A Reporter's Guide to Yucca Mountain

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Preface

The planned Yucca Mountain nuclear waste disposal site outside of Las Vegas is a national story ("writ big" as they say, with prime-time network news and network "news magazine" coverage), but clearly one with lots of important local angles.

And in many ways, the future of the Yucca site is also an emerging local story, one spanning the continent from the Great Lakes to the Gulf of Mexico, from the Chesapeake Bay to the Oregon and California coasts, and one that directly or indirectly could affect hundreds of communities and transportation corridors spidering from all directions.

Whether the proposed Yucca Mountain waste site ever actually opens is, to some extent, beyond the point in terms of its potential for making news over the short- to near-term. As many as 72 commercial and 43 research sites in 43 states across the country could be sending commercial spent nuclear fuel, and also defense-related radioactive wastes, to the previously little known 1,200-foot-high ridge some 100 miles northwest of Las Vegas, the nation's fastest growing metropolitan area. That spent fuel raises environmental, safety, security, and management challenges both for as long as it resides in current containment facilities, and if decisions are finalized on its shipment to and disposal at the Yucca Mountain facility. If it opens, it will operate 33 years and hold as much as 70,000 metric tons.

Along with its potential status as the nation's first geological repository for disposal of commercial radioactive wastes, Yucca also serves up another milepost certain to capture headlines: In the 14 years of research and development, planning, and engineering work, the Federal Government through August 1999 had invested some $3 billion in preparing the site.

So whether "first glances" suggest Yucca as a national story or as a local story, it is likely that experienced reporters may come to see it as either and both. No experienced journalist, after all, would likely stop at first glance.

Look again and the local angles in what may become the nation's first permanent geological repository for disposal of spent nuclear fuel and high-level radioactive wastes begin to emerge.

It's a story involving how scores upon scores of local government agencies, regulators, utilities, and even many local universities — all those involved currently in managing the commercial spent nuclear fuel and defense-related radioactive wastes — reach important decisions on sensitive nuclear waste management issues.

It's a story of highly radioactive spent nuclear fuel being moved from commercial reactors, government-funded research centers, and university R&D facilities along thousands of miles of public thoroughfares to a previously little known 1,200-foot-high ridge about 100 miles northwest of Las Vegas, the nation's fastest growing metropolitan area.

Yucca Mountain — its evolution, its current status, and its long-term prospects for someday actually opening — is a story with news "pegs" aplenty: years of courtroom jousting, billions of federal dollars invested so far, decades in the planning stages, a half-dozen or more major federal agencies and scientific bodies deeply involved, state and local opposition, and substantial controversy. Add to that mixture a paradoxically pressing deadline in the face of what seems to some to have been interminable delays in finally reaching a go/no decision on whether to proceed with the Yucca site.

This guide is one of a series of companion resources developed by the nonprofit, nongovernmental National Safety Council's Environmental Health Center as a resource for news media and, importantly, for those dependent on the news media either as carriers or as sources of information on timely issues.

Like its companion guides, this one tells of a broad national story. It outlines the broad parameters that can serve as a start for the kind of comprehensive national reporting the issue clearly demands. And, it serves too as something of a blueprint for the kinds of local stories best able to meet the needs of diverse communities. The fine details in the end can be filled-in at the local level only when local media do their job.

The geography most identified with the proposed Yucca Mountain site — Nye County, Nevada, Nellis Air Force Range, and the Nevada Test Site — may well seem remote and distant to many of your editors and perhaps also to your audiences.

That may be the case as the proverbial crow flies.

But the problem, the issue, that some hope Yucca Mountain will help address — responsibly managing well into the future the radioactive waste materials left from both national defense and peacetime uses of nuclear power — are as close as the nearest nuclear reactor or research laboratory, each eager to see its nuclear wastes safely and economically shipped to the mystical "somewhere" presumably well-equipped to handle them.

Journalists use a term to capture those parties strongly committed to one side or the other of sensitive public policy issues: "true believers."

They're certain to encounter some of those in their coverage of Yucca, just as in their coverage of virtually all other environmental pollution or radioactive waste stories. That only heightens the respon-sibilities they face in best informing their audiences on this issue.

At the risk of seeming old-fashioned indeed, reporters could do worse than resort to the "5 Ws" (and "H" for How!) strategy they first learned in Journalism 101.

But in this case, it will take more too. Editors and reporters willing to delve into the sciences involved in this continuing story — the geology, the geography, the nuclear physics, and, yes, also the political science — may in the end be best equipped to meet their audiences' needs for timely and responsible information.

Note the term "continuing story."

No one should be surprised that our society's efforts to responsibly deal with the leftovers of the Cold War era (and of domestic nuclear power generation generally) have continued well beyond that era itself. Whatever society's eventual decisions on Yucca Mountain — and the ultimate decisions on actually opening or not opening the site may lie well off into the future — the long-term post-closure management responsibilities associated with the site, if in fact it ever is opened, will extend for decades into the future.

"Yucca Mountain," and all that's embodied in that shorthand term, has been, continues to be, and no doubt will remain an important thread in the complex fabric of this nation's energy picture. The issue will shift just as the desert winds surrounding the site itself so frequently do. Keep in mind that inherent in its being a story of where radioactive materials may be *shipped to*, it's also an important story — and at the local level, in many cases — of where those materials are *shipped from.* (And, of course, how and how safely.) The combination of those two factors makes it both an important national story, and an important local one.

Yucca Mountain, as with any other environmental story worth doing, is by no means a "first glance" kind of story. Far from it.

Step back. Look hard and look again. Listen closely, and then more closely still.

The media have their work cut out for them in fairly, honestly, and comprehensively addressing the issues raised by the Yucca Mountain facility, no less, perhaps, than scores and scores of decisionmakers in and outside of government have their work cut out for them in making sound decisions.

It's to the mass media that citizens in the end will look for input in reaching their own decisions on Yucca Mountain and its suitability for the purpose being considered for it.

First glances alone — either by citizens themselves or by the media on which they will depend for drawing informed decisions — won't cut it.

Bud Ward
Executive Director
Environmental Health Center
National Safety Council
June 2001

Yucca Mountain – A Potential Geologic Repository

The Department of Energy (DOE) is studying Yucca Mountain as a potential repository for radioactive waste. If approved, the site would be the nation's first geological repository for disposal of spent nuclear fuel and high-level radioactive waste. Yucca Mountain is located in Nye County, Nevada, about 100 miles northwest of Las Vegas on federally owned land on the western edge of the Nevada Test Site. The northwestern part of the site is located on the Nellis Air Force Range, and the southwestern portion is owned by the Bureau of Land Management.

The design goals of the potential repository are as follows:

- To protect the health and safety of both the workers and the public during the period of repository operations
- To minimize the amount of radioactive material that may eventually reach the accessible environment
- To maintain costs at an acceptable level, without jeopardizing public health, safety, and the environment

The repository would store as much as 70,000 metric tons of radioactive waste from 72 commercial and 43 research reactor sites in 43 states across the country.

A Brief Chronology of Yucca Mountain-Related Events

1955 More than 40 years ago the U.S. Atomic Energy Commission (AEC) asked the National Academy of Sciences (NAS) to study disposal methods for radioactive wastes from nuclear weapons production in the United States. (AEC was disbanded in 1974, and some of its functions eventually became the responsibility of the Department of Energy (DOE), the Nuclear Regulatory Commission (NRC), and the Environmental Protection Agency (EPA).)

1957 A NAS report to the AEC recommended that transuranic and high-level radioactive wastes be buried in geologic formations and that the feasibility of using salt beds or salt domes as a disposal medium be investigated.

1970 The AEC tentatively selected a nuclear waste repository site in salt deposits near Lyons, Kansas.

1972 The federal government withdrew the Lyons, Kansas, site from consideration for the repository because of concerns that drilling in the vicinity had compromised the salt deposits' geologic integrity.

1982 The Nuclear Waste Policy Act (NWPA) was passed to help resolve the issue of long-term safe disposal of radioactive waste. The Act established geologic disposal as the United States' long-term strategy for isolation of spent nuclear fuel and high-level radioactive waste. The Act confirmed the federal government's responsibility for managing and disposing of commercial spent nuclear fuel and identified specific roles for federal agencies. DOE would design, build, operate, and close the underground geologic repository. EPA would develop generally applicable or generic public health and safety standards. NRC would license the repository, incorporate EPA's Yucca Mountain standards into its regulations, and implement them.

