ADVISORY COMMITTEE ON NUCLEAR WASTE WORKING GROUP MEETING ON THE POTENTIAL FOR NATURAL RESOURCES AT A HIGH LEVEL WASTE REPOSITORY
OCTOBER 20, 1992
LAS VEGAS, NEVADA

A Working Group meeting on natural resources of the Advisory Committee on Nuclear Waste (ACNW) was convened by Working Group Chairman William Hinze at 8:30 a.m. on October 20, 1992 at the St. Tropez Hotel in Las Vegas, Nevada. The purpose of the meeting was to discuss methodologies for assessing the potential for natural resources at the proposed Yucca Mountain site and the relationship between natural resources and the potential for human intrusion. The entire meeting was open to public attendance. Howard Larson was the designated Federal Official for the meeting. Appendix I contains a copy of the annotated agenda.

A list of meeting participants and attendees is as follows:

Participants:

ACNW

P. Pomeroy, ACNW member
W. Hinze, Working Group Chairman
M. Steindler, ACNW member
D. Moeller, ACNW Chairman
K. Foland, ACNW Consultant
J. Corbett, ACNW Consultant
L. McKauge, CNWRA

Invited Participants:

J. Price, Nevada
H. Lefevre, NRC
C. Johnson, Nevada
D. French, Consultant
T. Jennings, Argonne National Lab
A. Wallace, Cordex Minerals
M. Einaudi, Stanford University
J. Corbett, Consultant
R. Raney, U.S. Bureau of Mines
M. Miklas, CNWRA
J. Bergquist, USGS
John Grow, USGS

Attendees:

H. Minwalla, R.F. Weston
H. Bonhan, University of Nevada-Reno (UNR)
J. Tingley, UNR
R. Wallace, USGS
S. Mattson, SAIC

M. Murphy, Nye Country
E. Tiesenhausen, Clark County
R. Spengler, USGS
D. Livingston, State of Nevada
D. Noble, UNR
S. Weiss, UNR
J. Accordi, R. F. Weston
J. Daka, R. F. Weston
R. Luce, NWTRB
A. Eiss, NRC
J. Blair, M&O Contractor
D. Tillson, State of Nevada
J. Gonzalez, DOE YMPO
A. Gil, DOE YMPO
S. Skutcho, DOE HQ
S. LeRoy, YMPO M&O Contractor
K. McConnell, NRC
D. Buesch, USGS
J. Boak, DOE
R. Rodgers, M&O
P. Cashman, UNR
B. Price, Assemblyman, State of Nevada
P. Justus, NRC
C. Pflum, SAIC
P. Prestholt, NRC
T. Bradshaw, University of Las Vegas
D. Bechtel, Clark Country
D. Bayer, Nevada Legislative Council
K. Rogers, Las Vegas Review Journal
C. Meyers, Moapa Band of Paiutes

1. Opening Remarks

Dr. Hinze convened the Working Group meeting at 8:30 a.m. He introduced ACNW members, Drs. Dade Moeller, Martin Steindler, and Paul Pomeroy, and ACNW consultants, Drs. Ken Foland and Jack Corbett, as well as Dr. Larry McKauge.

Dr. Hinze indicated that the Working Group would examine the broad issues of the potential for natural resources at the Yucca Mountain proposed high level waste site and methodologies to assess the generic potential for mineral and hydrocarbon resources. He said that the ACNW would hold a similar meeting in the future to consider groundwater and geothermal resources. He listed key issues to be considered at the meeting:

- What is the potential for mineral resources and energy resources of present and future economic value at the Yucca Mountain site?

- What are the appropriate geochemical, geophysical and geologic methodologies for evaluating potential mineral and

energy resources at the Yucca Mountain site? What data are required to estimate this precisely or as well as we can?

- What is the likelihood that mineral and energy resources will lead to future exploration and human intrusion?

- How should the perception of natural resources, regardless of resource potential, be factored into both site suitability determinations and quantitative assessments of site performance?

- Is a high probability of mineral occurrence at the Yucca Mountain site in itself enough to "disqualify" the site under DOE's 10 CFR 960 regulation regardless of the results of a quantitative performance assessment?

- What is the likelihood that hydrocarbons may be trapped in large thrust features beneath Yucca Mountain? What approach should be used to assess this?

- 10 CFR Part 60.21(c)(13) requires DOE to consider future resource values based on credible projected changes in economic or technological factors. What methods should be used to make these projections and how precisely can we make them?

- What should the priorities be for assessing natural resource potential to demonstrate regulatory compliance?

After asking the invited participants at the table to introduce themselves, Dr. Hinze indicated that Dr. Steindler would like to make a few comments regarding the recent National Energy bill that was passed by the U. S. Congress and its possible implications. Dr. Steindler mentioned that the National Energy Bill requires the National Academy of Sciences (NAS) to examine the issue of setting standards for high level waste disposal, specifically, the NAS is mandated to "study and provide, no later than December 31, [1993], findings and recommendations on reasonable standards for the protection of the public health and safety, including Item C, whether it is possible to make scientifically supportable predictions of the probability that the repository's engineered or geologic barriers will be breached as a result of human intrusion over a period of 10,000 years." He added that the results of the Working Group meeting would likely be critical input to the NAS study. Dr. Hinze then introduced the first speaker, Jonathan Price, State Geologist of Nevada, Director of the Bureau of Mines and Geology.

2. Invited Presentations

Jonathan Price, State Geologist and Director of Bureau of Mines and Geology

Dr. Price opened with his main point that Nevada has wide and variable resources, which are a major part of the state's economy, and that Nevada is in the midst of a gold boom, and a population boom, both of which are related to mineral industry issues. Dr. Price provided details of the geologic history and setting of Nevada. He indicated that there had been a great deal of igneous activity throughout geologic time in Nevada, which is related to existing mineral resources. He noted that active faulting is ongoing, as well as volcanism and geothermal activity. Gold is the dominating mineral resource in the state. In 1991, 5.8 million ounces of gold was produced, worth about 2.1 billion dollars, or nine percent of the world production of gold. Other recently mined commodities include silver, petroleum, geothermal energy, sand and gravel, crushed stone, gypsum, barite, clays, copper, diatomite, gemstones, lime, lithium, magnesite, mercury, molybdenum, pearlite, salt, silica, sand, zeolite.

