S. HRG. 109–1024

STATUS OF THE YUCCA MOUNTAIN PROJECT

HEARING

BEFORE THE

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS UNITED STATES SENATE

ONE HUNDRED NINTH CONGRESS

SECOND SESSION

MARCH 1, 2006

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ONE HUNDRED NINTH CONGRESS
SECOND SESSION

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C O N T E N T S

ADDITIONAL MATERIAL

STATUS OF THE YUCCA MOUNTAIN PROJECT

WEDNESDAY, MARCH 1, 2006

U.S. SENATE,
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS,
Washington, DC.

The committee met, pursuant to notice, at 2:30 p.m. in room 628, Senate Dirksen Building, Hon. James M. Inhofe (chairman of the committee) presiding.

Present: Senators Inhofe, Warner, DeMint, Jeffords, Boxer, Carper, and Lautenberg.

Senator INHOFE. The committee will come to order. The hearing will come to order.

I would like to make the announcement, with the concurrence of Senator Jeffords that, when either Senator Harry Reid or Senator John Ensign arrive for their brief statements, we are going to interrupt what we are doing so they can be heard. OK? I will go ahead and start, though, with an opening statement. You guys, watch out for them, will you?

STAFF. Senator Ensign just walked in.

Senator INHOFE. Senator Ensign just walked in. So we will recognize Senator Ensign at this time.

STATEMENT OF HON. JOHN ENSIGN, U.S. SENATOR FROM THE STATE OF NEVADA

Senator ENSIGN. Thank you, Mr. Chairman. I appreciate your allowing me to testify before your committee on the second proposed rule concerning Yucca Mountain radiation standards.

This rule, on its face, I believe doesn't make sense, and the closer one looks, the worse it appears. The EPA found itself in a very difficult position. The original EPA Yucca rule had been thrown out by a Federal Court, which found its 10,000-year compliance period was not consistent with the recommendations of the National Academy of Sciences.

The EPA could have simply modified its rule by extending it to cover the time of peak radiation exposure as required by the Court. We know why the EPA did not do this. It didn't do this because Yucca Mountain could not be engineered to meet the standard. Yucca Mountain could not be built if that was the case. So, instead of putting forth a common sense solution, the EPA proposed the weakest peak dose standard in the world, a proposal opposed by the National Council of Radiation Protection. Again, when it comes to Yucca Mountain, sound science has been rejected.

There are those who believe Congress should ignore recommendations by the National Academy of Sciences and simply

lower the safety standards for the storage of the planet's most deadly material. Senator Reid and I are committed to making sure that that doesn't happen.

Mr. Chairman, Yucca Mountain continues to be plagued with problems and delays. The Department of Energy no longer even pretends to know when Yucca Mountain could open or how much it will cost. DOE once again has stopped work at Yucca Mountain after an NRC audit revealed that several years of data collection was done with equipment that had not been calibrated. This data is critical to health and safety because it relates to how water could enter the repository and cause corrosion of the nuclear waste storage casks.

We need to find another solution to our country's nuclear waste problem. We need to amend the Nuclear Waste Policy Act of 1982 to require the DOE to take title of all spent nuclear fuel. We need to invest in new technologies at our national labs to recycle the waste without producing weapons grade plutonium as a by-product. Transmutation technology, for example, which transforms radioactive products into less dangerous materials and produces electricity as a result is quickly emerging as a viable alternative.

Mr. Chairman, this new proposed radiation standard, like so much of the so-called science of Yucca Mountain is a farce. The EPA was forced to create this ridiculous standard to make Yucca Mountain look scientifically feasible on paper; it is not. I believe this project is dangerous and misguided, fraught with junk science and fraudulent data.

Mr. Chairman, I appreciate the opportunity to testify.

Senator INHOFE. Thank you for that excellent statement, Senator Ensign. You may either be excused or stay, whichever you would prefer.

Senator ENSIGN. I have other things pending, as all of us Senators do. Thank you very much.

Senator INHOFE. I am shocked.

Remind me if you see Senator Reid coming. Anyone out by the door, do you see Senator Reid coming?

I will go ahead and start with my opening statement, Senator Jeffords.

OPENING STATEMENT OF HON. JAMES M. INHOFE, U.S. SENATOR FROM THE STATE OF OKLAHOMA

Today is our first oversight hearing on the status of Yucca Mountain, the designated site for long-term storage of high level nuclear waste. Before us today, we have the Department of Energy, the Environmental Protection Agency, as well as other interested parties. We will be looking at a number of issues, including the status of EPA's revised proposed standard.

The way the process is supposed to work is for DOE to construct and operate the site in accordance with the radiation standards that EPA sets and the NRC to regulate the facility. There is a role for each one of them. This committee has the sole jurisdiction over the EPA and the NRC, and it is our responsibility to ensure that this site moves forward in accordance with the law and that we can start shipping waste there as soon as practical.

After personally visiting the site, I strongly support the storage of nuclear waste at Yucca Mountain, and I encourage all members of the committee to visit the site. It is amazing to witness the amount of research that has been conducted on this site. It is certainly the most well studied mountain in the world. I do have a document here that is almost the title of it, "The Most Studied Real Estate on the Planet," if anyone would like to get some of our documentation.

How can we not support this site which has gained both national and international scientific peer approval over 20 years and $8 billion worth of scientific, environmental, and engineering field work? How many more thousands of rock samples do we need to further reconfirm what is already known about the site's engineered and natural barriers' ability to contain radioactive materials for thousands of years?

The Nuclear Waste Policy Act of 1982 required DOE to provide a Federal repository for used nuclear fuel no later than January 31, 1998. Here we are, 8 years after that deadline, and there is still no central repository for spent nuclear fuel. In fact, according to current scheduling projections, the placement of waste underground at the Yucca site would not take place until 2015 at the earliest, and then only if it receives full regulatory approval and the budget requests are met. That leaves the United States at 17 years behind schedule.

Meanwhile, millions of American families and businesses have been paying twice for this delay in the storing of nuclear fuel. They pay once to fund the Federal management of the used nuclear fuel at a central repository and again when electric utility companies have to build additional temporary storage capacity at nuclear power plant sites because the Federal Government did not meet its obligation to begin moving the used fuel in 1998.

As a result, since 1983, the American consumers have paid approximately $18 billion for this nuclear waste fund through additions or add-ons to their utility bills with really nothing to show for it. Still, the Federal Government continues to collect nearly $700 million a year from electricity consumers. Future generations of Americans—our children, our grandchildren—will pay a high price for continued inaction. We owe it to the American people to do better.

Nuclear energy makes up roughly 20 percent of our Nation's energy mix. If we are going to continue to grow this economy, we need to take the pressure off the natural gas, expand our nuclear capacity, and increase our use of clean coal and clean coal technology. In order to expand nuclear capacity, we have to solve the waste issue which appears to be more of a political issue than a scientific issue.

In addition to the Federal Agencies, we will hear from several scientists, the State of Nevada, and of course, Senator Reid, who we are expecting here in just a moment.

Finally, I would like to point out to my colleagues that we decided against having the NRC testify today on the Federal panel since they will be regulating DOE. We will have them next week at the Nuclear Safety Subcommittee hearing, chaired by Senator

Voinovich, if members have specific questions for them about Yucca Mountain.

[The prepared statement of Senator Inhofe follows:]

STATEMENT OF HON. JAMES M. INHOFE, U.S. SENATOR FROM THE STATE OF OKLAHOMA

The hearing will come to order.

Today is our first oversight hearing on the status of Yucca Mountain, the designated site for the long-term storage of high level nuclear waste. We have before us today both the Department of Energy and the Environmental Protection Agency, as well as other interested parties. We will be looking at a number of issues including the status of EPA's revised proposed standard.

The way the process is supposed to work is for DOE to construct and operate the site, in accordance with the radiation standards that EPA sets, and the NRC is to regulate the facility. This committee has the sole jurisdiction over the EPA and the NRC, and it is our responsibility to ensure that this site moves forward in accordance with the law, and that we can start shipping waste there as soon as practicable.

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How can we not support this site which has gained both national and international scientific peer approval with over 20 years and $8 billion worth of scientific, environmental and engineering field work? How many more thousands of rock samples do we need to further reconfirm what is already known about this site's engineered and natural barriers ability to safely contain radioactive materials for thousands of years?

The Nuclear Waste Policy Act of 1982 required the Department of Energy to provide a Federal repository for used nuclear fuel no later than January 31, 1998. Here we are 8 years after that deadline and there is still no central repository for spent nuclear fuel. In fact, according to current scheduling projections, the placement of waste underground at the Yucca site would not take place until 2015 at the earliest, and then only if it receives full regulatory approval and the budget requests are met. That leaves the United States at least 17 years behind schedule.

Meanwhile, millions of American families and businesses have been paying twice for this delay in storing used nuclear fuel. They pay once to fund the Federal management of used nuclear fuel at a central repository and again when electric utility companies have to build additional temporary storage capacity at nuclear power plant sites because the Federal Government did not meet its obligation to begin moving the used fuel in 1998.

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In addition to the Federal agencies, we will hear from several scientists, the State of Nevada, and Senator Reid, a former member and briefly chairman of this committee, in addition to being the minority leader. Finally I would like to point out to my colleagues that we decided against having the NRC testify today on the Federal panel since they will be regulating DOE. We will have them next week at a Nuclear Safety Subcommittee hearing chaired by Senator Voinovich, if members have specific questions for them about Yucca Mountain.

Senator INHOFE. Senator Jeffords.

OPENING STATEMENT OF HON. JAMES M. JEFFORDS, U.S. SENATOR FROM THE STATE OF VERMONT

Senator JEFFORDS. Thank you, Mr. Chairman.

Today, we are conducting a very important hearing to determine the status of the Federal project to develop Yucca Mountain as a permanent disposal site for the Nation's nuclear waste.

My State of Vermont, along with 39 other States, relies on nuclear power for a large portion of its electricity generation. It is an important part of the energy mix. Nonetheless, we must be realistic in dealing with the downsides associated with nuclear power.

Over 30 years ago, as Vermont's Attorney General, I was concerned about the impact of nuclear waste on our environment and the health care of Vermonters. As Attorney General, I fought to improve the safety standards at Vermont Yankee by calling for the use of new technology that dramatically reduced airborne radiation.

When the industry resisted, I required Vermont Yankee to enter into a contract with the State to use the best available technology to control radiation and to accept State monitoring, protecting the Connecticut River and the people of Vermont. The Atomic Energy Commission later accepted these technologies as their industry standard.

Throughout my time in Congress, I have continued to work for a comprehensive solution to our nuclear waste problem. Back in 1977, I introduced a bill in the House, calling for a comprehensive Nuclear Waste Disposal Strategy. I maintained then, as I do now, that finding an effective solution to the waste problem is critical to the future of nuclear power in this country. I supported the Yucca Mountain in the past in the belief that it would resolve the problem and contain both our past and future nuclear waste.

I have consistently supported a central storage solution for nuclear waste. I continue to believe that it is essential that we find a permanent geologic storage site if we are to continue to produce nuclear energy.

However, the truth is that Yucca Mountain will not provide the solution, and the project faces many challenges. It is now clear that Yucca Mountain will only take part of the waste, leaving some, if not most, of the waste that would be produced, sitting along the banks of the rivers beside our small local communities and our largest population centers. Yucca Mountain will certainly not hold waste from any new nuclear plants that the industry is planning to build. This is not adequate, and this is not acceptable.

Moreover, we will examine today that we should not try to beat a square peg into a round hole by trying to make the science or regulations fit our efforts to build the Yucca site. If the agencies working through the Yucca project cut corners, we will undermine to develop a sound permanent and comprehensive solution to the problem of nuclear waste disposal. This will also lull us into a false sense of security, believing that important issues related to disposal are taken care of. They are not.

Americans need to know that, under a geological disposal solution, high level waste will be stored safely and that we have set the highest and the best standard to protect the environment and the human health where we have to build future disposal sites.

I urge my colleagues to be diligent today, to be focused in their questions and push for the answers about whether we are getting a real and comprehensive solution to the nuclear waste disposal.

I look forward to hearing from the witnesses.

Thank you, Mr. Chairman.

[The prepared statement of Senator Jeffords follows:]

STATEMENT OF SENATOR JAMES M. JEFFORDS, U.S. SENATOR FROM THE STATE OF VERMONT

Today we are conducting a very important hearing to determine the status of the Federal project to develop Yucca Mountain as a permanent disposal site for our Nation's nuclear waste. My State of Vermont, along with 39 other States, relies on nuclear power for a large portion of its electricity generation. It is an important part of our energy mix. Nonetheless, we must be realistic in dealing with the downsides associated with nuclear power.

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Yucca Mountain will certainly not hold waste from any new nuclear plants that the industry is planning to build. This is not adequate. This is not acceptable.

Moreover, as we will examine today, we should not try to beat a square peg into a round hole by trying to make the science or regulations "fit" our efforts to build the Yucca site. If the agencies working to site the Yucca project cut corners, we will undermine our efforts to develop a sound, permanent and comprehensive solution to the problem of nuclear waste disposal. This will also lull us into a false sense of security, believing that important issues related to disposal are taken care of. They are not.

Americans need to know that under a geologic disposal "solution," high-level waste will be stored safely, and that we've set the highest and best standards to protect the environment and human health when we have to build future disposal sites.

I urge my colleagues to be diligent today, to be focused in their questions, and to push for answers about whether we are getting a real and comprehensive solution to nuclear waste disposal. I look forward to hearing from the witnesses.

Senator INHOFE. Let me interrupt you just for a moment.

At this point, we had announced, Senator Reid, that when you arrived, we would stop our proceedings, and we would look forward to any statement you would like to make.

Senator Jeffords, we appreciate your doing that.

Senator John Ensign has already been here and made his statement.

Senator Reid, you are recognized.

STATEMENT OF HON. HARRY REID, U.S. SENATOR FROM THE STATE OF NEVADA

Senator REID. Mr. Chairman, I appreciate that very, very much. I tried to get here. I try to be on time; sometimes you can't be. I appreciate it. Also, Senator Jeffords, thank you very much.

The proposed Yucca Mountain nuclear waste dump, I don't believe, Mr. Chairman, will ever be built. The project is mired in scientific, safety, and technical problems.

In 1982, Congress passed the Nuclear Waste Policy Act which called for disposal of nuclear waste in a deep, geological repository that would remain stable for thousands of years and directed DOE to pick the most suitable site based on the natural geologic features of the site. In 1987, Congress took action based on political expediency and limited DOE's study to Yucca Mountain, eliminating the State of Washington and the State of Texas, despite the fact the criteria in the act would disqualify the Yucca Mountain site.

DOE has been studying the site, as I have indicated, for more than 20 years. The studies are even today incomplete and don't provide a basis for evaluating whether Yucca Mountain is a safe site for storing nuclear waste and whether it can be transported safely across America's highways and railways, and through our communities, past our schools and hospitals and homes, and through major metropolitan areas.

Transportation of nuclear waste around the country and to Yucca poses hazardous to public health, economic, natural security, and environmental safety from accidents and terrorist attacks which DOE has simply not addressed at all. Moving almost 80,000 tons of waste to Yucca would involve about 53,000 truck shipments and 10,000 rail shipments over about 25 years through cities and counties where nearly 250 million people: Sacramento, CA; Buffalo, NY; Denver, CO; Chicago, IL; and the District of Columbia; and, of course, Nevada.

Before he was elected the first time, President George W. Bush wrote, "I believe sound science, not politics, must prevail in the designation of any high level nuclear waste repository." He went on to write, "As President, I would not sign legislation that would send nuclear waste to any proposed site unless it has been deemed scientifically safe." Now, President Bush, I am sorry to say, hasn't followed what he said he would do because now it is obvious that unsound science is prevailing at Yucca Mountain.

A few of the scientific problems, and these are only a few that we have seen in the last year or 18 months:

The Court threw out EPA's first Radiation Protection Standards because they were not strong enough to protect the public from radiation exposure, and they failed to follow recommendations of the National Academy of Sciences.

EPA published its revised standards for the proposed Yucca Mountain high level waste dump which are wholly inadequate, do not meet the law's requirements, and do not protect the public health and safety. In fact, EPA is proposing the least protective public health radiation standard in the whole world.

Additionally, numerous scientific and quality assurance problems, transportation problems, corrosion of casks, effectiveness of materials, and many other things have caused DOE to suspend

work on the surface facilities and the Nuclear Regulatory Commission to issue a stop order on the containers.

Additionally, DOE revealed the documents and models about water infiltration at Yucca have been falsified, that is, there has been cheating. They whitewashed this problem, or tried to, but cannot whitewash the DOE Inspector General's report that DOE continues to ignore falsification of technical and scientific data on the project.

In numerous media reports, the Administration has confirmed that it is preparing a legislative package that will remove health, safety, and legal requirements—a clear admission that the project is a complete public health, safety, and scientific failure.

It should be clear to anyone that the proposed Yucca Mountain project is not going anywhere. It will never open. Yet, we must safely store spent nuclear fuel. So it is time to look at other waste alternatives.

Fortunately, Mr. Chairman, the technology is there to realize a viable, safe, and secure alternative. This can be fully implemented within a decade or less if we now act. The technology is onsite dry cask storage containment. Dry casks are being safely used at 34 sites throughout the country. NEI projects 83 of the 103 nuclear reactors will have dry storage by the year 2050.

I and Senator Ensign have a bill that would safely store nuclear waste while we look for a scientifically based solution, The Spent Fuel Onsite Storage and Security Act. Our bill requires commercial and nuclear utilities to secure waste in licensed onsite dry cask storage facilities.

There is no justification, absolutely no justification for endangering the public by ruling that there are no problems. There is no reason to rush headlong toward a repository that is fraught with scientific, technical, and geological problems when it can be stored safely and securely in dry casks.

Our bill guarantees all Americans that our Nation's nuclear waste will be stored in the safest way possible. It is time we addressed the problem at hand, the safe storage of spent nuclear fuel, and stop pouring taxpayers' money down the drain on a project that could endanger all of our citizens. The Yucca Mountain project is a failure, and I will continue to do what I can to point that out to the public.

I would say, Mr. Chairman, one of the things I didn't want to take the time for, because I know how rushed you all are, is that there are members of Senate, some more than others, who are tremendously concerned about costs, how much things cost. Certainly, the presiding officer of this meeting, the chairman of this full committee, has been concerned about dollars ever since I have served with you. You must take a look at this waste of money with this project. Right now, we have spent upwards of $10 billion on nothing. We have nothing for this.

I would respectfully submit that this is not a game, saying we are winners and losers. Let us do the right thing. Leave it onsite in dry cask storage containers. It will be safe there for at least 50 years, and thereafter, we will have some idea of what to do with this.

The President of the United States is in India, trying to work out something on the safe use of producing nuclear energy. I have talked to him about this. I don't just, at hand, say that what he is doing is wrong. I think it is something we need to take a look at. We need to take a look at doing something similar to that in the United States, but we have to solve the waste problem. Until we solve the waste problem, and I think the way to do it cheaply, not by spending $10 billion but a few million dollars, is to store it onsite. It certainly would be the right thing to do in my opinion.

I appreciate the committee's taking a look at this.

Senator INHOFE. Senator Reid, thank you for that excellent opening statement. You certainly are invited to stay if your schedule would permit or to leave if you are unable to do that.

Senator Jeffords, we did interrupt your statement. If you would like to start over, that would be fine, or just pick up where you dropped off.

Senator JEFFORDS. Where I left off, basically.

Senator INHOFE. Then that will be reflected in the record as if not interrupted.

Senator JEFFORDS. Thank you.

[The complete statement of Senator Jeffords appears at a prior point in the record.]

Senator INHOFE. Thank you, Senator Jeffords.

Senator Boxer.

OPENING STATEMENT OF HON. BARBARA BOXER, U.S. SENATOR FROM THE STATE OF CALIFORNIA

Senator BOXER. Hello, Mr. Chairman. Thank you very much.

Mr. Chairman, protecting public health and safety should be the primary test in assessing nuclear waste disposal options, and with that measure in mind, Yucca Mountain continues to fail the test in my view.

The focus of the hearing today is the status of the Yucca Mountain project, including the establishment of radiation standards that will ensure that public health and the environment are protected. EPA's first effort to establish radiation standards was largely struck down by the D.C. Circuit for failing to comply with National Academy of Sciences recommendations. EPA's current proposal for radiation standards at Yucca Mountain has yet to be finalized but has drawn criticism from an expert on nuclear issues for failing to ensure that the public does not face unacceptable cancer risks.

Technical problems with the Yucca Mountain project continue to raise red flags. A January 2006 order from the Department of Energy has stopped all work on the repository because of quality assurance problems. Whether the plan to address the problems is successful remains to be seen.

On February 9, 2006, the National Academy of Sciences called for DOE to further analyze and account for potential terrorist acts on the transportation of nuclear waste before large shipments take place. The National Academy of Sciences also called for, among other things, additional analysis of safety measures for high intensity fires.

Clearly, the potential risks associated with this project remain very high. My longstanding concerns about this project have not been addressed. My State of California is one of the most affected by the Yucca Mountain project which is only 17 miles from the California border and Death Valley National Park. Studies have shown that the groundwater under Yucca Mountain flows into Death Valley, one of the hottest and driest places on Earth. If radiation contaminates this groundwater, it could be the demise of the National Park and the surrounding communities.

The threat posed by nuclear waste transport in California is also clear, and in the past I have laid that out. Mr. Chairman, I won't do that today. I will spare you that, but I will say that over 7.5 million people in California live within 1 mile of a possible nuclear transport route, 7.5 million people. That is more people than we have in most of our States.

Yucca's geology also remains a concern. Two active faults run through Yucca mountain, though they don't cross the repository. Quakes of 5.6 and 4.4 on the Richter scale occurred in 1992 and 2002, just 12 miles away from the site, just 12 miles away.

Strong science, good planning, and public confidence must be part of any solution to the nuclear waste disposal problem. We have not achieved that at Yucca Mountain in my view. A nuclear waste repository poses dangers that have no parallel in human history. We must not short-circuit the vital scientific and public processes needed to address these dangers.

No nuclear waste disposal project should move forward until the health and safety of the public are assured, and I will do everything in my power to make sure that this does not move forward unless I feel that the health and safety of the public has been assured.

Thank you very much.

[The prepared statement of Senator Boxer follows:]

STATEMENT OF HON. BARBARA BOXER, U.S. SENATOR FROM THE STATE OF CALIFORNIA

Mr. Chairman, protecting public health and safety should be the primary test in assessing nuclear waste disposal options. Yucca Mountain continues to fail that test.

The focus of the hearing today is the status of the Yucca Mountain project, including the establishment of radiation standards that will ensure that public health and the environment are protected.

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A nuclear waste repository poses dangers that have no parallel in human history. We must not short-circuit the vital scientific and public processes needed to address these dangers. No nuclear waste disposal project should move forward until health and safety of the public are assured.

Senator INHOFE. Thank you, Senator Boxer.

Senator Carper.

OPENING STATEMENT OF HON. THOMAS R. CARPER, U.S. SENATOR FROM THE STATE OF DELAWARE

Senator CARPER. I will be very brief. I am glad we are having the hearing. I look forward to hearing from the next panel of witnesses, and I was pleased to hear from at least one of our colleagues a moment ago.

We all know we have a huge and growing reliance on foreign oil. We have a huge trade deficit. It was about $750 billion last year. Roughly a third of that was attributable to the oil that we imported, in some cases from places around the world where they don't like us very much, and I am convinced they use our money to try to harm us.

We have had nuclear power plants now for less than 60 years. If we could figure out how to send a man to the moon back in the 1960's and do it within less than 10 years, we ought to be able to figure out how to safely dispose of nuclear waste so that we can, frankly, increase our reliance on nuclear energy and reduce our reliance on fuels from other places around the world.

Thank you.

Senator INHOFE. Thank you, Senator Carper.

We would ask now for our No. 2 Panel, William Wehrum and Paul Golan to take the table. Paul Golan is the Acting Director of the Office of Civilian Radioactive Waste Management for the Department of Energy. William, is it pronounced Wehrum?

Mr. WEHRUM. Wehrum.

Senator INHOFE. Wehrum, yes. We have visited before, but I can never pronounce it properly. He is the Acting Assistant Administrator of the Office of Air and Radiation, Environmental Protection Agency, but has just been nominated by the President to be the Assistant Administrator. We will look forward to having a hearing very shortly to hear you.

So if the two of you would like to go ahead and be heard, what we will do at this time is dispense with any more opening statements from other members who may come, which is a tradition of this committee. We would like to ask you to try to hold your opening comments to maybe 6 minutes, but your entire statement will be made a part of the record.

Mr. Wehrum.

STATEMENT OF WILLIAM WEHRUM, ACTING ASSISTANT ADMINISTRATOR, OFFICE OF AIR AND RADIATION, ENVIRONMENTAL PROTECTION AGENCY

Mr. WEHRUM. Thank you, Mr. Chairman, members of the committee, Senator Jeffords, Senator Boxer. It is a privilege to be here. I appreciate the opportunity.

My name is Bill Wehrum. I am the Principal Deputy Assistant Administrator for the Office of Air and Radiation at the U.S. Environmental Protection Agency. I am pleased to be here today to provide you with an update on the status of EPA's public health and safety standards for the proposed spent nuclear fuel and high level radioactive waste repository at Yucca Mountain, NV.

I would like to begin by providing the committee with a short history of the EPA's responsibilities and why we have proposed revised standards.

The Nuclear Waste Policy Act of 1982 described the roles and responsibilities of Federal agencies in the development of disposal facilities for spent nuclear fuel and high level waste. EPA was identified as the Agency responsible for establishing standards to protect the general environment for such facilities. In the Energy Policy Act of 1992, Congress delineated EPA's roles and responsibilities, specific to the Federal Government's establishment of the potential repository at Yucca Mountain.

EPA's role is to determine how the Yucca Mountain high level waste facility must perform to protect public health and the environment. Congress directed EPA to develop public health and safety standards that would be incorporated into the Nuclear Regulatory Commission's licensing requirements for the Yucca Mountain facility. The Department of Energy would apply for the license to construct and operate the facility, and the facility would open only if NRC determines that DOE can meet EPA standards.

In establishing EPA's role, Congress also stated that the EPA safety standards are to be based upon and consistent with the expert advice of the National Academy of Sciences.

EPA established its Yucca Mountain standards in June 2001. As required by the Energy Policy Act, these standards addressed releases of radioactive material during storage at the site and after final disposal. The storage standards had a dose limit of 15 millirem per year for the public outside the Yucca Mountain site. The disposal standards consisted of three components: an individual dose standard, a standard evaluating the impacts of human intrusion into the repository, and a groundwater protection standard.

The individual protection and human intrusion standard set a limit of 15 millirem per year to the reasonably maximally exposed individual who would be among the most highly exposed members of the public. The groundwater protection standard is consistent with EPA's drinking water standards which the Agency applies in many situations as a pollution prevention measure. The disposal standards were to apply for a period of 10,000 years after the facility is closed. Dose assessments were to continue beyond 10,000 years and be placed in DOE's environmental impact statement but were not subject to a compliance standard.

The 10,000-year period for compliance assessment is consistent with EPA's generally applicable standards developed under the Nuclear Waste Policy Act. It also reflects international guidance regarding the level of confidence that can be placed in numeric projections over very long periods of time.

Shortly after the EPA first established these standards in 2001, the nuclear industry, several environmental and public interest groups, and the State of Nevada challenged the standards in Court. In July 2004, the Court of Appeals for the D.C. Circuit found in favor of the Agency on all counts except one, the 10,000-year regulatory timeframe.

The Court did not rule on whether EPA standards were protective but did find that the timeframe of the EPA standards was not consistent with the National Academy of Sciences recommendations. The National Academy of Sciences, in a report to EPA, stated that EPA standards should cover at least the time period when the highest releases of radiation are most likely to occur within the limits imposed by the geologic stability of the Yucca Mountain site. It judged this period of geologic stability, for purposes of projecting releases from the repository, to be on the order of a million years. EPA's 2001 standards required DOE to evaluate the performance of the site for this period but did not establish a specific dose limit beyond the first 10,000 years.

EPA proposed a revised rule in August 2005, to address the issues raised by the Appeals Court. The new proposed rule limits radiation doses from Yucca Mountain for up to 1 million years after it closes. No other rules in the United States for any risks have ever attempted to regulate for such a long period of time.

Within that regulatory timeframe, we have proposed two dose standards that would apply based on the number of years from the time the facility is closed. For the first 10,000 years, we would retain the 2001 final rule's dose limit of 15 millirem per year. This is the protection at the level of the most stringent radiation regulations in the United States today. From 10,000 years to 1 million years, we propose a dose limit of 350 millirem per year. This represents a total radiation exposure for people near Yucca Mountain that is no higher than natural levels people live with routinely in other parts of the country.

One million years, which represents 25,000 generations, includes the time at which the highest doses of radiation from the facility are expected to occur.

Our proposal requires DOE to show that Yucca Mountain can safely contain wastes, even considering the effects of earthquakes, volcanic activity, climate change, and container corrosion over 1 million years.

The public comment period for the proposed rule closed on November 21. We are currently reviewing and considering the comments as we develop our final rule. We held public hearings in Las Vegas and Amargosa Valley, NV and in Washington, DC. We are considering comments from these hearings, as well as all the comments submitted to the Agency's rulemaking docket. A document describing our responses to all comments will be published along with the final rule.

Thank you again for the opportunity to appear before the committee and present an update on EPA's Yucca Mountain standard. This concludes my prepared statement, and I would be happy to answer any questions you may have.

Senator INHOFE. Thank you, Mr. Wehrum.

Mr. Golan.

STATEMENT OF PAUL GOLAN, ACTING DIRECTOR, OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT, DEPARTMENT OF ENERGY

Mr. GOLAN. Thank you, Mr. Chairman and members of the committee. My name is Paul Golan. I am the Acting Director of the Department of Energy's Office of Civilian Radioactive Waste Management. I appreciate the opportunity to provide an update on the project today.

For more than 50 years, our Nation has benefited greatly from the power of the atom and from nuclear energy, but we have been left with a legacy marked by the generation of accumulation of over 50,000 tons of spent nuclear fuel from commercial power reactors and defense activities. There is a strong global scientific consensus that the best and safest option for dealing with this waste is geologic isolation, including the National Academy of Sciences which has generally endorsed the geologic disposal option from as far back as 1957.

Yucca Mountain possesses features that make it very suitable as a geologic repository. With this in mind, in 2002, Congress approved the President's recommendation for the development of Yucca Mountain as the Nation's high level waste repository. The President's recommendation was based on more than 20 years of scientific research and recognizes that Yucca Mountain will provide a safer and more secure location for the Nation's nuclear waste than the current temporary storage facilities offer.

Allow me to address three topics this afternoon: First, an explanation of the clean-canistered approach to waste handling; second, where the project is in developing a licensing schedule; and last, a discussion of the proposed EPA Radiation Protection Standards.

Though this program had intended to submit a license application to the NRC in December 2004, a number of external and internal issues arose that prevented that from happening. In mid-2005, Secretary Bodman directed a thorough review of our overall approach to the project to determine if there were ways to run the repository better. His guidance to me was clear: Make it simpler and safer.

Late last year, we announced a redirection to a predominantly clean-canistered approach to fuel handling operations. A single canister would be used to transport, age, and dispose of the waste without ever needing to reopen the waste package. We believe that the technical challenges can be resolved which will result in a simpler, safer, and more reliable operation.

The clean-canistered approach will significantly reduce radiation risks and exposures of contamination from handling spent fuel at the repository and eliminate the need to handle spent fuel several times. It also eliminates the need for construction of two large dry fuel handling facilities. With this new approach, the spent fuel will

be handled primarily by the utilities. The Department would take advantage of commercial reactor sites with existing capability and skills.

We are working with industry today to develop canister specifications which should result in a path forward that is easier to design, license, build, and operate. While this approach will have significant financial and safety benefits, it does require additional time to redevelop and revise portions of our license application. Later this spring, the Department expects to have a new design for the surface facilities that support the canistered approach, and after approval by the Secretary, we will incorporate that design into our baseline.

We are committed to developing a realistic schedule that will result in the submission of a strong license application later this summer. Later this summer, we will publish our schedule for submittal of the license application to the NRC.

As was mentioned before, in August 2005, the EPA proposed revised standards for Yucca Mountain. Specifically, EPA proposed a radiological exposure limit for the time of peak dose to the general public during the 1-million-year period following the disposal of waste at Yucca Mountain.

As the committee knows, there is limited temporary surface storage of waste at 122 sites in 39 States across our Nation, including many of the States this committee represents.

Let us be mindful that the 70,000 tons of fuel that will be disposed of at Yucca Mountain will have produced over 2,000 gigawatt years of electricity. As a result of this, according to a report issued by scientists from the University of California-Berkeley, we are leaving the future generations 5 billion tons of coal that would otherwise have been consumed. Additionally, we did not generate 700 million tons of particulate matter, sulfur dioxide, and other pollutants including 650 tons of mercury that would have been released into the environment. The report also will opine that there were 300 coal mining deaths avoided as a result of using nuclear power instead of coal. Nuclear energy will also allow us to pass on to future generations a secure energy source that is safe, reliable, and essentially emission-free.

The proposed EPA rule retains the existing 10,000-year individual protection standard of 15 millirem per year and supplements it with an additional standard of 350 millirem per year at the time of peak dose. The Department supports this approach. A rule with two compliance periods recognizes the limitations of bounding analyses, the greater uncertainties at the time of peak risk, as well as the lessened precision and calculated results as time and uncertainties increase.

Retaining the 15 millirem per year for the initial 10,000 years ensures that the repository design will include all prudent steps, including the use of engineered systems and natural barriers to limit offsite doses. Through the 1-million-year performance period, the natural and engineered barriers will continue to keep exposure levels low, below what people receive today based on where they live or where they work. Importantly, this reflects a level of risk that society normally lives with today and that the allowable dose for an individual at Yucca Mountain, several hundred thousand

years in the future, would be no greater than the average dose of a resident of Denver or similar high altitude location receives today.

Studies show that areas with higher levels of natural background radiation have no greater rate of cancer or other radiation-linked illnesses than have been detected in areas with lower levels of natural background radiation. I believe our license will provide the necessary assurances that we can operate Yucca Mountain in compliance with the performance requirements of the EPA and NRC. We will demonstrate our better approach to operate Yucca Mountain will be safe, carefully planned, logical, and methodical.

Yucca Mountain is a good site, and there is a clear need for Yucca Mountain, even if we could reduce the Nation's electricity consumption by 20 percent and were able to shut down every commercial reactor and nuclear power plant in the country today. We could spend another 20 years and several more millions of dollars and arrive at the conclusion that we need to study Yucca Mountain more before we can proceed. Moving forward into licensing will allow an open public debate on the safety of Yucca Mountain.

The waste is here today. Let us not pass this burden on to our children. This is our responsibility, and we need to deal with it.

Thank you very much.

Senator INHOFE. Thank you, Mr. Golan.

Mr. Wehrum, when do you expect to finalize the proposed rule?

Mr. WEHRUM. We currently are in the process of reviewing comments that were submitted during the public comment period and the testimony provided during the public hearings. Once we finish that assessment, we will move into focused work on preparing the final rule, and we hope to get that done by the end of this year.

Senator INHOFE. By the end of the year?

Mr. WEHRUM. That is correct.

Senator INHOFE. All right, sir. I would like to ask you: How similar is the standard to comparable waste disposal standards in Europe? It is my understanding that we protect the 90th percentile individual person which leads to an extremely conservative standard, whereas Europe reaches 50, approximately the 50th percentile. I would ask you the question: Is this too conservative and how did we arrive at that?

Mr. WEHRUM. Yes, Mr. Chairman. We believe our approach is very consistent with the approach that is used internationally, and certainly several countries in Europe have similar sorts of standards in place. Our standard is based on an assessment of exposure to what we call the reasonably maximally exposed individual. We like our acronyms at EPA. That is the RMEI.

My understanding is that many of the international standards and those in Europe apply a different methodology of identifying the potentially affected population, and that would be a critical group type approach. So when you compare and contrast the relative differences between what we are doing and what other countries in the world do, we believe that there is actually a high level of consistency, and that we are, at least with regard to the individual exposure, not being significantly more stringent.

Senator INHOFE. I would ask the same thing about the million-year standard, placing the high priority on hypothetical long term

hazards. It is my understand that, in doing this, you are assuming that technology is going to be static during this period of time, is that correct?

Mr. WEHRUM. That is correct, Mr. Chairman.

Senator INHOFE. Is that reasonable?

Mr. WEHRUM. It——

Senator INHOFE. Can you think of any time in history that would, well, scrub that.

[Laughter.]

Senator INHOFE. In my opening statement, Mr. Golan, I mentioned how the DOE, the EPA, and the NRC interact in this process. I would ask you: When do you expect the DOE to submit a license application to the NRC?

Mr. GOLAN. Sir, we are in the process of developing our design for the surface facilities to handle primarily canisterized waste. Once that has been reviewed and approved by the Secretary of Energy, it is our intent to publish a license schedule this summer. So we would like to get back to you after we have a chance to look at the design, incorporate it into our baseline, and have a basis to provide you a schedule.

Senator INHOFE. Is that assuming no litigation, that is not foreseen at this time, would be there?

Mr. GOLAN. Our step in submitting the license application, again, I think the litigation would come after that.

Senator INHOFE. I see, OK. You heard Senator Reid when he was in here, and he was talking about the amount of money and that we are all concerned about the amount of money that is being spent.

I would ask you, on the other side of that: What are the financial impacts on the Federal Government for not opening a waste repository as scheduled right now? For example, I note that you have already lost three lawsuits, one with TVA around $35 million, and I believe one with the State of South Carolina, and one with Exelon. What effect would this have, financial effect?

Mr. GOLAN. Sure. The estimated liability that the Government has for not accepting waste in 1998 through 2010, so for a period of 12 years, is estimated somewhere between $2 and $3 billion. After that, we estimate that the additional costs for the incremental onsite storage costs would be in the order of several hundred million dollars a year extra on top of that.

Senator INHOFE. The reason I am concerned about this is that I know this panel has heard me say several times that nuclear energy and the expansion of nuclear energy and opening it up are absolutely necessary. There is no other way that we are going to become independent. We need clean coal technology. We need oil and gas. We need renewables. We need all of the above, but certainly a very important thing is nuclear energy.

It seems to me some of us are old enough to remember back in the sixties and seventies when there were a lot of protests going on. There was a perceived danger that was there. Since we have been getting into all the problems with clean coal, with coal and the ambient air problems that we deal with on this committee, it would seem to me, and it appears to be, that a lot of the people who were opposed to the expansion of nuclear energy back in those

years are now recognizing that it is the cleanest and the safest form that is out there.