1983 DOE selected nine sites in six states for study as potential sites for a first repository. In accordance with the NWPA, DOE identified sites in 17 eastern states as potential locations for a second repository.

1986 The Secretary of Energy nominated five of the nine sites for further consideration, and the President approved three sites (Hanford, Washington; Deaf Smith County, Texas; and Yucca Mountain, Nevada) for further study (i.e., site characterizations).

1987 Based, in part, on a desire to keep costs down, Congress amended the Nuclear Waste Policy Act to direct DOE to study **only** Yucca Mountain.

1990s The 1990s brought a wave of Congressional and constituent dissatisfaction, regulatory modifications, court cases, legislative mandates, and projected cost increases that caused DOE's Office of Civilian Radioactive Waste Management to reorganize and redirect a series of programs. The scientific and regulatory issues had become much more complex than most had anticipated. In addition, projected costs were significantly higher than initial expectations. Initial cost estimates of site characterization were less than $1 billion, but by 1996, $4 billion had already been spent on the Yucca Mountain program.

1992 The Energy Policy Act was enacted, requiring EPA to develop site-specific public health and safety standards for Yucca Mountain, Nevada

1997 The Energy and Water Development Appropriations Act directed that by September 30, 1998, the Secretary of Energy provide to the President and Congress a Yucca Mountain Viability Assessment.

1997 DOE completed construction of the Exploratory Studies Facility at the site.

1998 The Yucca Mountain Viability Assessment was issued in December. It addressed the design of the repository, how it would work, what would be required to license it, and its expected cost. It did not include a formal site recommendation. Following submission of the Viability Assessment, Energy Secretary Bill Richardson told the news media that the assessment "reveals that no showstoppers have been identified to date," although a number of independent oversight entities criticized the data and analysis.

1999 DOE issued its proposed Environmental Impact Statement for the facility in August.

1999 EPA proposed site-specific environmental radiation protection standards for Yucca Mountain, Nevada, in August.

Next Steps

Whether Yucca Mountain, Nevada will be the location of the first geologic repository for disposal of high-level radioactive waste and spent nuclear fuel remains unclear. The following steps are required:

- EPA must finalize its environmental radiation protection standards for Yucca Mountain (expected June 2001)

- DOE must prepare the Final Environmental Impact Statement (expected in 2001) and Site Recommendation Considerations Report (expected in Fall 2001).

- The Secretary of Energy must decide whether to recommend to the President if Yucca Mountain should be established as a commercial nuclear waste disposal site.

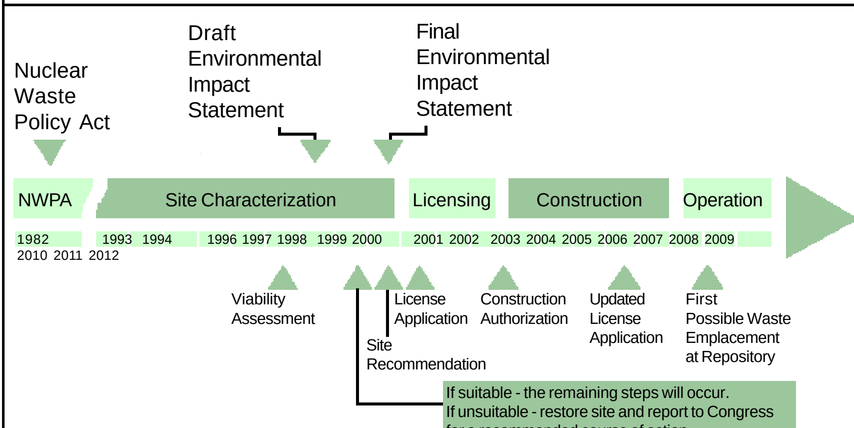
- If the Secretary of Energy recommends the site and issues a Site Recommendation Statement, the President must decide whether to recommend the site to Congress.

- If the President recommends the site to Congress, the Governor of Nevada or the Nevada Legislature has the right to submit a "Notice of Disapproval."

- If the state does submit a Notice, Congress can then decide to override the "Notice of Disapproval" and approve the Yucca Mountain site, or concur with the Notice and disapprove the site.

- If Congress, through a simple majority vote of both the House and Senate, approves the Yucca Mountain site, DOE is to submit an application to the NRC to construct the repository.

Figure 1. Yucca Mountain Timeline/Milestones



Source: Department of Energy, http://www.ymp.gov

- If NRC approves the application, DOE is to construct the repository and apply to the NRC for a license to accept waste. Under this schedule, if DOE receives the license, waste disposal could begin as early as 2010.

The total cost estimate to complete the design, and to license, construct, operate and monitor a geologic repository at Yucca Mountain over the next century is $43 billion, according to Jon Christensen of the *New York Times*.

Site Characteristics

As early as 1957, the National Academy of Sciences recommended burying radioactive waste in geologic formations. After more than two decades of additional study, DOE concluded that disposal in an underground mined geologic repository is the preferred approach. Optimum characteristics of a geologic repository would be high stability, no circulating groundwater, location where severe earthquakes or volcanic eruptions are highly unlikely, and deep enough to allow for buffers of the same rock above and below storage.

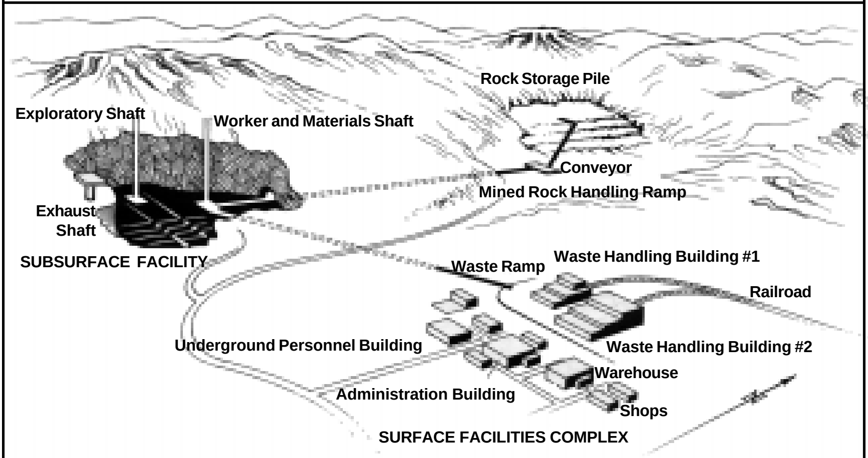
Yucca Mountain is a 1,200-foot-high, flat-topped volcanic ridge extending six miles from north to south. The mountain is comprised of "tuff," a rock made from compacted volcanic ash formed approximately 13 million years ago. Yucca Mountain has a desert climate and receives about six to seven inches of precipitation per year. The mountain has a deep water table. The repository would be built approximately 1,000 feet below the land surface and 1,000 feet above the water table.

Site Characterization and Environmental Impact Statement

DOE is conducting site characterization activities and preparing an Environmental Impact Statement (EIS), as required by the Nuclear Waste Policy Act.

DOE's site characterization is an intensive scientific study that will evaluate whether Yucca Mountain is a suitable site for developing a geologic repository for spent nuclear fuel and high-level radioactive waste. As part of this evaluation, scientists are studying Yucca Mountain's geology, hydrology, biology, and climate to determine whether any adverse conditions exist that would disqualify the site.

Figure 2. Artist's Sketch of Yucca Mountain



Source: DOE, http://domino.ymp.gov/va/va.nsf

In April 1997, DOE completed construction of the Exploratory Studies Facility — a five-mile-long, north-south horseshoe-shaped tunnel; a smaller east-west drift off the main tunnel; and a series of test alcoves that will permit scientists to conduct seismological, geological, hydrological, hydrochemical, and thermo-mechanical studies. Scientists have also simulated the reaction of rock and water to the heat that would be released by the spent nuclear fuel placed in the repository. These data will assist scientists in designing the repository and analyzing its performance. The Site Characterization Report is to be completed in 2001.
DOE will also issue a Site Recommendation Considerations Report open to public comment for 90 days. If DOE determines the site is suitable and plans to recommend it for repository development, a Site Recommendation Statement will be prepared and submitted to the President in 2001.

