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SERIES: The Leftovers Of the Nuclear Age. Second in a series

HEADLINE: THE LEFTOVERS OF THE NUCLEAR AGE / WANTED: SAFE SPOT FOR NUCLEAR WASTE / $3B LATER, NEV. SITE IS STILL IN QUESTION

BYLINE: By Earl Lane. WASHINGTON BUREAU

DATELINE: Yucca Mountain, Nevada

BODY:

Yucca Mountain, Nevada - This barren desert ridge about 100 miles northwest of Las Vegas is surrounded by some of the most forbidding territory in the world.

To the southwest is fabled Death Valley. To the east, the desert floor is pockmarked by manmade craters and laced with radioactive debris created during 825 underground and 100 atmospheric nuclear test explosions.

Yucca Mountain would seem a good candidate for the last resting place for some of the nation's most dangerous nuclear waste. For some, there is an appealing symmetry to burying the spent fuel from the nation's commercial nuclear program in the same remote territory that helped give birth to the Atomic Age.

But despite the expenditure of nearly $3 billion and two decades of investigation, federal officials still cannot say for sure whether it would be safe to put the spent reactor fuel - as well as some radioactive waste from military operations - in a hole some 1,000 feet below the crest of Yucca Mountain.

There is a hum of activity at the site and an intimation of progress. Huge ventilation fans whine at the north portal to the five-mile, U-shaped tunnel that has been dug through the heart of the mountain. Work crews and researchers shuttle in and out of the facility on small rail cars, heading for cave-like alcoves where experimental equipment has been arrayed to study the underground environment in detail.

Outside, dozens of boreholes have been sunk into the mountain and its nearby landscape. A U.S. Geological Survey team lowers sensors into a deep shaft from the crest of the 4,960-foot mountain to determine its "pneumatic" behavior - or how the mountain breathes gases in and out of its fissures according to changes

in atmospheric pressure.

Probably no other patch of land on Earth has received more scientific attention during the past decade. The "site characterization" process has involved hundreds of scientists - geologists, hydrologists, seismologists, vulcanologists. Lake Barrett, acting director of the Department of Energy's office for civilian radioactive waste, estimates the scientific analyses of **Yucca Mountain** now are approaching 1 million pages.

And yet fundamental questions, particularly about the amount of **water** infiltration and its flow rates through the mountain, remain unanswered even as federal officials promise to deliver a viability decision on the repository site by late next year. A final recommendation on the site's suitability would come three years later.

Project officials cite the recently completed tunnel as a milestone toward resolving Yucca Mountain's future. Some critics see it as but a metaphor for the money pit of unfulfilled dreams in a nuclear waste disposal program that has been marked by cost overruns, schedule delays, changing criteria, management problems, scientific controversy and political opposition.

"The nuclear establishment is harvesting the fruits of years of incompetence and mendacity," said Dean Abrahamson, a public-policy specialist at the University of Minnesota who also spent 20 years in the nuclear industry.

When commercial reactors were being built in the 1960s, he said, federal officials "treated waste as if it were a non-problem." The attitude, Abrahamson said, was "when we get enough of it, we'll dig a hole someplace and bury it."

Now, in the twilight of the 20th Century, that has proved to be much easier said than done. Daniel Dreyfus, Barrett's predecessor at the Energy Department, said the Yucca Mountain project was unfocused when he took over in late 1993. "The scientific approach to the thing was to collect a lot of data and not to design a facility," Dreyfus said. There was little sense of closure and "in trying to get a composite plan together, there were great big pieces of it nobody got around to." He cited the lack of studies on how close the fuel canisters should be spaced in the tunnels and what heat output would be acceptable.

Barrett is confident there will be enough data by 2001 to decide whether to proceed with a formal application to the Nuclear Regulatory Commission to build the repository. He declines to lay odds, although Sen. Frank Murkowski (R-Alaska), chairman of the Senate Committee on Energy and Natural Resources, says department officials tell him privately that they think there is an 80 percent chance the mountain will prove suitable as a burial site.