Nevada ranks third in the nation for non-fuel mineral production, and first in the nation in the production of gold, silver, barite, and magnesite. The first gold was discovered in Nevada in 1875 on the Comstock Lode.

He said that mineral exploration takes place with conventional drill rigs. During the exploration phase, holes are drilled about 100 to 200 feet apart. Many of the new production deposits are blind deposits, which are buried under alluvium or rocks younger in age than the mineralization, requiring use of very sophisticated geophysical and geochemical techniques and much drilling. He cited Rabbit Creek deposit as an example of a blind deposit, which is buried under 300 feet of alluvium. Much of the gold ore mined is very low grade, but is still economical due to technology advances. An example of low grade ore is the Round Mountain deposit, which is a deposit in volcanic rock similar to those seen at Yucca Mountain. Heap leaching, or use of cyanide solutions percolated over piles of crushed rock, is a very efficient recovery method, allowing mining of low grade ore still to be profitable. Another technology used to enhance profit is use of a robotics laboratory to reduce costs of multiple analyses.

While most existing mines are pit mines, the recent trend is development of underground mines to go deeper into sedimentary deposits, which increases expense. Silver and mercury are byproducts of gold mining. However, because the price of silver is so low, mining it other than as a byproduct of gold mining is not economical. A big cost associated with mining today is

reclamation.

The Nevada petroleum industry produces a few tens of millions of dollars worth of petroleum each year. The two major areas of production are Pine Valley and Railroad Valley in Nye Country. There are both mature fields, such as Eagle Springs, which has reached its production peak and is now declining, and areas on the upswing, such as the Grant Canyon field. He stated that overall Nevada is a frontier area for petroleum exploration. The average number of exploration wells drilled per year is only about 30, while there has only been about 800 oil well tests drilled within the state. Thus not much is known about oil resources based on wells. Don French indicated that the average depth of the wells drilled is about 5000 - 6000 feet. Mr. Price concluded by saying that there is a tremendous amount of mining activity within the state, and mining has been a large part of the state's history due to the tectonic and igneous activity.

During the question period, Dr. Hinze asked why the slide shown revealed very little metallic mineral districts in southern Nye County. Mr. Price responded that it is likely due to lack of access of land due to the Nevada Test Site and Nellis Air Force Base rather than a lack of mineral resources. In response to a question from Dr. Hinze about a forthcoming publication on the criteria for various metallic districts, he said that a map will go to press in a few weeks on mining districts in Nevada, describing the history of individual districts, commodities from the districts, and geological information. Dr. Hinze asked to receive a copy. Dr. Hinze also asked whether the volcanic gold deposits go deep similar to the sedimentary deposits. Mr. Price responded that he was not aware of deposits that went to great depths in volcanic-hosted rocks, similar to sediment hosted trends, such as the Carlin formation, which has gold mineralization continuing at depths of thousands of feet. Dr. Hinze asked Mr. Wallace what the deepest blind deposit was in the state, and he indicated about 2000 feet.
Dr. Steindler asked how the occurrence of minerals can be predicted. Mr. Price indicated that there is much discussion in the geologic community involving the model used by USGS to predict mineral occurrence, which is to compare types of deposits to mineral deposit models. This approach involves use of expert judgment. In addition to individual mineral deposits, metalogenic and province geologic characteristics can be used to predict mineral occurrence. He added that thirty-five years ago the potential for gold deposits in Nevada would have been grossly underestimated by several orders of magnitude because there was no model for the Carlin type and Round Mountain type deposit, which is dispersed micron- and submicron size gold. Thus, approaches that only look at mineral deposit models, and do not take into account the metalogenic province concept, can be flawed.

Harold Lefevre, NRC Staff

Mr. Lefevre indicated that he would discuss NRC regulations that deal with natural resources, the status of concerns identified by the NRC regarding DOE's site characterization of natural resources, DOE Study Plans on natural resources, NRC guidance documents relating to natural resources, and the overall NRC perspective regarding natural resources.

Mr. Lefevre discussed specific and related regulatory requirements in 10 CFR Part 60 that deal with natural resources. Direct requirements include 10 CFR 60(c)(13), which mandates identification and evaluation of natural resources in the Safety Analysis Report. In addition, there are four potentially adverse conditions that must be identified, if present, and investigated to demonstrate they do not impact site safety. These include: 10 CFR 60.122(c)(2), human activity and groundwater use; 10 CFR 60.122(c)(17), the occurrence of natural resources, both discovered, undiscovered, and economic approaches used to assess the resources; 10 CFR 60.122(c)(18), evidence of subsurface mining; and 10 CFR 60.122(c)(19) evidence of drilling of any kind. A related regulation includes performance objective 10 CFR 60.113, which deals with performance of engineered barriers after closure [this regulation addresses anticipated processes and events only, which does not include human intrusion]. In addition, the overall system performance objective, 10 CFR 60.112, requires that releases after closure meet the EPA standards with respect to anticipated and unanticipated events. This includes consideration of human intrusion. Mr. Lefevre noted that these standards are uncertain at this time due to the recently passed National Energy Act of 1992.
Dr. Hinze asked Mr. Lefevre whether the regulations reflected the intent to guard against siting a repository in an area with natural resources due to their value, in addition to human intrusion concerns. Mike Miklas from the CNWRA clarified that the staff analysis of the public comments on 10 CFR 60 in 1983 has wording in it that the Commission was concerned that natural resources at a site could be "valuable enough" to avoid putting a repository there, although this language does not appear in 10 CFR 60. Dr. Hinze asked whether the term, "valuable enough" was a problem because it is a subjective term, and Dr. Miklas said yes. Dr. Hinze questioned whether NRC should provide guidance as to what this phrase means, and Mr. Lefevre indicated that he would look into it.