I, certainly, as chairman of this committee, believe that and believe that we need to get very aggressive in our licensing system and encouraging expansion of nuclear energy in this country. When you look at some of the European countries that are 80 percent nuclear, you just wonder how we can do it without that expansion. I don't think we can.

Senator INHOFE. Senator Jeffords.

Senator JEFFORDS. Excuse me. Mr. Wehrum, I would ask you this about the groundwater protection standards at Yucca Mountain. EPA proposes to stop the groundwater standard after the first 10,000 years when the groundwater will become increasingly contaminated. The EPA will protect the public after 10,000 years by another part of the standard, but that part of the standard is more than 23 times higher after 10,000 years than it is before that time. Why is the compliance period for groundwater only 10,000 years?

Mr. WEHRUM. Senator Jeffords, our strategy in proposing the regulation is to take a two-pronged approach. The first prong is to reiterate the standards that were adopted in 2001. We believe those standards were fully protective of human health and safety and have the added benefit that while 10,000 years is a very long period of time, it is a period of time where we believe we have greater confidence in the analytical tools that are available and our ability to predict with greater precision how the repository will behave. Beyond the 10,000-year period of time and up to the million-year period of time, our ability to analyze and predict with great precision is much less.

A million years is a very, very long period of time. It is unprecedented given, certainly, our regulatory activity within the Environmental Protection Agency. So it is our belief that the proposed standard of 350 millirem per year over the million-year period is appropriate, and is protective, and is consistent with our ability to reasonably analyze and reasonably predict the behavior of the repository and the material stored in the repository.

Senator JEFFORDS. Thank you. Mr. Wehrum, the EPA is currently revising its Yucca Mountain radiation regulations. Some observers have suggested that the legislation will be forthcoming from the Administration to set a radiation standard at Yucca Mountain. Given that EPA is set to finalize its revised regulation in the coming months, it does not seem wise to proceed with that legislation, does it?

Mr. WEHRUM. Senator Jeffords, our current obligation under law is to complete the Radiation Protection Standard that has been proposed, and we will continue to press forward and attempt to complete that standard as soon as we reasonably can. I would defer to my DOE colleague on questions about legislation and the possible desire to draft or propose legislation.

Senator JEFFORDS. Mr. Golan, in July 2002, Congress authorized DOE to submit a license application for the Yucca Mountain project to the NRC. The law gave DOE 90 days to do so after the vote. DOE promised to file by December 2004. After repeated postponements, DOE no longer has a date for submitting an application.

Presumably, that original authorization has lapsed. Doesn't DOE need to come back to Congress for reauthorization?

Mr. GOLAN. I would have to get back to you on the authorization question, Senator Jeffords. We are in the process right now of putting together a license application schedule, as I said, based on the clean canister design. That will meet the EPA Radiation Protection Standard. Again, that is another issue that arose after the 2002 date for Congress to submit a license application. So there are things that happened after that authorization that we are factoring into the development of our license application.

Again, we expect to have a schedule that will have a technical basis to submit a solid license application this summer.

[The response to the referenced authorization question follows:]

On July 23, 2002, the President signed into law Joint Resolution No. 87 which was approved by both the House and Senate. Public Law 107–200; 116 Stat. 735 (2002); 42 USC 1035 note. This statute affirmatively approved the Yucca Mountain site, thus concluding the site-selection process and obligating DOE to seek, as expeditiously as possible, a license from the Nuclear Regulatory Commission to build and operate a repository at the site. Failure to file an application within 90 days does not affect the validity of the Site Recommendation or DOE's obligation under the NWPA to file an application once the President and Congress approved the Site Recommendation decision.

Senator JEFFORDS. DOE is pursuing a new nuclear waste reprocessing program called The Global Nuclear Energy Partnership that could impact the role of the Yucca Mountain project. This program relies on reprocessing technologies that are currently under development. Existing reprocessing technologies produce a by-product which is highly radioactive sludgelike residue that must be solidified and sealed in a stainless steel canister before it is shipped. How long will it be before these new reprocessing technologies are viable?

Mr. GOLAN. Senator Jeffords, as you mentioned, the Department did propose The Global Nuclear Energy Partnership starting in Fiscal Year 2007. In many ways, it is a continuation of efforts the Department has been undergoing with the Advanced Fuel Cycle Initiative, and the Department has requested $250 million in fiscal year 2007 to continue that and to accelerate it.

Impacts on Yucca Mountain over the long term would be tremendous and positive. If we could reduce the heat, if we could reduce the half-life of the actinides, and of the fission products, and of the nuclear waste at the site, and if we could reduce the volume, those would be definite advantages of a reprocessing capability that does not separate purified plutonium.

As you mentioned, these technologies are under development, and it is going to be several decades before we go through engineering scale and then through actual commercial industrial scale demonstrations here. You are right in terms of they will produce a by-product under any fuel cycle scenario at Yucca Mountain where a deep geologic repository would be needed. We are proceeding along with developing the license application for Yucca Mountain in parallel with the GNEP. Again, we would need it, even if all the technologies of GNEP prove successful, and again there is about 13,000 tons of waste, defense-generated waste located at Savannah River, Hanford, West Valley, and Idaho that is vitrified or going to be vitrified that will ultimately end up at Yucca Mountain.

Senator JEFFORDS. Thank you.

Senator INHOFE. Thank you, Senator Jeffords.

Senator Boxer.

Senator BOXER. Thank you, Mr. Chairman.

My chairman takes a large picture view of this which I think is important, making the point that we want to become energy independent, and therefore we need to do this because we need to build more nuclear power plants. I would just be a devil's advocate on this, much to the surprise of my chairman.

[Laughter.]

Senator BOXER. I even surprise Senator Jeffords.

I think if you are a proponent of nuclear power, the worst thing you can do, it seems to me, is not deal correctly or safely with the waste issue because I would posit if there is just one accident, it could be so horrific that it would be the end of nuclear power. For example, if you were moving the spent fuel on trucks, and there was a horrific accident or a terrorist incident, and something horrible happened, and it never made its way to Yucca Mountain but it polluted communities, killed people, gave people cancer, and maybe terrorized a community, I would say very quickly that nuclear power would not be what people turn to in this country.

So I think the way we deal with this is essential, and I think that Senator Reid ought to be listened to.

Mr. Wehrum, I just have to say, your explanation of this court suit I found very, shall we say, disingenuous. I don't share the way you analyzed it. You said, we were upheld on everything but one count. Well, there were three counts. The three counts dealt with the safety standards. One standard was individual protection or IP; the other was human intrusion into the facility or HI; the third was groundwater protection. Guess what? The Court threw this out on two out of the three. The only one that they upheld was groundwater, and that was the one that was challenged by industry.

The Court found that there wasn't individual protection with the standard, and there was possibility of human intrusion. So that was a disaster.

Now, you are going back. You are writing another rule. If you think this thing is getting off dead center, I have to agree with Senator Reid, this is a never ending situation because what you are thinking of doing, I don't think responds to the Court. We will see what the Court says because you know there is going to be another lawsuit. But from what I hear you saying, you are not really correcting the issues. This thing has gone around in a circle.

Mr. Golan, you testified that President Bush has recommended using Yucca Mountain as the Nation's nuclear waste repository, "based on more than 20 years of scientific research," is that correct?

Mr. GOLAN. Yes, ma'am, I did.

Senator BOXER. OK. Well, then I am very confused because on February 19th, just 2 weeks ago, Ken Mehlman, the Chairman of the Republican National Committee told a Nevada newspaper, and I have the paper here, that President Bush doesn't favor or oppose the site. So is it still your opinion that the President, in fact, does favor the site?

Mr. GOLAN. The President did send his recommendation to Congress, and Congress approved that recommendation in 2002. I have no reason to doubt that the President has changed his opinion on Yucca Mountain.

Senator BOXER. OK. Well, I think we need to let Mr. Mehlman know that when he is in Nevada, he can't say the President doesn't support it, and then you come here and testify to us that the President supports it. So at least let us find out what the truth is, and I am going to say you are being truthful. I just look at you, and I believe that.

Senator INHOFE. You never say that about me.

Senator BOXER. You are always truthful. I always think you are truthful. I just don't agree with you, but you are truthful.

[Laughter.]

Senator BOXER. Now, Mr. Wehrum, I have an analysis from Dr. Thomas Cochran, a respected nuclear physicist, which shows that EPA's Proposed Radiation Standard for 10,000 to 1 million years creates a one in five risk of increased fatal cancers for the general population and a one in four risk for women. Do you believe that is an acceptable risk of fatal cancers for the public?

Mr. WEHRUM. The proposed standard of 350 millirem was based on an assessment of natural levels that people currently live with safely in other parts of the country. What we attempted to do is identify another part of the country that was comparable to Amargosa Valley, and that area was Colorado. What we found in the area of Colorado that we investigated is the average natural exposure to radiation was on the order of 700——

Senator BOXER. So I take that as yes, you think then that a one in five risk of increased fatal cancers for the general population and a one in four risk for women to get cancer is acceptable.

Mr. WEHRUM [continuing]. Senator, my testimony is that I believe that the standard we have proposed protects individuals and protects the safety as we are instructed to do by the standard.

Senator BOXER. First of all, it was kicked out of the Court. So they don't agree with you. Second of all, Dr. Thomas Cochran says that you are creating a one in five risk of increased fatal cancers for the general public and a one in four risk in women. Do you disagree with his assessment?

Mr. WEHRUM. Senator, as I said, my belief is that the proposed level of 350 millirem is protective of human health and safety.

Senator BOXER. Well, the Court already threw that out. I am asking you this question. Do you agree with Dr. Thomas Cochran?

Mr. WEHRUM. Senator, the Court did not have before it the proposed 350 millirem standard.

Senator BOXER. But what you are doing is now fooling with the time period. I can guarantee, I believe if you want to discuss that, they will throw it out because you are being a little cute here in what you are doing, but that is beside the point.

My question is: Do you agree with Dr. Thomas Cochran, a respected nuclear physicist who says that there will be a one in five risk of increased fatal cancers for the general population and a one in four risk in women? Your answer is that that is the same risk in a naturally occurring environment. This is not a naturally occurring environment. You are doing this to the people, and I am ask-

ing you: Is that an acceptable risk, yes or no? Answer me, yes or no.

Mr. WEHRUM. Senator, my answer is our proposed standard is 350 millirem per year.

Senator BOXER. Well, I am sorry, you are not answering. Yes or no?

Mr. WEHRUM. I understand that, Senator, but we have many commenters who have offered a variety of opinions on the standard that we have proposed, that being one of them.

Senator BOXER. But your answer is it brings it up to the level of naturally occurring radiation, and we are doing this to people. I am asking you if that is unacceptable, and you won't answer it. You won't answer it, and I think that speaks volume to the people of Nevada.

Thank you, Mr. Chairman.

Senator INHOFE. Senator Boxer, we will have another round in just a moment here.

Senator BOXER. I am fine.

Senator INHOFE. All right, we have been joined by Senator Warner. Senator Warner, in addition to his seniority on this committee is the Chairman of the Senate Armed Services Committee, which is, of course, very interested in the subject at hand today.

Senator Warner.

Senator WARNER. Thank you, Mr. Chairman. I will just follow these proceedings because it does relate overall to our defense and our ability to look to this as a repository as planned over these very, very many years. So at this time, I may have questions to submit for the record, and I thank the Chair.

Senator INHOFE. Thank you, Senator Warner.

Let me just follow up. First of all, I do agree with the concern that Senator Boxer has in terms of an accident. I don't think we deal with anything up here that you can't have some kind of an extreme scenario by which there would be some tragic accident. Nonetheless, we have been so cautious in approaching this. I just would ask either one of you: Do you think that we have been deliberate enough in pursuing this and taking as many precautions as we can?

Mr. WEHRUM. Mr. Chairman, I will take a first crack at that. The Agency takes its responsibility very, very seriously. We did in the first round of standard setting, and we continue to take that responsibility very seriously in our effort to respond to the remand of the Court. We have experts in the field who are focused on these questions. We have made an intensive effort.

Senator INHOFE. Pull your microphone up. Are you sure it is on because I can hardly hear you up here?

Senator JEFFORDS. Many people in the audience are quite anxious to have the benefit of your remarks.

Mr. WEHRUM. Yes, Mr. Chairman. Yes, Senator, I will speak more directly into the microphone.

My point is that we take our responsibility very seriously, and we have devoted significant resources including experts in the field, some of the greatest experts in the country we have available. We have tried very hard to solicit a wide range of input from everyone who has an interest in this issue. We know there are those who

have a different opinion, and it is important to us to understand that different opinion.

Our goal is to establish a standard, consistent with the law and consistent with our obligation to protect human health and safety. I fully believe that we are doing that.

Senator INHOFE. Do you agree with him, proper precautions having been taking place, Mr. Golan?

Mr. GOLAN. Yes, Mr. Chairman, I do. I think we have been deliberate, and I also believe that the prescribed process through the licensing of Yucca Mountain will provide additional opportunities for us being deliberate.

Senator INHOFE. I see. Mr. Golan, Senator Jeffords made the comment that Yucca Mountain would only take part of the waste and will leave some or most of the waste. It is my understanding that Yucca Mountain is currently designed to hold 70,000 metric tons of waste. Could this be expanded? How would you respond to Senator Jeffords' remark that it would just take part of the waste?

Mr. GOLAN. According to the Nuclear Waste Policy Act, there is statutory cap of 70,000 tons. That does not represent the technical capability of Yucca Mountain. Our Environmental Impact Statement analyzed for nearly 120,000 tons of waste into Yucca Mountain. But again, the Nuclear Waste Policy Act is the limit on that, and it is based on an administrative control.

Senator INHOFE. We had an excellent briefing on that when I was out at Yucca Mountain. I would certainly hope that many members can go and take advantage of that.

Mr. Golan, Senator Jeffords talked about the Global Nuclear Energy Partnership program which is the reprocessing program. I agree with the President; we need to have that. There are some people who are saying, well, that is in lieu of the storage program. Of course, I think that should be clarified for the record, No. 1.

No. 2, the sum, $13 billion that would be over the next 10 years spent on that program, can you give us some assurance that that money would not be taken out of the Yucca Mountain program?

Mr. GOLAN. Sure. On your first point, Mr. Chairman, the Global Nuclear Energy Partnership is not in lieu of Yucca Mountain. Yucca Mountain is——

Senator INHOFE. I think that is very important to bring out because I have had more people come up and say, well, this is a change. It is not. We know that only about 10 or 15 percent is actually used, and there is a lot left over, and a reprocessing that needs to take place before final storage.

Mr. GOLAN. Yes, sir. Under any fuel cycle scenario, a deep geologic repository would be needed. Additionally, the defense waste Senator Warner was talking about that is at Savannah River, Hanford and at Idaho, which has already been reprocessed, would be going to Yucca Mountain. So it has already been through that step.

The Administration has proposed a Global Nuclear Energy Partnership. It is going to be requesting funding through the budgetary process, not through the Nuclear Waste Fund to fund those activities.

Senator INHOFE. So both of you would agree, I assume, that the GNEP program should not deter the forward progress of Yucca Mountain.

Mr. WEHRUM. Absolutely not, sir.

Mr. GOLAN. That is correct, Mr. Chairman.

Senator INHOFE. Senator Jeffords.

Senator JEFFORDS. Mr. Golan, the Yucca Mountain repository is designed to house 70,000 metric tons of nuclear waste. As of 2003, there were 49,000 metric tons of spent nuclear fuel onsite at the country's nuclear reactors waiting for permanent storage. By the year 2035, the United States is projected to produce 105,000 metric tons of nuclear waste, and that is not including waste from any new plants we build. Given this projection, the Yucca Mountain repository would essentially be full as soon as it opens, is that right?

Mr. GOLAN. Yes, sir. Your numbers are basically correct, and we run into the statutory capacity limit sometime later next decade.

Senator JEFFORDS. Is DOE considering a second disposal location, and what is the timing of that decision?

Mr. GOLAN. Yes, sir, Senator Jeffords. In accordance with the Nuclear Waste Policy Act, between 2007 and 2010, the Secretary is required to provide a report to Congress, assessing the need of second repository. I think you will recall there are a couple dozen States that were initially considered for the first and second round of repositories. The Department would certainly go back and look at those States as it considered a second repository.

Senator JEFFORDS. What types of waste would be produced by the new reprocessing technologies?

Mr. GOLAN. The new reprocessing technologies have to be proved out in an engineering scale and on industrial scale, but they would produce far less waste product that would need ultimate disposal, the way the Global Nuclear Energy Partnership has envisioned. These would take out the actinides, the plutoniums, and all the fissile materials and then reuse those in fast flux reactors or fast spectrum reactors. That waste that was generated as a result of the fast spectrum reactors would be reprocessed or recycled again and reburned in reactors.

So, depending on how this technology moves along, there could be 80 percent or more of the volume reduced as a result of the technologies envisioned by the Global Nuclear Energy Partnership.

Senator JEFFORDS. What changes would be needed in the Yucca Mountain project to accommodate this new type of reprocessing waste?

Mr. GOLAN. Senator Jeffords, under our current license application, we contemplate disposal of the reprocessed waste that is at Savannah River, Hanford, West Valley, and Idaho today. That was reprocessed waste from the defense and, in the case of West Valley, a pilot plant for commercial reprocessing. We have vitrified waste form down in Savannah River and up in West Valley, NY. We are working on vitrifying waste forms at Hanford and at Idaho.

Those are already included in our license application, so they are already included in the design. In my opinion, it is a much better waste form because you don't have criticality concerns. The heat load is significantly reduced. So we have incorporated those waste forms in our design.

If we would look into the reprocessing or the recycling on the commercial side of the reactors, we basically have incorporated that waste form. What we would do is look at changing the mix in terms

of reprocessing waste or the defense waste versus the spent fuel, and we would look at changing those. As we would decrease the amount of spent fuel, we would increase the amount of reprocessed waste that would go to Yucca Mountain. But that waste form is already anticipated today.

Senator JEFFORDS. I asked, Mr. Golan, about the waste produced by the Administration's proposed nuclear waste processing program. Am I correct in my understanding that we do not currently have environmental regulations that would govern nuclear waste produced by a large scale reprocessing program?

Mr. GOLAN. No. We have environmental regulations that we would, the Department would be obliged to meet.

Senator JEFFORDS. Mr. Golan, DOE recently released a report which investigated the scientific issues behind the e-mails between USGS employees which implied that scientific data on the Yucca Mountain project had been falsified. The accompanying press release said that the report is "confirming the technical soundness of the infiltration modeling work performed by the USGS employees."

Sandia Laboratories, recently chosen to be the lead Federal laboratory on the project, will now be conducting its own tests to verify the results. How will Sandia Laboratories ensure that similar mistakes will not occur as they did with USGS?

Mr. GOLAN. Senator Jeffords, that is an excellent question. One of the reasons Sandia National Laboratory was chosen as the lead laboratory for Yucca Mountain was its excellence in science for the Waste Isolation Pilot Plan in Carlsbad, NM. We are working with Sandia to ensure that the quality assurance requirements for the project have been met. We have actively engaged the Nuclear Regulatory Commission.

After Sandia completes its work on redeveloping of the computer model for infiltrations, much like we did with the report that you are referring to, we had a group of independent scientists—these are scientists independent of the Department of Energy—evaluate and review the report. Before we replace the work that is currently in our model with the Sandia work, we are going to follow that same process. It is called Trust But Verify Process. It is a process that is used in the Naval Nuclear Propulsion Program and the Commercial Reactor Programs, and it is a process that we are going to make a practice in this program.

Senator JEFFORDS. Thank you. That is reassuring.

Senator INHOFE. Thank you, Senator Jeffords.

Senator Boxer.

Senator BOXER. I know you will be happy to know I want to get back to the safety standard.

Senator INHOFE. Excuse me, Senator Boxer. I meant to go back and forth here.

Senator BOXER. Yes, I will definitely yield. I will definitely yield and let you wait a while.

Senator INHOFE. All right.

Senator DeMint.

Senator DEMINT. Thank you, Mr. Chairman. It is OK?

Senator INHOFE. Yes.

Senator DEMINT. I apologize for being late and missing a lot of the testimony, but this hearing is of great interest to me. South

Carolina has been the recipient of a lot of radioactive low level/high level waste over the years with a promise—Yucca is part of that promise—that one day this above ground storage, which is not only in South Carolina but as you know all around the country, thousands of tons of nuclear waste.

There is some talk now that perhaps with the movement toward reprocessing nuclear fuel that we no longer need Yucca as most of the waste we are holding is not reprocessing material; it is material that needs to be stored underground. My concern is, in a lot of these hearings, we seem to now be looking for a lot of reasons why we shouldn't do Yucca. The potential health risk, and we see the EPA expanding its standards to a million years. Incredible.

I would like to just ask maybe both witnesses: Instead of talking about the problems with Yucca, could you talk about the health risks of not doing Yucca? As we look at the above ground storage around the country, the possible leaks, the groundwater contamination that could occur everywhere, what do you see as the risk of continuing this delay and leaving the status quo in place, particularly as the United States has recognized its need to develop more nuclear generation in the face of an energy crisis?

We need to move ahead, yet we continue to be looking for every reason in the world not to move ahead. We have already studied Yucca Mountain more than any other piece of ground that has ever been studied in the world. Could you, sir, just give me, what are your assessments of the health risk of just leaving this waste where it is?

Mr. GOLAN. Sure, Senator DeMint. In your State, not only do you have the defense waste at Savannah River, but you have 3,500 metric tons, as your State gets 55 percent of its energy from nuclear energy.

We assessed the option of doing nothing, and part of the option of doing nothing was that we would have to repackage the spent fuel at the reactor sites every hundred years.

Now for the near term, there is probably not an incremental health risk because the storage casks have been licensed by the Nuclear Regulatory Commission for several decades. But again, you bring up an interesting point, that is, if we did not have Yucca Mountain and we would have to store in perpetuity this waste at the surface next to the lakes and the rivers and the waterways, it would present health risks several orders of magnitude, in my opinion—again, we can point you back to our Environmental Impact Statement—if we did not do the repackaging of the waste very hundred years.

So we would be leaving a burden onto our children for the radioactive exposure, the radiation exposure, for repackaging. If we didn't do that, then the casks and the way the fuel is packed over the course of time, over the course of the centuries and millennia, would certainly pose an environmental problem.

Senator DEMINT. The site is a perfect dirty bomb site as far as the ability of a terrorist to create a disaster by exploding some of that material. So, in addition to what might happen over natural aging over time, we have an exposed target, not only in South Carolina but, as you know, in many places around the country.

Mr. GOLAN. Yes, sir.

Senator DEMINT. EPA, are you going to help us get this done?

Mr. WEHRUM. Yes, Senator, we will. I am not aware that the EPA has done an analysis of the sort that you have just asked about, of the risks associated with managing waste in the current manner as opposed to Yucca. What I will say, just to reiterate, our job at EPA is to set standards for the Yucca Mountain repository that are fully protective of human health and safety. I am convinced, it is my belief that we can do that, and we will do that when we take final action later this year.

Senator DEMINT. But you will do an assessment of leaving it in South Carolina for a million years as well?

Mr. WEHRUM. If Congress directs us to do that assessment, we would be more than happy to do so.

Senator DEMINT. Because I think we do need to look at our choices. I am afraid the way we are dealing with this now is we assume that we can leave things the same and actually be safer than if we moved ahead with what we have been trying to do for a number of years.

Thank you, Mr. Chairman. I yield back.

[The prepared statement of Senator DeMint follows:]

STATEMENT OF HON. JIM DEMINT, U.S. SENATOR FROM THE STATE OF SOUTH CAROLINA

Thank you, Chairman Inhofe, for holding this hearing this afternoon. Yucca Mountain is a vital component of America's energy security, and I appreciate the close attention Yucca is finally receiving.

I must admit I have a keen interest in the Yucca Mountain Project. My State relies on nuclear energy for more than half of its electricity and has played an integral role in building and maintaining our Nation's nuclear deterrent during the cold war. As a result, South Carolina has more than 6,100 metric tons of high-level radioactive waste—almost 10 percent of all the waste currently planned for storage at Yucca Mountain.

This waste has been sitting in tanks and above ground storage facilities for decades. These methods of storage were meant to be "temporary," but due to constant delays with Yucca Mountain the term temporary no longer applies. Over the years, the people of my State have demonstrated time and again that we can handle high-level radioactive materials safely. However, it is time our Nation's nuclear waste is disposed of permanently.

Now some have argued that the Administration's proposal to reprocess nuclear waste eliminates the need for Yucca. However, this is false. Reprocessing will reduce the amount of waste, but it does not eliminate all the waste. In addition to the civilian waste left over from reprocessing, the thousands of tons of cold war waste still need to be disposed of permanently.

Instead of storing nuclear waste above ground at 131 sites in 39 States, it is infinitely safer to consolidate the waste into one desolate place and bury it deep underground. Science and common sense both dictate this solution and Yucca fits this description.

My staff has been to Yucca Mountain and spoken with the citizens of Nye County, NV. In the process, they have not heard objections to Yucca, just the opposite. The people of Nye County have said they want the project to move forward. It is the political leaders opposed to nuclear energy in America that constantly speak against Yucca Mountain.

Sadly, politics as usual has crept into the decisionmaking and is starting to undermine the long-term security of America and our energy independence. It is my sincere hope that today we can find some consensus on moving forward with Yucca and opening this important facility.

Senator INHOFE. Well, I think that is an excellent point to bring up. I would encourage you to at least pursue doing such a study because we have these questions, and we would like to be able to

have some kind of answer or maybe lead us to the appropriate body to do something like this. It would be very useful.

Thank you, Senator DeMint.

Senator Boxer.

Senator BOXER. This issue is complex because there is no good answer. You leave it where it is, it is an issue. You start moving it, talk about giving terrorists a chance at it. That is what you would have to do. Put it on a train. Put it on trucks. So it is a complicated matter. If we do look at it, I think we need to look at both sides of it.

The thing about this issue that is so intriguing is that when you are dealing with what God has created, namely this world, and you take responsibility for it because we are the stewards of this world that was created, in my view by God, then you have to make sure that you do your best to protect this world forever because that is our job. If we don't do the right thing here, we could jeopardize all of it. So it is very, very serious business here. That is why I pressed you on the standard because there is a moral question.

You said, when I asked you if you felt it was acceptable that one in four people, one in four women gets cancer from a lifetime of exposure to the radiation there, which is what we are being told by Dr. Thomas Cochran, a respected nuclear physicist, and a man has a one in five risk, you won't answer the question. But I will ask it a different way.

Right now, we regulate low level nuclear waste disposal facilities at 25 millirem. Do you think Congress ought to look at increasing that, that risk, in future years? Since you are perfectly willing to do it for the high level waste, are you proposing that we do it for the low level waste?

Mr. WEHRUM. Senator, I will readdress the questions you previously answered.

Senator BOXER. No. Can't you just answer the questions I ask you, please? That would be so refreshing.

Mr. WEHRUM. Yes, Senator. I will answer this question, but I——

Senator BOXER. Thank you.

Mr. WEHRUM. My belief is it is an apples and oranges situation.

Senator BOXER. Because?

Mr. WEHRUM. We, as I explained a bit earlier, are proposing a two-pronged strategy in our Yucca Mountain standard. The first prong deals with the relative near future, and by that, I mean between now and 10,000 years from now or at least 10,000 years from the time the storage facility is closed and disposal occurs according to our regulations. The second prong addressing the much longer period of time from 10,000 years to 1 million years. I believe, and we at the Agency believe, that it is appropriate to have a value of 350 millirem per year for the longer period of time that we are currently contemplating, that within which the peak dose would occur, given the limits of geologic stability of the Yucca Mountain site.

That 350 is based on a couple of things. One, as I mentioned earlier, is it is based in part on our assessment of naturally occurring radiation that people safely live with in comparable areas in other parts of the country. It is also just based on the reality that projecting with confidence over a million-year period of time is a very

difficult thing to do. We should not suggest to ourselves, and should not suggest to the public that we are responsible to, a false precision associated with our ability to know what is going to happen in a million years.

Senator BOXER. Sir, I really appreciate this, but I don't have time. I asked you a simple question. You are not recommending changing the level of exposure in low level radioactive waste sites. To me, you can call it apples and oranges, but it really makes the case. You are doing it this way as a way to get around the Court decision. You are taking two standards. One, as you say, the relatively near future and one further up, but yet we have these other standards.

Let me ask you this: Are you going to go back and suggest to EPA that they change their regulations? Do you know what the acceptable risk is typically in most of our regulations at EPA in terms of cancer risk?

Mr. WEHRUM. It varies from standard to standard, Senator.

Senator BOXER. Well, I have the range. Do you not know it? Do you want to tell us what it is?

Mr. WEHRUM. I don't have the information that you have.

Senator BOXER. It is 1 in 10,000 to 1 in a million, not 1 in 5, not 1 in 4. So since you are so gung-ho about this deal, why don't you go back and change the regulations as they apply to the low level nuclear waste? Why don't you go back and change the acceptable risk in all these other deals?

Let us face it. This is such a nightmare that we are abandoning all of our traditions, all of our history in what we consider to be an acceptable cancer risk. Look, that is it. Maybe some people think it is fine; it has to be done. I happen to not think that way.

But I also want to say, all this talk about naturally occurring, as if there are no cancers. Do you know what happens to people who live in areas that have naturally occurring radiation? Do you think they are cancer-free? Do you know what percent of cancers they get?

Mr. WEHRUM. I am sure they are not cancer-free, Senator.

Senator BOXER. You are correct, 18,000 U.S. deaths annually. So you talk about naturally occurring as if that is some glorious nirvana, but it isn't.

Let me ask you, Mr. Golan. "A January 9, 2006, Nuclear Regulatory Commission audit of an earlier audit by Bechtel on the corrosion rate of casks concludes that the Bechtel audit was not effective in identifying, documenting, and alerting DOE management to the significance of the issues which were in noncompliance with quality assurance requirements." Has DOE issued a stop work order on building the casks until these problems are resolved?

Mr. GOLAN. Senator Boxer, the Department issued a stop work order on the particular work activity for these humidity gauges. So we did issue a stop work on the affected work which you are referring to.

Senator BOXER. OK. What is the status now? If I could just finish this, and then I'll stop.

Mr. GOLAN. Sure. We are conducting, my office, not Bechtel, is conducting an independent investigation on what happened.

One of the things I will share with you, Senator Boxer, is I have a stack of reports from the GAO, from the IG, from various other people inside and outside the Department that have looked at the quality of Yucca Mountain. I have read all those reports, and they are missing one thing. They are missing accountability. So I am going to hold the folks accountable.

Senator BOXER. Good, good. I knew I liked you.

Senator INHOFE. Thank you, Senator Boxer.

Senator DeMint, would you like a second round?

Senator DEMINT. No, thank you.

Senator INHOFE. All right. Well, I thank both of the witnesses for your fine testimony. You may be excused now.

We would ask our Panel No. 3 to come up, which would be Robert Fri, chairman of the National Research Council for the Committee on Technical Bases for Yucca Mountain Standards; Ms. Allison Macfarlane, research associate, Program in Science, Technology and Society, MIT; Mr. Robert Loux, executive director of the Nevada Agency for Nuclear Projects, the Office of the Governor; Dr. Dade W. Moeller, former president of the Health Physics Society.

Senator BOXER. Mr. Chairman?

Senator INHOFE. Yes?

Senator BOXER. May I submit further questions for the record?

Senator INHOFE. For this panel?

Senator BOXER. No, the previous panel.

Senator INHOFE. Of course.

What we will do here, we will only have one round of questioning because of the time constraints, and we would like to have your opening statement. The same will go for you as went for the previous panel, that is, your entire statement will be made part of the record, and we would like to have you hold your opening statement down to close to 5 minutes, if you could.

Mr. Fri.

STATEMENT OF ROBERT FRI, CHAIRMAN, NATIONAL RESEARCH COUNCIL, COMMITTEE ON TECHNICAL BASES FOR YUCCA MOUNTAIN STANDARDS

Mr. FRI. Thank you, Mr. Chairman. My name is Robert Fri. I have the honor of having been the chair of the National Research Council Committee that produced the report on the Technical Bases for the Standards at Yucca Mountain, the Academy report which has been referred to already a couple of times in these hearings.

Let me summarize my statement by hitting on two major points. First of all, the committee, which disbanded after it issued its report in 1995, was very sensitive to the fact that science can only take you so far to coming up with a standard. At some point, policy has to step in and make the final decisions.

That is particularly true in the level of risk that the public is willing to accept from Yucca Mountain or any other nuclear waste facility. Science can tell you a lot about the nature of the effects and other matters, but the ultimate decision is a policy decision, and the report did not, nor will I, be in a position to talk to you about what the right answer is to that policy decision because science doesn't get you that far.

The second point I would like to summarize has to do with this business of 10,000 years versus a million years because, as you know, the most recent remand by the Courts, that produced the most recent version of the standard that EPA produced, really rested on that issue that was in the Academy's report. If I may, I am going to use this cartoon next to me to try to explain a little bit about what is going on.

What you have to do after you set a standard is to do an analysis to see if the repository will comply with it. So, you use computer models to model the migration of the radioactive materials down to the water table and throughout the water table to where human beings can come into contact with it.

There are two big things you have to decide how to do in these so-called compliance analyses. One is to decide how long to run the model, and the other is to decide on the exposure scenario by which individuals come in contact with the radioactive material.

The Academy report said there is no scientific basis for stopping at 10,000 years, and that being the case, it is appropriate to continue this analysis up to the point of peak risk or until the point at which you don't think the models are going to fairly represent what is going on geologically. The panel, the committee said that is probably on the order of a million years. We weren't trying to predict, and we weren't suggesting that these models will predict what is going to happen in a million years, much less what is going to happen in 10,000 years. We are simply saying that, in terms of doing the analysis, the way the professionals do it, there is no scientific basis for stopping at 10,000 years. Therefore, we selected a much longer time period for analysis.

The second issue is the exposure scenario. How do people come into contact with this radioactive material that gets offsite as it migrates through the water table which they may do by drilling a well into it and drinking the water, or eating vegetables that were irrigated with the water, and the like? The site at Yucca Mountain was picked because, among other reasons, there aren't a lot of people there.

So, the committee said that we think the appropriate way to approach this, just as a kind of statistical matter, is to have what is called a probabilistic exposure scenario, to say that it isn't absolutely necessary that somebody will come in contact with this stuff, but there is a chance that they will and it ought to be modeled on a statistical or probabilistic basis.

Now, EPA said, no, let us stick with the short time period, 10,000 years, but as the gentleman from EPA pointed out, they had this idea of Reasonably Maximally Exposed Individual which is a deterministic concept. It says that that individual will become, will come into contact with the material that is migrating offsite. So you have these two variables.

This little chart is sort of designed to suggest that. The vertical axis says Shorter Compliance Time at the bottom and Longer Compliance Time at the top. Across the top, it says Deterministic Exposure Scenario and Probabilistic.

Now you really don't need to get into technical details but just to show you what happened. EPA said, down in the lower left hand corner, let us have a shorter compliance time and the deterministic

scenario, and the Academy said, let us have a longer compliance and a probabilistic scenario. So they were kind of at opposite ends of the spectrum.

Now the Court said, you have to stick with the longer compliance time, the million years. So EPA basically had three options, it seems to me. One is to adopt a more probabilistic exposure scenario the way the Academy did. They elected not to do that because they want to stick with this RMEI, this Reasonably Maximally Exposed Individual, which is fine. They could have tried to show that the two versions of the standard are functionally equivalent, and they may be for all I know, but that demonstration wasn't made.

So they are kind of stuck in the upper left hand corner, and that is a place where the committee did not want to be. We actually considered it. We thought that was too conservative a place to be, given the circumstances at Yucca Mountain. So EPA finds itself in some place where the committee probably wouldn't have agreed that it should be.

EPA did not select the option of going with the million years and the probabilistic exposure scenario. What they did was, after 10,000 years, to change the standard. That does have the effect of releasing——

Senator INHOFE. If you could draw to a conclusion here in a moment, Mr. Fri?

Mr. FRI. That is it. I am done.

Senator INHOFE. That is it?

Mr. FRI. Yes.

Senator INHOFE. Thank you.

Mr. FRI. Thank you very much.

Senator INHOFE. Ms. Macfarlane.

STATEMENT OF ALLISON MACFARLANE, RESEARCH ASSOCIATE, PROGRAM IN SCIENCE, TECHNOLOGY AND SOCIETY, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Ms. MACFARLANE. Mr. Chairman and members of the committee, it is an honor to have the opportunity to address you on the issue of the status of nuclear waste disposal at Yucca Mountain. I am a research associate at MIT's Program in Science, Technology and Society, and I have a Ph.D., in Geology from MIT.

Mr. Chairman, Ranking Member Jeffords, let me begin by emphasizing that, in my expert opinion, the best solution to the problem of high level nuclear waste disposal remains a geologic repository. On this issue, all countries with nuclear energy programs are in agreement, though none has yet to implement such a facility.

In light of the push for more nuclear power in the United States, even taking into consideration the President's proposed Global Nuclear Energy Partnership, it is highly likely that multiple Yucca Mountain type repositories will be necessary. Therefore, it is imperative that we continue to work toward a solution to the problem of high level nuclear waste.

Yucca Mountain is a relatively complex site geologically, and this complexity increases the uncertainties associated with predicting the performance of the repository in the future. The DOE has attempted to predict the behavior of Yucca Mountain over time, using

a complex computer model called probabilistic performance assessment, which is made up of numerous submodels.

The DOE has stated that it has validated these submodels. From the perspective of an earth scientist, it is not possible to validate or verify models of earth systems. This is because earth systems are, by definition, open systems, accessible to exchanges of matter and energy. As a result, it is not possible to know all the processes that might affect the system.

Defense Secretary, Donald Rumsfeld probably put it best when he noted, "There are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns—the ones we don't know we don't know." It is the unknown unknowns that I am concerned about here.

The DOE and the NRC will use the results of the performance assessment to determine the suitability of Yucca Mountain. They are forced to use this complex model in part because the EPA standard requires these agencies to show that the site will meet a specific dose limit over a specified time period. To do so requires quantitative analysis, and thus the need for a performance assessment model. Other countries have recognized the limitations of quantitative performance assessments, including France and Sweden.

So what policy would best respond to the complex geology at Yucca Mountain and the inability of performance assessment models to produce verifiable results? I have four suggestions.

No. 1, there is a natural opportunity to make changes to our system of site evaluation right now while the EPA standard is being reconsidered. Once the EPA standard is promulgated, the NRC and DOE will have to adjust their regulations and can take this opportunity to rethink them.

No. 2, in making changes to regulations, the DOE and NRC should move away from sole reliance on probabilistic performance assessment and opt for a broader and more qualitative assessment scheme similar to that of France and Sweden.

No. 3, work must continue on the Yucca Mountain site to determine whether it will be suitable as a geological repository. I suggest a comparative analysis, using data that already exists for a number of investigated repository sites around the world.