If it is not, analysts say, there are no alternatives on the horizon. And given the history of the Yucca Mountain project, few are willing to predict when or if it will be completed. The proposed opening of the repository already has been set back twice - first from 1998 (the deadline set by law) to 2003; and then to 2010. Energy Department officials have talked about 2015 as a more realistic target.

Such uncertainty has helped drive the nuclear industry's campaign on Capitol

Hill for an interim storage site - essentially a parking lot for casks filled with spent fuel - on several dozen acres of desert adjacent to Yucca Mountain. More than 30,000 tons of spent fuel has accumulated at commercial power reactors nationwide, and industry officials say they are running out of space to keep it. But the Clinton administration opposes any effort to mandate such a storage facility until it is clear the mountain will be the ultimate burial site for the waste.

Determination of that suitability has been a fitful process with changing financial resources and technical criteria. In 1981, according to one account, federal officials had estimated that repository site studies could be done for $60 million to $80 million. By 1987, the estimate was $2 billion each for three sites - and Congress stepped in to declare Yucca Mountain the sole candidate.

By 1992, the Energy Department was projecting it would cost $6.3 billion to study Yucca Mountain and prepare a license application. Congress balked, cutting annual appropriations and forcing a reorganization of the project and a loss of 1,075 contractor jobs.

The result has been a leaner effort, Energy Department officials said, which is aimed at coming to closure on some key scientific issues. They include:

- Earthquakes: The Yucca Mountain site is on or near 33 active faults, including one - the Ghost Dance fault - that intersects the repository level deep underground. The Nevada Agency for Nuclear Projects - a state office that monitors the Yucca Mountain project - reviewed earthquake data for southern Nevada and found that since 1976 there have been 621 seismic events of greater than 2.5 magnitude within 50 miles of Yucca Mountain. Most notable was a 5.6-magnitude earthquake near Little Skull Mountain - eight miles southeast of Yucca - on June 29, 1992. That quake caused nearly $1 million worth of damage to a Department of Energy field office at Yucca Mountain.

Energy Department officials say - and scientists generally agree - that earthquakes pose less hazard to underground structures than they do to surface facilities because of the way shock waves travel through soils versus solid rock. In any event, the agency says, the repository site has been stable for the past million years (evidence suggests the last major disturbance of the Ghost Dance fault occurred 11 million to 12 million years ago). A 1995 National Research Council report found the regional geology is expected to remain relatively stable for about 1 million years.

- Volcanoes: Yucca Mountain was formed millions of years ago by volcanic eruptions that produced layers of ash that eventually condensed into a very hard, dense form of rock called tuff. The explosive-type volcano that formed Yucca is extinct, but there remain seven small, dormant volcanoes in the area that are under study. Two of the cones are 12 to 27 miles away and may have been active within the past 100,000 years. A panel of scientists estimated last year that the possibility of an eruption through the repository in the next 10,000 years is about 1 in 10,000.

- Geology and **water** flow: Probably the biggest question mark at **Yucca Mountain** remains the amount and flow of **water** in and near the repository site. Although it is an arid region - with an average of about 6.6 inches of rainfall a year - some **water** infiltrates the mountain, and a climate change could bring

more.

Deep within the mountain, researchers have found unexpected traces of radioactive chlorine-36 produced during the atmospheric bomb tests. They conclude that the material, carried along by water infiltration, traveled nearly 1,000 feet into the mountain fairly rapidly during the half-century since the beginning of the bomb testing. This raises the question of whether there are "fast pathways" for carrying moisture through cracks and fissures in the mountain to the repository level. Over time, such moisture would cause the fuel containers to corrode. As their contents are released, the seeping water could transport radioactive material into the rock and eventually to the underlying ground water table.

Researchers also have found pockets of trapped water in the mountain. Although the pockets are below the proposed repository level, scientists say it is important to understand how they formed and whether any similar pockets could be breached during excavation of repository tunnels.

"We have found very little liquid water in the mountain," says geologist John Peck.

In theory, the containers of spent fuel will produce enough heat to drive off any nearby moisture. Still, as the fuel containers - and the surrounding rock - cool over time, any water vapor present could condense out as liquid **water** that could corrode the containers.