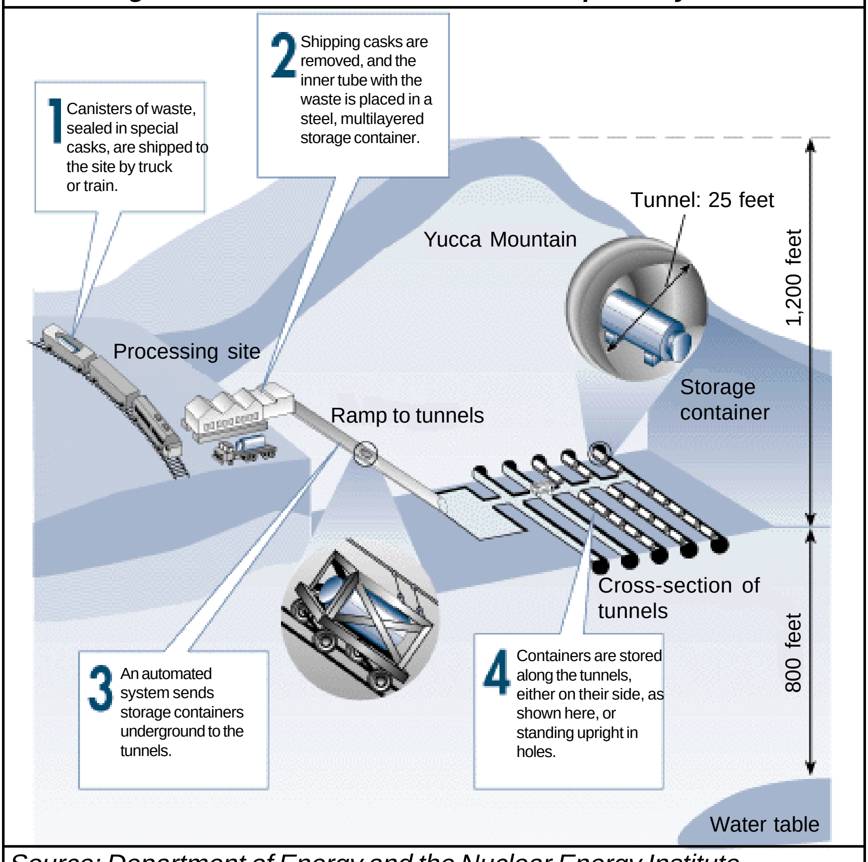
The Environmental Impact Statement will assess the potential environmental impact if the Yucca Mountain facility serves as a repository for spent nuclear fuel and high-level radioactive waste, including the transportation and disposal of the waste. It will also assess the impact of the alternative of not building the facility and leaving the waste at 72 commercial sites and 43 research sites in 43 states across the country. DOE published the Draft EIS on August 13, 1999, and accepted public comments through February 26, 2000. The Final Environmental Impact Statement is expected to be completed in 2001.

The Disposal System

The goal for the potential repository at Yucca Mountain is to isolate the waste from the environment in the following ways:

- Position the waste above the water table where the relative dryness of rocks would minimize exposure to groundwater
- Contain the waste in thick, corrosion-resistant packages
- Bury the waste deep — approximately 1,000 feet below the land surface — preventing most kinds of accidental contact with the waste from natural causes such as severe weather

Figure 3. Yucca Mountain Potential Disposal System



Source: Department of Energy and the Nuclear Energy Institute

The facility is being designed with an engineered barrier system that will work with the natural geologic barriers. The current design includes long-lived waste packages supported by concrete and steel and covered by inverted U-shaped drip shields, host rock, and a concrete tunnel floor.

Under current DOE plans in the Viability Assessment, the underground repository would consist of about 100 miles of tunnels. The main tunnels would allow for moving workers, equipment, and waste packages. Ventilation tunnels would supply air to the workers in the underground repository. The emplacement tunnels (or drifts) would accommodate the waste packages. Two sloping access ramps and two vertical ventilation shafts would connect the underground and surface areas.

The current waste package design would have two layers: an outer layer of a corrosion-resistant high-nickel alloy that is two centimeters thick, and an inner layer of stainless steel, five centimeters thick that provides physical strength to the package. Inside the waste package would be additional barriers. Most spent nuclear fuel would be encased in zircaloy, a metal cladding that is highly resistant to corrosion. The high-level radioactive waste would be inside a cover to protect against the possibility of dripping water contacting the waste package directly, and it would be made out of a high grade of metal titanium, which is also highly corrosion resistant. Because of the excessive heat from the high-level radiation, a remotely-operated rail car would carry the canisters down a ramp into a network of tunnels and robots would position the canisters.

The facility could hold up to 70,000 metric tons of waste, the limit imposed by Congress in the Nuclear Waste Policy Act of 1982. However, if authorized by Congress, the site could accept additional waste. DOE estimates that by 2010, approximately 64,000 metric tons of spent nuclear fuel and 286,600 cubic meters of high-level radioactive waste will be in temporary storage in the United States.

Issues and Concerns About Yucca Mountain

There is ongoing debate over whether the geologic features and proposed manmade barriers at Yucca Mountain will provide sufficient isolation. A number of interested parties believe Yucca Mountain has certain characteristics that pose a concern for long-term isolation of highly radioactive material. Others point to Yucca Mountain's location in an active seismic (earthquake) region; the presence of numerous earthquake faults (at least 33 in and around the site) and volcanic cinder cones near the site; evidence of hydrothermal activity within the proposed repository block; and the presence of pathways (numerous interconnecting faults and fractures) that could allow the rapid movement of groundwater (and any escaping radioactive material) through the site to the aquifer beneath and from there to the accessible environment.

Water flow is a critical factor. Some groups maintain that using chlorine-36 (a chemical isotope left by atmospheric atomic bomb testing) as a tracer, rainwater residues less than 50 years old have been detected at the level of the proposed repository.

Another concern surrounding water is the identification of calcite crystals. Some believe the crystals may have been fed by minerals carried by rainwater descending through the volcanic rock. Water in the tunnels could corrode the canisters and help to spread the radioactive material through the rocks and into the local water table, where it would threaten future residents in the area.

Still others question whether the site can remain stable for 10,000 years. And barriers could be damaged from drilling new tunnels.

Radiation

Radiation is energy — in the form of particles or waves that can move through empty space. All matter is made up of atoms and some atoms are unstable. As the unstable atoms, known as radionuclides, change to become more stable, they give off energy waves or particles called radiation.

Types of Radiation

Radiation is classified as either ionizing or nonionizing depending on the amount of energy involved. Nonionizing radiation has lower energy levels and longer wavelengths. It is not strong enough to affect the structure of atoms it contacts. Ionizing radiation has enough energy to change the electric charge of atoms or molecules. Ionizing radiation has three main forms:

- **Alpha particles** can travel only a few inches in the air and lose their energy almost as soon as they collide with anything. They are easily shielded by a sheet of paper or the outer layer of a person's skin.

- **Beta particles** are generally less energetic than alpha particles. They can travel in the air for a distance of a few feet. Beta particles can pass through a sheet of paper but can be stopped by a sheet of aluminum foil or glass.

Table 1. Common Sources of Everyday Exposure to Radiation

Radiation Source	Dose (millirem)
Medical X-ray	40*
Cosmic rays	46 (annually)
Household radon	200 (annually, U.S. average)

Source: EPA, http://www.epa.gov/radiation/students/calculate.html

*The value given for dose to the public from medical diagnostic x-rays is 40 millirem. This value is determined by estimating the the total dose to the U.S. population from all diagnostic x-ray procedures and dividing by the number of people living in the U.S. in the year the estimate was made. The value for any individual can vary greatly from this average value. If yo don't have any medical diagnostic procedures in a particular year, your medical dose that year is zero. If you have a routice chest x-ray, it will probably be below 10 millrem. If you have a complicated surgery with extensive medical x-rays (e.g., from fluoroscopy), you will get a dose much larger than 40 millirem. It is important to keep in mind that your annual medical dose depends on the number and type of x-rays you receive in that year.

- **Gamma rays** are waves of energy and are similar to x-rays. They travel at the speed of light through air or open spaces. Concrete, lead, or steel are used to block gamma rays.

Measurement of Radiation

Radiation is measured in different ways. Measurements used in the United States include the following:

- **Curie** is a unit of radioactivity. One curie refers to the amount of any radionuclide that undergoes 37 billion atomic transformations per second. A nanocurie is one one-billionth of a curie.

- **Roentgen** is a measure of exposure; it describes the amount of radiation energy, in the form of gamma or x-rays, deposited in the air.

- **Rad** (radiation absorbed dose) measures the amount of energy absorbed by a material, such as human tissue.