No. 4, if Yucca Mountain is found lacking in the comparison, Congress would need to revisit repository siting. In the United States, we are fortunate to have a large country with many geologically appropriate locations for a nuclear waste repository that have arguably simpler geology than Yucca Mountain.

For a repository to succeed, the process must be fair and perceived to be fair by all participants.

A large amount of high level nuclear waste already exists in the United States and requires disposal. This problem deserves rapid and focused attention for the betterment of our environment. It is within our grasp to solve this problem.

Thank you for the opportunity to present my views.

Senator INHOFE. Thank you, Dr. Macfarlane.

Is it Mr. Loux?

Mr. LOUX. Loux.

Senator INHOFE. You are recognized, Mr. Loux.

STATEMENT OF ROBERT LOUX, EXECUTIVE DIRECTOR, NEVADA AGENCY FOR NUCLEAR PROJECTS, OFFICE OF THE GOVERNOR

Mr. LOUX. Thank you, Mr. Chairman. I, too, am grateful for your invitation on behalf of Governor Guinn. I am testifying here on his behalf. I am Bob Loux, and I am the executive director of the Nevada Agency for Nuclear Projects which is in the Governor's Office itself. The Agency was established in 1985 to carry out the State's statutory oversight of the high level waste program under the Nuclear Waste Policy Act.

Since you have already indicated our written remarks will be submitted for the record, I won't ask that.

As to the status of the Yucca Mountain project, the most important and obvious fact is that there is no current schedule or budget for DOE's submittal of a Yucca Mountain repository license application to the Nuclear Regulatory Commission. As you already noted, by law, DOE was to have submitted the application 90 days after the site recommendation was confirmed by Congress in mid-2002, and the last announced date for site application was December 2004.

Even if a final EPA standard was in place today, DOE would be unprepared to submit a license application because of its recently announced shift to a single container approach for transportation, storage, and disposal of radiated fuel. This very same approach was rejected by DOE a decade ago for being too costly and logistically too difficult to implement. So it will be interesting to see how DOE is going to approach it this time.

The current change involves design and certification of new containers, fundamental redesign of the Yucca Mountain surface handling facilities because of the change in concept of operations, and shifting the complex waste packaging operations to the reactor sites, some of which, maybe as much as 40 percent of the reactor sites, no longer have crane or rail capacity access for the newly planned containers.

The probability of earthquakes damaging the operational facilities and the renewed volcanism disrupting the repository are sufficiently high, that radiological consequences of such events must be considered in the repository safety assessments, and work on these topics is ongoing.

DOE is unprepared to complete the license application because scientific work critical to the NRC regulatory review is in jeopardy. The model for how water penetrates the mountain is being redone because of quality assurance failures and allegations of falsification of information, which still are being investigated by congressional committee along with others including the Justice Department. Recently, the scientific work to determine the rate at which disposal containers will corrode and release waste into the environment has come into significant question as a result of an audit of scientific experiments and their quality assurance.

The planned repository surface facility, including storage aging pads if you would, is located beneath a military training and testing airspace that is dedicated to National security. Aircraft crash

hazards remain issues unresolved for the safety analysis and the license application.

DOE has yet, also, to complete a draft Environmental Impact Statement for the 319 mile long rail line to Yucca Mountain. It is also the subject of litigation. The expected costs of the line recently was raised from $1 to $2 billion. The corridor selected crosses seven mountain ranges and traverses areas known to flash flooding.

By 2010, there will be enough generated waste to fill the statutory capacity of Yucca Mountain. Extremely costly strategies recently announced to reduce the volume of waste won't be available for decades, if ever, and I am speaking of the GNEP which we have been talking about. Expanding Yucca Mountain's statutory capacity without having defined and studied the expansion area is irresponsible from a safety perspective.

DOE is required by statute to maintain retrievability of the waste for decades after en-placement. It is unlikely this ability can be demonstrated due to the high heat, radiation environment, and deterioration of tunnel conditions. In fact, in its 2007 budget proposal, DOE is asking for funds to maintain and upgrade existing tunnel facilities in just over 10 years after initial construction.

I have described to you the status of the Yucca Mountain project and gave some insight why the schedule for the license application is unknowable. If the past 23 years of the program provides any message, it is that the schedule in reality is largely unknowable.

Mr. Chairman, I agree with your statement early on that really no more work is really necessary at Yucca Mountain, although it is not for the same reasons. I agree with that because most believe, independent scientists, that the Yucca Mountain science is faulty. It has been recognized to be such by most independent scientists nationally and internationally.

So with that, Mr. Chairman, I thank you for your time and look forward to questions.

Senator INHOFE. Thank you, Mr. Loux.

Dr. Moeller.

STATEMENT OF DADE W. MOELLER, FORMER PRESIDENT, HEALTH PHYSICS SOCIETY

Mr. MOELLER. Thank you, Mr. Chairman, and Senator Jeffords, and Senator Boxer. I appreciate the opportunity to share with you some of the views of the Health Physics Society.

As all of you are aware and as we have heard here repeatedly this afternoon, progress on the proposed Yucca Mountain repository is essentially at a standstill. At the same time, high-level wastes are being stored at multiple locations throughout the United States. These materials will remain there until this log-jam is broken.

Rather than talk, though, about that past, I would like to talk about the future, and I want to share with you what the Health Physics Society would propose. The key element of our proposal is that, rather than seeking to dispose of the waste at this time, that the waste be stored in the proposed Yucca Mountain for a time period of 100 years.

To ensure that the stored waste is not contaminating the environment, the facility would have to be properly monitored, and in-

strumented to provide, throughout the suggested 100-year period, immediate warnings if anything has gone wrong. Any packages showing signs of deterioration would need to be promptly retrieved and stabilized.

Now at this point, I want to discuss the primary basis for our policy, and in order to do so, Mr. Chairman, I have an enlarged picture of the graph that is on the bottom of Page 4 of my testimony. I would be glad, if it is permissible, to have all of you have copies.

Senator INHOFE. We have a policy that any graphs used have to be submitted in advance, but yours was. So that will be all right.

Mr. MOELLER. It was in my written testimony.

Senator INHOFE. Please use it. Your clock is ticking.

Mr. MOELLER. OK. Storing the waste for 100 years will enable us and our Nation to take advantage of the many significant technological advances that you have already heard Mr. Golan describe. One of these is to begin reprocessing spent fuel once again.

To demonstrate the benefits of reprocessing, I would like to go through with you what is shown on the graph. Across the bottom, it gives time in years. This is shown on a logarithmic scale. Following this approach, the years are shown with each division representing 10 times the number of years as the previous one. For example, the first maker represents 1 year, the second 10 years, the third, 1,000 years, etc.

Shown by the curve at the upper left-hand corner of the graph is the toxicity of the radioactive waste that we are going to assume has been chemically reprocessed and that about 95.5 percent of the plutonium has been removed.

Now Mr. Golan said their newer chemical techniques would be applied. These would remove not only more of the plutonium, but also most of the actinides and transuranics. If you look at the graph, after a period of slightly more than a hundred years, the waste would be equivalent in terms of toxicity to naturally occurring uranium ore which has a concentration of 3 percent, that is, ore in which 3 parts in every 100 are uranium. After about 350 years, the waste will have decayed to the point where it is comparable in its toxicity to uranium ore that contains $\frac{2}{10}$ of 1 percent uranium.

Why do I emphasize this? I do so because that is the concentration of uranium in the ore that has been mined at, for example, Grand Junction, CO and has served as fuel for our commercial nuclear power plant.

Now why has this decrease in toxicity occurred at such a rapid rate? Well, in reprocessing the fuel, you remove the cesium-137 and the strontium-90, two of the most important fission products. These have half-lives of 30 years, and they become important components of the waste.

Then why do I say 300 to 350 years as important milestones in the toxicity of the waste? Well, 300 years is 10 times a half-life of either strontium or cesium. If you take a half of a half of a half of a half for 10 times, you don't have much left. In essence, it is essentially a stable mass that is left in terms of those two radionuclides.

Thereafter, the waste will continue to decay, and after a period of about 2,000 years, its toxicity will have decreased to about $\frac{1}{10}$

of ore containing a concentration of about 0.2 percent uranium. Subsequently, as the graph indicates, the toxicity of the waste will slowly increase, finally leveling off at about 1 million years being equal to that of ore containing 0.2 percent uranium.

Why does toxicity increase? It does so because the uranium is gradually decaying and producing its toxic decay products. Nonetheless, as the graph indicates, the highest toxicity the reprocessed waste can ever reach during this time-period will be only slightly higher than that of the original 0.2 percent uranium ore.

Have I had my 6 minutes yet?

Senator INHOFE. Yes, you have, if you could try to wind up, please.

Mr. MOELLER. All right, I will finish with this summary statement. If the maximum toxicity of the reprocessed waste is comparable to that of the original ore that was near or at the surface of the Earth, as contrasted to the waste which will be buried more than 600 feet beneath the ground, what do we have to worry about?

Senator INHOFE. OK. Since you are still warmed up there, Dr. Moeller, let me ask you a question.

Mr. MOELLER. Certainly.

Senator INHOFE. During the last panel, Senator Boxer cited some very high risk numbers based on EPA's proposed doses. From a radiation standpoint, can you derive quantitative risk numbers as high as Senator Boxer quoted, considering the EPA's standard is 350 millirem?

Mr. MOELLER. I am delighted that you asked me because I am pleased to answer the question.

Senator Boxer, your estimate from Dr. Tom Cochran, whom I know very well, sounds to me to be high. But to answer your question, if indeed his calculations were correct and the dose rate limit of 350 millirems a year creates a one in four risk of women dying of cancer, that is totally unacceptable. No one would approve that.

Now, on average, about 20 percent of the members of the U.S. public die of fatal cancers. Some of those may be due to radiation, but there are many other causes.

Before I could answer your question, I would need to review the process Dr. Cochran used in making his estimate. As you will note in my written testimony, I calculated the fatal cancer risk for a lifetime dose rate of 350 millirems per year and obtained an estimate of about a 1 percent increase in death due to all types of cancer. When you take into account the conservatism in that estimate, the true value is about half of 1 percent.

Senator INHOFE. I am sure that Senator Boxer will have some responses to that.

Dr. Macfarlane, you were here when Senator DeMint was asking his question, his concern—I wasn't even aware of what is happening in South Carolina to the extent that it has been happening—but his concern about the current policy of leaving things above or storing wastes in existing sites until they can apply future technologies.

Wouldn't it still be better, though, for the next 100 to 300 years, if that waste were put into Yucca Mountain in a fully retrievable

state rather than to leave it there as it is now? Maybe I am misunderstanding what your testimony was.

Ms. MACFARLANE. No. I guess what I am trying to say is, in terms of interim storage, temporary storage, I think it is fine for a hundred year timeframe. I think we have a responsibility to deal with the issue of nuclear waste right now. It is an ethical responsibility, seeing how we made this waste.

I don't agree with the proposals to sit around and wait until we have better technology, and I think the best solution to this material is a geologic repository, but I am not sure that Yucca Mountain is the right location for a geologic repository.

Senator INHOFE. First of all, I see a political problem in your response because I would hate, if I were in Jim DeMint's position, to have to go home and say, it is all right for a hundred years; we will take care of this problem.

You mentioned, I think you said that there are other sites that are better than Yucca. Did I misunderstand you? If so, where are they?

Ms. MACFARLANE. I think there are multiple sites all over the country that are probably better than Yucca.

Senator INHOFE. Name one.

Ms. MACFARLANE. I don't want to end up naming specific sites and frightening certain State people, but I think these locations exist. You could look at——

Senator INHOFE. You are not suggesting one might be in Oklahoma, are you?

Ms. MACFARLANE. Oh, I am sure there are, for instance.

[Laughter.]

Senator INHOFE. All right.

Ms. MACFARLANE. But the point is that Yucca Mountain violates one of the main criteria of siting a nuclear waste repository, which is that you find a geologically stable location, and Yucca Mountain is neither seismically nor volcanically stable.

Senator INHOFE. Thank you very much.

Mr. Fri, the National Academy of Sciences issued a study in 2001, reaffirming that the geologic repository is the best method for permanent disposal of used fuel. Has anything happened since that time that they would have changed their position on that?

Mr. FRI. I haven't been a part of those studies since 1995, but I think the general feeling is that the ultimate disposal site as a geologic repository remains, as Dr. Macfarlane said earlier, the best option.

Senator INHOFE. I see. I have a feeling you would have heard about it if a change of position had taken place.

Senator Jeffords.

Senator JEFFORDS. I have no questions.

Senator INHOFE. All right, Senator Boxer.

Senator BOXER. Mr. Chairman, what I want to do is put in the record the study of Dr. Cochran, the nuclear physicist, and I think that what I would like to do is put in his little profile and then the one page of work he did which came out with the cancer risks that I am glad to see Dr. Moeller said was unacceptable because I certainly think it is as well. So we will put that in the record.

Senator INHOFE. Without objection, that will be in the record.

Senator BOXER. Thank you so much.
[The referenced material follows.]

NATURAL RESOURCES DEFENSE COUNCIL

References/Links
Profiles

Thomas B. Cochran

PROFILE
I am a nuclear physicist and an environmentalist. The primary focus of my work has been on matters related to nuclear weapons, fissile material control, and nuclear waste management.

VITAL STATS
Age 59. Married: Carol is an elementary school counselor. Two children: Jaquelin is in graduate school at the University of California, Berkeley, in the ERG Program; Carrie works on a Chesapeake Bay Foundation farm growing organic vegetables for low income families.

PRESENT ACTIVITY
Right now my time is divided between two projects: NRDC's Nuclear War Plans Project and assisting in the development of a mechanism for raising money to secure Russian weapons-usable fissile material against theft and diversion. With regard to the first, my colleague, Matthew McKinzie, and I are developing a computer model for assessing the blast and radiological impacts of using nuclear weapons under U.S. and Russian war fighting scenarios. Even today, a decade after the Cold War ended, a military officer follows each of the two presidents with a case holding a list of war scenarios which are very real and are tied to nuclear weapons on alert in both countries. Our computer program attempts to replicate the war plans and simulate realistically the use of nuclear weapons on likely targets under the various scenarios.

Thomas B. Cochran is the director of NRDC's Nuclear Program and holds the Wade Greene Chair for Nuclear Policy. He initiated NRDC's nuclear weapons databook project and the U.S.-Soviet nuclear weapons verification project, a four-year collaboration between NRDC and the Soviet Academy of Sciences, to demonstrate that a low-threshold nuclear test ban treaty could be verified. Dr. Cochran has been a member of numerous government advisory committees on nuclear energy, nonproliferation and nuclear clean-up issues; he joined NRDC in 1973.

(For another profile of Dr. Cochran, see the May 1998 issue of Scientific American.)

FAVORITE PLACE
Monterey/Carmel peninsula -- it's hard to beat. I spent four years and met my wife there. The landscape is gorgeous, it's well zoned, there is little pollution because of the prevailing winds from the ocean, and the weather beats the East Coast.

ENVIRONMENTAL HEROES
There are many terrific environmentalists at NRDC and elsewhere. The champion of all of them is [NRDC president and founder] John Adams. He has spent 30 years building and leading NRDC, the premier environmental organization in the world. He has managed it almost flawlessly, instilling qualities in the organization that make working at NRDC rewarding and a pleasure.

MOST WORRISOME PROBLEMS
The most troublesome environmental problems are hunger, lack of potable water, good hygiene and decent medical care throughout much of sub-Saharan Africa, south Asia and North Korea; and now in Russia we are seeing serious and rapid deterioration of the quality of life due to a lack of food and adequate medical care and widespread pollution, primarily from the production and use of industrial chemicals.

WORST POLLUTION IN RUSSIA
Lake Karachay at Chelyabinsk-65, a Russian nuclear weapon production site, contains 120 million curies of radioactivity, mostly cesium-137. That's equivalent to emptying essentially *all* the high-level waste tanks at the Hanford Reservation in Washington state into a 30-acre lake that's only about eight feet deep. The radioactivity has been seeping into the groundwater for decades and the Russians don't have the money to clean it up.

HOW TO REMEDY THE PROBLEM
It's a national sacrifice area -- it will never be cleaned up entirely. The situation can be partially stabilized by filling in the lake and covering it over. Even in this case, wealthy folks in the West are going to have to ante up, otherwise it's just not going to happen. There is no money available for environmental remediation in Russia. The Russian economy is cratering. Western investors are scared off by rampant corruption and a failed legal system -- it's like Chicago in the 1930s.

FUTURE OUTLOOK
The United States is spending about $6 billion cleaning up the nuclear weapons complex, and even here the Department of Energy is relaxing standards, creating our own national sacrifice areas and cutting other corners to save money. In Russia, the pollution is far worse, and there is essentially no clean-up program whatsoever. It looks bleak.

last revised 6.19.00

Website: http://www.nrdc.org/reference/profiles/prococh.asp

BEIR VII Cancer Risks
Table ES-1, p. 28.

The Committee's preferred estimates of the lifetime attributable risk (LAR) of incidence and mortality for all cancers and for leukemia with 95% subjective confidence intervals. Number of cases or deaths per 100,000 exposed persons.

	All solid tumors		Leukemia	
	Male	Female	Male	Female
Excess cases (including non-fatal cases) from exposure to 0.1 Gy	800 (400,1600)	1300 (690,25000)	100 (30, 300)	70 (20, 250)
Number of cases in absence of exposure	45,500	36,900	830	590
Excess deaths from exposure to 0.1 Gy	410 (200, 830)	610 (300, 1200)	70 (20, 220)	50 (10,190)
Number of deaths in absence of exposure	22,100	17,500	710	530

							M+F			
For 1,000,000 person exposed to 1 rem					Male	Female	Average			
Excess cases	800	1,300	100	70	900	1,370	1,135			
Cases absent exposure	450,000	369,000	8,300	5,900	458,300	374,900	416,600			
Excess deaths	410	610	70	50	480	660	570			
Deaths absence exposure	221,000	175,000	7,100	5,300	228,100	180,300	204,200			
							M+F	Male	Female	M+F
For 1,000 person exposed to 1 rem							Average	Excess (%)	Excess (%)	Excess (%)
Excess cases	0.80	1.30	0.10	0.07	0.90	1.37	1.14	0.196	0.365	0.272
Cases absent exposure	450.00	369.00	8.30	5.90	458.30	374.90	416.60			
Excess deaths	0.41	0.61	0.07	0.05	0.48	0.66	0.57	0.210	0.366	0.279
Deaths absence exposure	221.00	175.00	7.10	5.30	228.10	180.30	204.20			
							M+F	Male	Female	M+F
For 1,000 persons exposed to 70 rem							Average	Excess (%)	Excess (%)	Excess (%)
Excess cases					63	95.9	79.45	13.7	25.6	19.1
Cases absent exposure					458.30	374.90	416.60			
Excess deaths					33.6	46.2	39.9	14.7	25.6	19.5
Deaths absence exposure					228.10	180.30	204.20			

Senator BOXER. First, I want to thank the panel very, very much. As I said, it is complicated. We are dealing with issues here that just pose tremendous risks, and any way you look at it, it is risky: to leave it, to move it, to store it. But I come down on the side of the greater risk is to go with Yucca Mountain for lots of reasons, and a couple of you really have underscored that for me.

Mr. Loux, I understand DOE still needs to build a rail line to Yucca Mountain, and that cost estimates for this line have increased from $800 million to more than $2 billion in the last year, and I have a newspaper article that so states. If DOE cannot finish the rail line prior to accepting waste at Yucca, I understand DOE plans to temporarily use trucks to ship the waste from the nearest railroad.

I would love to hear you give an opinion on how DOE's failure to complete this rail line may impact Yucca Mountain operations, including potential security or safety concerns.

Mr. LOUX. Well, thank you, Senator. We have grave doubts whether such a line ever can be built, especially given that DOE is the one in charge. The costs have escalated. We think they are going to go actually much higher.

Senator BOXER. Higher than $2 billion?

Mr. LOUX. Yes. We think it is going to take a lot longer than DOE says, perhaps maybe as long as a decade to complete. Therefore,——

Senator BOXER. Who is going to pay for this rail line?

Mr. LOUX. The ratepayers and the taxpayers.

Senator BOXER. OK.

Mr. LOUX. Ultimately, we believe that if Yucca Mountain should go forward, that in the final analysis, most if not all the shipments will be by truck. As I mentioned in my testimony, a full 40 percent of the reactor sites no longer have rail access into them. So then you see a problem with having to move that stuff to marshaling yards in Omaha, Chicago, other sorts of places like that where you would have to accumulate enough waste then to build a train to actually take it, assuming the rail line was built.

Senator BOXER. Well, you have walked right into my next question because I am very concerned about movement by truck. I am concerned about movement of this material in any way, shape, or form, but by truck in particular. California contains some main routes proposed for transporting radioactive waste to Yucca Mountain. A lot of other States' waste will go through my State on the way there.

Last month, the National Academy for Sciences said that the DOE should analyze their transportation plans to account for terrorist acts and high intensity long duration fires. What is your opinion on how well DOE current transportation plan addresses these two vitally important issues, long duration fires and the possibility of a terrorist attack?

Mr. LOUX. Well, Senator, when you start out with the assumption that all nuclear waste shipments are 100 percent safe and nothing can go wrong, it biases your point of view about what the actual risks are. That is sort of DOE's opinion, that it all will be done safely, 100 percent safely without any risk to anyone. We find that to be the contrary, and that is what we found so refreshing

about the actual National Academy report because it was the first time that any of these Government agencies have said something other than the fact that this is 100 percent perfectly safe.

Senator BOXER. So when I ask you your opinion of how well DOE's current transportation plan addresses the terrorism issue and long duration fires, your answer is that they really don't address them.

Mr. LOUX. It does not.

Senator BOXER. They just kind of shove it under the rug and say, we don't need to look at it because this is so safe. Is that what you are basically telling me?

Mr. LOUX. In general, yes.

Senator BOXER. OK. Can I have time for one more question?

Senator INHOFE. Sure.

Senator BOXER. OK.

Ms. Macfarlane, in 1995, the National Academy report included a reference to a prediction that the geologic stability of the Yucca Mountain site was on the order of a million years. You have done recent research on this project. I know you gave us sort of the Don Rumsfeld answer, but I am going to pin you down a little more here.

Please give me your expert opinion on these two questions: Is the stability prediction based upon either current science or science from a decade ago, and does it comport with our current understanding of Yucca Mountain's geology, the fact that it will be stable for a million years?

Ms. MACFARLANE. That is a good point. I think it was based on science from a decade ago. Science has progressed in a number of ways. One of the things I would note about the National Academy study is—I think it is page 68 of the study itself—when they talk about their basis for that statement, one of the things they don't mention is volcanism and the potential for future volcanism. We now know that there is that potential. It is not very well bounded. It is quite an uncertain number, and it certainly becomes a lot more uncertain as you go out toward a million years.

Senator BOXER. Thank you. Mr. Chairman, I want to thank you for the opportunity. As always, you were very generous to me. Thank you.

Senator INHOFE. Thank you, Senator Boxer. Let me just, I saw Mr. Fri wiggling around a little bit during one of your questions, Senator Boxer. So let me give him a chance to perhaps answer.

Senator BOXER. Of course.

Senator INHOFE. It is true, I understand, that a recent National Academy of Sciences study, studying the transportation of this waste, came to the conclusion that there is "no real risk to public health and safety in transporting the fuel." Now, it is my understanding, Dr. Boxer—I said Dr. Boxer.

Senator BOXER. I will take it.

Senator INHOFE. Senator Boxer, this study is less than a month old. So that would have taken into consideration the point that you bring up about terrorists. Mr. Fri, am I accurate in quoting from this study?

Mr. FRI. I am sure you are. I was not a party to that study, so I don't know what is in it.

Senator INHOFE. All right.

Senator BOXER. Well, I just think Mr. Loux——

Mr. FRI. The staffer at the Academy whispers in my ear, however, that there may be a misstatement some place in there.

Senator INHOFE. I see. I certainly wouldn't want to be guilty of that.

Well, thank you very much. We had a very distinguished panel, and you have been very patient to wait through a rather lengthy panel to get on, but I appreciate the sacrifices you have made to be here. We will leave the record open. So there will be questions for the record that will be submitted to you, and we look forward to your answers at that time.

With that, we are adjourned.

[Whereupon, at 4:30 p.m., the committee was adjourned.]

[Additional statements submitted for the record follow:]

STATEMENT OF SENATOR GEORGE V. VOINVOICH, U.S. SENATOR FROM THE STATE OF OHIO

Mr. Chairman, thank you for holding the committee's first hearing on this very important matter. The operation of Yucca Mountain as our Nation's long-term high level nuclear waste repository is important to meeting our environmental, energy, and economic needs.

I am pleased that this follows the hearing that I held in my subcommittee on natural gas prices. Clearly, we have not harmonized our policies. The energy challenges that we face today and into the future threaten our global competitiveness. I am calling for a "Second Declaration of Independence" to make us less dependent on foreign sources of energy, and nuclear power plays an integral role.

Nuclear power provides about six percent of the electricity consumed in my state and about 20 percent nationally. It is emission free power, and by increasing its use, we could continue at a greater rate our progress in cleaning up the air.

That is why I am pleased that this committee acted to include three pieces of legislation that I authored with Chairman Inhofe in the Energy Policy Act of 2005 to provide for the safe and secure growth of nuclear power. These provisions—NRC reforms, security, liability insurance, and human capital—combined with the Energy bill's sections on risk insurance, production tax credits, and loan guarantees provide the foundation for the construction of new nuclear plants. In fact, NRC Chairman Nils Diaz recently told me in a meeting that the NRC expects to receive applications for up to 11 new plants by 2009.

Other countries have also recognized the advantage of constructing new nuclear plants. China, which continues to grow and threaten our economic security, expects to construct 20 new nuclear reactors by 2010.

The challenge for nuclear energy is its waste. This problem was recognized when the Nations' top scientists met in Princeton in 1955, leading us to begin searching for the most optimum site for nuclear waste disposal.

Frankly, I am extremely frustrated that more than 50 years later, we have yet to solve this issue. We have spent $8 billion of ratepayer funds with over $250 million contributed by Ohioans to the Nuclear Waste Fund. Congress passed the Nuclear Waste Policy Act requiring that a final disposal facility be operational by 1998. The President, Senate, and House in 2002 designated Yucca Mountain as the site.

So where are we today? Spent nuclear fuel is stored at sites across the Nation including 790 metric tons in Ohio instead of one safe and secure repository. Eight years after the law requires a storage facility to be operational, the Department of Energy has yet to even submit a license to the NRC.

The really exasperating part is that while we are providing numerous regulatory incentives for the growth of nuclear power we are providing a significant disincentive by leaving the waste question unanswered.

Again, Mr. Chairman, thank you for holding this hearing. Unfortunately, there seems to be a lot more questions than answers: lack of a DOE license application to NRC, EPA's million year standard, reprocessing, and many others.

I look forward to the testimony from the witnesses and hopefully getting some answers to these questions.

Thank you.

STATEMENT OF HON. JOHN ENSIGN, U.S. SENATOR FROM THE STATE OF NEVADA

Thank you for the opportunity to testify on the second proposed rule concerning Yucca Mountain radiation standards. This rule, on its face, does not make sense. The closer one looks, the worse it appears.

I understand that the EPA was in a difficult position. The original EPA Yucca rule and the subsequent NRC standard were thrown out by a Federal appeals court. The Court found that the 10,000-year compliance period was not "based upon and consistent with" the NAS recommendations required by law. It failed to protect at the point when the waste would be at its peak radiation. So what did the EPA do?

Well, EPA did not put forth a common-sense solution. That would have been to extend the 15-millerem-per-year standard that it originally proposed in order to cover the peak dose period as required by the Court. We know why EPA did not do this. It didn't do it because Yucca Mountain could not be engineered to meet that standard. Yucca Mountain could not be built.

Instead, the EPA took the old standard that was rejected by the Court, reproposed it in its entirety for the first 10,000 years, and then proposed a standard for the 10,000 to 1 million-year period that would be, by far, the weakest peak dose standard in the world. The President of the National Council on Radiation Protection has publicly opposed it. So, once again, sound science was sacrificed for expediency.

The Agency for Nuclear Projects of the State of Nevada has done an excellent, thorough analysis of this scientifically indefensible approach. I know that you will be hearing today from the Executive Director, Bob Loux, who will explore the weaknesses of the rule in detail, so I will not do so here. I will, however, underscore that it is important for this committee to look at several areas—the two-tiered radiation exposure limits, the use of mean performance results in the first 10,000 years and then median performance results later, the groundwater protection standard that disappears before the period of peak exposure, and the odd decision to set a health-based standard that relies on comparing radiation doses in Amargosa Valley, NV, to Colorado.

There are some who believe that Congress should ignore the recommendations of the National Academy of Sciences and simply lower the safety standards for the permanent storage of this deadly material. Senator Reid and I are committed to making sure that doesn't happen. But in a broader sense, legislation won't make nuclear waste safe—and burying it in Yucca Mountain definitely won't make the problem go away. Even with a central repository, there will continue to be nuclear waste stored at all operating reactor sites. Mr. Chairman, we produce 2,000 metric tons of nuclear waste a year. The DOE plans to transport 3,000 metric tons a year. Just do the math. Under the current plan, we won't get rid of the nuclear waste backlog for nearly a century.

Mr. Chairman, Yucca Mountain continues to be plagued with problems and delays. The Department of Energy no longer even pretends to know when Yucca could open or how much it will cost. DOE once again has stopped work at Yucca Mountain after an NRC audit revealed that several years of data collection was done with equipment that had not been calibrated. These data are critical to health and safety because they relates to how water could enter the repository and cause corrosion of the nuclear waste storage casks. We need to find another solution to our nuclear waste problem. I think that we need to amend the Nuclear Waste Policy Act of 1982 to require the title to all spent nuclear fuel, stored in dry casks, to be passed on to the DOE upon onsite transfer from storage pools to casks. Senator Reid and I introduced legislation to allow the DOE to assume liability of the waste onsite before it is transferred to Yucca Mountain. Conveying the title means the DOE will have full responsibility for the possession, stewardship, maintenance, and monitoring of all spent nuclear fuel. Through the Act, the DOE would also be made responsible for various maintenance and oversight that would be associated with implementation.

Furthermore, we need to invest in new technologies at our national labs to recycle the waste without producing weapons-grade plutonium as a byproduct. A potentially viable option to "recycle" nuclear waste is Accelerator-driven Transmutation of Waste (ATW). Simply put, ATW transforms long-lived radioactive products into less hazardous materials and generates electricity as a byproduct. After 300 years, the residual activity and radiotoxicity of waste in the repository following the ATW process would be less than that for a non-assisted repository after 100,000 years. We know that we can store waste safely for 300 years. It can't be certain that Yucca Mountain will prove safe at the time of peak dose radiation as truly needed to protect the health of our citizens.

Mr. Chairman, this new proposed radiation standard is a farce. EPA was forced to create this ridiculous standard to make Yucca Mountain "work" on paper. But

that's not EPA's job. No amount of data manipulation is going to make Yucca Mountain work.

STATEMENT OF HON. HARRY REID, U.S. SENATOR FROM THE STATE OF NEVADA

I want to thank the Chair, the Ranking and other members of the committee for the opportunity to testify today on this issue, which is very important to me, my home State of Nevada and the rest of the country.

I am convinced that the proposed Yucca Mountain nuclear waste dump will never be built because of the myriad scientific, safety and technical problems in which it is mired. It simply is neither safe nor secure, as illustrated by several significant scientific, legal and budgetary setbacks this past year and a half.

Nuclear power plants and defense activities generate highly radioactive waste materials that remain toxic for thousands of years. Consequently, society must develop a secure way to store high-level nuclear waste and spent nuclear fuel rods that protects human health and the environment.

In 1982, Congress passed the Nuclear Waste Policy Act to address the difficult issue of storing such waste. The Act called for disposal of nuclear waste in a deep geological repository that would remain stable for thousands of years and directed the Department of Energy (DOE) to study a number of sites in detail and pick the most suitable site based on the natural features of the site. The Act instructed DOE to develop a list of natural, geologic features that constitute a safe repository, including factors pertaining to rock characteristics, hydrology, proximity to water supplies and population, and seismic activity. Some of these criteria specifically disqualified any site that would require complex engineered measures to prevent groundwater flow through the repository or damage from earthquake activity, both of which are concerns at Yucca Mountain.

The Nuclear Waste Policy Act of 1982 directed DOE to evaluate three sites in Washington, Texas and Nevada. Under the Act, the geologic characteristics of a site were supposed to prevent radioactive waste from escaping the storage facility. Using the original criteria for site suitability in the Act, the characteristics described above should have disqualified Yucca Mountain from consideration as a repository for high-level nuclear waste.

DOE has proposed that 77,000 tons of high-level nuclear waste can be stored in tunnels beneath the mountain, isolated from the environment for hundreds of thousands of years. Yucca Mountain is a volcanic ridge in southwest Nevada, about 90 miles from Las Vegas. Yucca Mountain is located only about 90 miles southwest from Las Vegas the fastest growing city in the United States.

As DOE research progressed, it became clear that geology alone would not contain radioactive waste at Yucca Mountain, and DOE began to design engineered waste containers to compensate for geologic weaknesses that would have disqualified the site under the 1982 Act.

Then, in 1987, Congress amended the Act to limit DOE's studies to Yucca Mountain. This move was not based on science. In fact, DOE was behind schedule on its characterizations of the three sites and had reached no conclusion on the suitability of any of them. Rather, Congress took action based on political expediency and cost considerations. Since 1987, DOE's mission has shifted from objectively evaluating whether a site was suitable to isolate radioactive waste to justifying Yucca Mountain as a safe site for storing nuclear waste.

On February 15, 2002, President Bush approved a recommendation from Secretary of Energy Abraham to build an underground storage facility for high-level nuclear waste at Yucca Mountain in Nevada. Governor Guinn of Nevada vetoed the site in April 2002. On June 9, 2002, Congress overrode the veto.

Although DOE has been studying the site for 20 years, their studies are incomplete and do not provide a basis for evaluating whether Yucca Mountain is a safe site for storing high-level nuclear waste, nor that it can be transported across America's highways and railways and through our communities safely.

Before transporting nuclear waste across the country's highways, rails, and waterways, adequate consideration must be given to the risks of, and we must be prepared to deal with, accidents, terrorist threats and containment breaches that may result. To date, we are not. Bad science, bad law and bad policy are what characterize Yucca Mountain and the decisions around transportation issues. The result is that transportation of highly radioactive nuclear waste around the country and to Yucca poses extraordinary hazards to the public health, economic security and environmental safety.

Moving all the high-level nuclear waste to Yucca Mountain and a second repository would take nearly 40 years and involve 105,000 truck shipments, or nearly

20,000 rail shipments over more than 40 years. Moving just the waste currently allowed by law to go to Yucca Mountain would involve nearly 53,000 truck shipments or 10,000 rail shipments over 24 years. As most of the waste is generated east of the Mississippi, that means most waste will be traveling across the country. Tens of thousands of shipments of deadly radioactive waste, an average of approximately 2,800 each year, will be rolling through neighborhoods in 43 States and hundreds of major metropolitan areas on its way to Nevada for the next several decades. Approximately 125 million people live in the more than 700 counties on DOE's highway routes, and approximately 110 million live on the train routes.

Communities through which nuclear waste could pass include: Sacramento and San Bernardino, CA; Denver, CO; Boise, ID; the Chicago metropolitan area; the Washington, DC, metropolitan area; Buffalo, NY; and Las Vegas, NV. If you live within 1.5 miles of a highway or railway, you live within 1.5 miles of a possible nuclear waste delivery-route.

Because of the enormous number of individual loads involved, the Government has acknowledged that there will be accidents no matter what we do. The effects could be catastrophic. One accident, one nuclear waste leakage or spillage, could be deadly. According to DOE, an accident or fire involving a 25-ton payload of nuclear waste could kill thousands immediately. The potential lasting effects are likely more significant, from radiation-induced cancers to poisoned groundwater. The cleanup costs could be in the billions. Other analyses show that contamination could spread anywhere from 40 to 500 square miles and latent cancer fatalities run into the tens of thousands, depending on the type of accident, transportation and population patterns in the area and the type of clean-up undertaken.

Shipping nuclear waste across the country also significantly increases the risk of terrorist attack. Unfortunately, the last few years have taught us that we are not immune from terrorist attack and that terrorists are getting more sophisticated. In addition, this is a large-scale, high profile Federal program—an attractive target for terrorists. Each shipment has the potential for hijack.

Imagine literally hundreds of moving targets all across America passing through towns just like this one. If waste is transported through a combination of methods, the casks will have to be switched out, parked on a siding, unloaded and reloaded from and into, barges, trains and trucks. Waste would be vulnerable to attack during packaging, shipment, temporary storage, repackaging, and in a national repository where nuclear waste will be stored above-ground for several years awaiting placement in the repository. Each shipment could be sabotaged to crash in populated areas or blown up with black-market high explosives or a missile in order to create what military scientists refer to as a dirty bomb.

Terrorism experts have termed DOE's planned transportation effort as a "target rich environment where a terrorist could pick and chose the time and place for an attack."[1] Unfortunately, DOE and the NRC are not been willing to take the necessary steps to secure the safety and security of nuclear waste shipments.

As Governor of Texas, President Bush wrote, "I believe sound science, not politics, must prevail in the designation of any high-level nuclear waste repository. As President, I would not sign legislation that would send nuclear waste to any proposed site unless it's been deemed scientifically safe." As President, Mr. Bush is apparently willing to endanger the health and safety of millions of Americans by letting politics and bad science prevail in the decision to site a nuclear waste repository at Yucca Mountain. Clearly, the push for the proposed Yucca Mountain nuclear waste repository waste has been driven more by politics and bureaucratic bias than by science.

Some of the highlights of the scientific and technical problems that have plagued the Yucca Mountain project the last year and a half alone include:

• On July 9, 2004, the D.C. Circuit Court of Appeals sided with the people of Nevada in a lawsuit to stop the proposed Yucca Mountain project. The court held that U.S. Environmental Protection Agency's radiation standard for the site was not stringent enough to protect the public from the significant risks associated with nuclear waste and failed to follow the recommendation by the National Academy of Sciences.

• On August 31, 2004, the Nuclear Regulator Commission's Atomic Safety and Licensing Board rejected DOE's Yucca Mountain document data base, saying it had failed to make public many of the documents that it had in its possession. The Board said, "Given the 15 years that DOE had to gather, review, and produce its

[1] Testimony of James David Ballard, Ph.D., Consultant, on behalf of the State of Nevada on "Transportation of Spent Fuel Rods to the Proposed Yucca Mountain Storage Facility" before the Subcommittees on Highways and Transit and Railroads Committee on Transportation and Infrastructure, U.S. House of Representatives, April 25, 2002.

documents and the fact that the date of production, and the incompleteness of its privilege review, it is clear to us that DOE did not meet its obligation, in good faith, to make all reasonable efforts to make all documentary materials available."

