WISE

Washington Internships for Students of Engineering

The Diffusion of Science and Policy in Government Agencies: Focus on Yucca Mountain

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Kansas State University

Washington Internships for Students of Engineering
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About The Author

Justin Hendrix is a senior at Kansas State University, Manhattan, Kansas. He is currently studying Mechanical and Nuclear Engineering and receiving a minor in French. Sponsored by the American Nuclear Society, this report was written to examine the policy issues involved with the Yucca Mountain permanent waste repository.

About WISE

The Washington Internships for Students of Engineering program (WISE), is a ten week internship in which engineering students from varying fields learn how science and public policy are intertwined. This is accomplished through visiting different government agencies and offices through personal and group visits. Students choose a topic that is of interest to them and their sponsoring society, then conduct a thorough examination of the topic, expressing this through a written report. It is essential that engineers be involved with developing public policy in order that things are properly balanced. Science and policy work together in a very fine balance that lets the United States government run effectively. Our government should never be left to irresponsible action, but directed by a varying host of professionals who can make well-balanced decisions, engineers being part of that. The WISE program teaches a select group of individuals each summer how to play an active part in developing public policy by living and learning in Washington DC.

> ***"Government is not reason, it is not eloquence, it is force; like fire, a troublesome servant and a fearful master. Never for a moment should it be left to irresponsible action." George Washington***

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Executive Summary

The use of nuclear power to produce electricity has played a large part in the prosperity of the United States. The American nuclear power industry is a success story of developing a powerful energy source that safely provides over 20% of our nation's electricity. Like any other energy source, nuclear reactors have produced a waste product that must be properly handled to protect the workers and the general public. The Yucca Mountain permanent waste repository provides a place to store our nation's spent fuel in a centralized location where it can be properly contained. There are many parties involved with the development of Yucca Mountain and many issues where science and public policy are intertwined.

The Nuclear Waste Policy Act (NWPA) of 1982 charged the Department of Energy (DOE) with building a permanent waste repository for the safe keeping of our nations spent fuel. In 1987 the sites were narrowed to one, Yucca Mountain, under the amendments to the NWPA. The DOE was supposed to have taken title to our nation's spent fuel by January 31, 1998, but the deadline was missed and the conduction of research of Yucca Mountain continues. Yucca Mountain is located in the deserts of Nevada, 100 miles northwest of Las Vegas on government land. The nuclear waste trust fund has approximately $17 billion committed by collecting a small surcharge on electricity, one mill (one-tenth of one cent) per kilowatt-hour. Of this money, approximately $7 billion has thus far been spent.

In the proposed Yucca Mountain site, there are three primary agencies that are involved as well as Congress and the President. The Department of Energy (DOE) is responsible for building the site by conducting research and contracting the construction work. The Environmental Protection Agency (EPA) is responsible for setting the radiation standards and the Nuclear Regulatory Commission (NRC) is responsible for the licensure process. The conflicts that have arisen between the NRC and the EPA involve the radiation standards being set, primarily the proposed groundwater standard. Science and policy are both considered when developing the standards, but policy has overruled in the case of the groundwater standard.

The NRC has proposed a 25 mrem standard (one-thousandth of a rem) through "all pathways" and the EPA has proposed 15 mrem through all pathways, plus a four mrem limit to groundwater. An additional groundwater standard provides little additional protection to the public and adds much confusion to the licensing process. The scientific research that was used to determine the four mrem standard was conducted 40 years ago and is considered outdated compared to the knowledge that we have today. The average American receives 300 mrem per year from natural background radiation and medical uses. Although it is necessary to protect the public from excess radiation, being overly conservative costs considerably more and does not provide significant additional benefit. If these conflicts cannot be resolved, it should be the responsibility of Congress to intervene.

Timeline

1982 Nuclear Waste Policy Act
1987 Nuclear Waste Policy Act Amendment -- Focus on Yucca Mountain
1998 January 31 Deadline for the DOE to begin taking spent fuel
2001 Site recommendation by the President
2001 License Application
2005 Receive construction authorization and begin construction *(If licensed)*
2010 Begin Waste Emplacement (If licensed)
2033 Complete Waste Emplacement
2116 Close Repository (Speculated)

A permanent geologic repository is a responsible solution to dealing with spent fuel. The science that has been conducted at Yucca Mountain has shown, with certain confidence levels, that the area will be a stable and safe place to harbor spent fuel. It is somewhat immaterial as to whether this will effect the future of the nuclear industry. Spent fuel must be properly stored and a centralized location will be the best place to do that. Although science cannot guarantee the future of the mountain, we equally cannot predict the future of our society. Future generations may not be technically educated in the nuclear field and severe problems could arise if spent fuel was to be continually monitored at individual sites. A permanent repository is the best solution to storing spent fuel and Yucca Mountain is the best choice.

The Diffusion of Science and Policy in Government Agencies: Focus on Yucca Mountain

I. ISSUE DEFINITION

Politics and science play a role together in many different government agencies. The effort to build a permanent high level waste repository has encompassed a large range of involvement from many different levels within the government. Scientists and politicians work equally hard in different fields to prove, or disprove, the validity and safety of storing spent fuel in a proposed repository at Yucca Mountain, Nevada. Three of the primary agencies involved include the Department of Energy (DOE), the Nuclear Regulatory Commission (NRC), and the Environmental Protection Agency (EPA). Besides the agencies, the Congress and the President make final executive decisions about the program.

The first objective of this paper is to analyze the ways in which the agencies work together in the proposed Yucca Mountain repository, as well as the involvement of Congress and the President. The DOE is responsible for building the repository, the EPA sets the radiation standards, and the NRC is responsible for the licensing process. Although setting radiation standards is primarily based on science, there are many political factors involved. In the case of the EPA, the standards seem to be based more on policy than scientific evidence. If this controversy is not settled internally between the agencies, then it can become the job of Congress to determine a final ruling on justifiable standards.

The second objective is to describe the connection between science and public policy in making technical decisions that effect the general public. In describing relations between the agencies and Congress, the controversy in setting the radiation standards will be analyzed. Science and policy must be used together in order to develop proper standards. Science can show evidence and aid in making decisions, but the policy side must be equally balanced.

