atomic Safety and Licensing Boards
  - Hears challenges to technical and legal aspects of the application

# Licensing Review...

- This review takes more than 100 staff and contractor employees with expertise in areas such as:
  - Geochemistry
  - Hydrology
  - Climatology
  - Structural Geology
  - Volcanology
  - Seismology
  - Health physics
  - Numerous areas of engineering

# Licensing Review

- During review, additional information may be sought from DOE
- Requests for additional information and DOE's responses are made publicly available, unless it contains sensitive material
- Upon completion of review, the NRC will issue a Safety Evaluation Report (SER) containing its findings

# Adjudicatory Process



- October 22, 2008- published notice of opportunity to request a hearing
- There are 16 full time judges and several part-time judges with legal and technical expertise
- The panel appoints 3 judges to a board, and there are multiple boards which hear a variety of issues regarding Yucca Mountain
- 319 contentions have been filed by 12 groups petitioning to become parties to the hearing
- The hearing runs like a trial – to become a party you must have standing
- [www.lsnnet.gov](http://www.lsnnet.gov): Licensing Support Network. You can find documents which are relevant to the proceedings here

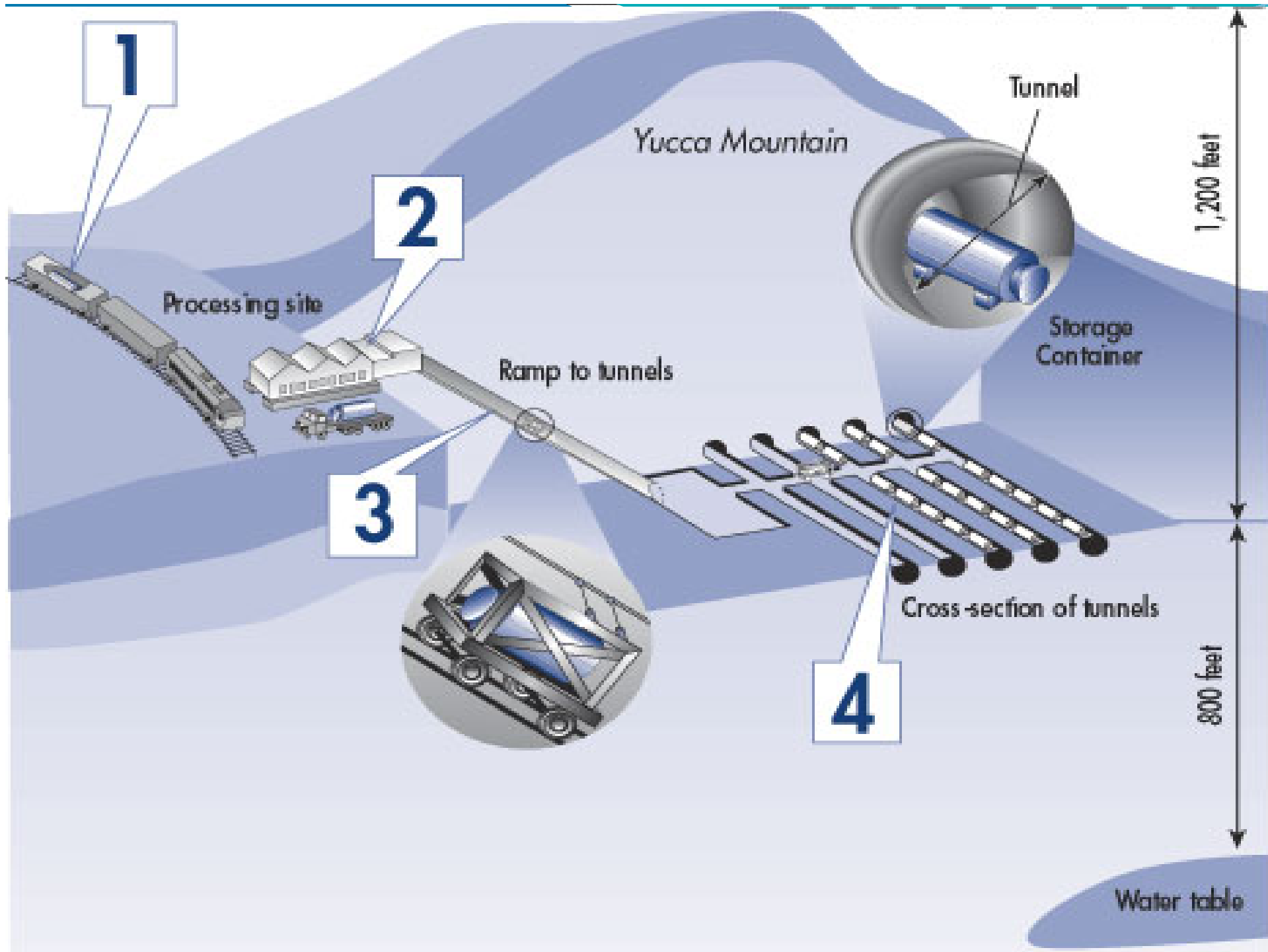
# Regulations relevant to the Yucca Mountain review and hearings

- 10 CFR Part 2 – Rules of practice for domestic licensing proceedings and issuance of orders; Subpart J and Appendix D.
- 10 CFR Part 51 – Environmental protection regulations for domestic licensing and related regulatory functions (10 CFR 51.109).
- 10 CFR Part 63 – Disposal of high-level radioactive wastes in a geologic repository at Yucca Mountain, Nev.
- 10 CFR Part 71 – Packaging and transportation of radioactive material.