Mr. Lefevre then discussed the status of NRC regulatory concerns with the Site Characterization Plan (SCP). He mentioned three specific concerns cited in the NRC's Site Characterization Analysis (SCA) that remain as open items. DOE has indicated that these concerns will be addressed in forthcoming Study Plans. The first concern, Comment #53 of the SCA, deals with the need to integrate geologic, geophysical and geochemical studies to

support natural resource investigations. The second concern, Question #14 of the SCA, addresses the need to do a more complete search of historical documents and field investigations related to existing exploration/exploitation activities. The third concern, Question #15 of the SCA, addresses the need to provide a basis for DOE's conclusion that mineral potential at the site is low. Mr. Lefevre pointed that one problem with the four related forthcoming Study Plans is that they are dependent on other studies, such as drilling and geophysical methods being done for other purposes. In addition, justification for the data used in the Study Plans is provided in topical reports, which must be submitted in addition to the Study Plans before the open issues can be closed out. Dr. Hinze asked whether the NRC staff anticipates that by the time it receives and reviews the overall summary Study Plan on natural resources, they will have received the peripheral Study Plans on geophysics that feed into it. Mr. Lefevre's response was no, that the two most critical Study Plans deal with tectonic and geologic issues and integration of activities dealing with drilling and geophysical work. He does not know the schedule for their submittal. It is difficult to separate out review of the natural resource Study Plans, and to close any of these issues until all relevant Study Plans are reviewed.

Mr. Lefevre then discussed NRC guidance. He mentioned the NRC Standard Format and Content Regulatory Guide (SFCG), which will be published in final form in 1994; NUREG 1347, which contains the NRC Site Characterization Analysis (SCA) of the DOE's Site Characterization Plan (SCP); and the July 31, 1991 letter from NRC to DOE containing NRC staff responses to DOE's responses to the SCA. Additional guidance includes information documents prepared by the U. S. Bureau of Mines, and a new document on compliance methodologies for natural resource regulations prepared by the Center for Nuclear Waste Regulatory Analyses (CNWRA).

Dr. Steindler asked, considering the limited guidance available, if NRC staff has provided DOE with clear guidance on what is needed. He indicated that it was not clear to him that specific information needs have been codified for DOE. Mr. Lefevre indicated that specific guidance is under development, called a License Application Review Plan (LARP), that provides much more detail about information needs specific to Yucca Mountain. He also mentioned that the Center's new document on compliance methodologies will be available to the public on October 30, 1992. Future issuances includes guidance on conforming to the EPA standard, 40 CFR 191, which will be put on hold pending results from the National Academy of Sciences; the SFCG due in 1994; and the LARP, due in 1998. Additional staff activities include the Iterative Performance Assessment (IPA) Phase II, to be completed and published this year, which considers human intrusion scenarios related to natural resources. During the

question period, Dr. Pomeroy asked whether the Center's new document is considered to reflect the opinion of the NRC staff. Mr. Lefevre indicated that the document has a disclaimer that it does not, and that the document is an interim product. Dr. Pomeroy expressed concern for how DOE is to proceed with an interim product, and that NRC may receive criticism for using of a contractor's product for its guidance. Keith McConnell clarified that NRC staff considers the Center's document to be an independent product of the Center, but it will form the basis for the staff's positions in the LARP dealing with compliance strategies and compliance demonstration methods. Thus DOE can view it as a basis document that NRC will use to develop official guidance. In addition, the NRC staff considers that it has been clear in stating what is needed to resolve NRC concerns on natural resources in the SCA, and this is where DOE should start.

Carl Johnson, Nevada Agency for Nuclear Activities

Mr. Johnson indicated that he would revisit points made in a presentation by Steve Freishman to the ACNW in a meeting on human intrusion two years prior. He mentioned that DOE issued in its EIS in 1980 a statement that it would be best to avoid potential repository sites with natural resources, and a similar statement during NRC's waste confidence rulemaking in 1980. He then indicated that the provisions in the Energy Legislation passed in 1992 for DOE to be the caretaker of the repository for the next 10,000 years may make the discussion on human intrusion due to natural resources moot.

Mr. Johnson reviewed the points made to the ACNW in 1990 by Larry Larson of the University of Nevada-Reno, the major points being, is there potential for natural resources and will there be human interference at Yucca Mountain due to natural resources. Mr. Larson made the point that Yucca Mountain is in an area of widespread precious metal mineralization where there has been intense exploration. In addition, in 1989, data were insufficient to determine the potential for natural resources at Yucca Mountain and further work was necessary, these comments are applicable today.

Mr. Johnson referred to a study ongoing at the University of Nevada-Reno by Larry Larson, Don Noble, and Steve Weiss on mineral resource assessment. The study deals with the presence of hydrothermal mineralization in and around the Yucca Mountain area, and the genesis of the mineralization. Another area of research is looking at alteration using petrologic and chemical analysis of deep drilling cores collected by DOE. Dr. Hinze asked where the data had come from to develop the figure showing a cross-section with possible zones of hydrothermal alteration. Mr. Jonson replied that they superimposed results of the analysis of the deep drill core onto an existing map prepared by DOE. Dr. Hinze asked how many drill holes had been used and the depths at

which the data were collected. Mr. Johnson indicated that there are only several holes that go below 2000 feet. However, as many as 100 holes have been drilled, from which 75 cores have been taken, which are available for study. Dr. Hinze asked how many of the 75 cores would show alteration, and Mr. Johnson guessed about 20, clarifying that the older tuff units, below the water table, are the units that show alteration, and not cores from the repository horizon tuff unit.