Project scientists plan several tests to see just how the rock behaves when it is heated. One small-scale heating test is now under way in an alcove off the main **Yucca Mountain** tunnel. A larger test is scheduled to begin in several years, too late to provide any data for the "viability assessment" due next year.

The Nuclear Waste Technical Review Board, a peer-review group that reports to Congress and the Energy Department, and the Lawrence Livermore National Laboratory in California have raised questions about whether the agency is doing large heating tests for long enough times. The Livermore researchers have argued that it would take a miniumum of six years of heating to provide an adequate look at the rock behavior. The large-scale test now is planned for four years.

Project officials have been studying further steps - in addition to the packaging of the spent-fuel assemblies in double-walled metal canisters - to keep water away from the waste for a longer time. These can include additional fillers in the casks, drip shields above the canisters to deflect water, drains in the storage tunnels, backfilling the repository to slow or divert **water** flow and even use of additives on the tunnel floors to react with any waste that does escape the casks.

Even as some key members of Congress have pushed for a prompt decision at **Yucca Mountain**, the congressional General Accounting Office reported earlier this year that budget-cutting and the resulting constriction of scientific activity on the project could mean more delays.

GAO had pointed out in May, 1993, that the underlying reason for the slow progress and escalating costs at Yucca Mountain had been the Energy Department's

top-heavy management and support structure on the project. Less than half of the money was being spent on scientific and technical investigations at the mountain.

Energy Department officials say that has changed, with a sharper focus now on ways to contain and isolate the waste within a repository.

To complicate matters, the agency is trying to determine whether Yucca Mountain is a safe location for a waste repository as the regulatory standards by which the site will be judged are changing.

The Nuclear Regulatory Commission's licensing standards must be consistent with radiation health standards of the Environmental Protection Agency. But EPA is just beginning the process of issuing its health standards for Yucca Mountain site. And those standards are expected to reflect a different - and more controversial - approach than the agency took originally in setting standards for nuclear waste repositories.

Previously, the standard emphasized limiting cumulative releases of radioactive materials - and their concentrations in air, water and soil - over a 10,000-year time frame. The new approach, recommended by an advisory panel convened by the National Academy of Sciences, is expected to emphasize the level of risk for a "critical group" of people living near the repository rather than the absolute amount of radiation released.

That could mean acceptance of releases that do not directly threaten the health of nearby residents generally. But one member of the panel - Thomas Pigford of the University of California at Berkeley - argued strongly that the critical group should be narrowly defined as the so-called subsistence farmers who draw water from wells near the waste dump, grow most of their own food and live at the time of maximum radiation releases. While such farmers may be few and far between, protecting them would be a conservative approach that avoids what Pigford said would be "an unjustified and unprecedented leniency in public health protection from radioactive waste."

Larry Weinstock, acting director of the EPA's Office of Radiation and Indoor Air, said the agency is likely to issue its Yucca Mountain standards in the fall. "You don't have to go all the way to the subsistence farmer to come up with something that is reasonable," Weinstock said. He said the agency is going to define an area around Yucca Mountain and the population of concern. He said EPA also probably will "set some maximum level of dose or contamination of groundwater that could exist outside of a certain region."

Nevada officials say pending legislation in Congress - which the White House said it will veto - would pre-empt the EPA by setting an average annual exposure limit of 100 millirems for the repository. State officials consider that limit - equal to one-third of the natural radiation we receive annually from background sources such as cosmic rays - to be too high.

As a practical matter, project scientists say it is highly unlikely any person will be exposed to whatever maximum the EPA comes up with. A 1995 computer analysis concluded that during the first 10,000 years after burial, the peak radiation releases to exposed individuals would be only 0.8 millirems per year - far below the annual background exposure of 300 millirems. Even under the worst-case assumptions, the radiation doses to the maximally exposed individuals

would be about 40 millirems per year.

But Pigford says it is the potential radiation exposures over the longer haul - say after 100,000 years - that could be more serious. It is then, after a slow buildup of contamination in the ground water over hundreds of millenia, that some people who use the water could receive radiation doses much higher than those predicted for the first 10,000 years, Pigford says.