In showing the process of developing a permanent spent fuel repository at Yucca Mountain, the roles of the involved government agencies can be viewed, as well as the direct connection between science and policy.

A. <u>Background</u>

Science and policy often play a role together in decision-making processes that directly concern the people of the United States. In 1979, President Jimmy Carter made an executive decision to prohibit the recycling of spent fuel in the United States, thus accelerating the need for a place where spent nuclear fuel could be safely and securely stored. The Nuclear Waste Policy Act (NWPA) of 1982 charged the Department of Energy with building a permanent repository for the storage of our nation's high-level waste.[1] Although many different solutions were examined, a geologic repository was determined to be the most viable solution to the situation.

In the deserts of Nevada, Yucca Mountain has become one of the most highly studied pieces of real estate in the world. Yucca Mountain is the proposed future site where the United States government hopes to permanently store our spent nuclear fuel. Different government agencies that are involved must complement the scientific research that is being conducted with good policy by working together on this issue to make the best decisions. Science cannot always show the "right" or "best" answer, so it becomes necessary for our leaders to make the right choices with the information that they are given such as with the storage of nuclear waste. There are never perfect answers, so positive advantages and negative disadvantages of any situation must be analyzed to determine an optimal choice. Dealing with exhausted nuclear fuel is an important and controversial issue that is facing the nation and must be dealt with by making use of all available scientific knowledge to make the most appropriate decisions.

Since the creation of a powerful energy source that has been used for the last 30 years to produce power and better America, a hazardous by-product has been left behind. America has benefited from the use of nuclear power, but has not determined a positive solution to dealing with spent fuel. Nuclear power plants, which provide more than 20% of America's electricity, burn small uranium pellets that are contained in fuel rods. Most nuclear reactors are refueled systematically, usually at intervals between 12 and 24 months, where approximately one-fourth to one-third of the exhausted fuel is removed, meaning that it is "spent".[2] A typical nuclear power plant will accumulate about 30 tons of spent fuel per year. Currently, around 40,000 metric tons of spent fuel is being stored at nuclear power plants at 71 sites around the country.[3] The high density of the fuel means that it does not have a large volume: if all of the spent fuel from the last 30 years were placed on a football field, it would stand to a depth of about three yards. Spent fuel has traditionally been stored at each individual plant site, but as space begins to diminish, the need for a permanent repository has become much more acute. Multiple solutions and locations have been studied in the past, but the focus on Yucca Mountain as the sole repository has brought much controversy to the involved parties and much attention to the problem.

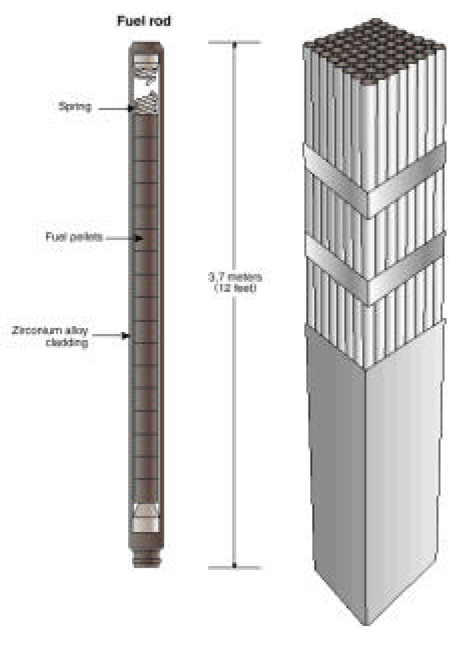


Figure 1
Typical Fuel Assembly
Taken from DOE/EIS-0250D

B. Storage Methods and Alternatives

Spent nuclear fuel is extremely dangerous to an unprotected population and must be shielded to prevent the release of radionuclides to the environment. Spent nuclear fuel can be characterized by its fission products whose half-lives, i.e., the time required for one-half of the material to undergo radioactive decay, can be of the order of thousands of years:

Isotope	Half-Life	Isotope	Half-Life
^{233}U	159200 Years	^{239}Pu	24100 Years
^{235}U	703.8E6 Years	^{240}Pu	6564 Years
^{238}U	4.47 E9 Years	^{241}Pu	14.29 Years

Data from the National Nuclear Data Center

The current method of storing fuel is by submerging it underwater, where the water serves as a shield and coolant. Once the fuel has cooled down sufficiently to lower thermal loads, dry storage is a possibility. Dry storage has only been used by a small number of reactor facilities, mainly because of its high cost. Independent Spent Fuel Storage Installations (ISFSIs) are dry storage facilities, constructed of concrete and encompassing an engineered fuel cask. Though dry interim storage is effective, it is a temporary and expensive solution that lets the fuel remain at each reactor plant site. Because of safety issues to the general public, as well as non-proliferation issues, a single permanent storage site is the most viable solution.

A single permanent repository will serve different purposes, but mainly to store the spent fuel permanently. A secured storage site will prevent the release of radionuclides as well as prevent intervention from the small possibility of sabotage and terrorists that may disturb the fuel. A geological repository has been considered the most viable solution to the problem because of the confidence that we can have about future conditions. Other ideas that have been analyzed include deep hole waste disposal, island-based geologic disposal, sub-seabed disposal, ice sheet disposal, well injection disposal, transmutation, and space disposal in which the fuel would be launched into outer space in a trajectory toward the Sun.[4]

The controversy that arises from the issue of a single storage site is that no state or population is willing to host high-level waste in a permanent facility. Questions arise to the effect that our current knowledge of science is not capable of forecasting geological changes to the magnitude of hundreds of years, let alone thousands of years. This current generation of Americans has benefited in many ways from the use of nuclear power, but no one is willing to take the responsibility for the consequences.

C. Focus on Yucca Mountain

The DOE analyzed three primary sites as potential repository sites: Deaf Smith County in Texas, Yucca Mountain in Nevada, and the Hanford Reservation site in Washington.[5] Congress directed the Secretary of Energy in 1987, in an amendment to the NWPA of 1982, to focus attention solely on the Yucca Mountain site. Yucca Mountain is located on federal land in the Mojave Desert of Nevada in the Nye County region.