- **Rem** (roentgen equivalent man) measures the biological damage of radiation. It takes into account both the amount, or dose, of radiation and the biological effect of the type of radiation in question. A millirem is one one-thousandth of a rem.

- **Sievert** (Sv), a unit in the International System of Units that was adopted in 1979 by the General Conference of Weights and Measures, is now in general use throughout the world. One sievert is equal to 100 rem. A millisievert (mSv) is one one-thousandth of a sievert.

Everyday Exposure to Radiation

Individual exposures vary, but humans are exposed routinely to radiation from both natural sources, such as cosmic rays from the sun and indoor radon, and from manufactured sources, such as medical x-rays. Even the human body contains natural radioactive elements.

On average, people in the United States are exposed to about 360 millirem each year, mostly from natural sources. The following table shows average radiation doses from several common sources of human exposure.

Effects of Radiation on Humans

Ionizing radiation is powerful enough to alter cellular chemicals and disrupt normal cell functioning. All three types of ionizing radiation are potentially harmful to humans. Alpha and beta particles can cause damage to tissue primarily through inhalation or ingestion. Inhaling or ingesting particles that emit gamma rays is also potentially harmful; in addition, gamma rays from outside sources can penetrate and cause damage throughout the human body.

Two types of cellular damage can result from exposure to ionizing radiation:

- **Genetic damage**, which alters — or mutates — reproductive cells, resulting in damage to future generations.

- **Somatic damage**, which alters ordinary, nonreproductive cells, harms the exposed individual during his or her lifetime, but is not passed on to offspring. Cancer, including some leukemias and bone, thyroid, breast, skin, and lung cancer, is the dominant type of somatic damage resulting from exposure to ionizing radiation. Other types of somatic damage include burns and cataracts.

The nature and extent of damage caused by ionizing radiation depend on a number of factors, including the amount of exposure, the frequency of exposure, and the penetrating power of the radiation to which an individual is exposed. Rapid exposure to very large doses of ionizing radiation is rare but can cause death within a few days or months. The sensitivity of the exposed cells also influences the extent of damage. For example, rapidly growing tissues, such as developing embryos, are particularly vulnerable to harm from ionizing radiation.

Types of Radioactive Waste

There are five general categories of radioactive waste: (1) spent nuclear fuel from nuclear reactors and high-level waste from reprocessing spent nuclear fuel; (2) transuranic waste, resulting mainly as by-products from defense programs; (3) uranium mill tailings, from the mining and milling of uranium ore; (4) low-level waste, from contaminated industrial or research waste; and (5) naturally occurring radioactive materials.

Spent Nuclear Fuel

Spent nuclear fuel is fuel that has been removed from a nuclear reactor once it is no longer efficient at powering the reactor. Once a year, approximately one-third of the nuclear fuel is replaced with new fuel. This used fuel is called spent nuclear fuel and is highly radioactive, containing plutonium and other radionuclides.

Sources of spent nuclear fuel include commercial power plants; government-sponsored research and development programs in universities; nuclear-weapons production reactors controlled by the federal government; Naval and other Department of Defense reactors; experimental reactors, such as high-temperature, gas-cooled reactors; and American-owned, spent nuclear fuel originating from reactors located outside the United States.

High-Level Radioactive Waste

High-level radioactive waste in the United States is primarily a by-product of producing nuclear materials for defense uses. There is a small amount of commercial high-level waste. High-level waste is created when spent nuclear fuel is treated chemically to separate uranium and plutonium, a process known as "reprocessing," which is used to recover desired radionuclides. In the United States, only defense spent nuclear fuel is reprocessed; commercial spent nuclear fuel is not currently being reprocessed.

The high-level radioactive waste from reprocessing spent nuclear fuel is stored in various forms such as sludge, liquid, or pellets. NRC regulations (10 CFR 60.135) require that liquid high-level radioactive waste be solidified before disposal. DOE plans to solidify this waste by mixing the radionuclides that are not recovered with liquid borosilicate glass specially formulated for this purpose. The mixture is then poured into large metal containers to cool and solidify. This process is known as "vitrification." Only solid high-level radioactive waste will be allowed to be disposed of in the proposed repository at Yucca Mountain.

Wastes Proposed for Yucca Mountain

Spent nuclear fuel and high-level radioactive wastes make up most of the material proposed for disposal in the Yucca Mountain repository.

Approximately 90 percent of the material proposed to be disposed in the repository will be commercial spent nuclear fuel, and approximately 10 percent will be high-level radioactive waste from defense programs. However, small volumes of other types of radioactive wastes could be identified for storage or disposal at Yucca Mountain.

Duration of Radioactivity at Yucca Mountain

Spent nuclear fuel and high-level radioactive waste contain short- and long-lived radionuclides. Most radionuclides in this waste will decay to insignificant levels within several hundred years. A significant inventory of radionuclides will take many thousands of years to decay to nonthreatening levels.

Public Participation and Federal Agency Decisions Related to Yucca Mountain

Public Participation in Yucca Mountain Decision Making

Government decisions about the Yucca Mountain repository system are governed by a range of laws and regulations covering nuclear waste, hazardous waste, transportation, environmental pollution, and even the procedures by which the government makes decisions. Some decisions about Yucca Mountain have already been made, and citizens have been involved in the decision making through comments and testimony to federal agencies, such as EPA, DOE, and NRC, state government agencies, and state and federal elected representatives.

The following federal laws address primary responsibility for storage and disposal of spent nuclear fuel and high-level radioactive waste:

- Nuclear Waste Policy Act of 1982
- Nuclear Waste Policy Amendments Act of 1987
- Energy Policy Act of 1992

DOE, NRC, and EPA are the three primary federal agencies with specific responsibilities. Each has sought public participation through public meetings, hearings, comment periods, and other mechanisms. EPA and DOE must follow the Administrative Procedure Act, which stipulates that agency actions are subject to public comment. NRC operates under the Sunshine Act, which also requires public comment.

DOE held 21 public hearings throughout the country in 1999 and early 2000 and received written public comments for more than 180 days concerning its Draft Environmental Impact Statement. Citizens can share their comments and concerns at DOE’s Yucca Mountain Web site (http://www.ymp.gov).

Citizens can learn about NRC’s rulemaking process and the status of specific rules and share their comments on proposed NRC regulations through NRC’s Web site (http://ruleforum.llnl.gov) and toll-free line, (800) 368-5642, and through NRC public meetings. Individuals can petition NRC to initiate, modify, or terminate a rule.

EPA held public hearings on its proposed standards for Yucca Mountain in October 1999 and received about 800 comments during the 90-day public comment period. Information about EPA's Yucca Mountain activities is available by calling the Agency's toll-free Yucca Mountain Information Line at (800) 331-9477. EPA also has a Yucca Mountain Web page (http://www.epa.gov/radiation/yucca).

Table 2. Roles of Federal Agencies	
Department of Energy	The U.S. Department of Energy (DOE) is responsible for the construction, management, and operation of the potential geologic repository at Yucca Mountain, Nevada. DOE follows Occupational Safety and Health Administration regulations to ensure the safety and health of workers on-site. DOE is working with the Department of the Interior's U.S. Geological Survey on site characterization issues and activities. If the site is licensed and approved to accept radioactive waste, DOE would obtain a license, construct, operate, monitor, and close the repository. Before any waste could be transported to the site, DOE would route the carriers using Department of Transportation and Nuclear Regulatory Commission guidelines.
Environmental Protection Agency	The Environmental Protection Agency (EPA) is responsible for developing site-specific standards for Yucca Mountain, Nevada. These standards protect public health and the environment from harmful exposure to the radioactive waste which would be stored and disposed in the proposed underground geologic repository. EPA's standards address all environmental pathways: air, ground water, and soil. The Nuclear Regulatory Commission is responsible for implementing the standards developed by EPA.
Nuclear Regulatory Commission	The Nuclear Regulatory Commission (NRC) is responsible for determining whether DOE will receive the necessary licenses to dispose of spent nuclear fuel and high-level radioactive waste in the potential repository at Yucca Mountain. Once EPA's standards are finalized, NRC would revise its regulations to be consistent with EPA's standards. If the Yucca Mountain site is approved to accept waste, shipments by NRC licensees to the site would be made in accordance with NRC and DOT transportation regulations. NRC is the approving authority for safeguard and security (theft and sabotage protection) of spent fuel transportation.