In the end, Energy Department officials say, it is unreasonable to expect that all the technical answers will be available before Uncle Sam decides whether to go ahead with the repository. Some of the information - on the performance of the waste canisters over time, for example - can only be gathered and analyzed once the repository is built and loaded. The design of the repository (which also continues to evolve) will allow the Energy Department to retrieve the waste canisters for a period of time - probably about 70 years - during which performance of the repository can be carefully monitored.

"We're not trying to prove Yucca Mountain is the best site," says Theodore Garrish, a vice president of the Nuclear Energy Institute, the industry's policy organization. "We are trying to prove it is a good site . . . engineering and good science can make this site work." He predicted that if Yucca Mountain ultimately is deemed unsuitable, "it'll be years and years before the country comes to a solution" for the nuclear waste dilemma.

Arjun Makhijani, a physicist at the nonprofit Institute for Energy and Environmental Research, said his organization would like to see an independent agency manage any spent-fuel repository. "The Department of Energy does not have a good record of managing its own wastes" at nuclear weapons facilities, Makhijani said.

Some analysts have argued that the spent fuel should be left in temporary storage at reactor sites not only until questions at Yucca Mountain are resolved but also until social acceptance of the project is higher.

Federal officials see that as a recipe for further inaction.

Barrett said: "Those who call for no solution as the best solution and just let's think about it for a decade or two are repeating the mistakes of the early 1950s," when tough decisions on how to manage spent fuel were left for another day. Plan for Nuclear Waste The U.S. government is investigating a site at Yucca Mountain, Nev., to be the repository for the nation's nuclear waste. Site studies currently are going on there and the repository could be operational in about 15-20 years. Here is a look at how nuclear waste might be stored at the planned facility: Preparing the Waste How the waste is prepared at the waste handling building for storage in the repository. 1. The cask used for transporting the waste to Nevada is removed from its carrier. 2. The cask is then opened and the nuclear wastes is moved to a staging rack. The waste is then loaded into a storage container. 3. The lids are welded onto the disposal containers. The containers' outer lids will take as much as 33 hours to weld on. 4. The sealed container is placed on a rail car and pushed up to a transporter. A remote-controlled mechanism in the transporter pulls the container and the rail car inside. The Process 1. Canisters of nuclear waste, sealed in special casks, are shipped to the site by truck or train and are initially stopped at security station. 2. Casks are cleared to the carrier staging shed, where they

are inspected for external contamination. 3. Casks then are sent to the waste handling building, where the waste is removed from the casks and placed in special containers that will be stored in the mountain. 4. Storage containers are placed into transporters. A locomotive attaches itself to the transporter and pulls it from the building, through the north portal, down the north ramp and to its destination at one of the emplacement blocks. 5. Containers are pushed into one of the tunnels in an emplacement block, where it will be periodically checked by sensors and robots. Tunnel Travel How the storage containers are deposited in the emplacement drifts. 1. The transporters carrying the nuclear waste are pulled through the portals and ramps by locomotives. 2. Once the transporter reaches an emplacement drift, it pushes the storage container out onto a loading dock. 3. A transfer locomotive then backs up an emplacement locomotive to the leading dock. 4. Emplacement locomotive pushes storage container to its position in the emplacement block. Types of Waste The Nevada site is being designed to handle three types of nuclear waste: Fuel assemblies from boiling-water reactor power plants Fuel assemblies from pressurized water reactor power plants Pour canisters filled with a mixture of glass and waste from defense-related programs.

SOURCE: Department of Energy; Nuclear Regulatory Commission

GRAPHIC: Newsday Illustrated Color Chart by Steve Madden-Plan fo Nuclear Waste: Here is a look at how nuclear waste might be stored at the planned facility Source: Department of Energy; Nuclear Regulatory Commission. (SEE END OF TEXT; ILLUSTRATIONS NOT IN TEXT DATABASE). Color Photos by Ken Korotkin- 1) Above, possible site for a temporary waste repository near the 2) permanent facility proposed at Yucca Mountain, Nev., below.

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