Another ongoing study by the state is the hydrocarbon resource potential study being done by Patricia Cashman and James Trexler, University of Nevada-Reno. Their study is looking at fault block plays, thrust-belt play models, basin stratigraphy, and source and reservoir rocks. The study focuses on two questions, what is the hydrocarbon potential of the Iliana strata; and is the Eleana formation under Yucca Mountain, and if so, what facies is present. Based on preliminary results, the State believes that the Eleana consists of two facies: the eastern facies is comprised of a shale which is equivalent to the source rock for many of the oil production areas in Nevada, and the western facies, which has not been found equivalent to any other formation in the area. Further work will focus on determining whether the Eleana is actually a source rock, or whether it is, in fact, two separate facies. In response to a question from Don French about where the data have been published, Pat Cashman clarified that these results were based on 15 or 20 analyses, published by Claypool of the USGS. She added that future work will focus on determining the present position of the eastern facies of the Iliana and on reconstructing its maturation history.

Mr. Johnson concluded by saying that resource potential must be viewed in the context of what will attract an explorationist or prospector to an area. This inlcudes either known or perceived resources. Known resources start out as perceptions, and wherever resources exist, known or perceived, exploration will occur.

During the question period, Dr. Moeller asked if the issue should really be whether this site has unique resources, or is a primary source for a particular resource, as opposed to just looking at mineral potential, in general, given that nearly any site would have some mineral potential. Mr. Johnson responded that not all areas have mineral potential or indicators of potential comparable to the Yucca Mountain vicinity.

Don French, Petroleum Geologist

Don French indicated he would address petroleum exploration and results in Railroad, Valley, Nevada, including a history of exploration, geology, and oil production, as well as useful information for evaluating the potential for oil at Yucca Mountain.

Railroad Valley is a basin which lies between the Pancake Range to the West, and the Grant Range on the East. Successful exploration began in this area in 1954 with the discovery of the Eagle Springs Field. Subsequent exploration and production began in Railroad Valley in the 1970's and continues today. Most of the oil in Railroad Valley originated from the Chainman Shale formation. Mr. French pointed out the importance of several major unconformities to oil production where Tertiary volcanic rocks directly overlie Paleozoic rocks, including the Chainman Shale formation, where the Sheep Pass Formation [Mesozoic] is largely missing. Oil fields found so far in Railroad Valley are limited by unconformities and high angle normal faults. Oil recovery is controlled by fracture controlled production, which enables very high production rates on the order of thousands of barrels per day. A drawback to fracture control production is that it is difficult to estimate oil reserves. In addition, oil columns in this area are very thick, on the order of 500 to 2000 feet thick, which is extremely rare in the United States. The thick vertical extent and limited areal extent results in low success rates in exploration and development. The Railroad Valley fields have produced very little gas, and the oil that is produced is of low quality, which affects prices. In addition, the remote location of Railroad Valley leads to expensive operations.

Mr. French devoted most of his talk to the approach used to estimate the hydrocarbon potential (volume of oil generated and accumulated) for the Chainman Shale in Railroad Valley. He explained that it is necessary to: 1) identify and characterize the source rock, 2) locate the generation sites in time and space, and 3) evaluate conversion factors to assess how much of the source rock can be converted into petroleum, including conversion of total organic carbon into oil, and conversion of oil into accumulated oil by expulsion and migration. Mr. French showed the equation used to calculate petroleum potential: PR = (SR x IPP) x PGI x PEE x (1-ML), where SR = source rock mass; IPP = initial petroleum potential; PGI = Petroleum generation index, the fraction of source rock converted to petroleum for given maturity level; PEE = Petroleum expulsion efficiency, the fraction of petroleum expelled for given maturity level; and ML = Migration loss, the fraction of expelled petroleum lost in migration (from MacKenzie and Quigley, 1989). Mr. French focused primarily on SR, the source rock mass term, from which can be estimated the conversion rate (PGI) for the source rock and how

much oil it generates. The other terms factor in the portion of oil to discount that will not be expelled from the source rock (PEE), and the portion of which is expelled that does not reach a commercial accumulation (ML), or migration loss. The values used for these terms are typically literature values or rough estimates.

To estimate the SR term, Mr. French used a map published by the USGS on the maturity state of the Chainman Shale based on conodont alteration from thermal exposure. Based on this map, the Chainman Shale is sub-mature. This was verified with the deposition history of the shale (feet of burial over time). The shale underwent deposition about 360 million years ago through about 320 million years ago, and then was buried under Pennsylvanian, Permian, and Triassic rocks, followed by a long period of erosion, and subsequent burial during the Basin and Range Orogeny. The shale never was buried deep enough to reach the temperatures needed for oil generation until the very late stages. The shale was folded during the Sevier and the Basin and Range Orogeny and this folding was later overprinted by normal faulting during the Basin and Range Orogeny. Mr. French concluded that: 1) the Chainman Shale in producing areas is sub-mature, and 2) oil production thus far has been from rocks below the valley fill, in basins that formed during the Basin and Range Orogeny during the Miocene/Pliocene period. From this he deduced that if the Chainman Shale is sub-mature in the vicinity of petroleum accumulations, then the accumulations must be the result of pre-Basin-Range burial or tectonic burial events not evident from the map, or more likely, burial and generation occurred since the onset of the Basin and Range Orogeny. Finally, he concluded that if the Chainman Shale didn't reach generation conditions prior to the Basin-Range Orogeny, then the pre-basin range distribution of the shale must be determined in order to constrain areas where there are generation sites.

Mr. French then walked through development of a paleographic map to portray the pre Basin-Range distribution of shale. This was done by deducing what the pre-existing geology looked like before the volcanic rocks were deposited using data from wells and outcrops to map volcanic contacts. The map revealed a large anticline present underneath the western side of Railroad Valley, and syncline under the eastern side. Mr. French overlaid a gravity map on top of the paleogeologic map to reveal a density low due to the valley fill deposits in Railroad Valley. The fill was deposited over the past 17 million years, overprinted on top of the old anticline and syncline structures.