Department of Transportation	If waste transportation to Yucca Mountain is authorized, the Department of Transportation (DOT) would be charged with ensuring that waste carriers comply with routing regulations and guidelines. Radioactive waste carrier drivers must be trained and retrained each year to tackle a variety of transport conditions and situations, including rough terrain and severe weather conditions. Drivers must complete a First Responders Course, to help them prepare for incident prevention and response. Additional emergency response support would be provided by the Federal Emergency Management Agency which assists state and local governments in developing emergency response plans.
Mine Safety and Health Administration	The Mine Safety and Health Administration (MSHA) of the Department of Labor is responsible for ensuring the health and safety of underground workers at the Yucca Mountain facility. MSHA provides technical assistance and consultation services and conducts on-site safety and health visits at the facility.

EPA's Regulatory Role Concerning Yucca Mountain

The Energy Policy Act of 1992 gave EPA responsibility for setting site-specific radiation protection standards — limiting the public's exposure to radiation from management and disposal of the waste at Yucca Mountain. In other words, EPA's radiation protection standards are developed specifically for Yucca Mountain, Nevada.

The Energy Policy Act requires EPA to set the standards based on, and consistent with, the findings and recommendations of the National Academy of Sciences' "Technical Bases for Yucca Mountain Standards," which was published in 1996 (http://books.nap.edu). During the development of its Yucca Mountain standards, EPA considered the report, public comments received on the report in public meetings, and additional written comments. EPA also considered its generic standards at 40 CFR Part 191, "Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes," for this type of waste. These standards were used to certify the safety of the Waste Isolation Pilot Plant — a deep geologic repository for disposal of transuranic waste located in southeastern New Mexico near Carlsbad.

EPA worked with a variety of interested parties to develop its standards including other federal agencies, the scientific community, members of the public, and the Administration. A significant amount of this time was spent addressing scientific issues in coordination with the National Academy of Sciences, the Administration's Office of Science Technology and Policy, the Department of Energy and the Nuclear Regulatory Commission. The Agency's proposed radiation protection standards were available for public comment for 90 days. EPA held public hearings on the proposal in Washington, DC; Amargosa Valley, Nevada; Las Vegas, Nevada; and Kansas City, Missouri. EPA considered and responded to all public comments received before it issued its final public health and environmental radiation protection standards for Yucca Mountain, NV, in June 2001.

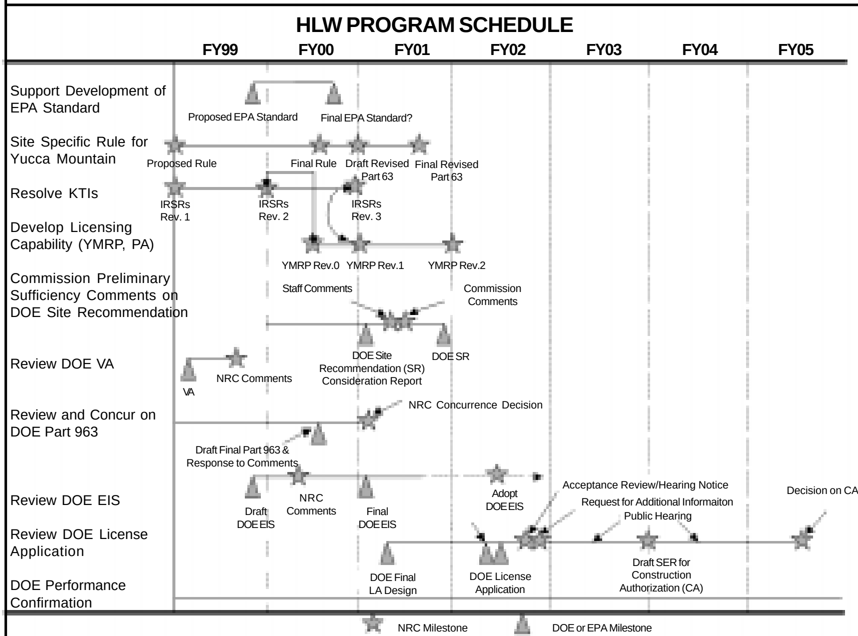
NRC's Regulatory Role Concerning Yucca Mountain

NRC developed regulations for Yucca Mountain which address, for the most part, licensing requirements for the proposed repository. The proposed regulations were published in the *Federal Register* on February 22, 1999 (64 FR 8640). NRC has worked with EPA as EPA has developed its standards for disposal of spent nuclear fuel and high-level radioactive waste that consider NAS recommendations. NRC must revise its licensing regulations to incorporate EPA's final standards for Yucca Mountain. NRC's regulations must be revised one year after EPA's final radiation protection standards are signed and published in the *Federal Register*.

If Yucca Mountain is approved by the President and Congress, current plans call for licensing of the repository to occur in three phases.

- **Application for construction (Phase I)**
  Following site characterization, if DOE applies to NRC for permission to build a geologic repository. NRC will have three years to review the application, conduct public hearings, and make a construction authorization decision by an independent licensing board. NRC has already begun to review DOE's site characterization research to find and resolve potential licensing concerns. However, within the licensing process, all issues can potentially be reopened to the licensing board and become issues of contention during the hearing.

Table 3. NRC’s Yucca Mountain Licensing Schedule



Source: NRC, http://www.nrc.gov/NMSS/DWM/schedule.htm, May 2000

- **Application to receive waste (Phase II)**
  In the second phase, during construction of the repository, DOE will apply for a license to receive radioactive material at Yucca Mountain. If NRC issues the license, DOE will start emplacing spent nuclear fuel and high-level radioactive waste into the repository.

- **Application to decommission (Phase III)**
  In the third phase, once the repository is full, DOE will apply for and request a license amendment from NRC to decommission and permanently close the repository.

NRC’s Key Technical Issues

One of NRC’s main responsibilities is to analyze DOE’s site characterization program and identify any concerns that relate to licensing. NRC also witnesses site characterization activities in the field, such as drilling and tunneling, and reviews DOE’s quality assurance audits.

NRC is most interested in the following 10 key technical issues:

- Likelihood and results of volcanic activity
- Evaluation of earthquake and fault activity
- Modifications in the waste package environment over long periods of time
- Forecasts of the waste package container lifetime, including estimates of the types of radiation that may escape from deteriorated waste packages and the rate of such release
- Understanding the effects of heat caused by the waste on moisture flow around the repository
- Evaluating how heat from the waste may affect the mechanical properties of the repository design
- Characterization of groundwater flow near the repository
- Identification of key geochemical processes that may control radionuclide transport at Yucca Mountain
- DOE's capacity to conduct and review total-system performance assessments
- Development of revised environmental standards and implementing regulations for Yucca Mountain

NRC has discussed these issues in various public forums, and the public has had opportunities to comment on them. New issues may be added in the future. NRC plans to periodically reevaluate the priority of these issues and offer progress reports to document resolution of these key issues.

Transporting Waste

Although DOE does not plan to make transportation decisions until Yucca Mountain has been approved, many options are under consideration. Current plans call for the shipments to originate in the 35 states with nuclear reactors and government weapons facilities. Figure 4 shows the location of sites from which nuclear waste may be transported to the potential repository. The waste is expected to be transported by truck and rail to Nevada. Transportation routes have been identified in 43 states.

Radioactive materials have been shipped in the United States for more than 50 years. Each year, roughly three million packages of radioactive materials are carried in the United States by trucks, trains, boats, and airplanes. Most go by truck and most are small packages involved in medical, commercial, and research uses, or low-level waste. While some transportation accidents involving radioactive materials have happened during the last 50 years, none has resulted in death or serious injury from exposure to released radiation, according to DOE.

However, environmental groups and other interested parties point out that the past record of shipping spent nuclear fuel and other radioactive materials is not a sound basis for predicting risks from a repository shipping campaign. Average shipping distances would increase dramatically, from less than 200 miles to more than 2,000 miles, increasing the risks of accidents or sabotage.