# What would Yucca Mountain look like as a repository site?

- It would resemble a mining complex
- There would be waste handling facilities on the surface
- Approximately 1000 feet below the surface would be the disposal site for contained waste
- Construction has begun, but right now its mostly a series of tunnels through the earth



# What does the State of Nevada think?

- Residents do not like the plan, and have been vocal in saying so
- “The state doesn’t even have a nuclear plant, so it would be patently wrong to force it to be the nuke dump site for the rest of the nation.”

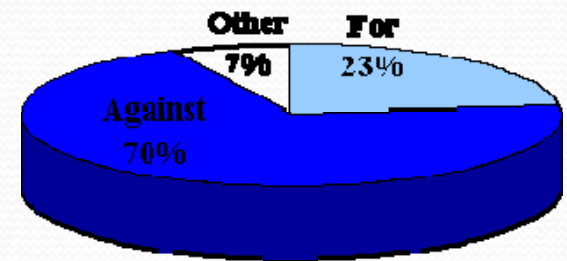


# Yucca Mountain Controversy

- The state of Nevada says Yucca Mountain involves fundamental issues of a state's right to determine its economic and environmental future and to consent or object to federal projects within its borders.
- State of Nevada Scientists do not believe the site is safe for holding nuclear waste because it is geologically and hydrologically active and complex
- Radioactive releases could occur through volcanoes, earthquakes, or hydrothermal activity at the site
- Accidents could occur in transportation to the site, which would harm the State of Nevada

# Who Opposes Yucca?

- Two-thirds of the population in Nevada
- Nevada Legislature
- Nevada State Medical Association
- Nevada State Firemen's Association
- Nevada Parent Teachers Association Board of Directors
- Cities of Las Vegas, Henderson, Boulder City, Lovelock, Reno, and Sparks
- Nevada Commission on Nuclear Projects





# The Obama Administration

- January 2008 – President Obama campaigned in Nevada and promised voters that he was against Yucca
- For 2010, the administration dramatically reduced Yucca Mountain’s budget, basically cutting funding
- Yucca was slated to open by about 2020, but this budget cut could delay or even stop its opening, while nuclear waste continues to build up in temporary storage facilities
- Energy Secretary Stephen Chu told Congress earlier this year that Yucca Mountain is “not an option”
- The number of employees there is down from a high of 4,000 to 50

# A Response to the Budget Cut

- Lawmakers Rep. Jerry Lewis and Sen. John McCain say with no long term repository for America's nuclear waste, the re-licensing of existing plants and construction of new ones is in jeopardy, just as the nation reconsiders nuclear energy as a clean and dependable source of electricity.



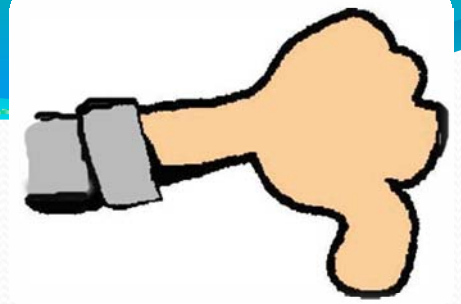
# Competing in the World Economy

- “If the U.S. is going to be able to compete in the world economy in the future, we have to expand nuclear at the pace of other countries,” said Aris Candris, chief executive of Westinghouse. “Energy is behind every source of wealth generation.”
- 70 new nuclear plants are under construction around the world
- The United States now has new applications for 26 nuclear power reactors, but no building has begun
- How can we build if we have no where to store the waste?

# Pros to Yucca Mountain



- The waste has to go somewhere
- It is federally owned and protected land within the secure boundaries of the Nevada Test Site in Nye County, Nevada
- The land is fairly remote and sparsely populated
- The mountain is in a basin, so if any waste does leak, it should stay contained to that area
- The planned engineering barriers are designed to help maintain the site for thousands of years
- The US has already sunk \$10 billion into this site



# Cons to Yucca Mountain

- Nevada should not have to store other states' waste
- Risk of contamination while transporting waste to the site
- Approximately 90 miles northwest of Las Vegas
- Chance of earthquakes in the area, which could lead to corrosion
- Uncertainty- what will really happen in the future?  
Will this repository really work?