From the map, portions of the Chainman Shale buried underneath Railroad Valley is evident, and is considered a potential generation site. From here, Mr. French needed to characterize thermal conditions of the potential generation area, which he did using a drill stem test, which forces fluid to the surface

indicative of ambient rock temperature at depth. He plotted temperature versus depth, and noted a shallow geothermal gradient, 1.3 degrees per 100 feet, and a much steeper thermal gradient, 2.5 degrees per 100 feet. He and others concluded that the unconformity (volcanics on top of Paleozoic rocks) acts as a permeability barrier restricting flow causing a thermocline, with higher temperatures below the unconformity and lower temperatures above. The potential implications are that the thermocline reduces the amount of valley fill needed to obtain generation conditions, by creating a setting for enhancement of permeability by secondary mineralization. Mr. French's theory is that the hotter water comes into close contact with cooler water, and the hotter water carries solids that precipitate out, thus enhancing the seal or existing permeability barrier. Current research is revealing evidence of late mineralization in the valley fill just above the unconformity, which would support this hypothesis.

Mr. French showed a cross-section that displayed the area of the Chainman Shale under Railroad Valley where there are generating conditions. From the surface and cross-sectional area he calculated a volume of source rock mass--the first term in the equation, SR. After discounting for the other terms in the equation, he calculated the oil potential to be 785 million barrels, with only 7.5 percent of this having been found to date. He pointed out that 785 million barrels for a basin system is quite small, implying that this would not be economical for a frontier exploration.

To assess the potential for petroleum exploration in other areas, like Yucca Mountain, Mr. French indicated one would need to determine generation sites and thermal regimes as was done for the source-rock play at Railroad Valley. The Eleana is a potential source rock at Yucca Mountain, part of which is equivalent to the Chainman Shale. In assessing oil potential, DOE should be able to answer what is the quality, distribution, and maturity state of the Eleana formation.

Questions were deferred until after the next speaker's presentation due to a time overrun.

Ted Jennings, Argonne National Laboratory

Dr. Jennings caveated his discussion by saying that he would be giving his opinions, not those of the Argonne National Laboratory. He opined that if one looks at history, there will be perceived potential for natural resources at Yucca Mountain. He went over a few of the key introductory questions asked by Dr. Hinze. He likened Yucca Mountain to a frontier area having complex geology, largely unexplored. Thus to make exploration economically viable, it would be necessary to develop large acreage blocks to ensure enough potential to justify the risks. He speculated that none of the big oil companies would rush to

Yucca Mountain if it were accessible, because the exploration strategy would be to move from the known to the unknown. The potential players would need to be the big companies because of the dollars and time commitment that would be necessary.

Dr. Jennings indicated that the probability of there being a billion barrel oil field below Yucca Mountain is extremely low because we do not have enough information, but perception is important. Nevada has known shallow production, with large single well capacity, and numerous shows, thus various scenarios could be hypothesized. Potential models could include short-range migration, long-range migration, vertical upward, downward, and lateral migration, since we do not know where the oil is generated, or migration pathways. It has been speculated that Yucca Mountain lies within a "maturation fairway." But it is difficult to impossible to quantify the various hypothesis. An explorationist can use an historical analogue approach or technical approach. The historical approach is difficult because there is no analog. The technical approach involves assessing the probabilities for the reservoir, for the source rock, the seal, the migration pathways, and the amount of reserves. He indicated that it is important to establish at Yucca Mountain whether source rock is present and where it is, as well as the pathways from source rock to a potential reservoir. Current studies proposed by the DOE include these tests, such as evaluating for source rocks, determining the thermal history, preparing a structural map, and drilling. However, he expressed concern for whether these studies would be done soon enough to be meaningful. He suggested bringing interested parties together to drill some deep holes. He concluded by saying that the likelihood of inadvertent intrusion is very low.
During the question period, Carl Johnson asked Dr. Jennings and Dr. French how source rocks can be evaluated at Yucca Mountain when only one drill hole penetrates through the volcanic rocks, while as many as 50 holes were drilled at Railroad Valley. Mr. French responded that the purpose of drilling so many holes at Railroad Valley was to facilitate that model to unknown areas, if the model is applicable.

Dr. Steindler stated that he disagreed with Dr. Jenning's logic that the probability of oil potential at Yucca Mountain is low because of lack of data. The probability of an event is not related to the absence of data. He noted that the important issue for DOE and the NRC is to recognize limitations on time and resources, and assess the minimum key things needed to be done to put bounds on the assessment of probability of occurrence. He stressed that he had not heard yet those key activities that need to be done. He further questioned whether there is a consensus that would allow development of guidance to both the NRC and the DOE on a modest program to optimize, to the degree possible, information, and attempt to bound uncertainty.

Dr. Corbett asked whether the deep hole was intended to be drilled offsite or onsite. Dr. Jennings implied that he meant off site, and make inferences using other data about the geology onsite. Mr. Corbett asked how far off site such holes should be. He suggested that there are some geophysical methods that would enable one to infer subsurface conditions on site, and he would address this in his presentation.

Mr. Barker of the USGS added that he has begun sampling wells on the Nevada Test Site and considers the area to be well drilled, with the exception of deep wells. He indicated that they have a good idea now of what the source rock distribution will be, and there are more data available than presenters thus far have suggested.

Dr. Hinze asked whether it was important to prove whether there is an overthrust feature under Yucca Mountain. Mr. French indicated that this can never really be proven or disproven, given the complex geology.

Andy Wallace, Cordex Minerals

Andy Wallace opened by saying that exploration is usually done by analogy; explorationists learn the characteristics of what has been found and try to find duplicates. Step one is a regional overview. There has been heavy mineral exploration in the past 20 years, and they estimated that as much as 70-80 percent of U.S. exploration dollars have been spent in Nevada in the past five years.