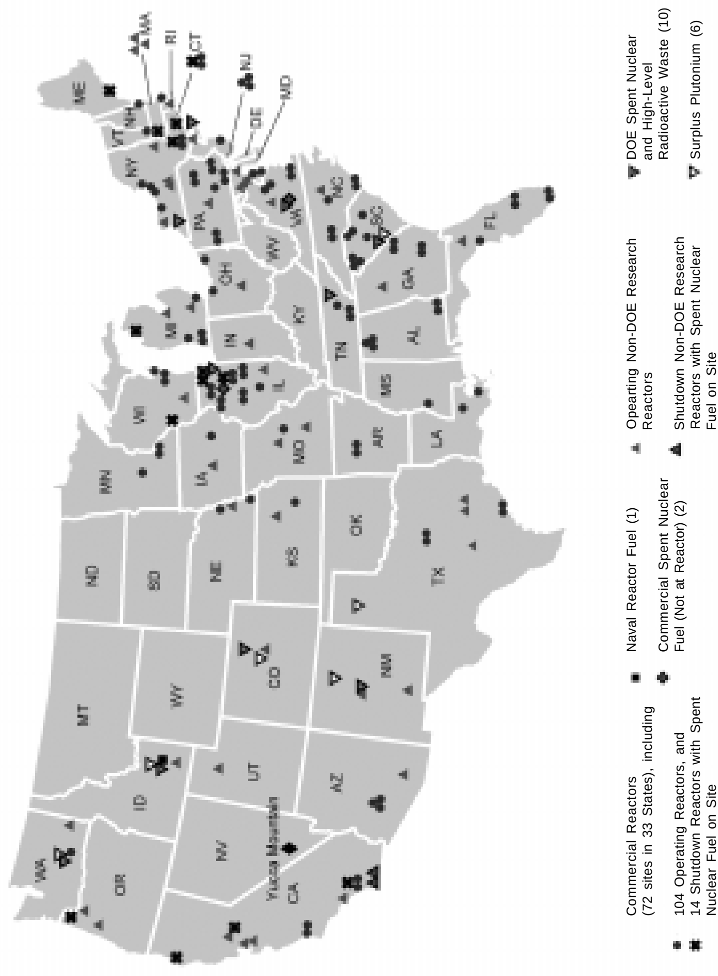
Transportation Routes

Highway transportation routes for high-level radioactive waste and spent nuclear fuel shipments are governed by Department of Transportation (DOT) regulations (49 CFR 397). For transportation purposes, high-level waste and spent fuel are referred to as Class 7, or "Highway Route Controlled Quantity" (HRCQ) materials. For these materials, DOT regulations make the carrier responsible for using "preferred routes" and for "minimizing radiological risk."

Carriers must consider several factors in minimizing radiological risk:

- accident rates on particular routes
- the time required to transit a route
- population density along the route
- human activities along the route

Figure 4. Current Locations of Spent Nuclear Fuel and High-Level Radioactive Waste Destined for Geologic Disposal



Source: http://www.rw.doe.gov/wasteaccept/snflocationspic.jpg

- time and day of week when the shipment will transit the route

Generally, the "preferred routes" are interstate highways, using beltways and bypasses to avoid passing directly through a city. State or tribal governments can specify alternatives to the preferred routes, if they do so within DOT guidelines.

Shipments can deviate from preferred routes only for certain specified reasons — such as picking up or dropping off the shipment; stops for necessary rest, fuel, or vehicle repair; emergencies; or unsafe conditions. In general, routes must be selected to achieve the shortest transit time along preferred routes, and the shortest distance for any necessary deviations.

Prior to shipping waste, carriers must file a written plan which specifies the points of origin and destination, the route between them, all planned stops, estimated departure and arrival times, and telephone numbers for emergency assistance in each state. They must file an amendment if they vary from the plan.

In addition, NRC regulations require shippers of spent nuclear fuel and

Figure 5. Potential Transportation Routes to Yucca Mountain

Source: State of Nevada, Agency for Nuclear Projects, Nuclear Waste Project Office high-level radioactive waste to notify the governor of each state through which it is to pass at least seven days before the shipment leaves its point of origin. This is intended to allow time for police and emergency response agencies to prepare. For security reasons, it is unlikely this information will be shared with the media.

Using DOE preliminary plans and models, the Nevada Agency for Nuclear Projects developed the map on page 27 of potential transportation routes. More detailed state-by-state maps can be found on DOE's Web site at http://www.ymp.gov/timeline/eis/routes/routemaps.htm.

Transport Vehicles

To date, most high-level radioactive waste and spent nuclear fuel has been transported by truck. Some waste has been transported by rail and some — typically for shipments from abroad — has been transported by ship or barge. DOE is considering options for the waste to be transported to Yucca Mountain but does not expect to make a final decision until after approval of the site.

One advantage of rail over highway transport is that railroad cars can carry more weight. If a large number of reactor sites decide to use large, dual-purpose (storage/transportation) containers for shipment of spent fuel, then the proportion of shipments going by rail may increase.

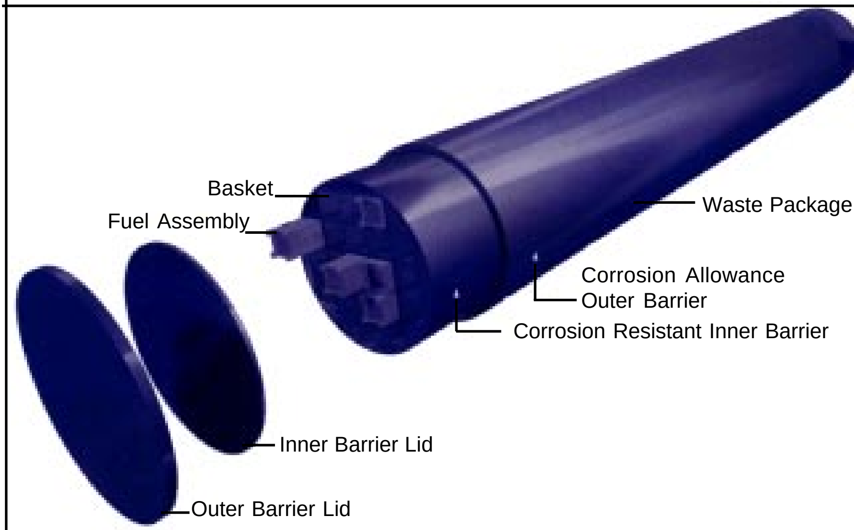
Transport Containers

Radioactive waste is currently shipped in specially designed containers, called casks that function as barriers against the release of radiation during transport. Casks are heavily shielded to reduce the radiation to the allowable limits established by NRC and must be certified by NRC to withstand extreme conditions.

Several different kinds of casks are currently in use for different kinds of shipments — and several others are being developed for possible future use in shipments like those that would go to Yucca Mountain. One cask that DOE has used frequently to transport spent nuclear fuel is made of steel and lined with aluminum, has walls approximately eight inches thick, and weighs 26 tons.

Federal regulations do not dictate a particular kind of container to be

Figure 6. Transportation Cask



Source: DOE, http://domino.ymp.gov/va/va.nsf

used, but do specify particular requirements that any container must meet before it can be certified for use. Casks for spent nuclear fuel and high-level radioactive waste, called Type B transportation casks, must be shown to retain their integrity and not leak radioactive material following four tests — with the first three done one immediately after the other:

- A 30-foot drop in which the container's weakest point strikes a flat, unyielding surface
- A 40-inch drop in which the container's weakest point strikes a six-inch-diameter steel rod eight inches long
- Engulfment of the entire container in a fire of 1,475°F for 30 minutes
- Immersion of the entire container under three feet of water for eight hours

Presently, there are no requirements for physical testing of transportation casks. Cask designs must only demonstrate that they meet physical testing requirements through computer simulations. Scale model tests are optional.

However, it is worth noting that in the 1980s Sandia National

Laboratories conducted full-scale crashes of transportation casks in various scenarios, such as a train hitting a truck loaded with a cask, and a train carrying a cask and running into cement walls.

Driver Training

Any driver of a vehicle carrying spent nuclear fuel or high-level radioactive waste must complete training in the characteristics and hazards of HRCQ Class 7 materials. Training must have occurred within the previous two years and must be in writing. Training includes federal rules (49 CFR Parts 172, 173, and 177), the properties and hazards of Class 7 materials, and procedures to be followed in case of accident or other emergency.

Drivers of vehicles carrying spent nuclear fuel or high-level radioactive waste must have in their possession a certificate of training showing the driver's name and license number, the dates training was provided, and the name and address of the person providing the training.

Tracking Waste Shipments

DOE plans to constantly monitor and track all shipments of high-level radioactive waste and spent nuclear fuel to Yucca Mountain. DOE currently has a system in place known as TRANSCOM for tracking radioactive waste shipments. It has been used successfully to track shipments going to the Waste Isolation Pilot Plant near Carlsbad, New Mexico. DOE expects to use this system (or an updated version) to track waste going to Yucca Mountain.