The geology of the site seems practical because of the mountain rock composition. Past volcanic activity has formed a type of "tuff" rock that is stable and forms a protective barrier of natural isolation from the outside air.[6] Although it is difficult to forecast the evolution of the rock over the next 10,000 years, we can analyze this form of geological terrain to relatively high degrees of confidence. The dryness of the Yucca Mountain region in the desert will be a key to its safety, since water can easily transport radionuclides. The Yucca Mountain region receives approximately seven inches of precipitation per year, of which 95% evaporates.[7] A location with low rainfall is desirable, but it is just as important to isolate any contamination from the

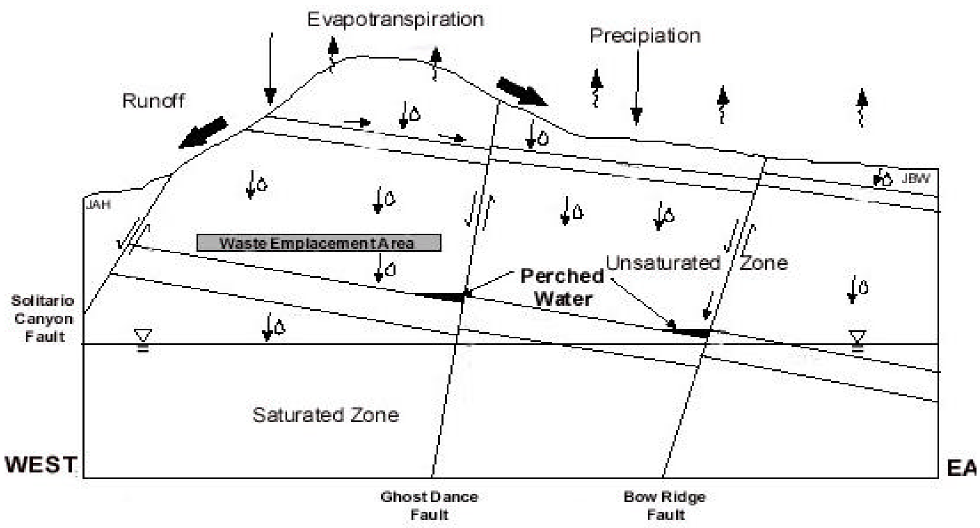


Figure 2
Cross-Section of Yucca Mountain showing fault lines, perched water, and water runoff, relative to the storage tunnel.
Taken from DOE/EIS-0250D

groundwater resources to prevent the migration of radionuclides into the biosphere. One design feature of the repository is its large distance from any water supply. The storage area was designed to place the waste a considerable distance from the water table to prevent contamination of the area groundwater: 1000 feet above the water table and 1000 feet below the surface.[8] Engineered features of the storage containers provide additional effective protection to the surrounding environment from the high-level waste.

Primary geological concerns that have fueled heated debates have included uncertainties in the terrain and the proximity of the storage containers to the groundwater supply. There are known fault-lines that run on the edges of the proposed repository and which have been the focus of many studies. Various earthquakes have been recorded during the studies of Yucca Mountain, but even though large effects were felt on the surface, the core of the mountain remained undisturbed. Although earthquakes are a large concern, the general scientific evidence shows that most activity is dissipated at the surface, not harming the contents on the inside of the mountain.[9]

One other aspect that has been considered is the possibility of future volcanic activity, which some people predict would cause drastic effects. It is believed that with extreme heat and pressure, the containers would fail, emitting radioactivity with the fallout from the volcanic ash. This, of course, is a scenario that must be considered in the whole process. Relating the science to the policy side, there is a certain extent to which we can predict what will happen in the future, geologically, but deciding to build becomes purely a choice of policy.

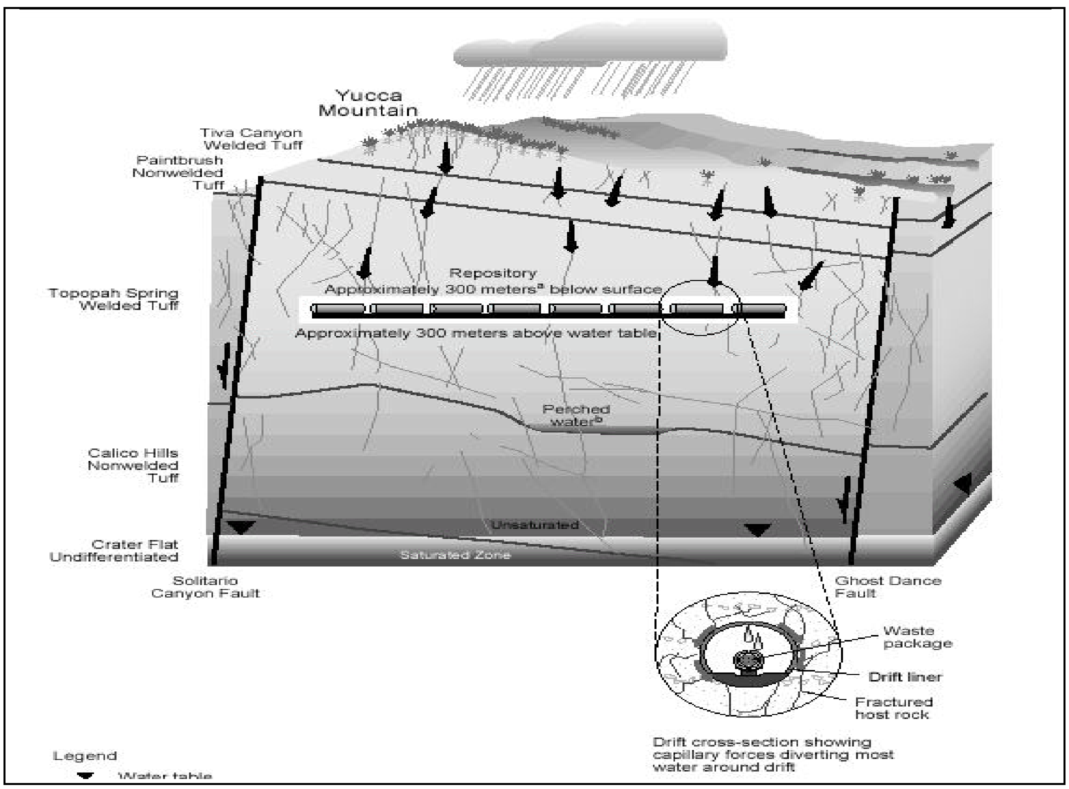


Figure 3

Cross Section of Yucca Mountain---Showing storage tunnels, fault lines, and water table

Taken from DOE/EIS-0250D

It is important for those who make the decisions to have as clear an understanding of technical issues, as well as policy, to make the most responsible choices based on the scientific evidence that is available.