• On October 4, 2004, the DOE Inspector General found that DOE has given away more than $500,000 worth of Yucca Mountain construction equipment in 2003. Half a million dollars is a tremendous amount of the people's money to waste.

• On November 22, 2004, the Nuclear Waste Technical Review Board said DOE does not have a plan for safely transporting nuclear waste to the proposed repository.

• On February 7, 2005, Dr. Margaret Chu, most recently the Director of the Office of Civilian Radioactive Waste Management, said the project would be delayed until 2012 and that DOE's license application to the Nuclear Regulatory Commission would not be filed until December 2005, delayed another year. To date, the license application still has not been filed.

• On February 8, 2005, the Nuclear Waste Technical Review Board called for hearings to review concerns over the corrosion of the titanium drip shields that are intended to keep water from leaking into casks inside Yucca Mountain.

• On February 28, 2005, a DOE official said the proposed Yucca Mountain repository may not open until 2015.

• On March 16, 2005, DOE revealed that documents and models about water infiltration at Yucca Mountain, a key issue, had been falsified.

• On July 18, 2005, DOE announced that it will use dedicated train service for its rail transport of spent nuclear fuel and high-level waste to Yucca Mountain, a shift from two decades of administration policy that ignores the fact that about one-third of reactor sites are not capable of shipping fuel by rail.

• On August 22, 2005, EPA published its revised radiation standards for the proposed Yucca Mountain high-level waste dump. These standards are wholly inadequate, do not meet the law's requirements and do not protect public health and safety. In fact, EPA is proposing the least protect public health radiation standard in the world, a standard that is 40 times weaker than the public health standard for low level radiation. This proposal is unacceptable and will needlessly expose people to the risk of horrible adverse effect for generations. Please see the comments that Senator Ensign and I submitted to the EPA and Nuclear Regulatory Commission (NSC), which I have attached to this statement.

• On October 6, 2005, the DOE Inspector General (IG) found that DOE repeatedly gave business to Bechtel Corporation din spite of poor work performance. According to the IG, DOE paid Bechtel $4 million in "incentive based fees" even though "Bechtel did not meet contract specifications."

• On October 13, 2005, DOE asked staff to develop a series of actions to overhaul the Yucca Mountain project, going back to the drawing board and revisiting proposals discarded decades ago as unsafe or unworkable.

• On October 25, 2005, DOE announced that it would be redesigning the spent fuel storage process, both the containers and surface facilities admitting that their previous design was neither clean nor uncontaminated. DOE has offered scant details on the redesign.

• On November 16, 2005, the DOE Inspector General announced that DOE has ignored numerous of admitted instances of falsification of technical and scientific data on the project, showing that years of quality assurance problems continue.

• On November 17, 2005, DOE sent a detailed letter to its contractor regarding some of the desired changes in the site proposal, but still has not provided details to Congress or the public.

• On November 19, 2005, the Energy and Water Appropriations bill became law, cutting the Yucca Mountain budget to $577 million, half of what DOE said it would need to keep the project on track.

At the December 7, 2005, at the NRC-DOE quarterly meeting on Yucca Mountain, DOE announced that it expects to re-baseline the project mid–2006, requiring many of the technical and scientific analyses to be redone. There is still no timeline for when DOE will file its license application.

• On December 14, 2005, DOE suspended work on the surface facilities because of quality assurance concerns with the work of its contractor, Bechtel. DOE has since extended Bechtel's contract for work on Yucca Mountain.

• On January 30, 2006, concerns about the quality of the scientific work that is supposed to ensure the safety of waste stored at Yucca Mountain caused the NRC to issue a stop work order. The concerns are about the container's corrosion rate studies; the measurements are flawed.

• On February 9, 2006, the National Academies of Science (NAS) found that in order to safely transport spent nuclear fuel several things must occur, none of which DOE is currently undertaking, including: it must be done with great care and all

the existing regulatory requirements and guidelines must be followed; transportation must wait until it can be done almost entirely through dedicated train transport; the possibility of fires is investigated in more depth because of the unique safety concerns fires present; transportation routes are carefully selected based on safety and social concerns; NAS does a careful analysis of the security issues (terror risks, sabotage, etc.); and full scale testing of casks.

• In addition, we expect that a Government Accountability Office report on quality assurance issues that will released in March to confirm the on-going quality assurance problems with the work by DOE and its contractors.

• In numerous media reports, DOE has confirmed that it is preparing a legislative package that addresses Yucca Mountain. According to reports, this proposal will remove health, safety and legal requirements, a clear admission that DOE cannot meet the current public health, safety and technical requirements.

It should be clear to anyone that the proposed Yucca Mountain project is a failure. It is based on unsound science and cannot meet the requirements of law. It is not going anywhere. Delay after delay costs the taxpayers billions and billions of dollars for a project that the courts have ruled does not meet sufficient safety or public health standards. I do not believe that Yucca Mountain will ever open, and Nevada and the country will be safer for our successful efforts to stop the project.

In addition, DOE has consistently underestimated the costs of the Yucca Mountain Project, and total cost projections have grown more by tens of billions since 1983. In several reports on total project costs, DOE has cautioned that its cost estimates are a snapshot in time, based on preliminary design, and should be expected to change as the repository design develops. If history is any guide, the more DOE learns about Yucca Mountain, the more it will cost to site a nuclear waste repository there and the more taxpayer money we will waste on a flawed proposal.

Yet, we must safely store spent nuclear fuel.

A 1979 study by the Sandia National Laboratory determined that, if all the water were to drain from a spent fuel pool, dense-packed spent fuel would likely heat up to the point where it would burst and then catch fire, releasing massive quantities of volatile radioactive fission products into the air. Both the short-term and the long-term contamination impacts of such an event could be significantly worse than those from Chernobyl. The consequences would be so severe and would affect such a large area that all precautions must be taken to preclude them. This is the type of serious, avoidable risk against which all the Nation's nuclear sites can and should be protected to counter terrorist threats.

It is time to look at other nuclear waste alternatives. Fortunately, the technology to realize a viable, safe and secure alternative is readily available and can be fully implemented within the next decade if we act now. That technology is dry cask storage.

The technology for long-term storage of spent nuclear fuel in dry storage casks has improved dramatically in the past 20 years. Seventeen cask designs have been licensed by the Nuclear Regulatory Commission, which says that spent nuclear fuel can be safely stored using dry cask storage onsite at the nuclear power plants for at least 100 years. Already, dry casks safely store spent nuclear fuel at 34 sites throughout the country, many of them near communities, water ways and transportation routes. The Nuclear Energy Institute has projected 83 of the 103 active reactors will have dry storage by 2050.

Compared to water-filled pools, dry storage casks are significantly less vulnerable to natural and human-induced disasters, including floods, tornadoes, temperature extremes, sabotage, and missile attacks. In addition, dry storage casks are not subject to drainage risks, whether intentional or accidental.

On March 28, 2005, the Washington Post revealed that a classified National Academy of Sciences report concluded that the Government does not fully understand the risks a terrorist attack could pose to spent nuclear fuel pools and that it ought to expedite the removal of the fuel to dry storage casks that are more resilient to attack.

Senator Ensign and I have a bill that would do this The Spent Fuel On-site Storage and Security Act of 2006, S. 2099. Our bill requires commercial nuclear utilities to safely transfer spent nuclear fuel from temporary storage in water-filled pools to secure storage in licensed, onsite dry cask storage facilities. After transferal, the Secretary of Energy would take title and full responsibility for the possession, stewardship, maintenance, and monitoring of all spent fuel thus safely stored. Finally, our bill establishes a grant program to compensate utilities for expenses associated with transferring the waste. The costs of transferring the waste and providing the grants will be offset by withdrawals from the utility-funded Nuclear Waste Fund, stopping the double payments taxpayers are making for the storage of nuclear waste. No longer would they pay into the Nuclear Waste Fund when they pay their

utility bills, then pay again as taxpayers when the Government pays the utilities for the cost of onsite storage. Taxpayers should not have to pay twice.

Nuclear facilities currently provide 20 percent of our Nation's electricity, but in light of the events of September 11, they also present a security risk that we simply must address. There cannot be any weak links in the chain of security of our Nation's nuclear power infrastructure. There is absolutely no justification for endangering the public by densely packing nuclear waste in vulnerable spent fuel pools or in rushing headlong toward a repository that is fraught with scientific, technical and geological problems when it can be stored safely and securely in dry casks. Our bill guarantees all Americans that our Nation's nuclear waste will be stored in the safest way possible.

Instead of sticking to the commitment that Yucca Mountain, or any storage of spent nuclear fuel, would be based on sound science, this administration has cast sound science aside in favor of political expediency in the myopic and dangerous pursuit of Yucca Mountain. It is time we addressed to problem at hand the safe storage of spent nuclear fuel and stopped pouring taxpayers' money down the drain on a project that could endanger all of our citizens. Yucca Mountain is a failure.

STATEMENT OF WILLIAM WEHRUM, ACTING ASSISTANT ADMINISTRATOR, OFFICE OF AIR AND RADIATION, ENVIRONMENTAL PROTECTION AGENCY

Good afternoon. My name is Bill Wehrum and I am the Acting Assistant Administrator for the Office of Air and Radiation at the United States Environmental Protection Agency ("EPA"). I am pleased to be here today to provide you with an update on the status of EPA's public health and safety standards for the proposed spent nuclear fuel and high-level radioactive waste repository at Yucca Mountain, NV.

I would like to begin by providing the Committee with a short history of EPA's responsibilities and why we have proposed revised standards. The Nuclear Waste Policy Act of 1982 described the roles and responsibilities of Federal agencies in the development of disposal facilities for spent nuclear fuel and high-level waste. EPA was identified as the agency responsible for establishing standards to protect the general environment for such facilities. In the Energy Policy Act of 1992, Congress delineated EPA's roles and responsibilities specific to the Federal Government's establishment of the potential repository at Yucca Mountain. EPA's role is to determine how the Yucca Mountain high-level waste facility must perform to protect public health and the environment. Congress directed EPA to develop public health and safety standards that would be incorporated into the Nuclear Regulatory Commission's ("NRC") licensing requirements for the Yucca Mountain facility. The Department of Energy ("DOE") would apply for the license to construct and operate the facility and the facility would open only if NRC determines that DOE can meet EPA's standards. In establishing EPA's role, Congress also stated that the EPA's safety standards are to be based upon and consistent with the expert advice of the National Academy of Sciences.

EPA established its Yucca Mountain standards in June 2001. As required by the Energy Policy Act, these standards addressed releases of radioactive material during storage at the site and after final disposal. The storage standard set a dose limit of 15 millirem per year for the public outside the Yucca Mountain site. The disposal standards consisted of three components: an individual dose standard, a standard evaluating the impacts of human intrusion into the repository, and a ground-water protection standard. The individual-protection and human-intrusion standards set a limit of 15 millirem per year to a reasonably maximally exposed individual, who would be among the most highly exposed members of the public. The ground-water protection standard is consistent with EPA's drinking water standards, which the Agency applies in many situations as a pollution prevention measure. The disposal standards were to apply for a period of 10,000 years after the facility is closed. Dose assessments were to continue beyond 10,000 years and be placed in DOE's Environmental Impact Statement, but were not subject to a compliance standard. The 10,000-year period for compliance assessment is consistent with EPA's generally applicable standards developed under the Nuclear Waste Policy Act. It also reflects international guidance regarding the level of confidence that can be placed in numerical projections over very long periods of time.

Shortly after the EPA first established these standards in 2001, the nuclear industry, several environmental and public interest groups, and the State of Nevada challenged the standards in court. In July 2004, the Court of Appeals for the District of Columbia Circuit found in favor of the Agency on all counts except one: the 10,000-year regulatory timeframe. The court did not rule on whether EPA's standards were protective, but did find that the timeframe of EPA's standards was not

consistent with the National Academy of Sciences' recommendations. The National Academy of Sciences, in a report to EPA, stated that the EPA's standards should cover at least the time period when the highest releases of radiation are most likely to occur, within the limits imposed by the geologic stability of the Yucca Mountain site. It judged this period of geologic stability, for purposes of projecting releases from the repository, to be on the order of 1 million years. EPA's 2001 standards required DOE to evaluate the performance of the site for this period, but did not establish a specific dose limit beyond the first 10,000 years.

EPA proposed a revised rule in August 2005 to address the issues raised by the appeals court. The new proposed rule limits radiation doses from Yucca Mountain for up to 1 million years after it closes. No other rules in the United States for any risks have ever attempted to regulate for such a long period of time. Within that regulatory timeframe, we have proposed two dose standards that would apply based on the number of years from the time the facility is closed. For the first 10,000 years, we would retain the 2001 final rule's dose limit of 15 millirem per year. This is protection at the level of the most stringent radiation regulations in the United States today. From 10,000 to 1 million years, we propose a dose limit of 350 millirem per year. This represents a total radiation exposure for people near Yucca Mountain that is no higher than natural levels people live with routinely in other parts of the country. One million years, which represents 25,000 generations, includes the time at which the highest doses of radiation from the facility are expected to occur. Our proposal requires the Department of Energy to show that Yucca Mountain can safely contain wastes, even considering the effects of earthquakes, volcanic activity, climate change, and container corrosion over 1 million years.

The public comment period for the proposed rule closed on November 21, 2005. We are currently reviewing and considering the comments as we develop our final rule. We held public hearings in Las Vegas and Amargosa Valley, Nevada, and Washington, DC. We are considering comments from these hearings, as well as all of the comments submitted to the Agency's rulemaking docket. A document describing our responses to all comments will be published along with the final rule.

Thank you again for the opportunity to appear before the Committee and present this update on EPA's Yucca Mountain standards. This concludes my prepared statement. I would be happy to address any questions.

RESPONSES BY WILLIAM WEHRUM TO ADDITIONAL QUESTIONS FROM SENATOR INHOFE

Question 1. Do you believe that a million-year standard places a higher priority on hypothetical long term hazards over near term concrete hazards?

Response. EPA believes that extending the application of the 15 millirems per year (mrem/yr) dose limit in the 2001 standards to 1 million years would inappropriately give "long-term hypothetical hazards" precedence over "near-term concrete hazards," EPA believes that a regulatory standard applicable for extremely long times must balance the level of protection offered by the standard, the ability to make meaningful projections of complex system performance over such periods, and the needs of the regulatory decision-making process in which the standard will be used. EPA believes its proposal, and the reasoning underlying it, provide an appropriate balance of these factors. In developing its proposal, EPA considered international guidance and practices regarding the use of long-term projections in regulatory decision-making and the appropriateness of referring to natural sources of radioactivity as a benchmark during extremely long compliance periods.

We have established the 10,000-year standard as an indicator for the time when uncertainties in projecting performance are more manageable and for which comparisons can be made with other regulated systems. While we believe there is some value in performing calculations beyond the first 10,000 years, we also believe that over the very long periods leading up to the time of the peak dose, the uncertainties in projecting climatic and geologic conditions become extremely difficult to reliably predict and a technical consensus about their effects on projected performance in a licensing process would he very difficult, or perhaps impossible, to achieve. This is one of the major reasons that the 10,000-year time frame was originally selected in the generic standard for land disposal of the types of waste intended for the Yucca Mountain repository.

EPA also considered guidance from national and international organizations regarding protection of future generations. The question uses the same terminology used in the "Chain of Obligation Principle" as framed by the National Academy of Public Administration in its 1997 report "Deciding for the Future: Balancing Risks, Costs, and Benefits Fairly Across Generations," The principle reads: "Each generation's primary obligation is to provide for the needs of the living and succeeding gen-

erations. Near-term concrete hazards have priority over long-term hypothetical hazards." EPA believes that extending the application of the 15 millirems per year (mrem/yr) dose limit in the 2001 standards to 1 million years would undermine the Chain of Obligation Principle by giving "long-term hypothetical hazards" precedence over "near-term concrete hazards."

Question 2. Are there any other examples of regulating to 1 million years?

Response. For time frames extending potentially to 1 million years, there are no precedents in U.S. regulation. Other countries have only considered such long time frames when dealing with disposal of long-lived radioactive waste. For example, Switzerland states no time limit for performance analyses. Sweden explicitly limits analyses to 1 million years. However, we believe that the United States has the only example (these proposed standards) that would set. a numerical standard for a compliance period of 1 million years.

Question 3. Could you further address Dr. Thomas Cochran's analysis as used by Senator Boxer? Suggesting that EPA's Proposed Radiation Protection Standard for 10,000 to 1 million year (350 millirems per year) creates a one in five risk of increased fatal cancers for the general population and a one in four risk for women'?

Response. EPA's current risk estimate for radiation-induced cancers is an order of magnitude smaller than the values cited by Senator Boxer. Using EPA's current cancer risk coefficients, we estimate that members of a population receiving an extra 350 mrem/yr for their whole life would have an additional cancer mortality risk of 1 to 2 in 100, It is important to note that these estimates of cancer incidence relate to the dose standards proposed to apply only to the hypothetical Reasonably Maximally Exposed Individual, who is among the most highly-exposed members of the population. Therefore, these estimates do not represent a prediction of increased cancer incidence for the population as a whole. The current U.S. baseline cancer risk is about 22 percent, or 1 in 5. In his testimony to the committee, Dr. Dade Moeller, former president of the Health Physics Society, also cited a similar Value as the overall fatal cancer rate.

Therefore, the increase in cancer mortality at 350 mrem/yr would be relatively small compared with the current baseline cancer mortality rate. The values cited by Senator Boxer during the hearing would require one to assume that every fatal cancer in the country today is attributable solely to background radiation. If this were true, no other behavioral, environmental, or genetic influences, including smoking, would cause a fatal cancer.

The estimate of the population-weighted risk of fatal cancers in the recently released, and seventh, National Academy of Sciences (NAS) report entitled Biological Effects of Ionizing Radiation (BEIR VII) is consistent with EPA's current estimate, To address Senator Boxer's question regarding higher risk levels for women, EPA's cumulative risk estimates account for gender. However, if we calculate the lifetime risk to men and women separately, using the BEIR VII gender-specific risk estimates, the risk for each group still falls between 1 and 2 percent.

RESPONSES BY WILLIAM WEHRUM TO ADDITIONAL QUESTIONS FROM SENATOR JEFFORDS

Question 1. If the revised standard EPA recently proposed were to be the final standard, what is the risk to individuals exposed to the radiation levels contained in that standard in 10,000 years and in 1 million years? How many additional cancers or other health effect to exposed people should we expect to occur?

Response. EPA currently estimates that there is roughly an 8 in 10,000 chance of developing a cancer (fatal and nonfatal cancers combined) for every 1,000 millirems of radiation exposure an individual receives. Based on an assumption that the current cancer risk estimates are valid in the distant future, it is projected that there would be about one extra cancer in 1,000 exposed people over a period of 75 years at 15 mrem/yr (the dose limit over the first 10,000 years) and about two extra cancers in 100 exposed people at 350 mrem/yr (the dose limit for 10,000 up to 1,000,000 years). It is important to note that these estimates of cancer incidence relate to the dose standards proposed to apply only to the hypothetical Reasonably Maximally Exposed Individual, who is among the most highly-exposed members of the population. Therefore, these estimates do not represent a prediction of increased cancer incidence for the population as a ' whole. DOE may project peak exposures at levels less than 350 mrem/yr. In that case, the projected number of additional cancers would be lower. Therefore, the actual number of extra cancers will depend on the magnitude of actual exposures as well as the size of the exposed population and the duration of exposure.

Question 2. If the revised standard EPA recently proposed were to be the final standard, do women, children, and the elderly exposed to these radiation levels face the same risks of harmful health effects as men?

Response. The calculated radiogenic cancer risk does vary with age and, for some organs, there are gender differences in the risk of cancer. EPA's risk estimates are age-, gender-, and organ-specific. EPA takes into account the differences in cancer risk from radiation exposure for men and women separately at each age from infancy through adulthood. Therefore, while risks vary with age and gender, these differences are accounted for in our cumulative risk estimates for the exposed populations, as detailed in the preceding responses.

Question 3. Do the man-made nuclear waste disposal containers have to remain intact for 10,000 years of more in order for Yucca Mountain to meet a proposed 15 millirem standard?

Response. EPA has not developed its proposed Yucca Mountain standards on the basis of whether the proposed disposal system will be demonstrated to comply with such standards. Rather, as required by the Energy Policy Act of 1992, EPA has developed radioactive waste disposal standards that we believe are protective of public health and safety. It may be reasonable for DOE to consider that some waste packages may fail during the first 10,000 years. Failure of the waste packages does not necessarily mean that the standard cannot be met. it is the responsibility of the Nuclear Regulatory Commission to implement EPA's standards and determine, during its licensing review process, whether a repository design could meet the 15 mrem standard even if waste disposal containers do not remain intact for 10,000 years.

Question 4. The primary contact that the public would have with the radioactive waste stored in Yucca Mountain is via groundwater and the peak radiation dose is expected to be after 10,000 years. We discussed this some in the hearing, but why is the compliance period for groundwater under the proposed EPA rule only 10,000 years? Shouldn't it cover the peak dose to maximize public health protection? Why has the EPA not allowed public comment on this portion of the rule?

Response. The NAS specifically declined to make recommendations on separate ground-water standards because it did not consider such "requirements necessary to limit risks to individuals," (NAS Report, p. 121) NAS deferred to EPA's policy judgment, and these standards were upheld under judicial review. Because of the uncertainties encountered in making risk projections for up to 1 million years, we believe that the individual protection (all-pathways) standard is reasonable and protective (See the response to Senator Inhofe's first question). In our original standards, EPA used its policy discretion and issued separate ground-water standards for the 10,000-year compliance period in order to be consistent with previous Agency uses of groundwater protection standards for resource protection. In our current proposed revision, we maintain the ground-water protection standard from the original regulation. We have not sought comment on the ground-water standards because our current rulemaking includes only those standards specifically vacated by the D.C. Circuit Court of Appeals.

Question 5. EPA includes indoor radon exposure as part of its estimates of natural background radiation. Radon is normally not included as part of background dose, because indoor radon exposure is a man-made public health risk. According to the EPA, radon exposure is the second leading cause of lung cancer in the United States. How does EPA justify including radon—an exposure that EPA urges the public to mitigate by renovating their homes—as part of "background radiation?"

Response. The source of the radon is predominantly from soil and rock underlying homes and is not classified as solely a man-made source of radiation exposure, such as exposures from medical procedures. Indoor radon was included in natural background because everyone in the United States spends time indoors and will be exposed to some level of radon in the course of their daily lives. Since at least 1975, the National Council on Radiation Protection and Measurements has discussed indoor radon as a component of natural background radiation (NCRP Report No. 45). For these reasons, indoor radon is an expected component in the exposures people normally encounter over a given year.

Question 6. I asked Mr. Golan about the waste produced by the Administration's proposed nuclear waste reprocessing program. Do we currently have environmental regulations that would govern the type of nuclear waste produced by a large scale reprocessing program?

Response. Wastes (i.e., high-level waste) from reprocessing operations would be covered under EPA's generally applicable standards for spent nuclear fuel, high-level waste, and transuranic radioactive waste (40 CFR Part 191), However, these standards currently apply to storage and disposal of these wastes only at Nuclear

Regulatory Commission (NRC)-licensed facilities. High-level wastes stored at any non-NRC licensed DOE facility are not covered unless it is also a disposal facility.

As for reprocessing itself, it is covered under 40 CFR Part 190 insofar as the fuel being reprocessed is part of the uranium fuel cycle and was used for the production of publicly used electrical power. No other fuel cycles are included, nor is reprocessing if undertaken for fuel other than that used for commercial electrical power production.

However, if the high-level waste from reprocessing was intended to be disposed of at Yucca Mountain, EPA's Yucca Mountain standards would apply as it covers storage as well as disposal of spent nuclear fuel and high-level waste at the Yucca Mountain site (40 CFR Part 197).

RESPONSES BY WILLIAM WEHRUM TO ADDITIONAL QUESTIONS FROM SENATOR VOINOVICH

Question 1. Is it true that the million-year standard assumes no new technological advances over the next million years?

Response. Yes, that is true. In its report, Technical Bases for Yucca Mountain Standards, upon which EPA was to base its Yucca Mountain standards, the National Academy of Sciences stated: ". . . we believe that it is not possible to predict on the basis of scientific analyses the societal factors that must be specified in a far-future exposure scenario. (p. 96). Later, on p. 122, the Academy recommends: ". . . the use of assumptions that reflect current technologies and living patterns." Therefore, the Agency followed that recommendation. It is certainly reasonable to expect technological advances in the future, but EPA has consistently applied a cautious regulatory approach.

Question 2. What is the range of background radiation around the United States and within the State of Nevada, and how does it compare to the radiation exposure expected at Yucca Mountain?

Response. Statewide-average background radiation dose rates (defined here as exposures from cosmic, terrestrial sources and indoor radon) can vary significantly. In its review of statewide background radiation dose rates, EPA found that they range from a low of about 130–140 mrem/yr (Florida and Washington) to a high of about 960 mrem/yr (South Dakota), with the national average being about 300 mrem/yr.

Variation within a single state can be greater than between neighboring states. Across the State of Nevada, based upon countywide averages the background dose rates vary from about 230–990 mrem/yr. This significant localized variation. led EPA to locus on statewide averages.

EPA's proposed standards are not dependent on any specific projections of radiation exposure expected from the proposed repository. Our proposed 350 mrem standard out to 1 million years is consistent with the range of background radiation levels found across the country.

RESPONSES BY WILLIAM WEHRUM TO ADDITIONAL QUESTIONS FROM SENATOR BOXER

Question 1. I understand that before EPA released its proposed draft radiation protection standard for formal public comment, EPA held behind-the-scenes, closed-door meetings with Department of Energy ("DOE") regarding the substance of the standard. Did DOE advocate a standard or an approach to this rulemaking? What was their approach?

Response. EPA met with a wide range of stakeholders as we routinely do when developing proposed rules. For example, we met with Federal agencies, including NRC and DOE; industry and environmental groups; the State of Nevada; and affected counties in Nevada and California to share basic information about the development of the standards and ensure we took into account the full range of views and technical issues, Our final rule will include detailed information on what we considered and how it affected our approach.

Meetings with Federal agencies were consistent with Administration policies and the shared responsibilities for Yucca Mountain conveyed to EPA, NRC, and DOE by statute. Decisions on the nature and form of the proposed standards were made by EPA. Our reasoning and all data supporting our proposed rule arc public information.

DOE preferred standards that are clear, reasonable, and implementable. The views they provided are reflected in their written comments. Those comments are publicly available in our docket.

Question 2. Mr. Wehrum, EPA's proposes a 350 millirem dose limit for the period after 10,000 years, using the median calculated dose as opposed to the mean, or average, calculated dose.

This median radiation dose equals an average radiation dose of about 1,000 millirems per year, or over a lifetime of exposure, about 70,000 millirems. The National Academy of Sciences said that EPA should use the "mean" when assessing compliance with standards.

Since using the "mean" is more protection of public health, would you explain the rationale for departing from the NAS recommendation.

Response. There is no consistent correlation between the mean and median for probabilistic distributions. Knowing the median of a distribution does not indicate the mean. The median was proposed because of the increasing uncertainty in projecting possible doses from the repository over the 1 million-year geologic stability period. With this increasing uncertainty, the confidence that can he placed in the range of projected calculated doses diminishes significantly over time. In the context of our "reasonable expectation" approach for determining compliance, and the increasing uncertainty in the reliability of dose projections, our preamble to the regulatory proposal explained that high-end dose assessments for these exceedingly long periods should not be weighed more heavily than lower-end dose projections in making compliance decisions, and the median, as the mid-point of the spread of dose projections is reflective of this even-handed approach.

Question 3. Mr. Wehrum, governmental, scientific and public health communities acknowledge that children suffer disproportionately from environmental health risks. Specifically children, particularly female children, are at significantly greater risk from radiation exposures than adults.

Did the EPA calculate the health risk to the most vulnerable group, namely children, in proposing its radiation exposure limit for the Yucca Mountain?

Response. Yes. The Agency uses a cancer risk assessment method that accounts for the risk to men and women separately at each age of radiation exposure. Our risk estimates assume that at each age the exposed population receives the maximum dose allowed by our proposed standard. The dose standard must be set at a level that provides protection over a lifetime, including radiation exposures that occur during infancy, childhood, and adulthood. Therefore, while risks do vary with age and gender, all these differences are accounted for in our final risk estimate for the exposed population.

STATEMENT OF ALLISON MACFARLANE, RESEARCH ASSOCIATE, PROGRAM IN SCIENCE, TECHNOLOGY AND SOCIETY, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Mr. Chairman and members of the committee: It is an honor to have the opportunity to address you on the issue of the status of nuclear waste disposal at the Yucca Mountain, NV, site.

I am a Research Associate at MIT's Program in Science, Technology, and Society. I have a Ph.D. in geology from MIT and have been studying and publishing on the issue of nuclear waste disposal since 1996. I am editor of the forthcoming book, *Uncertainty Underground: Yucca Mountain and the Nation's High-Level Nuclear Waste.* I have appended a longer biographical sketch to the end of this testimony.

Mr. Chairman, Ranking Member Jeffords, I would like to use this opportunity to discuss some of the problems with the U.S. nuclear waste disposal program and make suggestions as to how to best address these problems.

Let me begin by emphasizing that in my expert opinion, the best solution to the problem of high-level nuclear waste remains a geologic repository. On this issue all countries with nuclear energy programs are in agreement, though none has yet to open such a facility. In light of the push for more nuclear power in the United States, even taking into consideration the President's proposed Global Nuclear Energy Partnership, it is highly likely that multiple Yucca Mountain-type repositories will be necessary. Therefore, it is imperative that we continue to work toward a solution to the problem of high-level nuclear waste.

Some policymakers have suggested that long-term above-ground storage of spent fuel is a better solution to the current problem. Their idea is to wait until a better alternative to geologic disposal is discovered. Interim storage is just that an interim, temporary solution. Interim storage is fine for 100 years, but longer than that one cannot be assured the containers would prevent radioactivity from entering the environment. In the unlikely case that societal control is lost over the interim storage site or technological advance cannot provide a better alternative to geologic disposal in the next 100 years, interim storage fails its task and exposes future generations

to radioactivity. Thus, I would argue for continued work on geologic repository disposal of high-level nuclear waste.

The main focus of my remarks will be about the Yucca Mountain site, its complex geology, the uncertainty associated with predicting future performance of a geologic repository there, and the implications for the Environmental Protection Agency (EPA) standards proposed for the site. I will conclude with some suggestions for changes to the current program.

YUCCA MOUNTAIN: A COMPLEX GEOLOGICAL SITE

Yucca Mountain is a relatively complex site geologically. The mountain is a low topographic feature, has a low water table, and is an arid region 90 miles northwest of Las Vegas, Nevada. In the following I will provide some examples of the complexity of the site and the uncertainties in the data that arise from this complexity.

Yucca Mountain is located in the Basin and Range extensional province of the western United States, a tectonically active area. The Yucca Mountain region is both seismically and volcanically active. For example, in 1992, a magnitude 5.6 earthquake, centered at Little Skull Mountain 12 miles southeast of Yucca Mountain shook the region, including Jackass Flats, the proposed staging area for nuclear waste at which buildings sustained damage. In 2002 the same fault system produced a 4.4 magnitude earthquake.

The repository footprint itself is bounded by two faults, the Ghost Dance fault on the east and the Sundance fault on the west, neither of which appears to be active. Two other faults on Yucca Mountain are suspected of being active: the Bow Ridge fault and the Solitario Canyon fault, as are other faults in the region.[1] Earthquakes could cause rockfall on waste packages that might breach the packages. To assure that this does not happen, the Department of Energy (DOE), tasked with managing the repository, is intending to add titanium drip shields to protect waste canisters. Earthquakes can also open new fractures in the rock surrounding the repository, allowing for new water transport pathways.

Volcanism poses a greater problem for a repository at Yucca Mountain than seismicity. Though the likelihood of an explosive volcano erupting directly beneath the repository is remote, the outcome would be devastating, spewing radioactive material directly into the atmosphere. More likely would be a scenario in which magma intersects a repository tunnel (not to be backfilled by design), and the associated heat, corrosive gases, and water would affect the waste packages, increasing corrosion rates and thereby releasing radioactivity into the environment much sooner than expected.

The rocks that make up Yucca Mountain are volcanic in origin and formed between 11.6 to 13.5 million years ago.[2] These rocks are composed of tuff, a fine-grained rock formed from cemented ash and rock fragments. The region was affected by three episodes of volcanism since 4 million years ago: one at 3.7 million years ago, one at 1 million years ago, and one at 80,000 years ago. These episodes have left volcanic cones and lava flows adjacent to Yucca Mountain. Though the 80,000-year event suggests that volcanism may be continuing, it is difficult to make precise predictions due to small number of volcanic cones or lava flows on which to base evaluations.

Partly as a result of the lack of evidence, the Nuclear Regulatory Commission (NRC) and the DOE have not yet come to agreement about the likelihood of future volcanism at Yucca Mountain over the 10,000-year time of compliance set out in the old EPA standard.[3] Extending the standard out to 1 million years, as the EPA has proposed, will vastly increase the uncertainties associated with our understanding of the probability of future volcanism.

Besides the potential for future volcanism, the "dryness" of the Yucca Mountain site weighs heavily on the suitability of the site. The repository at Yucca Mountain is to be located about 200–300 meters below the ground surface and 200–300 meters above the water table. The Yucca Mountain region is arid, receiving only 17 centimeters of precipitation a year. The idea behind locating a repository in the unsatu-

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[1] Civilian Radioactive Waste Management System Management and Operating Contractor (1999) Geology/Hydrology Environmental Baseline File, Department of Energy, B00000000–01717–5700–00027 REV 01, DCN 1, June 1999.

[2] Carr, W.J., Buyers, F.M., and Orkild, P.P. (1986) Stratigraphic and Volcano-Tectonic relations of the Crater Flat Tuff and Some Older Volcanic Units, Nye County, Nevada. U.S. Geological Survey. Professional Paper 1323, and Sawyer, D.A., Fleck, R. J., Lanphere, M.A., Warren, R.G., and Broxton, D.E. (1994) Episodic Volcanism in the Miocene Southwest Volcanic Field: Stratigraphic Revision, 40Ar/39Ar Geochronologic Framework, and Implications for Magmatic Evolution. Geological Society of America Bulletin 106, pp. 1403–1318.

[3] They are one order of magnitude off from each other in their probability estimates.

rated zone, above the water table, was to take advantage of the assumed slowly flowing water in the rocks. The DOE asserts that the average infiltration rate of water in the unsaturated zone is about 5 millimeters per year.[4] In such a location, the DOE assumed that little water would come into contact with the waste packages and corrode them over the millennia.

In the mid-1990's, the discovery of bomb-pulse tracer isotopes affected the models of water transport in the unsaturated zone at Yucca Mountain. Scientists at Los Alamos National Laboratory found unusually high values of chlorine-36 in the repository-level rocks at Yucca Mountain. High values of chlorine-36 result from nuclear weapons tests over the Pacific Ocean conducted in the 1950's. Because of these tests, chlorine-36 was put into the atmospheric circulation and carried eastward until it was precipitated out in places like Nevada. The implications for the repository are that water traveled 200–300 meters down in less than 50 years, at rates many times higher than the average infiltration rate used by the DOE. These fast pathways appeared to be associated with fault zones and fractures in the rocks.

The DOE continues to study water transport in the unsaturated zone and has attempted to redo some of the studies done by Los Alamos, but these analyses were problematic. Questions remain as to which fractures may carry flowing water, what processes control fracture flow, and how water is partitioned between fractures and rock. In addition, the DOE has not included in its models of fracture flow events like thousand-year storms that would dump huge amounts of water on the land. Thus the DOE still has an incomplete picture of water transport in the unsaturated zone at Yucca Mountain.

Why all the focus on water? The problem is that it is difficult in the air-filled environment expected in the repository—an oxidizing environment—to prevent corrosion of the waste package and the spent nuclear fuel, the dominant waste form. All metals oxidize, just as iron turns to rust, so selecting a metal alloy for the waste package canister was challenging. The DOE has selected a material called Alloy-22, a chromium, nickel, molybdenum alloy, to form the outside layer of the waste canister. Alloy-22 is a corrosion-resistant alloy. The particular composition selected by the DOE has been in existence since 1981. Data from DOE laboratory tests of 6 months to 5 years in length have been extrapolated out to hundreds of thousands of years and suggest that the waste packages will begin to fail at 50,000 years.[5]

Once the waste canister fails, the spent fuel in its zirconium alloy cladding will be exposed to any water present. Spent fuel is basically uranium dioxide in addition to small amounts of fission products and actinides.[6] Uranium dioxide, as we know from natural analogues, is not stable in an oxidizing environment in the presence of water and it will alter, or rust, to form other minerals. It is not known whether these new minerals will retain the radioactivity.

One of the reasons that almost all other countries with repository programs are planning to use a wet or reducing (as opposed to oxidizing) repository environment is because spent fuel is stable in such under such conditions. As a result, by carefully selecting the repository conditions, these countries[7] have reduced the uncertainties associated with predicting future repository performance.

One final example of the complexity of the repository site is how the geochemical environment in the repository will evolve over time, especially the chemistry of the local waters. The DOE's strategy for Yucca Mountain is to emplace a large amount of thermally hot radioactive material into rock that contains water. Over time, there will be interactions between the thermally hot waste and the water and the rock, and the radioactively hot waste and water and rock. These thermochemical, thermomechanical, thermohydrological, and radiation interactions will produce processes and features that are impossible to predict in advance. Thus, we cannot really know the chemistry of the water over time or how it will interact with the waste package.

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[4] Civilian Radioactive Waste Management System Management and Operating Contractor (1999), op. cit.

[5] A recently published document suggests that the DOE has changed its analysis to find that waste package failure begins at 100,000 years hence. See Stahl, D. (2006) Drip Shield and Backfill, In A. Macfarlane and R. Ewing, editors, *Uncertainty Underground: Yucca Mountain and the Nation's High-Level Nuclear Waste. Cambridge, MA: MIT Press.*

[6] Fission products such as cesium-137 and strontium-90 form from the splitting of uranium-235 atoms whereas actinides such as plutonium-239 and neptunium-237 form from the absorption of neutrons by uranium-238.

[7] These countries include Sweden and Finland, two of the countries with the most advanced repository programs.

UNCERTAINTY AND YUCCA MOUNTAIN

There are many uncertainties associated with trying to understand the behavior of a high-level nuclear waste repository thousands or hundreds of thousands of years into the future. One question we need to ask in siting a repository is whether the earth system is well enough understood to make predictive models of a repository far into the future? Is it possible to verify or validate these models? If not, then can one site a repository?