The system uses Global Positioning System (GPS) devices, similar to those used by boaters, car owners, and hobbyists, to continually monitor the position of shipments. TRANSCOM is currently used for all nonclassified high-visibility shipments of nuclear waste. It is managed by the DOE's National Transportation Program in Albuquerque, New Mexico.

Information on the position and status of a shipment can be shared with individuals at other locations who have a need to know, such as those at the waste receiving site and other federal agencies, security personnel, or emergency responders. These individuals, when properly cleared, can tap into the system with only a personal computer and a modem. For obvious security reasons, DOE plans to restrict this information to people and agencies involved in getting the shipment safely to its destination.

Emergency Response

Carriers and state, local, tribal, and federal governments all have responsibility for preparing for and responding to radiological emer-gencies. Local emergency response personnel and state radiological emergency response teams are primarily responsible for initial response and for protecting public health and the environment from radiation exposure. Every state has a plan in place to respond to radiological emergencies.

Several federal agencies also have responsibility for providing support in response to any radiological incident, including DOE, NRC, EPA, and the Federal Emergency Management Agency (FEMA). FEMA helps states, local governments, and tribes develop emergency response plans. This effort involves training and equipping emergency response personnel, medical personnel, and others to deal with potential contingencies. In addition, nuclear power plants in the United States have agreed that regardless of who is shipping the radioactive materials, if an accident occurs, the closest plant will provide equipment and technical assistance to the emergency response team.

With proper handling and safeguards, spent nuclear fuel and high-level radioactive waste shipments can be, and have been, responsibly managed and successfully completed. However, these materials are extremely hazardous and require extraordinary precautions and vigilance.

Privatization of the Transport System

DOE, responding to a Congressional directive that private industry be used to the maximum extent practicable in the repository shipping program, is proposing that the system for transporting spent nuclear fuel and high-level radioactive waste to a repository be privatized and "market-driven." Under such a system, decisions regarding the type of shipping container, the shipment mode (rail or truck), and the shipment routes to be used would be left to the carrier selected to transport the waste. Critics of this approach contend that such a privatized system could add greatly to the complexities and uncertainties of the transportation system, thereby increasing risk, and could result in cost considerations overriding public health and safety matters.

Post-Closure Oversight of Yucca Mountain

If and when Yucca Mountain reaches its legal capacity (70,000 metric tons) in an estimated 33 years, it is precluded by current federal law from accepting more waste. According to DOE's Draft Environmental Impact Statement, by 2126 the repository is to be sealed with backfill, cement, and other materials to isolate the waste from the accessible environment. Then begins the long-term process of keeping the waste isolated from the environment.

DOE's current plan is to monitor the potential repository for at least 50 years once the last waste package has been disposed. After the monitoring phase, DOE intends to seal the tunnels and post a guard at the gate for as long as necessary. It is impossible to predict which government institutions may evolve or disappear over the next 10,000 years, so at the time of permanent closure DOE plans to use "passive" measures to warn people against disturbing the site. Monuments, warning markers, and widely distributed records would be used to inform people of the contents of the Yucca Mountain site and to keep them from intruding onto it.

Story Ideas for Articles on the Proposed Repository at Yucca Mountain

1. What are the latest issues that challenge Yucca Mountain as a suitable repository? What still needs to be learned? What would happen if gradual climate change made Nevada a wet area?

2. What sites containing highly radioactive nuclear waste are in or near your readership area or broadcast market (see maps at http://www.ymp.gov/timeline/eis/routes/routemaps.htm)? This could include nuclear power plants, nuclear weapons production plants, and research reactors. What condition is the waste in? How soon will nuclear reactors in your area be decommissioned, i.e., shut down? How is it stored? How safe is it? What risks might it present to the local/regional population and the environment? What will happen if there is no place to move it to?

3. What risk scenarios could follow from leaving the waste in place or above ground? Nuclear proliferation? Acquisition by rogue states? Terrorism? Natural disaster? Unintended criticality or catastrophic release?

4. What are the key decisions that lie in the path ahead before the nation makes a final decision on whether to go ahead and deposit waste in Yucca Mountain? What is the timetable, legally and realistically? What are the prospects for resolving the unresolved questions?

5. Congress is presently debating whether interim storage of high-level radioactive waste and spent nuclear fuel should occur at Yucca Mountain. What do interested parties in your area think of this option? How will this issue affect decisions regarding a long-term repository at Yucca Mountain?

6. If the Yucca Mountain site is approved, how will it be managed? Will DOE have authority to manage the site as it sees fit? Should it? Will other agencies oversee DOE's decisions and actions? Should they? What will happen to this arrangement if DOE is abolished?

7. What is the current thinking about a technical plan for emplacing waste at Yucca Mountain? How tentative or final is this plan? What

are the chief technical/engineering problems to be dealt with? (For example, decay heat, corrosion, water, material stability, seismic activity, or radioactivity) What sort of "engineered barriers" are contemplated?

8. If we were to imagine some "worst-case" scenarios for failure of the Yucca Mountain repository after waste was placed there, what sort of human exposures might result? How would such exposures compare to other radiological exposures and accidents?

9. What are the possible/likely transportation routes in your region for waste going to Yucca Mountain, if any? What sorts of shipments would be traveling these routes, and how often? What input has your state had into selecting such routes? What procedures and safeguards would your state apply to such shipments (e.g., police escorts)? What emergency responders would deal with any accidents, and how well prepared are they?

10. What has been the accident history over the 50 years during which radioactive materials have been transported on the nation's railroads, highways, and air corridors? How does this compare to the risks and experience for other forms of transport — such as passenger auto travel, passenger air travel, highway, or rail — to transport of other hazardous materials?

11. On what grounds will NRC's decision to license the Yucca Mountain facility be made? What must it consider and what can't it consider? What will be the opportunities for public participation, and what effect will public participation have? When would NRC's licensing decision be likely made?

12. [This one for the science-fiction writers among you:] The Yucca Mountain repository would have to contain wastes for at least 10,000 years — a period about as long as human civilization to date. What sort of future might we imagine in which the repository will have to perform? Consider changes in technology, climate, energy, population, political institutions, warfare, etc. How have such uncertainties been anticipated in planning the Yucca Mountain facility?

Glossary of Terms and Acronyms

AEC. Abbreviation for the U.S. Atomic Energy Commission. AEC was disbanded in 1974, and its functions were assumed by the Energy Research and Development Administration (ERDA) and the Nuclear Regulatory Commission (NRC). ERDA later became the Department of Energy (DOE). Part of the functions went to EPA in 1970.

alpha particle. A positively charged particle, consisting of two neutrons and two protons, emitted by certain radioactive materials. Alpha particles can travel only a few inches in the air and lose their energy almost as soon as they collide with anything. They are easily blocked by a sheet of paper or the outer layer of a person's skin.

atom. The smallest part of an element that still has all properties of that element. Its nucleus consists of protons and neutrons and is surrounded by orbiting electrons.

beta particle. A negatively charged particle, emitted by certain radioactive materials. Beta particles have the same properties (mass and charge) as electrons. They can travel in the air for a distance of a few feet and can pass through a sheet of paper. They can be blocked by aluminum foil or glass.

CFR. Code of Federal Regulations. The Code of Federal Regulations is a codification of the rules published in the *Federal Register* by the Executive departments and agencies of the federal government.

cosmic rays. Ionizing radiation (chiefly protons, alpha particles, and other atomic nuclei) which arrives on Earth from outer space.

curie. A measure of radioactivity. One curie of radioactive material will have 37 billion transformations of atoms (disintegrations) in one second. One curie of radium weighs approximately one gram.

disposal. Isolation of radioactive waste separated from the accessible environment with no intent of recovery; occurs when a repository is sealed.

DOE. Abbreviation for the United States Department of Energy. Yucca

Mountain is a DOE-owned facility.

DOT. Abbreviation for the United States Department of Transportation. DOT regulates the transport of radioactive materials.

element. A substance composed of atoms with a unique number of protons in each nucleus. There are 92 naturally occurring and 15 manmade elements.

Environmental Impact Statement. A document that describes the potential environmental impact of a project. The National Environmental Policy Act (NEPA) of 1969 mandates that all federal agencies and departments consider potential environmental impact before beginning projects or implementing rules and regulations. DOE must finalize its Environmental Impact Statement for Yucca Mountain before the facility can open.