Many political battles have arisen from the consideration of Nevada as the storage site for this fuel, including the facts that Nevada does not directly use nuclear power and that Las Vegas is one of the fastest growing cities in the country. Although Nevada does not host a nuclear power plant, the desert has been a site to test nuclear weapons shortly after their development in World War II. Because the area is already considered “polluted” from these tests, it seems more ideal than other areas to leave the land isolated and continue its use to harbor nuclear products. Being on the edge of a nuclear weapons test site, the area has been a host to more than 900 nuclear tests, both underground and above.[10] Federal land, which is owned by the government and cannot be used for private purposes, hosts the area surrounding Yucca Mountain and is separated from any type of public land by a distance of at least 20 miles.[11] Even with the city of Las Vegas rapidly expanding approximately 100 miles southeast of the site, the mountain will continue to be isolated from public use for the life of the site because of the government’s ownership of land.

One factor that was involved in progressing towards a permanent repository was considering whether technology in the future would provide for a way to transmute spent fuel into something

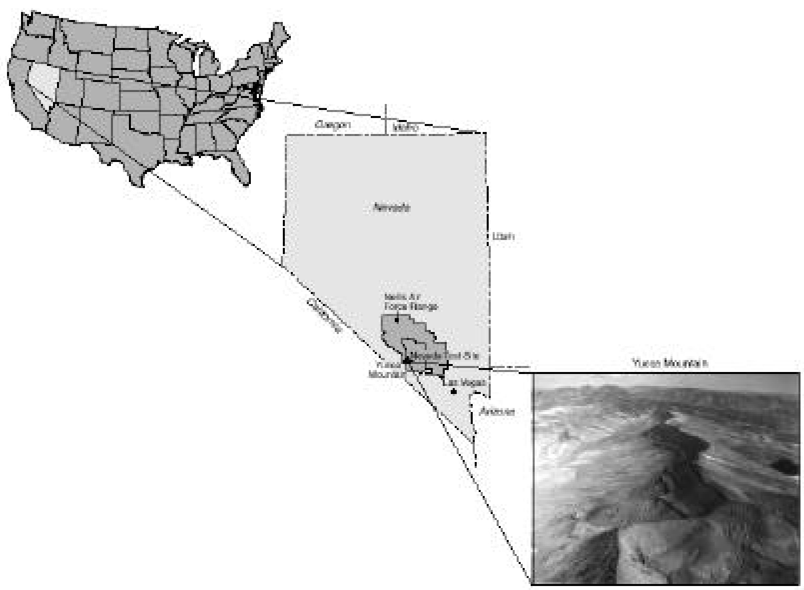


Figure 4
Exploded Map of the Yucca Mountain Site

Taken from DOE/EIS-0250D

that was of a much lower level of radioactivity and less harmful to the public. Although much progress has been made at Los Alamos National Laboratory, transmutation is still being studied and may be difficult to implement on a large scale. Large startup costs to build accelerators, reactors that accelerate neutrons towards a given target and make transmutation possible, discourage many investors from undertaking such a task. The Yucca Mountain Site allows for the retrieval of the storage containers at some point in time if future generations are able to properly handle it, but does not require it. Somewhere between 50 and 300 years after the beginning of fuel storage, a decision will be made as to whether the site should be permanently sealed, or if it should be left open to remove the exhausted fuel.[12] Depending on whether nuclear accelerator technology advances, or if no new discoveries are ever made, the waste will have been dealt with in a feasible manner and in a contained location. This option of fuel removal will also solve any problems dealing with unexpected geological changes that may occur which would put the storage of the fuel in a high-risk setting. Either way, sealed or open, the storage containers will be safely stored, but the decision of closure will have to be made by the next generation.

Besides scientific reasons for directing focus to Yucca Mountain, many political controversies were involved in this decision. Nevada is considered to be a "politically weak" state in many respects, based on its current population and representation in Congress. The state of Nevada hosts only two representatives in the House and so cannot affect the voting procedure by a vast amount (*n.b., This may change after restructuring from Census 2000*). The other two sites that had drawn attention were quickly dropped because of elevated influence from the Congressional members from Washington and Texas. The primary users of nuclear energy lie on the eastern half of the United States and have a much denser population of people. The idea of the permanent waste repository is that waste will be removed from the heavily populated areas of the East, then stored in a remote location, which is fairly isolated from a large collection of people.

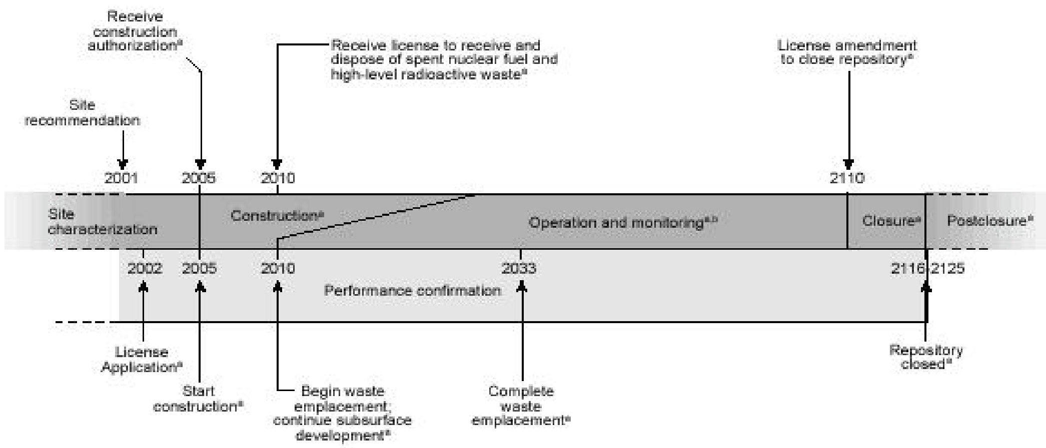
II. GOVERNMENT INVOLVEMENT

A. <u>Role of the DOE</u>

Under the Nuclear Waste Policy Act of 1982, the Department of Energy (DOE) was charged with building a permanent repository, then taking possession of the spent nuclear fuel of commercial power plants and storing it. Under the act and its amendments, the DOE was supposed to begin transportation of spent fuel by January 31, 1998.[13] Because of political and scientific reasons, the deadline was missed and spent fuel remains on site at individual facilities. Even though the DOE was supposed to have taken title to the spent fuel by now, they simply have no place to put it, thus the reason that it remains in the hands of the utility companies.