The DOE has argued that it has characterized all the relevant "features, events, and processes" at Yucca Mountain. I will argue that from my geologist's viewpoint that the DOE cannot know all the features, events, and processes it needs to describe the repository system because the repository is an evolving system whose basic thermodynamic and kinetic features are still not known. One example as just explained above is that of the evolution of the geochemical environment of the repository.

Perhaps our current Defense Secretary, Donald Rumsfeld put it best by noting in a 2002 press briefing, "There are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns—the ones we don't know we don't know." What we don't know we don't know could prove to be very important in the behavior of a geologic repository.

The DOE has attempted to predict the behavior of the Yucca Mountain repository over time using a complex computer modeling method called probabilistic performance assessment. The performance assessment of the Yucca Mountain repository[8] is made up of numerous submodels of systems that will affect repository behavior such as the climate, the unsaturated zone, the waste package, etc. The DOE has stated that it has validated these models by the use of laboratory tests, in situ tests, and field tests.

From the perspective of an earth scientist, it is not possible to validate or verify models of earth systems.[9] This is because earth systems are by definition open systems, accessible to exchanges of matter and energy. As a result, in open systems, it is not possible to know all the potential processes or input parameters that might affect the system. The Yucca Mountain repository is one of those open systems, and therefore it is not possible to legitimately validate the performance assessment model.

Models of earth systems cannot be validated or verified by comparison to laboratory, in situ or field data for two reasons.[10] First, the data may have errors in it that while small now, over time may result in a large deviation from actual behavior. Second, though model results may predict current behavior, over time the geologic system will change in unpredictable ways, and therefore it is not possible to predict future conditions.

The terms "validate" and "verify" powerfully signify the truth of model results, suggesting that the model is an accurate representation of future behavior of the system. These terms are used to convince policymakers of the truth of the model results, though in actuality, the models cannot be validated or verified.

More disturbing is a practice, perhaps an unconscious one, in which experts present model results as if they were actual data. Secretary of Energy Abraham was guilty of such practice when he stated, "The amount of water that eventually reaches the repository level at any point in time is very small . . ." We have not and cannot measure the amount of water that will reach the repository at any time in the future, but the DOE generated a model of the amount of water that might reach the repository, which provided the results stated by the Secretary. These are not facts, but instead unvalidatable model results.

Scientists and engineers from multiple disciplines have contributed to the DOE's performance assessment model, making the results of submodels difficult to compare and fold into a meaningful overarching model. Given the different backgrounds of the scientists, engineers, and managers involved, it is possible that another set of participants might have produced a performance assessment model that gave divergent results. In fact, the International Atomic Energy Agency conducted a study

[8] The latest version of which is in the DOE's draft license application, not available to the public.

[9] There is an excellent literature on this topic. Please see Oreskes, N., Shrader-Frechette, K., and Belitz, K (1994) Verification, Validation, and Confirmation of Numerical Models in the Earth Sciences, Science 263, pp. 641–646, and Oreskes, N., and Belitz, K. (2001) Philosophical Issues in Model Assessment. In Model Validation: Perspectives in Hydrological Science, M.G. Anderson and P.D. Bates, editors, New York: J.Wiley and Sons, pp. 23–41.

[10] Please see Oreskes, N., Shrader-Frechette, K., and Belitz, K (1994) op cit. for a longer discussion.

of performance assessments and reached this conclusion.[11] In their study, six groups of scientists developed separate performance assessment models of contaminant transport in fruits. These models all produced differing results. The IAEA attributed the differences to the differing ways in which the modelers approached the problem, and the differing ways in which they implemented the models and selected parameters used in the models.

Why all the emphasis on performance assessment? The results of probabilistic performance assessment will be used by both the DOE and the NRC to determine the suitability of the Yucca Mountain site. They are forced to use these complex models for two reasons. First, there is only one site to evaluate, so it cannot be evaluated in a relative sense, as was the plan in the 1982 Nuclear Waste Policy Act (NWPA).[12] The 1987 Nuclear Waste Policy Amendments Act changed this strategy by allowing the characterization of only a single site, Yucca Mountain. Thus, the DOE and NRC needed to develop a method to evaluate the site in an absolute sense. They decided by the early 1990's that performance assessment modeling was advanced enough to apply to a geologic repository.

Second, the EPA standard calls for the DOE and the NRC to show that the site will meet a specific dose limit over a specified time period. To do this requires quantitative analysis, and thus the need for performance assessment modeling. Other countries have recognized the limitations of quantitative performance assessments, including France and Sweden. France has set a dose limit in its site standard, but does not make extensive use of performance assessment modeling and will evaluate compliance with the standard by using both quantitative and qualitative analyses.[13]

Sweden has stated that it will depend on performance assessments for time periods of up to 1,000 years, but for time periods beyond 10,000 years, "Although such long-term calculations should be performed, it is understood that with increasing time perspectives, quantitative results, with associated uncertainties, should be regarded as safety indicators. Using such indicators, it is recognized that the final risk assessment will involve a substantial amount of qualitative judgments [sic]."[14] Moreover, in terms of compliance with standards, the Swedes state that "it appears obvious that a strict comparison of calculation results with criteria is not meaningful. Calculation results, e.g., doses, with associated uncertainty estimates should be regarded as indicators of the level of safety and radiation protection achieved rather than dose predictions. Thus, it appears that reasonable assurance' is the only justifiable approach."[15]

Both France and Sweden recognize the limitations of performance assessments and the inability to determine compliance with standards by direct comparison with performance assessment results. They are comfortable with using a more qualitative approach. I would argue that the current U.S. performance assessment methodology is actually a qualitative approach masquerading as a quantitative one. In the current situation, what should the United States do to bring more clarity to its process to determine site suitability?

WHAT SHOULD WE DO?

Given the strict limits placed by the EPA on the DOE and NRC's ability to evaluate the Yucca Mountain site and their inability to determine whether the numbers produced by the performance assessment models are valid, how should the United States determine the suitability of a repository site? I would like to make the following suggestions.

• First, there is a natural opportunity to make changes to our system of site evaluation right now while the EPA standard is being reconsidered. Congressional legislation is not mandated to make the necessary changes; it can be done within the necessary agencies.

Once the EPA standard is promulgated, the NRC will have to adjust their regulations accordingly (currently 10 CFR 63), and the DOE will have to adjust their

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[11] Linkov, I., and Burmistov, D. (2003) Model Uncertainty and Choices Made by Modelers: Lessons Learned from the International Atomic Energy Agency Model Intercomparisons. Risk Analysis 23, pp. 1297–1308.

[12] The 1982 NWPA had planned for three sites to be simultaneously characterized in depth, including the sinking of exploratory shafts to examine the subsurface.

[13] Garrick, B.J. (2000) Letter to Chairman Meserve on ACNW Visits to Nuclear Sites and Information Exhanges in the United Kingdom and France, May 15–19, 2000. Letter dated August 18, 2000, http://www.nrc.gov/reading-rm/doc-collections/acnw/letters/2000/1200158.html

[14] From Nuclear Energy Agency, Radioactive Waste Management Committee (2004) RWMC Regulators' Forum: The Regulatory Control of Radioactive Waste Management Overview of 15 NEA Member Countries. Report number NEA/RWM/RF(2004)1, February 13, 2004, p. 139.

[15] Ibid. pp. 139–140.

guidelines (currently 10 CFR 963). At this point in time, the NRC and the DOE can alter how they will determine site suitability and licensability.

• Second, in making changes to the regulations and guidelines, the NRC and DOE should move away from sole reliance on probabilistic performance assessment as the method to determine compliance with the EPA's standard and opt for a broader and more qualitative assessment scheme, similar to that of France and Sweden. One of the best ways to achieve assurance that the repository will contain the radioactivity over the long term is to reduce the uncertainties associated with waste disposal. For example, the DOE intends to operate Yucca Mountain at relatively high temperatures to maintain the tunnels above the boiling point of water for the first few centuries. This plan increases uncertainties about waste canister corrosion. Another example of reducing uncertainties is Sweden and Finland's plans to dispose of their spent fuel in a reducing environment, as opposed to U.S. plans to use an oxidizing environment.

• Third, the EPA may want to reconsider its standard in this mode. Currently, the United States uses a dose-based standard to govern nuclear waste disposal. Some countries, for example, do not use a dose-based standard at all. For instance, the United Kingdom uses a risk-based standard of one in 1 million per year fatal cancers from radiation. The National Academy of Sciences, in its 1995 report, suggested that the EPA adopt a risk-based standard, though the EPA ignored this advice.

• Fourth, work must continue on the Yucca Mountain site to determine whether it will be suitable as a geologic repository. To supplement the performance assessment, which would be useful only for short time periods (on the order of centuries), a comparative analysis can be adopted similar to that proposed in the 1982 NWPA. As it is not practical or pragmatic to select other U.S. sites and begin in-depth characterization for the purposes of comparison with Yucca Mountain, I suggest an alternative method. A large body of data exists for a number of investigated repository sites around the world. I suggest that this dataset be used for comparative purposes with Yucca Mountain. Included in the list of sites for comparison should be the Waste Isolation Pilot Project in Carlsbad, NM, which stores transuranic waste from the U.S. nuclear weapons complex, the clay site at Bure in eastern France, the crystalline rock site in Okiluoto, Finland, and the crystalline rock sites at Forsmark and Oskarshamn in Sweden.

• Fifth, if Yucca Mountain is found lacking in comparison to the above-listed sites, the DOE and the NRC may decide that it is not appropriate for use as a geologic repository. In this case, Congress would need to revisit repository siting and issue new legislation that allows the DOE to search for and establish new sites. It is highly likely that Congress will have to address this issue in the next 10 years even if Yucca Mountain is approved by the NRC because it will not be able to contain all the waste produced in this country. In the United States, we are fortunate to have a large country with many geologically appropriate locations for a nuclear waste repository that have arguably simpler geology than Yucca Mountain. For a repository to succeed, the process must be fair and perceived to be fair by all participants.

A large amount of high-level nuclear waste already exists in the United States and requires disposal. This problem deserves rapid and focused attention. It is resolvable, but requires a delicate balance of technical prowess and fair and just policymaking. For the betterment of our environment, it is within our grasp to solve this problem.

Thank you for the opportunity to present my views.

RESPONSES BY ALLISON MACFARLANE TO ADDITIONAL QUESTIONS FROM SENATOR INHOFE

Question 1. You seem to be taking a position that we should continue to simply store waste at existing sites until we can apply future technologies. But if we put the waste in Yucca Mountain for a period of 100 to 300 years in a manner that is fully retrievable, as DOE has proposed, isn't there some advantage to moving forward now with Yucca Mountain given its dry nature?

Response. I am in no way advocating a position of "wait and hope" for new technologies. As I stated in my testimony, I believe that geologic repositories provide the best solution to the problem of high-level nuclear waste. The issue with Yucca Mountain is that it is a geologically complex site, and therefore may not be a reasonable location for a long-term repository.

Using Yucca Mountain as a retrievable storage site is one option, but I do not endorse it for economic and policy reasons. A repository or storage site at Yucca Moun-

tain entails high transportation costs, since the majority of reactors are located in the eastern or midwestern portion of the country. If Yucca is found to be unsuitable as a permanent repository, then billions of dollars will have been wasted carting spent fuel to Yucca Mountain. It would have to be transported elsewhere. Doesn't it make more sense to take the time to be comfortable with the decision to dispose of waste there, instead of simply rushing to a solution to appear to have solved the nuclear waste problem? Furthermore, even if the site is found to be unsuitable, once the waste is out there, it will be very difficult, politically, to move it elsewhere.

Question 2. Considering the advantages of Yucca Mountain's remoteness, do you see any scientific difficulties with using the site for interim storage above or below ground?

Response. Yes. Above ground seismicity will pose a problem for above-ground interim storage. The 1992 earthquake (magnitude 5.6) centered on an unexposed fault on Little Skull Mountain resulted in over 2000 aftershocks. One of the areas most affected was Jackass Flats, the basin just east of Yucca Mountain that will the staging ground for all waste disposal activities. During the 1992 earthquake, some of the already-existing buildings on Jackass Flats were damaged.

Jackass Flats is a basin filled with unconsolidated sediments about 100–300 meters deep. In an earthquake such sediments basically act like wobbly jello. This situation produced building damage experienced by the Marina district in the 1989 Loma Prieta earthquake in San Francisco, even though it was far from the epicenter of the quake. Thus, there is the potential for building/cask damage in the event of an earthquake in the vicinity of Yucca Mountain. Is an active seismic zone a reasonable location to store waste? Do we really want to pay for clean-up after each earthquake?

I think there are many other reasonable locations in the United States for interim storage of spent fuel. Spent fuel can be stored in dry casks (using exactly the same technology that would be employed at an interim storage site) at reactor sites—almost all of which face lower threats of earthquakes than does Yucca Mountain. Today, 25 reactor sites employ dry cask storage. This technology is over 20 years old.

Question 3a. In your testimony you cited that almost all other countries with a repository program is planning on using a wet or reducing repository environment as opposed to a dry site. Two countries specifically mentioned were Sweden and Finland. Couldn't the reason that other countries are pursuing wet sites be that they simply don't have any dry sites like Yucca Mountain?

Response. That is part of the reason. In Sweden, the siting process was in part controlled by SKB's seeking out communities that were willing to host the site. In exploring potential repository sites, Finland made an effort to consider all the different rock types in the country. Under the original 1982 Nuclear Waste Policy Act, the United States had a similar provision, requiring the three sites that were originally to be characterized in depth to represent three different rock types. (All that was abandoned with the 1987 Amendments.)

Question 3b. Can you site specific examples where any country considered and rejected a dry site in favor of a wet site?

Response. Not to my knowledge.

Question 3c. Can you site any specific international scientific studies concluding that wet sites are preferable to dry sites?

Response. The criteria for selecting repository sites outlined by the International Atomic Energy Agency (IAEA) in 2003 are the following (quoted from Macfarlane, 2003):

- Long-term (millions of years) geologic stability in terms of major earth movements and deformation, faulting, seismicity and heat flow;
- Low groundwater content and flow at repository depths, which can be shown to have been stable for periods of at least tens of thousands of years;
- Stable geochemical or hydrochemical conditions at depth, mainly described by a reducing environment and a composition controlled by equilibrium between water and rock forming minerals;
- Good engineering properties that readily allow construction of a repository, as well as operation for periods that may be measured in decades. [emphasis added]

Of the four criteria listed, the third emphasizes the need for a reducing environment. Note that Yucca Mountain fails three of these criteria. Yucca Mountain is not tectonically stable—it is both seismically and volcanically active, violating the first criterion. Yucca Mountain offers an oxidizing environment, not a reducing one, as

the third criterion requires. Also, one could argue that the second criterion is violated with the discovery of fast water pathways along fractures and faults in the mountain.

Question 3d. Isn't it true that there are also corrosion processes at work in wet sites, just different processes?

Response. Yes, but they operate significantly more slowly. We know this not only from laboratory tests, but, more importantly, from natural analogues. Under saturated or wet conditions, corrosion behavior is more predictable in part because the system is expected to persist for a long time. Changes to boundary conditions, such as those controlled by climate, will not affect the saturated system. In an unsaturated system, like Yucca Mountain, climate changes, for example, can affect the system.

The DOE has not adequately considered the effects of human-induced climate change over the next few hundreds years on the system at Yucca Mountain. If carbon in the atmosphere reaches levels approaching 1,000 ppm CO_2 by 2100, conditions not experienced by earth for 50 million years, Yucca Mountain may indeed become much wetter than it is now—with conditions similar to those 50 million years ago.

Question 3e. Is there any site in the world where waste containers have been demonstrated to be capable of lasting 10,000 to 1 million years with absolutely no degradation? If so, can you describe and site specifics?

Response. Not that I know of.

Question 3f. Could it not be true that the reason there is so much discussion about long-term corrosion processes at Yucca Mountain is that these processes are just more highly studied and better understood that those at other types of sites?

Response. No, that it incorrect. Corrosion processes have been studied in as much detail at the Swedish and Finnish sites.

Question 3g. Doesn't the safety analysis of Yucca Mountain take these corrosion processes into account in calculating a long-term radiation doses?

Response. Yes, but many experts are not satisfied with the results. The problem is that there are too many uncertainties. These uncertainties arise from the fact that too many corrosion processes, which occur over periods of geologic time under oxidizing conditions, are not well understood. Basic information, such as thermodynamic and kinetic data on the alteration products of uranium dioxide (the main component of spent fuel) are not yet known.

Question 3h. Before DOE decided that the Yucca Mountain site was the best suited site for waste disposal in 1986, eight other sites, along with thousands of pages of scientific analysis, were reviewed. Yucca Mountain's Environmental Assessment alone contained over 1,000 pages of scientific and technical information. All of this analysis was rolled into the Multiattribute Utility Analysis published in 1986. To what extent was Finland's scientific review before selecting a site? Did Finland consider multiple sites as the United States has before choosing the best site? Did Finland create an underground laboratory for choosing their site as we did at Yucca Mountain?

Response. In 1984, the DOE first selected five sites (Davis, Canyon, Richton Dome, Hanford, Yucca Mountain, and Deaf Smith County) from nine previously identified sites. The DOE's basis for their decision, which was not multi-attribute analysis, came under severe criticism. They asked the National Academy of Sciences to review their decision and the NAS handed down harsh criticism of their site selection methodology. The DOE then employed multi-attribute analysis (and came up with the same five sites). The NAS was more encouraged by the use of multi-attribute analysis, but warned that multi-attribute analysis alone was not adequate to make a site selection decision.

As I stated above, Finland did indeed consider five sites before selecting the Okiluoto site in 2001. In 1987, Finland chose 5 sites from a survey of the whole country. Each site represented a different rock type. In 1992, they selected three sites for environmental assessment. In 1997–99 they released the results of the environmental assessments. Of the three sites studied, only the community near Okiliouto favored developing a repository near them.

In Sweden's last iteration of site selection, they considered the five sites already occupied by nuclear power facilities. Four of the five communities were asked to participate in a feasibility study and two accepted. So Sweden is studying two sites in depth at the moment.

Finland is just beginning to mine a repository—it did not yet create an underground laboratory. Sweden, on the other hand, has created an underground laboratory in Aspo, the Hard Rock Laboratory.

Question 3i. You mentioned that there were other sites more suited for high level waste disposal than Yucca Mountain in the United States please identify these sites and describe your bases for concluding that these sites are better than Yucca Mountain?

Response. Suffice it to say that many states, especially those on the east coast (where the majority of reactors are located) would have reasonable geologies to host a repository for high-level nuclear waste. Note, though, that the Nuclear Waste Amendments Act of 1987 prevents us from considering most of those sites because they are crystalline rock, the study of which for a geologic repository is prohibited by the Act.

The criteria for a good site are those listed above that the IAEA developed. Germany has recently developed a similar list of criteria:

- A site must not have large vertical movements of >1 millimeter per year
- A site must have no active fault zones
- A site must have low seismicity
- A site must exhibit no Quaternary volcanism
- A site must not have young groundwater (the groundwater should not contain tritium or carbon–14)

Following these criteria and those of the IAEA should result in well-selected sites. The United States has many locations within its borders that fit these qualifications.

RESPONSES BY ALLISON MACFARLANE TO ADDITIONAL QUESTIONS FROM SENATOR JEFFORDS

Question 1. In your written testimony, you recommend several improvements for determining the suitability of Yucca Mountain as a geological repository for nuclear waste such as making changes to our system of site evaluation, reducing uncertainties associated with waste disposal and using comparative analysis with data from other sites. Can you provide some more detail to your recommendations, including identifying priorities and suggest how long additional evaluation of Yucca Mountain might take?

Response. First, let me quote from Chapter 24 of my forthcoming book, Uncertainty Underground: Yucca Mountain and High-Level Nuclear Waste (MIT Press, 2006):

How, then, should policy decisions on nuclear waste be made? Let's revisit the advice of the person who first suggested the United States consider the unsaturated zone in the Nevada desert: Ike Winograd. Winograd (1990) suggested that the DOE use "technical judgment" to evaluate the suitability of the site. Technical judgment includes the use of multiple barriers in a repository, and encourages the use of multiple techniques to analyze the site, with weighting as judged reasonable by experience. This is simply a more honest way of acknowledging our inability to specify the suite of correct conceptual models for analysis.

Technical judgment can be supplemented by comparative analysis. In the current situation that relies on performance assessment, Yucca Mountain is being evaluated in isolation—that is, without comparison to any other site. This makes it difficult for policymakers, the public, and even scientists to grasp all the important issues that will affect the safety of a repository over geologic time. For both scientific and social reasons, comparing the site to others makes sense (Flynn and Slovic, 1995). Thus, I suggest that Yucca Mountain be evaluated via comparison to other existing or planned sites about which a substantial set of information has been gathered. Potential sites for comparison include the Swedish site, the Olkilouto site in Finland, the clay site in France, and the Waste Isolation Pilot Project site in Carlsbad, New Mexico. If Yucca Mountain comes up significantly short in making such a comparison, then Congress will have to reconsider the waste issue.

Fortunately, an opportunity has recently emerged to make changes in the way Yucca Mountain is evaluated. Because of a July 2004 court decision (see Introduction), the Environmental Protection Agency must revisit the radiation protection standard for Yucca Mountain. This will cause the NRC to promulgate new regulations and the DOE to issue new guidelines. The NRC and DOE could de-emphasize performance assessment in determining whether the Yucca Mountain site is suitable and add in other measures such as those suggested above.

What else can be done to improve the current situation? Jasanoff (1995) has shown that the legitimacy of scientific assessments, especially those done by governmental bodies, can be improved by negotiation and compromise instead of controversy. Conflict over scientific assessments can be ameliorated by the use of the independent scientific community. Jasanoff (1995) suggests that policy decisions

should be arranged so that there is continual and repeated consultation among the scientists producing the analysis, independent scientific experts, the public, and policymakers. The Nuclear Waste Technical Review Board, which oversees the DOE's nuclear waste programs, is an oversight body, with its members appointed by the President from candidates recommended by the National Academy of Sciences. This appointment process can result in a sense of political dependence that may mute the Board's message. Instead, Congress or the DOE could provide funds to citizens' groups to consult with scientists not affiliated with Yucca Mountain to develop a list of independent experts to act as a review board. This was done very successfully for Waste Isolation Pilot Plant in New Mexico where a federally funded, state organization, the Environmental Evaluation Group, provided credible technical oversight of WIPP. Such an oversight group or board would be required to have meetings open to all who are interested during its review sessions. Such a measure would provide both oversight and legitimacy to the DOE's assessments. (quoted from Macfarlane, 2006)

In terms of priority, a few more studies must be concluded at Yucca Mountain, especially those that bear on water transport in the unsaturated zone (discussed below) and those that attempt to understand spent fuel and waste canister corrosion. These studies will take on the order of 5 years. Then it would be important to compare the Yucca Mountain site to others, as suggested. Not only the DOE, but a number of independent scientific groups, should perform their own analyses of this comparison. Then, policymakers would have a good source of information to make the choice of whether to proceed with Yucca Mountain or to look elsewhere.

Question 2. Much has been made of our need for a geologic repository. Your testimony suggests that DOE is now not really relying on the geology of Yucca Mountain to protect the public from radiation releases. Is there any way, based upon what we know at the site today, to take advantage of the site's geology to protect against releases of radiation?

Response. I think this issue deserves more study; the bottom line is that we do not know yet. Yucca Mountain has many weaknesses (see discussion on IAEA criteria). There are many unanswered questions, some of which can be addressed in the next 10 years or so. These include data on rapid water transport pathways from the surface to the repository. The DOE needs to understand which faults and fractures flow and what volume of water they might carry, in consideration of events such as thousand-year storms.

Eventually, though, the problem is that Yucca Mountain may be left with only engineering "fixes." These are not really solutions for the repository, which was supposed to operate using a "multiple barrier" approach that includes both geologic and engineered barriers. Right now, Yucca Mountain appears to have only engineered barriers. The most important decision in repository siting is site selection, and Congress made this decision in 1987.

STATEMENT OF ROBERT FRI, CHAIRMAN, NATIONAL RESEARCH COUNCIL, COMMITTEE ON TECHNICAL BASES FOR YUCCA MOUNTAIN STANDARDS

Good morning, Mr. Chairman and members of the committee. My name is Robert W. Fri. I am a Visiting Scholar at Resources for the Future, a Washington-based nonprofit organization that aims to improve environmental and natural resource policymaking through objective social science research. I was also the chair of the National Research Council's Committee on Technical Bases for Yucca Mountain Standards. Our committee's report, Technical Bases for Yucca Mountain Standards, was issued in 1995. I have been asked to summarize for you the recommendations in that report and to comment particularly on the current status of the health standard for the radioactive waste repository proposed for Yucca Mountain.

As background, the Energy Policy Act of 1992 directed EPA to arrange for an analysis by the National Academy of Sciences (NAS) of the scientific bases for radiation protection standards to be applied at Yucca Mountain. The Act also directed EPA to develop radiation protection standards that were "based upon and consistent with" the National Academy of Sciences' recommendations:

> *. . . the Administrator shall, based upon and consistent with the findings and recommendations of the National Academy of Sciences, promulgate, by rule, public health and safety standards for protection of the public from releases from radioactive materials stored or disposed of in the repository at the Yucca Mountain site. Such standards shall prescribe the maximum annual effective dose equivalent to individual members of the public from releases to the accessible environment from radioactive materials stored or disposed of in the repository.*

(P.L. 102–486, Title VIII, Section 801. 42 U.S.C. Section 10141) The NAS findings and recommendations to EPA on the technical bases for Yucca Mountain standards were provided in the National Research Council report entitled Technical Bases for Yucca Mountain Standards, hereafter referred to as the "TYMS report." This report was authored by a committee of experts that was appointed by the Chairman of the National Research Council. The TYMS committee was disbanded after its report was completed in 1995. Accordingly, I am appearing here today as past chairman of the TYMS committee, not as a representative of Resources for the Future. I will provide you with a summary of the TYMS report's recommendations relevant to the topic of this hearing and will then discuss their relevance to the EPA standard.

I will summarize the TYMS report's recommendations under three headings:
- The elements of the standard itself
- Treatment of human intrusion
- Compliance assessment

Compliance assessment has proved to be the most difficult of these issues and I will focus my comments on that topic.

THE ELEMENTS OF THE STANDARD

The TYMS report made five recommendations regarding the elements of the health standard for Yucca Mountain. They are:

1. The Form of the Standard. Although the Energy Policy Act stipulated that EPA should develop a standard that prescribes dose equivalents, the TYMS report recommended that EPA develop a standard that sets a limit on the risk to individuals of adverse health effects from releases from the repository.
2. Level of Protection. The TYMS report noted that the level of protection was a policy decision to be established through the rulemaking process. Science can provide some guidance in this matter, but in the end the level of protection that the public wants is up to them.
3. Protection of the General Public. The TYMS report concluded that an individual-risk standard would protect the health of the general public, provided that policymakers and the public were prepared to accept that very low radiation doses pose a negligibly small risks.
4. Technology-Based Standards. The TYMS report recommended against imposing repository subsystem performance requirements in the Yucca Mountain standards.
5. Alara. The TYMS report noted that there is no scientific basis for incorporating the ALARA principle into the standard.

With the exception of the committee's preference for a risk-based standard, EPA appears to have generally concurred in these recommendations regarding the elements of the standard. EPA has adopted a dose-based standard, which is functionally equivalent to a risk-based standard only so long as the arithmetic relationship between dose and risk is fixed. Moreover, a dose-based standard is less easily understood by the public than a standard stated in terms of the incremental risk associated with future releases of radiation from the repository.

TREATMENT OF HUMAN INTRUSION

The TYMS report recommended that the standards developed by EPA should require active and passive institutional controls in the near term, should be based on an explicitly assumed intrusion scenario in the long term, and should set limits for the human intrusion scenario that are no more stringent than the undisturbed case. EPA's standard is broadly consistent with this recommendation.

Compliance Assessment The differences between the standard proposed by EPA and the recommendations of the TYMS committee are greatest in the area of how to assess whether the repository will comply with the radiation standard that EPA sets. And it is on the issue of compliance assessment that the D.C. Circuit Court of Appeals remanded the proposed standard to EPA. I will first review the physical processes that the standard is meant to govern, then compare how the TYMS committee addressed the compliance issue, compare our approach to that of EPA, and finally comment on the decision of the appeals court.

Conceptually, the physical processes involved are relatively straightforward. Radioactive waste is placed in metal canisters and the canisters are buried in Yucca Mountain in a system of tunnels. Over thousands of years, these canisters will corrode and begin to release their waste into the geological formations in which they were buried. Infiltrating water from the surface of Yucca Mountain will carry this waste downward through the rock formations, ultimately reaching the water table. Once it reaches the water table, this radioactive waste will be carried by ground-

water away from the Yucca Mountain site. During this whole transport process, the level of radioactivity in the waste slowly declines, although some persists for hundreds of thousands of years.

As the radioactive waste is moved by groundwater away from the site, it can come into contact with human activity. The chief contact is likely to be through the extraction of contaminated groundwater for direct or indirect human consumption. If this occurs, humans could be exposed to radioactivity by drinking this extracted water or eating food irrigated with this water. The objective of compliance assessment is to determine whether this exposure of humans to radioactivity would result in a dose (or risk) that exceeds the EPA standard.

This brief summary of the physical processes by which the public could be exposed to radiation escaping from the repository serves to illustrate the importance of three recommendations made by the TYMS committee regarding compliance assessment.

1. How Long. The TYMS report concluded that there is no scientific basis for limiting the compliance assessment period to 10,000 years, as proposed by EPA. That being the case, the committee recommended that compliance assessment be conducted for the time up to which the greatest risk of exposure to radiation from Yucca Mountain occurs, within the limits imposed by the long-term stability of the geologic environment. The report concluded that the geological formations at Yucca Mountain were sufficiently stable to permit modeling of physical processes that control movement of radioactive waste from the repository for periods on the order of 1 million years. It is important to understand that this conclusion does not necessarily suggest that we can predict what will happen 1 million years from now, or even 10,000 years from now. Rather, the TYMS committee concluded that modeling physical processes for up to about a million years is not appreciably more difficult that doing so for ten thousand years. The longer time horizon provides more time for the radioactive waste released from the repository to migrate to distant locations where it is more likely to come into contact with humans.

2. Exposure Scenarios. An exposure scenario describes the means by which humans are exposed to the radioactive waste from Yucca Mountain—chiefly through extraction of groundwater. The TYMS report concluded that there is no scientific basis for predicting the societal factors required to establish exposure scenarios and, therefore, the report recommended that such scenarios be established through the rulemaking process. The practical consequence of this recommendation is to rely on knowledge of current human activity around the site rather than to speculate on what people might do in the future.

3. Who is Protected. The TYMS report recommended that EPA apply the standards to a critical group representative of those individuals in the population who, based on cautious, but reasonable, assumptions, have the highest risk resulting from repository releases. The purpose of this recommendation was to avoid the accumulation of overly conservative assumptions. In particular, Yucca Mountain was selected because of its isolation to reduce the likelihood that some individual would extract groundwater that is contaminated with radioactive waste from Yucca Mountain. The committee concluded that this isolation should be taken into account in compliance assessment, and so recommended that the probability of people being present be taken into account when selecting the critical group.

The inconsistency, if there is one, between the TYMS committee recommendations and the standard that EPA promulgated in 1999 lies in the different treatment of the time horizon of the compliance assessment and the definition of who is to be protected. The TYMS committee elected to carry the time horizon out to the point of greatest risk to the public, which is almost certainly more than ten thousand years. EPA limited its compliance standard to ten thousand years. On the question of who is protected, the committee recommended a probabilistic identification of a critical group that would account for the isolation of the Yucca Mountain site. EPA proposed to protect what it defined as the Reasonably Maximally Exposed Individual. This individual was assumed to live above groundwater that contains the highest concentration of radioactive contamination from Yucca Mountain, and eats food and drinks water that contains this contamination. In other words, the Reasonably Maximally Exposed Individual is a deterministic concept; there is no doubt that this person will encounter the most contaminated water from the repository.

These differences can be illustrated in the chart at Figure 1. The vertical axis represents the time horizon of the compliance assessment, and the horizontal axis represents the degree to which the person to be protected is selected on a probabilistic or deterministic basis. As you can see, the TYMS committee and EPA are at diametrically opposite ends of this representation. The TYMS report, in the upper right-hand corner, uses a longer compliance period and a probabilistic exposure scenario. The EPA standard is just the reverse—a short compliance period and a deterministic exposure scenario.

I will conclude my presentation by offering some personal observations on how the revised standard proposed by EPA in 2005 responds to the TYMS report recommendations. The DC appeals court concluded that EPA had not set a standard that was based upon and consistent with the findings and recommendations of the National Academy of Sciences, because EPA did not follow the committee's advice on the compliance period. However, in proposing a new standard in response to the court's direction EPA had to deal with the problem that the specification of the time horizon and the selection of the person to be protected are intimately connected.

So, in revising the standard, EPA could have looked at what combination of time horizon and selection of the person to be protected creates a reasonable case that is consistent with the court's opinion. For example, it could have shown that the protection afforded to the public by its remanded standard is functionally equivalent to the recommendations of the TYMS committee, and that there are good policy reasons for using the EPA approach. Or it could have accepted the longer time horizon but selected the individual at risk in a less deterministic way, thus avoiding an overly conservative approach.

It appears, however, that EPA had policy reasons for retaining the Reasonably Maximally Exposed Individual as the definition of the individual at risk. This decision would place the standard in the upper left-hand corner of Figure 1. But that is a place that the TYMS committee specifically did not want to be. We know this because one member of the committee did want to combine a long time horizon with a deterministic selection, a position that he outlined in some detail in the report.

But this position runs the risk of excessive conservatism. As I wrote in response to this committee member's proposal:

". . . the standard should avoid . . . an extreme case defined by unreasonable assumptions regarding factors affecting dose and risk'. . . . some members of the committee believe that the approach advocated by [the dissenting member] could become just such an extreme case." (TYMS report, page 188) What EPA did to avoid becoming overly conservative, as I interpret the new proposal, is to retain the 10,000-year standard and the Reasonably Maximally Exposed Individual as the person at risk, and to add a post-10,000 year all-pathways standard that applies to the time of peak dose at a period of up to 1 million years. The numerical value of that added standard is 350 millirem, which is higher than dose allowed for the 10,000-year standard. It is difficult to say whether EPA's proposed standard is consistent with the TYMS report, which only provided risk ranges as starting points for EPA's analysis. I would note, however, that the committee recognized that EPA properly had considerable discretion in applying policy considerations outside the scope of our study to the development of the health standard for Yucca Mountain.

Thank you for your attention. I would be happy to answer any questions you may have.

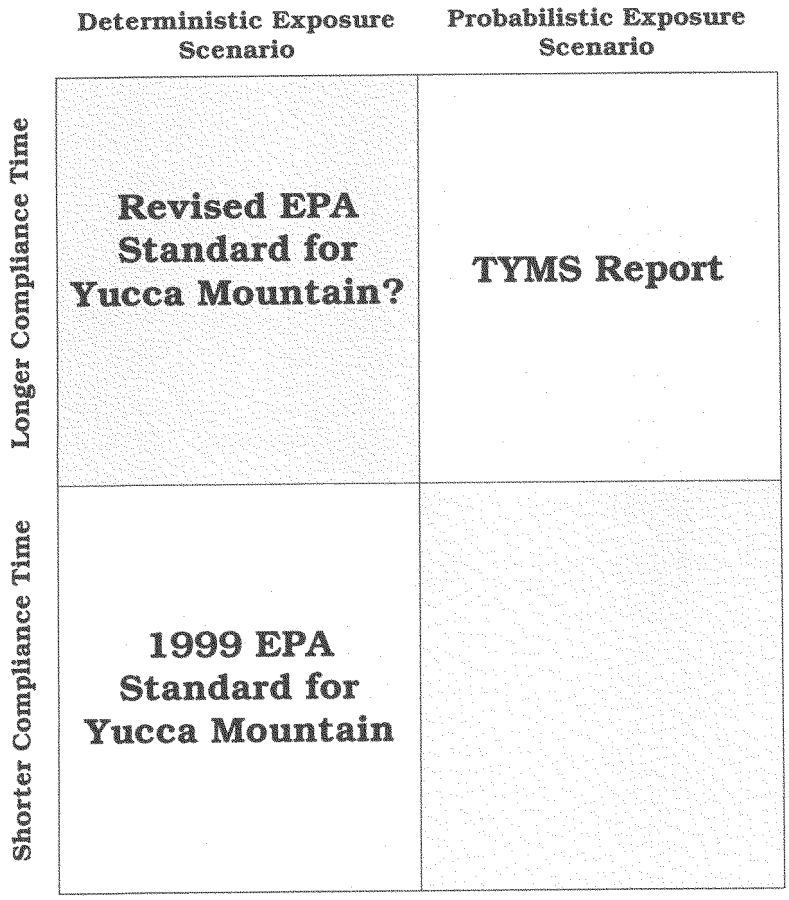

FIGURE 1: Approaches for setting a radiation standard for Yucca Mountain

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RESPONSES BY ROBERT FRI TO ADDITIONAL QUESTIONS FROM SENATOR INHOFE

Question 1. NAS issued a study in 2001 reaffirming that a geologic repository is the best method for permanent disposal of used fuel—has anything occurred since then to change that conclusion?

Response. The NAS report referred to in this question, Disposition of High-Level Waste and Spent Nuclear Fuel: The Continuing Societal and Technical Challenges (NRC, 2001), notes (p. 1) that "There has been, for decades, a worldwide consensus in the nuclear technical community for disposal through geological isolation of high-level waste (HLW), including spent nuclear fuel (SNF)." The report also notes (p. 3) that "After four decades of study, geological disposal remains the only scientifically and technically credible long-term solution available to meet the need for safety without reliance on active management." There have been no developments since this report was issued that would change these conclusions.

Question 2. What did the NAS mean when it stated that "selection of a time scale also involves policy considerations"?

Response. The 1995 NAS report on Yucca Mountain standards (NRC, 1995) focused on the technical bases for how long a risk-based standard should be applied. The report concluded (p. 55) that "there is no scientific basis for limiting the time period of the individual risk standard to 10,000 years or any other value." However,

the report notes that there might be policy reasons for setting such a time limit: "One [reason] would be to set a policy that beyond a set interval of time, it would not be necessary to protect public health." The report also notes (p. 56) that "EPA might choose to establish consistent policies for managing risks from disposal of both long-lived hazardous nonradioactive materials and radioactive materials." The report also recommended (p. 56) that "In drafting standards, EPA should as a matter of policy address whether future generations should have less, greater, or equivalent protection."