Mr. Wallace noted that he believes the lack of prospects in the test site is due to lack of access and exploration, rather than a lack of mineralization. He indicated that chances are good that the Nevada Test Site and the Nellis Bombing range would be an excellent place to explore if access were granted.

He discussed four important gold deposits of economic importance near Beatty, Nevada. He said these deposits occur in the same geologic pattern that is found at Yucca Mountain, which is Paleozoic sedimentary basement rocks covered by Tertiary volcanics and alluvium. Paleozoic basement rocks have been confirmed to be present at the proposed Yucca Mountain site based on several deep drill holes. Four separate gold ore deposits, Bullfrog, Secret Pass, Mother Lode, and Sterling, are localized along a major detachment fault. Economically minable gold has only been found where high angle normal faults intersect the fault. He suggested that these deposits represent the types of deposits that could be present at depth under Yucca Mountain. He discussed the characteristics of these deposits and how to look for similar deposits.

None of the four major gold deposits crop out at the surface. They form from hydrothermal alteration, and can be located by mapping the limits of hydrothermal alternation. There is a strong association of gold mineralization and fluorite mineralization. Gold in the area was first discovered due to the discovery of a fluorite deposit.

Mr. Wallace likened the geology of the proposed site to the Four Star Canyon, where the four gold deposits are located, but indicated that from reading the literature there are no known exposures of hydrothermal alteration or geochemically anomalous materials present at the proposed site. He added that this should be mapped and documented as part of site characterization.

Mr. Wallace researched drillers' logs from six to ten drill holes at Yucca Mountain. Hydrothermal alteration was logged in several of them. He noted that two of the logs were particularly interesting because of the presence of widespread pyrite and fluorite at a depth of about 1678 to 1693 meters. As an explorationist, he would infer that mineral deposits could be present at great depths, i.e., greater than 2000 ft. below Yucca Mountain. He added that the only direct evidence of mineralization is drilling, rather than any other exploration methodology.

Dr. Einaudi asked Mr. Wallace why explorationists would flock to the Nevada Test Site and Nellis Bombing Range if it were opened. Mr. Wallace replied that there are mineral deposits that were found and documented before the withdrawal of the test site, which are analogous to features indicative of the mineralization used today. Early day prospectors overlooked known deposits because they had to pan for gold visible in outcrops. Gold mined today in sedimentary rocks is very fine-grained i.e., not visible, and the economics have changed to make deposits previously of no interest, economical today.

Dr. Hinze asked Mr. Wallace if mineralization were evident in cores from Yucca Mountain from a 2000 foot depth, and access were granted, would Cordex minerals be interested in exploring in the near future. Mr. Wallace said probably not in the near future, which is less than six months. However, while there has been exploration in Nevada for 2000-2500 foot blind targets, they usually prefer to spend their money where mineralization is evident at the surface and may extend downward 2500 feet.

Mr. Harold Bonham from SAIC, who was in the audience, made two points: one, that it is important for qualified, economic geologists to analyze core samples, and two, he and his colleages looked at cores from the Crater Flat Tuff and found fragments containing sulfide, erupted from the volcano forming the tuff, meaning that there was a previously existing hydrothermal system with sulfide mineralization in the vent area from which the tuff

was erupted. He concluded by saying that this was an important area for further study in that Crater Flat Tuff was clearly erupted from an active hydrothermal system that formed a great deal of sulfide mineralization. This suggests the potential for zones of mineralization at Yucca Mountain. While some controversy took place between Andy Wallace and Rick Spengler of the USGS regarding the minerology of specific cores collected and logged, Steve Weiss of the University of Nevada-Reno concluded that the important issue is that from a library search, the cores were of interest to an explorationist, and cannot be ignored.

Marco Einaudi, Stanford University

Dr. Einaudi presented a three phase flow chart depicting geologic and geochemical evaluation methods for metallic mineral exploration. Phase I consists of literature studies, reconnaissance mapping, field mapping, and sampling to derive a preliminary set of maps and descriptions of mineral deposits in the Yucca Mountain vicinity, and includes consideration of existing models and known deposit types. Phase II consists of developing refined descriptive models of Basin and Range mineral deposit types in Yucca Mountain and vicinity, detailed field mapping and core logging, and ranking of descriptive models on the basis of likelihood and value. Phase III consists of assigning likelihoods of the presence of mineral deposits.

He began his talk by emphasizing the high degree of detail needed to analyze and document the mineralogy of core samples and to perform geologic mapping. He said that based on the ESSE, it is clear that the study of mineral resources is just barely getting underway. He compared two maps depicting mineral deposits at Yucca Mountain and its vicinity, both very different, to make the point that basic cataloging of metal types is still ongoing.

He defined the Yucca Mountain area as the area where potential intrusion would have an effect on the repository, and the Yucca Mountain vicinity as a much larger area that also must be studied.

For Phase I, in compiling the database, a description of the mineral deposits is needed, based on present and past mines, and anomalous hydrothermal and metal occurrences, rather than based only on economic ore deposits. In contrasting what an explorationist would do to assess mineral potential and what DOE must do, he indicated that DOE must use well defined models to pass the test of public scrutiny, and focus on all mineral commodities, not just a single mineral such as gold. A third difference is the timeframe of characterization. Explorations move quickly; DOE does not. In general, Phase I includes reconnaissance mapping, field mapping, and sampling to derive a preliminary set of maps and descriptions of mineral deposits in

the Yucca Mountain vicinity, that can be compared to a descriptive model of ore deposit types.

A descriptive model incorporates common features from numerous deposits. However, a model requires classification of ore deposit types, which is highly subjective. The model should incorporate important, common features essential to match a deposit and the deposit type, or the deposit and a mineral occurrence. He added that from what he has seen in the published literature, data are insufficient thus far to generate the type of detailed models that are needed for Yucca Mountain. He suggested that data could be obtained from the mineral industry. Examples of ore deposit types include volcanic hosted epithermal gold and silver deposits, and Carlin type sediment-hosted dissolved gold, plus others. He stressed the importance of developing a set of descriptive models of ore types, which requires classification of the deposits into types, based on common features, so that conclusions can be made regarding the degree of similarity between, for example, outcrop A and a portion of a type of ore deposit. Thus Phase I includes a preliminary set of key areas and a general set of descriptive models of deposits that might occur in the Yucca Mountain area.