The spent nuclear fuel at the power plants is either submerged under water or in dry storage. It is required by regulations that spent fuel pools are guarded and monitored continually in order that the fuel is not disturbed or moved. In the exhausted fuel, small amounts of enriched uranium and plutonium still remain which could aid in the development of a nuclear weapon. It must be noted that there is not enough enriched uranium in the fuel to be used in a weapon. The plutonium is not weapons grade as well. Most commercial light water reactors use an enrichment of around 4%, much less than weapons grade that is enriched to 90% ranges. A highly determined and equipped terrorist could possibly extract the plutonium from the spent fuel, but the process would be difficult and hazardous.

With an issue such as dealing with high- level waste, it is never wise to lose patience or rush the project because of financial concerns, but it does become burdensome when the costs continually rise. Aside from all of the money that has been spent on research and construction of the Yucca Mountain site, much more is being spent at each individual utility company. Efforts have been spent on reconfiguring spent fuel pools, transporting fuel to other sites, and/or developing outdoor storage casks that can hold the exhausted fuel once the fuel has cooled to acceptable levels.[14] Though efforts to push the permanent storage of spent fuel should not be rushed without proper scientific analysis, it is easy to see how the price of policy can spread to so many areas because of the variety of components that may be involved with any single issue. One issue that was proposed in S.1287 was the ability for the DOE to "take title" to spent fuel while it is still at



a. If Yucca Mountain is approved.
b. The EIS analysis assumed that waste emplacement would occur over a 24-year period ending in 2033.

Figure 5

utility sites.[15] Under this provision, the DOE would have been responsible for funding dry cask storage at individual sites, as well as continue the process of building a permanent repository. Although this provides financial relief for the power companies, it takes the sense of urgency away from building a permanent repository by posing a temporary solution. If the DOE had funded dry storage at individual sites by the nuclear waste fund, the money would have to be replaced in the future to provide for Yucca Mountain.[16]

The DOE's role in the Yucca Mountain permanent repository is to contract the work and development of the site, according to guidelines and regulations specified by the Environmental Protection Agency (EPA) and the Nuclear Regulatory Commission (NRC). Under the NWPA of 1982, power companies have collected a disposal fee for nuclear waste that has been one mill (one-tenth of one cent) per kilowatt-hour. Of approximately 17 billion dollars that has been committed, seven billion has thus far been spent on the research and development of the site. In view of the money that has been spent and the time that has passed, it becomes easy to see that the common attitude towards dealing with spent fuel is that if delayed long enough, it can simply become the problem of the next administration.

The Office of Civilian Radioactive Waste Management (OCRWM) is in charge of developing Yucca Mountain, including publishing the Environmental Impact Statement (EIS) and the

Viability Assessment (VA) report. In the EIS, the geological concerns of the site are discussed including the groundwater, fault-lines, and rock that compose the mountain. The EIS report also deals with transportation, as well as history of the site, including legislation and events that have led to this point. It provides information on a "no action" scenario, meaning the effects of leaving exhausted nuclear fuel at the utility sites where it is currently stored.[17] Timelines are included, discussing the DOE's proposals on receiving licensure, opening, operating, and then eventually closing the site.

B. Role of the EPA

The Environmental Protection Agency (EPA) is a governmental agency that sets regulations and guidelines to protect the environment and general health of the public. Under the Energy Policy Act of 1992, the EPA was directed to determine proper radiation standards towards a potential repository in Nevada, under the guidance and advice of the National Academy of Sciences (NAS).[18] To aid in developing a proper standard, the National Research Council's Board on Radioactive Waste Management (BRWM) appointed a board to provide scientific and technical advice on radioactive waste, specifically to Yucca Mountain.

In analyzing a situation such as Yucca Mountain in which a professional recommendation must be given, judgments have to be made between science and policy. Scientific information must be used to certain extents to address radiation levels, but acceptable levels are determined by societal value judgments. Science cannot tell us an acceptable probability of developing a radiation-induced illness, but only a number. It is the responsibility of the courts or the professional opinions of experts in the field to determine what is socially acceptable. For example, it has to be determined whether it is acceptable if 1 in 10,000 people get cancer from radiation exposure, or if 1 in 100,000 people is a more acceptable number. With discrepancies in knowledge of low-level radiation, it is unsure that if the one person in 10,000 that acquires an illness, actually was a direct result of excess radiation. According to current rates, approximately one-fourth of all Americans will eventually die of cancer, so making the distinction that it is caused by excess radiation becomes virtually impossible.[19] In assessing a proper radiation standard, science and policy must be considered together in order to set a standard for radiation release that is technologically possible and economically feasible at this point in time, but still considered safe for the workers and the general population.