It is important to recognize that when mandating this study, Congress directed the NAS to examine only the technical bases for the Yucca Mountain standards. The NAS refrained from addressing the policy bases, leaving that task to EPA. The NAS judged that it was EPA's responsibility to determine and clearly explain the important policy issues to be addressed in setting these standards.

Question 3. Could EPA have proposed a standard based on a peak dose incorporating policy considerations based on risk which only reached to 10,000 years and stay within the NAS recommendations?

Response. This is a hypothetical question that can only be answered by Congress or the courts. However, it is worth noting that the 1999 letter report by the NAS Board on Radioactive Waste Management (NRC, 1999) recommended that EPA acknowledge that its proposed 10,000-year standard was a policy choice. EPA declined to pursue this line of argument when it promulgated its final standards.

Question 4. Do you think that a million-year standard places a higher priority on hypothetical long term hazards over near term concrete hazards?

A properly designed standard can achieve both near-term and long-term protection. The recommendation in the 1995 NAS report (NRC, 1995) for a probabilistic critical group combined with a standard based on the time of peak risk was explicitly designed to achieve such a balance.

RESPONSES BY ROBERT FRI TO ADDITIONAL QUESTIONS FROM SENATOR JEFFORDS

Question 1. A reason to use a risk-based standard is so that you can compare the risks between different kinds of regulated activities, that is to say the public can know the risks of the Yucca Mountain repository compared to a chemical plant. Do you believe that doses stated in radiation measurements allow the public to compare the risks they face from this facility versus other facilities?

Response. The 1995 NAS report (NRC, 1995) recommended that the Yucca Mountain standards be based on risk rather than dose precisely because the authoring committee judged that nonexperts would more easily be able to make such comparisons. This was reiterated in the 1999 letter report from the NAS Board on Radioactive Waste Management (NRC, 1999). There are two issues involved with such comparisons. First, it is difficult for nonexperts to convert from dose to risk. Second, the dose-risk relationship is subject to change with advances in scientific knowledge of radiation health effects. In the latter case, EPA would have to adjust its dose-based standards to maintain a constant level of risk.

Question 2. In 1995, the panel predicted geologic stability was on the order of 1 million years. How was that prediction made? I am interested in better understanding this prediction because there has been some seismic activity at the Yucca Mountain project site in 2002.

Response. The 1 million-year time estimate for the stability of hydrological and geological conditions in the vicinity of Yucca Mountain was based on quantitative assessments of the rates of three geological processes: erosion, deposition of sediment, and faulting. The operation of these processes over time will change the land surface and subsurface geology in the vicinity of the proposed repository. These changes, in turn, will affect the groundwater system, which is the main pathway for projected radionuclide releases from the proposed repository. If future changes in the groundwater system are large, it will be very difficult to use quantitative models to estimate the long-term performance of the repository system. The committee examined the estimated rates of these three geological processes and concluded that geological and hydrological stability could be expected for periods on the order of 1 million years.

Question 3. Will you describe the type of individuals that comprise the "critical group" that the NAS recommended that EPA regulate to protect from radiation at the Yucca Mountain project. Can you describe, in greater detail, how the NAS recommendation and EPA's new regulation differ in their approach to risk regulation?

Response. The critical group is described in the 1995 NAS report (NRC, 1995, p. 53) as "representative of those individuals in the population who, based on cautious, but reasonable, assumptions, have the highest risk resulting from repository releases. The group should be small enough to be relatively homogeneous with respect to diet and other aspects of behavior that affect risks." The report also notes that it is necessary to define who these hypothetical persons will be in the future by making assumptions about lifestyle, location, and eating habits, among other factors. Based on knowledge of current lifestyles around the proposed Yucca Mountain repository, the individuals most likely to be at highest risk at long times into the future are those who use water that has become contaminated with material from the repository. Those individuals are likely to live near the repository and draw their water from the ground or from surface sources fed by groundwater. Both EPA and the NAS committee agree on which individuals are likely to be at highest risk. However, as explained the written testimony, the 1995 NAS report recommended that the critical group be based on probabilistic exposure scenarios, whereas EPA has chosen to use deterministic exposure scenarios.

Question 4. Your written testimony seems to suggest that EPA is being overly conservative when it seeks to regulate to protect people that will encounter the most contaminated groundwater from the Yucca Mountain project. Are you suggesting the National Academy panel you chaired did not think we should protect people we know will be exposed to the highest levels of radiation?

Response. The committee recommended that the analysis of compliance with the standard be extended to the time of greatest risk, which is well beyond the 10,000-year limit originally proposed by EPA. At the same time, the committee cautioned against making overly conservative assumptions when conducting the analysis. The design of the NAS recommended critical group was based on these two principles. See the answer to question No. 3 for additional details on protection of the critical group.

Question 5. Does the National Academy's 1995 report address the technical basis for changing the standard, namely moving from 15 millirem to 350 millirem, after 10,000 years, as EPA is currently proposing?

Table 2–4 on page 50 in the 1995 NAS report (NRC, 1995) provides some suggested starting points for EPA's consideration of risk-based standards. EPA's recommended 350 millirem standard is well above the numerical values in that table. The 1995 NAS report recommended that the health standard apply to the time of peak risk and did not explicitly recommend a two-part standard as EPA is currently proposing.

REFERENCES CITED

NRC [National Research Council]. 1995. Technical Bases for Yucca Mountain Standards. Washington, DC.: National Academy Press.

NRC. 1999. Comments on Proposed Radiation Protection Standards for Yucca Mountain, Nevada by the Board on Radioactive Waste Management. Washington, DC.: National Research Council—Board on Radioactive Waste Management.

NRC. 2001. Disposition of High-Level Waste and Spent Nuclear Fuel: The Continuing Societal and Technical Challenges. Washington, DC.: National Academy Press.

STATEMENT OF PAUL M. GOLAN, ACTING DIRECTOR FOR THE OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT, DEPARTMENT OF ENERGY

Mr. Chairman and members of the committee, my name is Paul Golan and I am the Acting Director of the Department of Energy (DOE) Office of Civilian Radioactive Waste Management. I appreciate the opportunity to provide the committee with an update on the Yucca Mountain Project.

INTRODUCTION

Over the last 50 years, our Nation has benefited greatly from nuclear energy and the power of the atom, but we have been left with a legacy marked by the generation and accumulation of more than 50,000 metric tons of commercially generated spent nuclear fuel, 2,500 metric tons of DOE spent fuel, and an estimated 20,000 or more canisters of DOE high-level radioactive waste. There is a global consensus that the best, safest, long-term option for dealing with this waste is geologic isolation.

The National Academy of Sciences has generally endorsed the geologic disposal option for high-level waste since 1957. In particular, the National Research Council has stated:

> "High-level waste should be put specifically into designed and engineered facilities underground, where the local geology and groundwater conditions have been chosen to ensure isolation of the waste for tens of thousands of years or longer, and where the waste materials will migrate very slowly if they come into contact with the rock."

As the committee knows, there is limited temporary surface storage of waste at 122 sites in 39 States across our Nation. Additionally, 2,000 metric tons of commercial spent nuclear fuel will be generated this year and in every succeeding year by the current fleet of commercial electrical power generating reactors as they supply 20 percent of our Nation's electricity. As a result, failure to address the issues of permanent disposal is not an option.

The Nuclear Waste Policy Act, as amended, defined the Federal Government's responsibility to provide permanent geologic disposal in a repository for all spent nuclear fuel and high-level radioactive waste. In 2002, Congress approved President Bush's recommendation for development of Yucca Mountain as the Nation's high-level radioactive waste repository. The President's recommendation of Yucca Mountain was based on more than 20 years of scientific research, and recognizes that Yucca Mountain will provide a safer and more secure location for the Nation's nuclear waste than the current temporary surface storage facilities, many of which are located near lakes, rivers, and waterways.

Within the Federal Government, the Department of Energy has the responsibility to construct and operate the Yucca Mountain repository. I will address the following topics today in my opening statement:

- First, a review of actions initiated by the Secretary over the last year and an explanation of the clean-canistered approach and why we believe that path is compelling;
- Second, a discussion of the Proposed Environmental Protection Agency (EPA) Radiation Protection Standard; and
- Third, where the Project is in terms of developing a baseline and schedule.

THE CLEAN-CANISTERED APPROACH

In mid–2005 Secretary Bodman directed a thorough review of the Department's overall approach to design, licensing, and operation of the Project to determine if there were better ways to run the repository. His guidance to me was clear: ". . . make it safer and simpler." Late last year we announced a redirection to a predominantly clean-canistered approach to spent fuel operations. A single canister would be used to transport, age, and dispose of the waste without ever needing to re-open the spent fuel package. While some have been critical of this approach, we believe that the technical challenges can be resolved; and the result will be a simpler, safer, and more reliable operation.

The clean-canistered approach will significantly reduce the risks of radiation exposure and contamination from spent fuel handling operations at the repository. It does this by eliminating the need for at least two massive fuel-handling facilities that are intended to handle individual spent nuclear fuel assemblies several times prior to packaging the waste for disposal. With this plan, the spent nuclear fuel primarily will be packaged for disposal by the utilities that generated the waste. This approach offers the advantage of having those who know most about the waste—the generators—be responsible for placement in canisters and packaging. We would thus take advantage of commercial reactor sites with existing capability and skills. We will not need to build new equipment and train operators for a capability that already exists in the private sector. We are working with industry to develop the specifications for a canister that can contain commercial spent nuclear fuel after it is discharged from the reactors and cooled. In addition to requiring fewer, cleaner, and simpler surface facilities, the new facility approach should be easier to design, license, build, and operate.

While this approach will have significant short-term and long-term fiscal and safety benefits, it will require additional time to redevelop and revise portions of the license application. Later this summer the Department expects to have a new conceptual design for the surface facilities at Yucca Mountain that support this approach.

PROPOSED EPA RADIATION PROTECTION STANDARD

On August 22, 2005, the Environmental Protection Agency proposed a revised "Public Health and Environmental Radiation Protection Standard for Yucca Moun-

tain" in response to a decision by the U.S. Court of Appeals for the District of Columbia Circuit which vacated portions of the existing EPA standard. Specifically, EPA proposed a radiological exposure limit for the time of peak dose to the general public during 1 million years following the disposal of radiological material at the Yucca Mountain site.

The proposed rule retains the existing 10,000-year individual protection standard of 15 mRem/year to the reasonably maximally exposed individual, and supplements it with an additional standard applicable at the time of peak dose. The Department supports this approach. A rule with two compliance periods recognizes the limitations of bounding analyses, the greater uncertainties at the time of peak risk, and the increased uncertainty in calculated results as time and uncertainties increase. Retaining the existing 15 mRem/year standard for the initial 10,000-year period ensures that the repository design will include all prudent steps, including the use of engineered and natural barriers, to minimize offsite doses during the first 10,000 years after disposal. These natural barriers, and to some extent the engineered barriers, will continue to operate throughout the million-year period, keeping exposure levels low, below what people receive today based on where they work or where they live. Importantly, this reflects a level of risk that society normally lives with today, in that the maximum peak dose at Yucca Mountain would be no greater than the average dose a current resident of Denver or similar high altitude location receives in an average year.

DEVELOPMENT OF A BASELINE AND SCHEDULE

Although the Yucca Mountain Program had intended to submit a license application to the NRC in December 2004, a number of issues arose that prevented this, including development of the amended draft EPA radiation protection standard as discussed earlier, redesign of the surface facilities to handle primarily canistered waste, and other matters that need to be addressed before we are ready to submit a license application. We believe that submission of our license application should not be driven by artificial dates. We are committed to developing a realistic schedule that will result in the submission of a strong license application to the NRC. We expect to receive and review our new design this spring and, after its approval by the Secretary, incorporate it into our baseline. Later this summer, we anticipate we will publish our schedule for submittal of the license application to the NRC.

CONCLUSION

There is a clear national need for Yucca Mountain, even if we could reduce our National electricity consumption by 20 percent and were able to shut down every commercial reactor and nuclear project in the country today. We are taking steps to ensure that we develop and construct the safest, simplest repository that we possibly can, based on sound science and quality work. I believe that our license application will provide the necessary assurances that we can operate Yucca Mountain in compliance with the performance requirements of the Environmental Protection Agency and the Nuclear Regulatory Commission. We will also demonstrate that our approach to operations will be carefully planned, logical, and methodical.

This completes my prepared statement.

RESPONSES BY PAUL M. GOLAN TO ADDITIONAL QUESTIONS FROM SENATOR INHOFE

Question 1. Given the scope of the work identified and re-planned in the proposed budget, what is the Department's plan to update cost estimates of the TSLCC reflecting the Department's best estimates and assumptions?

Response. The program is planning to develop new cost estimates once the Department selects new designs for surface facilities that incorporate a clean-canistered approach and that are approved by the Energy Systems Acquisition Advisory Board. Decisions on the designs are expected this summer.

Question 2. The Department is shifting important scientific and data quality work to Sandia as part of a restructuring of the program, and there has been a dramatic reduction of funding over the last 2 years in this area. Given the heightened concern over the fidelity and quality of data supporting the scientific mission and performance of the mountain, which must be relied upon in an NRC proceeding, what is the Department doing to ensure the personnel, quality controls, and checks and balances needed to preserve the fidelity and quality of the data that represents the underpinning of the scientific bases of the license application?

Response. While the quality assurance program has operated pursuant to Nuclear Regulatory Commission (NRC) approved parameters, this project has not achieved

the "nuclear culture" required of an NRC licensee when it undertakes the construction and operation of a nuclear facility.

We are implementing mandatory training on identifying conditions adverse to quality and the actions required to be taken if any such condition is identified.

Question 3. In addition to preparing the application for Yucca Mountain, I understand your office has been making progress on other related issues such as designing standardized canisters for the shipment of waste. How will this enhance the licensing process?

Response. We believe that the clean-canistered approach to receiving commercial spent fuel will allow us to greatly simplify the design and licensing of the facilities at Yucca Mountain. With a clean-canistered approach personnel will be handling primarily canistered waste, not individual fuel assemblies as previously planned. These canisters will provide another contamination barrier between the worker and the waste. For example, when routine maintenance is required in the canistered operating facilities, workers will not have to deal with radiological contamination as they would with individual fuel assembly handling operations.

Question 4. Why do you need the full fiscal year 2007 budget request for Yucca Mountain if the Department is not planning on submitting a license application this year?

Response. The fiscal year 2007 budget request does not assume a license application will be submitted to the NRC this year. The request includes funds for the development of the license application and repository surface design to support the cleancanistered approach. Additional funds are requested for ongoing science programs, data collection efforts, quality assurance, program management and activities for systems analysis. The Department is also requesting $70 million to develop the transportation infrastructure in 2007. This includes rail cars, rolling stock, casks and completing the environmental impact statement for rail access to the site. Last, we are requesting $40 million to make safety-required improvements to the infrastructure at Yucca Mountain.

RESPONSES BY PAUL M. GOLAN TO ADDITIONAL QUESTIONS FROM SENATOR JEFFORDS

Question 1. DOE.—I understand that the cost estimates for building a rail line to Yucca Mountain have increased from around $800 million to over $2 billion in the last year. If costs continue to escalate and DOE is not able to develop rail access to Yucca Mountain, what are the contingency plans for shipping waste to the facility from around the country?

Response. Previous cost estimates for the Nevada rail line were prepared prior to the designation of the Caliente rail corridor and were based on an average of all the rail lines being analyzed. The current estimate is specific to the Caliente rail corridor and includes the cost of facilities related to rail operations. These facilities include sidings and basic maintenance capability where the Nevada Rail Line connects to existing mainline track, track maintenance-of-way facilities along the track and an end-of-line facility proximate to the repository. The Department of Energy (DOE) believes the cost of constructing rail access to the repository along the Caliente corridor is still viable based on these considerations. If funding to construct and operate rail access to the repository is not provided, DOE would have to reconsider its decision to use the mostly rail mode of transport within the State of Nevada. Other transport modes available for consideration in Nevada are the mostly legal/overweight truck option, and the heavy haul truck option. Both the legal weight and the heavy haul truck options could be combined with the mostly rail option as the national transportation mode with interrnodal facilities used at the juncture of existing rail lines and major highways within the State.

Question 2. What is the latest Yucca Mountain cost estimate?

Response. The Department has not prepared a formal cost estimate since the 2001 Total Life Cycle Cost Estimate of $57.5 billion. The Department is planning to develop an updated cost estimate after the surface facility designs and clean-canister approach is approved later this year.

Question 3. A few months ago, DOE announced it was redesigning the Yucca Mountain project so as to transform it into a "clean facility." The centerpiece of this restructuring is the Transportation, Aging, and Disposal canister (TAD). An almost identical concept (the Multiple Purpose Canister or MPC) was put forth by DOE in the early 1990's and eventually abandoned as too costly and too logistically difficult. Since that time, more and more utility companies have moved to dry cask storage, almost all of which require the fuel to be put in welded storage canisters, making

retrieval and repackaging in TADs extremely costly and difficult for the utilities. If the use of the Multiply Purpose Canister was so logistically difficult, how will DOE ensure a multi-purpose canister like the TAD can be implemented when onsite dry storage is proliferating and existing storage canisters are not compatible with DOE's plans for using TAD canisters?

Response. The multi-purpose canister (MPC) approach was not rejected for being too costly and too logistically difficult to implement. The MPC approach was abandoned in the mid–1990's as a result of budget reductions and congressional guidance suggesting that the Department not spend additional resources on the development of storage and transportation technology.

The Department is aware that many utilities are utilizing dry-cask storage to meet their onsite spent fuel storage needs. The Department believes that transport, aging and disposal (TAD) based canister systems, which incorporate features required for long-term disposability, can be successfully developed, licensed and commercially deployed within five to 6 years. The Department is currently developing options for incentivizing both the utility industry and the cask vendor community to incorporate TAD-based systems into their waste management plans as early as possible.

Question 4. What is the status of design and licensing of the new TAD canister? How long will it take?

Response. The Department expects to have a performance-based specification for the TAD-based systems available later this summer. The Department believes that the TAD-based canister systems can be successfully developed, licensed and commercially deployed within 5 to 6 years.

Question 5. Without taking credit for man-made waste disposal containers that would have to remain intact for 10,000 years or more, can Yucca Mountain meet a proposed 15 millirem standard?

Response. The Department has stated previously that it believes it can demonstrate compliance with a 15 millirem standard during the initial 10,000 years after closure of the repository. The Environmental Protection Agency (EPA) developed this standard to reflect the use of both geological and engineered barriers. For the period beyond 10,000 years, EPA has proposed a 350 millirem standard. Based on past experience, DOE expects the Total System Performance Assessment model would take declining credit for engineered barriers as the number of years after closure increased.

Question 6. During the hearing, EPA Acting Assistant Administer Wehrum recommended I direct a question to you regarding legislation to set the EPA's radiation standards. EPA is currently revising its Yucca Mountain radiation release regulations, as mandated by the Court of Appeals for the D.C. Circuit in 2004, in order to make them "based upon and consistent with" NAS recommendations. Is DOE seeking legislation to set radiation standards at Yucca Mountain?

Response. The Administration is currently considering draft legislation regarding Yucca Mountain. Since the draft legislation is still under development and review, I cannot discuss specific provisions at this time.

Question 7. Global Nuclear Energy Paretnership.—The Global Nuclear Energy Partnership (GNEP) budget submission includes discussion of interim storage sites. Is Yucca Mountain or the Nevada Test Site currently being considered as a possible interim storage site, and is the Administration proposing or supporting efforts to change current law to allow interim storage at Yucca Mountain or anywhere else in Nevada? How much scientific, technical, or engineering work will need to be done to accommodate an interim storage facility, and what is the estimated cost?

Response. The Nuclear Waste Policy Act constrains the extent to which the Department can undertake interim storage of commercial spent fuel to be disposed of at the Yucca Mountain repository. The Administration's recently proposed amendment to the Nuclear Waste Policy Act did not include any provisions related to the interim storage of commercial nuclear spent fuel.

The Department is currently pursuing engineering scale demonstrations of an integrated fuel cycle that would: (1) separate spent nuclear fuel into its constituent elements; (2) fabricate the actinide-based elements contained in spent fuel into a new advanced fuel form; and (3) consume transuranics in a facility such as an advanced burner test reactor. The Department has published an Advance Notice of Intent to initiate an Environmental Impact Statement this year to examine these advanced technologies and the locations for conducting engineering scale demonstrations of the technologies.

Question 8. Is Yucca Mountain or the Nevada Test Site being considered as a possible site for a reprocessing plant envisioned under GNEP? What sites are being considered?

Response. No decisions have been made relative to siting the spent fuel recycling demonstration facilities. DOE will initiate the appropriate analyses and reviews required under the National Environmental Policy Act (NEPA) this year to inform a decision by 2008 as to where the engineering scale demonstration facilities would be located. In March 2006, DOE issued a request for Expressions of Interest from the public and private sectors for hosting advanced recycling facility demonstrations. The Department anticipates issuing a Request for Proposals this spring and awarding contracts in summer 2006 for site evaluation studies. The results of these studies should provide additional information for the NEPA analyses.

Question 9. How would reprocessing and fast neutron reactors, if developed to commercialization, affect the licensing of Yucca Mountain? Does DOE plan to submit a license application for spent fuel storage at Yucca Mountain before reprocessing and fast neutron reactors are technically viable and economic?

Response. Global Nuclear Energy Partnership (GNEP) technologies, if demonstrated, could have a positive impact on the future operation of the Yucca Mountain repository because of the reduction in volume of waste that needs geological disposal, the homogeneous waste form, the lower heat load, and the shorter half life of the radioactive constituents.

Successful deployment of GNEP technologies, however, is many years in the future. DOE does not intend to delay fulfilling its obligation to begin consolidating and disposing of the approximately 50,000 metric tons of commercial spent fuel already generated, as well as the approximately 2,000 metric tons being generated each year. DOE plans to proceed with licensing, constructing and operating the Yucca Mountain repository as planned. When GNEP technologies are deployed, DOE will take the necessary steps to make the repository accommodate the changes in the waste stream.

Question 10. Global Nuclear Energy Partnership.—The GNEP program is proposing an international fuel cycle program that would include providing fresh fuel to countries and taking back the spent fuel. Would any of that spent fuel or reprocessing waste end up in Yucca Mountain? Would the GNEP program subsidize the fuel supply and return program, so that the U.S. Government—and U.S. taxpayers—would pay to transport or store foreign nuclear waste at Yucca Mountain?

Response. We do not envision accepting spent fuel pursuant to GNEP until there is sufficient advanced recycling capability available in the United States. At that time, we would have to consider the conditions under which the United States would reprocess another country's spent fuel.

Question 11. Quality assurance (QA) is extremely important, especially for a project spanning several decades with thousands of people working on it. QA procedures are established to ensure that the data are generated, documented, and reported correctly. At Yucca Mountain, QA is integral to the accuracy of the water infiltration models, which have been used to predict how rapidly water can travel through the mountain, how waste containers will corrode, and when the containers will release material into the environment. The Government Accountability Office has issued 7 reports since 1988 repeatedly criticizing DOE's and USGS' quality assurance and model validation programs. Over the years, DOE has stopped its contractors' work on the project again and again in order to address these problems. In January 2006, the DOE instructed Bechtel SAIC LLC, its main contractor, to cease work on key areas of the site, including assurance practices, which were revealed by a whistleblower. In February 2006, NRC stopped work at Lawrence Livermore National Laboratory on research related to corrosion rates of the metals to be used to construct the waste package and drip shield, because researchers failed to calibrate equipment, referenced canceled documents, and incorrectly measured the corrosion rate. Does DOE intend to address the quality assurance problems that have been repeatedly found in research related to the site? If so, what is DOE specifically doing to stop these egregious acts of scientific fraud?

Response. Over the years, the Yucca Mountain QA program has been reviewed by many independent organizations including the Government Accountability Office, the Nuclear Regulatory Commission, and the Office of the Inspector General. These organizations have raised concerns about the effectiveness of the Yucca Mountain QA Program. The Department has generally concurred with the findings and instituted corrective action plans to address the deficiencies. These deficiencies, however, do not undermine the overall soundness of the science performed in connection with the Yucca Mountain Project.

Improving the quality and culture of this organization is essential to moving this project forward. The Department intends to demonstrate good quality, science, and processes in its license application and across the entire organization. The Department is working aggressively to improve the quality and culture of this organization, as demonstrated by its standards, its actions, its behaviors, and its performance. The Department has reviewed and revised its procedures and has taken measures to ensure that all Project employees are cognizant of the QA Program requirements. Individuals are being trained and managers will aggressively enforce these requirements. Holding people accountable is what society has a right to expect.

Question 12. Is it true that both DOE and NRC believe the risk of an airplane crash at the Yucca site is a significant safety issue that could prevent storage of waste onsite? Has the Air Force agreed to restrict its flights so Yucca can be licensed?

Response. It would be premature and inappropriate for DOE to state what it believes to be the safety significance of an airplane crash at the repository site. Instead, DOE is assessing all hazards to the safe operation of a repository (of which, aircraft crashes are one) in accordance with 10 CFR 63.111. DOE is assessing the hazards associated with aircraft crashes at the repository site and is evaluating design and operational approaches to mitigate the risks, as necessary, to meet the standards set forth in 10 CFR 63.111. DOE is continuing discussions with U.S. Air Force regarding appropriate flight restrictions over the repository site and land withdrawal area.

Question 13. When will DOE release additional details about intended rail shipment routes across the country to Yucca Mountain? What are the DOE's plans for implementing a dedicated train program for rail shipment for the roughly one-third of reactors in the United States that do not have rail access?

Response. The Department of Energy is working with stakeholders through the Transportation External Coordinating Working Group to establish the criteria and methodology for selecting transportation routes. A set of recommendations for routes in the Midwest has been provided by the Midwestern Office of the Council of State Governments. Further recommendations are expected from the Eastern Regional Conference of the Council of State Governments. These recommendations along with other stakeholder input and the Department's own analyses will be used to select the routes for shipments to Yucca Mountain. Final decisions will be made in time to provide funding for emergency preparedness training along the transportation corridors. The Department has consistently committed to providing these funds three to 5 years before the first shipments are made.

Part of the Department's transportation planning has included provisions for either heavy haul or barge shipments to a rail connection for those reactors that do not have direct rail access. The Department is working with State regional groups to identify where barge would be feasible. Two regional groups, the Southern States Energy Board and the Northeastern Regional Conference of the Council of State Governments, are working on studies for the use of barge in their respective regions. The Department will evaluate the tradeoffs of using barge, heavy haul truck or other truck options, with the input of the States and tribes as part of its transportation planning.

RESPONSES BY PAUL M. GOLAN TO ADDITIONAL QUESTIONS FROM SENATOR VOINOVICH

Question 1. DOE.—What is DOE currently doing to restore confidence in the data that was compromised by USGS employees?

Response. The USGS emails, while not directly involving data collection and technical work, have caused the Department to review the work contained in two reports, Simulation of Net Infiltration for Present-Day and Potential Future Climates and Analysis of Infiltration Uncertainty, which currently support the Total System Performance Assessment for the license application. The Department has conducted an evaluation of the potential technical impacts resulting from questions raised by the emails.

The evaluation concluded that, while the emails in and of themselves do not suggest a misrepresentation of the underlying science, they do appear to imply circumvention and/or misrepresentation of compliance with Yucca Mountain Project quality assurance requirements. Consequently, we have implemented remedial actions to address both potential technical and quality assurance issues associated with the supporting data, implementing software, and process models called into question.

The Department has tasked Sandia National Laboratories to review the existing infiltration model and to prepare a new model. After Sandia completes these tasks, its work will be independently checked by experts outside the Department. We have been very clear that it is vital to properly carryout this work, and we will take the time necessary to do so.

Question 2. Global Nuclear Energy Partnership.—How does the Department expect to fund the Global Nuclear Energy Partnership (GNEP) program at its current estimated cost of $13 billion over the next 10 years?

Response. The Department will seek Federal appropriations for the integrated advanced recycling technology demonstration program that is central to the Global Nuclear Energy Partnership. Over the next 10 years, the majority of the anticipated costs pertain to designing, building and bringing the three integrated advanced recycling facilities to initial operation. The Department has initiated discussions with countries on the technology demonstration effort and we are hopeful that the costs will be shared among the partners.

Question 3. University Reactor Infrastructure and Education Program.—To support the resurgence of nuclear power in the United States we will have to continue to fund the nuclear programs at universities, why did DOE cut this critical funding in the FY–07 budget proposal?

Response. Over the last decade, university nuclear engineering schools leveraged funding provided by DOE and industry partners to strengthen the nuclear engineering education infrastructure and attract students to careers in nuclear engineering. With enrollments at their highest levels in over a decade and four new university nuclear engineering programs launched over the last 5 years, the Department believes that the objectives of the Government's support to nuclear engineering programs have been achieved and funding has not been requested in fiscal year 2007.

However, DOE will continue funding university participation in DOE's nuclear energy research initiatives, through the Generation IV nuclear systems initiative, the Nuclear Hydrogen Initiative, and the Advanced Fuel Cycle Initiative (AFCI). Over the last 4 years, the Department has also sponsored AFCI fellowships for 25 students seeking post-graduate degrees in study related to advanced fuel cycles, including fuels, recycling and transmutation engineering. DOE will continue to support the AFCI fellowship program in fiscal year 2007 and would propose to begin a fellowship program as part of the Generation IV initiative for study in disciplines related to advanced reactor systems.

STATEMENT OF DADE W. MOELLER, FORMER PRESIDENT, HEALTH PHYSICS SOCIETY

INTRODUCTION

Mr. Chairman, Ranking Member Jeffords, and distinguished members of the Committee, my name is Dade W. Moeller. I am Chairman of the Board of Dade Moeller & Associates and am appearing today as a representative of the Health Physics Society (HPS), an independent nonprofit scientific organization of professionals who specialize in radiation safety. Thank you for providing this opportunity for the Society and me to serve as a resource as you examine the status of the Yucca Mountain project. I received a Masters in Environmental Engineering from the Georgia Institute of Technology in 1948, and a Doctorate in Nuclear Engineering from North Carolina State University in 1957. I served in the U.S. Navy for 2 years during World War II and as a commissioned officer in the U.S. Public Health Service from 1948 to 1966. Subsequently, I was appointed to the Faculty of the School of Public Health, Harvard University and remained there from 1966 to 1993. Initially, I served as Chairman of the Department of Environmental Health Sciences, and later as Associate Dean for Continuing Education. I am a past-President of the Health Physics Society, and the recipient of the Meritorious Achievement Award from the U.S. Nuclear Regulatory Commission. I was elected to the National Academy of Engineering in 1978 and to the Georgia Tech Engineering Hall of Fame in 1999. I received the Distinguished Engineering Alumnus Award from N.C. State University in 2001, the Robley D. Evans Commemorative Medal from the Health Physics Society in 2003, and the William McAdams Outstanding Service Award from the American Academy of Health Physics in 2005.

I am the author of more than 200 papers published on various aspects of environmental health, with emphasis on radiation protection, waste management, and environmental monitoring. The bulk of these during the last 5 to 10 years have related to independent assessments of potential radionuclide releases from the proposed Yucca Mountain high-level radioactive waste repository. I am the author of a widely

used textbook on Environmental Health, the third edition of which was published in 2005.

THE HEALTH PHYSICS SOCIETY

The HPS includes approximately 6,000 members in over 40 countries who are currently engaged in the practice, science, and/or technology of radiation safety. Its mission is to assure excellence in radiation safety. Society activities include encouraging research in radiation science, developing standards, and disseminating radiation-safety information. As a nonprofit scientific organization, it is not affiliated with any governmental, industrial, or private entity. The Society is affiliated with the International Radiation Protection Association, the American Academy of Health Physics, the American Board of Health Physics, the National Council on Radiation Protection and Measurements, and other scientific and professional societies and institutions.

In my testimony I will try to be clear as to whether statements are those of the Health Physics Society or are my own professional opinion.

BACKGROUND

At present, progress on the development of the proposed Yucca Mountain high-level radioactive waste repository is at a standstill. So long as controversies over the dose rate limit and the health effects of low doses of radiation exist, there will continue to be delays in completing this project. In the meantime, spent fuel and high level radioactive waste is being stored at more than 100 commercial nuclear power plants, and at multiple facilities of the U.S. Department of Energy. It will remain at these sites until this log-jam is broken. Although I will make some comments on the Environmental Protection Agency's environmental performance standards that are at the heart of the controversy contributing to this log-jam, my central message is to make a proposal for a path forward.

PROPOSAL

The key elements of the approach I propose are as follows:

1. Rather than seeking to "dispose" of the waste at this time, the suggested policy would be that, as an interim step, the waste be "stored" in the proposed facility for perhaps 100 years, during which time it would be subject to retrieval, if necessary.

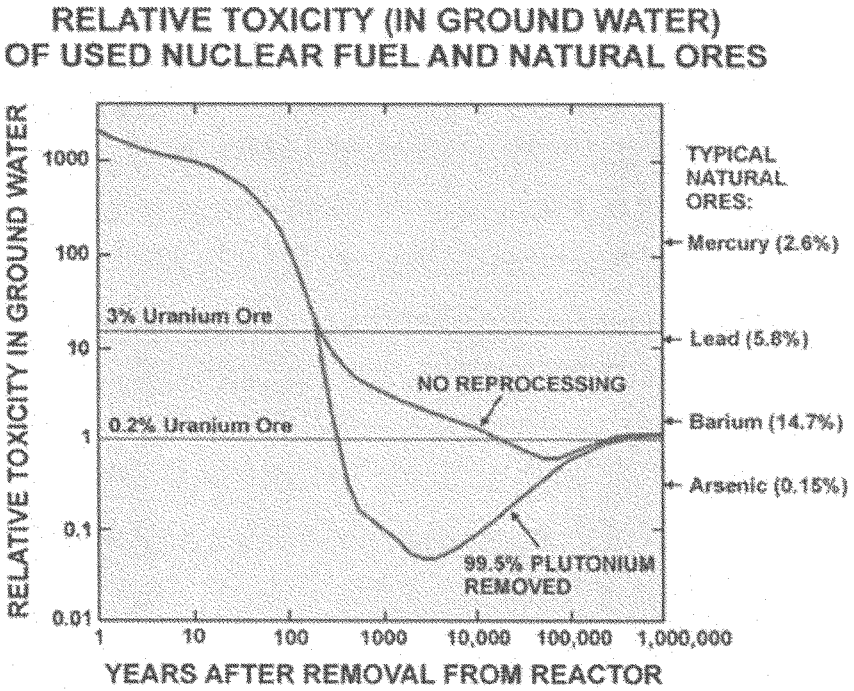
2. One of the immediate benefits in adopting this approach would be to enable the U.S. Congress to meet the obligation it assumed in passing the Nuclear Waste Policy Act of 1982, that is, for the Federal Government to accept responsibility for the management of high-level radioactive waste, an obligation that it has not been able, to date, to fulfill.

3. To ensure that the waste is not contaminating the environment, the Yucca Mountain facility would need to be equipped with monitoring devices that would provide, throughout the proposed 100-year period, immediate warnings of the deterioration of any waste packages and ensuing potential leakage. In anticipation of the potential occurrence of such events, provisions should be developed, and implemented if necessary, to retrieve and stabilize the affected waste packages. The monitoring program should include the status of engineered systems and components (such as borehole and shaft seals, backfill, and drip shields), as well as the thermal interaction effects of the waste packages, backfill, drip shields, rock, and unsaturated zone and saturated zone water. The program should also provide continuous online information on the condition of the waste packages, supported by laboratory experiments that focus on their internal condition (USNRC, 2001).

4. Another step that could be taken to enhance the comfort of the population groups that could be affected by radionuclide releases would be to limit, through regulations, the development of other nuclear related facilities within the region during the proposed 100-year period. Under these conditions, the applicable dose rate limit, based on the long-term dose rate limits recommended by the International Commission on Radiological Protection (ICRP, 1991, paragraph 191), the National Council on Radiation Protection and Measurements (NCRP, 1993, Section 15, page 46), the U.S. Nuclear Regulatory Commission (USNRC, 1991, 10 CFR Part 20.1301), and the Health Physics Society (HPS, 2003, recommendation 4), would be 1 mSv per year. The HPS recommendation also supports the ICRP "special circumstances" provision that states, "in special circumstances, a higher value . . . could be allowed in a single year, provided the average (dose rate) over 5 years does not exceed 1 mSv per year." (ICRP, 1991, paragraph 192). This means that, in case of an inadvertent release, the public dose rate limit for the year in which it occurred could be as high as 5 mSv.

5. Even though intruders who might seek to remove some of the waste would receive very high radiation doses (and obtaining the equipment required to remove any of the waste would be far beyond their capabilities), the facility would nonetheless need to be equipped with adequate security devices to provide surveillance 24 hours per day.

6. During the proposed 100-year storage period, many significant technological developments will occur, some of which could completely change current concepts on the best approach for the final disposition of high-level radioactive waste. Based on the information in the figure below (Boulton, 1978), one of the most promising changes would be to resume the reprocessing of spent nuclear fuel. As the graphs indicate, after about 200 to 350 years, the toxicity of the remaining waste (assuming 99.5 percent effectiveness in removing the plutonium) would be comparable to that of the original uranium ore that was mined to fuel the reactor from which the spent fuel was removed. This would, in essence remove the need for a dose rate limit in terms of periods of time on the order of thousands of years. Congress has recently shown an interest in moving toward a reprocessing capability as demonstrated, for example, in the Integrated spent fuel recycling provisions of the fiscal year 2006 appropriations to the Department of Energy (House of Representatives, 2005, pages 156–157).



Source: J. Boulton, Ed., "Management of Radioactive Fuel Wastes: The Canadian Disposal Program", AECL-6314, 1978.

7. Another technological advance that leading cancer specialists predict will be developed within the next 50 years, at most, is a method for the prevention, or cure, of many of the cancers that are common today. Adding support to this optimism is a recent item published in Science (von Eschenbach, 2005) in which the then current Director of the National Cancer Institute stated that NCI "could meet its target of eliminating suffering and death from cancer by 2010 if its nearly $5 billion annual budget were increased by $4.2 billion over 5 years." In this regard, the NCRP (1995) has offered the following comments:

"One of the most important factors likely to affect the significance of radiation dose in the centuries and millennia to come is the effect of progress in medical technology. Medical progress achieved during the past several decades has reduced the risk of premature death and increased the average age of the population, leading

to a relative increase in diseases prevalent in the elderly, e.g., cancer." . . . "At some future time, it is possible that a greater proportion of somatic diseases (diseases such as cancer) caused by radiation will be treated successfully. If, in fact, an increased proportion of the adverse health effects of radiation prove to be either preventable or curable by advances in medical science, the estimate of long-term detriments may need to be revised as the consequences (risks) to future populations could be very different." (NCRP, 1995, Report No. 121, Section 4.2.2.3).