Energy Policy Act of 1992. Act that gave EPA responsibility for setting site-specific radiation protection standards to limit the public's exposure to radiation from management of the potential Yucca Mountain facility. The Nuclear Regulatory Commission would license the repository, incorporate EPA's Yucca Mountain standards into its regulations, and implement them.

EPA. Abbreviation for the United States Environmental Protection Agency. For Yucca Mountain, EPA's responsibility under the Energy Policy Act is to develop site-specific public health and safety standards, which the NRC is responsible for implementing.

FR. *Federal Register*.

gamma rays. Waves of pure energy, similar to x-rays. Gamma rays travel at the speed of light through air or open spaces. Concrete, lead, or steel will block gamma rays.

genetic damage. A type of cellular damage that can result from ionizing radiation. Genetic damage refers to the alteration or mutation of reproductive cells, resulting in potential damage to future generations.

half-life. Measure of the amount of time it takes for half the radioactive atoms in a radionuclide to decay to a more stable form. The half-life of plutonium-239, for example, is about 24,000 years. After one half-life, half the radioactive atoms in a sample remain radioactive; after two half-lives, one-quarter of the original number remain radioactive; after three half lives, one-eighth of the original number remain radioactive; and so on. Half-lives range from a fraction of a second to billions of years.

hazardous waste. A solid waste, or combination of solid wastes, which because of its quantity, concentration, physical or chemical, characteristics may (1) cause, or significantly contribute to, an increase in mortality or an increase in serious irreversible, or incapacitating reversible serious, illness or (2) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, disposed of, or otherwise managed.

high-level radioactive waste. Highly radioactive material resulting from the reprocessing of spent nuclear fuel, or other highly radioactive material that is determined to require permanent isolation.

HRCQ. Abbreviation for Highway Route Controlled Quantity. Radio-active waste must be limited and transported on designated routes. HRCQ is the most highly regulated class of radioactive materials.

ionizing radiation. Radiation that is powerful enough to alter atoms by removing one or more electrons, leaving positively charged particles. Alpha and beta particles, gamma rays, and x-rays are forms of ionizing radiation.

isotopes. Different forms of the same element. Isotopes of an element have different numbers of neutrons in the nuclei of their atoms, but the same number of protons. Some isotopes, called radioisotopes, are unstable and emit radiation.

millirem. One one-thousandth of a rem.

low-level waste. Radioactive waste that consists of contaminated industrial or research waste. Most low-level waste is short-lived and has low levels of radioactivity.

NAS. Abbreviation for the National Academy of Sciences. NAS was required by the Energy Policy Act to provide technical bases for EPA's Yucca Mountain standards.

nonionizing radiation. Includes visible light, ultraviolet light, infrared light, and radio waves.

NRC. Abbreviation for the Nuclear Regulatory Commission. The Nuclear Regulatory Commission (NRC) would license the repository, incorporate EPA's Yucca Mountain standards into its regulations, and implement them.

Nuclear Waste Policy Act. Act that provides guidance to NRC on how and under what conditions NRC will issue licenses to DOE for various stages of the potential geologic repository at Yucca Mountain, Nevada. The Act also established a deadline for EPA to issue generic environmental radiation protection standards (40 CFR 191).

Rad (radiation absorbed dose). The amount of ionizing radiation absorbed by a material, such as human tissue.

radiation. Energy in the form of high-speed particles (ionizing) or electromagnetic waves (nonionizing).

radioactivity. The spontaneous emission of radiation from the nucleus of an atom. Radioisotopes of elements lose particles and energy through the process of radioactive decay.

radioisotope. An unstable isotope of an element that undergoes radioactive decay toward a more stable form. One form of radionuclides.

radionuclide. An unstable atomic nucleus, such as a radioisotope.

radon. A colorless, odorless gas produced by the decay of uranium in soil, rock, and water. Some radon isotopes are unstable and decay by emitting alpha particles. The radiation hazard from radon is manifested through inhalation.

rem (Roentgen equivalent man). A measure of the actual biological effects of radiation absorbed in human tissue. A millirem is one one-thousandth of a rem.

roentgen. A measure of exposure; it describes the amount of radiation energy, in the form of gamma or x-rays, deposited in the air.

site characterization. An intensive study that provides the physical description of Yucca Mountain and serves as a technical basis for deciding whether it is a suitable site for a spent nuclear fuel and high-level radioactive waste repository. Part of the evaluation is to study Yucca Mountain's geology, hydrology, biology, and climate to determine whether any adverse conditions exist that would disqualify the site.

somatic damage. A type of cellular damage that can result from exposure to ionizing radiation. Somatic damage refers to the alteration of ordinary, nonreproductive cells. Cancers, including some leukemias and bone, thyroid, breast, skin, and lung cancer, are the most common types of somatic damage resulting from exposure to ionizing radiation.

spent nuclear fuel. Irradiated fuel from a nuclear plant's reactor. Spent nuclear fuel is thermally hot and highly radioactive. Most spent nuclear fuel comes from commercial nuclear power plant operations.

TRANSCOM. Abbreviation for the Transportation Tracking and Communication System developed by DOE. TRANSCOM tracks and communicates with vehicles transporting radioactive and certain other types of hazardous waste. All shipments to Yucca Mountain will be tracked through TRANSCOM, which has a 24-hour control center in Oak Ridge, Tennessee, and uses satellite communications and computer networks to track shipments from beginning to end.

transuranic (TRU) waste. Waste that generally consists of protective clothing, tools, glassware, equipment, soils, and sludge that have been heavily contaminated with high concentrations of manmade radioactive elements heavier than uranium on the periodic table of elements (atomic number of 92). These elements include: plutonium, neptunium, americium, curium, and californium. Transuranic waste is produced during nuclear fuel assembly and during nuclear weapons research, production, and cleanup.

Viability Assessment. A report from the Secretary of Energy to the President in 1998 that discussed the design of the potential Yucca Mountain repository, as well as operational, licensing, and cost information.

WIPP. Abbreviation for the Waste Isolation Pilot Plant, the nation's first geological repository for permanent disposal of transuranic wastes and transuranic mixed wastes, which are transuranic wastes that also have hazardous chemical components. The WIPP facility is owned and operated by DOE and is located in southeastern New Mexico. EPA has certified that the WIPP meets its radioactive waste disposal standards. The WIPP is now accepting TRU waste for disposal.

Federal, State, Local, and Tribal Government

Dennis Bechtel

Appendix A:
Expert Contacts for Yucca Mountain

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Appendix B: Other Resources

Reports & Periodicals

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U.S. Environmental Protection Agency, Office of Air and Radiation. *Evaluation of Potential Economic Impacts of Final 40 CFR 197: Environmental Radiation Protection Standards for Yucca Mountain, Nevada*. January 2001

U.S. Nuclear Regulatory Commission. *High-Level Radioactive Waste.* Internet: http://www.nrc.gov/NMSS/DWM/background.htm. Accessed November 14, 2000.

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On-Line Resources

U.S. DOE	www.ymp.gov
U.S. EPA	www.epa.gov/radiation/yucca
U.S. NRC	www.nrc.gov
DOT	www.fhwa.dot.gov
MSHA	www.msha.gov
State of Nevada	www.state.nv.us/nucwaste/
Nuclear Waste Technical Review Board	www.nwtrb.gov/
Western Interstate Energy Board	www.westgov.org/wieb/
National Academy of Sciences	www.nas.edu/
International Atomic Energy Agency	www.iaea.org
National Safety Council/ Environmental Health Center	www.nsc.org/ehc.htm
Nuclear Information & Resource Service	www.nirs.org
Nuclear Energy Institute	www.nei.org/
Physicians for Social Responsibility	www.psr.org
Sierra Club Nuclear Waste Task Force	www.sierraclub.org/nuke/ nuke.html
Southern States Energy Board	www.sseb.org/
Nuclear Energy Agency	www.nea.fr
Western Governor's Association	www.westgov.org
Nevada Agency for Nuclear Projects	www.state.nv.us/nucwaste/ yucca/links.htm
Eureka County, NV	www.yuccamountain.org
Nye County, NV	www.nyecounty.com/index.htm
Clark County, NV	www.co.clark.nv.us/compplan/ nucwaste.htm
Inyo County, CA	www.sdsc.edu/Inyo/yucca-pg.htm

The following counties can be accessed at www.governet.net:

Lander County, NV
Esmeralda County, NV
White Pine County, NV
Churchill County, NV
Lincoln County, NV
Mineral County, NV