C. Setting the Standard

The Energy Policy Act of 1992 gives the EPA authority to establish radiation standards that protect the safety and health of the public. The Act stated that the EPA shall promulgate "public health and safety standards for protection of the public from releases from radioactive materials stored or disposed of in the Yucca Mountain repository." [801(a)(1) of the Energy Policy Act].[20] The BRWM committee held a series of meetings for gathering information and deliberating, then issued its recommendations in the 1995 Technical Bases for Yucca Mountain Standards report (TYMS report). The TYMS report included recommendations on multiple areas; who is protected, the level of protection, the controls on human intrusion, and exposure scenarios. Upon the basis of scientific studies and recommendations from the NAS, a standard was set that requires no more than 15 mrem per year be released from the storage site through "all pathways" and required that the DOE honor this standard for a repository life of 10,000 years.[21] Although the 15 mrem was not directly proposed by the TYMS report, it fell within the numerical value range that was recommended in the report.[22] This number is separate from the average 300 mrem dose that is received annually by Americans through nature and medical procedures. “All pathways” means soil, air, groundwater, or any other transportable means in which radiation could be released into the environment. The limit of 15 implies that the maximum radiation dose from any isotope through any passageway would not exceed this value. A conflict in the magnitude of the dose rate arose between the EPA and the NRC and the disagreement has not yet been settled.

The difference in these numbers may mean a substantial difference in cost, as well as licensing changes. The NRC recommended that 25 mrem would be a sufficient number to protect the general public without being overly conservative, but should still be able to license the repository under a stricter standard.

D. <u>The Groundwater Standard</u>

Straying from the advice and recommendations of the BRWM, the EPA proposed a separate groundwater pollution standard. A representative of the EPA, Stephen Page, stated in a hearing on June 23, 2000, that the groundwater standard was “an implementation of policy,” and not simply from scientific reasoning.[23] The EPA determined that 4 mrem per year, which is the maximum contamination level defined by the Safe Drinking Water Act, could be imposed into the groundwater. The stated arguments were that groundwater is a precious resource and that a specialized standard should be enforced to protect drinking water, irrigation, stock watering, showering, and many other industrial uses. The redundancy from this standard comes from the fact that groundwater is already included in the all-pathways standard. By enforcing a second, the licensing process becomes very complicated and turns the process into more of a political arena than a scientific decision.

Besides the controversy over simply having a separate groundwater standard, much other debate comes over the dose rate that it was limited to. Instead of the current knowledge of radiological assessment that is used in deriving dose limits, the groundwater standard is based upon science that is 40 years old. In the 1974 Safe Drinking Water Act, 4 mrem per year was set “at the tap,” meaning already having passed through all transportation systems to enter the residence.[24] At Yucca Mountain, this limit is to be enforced at the source, still complicating what the dose could possibly be if it ever reached the tap. Because of different decay rates of isotopes, the effects would change depending on the amount of time elapsed.

The research that was conducted to determine the 4 mrem limit was arbitrary in many ways, according to William Mills as a member of the Public Health Service working for the EPA. Mills stated “We couldn’t make even a guesstimate [of risk] to better than a factor of 10.”[25]

The DOE has tried to make agreements with the EPA on the distance from the source where the measurements are regulated, as well as the quantity of water that is being monitored. If an achievable agreement is reached, it still remains a question as to whether or not the Nuclear Regulatory Commission could license these requirements because of their complexity and uncertainty. Although thought scientifically unsound by many, it is a possibility that the proposed groundwater standard will have to be honored at Yucca Mountain.

E. Role of the NRC

The Nuclear Regulatory Commission (NRC) is an independent federal regulatory agency of the government, led by five commissioners. The commission is bipartisan by law, meaning that no more than three of the five commissioners can come from one party. The commissioners serve a fixed term, which insulates them to some extent from political influence, but are subject to Congressional oversight. Congress controls the budget, so politics are somewhat involved and can play a role in the commissions' considerations. One of the NRC's purposes is to license and regulate the civilian use of nuclear power and operations that are closely associated with it. The NRC also regulates the use of radioactive materials for many applications, including medical uses of radioisotopes. A license for a nuclear power plant is typically 40 years; now the new challenge for the NRC will be to license a permanent geological repository for a length of 10,000 years, proposed by the EPA.

The primary mission of the NRC is to provide reasonable assurance of adequate protection of public health and safety. The NRC has proposed standards for Yucca Mountain that provide a high level of safety without being overly conservative. The proposed 25 mrem standard from the NRC is consistent with the current existing limits on spent fuel storage installations (10 CFR Part 72). Unless court intervention takes place, the standards for Yucca Mountain will be based on the proposals by the EPA.

Many difficulties arise in licensing a permanent repository, for example, determining the corrective action if the storage containers degrade to a point where the repository is in violation of its license. If at some time the facility was determined to be out of compliance with applicable regulations, the repository cannot merely be shut down. In any power plant or research facility, if the NRC regulations are not followed, they are to take prompt and corrective actions to ensure a proper level of safety. This could become difficult in a facility such as Yucca Mountain, where once the exhausted fuel is placed in its proper position, immediate action may be difficult because there is no operation to stop or process to terminate. NRC officials must be very positive that the permanent storage containers as well as the site characterization will be able to isolate radiation release to the finalized standards.

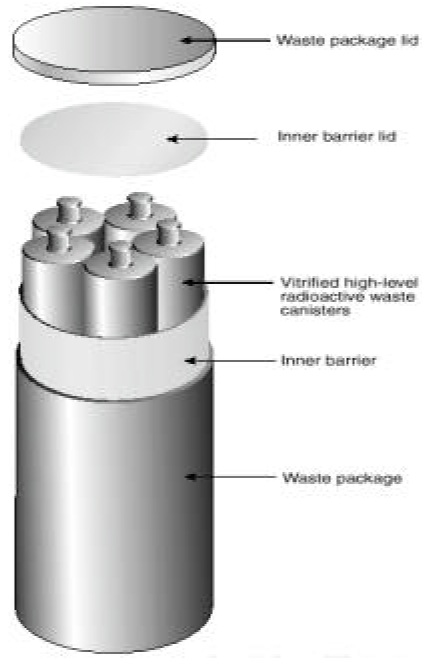


Figure 6
Potential Waste Package Design for Spent Nuclear Fuel.
Taken from DOE/EIS-0250D

In the licensing process, DOE must first certify to the President that it has thoroughly evaluated the Yucca Mountain proposed repository and determined it to be an acceptable site. If recommended by the President, DOE will file an application to the NRC for licensure. After a formal application to build the facility has been filed, NRC's review will include an independent evaluation of the Environmental Impact Statement (EIS) and the Viability Assessment (VA) and a decision will be made. It may take up to four years for the NRC to review the licensing application before the site construction could begin.