8. The temporary storage of the spent fuel for the suggested 100-year period would provide time for the United States to take advantage of these and similar developments. Since the hereditary effects of radiation have been shown to be minimal, absent the fear of cancer, the potential health problems associated with the disposal of the waste would be significantly reduced.

BENEFITS OF THE PROPOSED POLICY

The proposed approach offers multiple benefits. These include:

1. Centralized storage of waste is provided for security and controllability in a manner that is reversible, allowing for new technologies to be applied to the waste before being interned for perpetuity.

2. If reprocessing the spent fuel from nuclear reactors is judged to be warranted, the toxicity of the waste will be of concern for only 250 to 300 years (as noted above) such that the designation of an appropriate long-term dose rate limit would no longer be needed. Similar considerations will apply to the time-period for which it must be documented that the disposal facility, including the waste containers, etc., has been designed to maintain their integrity.

3. A benefit to reprocessing, if initiated, is that the extracted plutonium can be used as nuclear fuel, thus enhancing our capacity to generate electricity through a process that generates no airborne releases that will contribute to global warming.

4. Another benefit to reprocessing is that it will reduce the amount of waste requiring disposal in Yucca Mountain.

5. Also of note is that the proposed policy is based on sound science as illustrated by citations to the recommendations of the NCRP and the ICRP. The roles of these two organizations are important as sources of radiation protection standards since, in chartering the NCRP in 1964, Congress stipulated that it was to:

> "collect, analyze, develop and disseminate in the public interest information and recommendations about (a) protection against radiation and (b) radiation measurements, quantities and units, particularly those concerned with radiation protection."

Concurrently, Congress stipulated that the NCRP was to "cooperate with the International Commission on Radiological Protection." In accord with this directive, members of the NCRP are active participants in developing the documents that are published by the ICRP.

6. The proposed policy would also remove the implication that any human being, or government body, has the insight or knowledge to make recommendations beyond a few hundred years into the future. On reflection, most people would agree that the establishment of dose rate limits 10,000 to 1 million years into the future is ludicrous. Archeological discoveries have documented the presence of humans on earth only slightly more than 10,000 years ago, and written records documenting the presence of humans date only some 5,500 years ago (Whitehouse, 1999).

Undoubtedly, other approaches will be proposed. All should be given careful consideration, including detailed reviews and evaluations, prior to making a final selection.

EPA PERFORMANCE STANDARDS

The adoption of my proposed policy for monitored retrievable storage in the near future (i.e., 100 years) negates the need to evaluate the Environmental Protection Agency's (EPA) performance standards for Yucca Mountain as a permanent high-level waste repository until a decision on the final disposition of spent fuel and other high-level waste is made after incorporating the development of improved technology and scientific knowledge. However, it seems appropriate to make some comments on these standards since they are the currently proposed standards, and are of interest for this hearing.

These comments are offered with the understanding that my central message calling for a re-design of the purpose for the Yucca Mountain project will make these issues moot.

SCIENTIFIC BASIS FOR THE EPA STANDARDS FOR YUCCA MOUNTAIN—BEGINNING OPERATION TO 10,000 YEARS

The EPA standards for the period from when Yucca Mountain begins operation as a permanent waste repository to 10,000 years have been a long time in development and have gone through an extensive review during the rulemaking process. However, the HPS wants to take this opportunity to point out that the existence of a groundwater protection standard that is separate from an individual protection standard is not founded in science. The HPS understands the courts have upheld the EPA's right to establish a groundwater standard separate from an "all pathways" individual protection standard. However, the HPS believes it is appropriate to continue to reaffirm its position that "[Public radiation-safety standards] should be expressed as an effective dose resulting from all exposure pathways" (HPS, June 2003). Since the EPA's right to establish a separate groundwater protection standard is founded in their legislative authority and enabling legislation, alteration of this EPA approach, which is not consistent with current scientific knowledge, would require congressional action.

SCIENTIFIC BASIS FOR EPA STANDARDS FOR YUCCA MOUNTAIN—10,000 TO 1 MILLION YEARS AFTER BEGINNING OPERATION

Basis for Proposed Standard

It should be noted that the International Commission on Radiological Protection (ICRP, 1991) has for some time stated that one of the approaches for judging the acceptability of dose rate limits for members of the public "is to base the judgment on the variations in the existing level of dose from natural sources. This natural background may not be harmless, but it makes only a small contribution to the health detriment which society experiences. It may not be welcome but the variations from place to place (excluding the large variations in the dose from radon in dwellings) can hardly be called unacceptable."

Also to be noted is that there are large uncertainties in the dose rates from each of the components of natural background. In terms of radon, alone, there are large uncertainties in the measured value of the radon concentration (the presence of thoron; the status of the equilibrium of the radon decay products; the fraction that is unattached versus attached; etc.).

For these and other reasons, any such dose rate limit should be accompanied by an expression of the range of uncertainty it encompasses. The HPS has taken the position that "Estimation of health risk associated with radiation doses that are of similar magnitude as those received from natural sources should be strictly qualitative and encompass a range of hypothetical health outcomes, including the possibility of no adverse health effects at such low levels" (emphasis added) (HPS, 2004).

The EPA proposed rule has a detailed discussion about the "Effects of Uncertainty" (USEPA, 2005, pages 49025 to 49027). However, the uncertainty addressed by the EPA relates to uncertainty of projecting geological and human activity into the future. It does not discuss the uncertainty of today's knowledge of hypothetical health outcomes from low doses of radiation, which forms the basis for the dose rate limit in the proposed standards, including the possibility of no adverse health effects at these low levels.

Validity of the USEPA Analyses

Although the variation in the dose rates from natural background radiation can be a valid basis for making judgments for radiation protection purposes, a series of extensive studies that my colleagues and I have performed have shown that the variations estimated by the EPA (USEPA, 2005) could be improved through the incorporation of the following adjustments.

- One would be to base the dose estimates to the maximum extent onsite-specific values;
- Another would be to apply the latest estimated value of the coefficient for converting radon exposures into dose;
- A third would be to estimate the doses from both outdoor and indoor exposures;
- The last would be to discuss the uncertainties that accompany the dose rate estimates.

With respect to the last comment, our review and evaluation showed that the primary sources of the uncertainties, associated with the dose rate estimates for radon, are the measured values of the radon concentration, and the previously cited dose coefficient. For these and other reasons, any such dose rate limit should be accompanied by an expression of the range of uncertainty it encompasses. The significance of our assessments is that the estimated magnitude of the overall uncertainty in the current estimates of the combined (total) dose rate from all sources of natural back-

ground is about 150 percent. As a result, the differences in the estimated dose rates in one area of the country, compared to another, can only be realistically evaluated in light of these uncertainties. This leads to the realization that, even though the procedures used by the USEPA (2005) in developing their recommended dose rate of 3.5 mSv per year could have been improved, their estimate was nonetheless well within the range of the associated uncertainties and is therefore acceptable.

The peer reviewed studies that support the above statements and other analyses of the EPA standards are contained in five scientific articles, two of which have been published and three of which are in publication. The first two articles, Sensitivity Analyses Of The Standards For The Proposed Yucca Mountain Repository—A Review, Evaluation, And Commentary (HPJ, May 2005), and Impacts Of Stable Element Intake On ^{14}C And ^{129}I Dose Estimates (HPJ, October 2005) are attached. The remaining three articles will be forwarded to the Committee when they are published in the next several months.

PERSPECTIVE ON 3.5 MSV/YEAR

The discussions that follow are designed to provide perspective on the impacts of a dose rate of 3.5 mSv per year. One way of gaining perspective on this impact involves calculating an estimate risk of cancer from the exposure and comparing it to other risks, such as the "natural" risk of cancer. I must note that the HPS position is that "Estimation of health risk associated with radiation doses that are of similar magnitude as those received from natural source should be strictly qualitative and encompass a range of hypothetical health outcomes, including the possibility of no adverse health effects at such low levels."

However, the HPS does recognize that

" . . . risk assessment at low doses . . . can be used to inform decisionmaking with respect to clean up of sites contaminated with radioactive material, disposition of slightly radioactive material, transport of radioactive material, etc."

In the following discussions I am using quantitative risk calculations to inform decisionmaking but I am not stating that it is known for a fact that there will be actual cancer induction or death from radiation exposure at these levels. Also, the 3.5 mSv per year results in a lifetime dose that is greater than the lifetime dose of 100 mSv below which the HPS recommends not doing quantitative assessments.

Estimated Risk of a Cancer Fatality per Unit of Dose

According to the International Commission on Radiological Protection (ICRP, 1991, Table 4, page 24), the risk of death due to the exposure of a member of the public to ionizing radiation is 5×10^{-2}/Sv (5×10^{-5}/mSv) of effective dose. Expressed in another manner, the coefficient (5×10^{-5}/mSv) means that the chances of dying from a cancer caused by exposure to radiation are 5 in 100,000 per mSv of effective dose. At the same time, however, it is important to recognize that this coefficient incorporates the linear-no-threshold hypothesis (LNT), a concept that the ICRP has repeatedly stated leads to risk estimates that are conservative, that is, too high (ICRP, 1966, page 60; ICRP, 1977, paragraph 30). More importantly, keep in mind this is for a population with today's medical treatment and care, which does not account for the likely medical advances that will exist in 10,000 years when this dose rate limit will be applicable. Keeping this caveat in mind, if it is assumed that a population group receives an average dose rate of 3.5 mSv per year, they will receive a total dose during a lifetime of 70 years of:

(3.5 mSv per year) × (70 years) = 245 mSv.

Applying the ICRP risk coefficient, the estimated percentage of the people who would die of fatal cancer due to being exposed to a lifetime dose of this magnitude would be:

(5×10^{-5} per mSv) × (245 mSv) = (1225×10^{-5}) = 1.225×10^{-2} = 1.2 percent.

Prior to applying this risk estimate in evaluating the impacts of potential radionuclide releases from the proposed Yucca Mountain repository, it is important to recognize that the exposed people are assumed (a) to be adults, as required by the USNRC regulations (2001), and (b) to take in a sufficient amount of radioactive material each year that, during the 50 years that follow, they will ultimately receive a committed dose of no more than 245 mSv. This latter assumption leads to additional conservatism in the dose rate estimates, the reason being that many of the exposed people will not live long enough to receive the full 50-year dose commitment. In fact, the NCRP has estimated that the average adult, who is exposed under these conditions, will receive less than half of the estimated committed dose (NCRP, 1993, Section 6.1, page 25).

This is in contrast to the case on which the ICRP risk coefficient was based, namely, that the estimated doses are received in full by the exposed population group. Accounting for these considerations, and the fact that a relatively large frac-

tion of the radionuclides that will potentially be released from the proposed Yucca Mountain repository have long effective half-lives, the actual increase in the cancer fatality rate could readily be half of that estimated above, namely, about 0.6 percent.

On this basis, the relative increase in cancer fatalities within the exposed Amargosa Valley population can be estimated as follows. The spontaneous rate of cancer deaths in the United States currently is about 1800 per 10,000 persons, that is to say, 18 percent of our population die from cancer due to other causes (NRC, 1995, page 72). Based on an added radiation dose rate of 3.5 mSv per year, the chances of dying from cancer, for the average resident of the Amargosa Valley, would have been increased from 18 percent to about 18.6 percent. On a relative basis, this represents an increase of:

(0.6%) ÷ (18.6%) = ~3%.

Estimated Risk of Cancer Incidence per Unit of Dose

According to the NRC (2005, BEIR VII Report), ". . . approximately one individual in 100 persons would be expected to develop cancer from a lifetime (70 year) exposure to low-LET natural 'background' radiation (excludes radon and other high LET radiations)." According to the NCRP (1987, Table 9.6, page 148),and the ICRP (1991, paragraph 191), the total dose rate from natural background, excluding exposures to radon and its decay products, namely, (a) cosmic radiation, (b) terrestrial radiation, and (c) ingested naturally radioactive materials, is "about 1 mSv per year."

Since a dose rate of 1 mSv per year, over a lifetime of 70 years, will yield a total of 70 mSv, the probability of developing cancer would be 1 chance in 100 (1%) per 70 mSv of effective dose. The probability, based on a dose rate of 3.5 mSv per year would be 3.5 times as high, namely, about 3.5 percent. Once again, this estimate of the increase in the cancer incidence rate was based on the assumption that the estimated doses are received in full by the exposed population group. Accounting for this and other considerations, the actual increase in the cancer fatality rate could readily be half of that estimated above, namely, about 1.8 percent.

On this basis, the relative increase in cancer fatalities, within the exposed Amargosa Valley population, can be estimated as follows. The spontaneous rate of cancer incidence in the United States is about 42 persons per 100, that is, about 42 percent of our population, at some point in their lives, will develop cancer due to other causes (NRC, BEIR VII Report, 2005). Based on an added radiation dose rate of 3.5 mSv per year, the chances of suffering cancer, for the average person in the Amargosa Valley, would have been increased from 42 percent to about 43.8 percent.

This accompanying relative increase in cancer incidence would be:

(1.8%) ÷ (43.8%) = ~4%.

Although based on two different sources of information and risk estimation methodologies, this shows good agreement with the estimate for the increase in average risk of cancer fatalities (about 3 percent) presented above. Also to be kept in mind is that the estimated percentage increases in the number of cancer fatalities among residents of the Amargosa Valley would be 0.6 percent. and the comparable estimate of the increase in cancer incidence would be 1.8 percent.

Confirming the Cancer Risks due to a Dose Rate of 3.5 mSv per Year

The estimated risks of cancer incidence and death, due to exposures to ionizing radiation, are based on epidemiological studies, the most notable being the extensive studies of the survivors of the World War II atomic bombings in Japan. Just how difficult it is to quantify the health impacts of a dose rate of 3.5 mSv per year is illustrated by the fact that the National Research Council (NRC, 1995, Table 7–2, page 73) estimates that it would require careful data collection and study throughout the lifetime (i.e., 70 years) of a population group of at least 3,000 people to detect an increase in the total cancer mortality due to an annual exposure of 3.5 mSv for a total of 70 years. One of the reasons for this is that ". . . even at a continued exposure of 5 mSv per year, the change in the age specific mortality rate is very small." (ICRP, 1991, paragraph 191).

ICRP Recommended Dose Rate Limit for Members of the Public

The long-term annual dose rate limit for members of the public, as recommended by the ICRP (1991, paragraph 192), and the NCRP (1993, page 46) is 1 mSv per year. Compliance with this recommendation is to be based on what is called the "Critical Group," which was introduced by the ICRP in 1977, and defined as follows:

"It is often possible to identify population groups with characteristics causing them to be exposed at a higher level than the rest of the exposed population from a given practice . . . These groups . . . (are) known as critical groups . . ." (ICRP, 1977, paragraph 216).

In elaborating on the Critical Group, the ICRP stated:

"The actual doses received by individuals (within the Critical Group) will vary depending on factors such as differences in their age, size, metabolism and customs, as well as variations in their environment. . . . With exposure of members of the public it is usually feasible to take account of these sources of variability by the selection of appropriate critical groups within the population provided the critical group is small enough to be relatively homogeneous with respect to age, diet and those aspects of behaviour that affect the doses received. Such a group should be representative of those individuals in the population expected to receive the highest dose equivalent, and the Commission believes that it will be reasonable to apply the appropriate dose-equivalent limit for individual members of the public to the weighted mean dose equivalent to this group. Because of the innate variability within an apparently homogeneous group some members of the critical group will in fact receive dose equivalents somewhat higher than the mean. However, because of the maximizing assumptions used, the dose equivalent actually received will usually be lower than the estimated dose equivalent." (ICRP, 1977, paragraph 85).

In a later report, the ICRP (1985a, paragraph 69) offered the following commentary on additional characteristics of the Critical Group:

"It is obvious from the definition that some individuals will receive dose equivalents in excess of the calculated mean dose equivalent. Decisions on the acceptability of the exposure of the critical group will depend not only on the proximity of the calculated mean dose equivalent to the dose-equivalent limit but also the expected spread of the distribution of actual dose equivalents. It is also necessary to consider that other sources may contribute to the exposure of any one critical group. It is suggested that, in general, to satisfy the homogeneity requirement the ratio of maximum to minimum values should not exceed an order of magnitude. For many distributions, therefore, the mean will be a factor of two to three lower than the maximum postulated. The necessary degree of homogeneity in the critical group depends on the magnitude of the mean dose equivalent in the group as a fraction of the relevant source upper bound. If that fraction is less than about one tenth, a critical group should be regarded as homogeneous if the distribution of individual dose equivalents lies substantially within a total range of a factor of 10, i.e., a factor of about 3 on either side of the mean. At higher fractions, the total range should be less, preferably no more than a factor of 3."

The important fact to note is that, based on the criteria described above, some members of the Critical Group (as applied in determining the regulatory compliance of the proposed Yucca Mountain repository) would receive dose rates three times the limit. If the applicable long-term dose rate limit for members of the public were 1 mSv per year (as recommended by the ICRP and the NCRP), these individuals would be expected to receive dose rates up to 3 mSv per year.

ADDITIONAL PERSPECTIVE

On the basis of epidemiological studies, it is estimated that 30 percent of the cancer deaths in the United States are due to the use of tobacco products, and an additional 35 percent are due to improper diets, obesity, and the lack of exercise (Moeller, 2005, Table 1.2, page 5). In short, 65 percent of the fatal cancers that occur in the U.S. population are due to deficiencies in our personal habits, factors that are under our control. In contrast, only 2 percent of the cancer deaths in this country are estimated to be due to environmental pollution. In the overall scheme of life, the risk of fatal cancer due to an annual dose of 3.5 mSv throughout one's lifetime is certainly acceptable. As the ICRP has so eloquently stated:

"The Commission . . . wishes to emphasize its view that ionising radiation needs to be treated with care rather than fear and that its risks should be kept in perspective with other risks." (ICRP, 1991, paragraph 14).

CONCLUSION

Thank you Mr. Chairman and members of the committee for the opportunity to testify before you today as you oversee the status of the Yucca Mountain project. I would be happy to answer any questions you may have.

REFERENCES

Boulton, J., "Management of Radioactive Fuel Wastes: The Canadian Disposal Program," Report AECL–6314 (1978).

House of Representatives, "Making Appropriations For Energy and Water Development For The Fiscal Year Ending September 30, 2006, and For Other Purposes,

Conference Report," Government Printing Office, House of Representatives Report 109–275, November 7, 2005.

HPJ, "Sensitivity Analyses Of The Standards For The Proposed Yucca Mountain Repository—A Review, Evaluation, And Commentary," Health Physics Journal, Vol. 85, No. 5, pages 459–468, May 2005.

HPJ, "Impacts Of Stable Element Intake On 14C And 1291 Dose Estimates," Health Physics Journal, Vol. 89, No. 4, pages 249–354, October 2005.

HPS, "Ionizing Radiation-Safety Standards for the General Public, Position Statement of the Health Physics Society," Available at http://hps.org/documents/publicdose03.pdf, (June 2003).

HPS, "Radiation Risk In Perspective," Available at http://hps.org/documents/radiationrisk.pdf, (August 2004).

ICRP, "The Evaluation of Risks from Radiation," Publication 8, International Commission on Radiological Protection, Pergamon Press, New York, NY (1966).

ICRP, "Recommendations of the International Commission on Radiological Protection," Publication 26, Annals of the ICRP, Vol. 1, No. 3 (1977).

ICRP, "Principles for Monitoring for the Radiation Protection of the Population," Publication 43, Annals of the ICRP, Vol. 15, No. 1 (1985a)

ICRP, "1990 Recommendations of the International Commission on Radiological Protection," International Commission on Radiological Protection, Oxford, Pergamon Press; ICRP Publication 60, Ann ICRP 21(1–3) (1991).

Moeller, D.W., Environmental Health, Harvard University Press, Cambridge, MA (2005).

NCRP, "Exposure of the Population in the United States and Canada from Natural Background Radiation," National Council on Radiation Protection and Measurements, Report No. 94, Bethesda, MD, (1987).

NCRP, "Limitation of Exposure to Ionizing Radiation," Report No. 116, National Council on Radiation Protection and Measurements, Bethesda, MD (1993).

NRC, "Radiation Dose Reconstruction for Epidemiologic Uses," National Research Council, Washington, DC, National Academy Press (1995).

NRC, "Health Risks from Exposure to Low Levels of Ionizing Radiation—Phase 2," BEIR VII Report, Pre-publication Copy, National Research Council, National Academy Press, Washington, DC (2005).

USEPA, "Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada, Proposed Rule," U.S. Environmental Protection Agency. Washington, DC: Federal Register; Title 40 CFR, Part 197; pages 49014–49065 (2005).

USNRC, "Standards for Protection Against Radiation," U.S. Nuclear Regulatory Commission, Washington, DC: Title 10, Code of Federal Regulations, Part 20.1301 (1991).

USNRC, "Disposal of High-Level Radioactive Wastes in a Geological Repository at Yucca Mountain, Nevada: Final Rule." U.S. Nuclear Regulatory Commission, Washington, DC: Federal Register, 10 CFR Part 63; 2001: pages 55732–55816 (2001).

von Eschenbach, Andrew, "Buying Time," Science, Vol. 309, no. 5735, page 697 (29 July, 2005).

Whitehouse, D. 'Earliest writing' found; 1999, BBC News. Available at: *http://news.bbc.co.uk/1/hi/sci/tech/334517.stm*. Accessed on 16 January 2006.

RESPONSES BY DADE W. MOELLER TO ADDITIONAL QUESTIONS FROM SENATOR INHOFE

Question 1. Is it possible to quantify radiation risk at 350 millirem per year, which is the EPA proposal?

Response. It is not possible to quantify the radiation risk at any level of radiation exposure for a population 10,000 to 1 million years from now, which is the time period for which the EPA proposal is applicable. This is due to the fact that there is no technical basis for forecasting the causes of death among, and the life spans that will be experienced by, the affected groups. Without this, and related information, the risk estimates cannot be quantified and any proposed dose rate limit is meaningless. This point is so important to the evaluation of the EPA proposal for Yucca Mountain that I have covered this is a separate enclosure to this submittal titled "Implications of Risk Quantification on the Ruling of the Court of Appeals."

Risk coefficients exist for quantifying the health effects (i.e., fatal cancers) that may occur in a large existing population exposed to 350 millirem (mrem) per year. The resulting estimates, however, incorporate so many assumptions that they are highly uncertainty and, as noted above, they are applicable only to populations with today's (i.e., known) cancer rate experience and human life spans. As for the range

of the uncertainties, the Health Physics Society (HPS, 2004) cautions that the "Estimation of health risk associated with radiation doses that are of similar magnitude as those received from natural sources should be strictly qualitative and encompass a range of hypothetical health outcomes, including the possibility of no adverse health effects."

There are multiple factors that must be considered in estimating the risks of radiation exposures. The more important of these are discussed below.

Quantifying Risk.—Lifetime risk estimates are developed through the science of epidemiology. Fundamental to this process is the comparison of the health outcomes of a group of people, exposed to higher doses, to the health outcomes of a similar group (i.e., similar age, gender, nationality, cancer rates, etc), exposed to lower doses. After accounting for all potentially confounding factors, increases in the number of cases of illness and death that occur in the exposed group, as compared to the non-exposed, or less exposed (control) group, are attributed to the radiation exposure. It is important to recognize, however, that this is the observed increase in the risk for the exposed group at the time the comparison was made. To obtain the lifetime risk estimate, the observed difference must be projected to a time when everyone in both the exposed and control groups has died. This is particularly significant in terms of the survivors of the atomic bombings in Japan. In that case, only slightly more than half of the original atomic bomb survivors had died by 2005, 55 years after they were exposed (NRC, 2006, page viii). In order to project the health effects to the end of their lives, assumptions must be made about the relationship between radiation induced, and "naturally occurring" cancers, and the projected life spans of the people remaining in the study. Since the risk estimates currently available are applicable only to populations with known cancer rates and life spans, it is not appropriate to apply these estimates to populations who will be living 10,000 to 1 million years from now, the reason being that it is not scientifically possible to project the baseline cancer rates, or the extent of the life spans that populations will be experiencing, three or four decades from now, much less 10,000 to 1,000,000 years from now.

The problem of transferring risk coefficients derived from the Japanese atomic bomb survivor data to a population far into the future is more completely examined in the enclosure to this submittal, titled "Implications of Risk Quantification on the Ruling of the Court of Appeals."

Perspective on 350 millirem per year.—Although the current risk estimates cannot be responsibly used to predict risks to populations at the time the EPA proposed dose rate limit of 350 mrem (0.350 rem) per year would apply, they can be used to provide perspective on the health impacts on current populations that might be affected by radionuclide releases from the proposed repository. Assuming that the Amargosa Valley population was exposed at this rate throughout an average lifetime of 70 years, their total dose would be:

(0.350 rem/year) (70 years) = 24.5 rem = 0.245 Sv.

In this regard, it is important to note that this is higher than 0.1 Sv (10 rem), the minimum dose for which the BEIR VII committee states that fatal cancer risks can be estimated without unacceptable statistical limitations (NRC, 2006, page 7). Assuming a population consisting of 50 percent men and 50 percent women, the applicable fatal cancer risk coefficient would be 570×10^{-4} per Sv. (NRC, 2006, Table ES–1, page 15). On this basis, the estimated percentage of the Amargosa Valley population that might incur excess fatal cancers would be:

(570×10^{-4} per Sv) (0.245 Sv) = 0.014 = 1.4 percent.

For a population the size of that residing in the Amargosa Valley (about 1200 people; Rautenstrauch et al., 2003), this would mean that the estimated number of excess deaths due to radiation-induced cancer could be:

(1200) (0.014) = ~17.

Because the exposed population is so small, this estimate should probably be expressed as representing something in the range of perhaps 10 to 20 deaths. Since these would be expected to occur, if at all, over the 70-year lifetime of this population group, the average number of excess deaths would range from perhaps 1 every 7, to 1 every 3.5 years. The implications of this are discussed in the response to question No. 2 below. Concurrently, this same population group would be expected to suffer a total of 245 fatal cancers, or about 3 to 4 deaths per year, in the absence of the postulated doses due to radionuclide releases from the proposed repository (NRC, 2006, Table ES–1, page 15).

Question 2. Is it fair to extrapolate the effects of instantaneous high levels of radiation doses to low level exposure over an individual's lifetime?

Response. No, it is not, the key words being "over an individual's lifetime." Although risk models for fatal cancer have been developed for extrapolating the health effects of radiation exposures involving high doses received at high dose rates to those involving low doses received at low dose rates, the estimated health effects (for example, the number of fatal cancers that might result) can be expressed only for the affected population as a whole. They cannot be expressed in terms of the impacts on individual members of that group. At the same time, it must be recognized that estimates based on these processes are reasonably accurate only if the population group, being evaluated, is large, i.e., numbering in the tens of thousands. Compounding the situation is that assessments of health effects that involve either small population groups, or small doses will, in general, not be meaningful due to the lack of statistical rigor.

Even when the potentially affected population group is relatively large, the interpretation of the risks is not easy. This is well demonstrated by the information provided in the BEIR VII report (NRC, 2006). Within a group of 100,000 members of the U.S. population, for example, even in the absence of additional exposure from the proposed repository, there will be, on average, about 20,420 cancer deaths due to natural causes. If each member of this population group is exposed to an average dose of 1 rem over his/her lifetime, one can statistically estimate that an additional 57 of them may die from cancer. No method is available, however, to differentiate which members of this population will be among the 20,420 who will die from cancer due to "natural causes," or will be among the 57 additional members who may die due to the added average dose of 1 rem. Also of note is that, in this example, the increase in the estimated cancer deaths, due to the radiation exposure, is less than 0.3 percent of what otherwise would have occurred.

Question 3. What are your views on EPA's proposed rule and does it protect public health and safety? Is it overly conservative, not protective, or just right?

Response. On the basis of my review and analysis, I conclude that, considering the significant sources of conservatisms in the dose estimates, the calculated risks, and their associated uncertainties, the proposed EPA dose rate limit would be fully protective of public health and safety. Please note, however, the caveats in the separate set of comments on the "Implications of Risk Quantification on the Ruling of the Court of Appeals."

Technical Basis.—The approach adopted by EPA, in establishing the 350 mrem per year dose rate limit, was in accord with the guidance provided by the International Commission on Radiological Protection (ICRP), an organization in which members of the Health Physics Society continue to be active participants. One of the guidelines recommended by this organization for judging the acceptability of dose rate limits for members of the public "is to base the judgment on the variations in the existing level of dose from natural sources. This natural background may not be harmless, but it makes only a small contribution to the health detriment which society experiences. It may not be welcome but the variations from place to place (excluding the large variations in the dose from radon in dwellings) can hardly be called unacceptable." (ICRP, 1991, paragraph 190, pages 44–45).

Nonetheless, the ICRP certainly did not have in mind that this guidance would be used to establish a dose rate limit for a time-period 10,000 to 1 million years from now. Although, on the basis of my review and analysis, I concluded that the proposed EPA dose limit would be fully protective of public health and safety, that conclusion was made in the context of the conditions that exist today. Since it is impossible to predict the characteristics (particularly the lifestyles and fatal cancer rates) of populations who will live so far into the future, I also concluded that any dose rate limit that would be developed and recommended on the basis of today's society is essentially meaningless. Other aspects related to this subject are discussed in the response to question No. 4 below.

Discussion of Uncertainties.—While, in view of the conclusions stated above, comments on other aspects of this question would appear to be superfluous, it should be noted that there are considerable uncertainties in the dose rates from each of the components of natural background. In terms of radon, alone, these include relatively large uncertainties in the measured values of the radon concentrations, due to the presence of thoron (which interferes with the radon measurements); the status of the equilibrium of the radon decay products; the fraction of the decay products that are unattached; and the assumed residence time indoors. In fact, it is estimated that the combined uncertainty accompanying the radon dose estimates can be as high as 150 percent (Moeller and Sun, 2006). Two questionable procedures applied by EPA in the assessments, on which their recommended dose rate (350 mrem y^{-1}) was based, were (1) the use of generic, rather than site-specific data, for estimating the dose rate in both Nevada and Colorado; and, (2) basing the difference

in the dose rate in the region with a "high" natural background rate, versus that with in the Amargosa Valley, on the average for the State of Colorado versus the average for the State of Nevada, extrapolated to be representative of the Amargosa Valley. Both Colorado and Nevada obviously have regions with natural background dose rates that are higher than the state-wide average.

To provide an independent review and evaluation of the EPA estimate, an associate and I compared the average natural background dose rate in the Amargosa Valley to that for Leadville, CO. These two communities were selected since they are in the same general region of the United States; they are of comparable size; and in both cases site-specific data were available for the conducting the evaluations. Interestingly, the estimated difference in the natural background dose rates in the two communities was almost 400 mrem (4.00 mSv) per year, almost 15 percent higher than the EPA estimate. One of the primary reasons for the higher estimate is that the EPA contractor overlooked the fact that more than 90 percent of the population of the Amargosa Valley live in mobile homes which, due to their construction and placement a foot or more above the ground, have indoor radon concentrations that are less than those outdoors (Moeller and Sun, 2006).

Discussion of Conservatism.—Also to be considered in answering a question of this nature are the significant conservatisms that are incorporated into the methodologies used in documenting compliance with the dose rate limit. According to the regulations of the U.S. Nuclear Regulatory Commission (USNRC, 2001), the person on whom compliance with the regulations will be based is an adult. Under these conditions, the dose assigned to an intake of a radionuclide is that which will be imparted to the exposed person during the 50-year time-period following ingestion. Due to their nature, a majority of the more important radionuclides in high-level radioactive waste, that have the potential for release from the proposed repository, have long radioactive half-lives combined with long biological retention times in the body. For these reasons, the NCRP has estimated that many of the exposed people will not live long enough to receive their full 50-year dose commitment. In fact, the NCRP estimates that the average adult, who is exposed under these conditions, will receive less than half of the estimated committed dose (NCRP, 1993, Section 6.1, page 25). For these radionuclides, which include 226Ra, 237Np, 239Pu, and 241Am, this means that the calculated dose will be less than half of that which will occur.

It has been a long-standing policy of the ICRP and NCRP that radiation exposures from naturally occurring sources (other than those that are technically enhanced) are not to be included in assessments for compliance with regulations. In contrast, EPA requires that any naturally occurring radium in the groundwater being consumed by the residents of the Amargosa Valley must be included as a source of dose in the determination of compliance. EPA also requires that the U.S. Department of Energy (DOE), for purposes of determining compliance, must assume that the "reasonably maximally exposed individual" (RMEI) resides 18 km south of the border of the proposed repository, an area that is currently not inhabited. The Amargosa Valley, which is the most probable location of the primary population group that could potentially be exposed through releases from the proposed repository, is located some 35 km south of the proposed repository.

Another source of conservatism is the assumption by DOE that an aquaculture farm, shut down some 5 years ago but a significant potential source of increased intake of ^{14}C, is still operating. Still another conservatism is the failure to account for the fact that, although the primary radiation exposures due to the operation of the proposed repository will be through the ingestion of radionuclides, studies show that the health effects per unit dose, due to radionuclides non-uniformly distributed within the body, are significantly less than those for comparable doses from external sources of exposure (Bair, 1997). These, and other assumptions, lead to an estimated overall factor of conservatism of 10 in the dose rate estimates (Moeller and Ryan, 2006).

Question 4. Is regulating to 1 million years necessary to protect public health and the environment?

Response. No. Regulating to 1 million years becomes unnecessary if the technological and policy changes suggested in my testimony are adopted. In fact, if the proposed changes are implemented, the nature and toxicity of the waste requiring disposal will be such that it will only need to be monitored for a period of 300 to 500 years, at most. Our goal has been to present a plan that will provide a mechanism for ending the ongoing legislative wrangling. It will accomplish this by producing a waste that is far less toxic than that which otherwise will need to be disposed. Also not to be ignored is that the proposed technological changes will eliminate any need for establishing a dose rate limit from 10,000 to 1 million years.

In any discussion of this nature, it is important to keep in mind the genesis of the controversy. It occurred as a result of the ruling of the U.S. Court of Appeals (issued on July 9, 2004) that the "10,000-year compliance period selected by EPA violates section 801 of the Energy Policy Act (EnPA) because it is not, as EnPA requires, 'based upon and consistent with' the findings and recommendations of the National Academy of Sciences." In essence, the court ruled that the EPA's standard as of that time was "arbitrary and capricious" under the Administrative Procedure Act, and it was incumbent upon EPA to establish a dose rate limit extending beyond 10,000 to 1 million years. That ruling had nothing to do with science.

Technical Benefits of the Proposed Approach.—The fundamental change in the suggested approach is that the Nation's high-level radioactive waste be placed in interim storage at the existing Yucca Mountain facility for a period of 100 years. This will provide a "window" for DOE to reconsider its present approach not only in the management and treatment of its high-level waste, but also to dramatically change the conditions under which it will need to be disposed. The primary technical benefits can be summarized as follows:

1. This "window" would enable DOE to take advantage of new and ongoing technological developments in the physical and chemical processing of spent nuclear fuel. One example, already demonstrated at the laboratory level, has been shown to yield an increased effectiveness in the separation of the transuranic radionuclides (for example, 237NP, 239PU, and 241Am) from the fission products. This would produce a waste with a significantly reduced toxicity. In fact, after a decay period of about 350 years, its toxicity would be no higher than the original ore that was strip-mined to obtain the uranium that, after being used as a source of power for the reactors, produced the spent nuclear fuel that, after being processed, yielded the waste. This comparison is based on the assumption that the original ore contained a uranium concentration of 0.2 percent, that is, it was what is called a relatively low grade of ore. If the ore was of a higher grade, the difference in toxicity would be even more dramatic. After 1,000 years decay, the waste would have decayed to where the toxicity would be no higher than about 10 percent of that of 0.2 percent ore. Particularly noteworthy is that, while the uranium ore, when mined, was at or near the surface of the earth, the waste resulting from reprocessing would have been vitrified and buried in thick metal containers more than 600 feet beneath the surface of the earth.

2. The resumption of fuel processing would reduce the thermal heat load of the waste being placed in the proposed repository, thus yielding benefits in terms of reduced impacts on the surrounding geological structures. Equally important, it would eliminate the concerns related to criticality.

3. While the above discussion involves primarily technical issues, the suggested approach would have a significant bearing on the environmental health issues related to the disposal of high-level radioactive waste. The basis for this statement is that the recommended actions, if adopted, would essentially remove the need to consider a regulatory dose rate limit for more than perhaps 400 or 500 years after the waste were placed in the proposed repository. From a technical standpoint, it would enable DOE not only to remove the more toxic long-lived materials from the waste, prior to placing it in the proposed repository, but it would enable the un-used uranium and newly produced plutonium to be reclaimed and used as fuel in generating additional electricity in nuclear power plants. This suggested approach would also conserve our uranium resources and significantly reduce, as noted earlier, the toxicity of the waste.

4. Nonetheless, it is important to recognize that implementation of this proposal would require a full-scale safety review of all of its associated ramifications. A common error, in the adoption of what appear to be promising new approaches, is the failure of those implementing the suggestions to review and evaluate their full range of implications. These would include the impacts of the suggested changes on the challenges that must be solved in handling and vitrifying the waste, similar challenges in converting the transuranic radionuclides into fuel for use in commercial nuclear power plants, and safety considerations associated with transporting the waste to the storage facility. Also to be considered is the fact that, while the newer chemical technologies (a primary example being the UREX + Process developed at the Argonne National Laboratory East), has been proven at the laboratory scale, the upgrading of this process into an industrial scale operating facility would require considerable effort and time, the latter being perhaps as much as 10 to 30 years.

Policy Implications of the Proposed Approach.—From a policy standpoint, the proposed approach has far-reaching implications, many of which would be extremely beneficial to the United States' energy program and associated industries. For example:

1. Achieving a satisfactory solution for waste disposal problem would reduce our dependence on foreign oil, because it would enable us to move forward in generating copious supplies of electricity through the application of nuclear energy.
2. A satisfactory solution to the waste disposal problem would reduce our discharges into the atmosphere of the gases that cause global warming.
3. The resumption of spent fuel reprocessing would significantly reduce the amount of waste requiring transportation and disposal. At the same time, however, this could present challenges in terms of handling and transporting the waste. This and other potential ramifications would need to be given careful consideration.
4. The 100-year storage/monitoring period would enable the DOE staff to document more fully the adequacy of the capabilities of that facility for the "disposal" of high level waste. This would, in turn, provide additional assurance that the proposed facility would operate as anticipated, as well as an opportunity to incorporate beneficial changes in its design.
5. Finally, the proposed policy would enable the Federal Government to accept responsibility for high-level waste as mandated in the 1992 Nuclear Waste Policy Act.

REFERENCES

Bair, William J., "Radionuclides in the Body: Meeting the Challenge, Lauriston S. Taylor Lecture," Health Physics, Vol. 73, No. 3, pages 423–432 (September 1997).