Phase II includes ranking the various models in terms of their likelihood of occurrence and possibly ranking them on the basis of value. This, in turn, can be used to establish priorities for mapping, geochemical and geophysical studies.

Dr. Einaudi stressed the importance of using field mapping by experienced economic geologists as the key activity to guide geochemistry and geophysics studies. This should include mapping at a variety of scales, such as 1 to 600 for mapping altered rocks and 1 to 5000 for the surrounding rocks, and should include detailed measurements of strikes and dips of fractures, and mineralized zones. He recommended mapping different alteration minerals using different colors. Because gold is so fine, it cannot be seen or panned, thus geochemical analyses must also begin early to guide the mapping. Based on the geologic map, a geologist can begin to deduce the direction of hydrothermal fluid pathways through the rock, and predict fluid-rock interactions through time and space. The map summarizes alteration patterns around various mineral deposits and gives context for how the system evolved.

He noted the importance of geochemistry in exploration and mapping mineral deposits and in quantifying the types of minerals, and the importance of radiometric dating of hydrothermal minerals and igneous rocks. He cited Don Noble's work in southwest Nevada which is linking the evolution of volcanic rocks and ore deposits based on radiometric dating.

Phase III is the integration of descriptive models of deposit types with the database (maps) of Yucca Mountain and vicinity.

One way to do this is through use of artificial intelligence to match model types with individual deposits, and perhaps with this predict the tonnage grade. This, however, is highly uncertain. In addition, model types must be examined to see how they link together to consider what the occurrence of various mineral deposits mean in relation to the potential for other types of deposits. An example of this is the known linkage between fluorite and gold deposits. He concluded by saying that these types of links need to be dealt with more quantitatively.

Questions were deferred following John Corbett's talk.

John Corbett, Geophysicist

Mr. Corbett opened by saying his background is in exploration geophysics for base metals, particularly for gold. His first slide showed the physical properties that provide a signature or geophysical response using various geophysical methods. The properties include susceptibility, density, conductivity and radioactivity. Geophysical methods listed include magnetics, gravity, electrical resistivity, seismic, radioactivity, and thematic mapping. He divided geophysical methods into categories suitable for shallow (0-150 meters), intermediate (150-3000 meters), and deep targets (greater than 600 meters). For each category, he further divided the geophysical methods into active, where a signature is put in, and passive, which relies on the natural signature from the earth. He also showed the target types for each of the categories, including epithermal gold, massive and disseminated sulfides, industrial minerals, water table depth, lithology, depth of overburden, faults, clays, zeolite and evaporites, sand and gravel, and contaminants, hydrocarbons, and geothermal. He noted that the sophistication of geophysics equipment and ability to interpret results rather than the physical properties that have changed over time.

He discussed suitable applications for various methods. For example, use of passive seismic methods at great depths has evolved from earthquake technology, and have been successfully used to delineate fault systems. Magnetic methods can be applied at all three scales, as can gravity. Gravity has been used extensively to identify structure, and the tectonic framework in Nevada.

He also stressed the importance of first mapping the geology, before applying geophysics.

He indicated that he doesn't understand why more geophysics has not been done at Yucca Mountain to delineate features at depth. An would be to run a seismic line on a regional basis to look for

anomalies. He tried to make the point that geophysics, seismic or electric, will give you information, either positive or negative, i.e., indicating the presence or absence of something, which is very useful. Even if only noise can be detected, this may be useful information as 3-D data processing becomes more sophisticated.

Dr. Hinze asked Mr. Corbett what the role of geophysics should be in searching for potential calderas that may exist in the southern Crator Flats area. Mr. Corbett indicated that the role would not be big, but magnetics can be used to delineate the difference in susceptibility between the caldera and the outside rim of the caldera, which is important. Mr. Wallace agreed that magnetic techniques are becoming very common early on in early stages of exploration.

Rick Spengler commented that, throughout Mr. Corbett's talk, it sounded as though each of the geophysical methods discussed should be applied at Yucca Mountain. For clarity, he pointed out that all the methods listed for shallow, medium and deep environments have already been applied at Yucca Mountain, with varying degrees of success. Mr. Corbett agreed, but suggested that because the technology has improved so much in recent years, perhaps some of the methods should be run again, particularly seismic and electrical.

Russell Raney, Bureau of Mines

Mr. Raney opened by saying that the Bureau of Mines was contracted in 1985 to provide technical expertise to the NRC on mineral resources at a proposed HLW repository, with which he was involved. Mr. Raney said he would discuss two natural resource related scenarios associated with human interference, 1) mineral exploration, and 2) mining activities. Regarding mineral exploration, he indicated that to his knowledge neither economic minerals or past mining activities have been identified at Yucca Mountain. Concerning past mining activities, he referred to a Bureau of Mines map showing 125 mines and prospects near Yucca Mountain, pointing out why it would be easy to understand how a perception of natural resources at Yucca Mountain is easily conceived. The perception of mineral resources is the problem at Yucca Mountain, not the economic metals or potential for these metals. Even though the site is surrounded by mineralized areas, the data reveal no evidence of economic minerals at Yucca Mountain. Regardless, the perception is there as evidenced by Mr. Wallace's statement that he and other explorationists would explore Yucca Mountain if access were granted.