F. Controversy in Radiation Standards

One analogy to put the idea into perspective is the medical use of aspirin. If you take one aspirin, it will be somewhat beneficial by relieving pain, but if you take a whole bottle of aspirin, the probability of quickly dying becomes likely. The assumption of low-level radiation relates to the analogy that if a fatal dose of aspirin is 100 pills, and if 100 people each took one pill, we would expect one person to die. Though some scientists believe that low-level radiation poses no detrimental health effects, low levels must be controlled and can not be disqualified in their participation of radiation induced illnesses.

In contrasting the dose limits to natural background that an average person receives per year, the dose limits are rather small. Although different regions of the country will vary in natural background levels, most Americans receive on average 300 mrem per year from the earth, cosmic rays, and other natural and man-made sources.[26] A routine chest X-ray would give a radiation dose of approximately six mrem. Although a controversial issue, it is without doubt proper to set standards to our best knowledge of what would protect the general public of excess exposure.

It becomes increasingly costly to ensure lower levels of radiation exposure as recommended in Yucca Mountain. For example, according to the General Accounting Office, the estimates for cleanup of nuclear weapons test ranges in Nevada increase significantly, based on differing standards.

- 100 mrem standard $35 billion
- 25 mrem standard $105 billion (Three times as much)
- 15 mrem standard $210 billion (Six times as much)
- 5 mrem standard $980 billion (28 times as much)[27]

The costs rise nearly exponentially, as standards become stricter.

Science and policy are heavily involved in determining what a proper standard should be, along with mathematical models to make determinations. The EPA and NRC use the same fundamental scientific research, meaning BEIR and ICRP reports, but come up with differing standards because of different policies. Mathematical models and reasoning can be very complex, comparing cost/benefit analysis to varieties of areas that affect the global situation, not just the risk of cancer. For example, if a storage container is made that is twice as thick or considerably heavier, there are higher manufacturing risks in building and transporting this container.

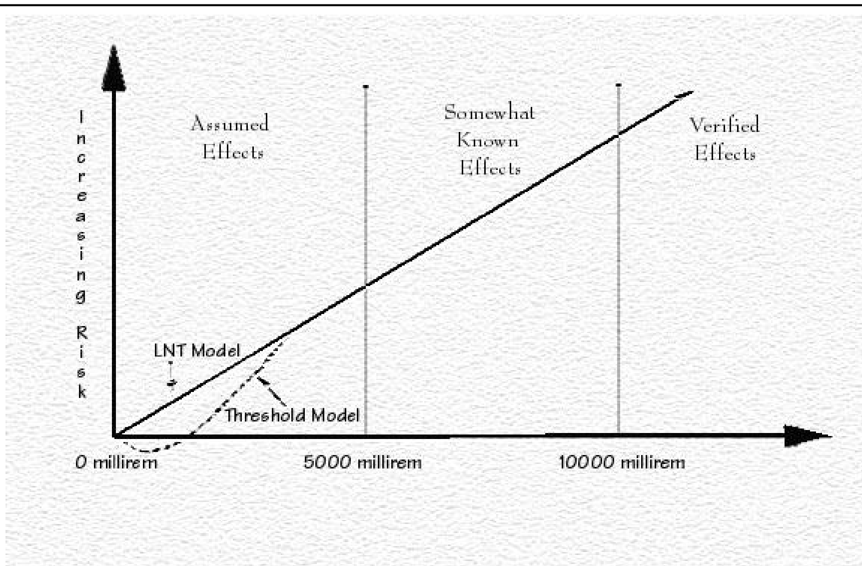


Figure 7

To simplify a model in setting a standard, it can be explained by just looking at the factors of economics and the linear no-threshold theory of comparing risk with dose. The costs are somewhat exponential, as shown earlier, and the risk model is linear. Plotting these together, it can be shown where the lines come to an intersection and a decision can be more clearly made.

G. The Role of Congress and the President

Outside of proponents and opponents, the congress of the United States and the President hold much power in making final decisions. Congress passed the laws that govern the way the DOE studies and spends money on repository sites. It was congress that narrowed the focus on Yucca Mountain, and Congress who might eventually end up making the final decision. In the role of events, it is the President's job to recommend the site, based on whether or not it is deemed safe and secure.

The last piece of legislation that was brought up concerning Yucca Mountain was S.1287, providing provisions to amend the Nuclear Waste Policy Act by stating that, once licensed, DOE could begin accepting fuel at an early receipt facility.[28] The bill would have given the DOE the responsibility of taking title to the spent fuel before the repository was completely built, thus relieving the utilities of some of the financial responsibility of storing the fuel. The bill was terminated as a result of a failed veto override by the Senate, but is still at this point eligible for a re-vote if it can be proven that votes will change.

Between the NRC and EPA, an ongoing disagreement exists between the scientific basis for radiation standards.[29] As new research continually unveils changing findings, the most current information cannot always be implemented because of the difficulties in changing set policies. If the governmental agencies cannot agree on proper standards, it can and should become the job of Congress to determine what is best through the rule-making process.

H. Relations Between Interested Parties

In completing a project such as the Yucca Mountain site, there are many different parties that are involved. The DOE will take title to the exhausted nuclear fuel, becoming the owner, upon building the site. In order to accomplish this, they must work in collaboration with the NRC and the EPA. The EPA sets the standards and NRC licenses the facilities in order that construction may be completed and fuel may be stored.[30] Besides the major players, there are many others who become considerably involved. There are proponents of the nuclear industry, such as the Nuclear Energy Institute who work with Congress and other government officials who take interest in nuclear issues. On the other side are the opponents of the nuclear industry, who use any information or people that oppose the project to aid in its termination. Although many times their information may not be totally factual, justifiable points are brought up by anti-nuclear groups that require further research to prove the validity of their respective state of safety.

There are also other agencies besides the ones discussed that play roles in the repository. The Department of Transportation is involved and will play a role in setting transportation standards, which is an important aspect of the repository. The Federal Emergency Management Agency will play a part in determining emergency procedures, if unexpected situations occur. Secondary agencies do not carry the full responsibility as some of the primary agencies, but are still important in the role that they play.