EPA, "Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada, Proposed Rule," Environmental Protection Agency, Washington, DC: Federal Register; Title 40 CFR, Part 197; pages 49014–49065 (2005).

HPS, "Radiation Risk In Perspective, Position Statement of the Health Physics Society," Health Physics Society, McLean, Virginia (August 2004)

ICRP, "1990 Recommendations of the International Commission on Radiological Protection," International Commission on Radiological Protection, Publication 60, Annals of the ICRP, Vol. 21, No. 1–4 (1991).

Moeller, Dade W., and Ryan, Michael T., "Review and Evaluation of Factors Affecting Dose Estimates for Long-Term Performance Assessments Using the Proposed Yucca Mountain Repository as an Example," Health Physics (in press).

Moeller, Dade W., and Sun, Lin-Shen C., "Comparison of Natural Background Dose Rates for Residents of the Amargosa Valley, NV, to Those in Leadville, CO, and the States of Colorado and Nevada," Health Physics (in press, 2006).

NCI, "Surveillance, Epidemiology, and End Results Program, 2005," National Cancer Institute, Bethesda, MD (2005). Available at SEER—*http://www.seer.cancer.gov*.

NCRP, "Limitation of Exposure to Ionizing Radiation," Report No. 116, National Council on Radiation Protection and Measurements, Bethesda, MD (1993).

NRC, "Health Risks from Exposure to Low Levels of Ionizing Radiation, BEIR VII Phase 2," National Research Council, National Academy Press, Washington, DC (2006).

Rautenstrauch, Kurt R., Smith, Anthony J., and Andrews, Robert, "Technical Basis Document No. 12: Biosphere Transport, Revision 1," Bechtel SAIC Company, LLC, Las Vegas, NV (September 2003).

USNRC, "10 CFR Parts 2, 19, 20, 21, etc., Disposal of High-Level Radioactive Wastes in a Proposed Geologic Repository at Yucca Mountain, Nevada; Final Rule," U.S. Nuclear Regulatory Commission, Washington, DC, Federal Register, 10 CFR Part 63; pages 55732–55816 (November 2, 2001).

RESPONSES BY DADE W. MOELLER TO ADDITIONAL QUESTIONS FROM SENATOR JEFFORDS

Question 1. In your written testimony, I was interested to see that you endorse temporarily storing spent nuclear fuel at the Yucca Mountain site for approximately 100 years. Congress has tried in the past to approve interim storage but has failed because of fears that the storage would become permanent and that the financial and political investment at the site would prevent an independent evaluation of the project as a long term repository. As a radiation health specialist, what do you see as the health benefits of interim waste storage at Yucca Mountain?

Response. This question involves multiple considerations. As noted in the written testimony that we prepared, approval of the proposal for storing the high-level waste for 100 years in the Yucca Mountain facility would need to be accompanied by a number of safeguards. First, the waste would need to be stored in a manner so that it could be monitored continuously to warn of any failures in the waste canisters or any other components of the system. To ensure that corrective measures could readily be implemented, if necessary, the waste would also need to be stored

so that it can be retrieved, and the defects or sources of the failures remedied. At the same time, all the data on the performance of the system would need to be made available. In fact, arrangements should be considered for having a team of independent, technically qualified, members of the U.S. Nuclear Regulatory Commission (USNRC, 2000) staff (referred to, in the case of commercial nuclear power plants as onsite "resident inspectors") be stationed at the Yucca Mountain facility to observe operations on a full time basis.

Benefits of 100-Year Storage Period.—In terms of the factors on which responses are requested, the benefits of the 100-year storage period would relate to potential developments in two specific areas. One would be methods for the cure and/or prevention of diseases that are directly related to the effects of radiation exposures. Obviously, the most important such disease would be cancer. The second benefit would be improvements in the development of chemical technologies for separating the transuranic radionuclides from the spent nuclear fuel. Since it appears more appropriate, the latter topic will be discussed in the response to question No. 2.

In terms of medical technologies, it should be noted that progress in developing methods for the cure and/or prevention of a variety of cancers is moving ahead at a rapid pace. For example, a recent article in U.S. News & World Report, describes a new vaccine that "may rid the world of cervical cancer." (Fischman, 2006). Similar progress is being made in developing vaccines for other types of cancer. Should these and related developments be successful, they would completely change the degree of protection required for the disposal of high-level radioactive wastes.

Supporting the importance of such developments, in terms of how the detrimental effects of cancer are viewed, is the following statement of the National Council on Radiation Protection and Measurements (NCRP, 1995):

> "One of the most important factors likely to affect the significance of radiation dose in the centuries and millennia to come is the effect of progress in medical technology. Medical progress achieved during the past several decades has reduced the risk of premature death and increased the average age of the population, leading to a relative increase in diseases prevalent in the elderly, e.g., cancer." . . . "At some future time, it is possible that a greater proportion of somatic diseases (diseases such as cancer) caused by radiation will be treated successfully. If, in fact, an increased proportion of the adverse health effects of radiation prove to be either preventable or curable by advances in medical science, the estimate of long-term detriments may need to be revised as the consequences (risks) to future populations could be very different." (NCRP, 1995, Report No. 121, Section 4.2.2.3).

Cautionary Notes.—In this regard, however, it is important to note that, even if a method for curing or preventing cancer is developed, this will not eliminate the health concerns of radiation. One of the remaining concerns will be the potential for hereditary effects. In this case, however, the concern appears to be even less. After a detailed review and evaluation of the latest information on human genetic disease and the mechanisms of radiation-induced genetic mutation, the BEIR VII committee concluded that the application of a new approach to genetic risk estimation leads the committee to conclude that:

> "At low or chronic doses of low-LET irradiation, the genetic risks are very small when compared to the baseline frequencies of genetic disease in the population." (NRC, 2006, page 12).

Another potential concern would be mental retardation. This effect, which is of concern in terms of exposures to the children of mothers during pregnancy, has been shown to be primarily of importance for exposures that occur during the period from 8 weeks to 15 weeks after conception. A similar but smaller effect has also been detected following exposures that occur during the period from 16 weeks to 25 weeks (ICRP, 1991, paragraph 92, page 23). In terms of the proposed Yucca Mountain repository, however, the concern should be small. As noted in the BEIR VII report, these effects occur only "at high doses." (NRC, 2006, page 1). Any effects that might be anticipated, due to operations in the proposed Yucca Mountain repository, would be extremely small.

Other Potential Health Benefits of Interim Storage.—Another benefit is that the suggested 100-year storage period would enable the U.S. Department of Energy (DOE) to incorporate new technological developments into the repository design while, at the same time, gather additional data to enhance their documentation that the proposed facility will perform as they anticipate, and to identify design and procedural changes that would further improve the retention of the waste.

Another advantage, which certainly has a strong relation to public health and safety, is that the storage of the spent nuclear fuel and high level waste in a single centralized and geologically safe facility, rather than at about 100 interim nuclear

waste disposal facilities (about 70 of which are at commercial nuclear power plant sites) throughout the country, would vastly increase the level of protection against potential human intrusion, terrorist attacks, as well as against the impacts of large aircraft crashes, whether deliberate or accidental. Another advantage is that the capabilities for security protection, as well as the ability to correct any failures in the waste canisters, would be vastly superior to those that could be provided at each of the 100 existing storage sites.

The Nuclear Waste Management Organization (NWMO, 2005), created by the Canadian Government in 2002 under the Federal Waste Act, is following a similar approach. Their timeframe for completion of a repository, however, is significantly longer (300 years) as compared to the 100-year timeframe suggested for the United States. So as to avoid storage of the waste at multiple individual reactor sites, Canadian authorities are also moving forward with plans for the development of a centralized facility for interim storage of the waste.

Question 2. In your proposal, you also state that during the proposed 100-year storage period, many significant technological developments will occur which could change the best approach for the final disposal of radioactive waste. Given that these new reprocessing technologies are unproven and, if viable at all, are still potentially 20 to 60 years away, can we say anything today about the health effects of the radiation these technologies will produce?

Response. While newly developed reprocessing technologies should not be applied without careful review and evaluation, there appear to be multiple benefits in the resumption of the reprocessing of spent nuclear fuel. Several of these are discussed below:

1. Although proven only at the laboratory scale, the UREX + Process (developed at the Argonne National Laboratory East) for removing the transuranic radionuclides (237Np, 239PU, and 241Am) from spent fuel, appears especially promising. Because the degree of separation is more efficient than was available with previous technologies, the toxicity of the waste thus produced would be orders of magnitude less than that of spent nuclear fuel.

2. Once removed, the highly toxic transuranic radionuclides could be used as fuel in commercial nuclear power plants and, through this process, converted into shorter lived fission products that would, in general, be far less toxic.

3. Another potential public health benefit would be that the application of these new techniques would reduce the volume of the waste that would need to be handled, transported, and disposed. While this would also involve other considerations, the potential benefits are promising.

4. The high-level radioactive waste, produced through the application of the improved separation techniques, would yield a much reduced heat load. This would significantly improve the performance of the proposed repository. Although these changes would not necessarily yield an immediate health benefit, they would certainly do so in terms of the long-term performance of the proposed repository and its projected health impacts on future generations.

Other Considerations.—As question No. 2 reminds us, it will be necessary to expand the capabilities of the UREX + Process so that is can be applied on an industrial scale. Nonetheless, its effectiveness in separating the transuranic radionuclides from the fission products has such promising benefits that I believe that DOE would be remiss not to undertake this effort. Although this could require as much as 10 to 30 or more years to accomplish, the suggested 100-year storage period should provide the time necessary to accomplish this goal. When considered in conjunction with the potential reductions in health effects (described in the response to question No. 1), this technology would certainly appear worthy of exploration.

At the same time, however, it must be acknowledged that the resumption of chemical processing and the implementation of the suggested new approach is not a one-way street. While it is anticipated to have multiple benefits, a change in any component of the waste disposal system will have impacts on other components. For this reason, the suggested changes will need to be implemented in a prudent and cautious manner. While there will undoubtedly be some surprises, the long-term benefits are considered to be well worth the effort.

REFERENCES

Fischman, Josh, "Sticking It To Cancer," U.S. News & World Report, Vol. 140, No. 12, pages 56–63 (April 3, 2006).

ICRP, "1990 Recommendations of the International Commission on Radiological Protection," International Commission on Radiological Protection, Publication 60, Annals of the ICRP, Vol. 21, No. 1–4 (1991).

NCRP, "Principles and Application of Collective Dose in Radiation Protection," Report No. 121, National Council on Radiation Protection and Measurements, Bethesda, MD (1995).

NRC, "Health Risks from Exposure to Low Levels of Ionizing Radiation, BEIR VII Phase 2," National Research Council, National Academy Press, Washington, DC (2006).

NWMO, "Choosing the Way Forward—Draft Final Report," Nuclear Waste Management Organization, (2005). *http://www.web.net/~robbins/index.html*

USNRC, "Staff Requirements—SECY–99–227—N + 1 Resident Inspector Staffing Policy," Memorandum from the Secretary to the Executive Director for Operations, U.S. Nuclear Regulatory Commission, Washington, DC (January 11, 2000).

RESPONSE BY DADE W. MOELLER TO AN ADDITIONAL QUESTION FROM SENATOR BOXER

Question. Is a "one in four risk" of fatal cancer for a woman exposed to 350 millirems per year of cancer acceptable?

Response. Senator Boxer, your estimate from Dr. Tom Cochran, whom I know very well, sounds to me to be high. But to answer your question, if indeed his calculations were correct and a dose rate limit of 350 millirems a year would create a one chance in four of a woman dying of cancer during her lifetime, "that would be totally unacceptable. No one would approve that."

Subsequent to the hearings, the following review and evaluation of the risk of such a lifetime dose rate for women has been estimated. The results are as follows.

According to the BEIR VII committee, which, under the auspices of the National Research Council, has just completed a detailed review and evaluation of the latest information on the health effects of ionizing radiation, the risk to women of fatal cancer due to exposure to ionizing radiation is 660×10^{-4} Sv^{-1} (NRC, 2006, Table ES–1, page 15). Assuming a woman were to receive a lifetime (70 years) radiation dose at a rate of 350 mrem per year, her total dose would be:

350 mrem/year) (1 rem/1000 mrem) (70 years) = 24.5 rem.

Since 24.5 rem is equal to 0.245 Sv, the estimated increase in fatal cancer risk that a group of women so exposed would incur would be:

$(660 \times 10^{-4}$ Sv^{-1} (0.245 Sv) = 0.016 = 1.6 percent.

That is to say, under the stipulated conditions, 1.6 percent of the women so exposed could die of cancer.

The risk estimated by Dr. Cochran (one chance in four) is equivalent of 25 percent. This is a factor of:

(25 percent) ÷ (1.6 percent) = 15.6.

times the estimate based on the latest guidance provided by the BEIR VII committee.

CONCLUSION

On the basis of these analyses, one can conclude that the risk estimated by Dr. Cochran, due to a total dose of 0.245 Sv, vastly exceeds the amount that such a dose would be expected to create. For purposes of perspective, it might be noted that the "natural" risk of fatal cancer among women residing in the United States is 19.78 percent (NCI, 2005). Rounding this off to 19.8 percent, the total risk of fatal cancer to a group of women, under the presumed circumstances, would be:

(19.8 percent) + (1.6 percent) = 21.4 percent.

On this basis, even the estimated risk of fatal cancer due to a postulated dose of 0.245 Sv, combined with that due to the "natural" background risk, would be less than the "one chance in four" risk ascribed by Dr. Cochran to the postulated dose alone.

REFERENCES

NCI, "Surveillance, Epidemiology, and End Results Program, 2005," National Cancer Institute, Bethesda, MD (2005). Available at SEER—*http://www.seer.cancer.gov.*

NRC, "Health Risks from Exposure to Low Levels of Ionizing Radiation, BEIR VII Phase 2," National Research Council, National Academy Press, Washington, DC (2006).

IMPLICATIONS OF RISK QUANTIFICATION ON THE RULING OF THE COURT OF APPEALS

INTRODUCTION

On July 9, 2004, the United States Court of Appeals ruled that the "10,000-year compliance period selected by EPA violates section 801 of the Energy Policy Act (EnPA) (U.S. Congress, 1992) because it is not, as EnPA requires, 'based upon and consistent with' the findings and recommendations of the National Academy of Sciences." (U.S. Court of Appeals, 2004) This being the case, the Court ruled that it was incumbent upon EPA to establish a dose rate limit extending from 10,000 to 1 million years. In contrast, close examination reveals that the recommendation of the National Research Council Committee on Technical Bases for Yucca Mountain Standards (NRC, 1995, pages 6–7) stipulated that the "assessment be conducted for the time when the greatest risk occurs . . ." Compliance with the ruling of the Court would, therefore, require that the EPA proposed dose rate limit be converted into an equivalent limit in terms of risk. This can be accomplished only if data on the health effects (cancer risks) per unit of radiation exposure to a future U.S. population, anticipated to exist 10,000 or more years from now, can be estimated. The ramifications of such a task are discussed in the sections that follow with the conclusion that the risk cannot be estimated. The implications of how the scientific issues discussed below impact the implementation of the ruling of the Court of Appeals is strictly that of Dade W. Moeller.

SOURCES OF INFORMATION ON RADIATION RISKS

Radiation health-effects experts worldwide agree that the primary sources of data on the cancer related risks of ionizing radiation are those generated through the epidemiological studies of the survivors of the World War II atomic bombings in Japan.

TRANSFER OF RISK ESTIMATES TO THE U.S. POPULATION

Although the Japanese data are comprehensive, they are directly applicable only to the population group that was exposed at the time of the bombings. They cannot be applied, without modification, to the United States, or any other population, particularly for interpreting the health effects from potential radionuclide releases from the proposed Yucca Mountain high-level radioactive waste repository. Even more importantly, they cannot be applied under any conditions for assessing the risks of exposures that occur 10,000 to 1 million years into the future. This is due to a host of reasons, the most prominent of which can be described as follows:

- The exposures in Japan involved relatively high doses received at high dose rates. In contrast, potential radionuclide releases from the proposed repository will involve low doses received at low dose rates. This is important because the health effects, per unit dose, received at low rates are less than those received at high dose rates. This difference is taken into account through the application of what is called a Dose and Dose Rate Effectiveness Factor (DDREF).
- The baseline risks for specific cancers within a population play a dominant role in terms of the magnitude of the excess cancer risks due to radiation exposures. Since the baseline risks for specific cancers within the U.S. population are not the same as those for the Japanese population, there are country-to-country, or spatial, differences in the risks of cancer in different body organs.
- The characteristics of the U.S. population in the future will be different than they are today. This means that there will be temporal differences in the risks of cancer in different body organs, per unit of dose—now as contrasted to the future.

Challenge No. 1: Converting Health Effects of High Dose and Dose Rates to Low Dose and Dose Rates

Based on extensive reviews and evaluations, the International Commission on Radiological Protection (ICRP, 1991, paragraph B62, pages 111–112), and the National Council on Radiation Protection and Measurements (NCRP, 1993, Section 7, page 29), have recommended that, for the evaluation of the health effects (per unit dose) of low dose and dose rate exposures, the estimated risks (increased cancers) observed among the Japanese a-bomb survivors be divided by a factor of 2.0. As noted above, this is known as the dose and dose rate effectiveness factor (DDREF). Although the BEIR VII committee recommended a value of 1.5 for DDREF (NRC, 2006, page 274), the value being almost universally applied today is 2.0.

Challenge No. 2: Transfer of Risk Estimates to the U.S. Population

Once the health risks have been modified, taking into account the dose and dose rates, the next step is to interpret (or translate) the risks from the radiation exposures that were observed among the Japanese population, to those that would be

anticipated for people currently living in the United States. To accomplish this task, it is necessary to account for critical differences in the characteristics of the populations in the two countries.

Epidemiologists use the term, "risk," for describing the excess health effects (e.g., cancer incidence and mortality) observed in populations who have been exposed to radiation. One methodology that has been developed for this purpose is the Excess Relative Risk (ERR) model. The basis for this model is that the excess risk of developing a specific cancer, due to radiation exposure, is assumed to be proportional to the baseline risk, and that the proportionality (percentage increase) due to a unit dose of radiation will be the same for the U.S. population as for the Japanese population.

Data show that the baseline risks for cancers of the colon, lung, female breast, and male prostate are higher in the U.S. population than in Japan. In contrast, the baseline rates for cancers of the stomach and liver are higher in Japan (NRC, 2006, pages 269 and 275). In applying the concept of proportionality, it is assumed that if a given radiation exposure increases the baseline risk of a specific cancer in the Japanese population by 10 percent, it will do likewise in the United States population. In a sense, this implies that the higher rates of colon, lung, female breast, and male prostate cancers in the United States mean that the U.S. population is more susceptible to these cancers. That being the case, they will similarly be assumed to be more susceptible to these same cancers, if exposed to radiation. Extending this concept, if vaccines (similar to that for cervical cancer) are developed for preventing additional types of cancers, and their baseline rates are reduced, then the probability of those cancers being caused as a result of being exposed to radiation will be similarly reduced. That is, if a vaccine reduces the baseline rate for a specific cancer, it will be assumed to reduce the probability that radiation will cause that same cancer.

Further complicating the transfer of data from one population to another is that the lifestyles and baseline cancer rates in populations do not remain constant with time. This was exemplified by the changes that occurred in the rates for cancers of the stomach, colon, lung, and female breast, among the Japanese population during the period from 1950 to 1988. This was attributed to the fact they were becoming more "westernized." (NRC, 2006, page 268).

Challenge No. 3: Transfer of Risk Estimates to Future U.S. Populations

In contrast to the discussion above, the ruling by the Court of Appeals stipulated that a dose rate limit be established for the time-period from 10,000 to 1 million years after closure of the proposed repository. Again, it is important to note that, while the National Research Council Yucca Mountain Committee (NRC, 1995) recommended that compliance be assessed on the basis of the time of "greatest risk," the Court stipulated that EPA promulgate a dose rate limit for purposes of determining compliance. The only way that a dose rate limit, regardless of its magnitude, has any relevance is if the risk of cancer, associated with that dose rate limit, can be quantified. As noted above, this depends on a host of characteristics of the presumed future population. Only after those characteristics have been defined, can such a transformation be made. That this will be a daunting task is exemplified by the example, discussed immediately above, of the impacts of "westernization" on the Japanese population. This occurred during a period of less than 4 decades. Currently, there is no scientific basis for projecting the changes that will occur during time-periods ranging from 10,000 to 1 million years.

Since there are multiple characteristics that determine the risks of cancer among exposed members of a population, and many of these are organ specific, this means that a host of characteristics, lifestyles, medical practices, and other factors, within the postulated future population must be specified. The examples that follow illustrate the magnitude and challenges of this task.

- Cancer screening approaches, such as colonoscopies, during which pre-cancerous lesions cannot only be detected, but also removed, thus reducing the incidence of colon cancer. Note: Such a statement presumes that colonoscopies will still be the common among populations living 10,000 to a million years from now! The same general concept applies to the other examples that follow.
- Procedures for vaccinating children for chronic hepatitis B, since such a practice reduced the incidence of liver cancer. In contrast, the increasing rate for Hepatitis C, for which a vaccine does not exist today, may lead to an increase in liver cancer.
- The age at which women have their first child—the younger the age the less risk they have of developing breast cancer in the future.

• The racial composition of the population. African-American men, for example, have higher rates of prostate cancer. In a similar manner, genetic susceptibility to cancer is different for various races.

Since, as noted, the National Research Council Committee (NRC, 1995, pages 6–7) recommended that "compliance assessment be conducted for the time when the greatest risk occurs . . .," it will be necessary to convert the EPA 3.5 mSv (350 mrem) per year dose rate limit (EPA, 2005) into an equivalent risk rate limit. If this is to be accomplished in any reasonably accurate manner, it will be necessary to know the baseline rates for all types of cancer at that time. This, in turn, will require having accurate information not only on the information listed above, but also on:

• How long members of the exposed population are anticipated to live—the risk of cancer increases with longevity, as well as the distribution of the population by age, since the susceptibility to cancer varies with age.

• Projections of future developments of cancer preventive therapies—most especially vaccines for cancers in specific body organs.

• The anticipated exposure of the population group to other carcinogens, such as tobacco.

In short, data will be needed on their age distribution, life spans, baseline cancer rates, exposures to other carcinogens, and dietary habits. In addition, it would require an accurate projection of the status of medical care, medical technology (including the availability of artificial lungs, stomachs, livers, etc.), and multiple other items of information relative to the postulated future population.

CONCLUSIONS AND COMMENTARY

The recommendation of a dose rate limit, without the ability to estimate the risk that it would represent, would provide essentially no benefit in terms of protecting future population groups. Unless the items of information enumerated above can be made available, it will not be possible to provide a useful dose rate limit. Since the data are not available (and cannot be projected), one can only conclude that it is not scientifically possible for EPA to respond to the ruling of the Court in any meaningful manner.

What the Circuit Court failed to recognize is that the time of "greatest risk" will not necessarily coincide with the time of "peak dose." The relationship between dose and risk is not linear with time, especially when dealing with tens of thousands to a million years. The time of peak does could, in reality, occur at a time of minimum risk.

REFERENCES

ICRP, "1990 Recommendations of the International Commission on Radiological Protection," International Commission on Radiological Protection, Publication 60, Annals of the ICRP, Vol. 21, No. 1–3 (1991).

NCRP, "Limitation of Exposures to loizing Radiation," National Council on Radiation Protection and Measurements, Report 116, Bethesda, MD (1993)

NRC, "Technical Bases for Yucca Mountain Standards," Committee on Technical Bases for Yucca Mountain Standards," National Academy Press, Washington, DC (1995).

NRC, "Health Risks from Exposure to Low Levels of Ionizing Radiation, BEIR VII Phase 2," National Research Council, National Academy Press, Washington, DC (2006).

U.S. Environmental Protection Agency. Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada, Proposed Rule," Washington, DC: Federal Register; Title 40 CFR, Part 197, pages 49014—49065 (August 22, 2005).

United States Court of Appeals, For the District of Columbia Circuit, *Nuclear Energy Institute, Inc.*, Petitioner v. *Environmental Protection Agency,* Respondent (Argued January 14, 2004; Decided July 9, 2004).

U.S. Congress, "Energy Policy Act of 1992," H.R. 776, Washington, DC (1992).

STATEMENT OF ROBERT LOUX, EXECUTIVE DIRECTOR, NEVADA AGENCY FOR NUCLEAR PROJECTS

Thank you for the opportunity to appear before you today. I am Robert Loux, Executive Director of the Nevada Agency for Nuclear Projects, which is a branch of the Office of the Governor of the State of Nevada. The Agency was created by the Nevada Legislature in 1985 to carry out the States oversight duties under the Nu-

clear Waste Policy Act. I have served as the Agency director since it was established. Our Agency also serves as staff for the Nevada Commission on Nuclear Projects.

Our State, being the home of the Nevada Test Site, has a long history of Federal nuclear programs, and our citizens are well informed about the proposed Yucca Mountain high-level nuclear waste repository located on and adjacent to the southwest portion of the Nevada Test Site, about 90 miles northwest of Las Vegas. The U.S. Department of Energy has occupied the Yucca Mountain site since 1978, and in 1983, after passage of the Nuclear Waste Policy Act of 1982, the site was named one of nine Potentially Acceptable Sites, located in six States. In 1986, after screening of the nine sites as required by the Act, Yucca Mountain was named as one of three Candidate Repository Sites slated for detailed site characterization. The two other sites were located in Deaf Smith County, TX, and on the DOE's Hanford Reservation, in Washington. According to the Act, after completion of site characterization, one of the three Candidate Sites would be recommended to the President by the Secretary of Energy for development of a repository.

As you know, in late 1987, Congress passed the Nuclear Waste Policy Amendments Act that terminated the site screening process under which the three candidate sites were being characterized, and singled out the Yucca Mountain site as the only site to be studied for a potential repository. The Amendments Act also terminated the required screening process for a second repository that involved potential sites in States in the northern mid-west and along the eastern seaboard in order to meet the geographic equity provision of the 1982 Act. The Amendments Act directs Congress to consider the need for a second repository between 2007 and 2010.

In order to assure the safety of a repository, the Nuclear Waste Policy Act of 1982 required the Environmental Protection Agency to "promulgate generally applicable standards for protection of the general environment from offsite releases from radioactive material in repositories." Sec 121(a). The Nuclear Regulatory Commission also was instructed to promulgate "technical requirements and criteria" for its use in approving or disapproving a repository license application that "shall not be inconsistent with any comparable standards promulgated by [EPA]" Sec. 121(b). The histories of the original EPA standard and NRC licensing rule are a matter of record, and others in this hearing likely will make reference to them.

At the time of passage of the Nuclear Waste Policy Amendments Act, in 1987, it was clear that there was no scientific basis for selection of the Yucca Mountain site as the single site to be studied for potential development of a repository, notwithstanding assurances to the Senate Energy and Natural Resources Committee by the then DOE Yucca Mountain Project Manager that it was "inconceivable" to him that the site could not meet the EPA standard by a margin of multiple orders of magnitude. By 1992 it was equally clear that the Project Manager had been wrong.

Studies of Yucca Mountain directed at air flow through the unsaturated zone above the water table, where the waste potentially would be emplaced, resulted in calculations indicating that airborne release of radioactive carbon–14 would exceed the EPA standard's radionuclide release limit by a factor of 6 to 8. DOE's attempts to have EPA revise the standard to allow for the expected carbon–14 release did not succeed after scientific scrutiny by a special panel of experts convened by EPA. DOE's efforts to have the National Academy of Sciences National Research Council Board on Radioactive Waste Management endorse a relaxation of the EPA standard also were unsuccessful after the Board examined the technical issues.

Congress then set a course to try to save Yucca Mountain from later disqualification by including Section 801 in the Energy Policy Act of 1992 which mandated a new Yucca Mountain site-specific EPA standard, and subsequent revision of the NRC licensing rule to be consistent with the new EPA standard.

"the [EPA] Administrator shall, based upon and consistent with the findings and recommendations of the National Academy of Sciences, promulgate, by rule, public health and safety standards for protection of the public from releases from radioactive materials stored or disposed of in the repository at the Yucca Mountain site. Such standards shall prescribe the maximum annual effective dose equivalent to individual members of the public from releases to the accessible environment from radioactive materials stored or disposed of in the repository." Section 801(a).

As instructed, EPA contracted with the NAS for a report of findings and recommendations to be titled "Technical Bases for Yucca Mountain Standards" which was published in 1995. Of interest in today's hearing is the report's finding that there is no scientific basis to limit the repository compliance period to 10,000 years as had been done in the original EPA standard; and, its recommendation: "We recommend calculation of the maximum risks of radiation releases whenever they occur as long as the geologic characteristics of the repository environment do not change

significantly. The time scale for long-term geologic processes at Yucca Mountain is on the order of approximately 1 million years."

Page 71–72. The 1 million-year period is referred to in the report as the period of geologic stability, during which, the report concluded, it is feasible to make a compliance assessment. The report also noted that, "In the case of Yucca Mountain, at least, some potentially important exposures might not occur until after several hundred thousand years." Page 55.

In June 2001, EPA promulgated its rule, Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada (40 CFR Part 197). The rule set a regulatory period of 10,000 years for compliance with EPA's maximum individual dose standard, which was set at 15 millirems per year. A separate groundwater protection standard was also set for the 10,000-year regulatory period, with dose and radionuclide concentration limits consistent with Safe Drinking Water Act standards that apply to all the Nation's public drinking water supplies. The rule did acknowledge that peak expected doses could occur after the 10,000-year regulatory period and required DOE to calculate the peak individual dose during the period of geologic stability after 10,000 years and include the results in the Yucca Mountain Environmental Impact Statement "as an indicator of long-term disposal system performance." But the rule further states that "No regulatory standard applies to the results of this analysis." Sec. 197.35.

Nevada and others (Nuclear Energy Institute, Natural Resources Defense Council, and several other environmental public interest organizations) challenged the EPA standard in lawsuits filed in the U.S. Court of Appeals for the District of Columbia Circuit in July 2001. Among Nevada's and others' issues was that the setting of a 10,000-year regulatory period was not "based upon and consistent with" with the findings and recommendations of the NAS, as required by the Energy Policy Act of 1992. The Court upheld this challenge and vacated that portion of the EPA standard that applied a 10,000-year regulatory period, as well as the portions of the NRC licensing rule (10 CFR Part 63) that adopted EPA's 10,000-year regulatory period. *Nuclear Energy Institute* v. *Environmental Protection Agency*, 373 F.3d 1 (D.C. Cir. 2004).

On August 22, 2005, EPA published in the Federal Register a Proposed Rule modifying 40 CFR 197 with respect to the Court's ruling. 30 FR 70, No. 161, pp.49015–49063. Nevada provided extensive comments on EPA's proposal before the close of the comment period in November 2005 (comments are included with this statement). Since the close of the comment period, new information relevant to two aspects of the Proposed Rule has emerged, and Nevada has provided two Supplemental Comments to EPA, on December 21, 2005 and January 11, 2006 (also included with this statement).

EPA's proposed Yucca Mountain Standard is unprecedented in its adoption of a two-tiered standard, bifurcating radiation exposure limits to the period up to 10,000 years after disposal, and the period from 10,000 to 1 million years. It is further unprecedented in its application of a dose limit up to 10,000 years that is based on conventional risk apportionment, while applying, for the first time ever in U.S. or international regulation, a contrived and arbitrary background-based dose limit for the remaining time period. The proposed 350 millirem per year individual dose limit after 10,000 years is 23 time higher than the 15 millirem per year mean (or average) dose standard applied up to 10,000 years, and 87.5 times higher than the groundwater protection standard which EPA improperly proposes to truncate at 10,000 years.

The 15 millirem per year standard, as EPA has applied it to the initial 10,000-year period, is consistent with current and accepted radiation risk protection levels in other U.S. and international regulation. It also represents an apportionment for waste disposal of the generally accepted limit of 100 millirems per year from the entire uranium fuel cycle, which includes operation of nuclear power reactors.

EPA's 350 millirems per year median dose limit is based on the differential between EPA's current estimated (but not verified) background radiation dose in Amargosa Valley, below Yucca Mountain, and the estimated average background dose in the State of Colorado. EPA cites the average Colorado background dose to be about 700 millirems per year (which is about double the national average), and estimates the Amargosa Valley background to be about 350 millirems per year. In essence, EPA's conclusion is that if 700 millirems per year background is acceptable to people in Colorado, it must be acceptable also for people in Amargosa Valley. Therefore, in EPA's view it is reasonable to impose an additional dose from the repository of 350 millirems per year in order to achieve an individual dose of 700 millirems per year. EPA rationalizes its approach by saying that such exposures that are expected to occur several hundred thousand years into the future should

not be considered to "pose a realistic threat of irreversible harm or catastrophic consequences." 70 FR 161, August 22, 2005, at 49039.

The numerous scientific and ethical flaws in EPA's approach are elaborated in our comments, and a supplemental comment, to EPA on its proposed standard. Foremost is that the Colorado average background dose includes 87 percent indoor radon exposure (over 600 millirems per year) which can be mitigated primarily by home ventilation, and is the focus of a major EPA radon abatement program nationwide, executed by the same EPA division that has proposed this standard. There is also U.S. policy, adopted by Congress, to bring indoor radon levels down to the very low level included in natural outdoor radiation exposure. It appears EPA believes its own indoor radon program and national policy on abatement will fail, and are of no regard in its setting of standards for Yucca Mountain.

EPA's choice to use a median dose limit for compliance determination is also disingenuous and scientifically unsupportable. The median dose is the dose level for which half of the scenarios calculated are larger, and half are smaller, and it does not reflect the range of dose levels. In DOE's performance calculations, at peak dose, a 350 millirem per year median dose is the equivalent of a 1050 millirem per year average dose.

We have concluded that EPA's proposal is not only unlawful, in that it is not consistent with the findings and recommendations of the NAS and therefore in violation of the Energy Policy Act of 1992, but has no justifiable scientific or ethical basis in its cavalier flaunting of all human radiation protection regulation worldwide.

The premise of the NAS Technical Bases report is simple and straight forward—humans must be protected from the maximum radiation risk from a nuclear waste repository, whenever that risk is projected to occur. If this protection cannot be reasonably assured at the outset, the problem is with the selected repository site and design, not with the premise. EPA's selection of a 1 million-year regulatory period is a reflection of the NAS finding that compliance assessment is feasible through that time period for most physical and geologic aspects of a repository at Yucca Mountain, given our knowledge and understanding of the natural characteristics and features and processes at Yucca Mountain and in the surrounding area. The wide range of possible assumptions about the longevity of the metal waste containers coupled with our current understanding of the physical and hydrologic characteristics of Yucca Mountain indicate it is very likely that the calculated peak individual dose will occur sometime during the million-year period of geologic stability. If there were no metal containers and shields protecting the waste from infiltrating water, DOE's calculations for time of peak dose (in the Site Recommendation performance assessment) put the average peak at about 2,000 years after repository closure. Using DOE's optimistic projections of the rate of container failure, the performance calculation shows the time of peak dose at between 200,000 and 300,000 years after closure. The magnitude of the calculated peak dose, in both cases is approximately the same, and both far exceed 15 millirems per year. In the case with no metal waste containers or shields, a 15 millirem per year standard would be exceeded within 500 years after closure of the repository.

The compliance test for a repository is whether there is reasonable expectation that the statistical maximum dose (or risk) to humans from releases from the repository fall within a pre-established regulatory dose limit. It is of great importance that the complex performance calculation is scientifically credible because the compliance decision is to be made prior to waste emplacement. After the waste is disposed and the repository is sealed, the performance calculation has no relevance as to how the repository will actually perform, and when the maximum dose to individuals will occur. It could appear in as little as a few thousand years. The wide range of uncertainty in performance is dominated by the great uncertainty surrounding not the geology and hydrology, but the failure rate of the metal waste containers. Once the waste containers begin failing by corrosion, the contamination of the groundwater will be relatively rapid, far reaching, and irreversible. Radionuclides from waste disposed at Yucca Mountain will eventually reach the land surface both through groundwater pumping and through natural playas and springs where groundwater that has traveled beneath Yucca Mountain reaches the land surface today.

We have concluded that EPA must withdraw its proposed Yucca Mountain standard and reissue a new draft that:

- does not promote arbitrary and scientifically unjustified bifurcated radiation exposure limits,
- continues strict groundwater protection requirements through the time of maximum radiation exposure from a Yucca Mountain repository,

• eliminates statistical gerrymandering through the use of median versus mean calculations, and that adheres to EPA's traditional health and risk based approach to radiation and environmental protection in accord with national policy.

EPA has indicated that it would like to have its final Yucca Mountain standard in place sometime this calendar year, and as soon as possible so as not to hinder DOE's ability to submit a license application to NRC in the near future.

Under current circumstances in the DOE repository program, EPA's withdrawal of its proposed standard, and issuance of a legally, scientifically, and morally sustainable proposal will not impede the DOE's plans for license application.

DOE has officially informed the NRC that it has no schedule for when it will submit a license application to the NRC, and that it does not know when it will have such a schedule. This announcement is a consequence of multiple ongoing changes, events and circumstances in the program, all remaining unresolved to the extent that a license application is unlikely within the period of time that a diligent EPA would take to reissue a proposed Yucca Mountain standard, and finally promulgate a defensible standard.

RESPONSE BY ROBERT LOUX TO AN ADDITIONAL QUESTION FROM SENATOR JEFFORDS

Question. The State of Nevada believes that EPA has failed to produce a revised standard that is fair to future generations of Nevada residents. What form should the standard take if it were to be fair, would it be the same standard, such as 15 millirem, imposed for a million or more years?

Response. The State of Nevada has provided extensive comments to the EPA on the proposed standard, which were attached to my written statement provided to the Committee prior to the hearing. In direct response to your question, Nevada proposed to EPA that, . . . the process of complying with the Court's ruling and the Academy's Technical Basis report is quite simple. All EPA needs to do is insert "extend the 15 millirem standard through the period when peak doses are available to the public".

This period could be as long as several hundred thousand years, if you believe DOE's story about how long the disposal containers will last (since DOE's performance assessments show no contribution to waste isolation from any aspect of the geologic setting) or as short as 500 to 1,000 years if the containers fail very quickly, as Nevada's research demonstrates convincingly. What the Nevada and DOE agree about is that once radioactive material leaves the containers inside Yucca Mountain this radiation shows up in existing drinking water wells in Amargosa Valley in 100 years or less.

This leads to the other part of the proposed standard that is of concern to Nevada. Protection of Nevada's groundwater is of paramount concern to Nevada and its citizens, and therefore we believe that the groundwater protection requirements in the proposed standard be extended thought the period of peak doses to the public, whenever that occurs and not arbitrarily cut off after 10,000 years.

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