III. CONCLUSIONS

The Yucca Mountain project is a classic example of how scientific knowledge and public policy are inter-connected. It is foolish to make critical decisions without considering the scientific basis for things in their proper context. Equally, it is worthless to conduct scientific research if it is never acted upon. Although billions of dollars have been spent in developing Yucca Mountain up to this point in time, many people still vehemently oppose its existence without properly understanding why. Because it is very unlikely that everyone will ever agree on a common solution, it is the job of Congress, as well as the government agencies to determine what is best for America.

Even if Yucca Mountain is not the most acceptable site, technically and politically, it should be realized that a common permanent waste repository is the best long-term solution to a long-term issue. Scientific research will only provide evidence at given confidence levels that this site is safe and will be a safe harbor for exhausted nuclear fuel. Science can give, with certain confidence levels, the likelihood of any type of disastrous occurrence that would jeopardize the environment and safety of the public from direct or indirect contact with exposed fuel. Up to this point in time, scientific research has not discovered any definite reasons to terminate the pursuit of opening the repository. Science can only give information on making a proper decision, then it becomes the decision of policy makers to determine if this is what is best for America. It has become very common to delay any decisions in order to let time elapse until a new administration would become responsible. This generation has benefited greatly by the use of nuclear power, but has not been willing to take responsibility for the by-products that were left behind.

Some people believe that America is at a pivotal point on whether we will continue the use of nuclear power, based on the outcome of Yucca Mountain. In many regards, the continuance of nuclear power is immaterial as to whether or not we should be responsible for the exhausted fuel. If the use of nuclear energy to supply electricity were discontinued today, dealing with the supply of exhausted fuel would still need to eventually be addressed. Spent nuclear fuel must be dealt with, and Yucca Mountain seems at this point the most responsible thing that we can do.

On July 10, 2000, I was able to ask Vice-President Al Gore about the Yucca Mountain permanent waste repository. In response to the question as to whether, if elected President, he would recommend the site given our current scientific knowledge, Vice President Gore said, “we don’t have the results of the full scientific analysis yet. The decision should be based strictly on the science and not on politics.”[31] Although this was a brief statement, I think it properly describes the heart of good policy making. Politics, in the literal sense of developing policy, plays a vital role in the overall process, but should not be the controlling factor. The state of Nevada will probably always protest the storage of spent fuel in their state, but if Yucca Mountain is approved, their feelings will have to come second to the “greater good” of the United States. It is not right to simply favor one group or another because of their influence or power, but to make decisions on the best understanding of the science that we have. Nuclear waste must be dealt with, but the completion of the Yucca Mountain site should only be done with the support of the conducted scientific research. In fully combining science and policy, the most competent decision will be made which best serves the people of the United States.

IV. RECOMMENDATIONS

A permanent geologic repository is one of the most responsible things that we can do to store spent nuclear fuel. Yucca Mountain is our best choice and progress towards opening the site should continue. Yucca Mountain will safely store spent fuel for generations after us in order that they will not have to continually monitor individual storage facilities.

The fuel should be retrievable in Yucca Mountain until there are no other possible solutions or technologies in sight to deal with spent fuel.

Unless proven necessary for public safety, the proposed four mrem groundwater standard should be dropped. The “all pathways” standard provides sufficient protection to workers and the public against the effects of low-level radiation.

There is controversy in the difference between the 25 mrem proposed by the NRC and the 15 mrem proposed by the EPA. If this cannot be settled internally within the agencies, it should be the responsibility of Congress to intervene. The EPA has the responsibility of protecting the public from low-level radiation, but they should do that according to reasonable and adequate limits.

APPENDIX -- DEFINITIONS
Sorce: *http://www.skullvalleygoshutes.org/glossary.html*

Absorbed Dose: The amount of radiation energy absorbed, especially by human tissue; measured in rads.

Background Radiation: The natural radioactivity in the environment. Background radiation consists of cosmic radiation from outer space, radiation from the radioactive elements in rocks and soil, and radiation from radon and its decay products in the air we breathe.

Cask: A container for shipping or storing spent nuclear fuel or high-level radioactive waste.

Code of Federal Regulations (CFR): The CFR contains federal regulations covering the various activities including transportation and storage of spent fuel.

Containment: The confinement of radioactive materials within a vessel or structure.

Cosmic Radiation: Energetic particles and rays from space that strike the Earth at nearly the speed of light.

Environmental Protection Agency (EPA): An agency of the Federal Government responsible for the protection of the environment and the enforcement of environmental legislation; formed in December 1979 under Public Law 97-604.
Half-Life: The amount of time needed for half of the atoms in a quantity of radioisotope to decay.

Isotope: Atoms of the same element that have equal numbers of protons but differing numbers of neutrons.

MilliRem (mrem): A unit of radiation exposure equal to one-thousandth of a rem.

Nuclear Radiation: Ionizing radiation (alpha, beta, and gamma) originating in the nuclei of radioactive atoms.

Nuclear Regulatory Commission (NRC): A Federal agency charged with the responsibility of regulating the use of nuclear energy and radioactive materials, including the licensing and regulating of storage facilities, shippers, and carriers.

Radiation: Energy that moves through space in the form of particles or electromagnetic waves.

Radioactive: A radioactive element gives off radiation—alpha particles, beta particles, or gamma rays, by the disintegration of its nucleus.

Radionuclides: Radioactive chemicals that are usually naturally occurring and found in drinking water. Typical radionuclides for which the EPA has established Maximum Contaminant Levels

(MCLs) as part of its enforcement of the Safe Drinking Water Act (SDWA) include radium 226 and 228, gross alpha particle activity, and beta particle activity.

Rem: A unit of exposure to ionizing radiation in human tissue; an estimate of the health risk that exposure to ionizing radiation could have on human tissue.

Spent Fuel: Fuel that has been used in a nuclear reactor and then withdrawn. Spent fuel is thermally hot and highly radioactive.

Uranium: A naturally occurring radioactive element with the atomic number 92 and an atomic weight of approximately 238.

Yucca Mountain, Nevada: The site designated by Congress in the amended Nuclear Waste Policy Act as the site to be characterized to determine whether it is suitable for a geologic repository.

END NOTES

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