Mr. Raney then reviewed possible effects of various mining scenarios outside the controlled area. The scenarios were assumed to occur west of the site south of Nellis Air Force Base boundary, about 2 kilometers from the site boundary. Six

scenarios were identified: 1) effects of airblast associated with blasting at a surface mine; 2) effects of surface or underground mining on groundwater; 3) seismic activities of drilling and blasting during exploration development and operation of the underground mine; 4) seismic effects of drilling and blasting during the exploration development and operational phases of an underground mine; 5) cyanide solution mining; and 6) mining using nuclear explosives. None of the scenarios analyzed appears to affect site safety except number 6, which is considered highly unlikely to occur. He concluded by saying that the geologic character and structural similarity of Yucca Mountain, which has no known resources, to areas having resources, suggest a potential for undiscovered resources, and even if this potential is never realized, human intrusion for resource exploration must be seriously considered due to the perception of natural resources.

Michael Miklas, Center for Nuclear Waste Regulatory Analyses (CNRWA)

Mr. Miklas outlined his subject area as dealing with the regulatory requirements related to natural resources, with an emphasis on four of the 24 potentially adverse conditions identified in 10 CFR Part 60.

He noted that the impacts of the activities of humans on the groundwater system should be considered when dealing with the overall system requirements. It is worth noting that there is a span of some 20 years between now and the time that the first waste will be in place. Predictions of groundwater travel time may be affected during that period by human activity. The allocation of groundwater travel time to the various zones could be a future consideration.

In discussing the presence of naturally occurring materials, Mr. Miklas noted that the question is one of economic analysis as to what might be inferred from geologic evidence at the site and then making an estimate of gross value.

One term relevant to this analysis is the definition of "foreseeable future." While some may believe the period to be 10,000 years, in so far as this part of the regulation, which has to do with economics, the period is probably closer to 50 years. He presented his perspective that the regulation does not require that the site be explored for all possible minerals of value, but rather for a reasonable integration of a reasonable collection of data.

Insofar as human intrusion, he noted that there are some constraints relevant to the consideration of human intrusion, such as: the use of permanent markers; the assumption that there will be some functioning organizations in the future that will

recognize and understand the nature of radioactivity; that the relevant repository records will be preserved for several hundred years, etc.

The appropriateness of methods that have been used to resolve the problem of naturally occurring resources, the identification of any limitations on acquiring information for evaluating a site, how expert judgment was used (and how possible bias from the resultant judgment was removed), are all issues that should be addressed prior to, or during, the license application submission phase.

In evaluating potentially adverse conditions, conditions both on-site and off-site, which might affect site performance, must be considered.

Dr. Hinze questioned the proper time for the involvement of expert judgement: whether it should be brought in early, during data acquisition, interpretation or synthesis or later, when data were being evaluated. In response, Mr. Miklas indicated that he believed that there would be times when it should be brought in early and that there would be other times when it would be proper to make a decision about the data in hand utilizing expert judgment.

Dr. K. McConnell, NRC, noted that Mr. Miklas' report was an independent product of an NRC contractor and that the NRC staff had not yet adopted the report. However, he did note that the report did place in one document the nuances of the rule, particularly with respect to natural resources, and does provide a great deal of insight into the Commission's intent at the time of issuance of Part 60.

Joel Bergquist, U. S. Geologic Survey (USGS)

Dr. Bergquist discussed USGS study plans for mineral and energy resources evaluations at the potential site.

He noted the five main activities in their study: geochemistry, geology, geophysics, geothermal and hydrocarbons, all of which fed into the fifth activity, the assessment of mineral and energy resources. While the geothermal and hydrocarbon evaluations were rather separate, the other evaluations were closely integrated. In discussing his program, he noted that although there was very intense data collection and evaluation, a considerable amount of expert judgment was involved in making the assessments.

The sampling program and analytical methods for the indicated main activities were also discussed in some detail, with some of the benefits and limitations of various methods noted. It was stated that to obtain a complete evaluation of the mineral resources at Yucca Mountain, it would be necessary to look at the

Paleozoic rocks that lie beneath it. Mineralization is also likely in the interface between the Paleozoic and Tertiary sections.

In response to a question from Carl Johnson as to whether the seismic reflection surveys were going to be tied into the deep drill holes, Mr. Rick Spengler, USGS, noted that one leg would go across Crater Flat, another leg would cut across Yucca Mountain just south of the repository area, and there will also be a line that extends up Yucca Wash.

Mr. Bergquist noted that one of the keys to mineral research assessment is the gathering of past information on mining exploration. He stated that they are using both published and unpublished data, searching USGS, BLM, Bureau of Mines. and county mine claim records, to name a few. In response to Dr. Hinze's question, Mr. Berquist noted that much of the data would have to be qualified, particularly that which had not previously been published. Dr. Steindler asked about model validation and was told by Mr. Price that there was an ongoing study on that topic currently within the Office of Mineral Resources of the USGS. Mr. Jennings asked if all study plans were peer reviewed and was told that they are peer reviewed both internally and externally.

Dr. Pomeroy asked whether implicit or explicit expert judgment methods were to be used. He was told that a formal protocol had not been planned but, if it was believed that a lack of such documentation was a concern, such a trail could be established.

Dr. Einaudi asked about assurance of the quality of the data. After discussion among several on the panel, Mr. Russ Dyer, DOE, noted several of the processes used by DOE to establish the adequacy of the data. He also noted the importance of the USGS scientific notebook process where all data gathering is logged and is available to anyone interested in reviewing it.

Dr. Hinze noted that the State of Nevada is generating a lot of information, and queried whether there was an MOU or accepted procedures that permit the State data to be put into DOE's system and made generally available. Mr. Dyer noted that although the information was available, insofar as inserting it into a digitized data base, that required more effort since the units would have to be standardized and the data put into a common language for use in such a database.

Mr. Johnson stated that DOE's and Nevada's purposes for gathering data are different. The State's program is to determine whether the site is suitable, whereas DOE's purpose is to characterize the site, if possible, and then develop the data in such a form that it will be possible to satisfy the NRC that the site is licensable. Therefore, although the data may look the same and

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be equally useful, the State has no plans to coordinate its activities with others. He also pointed out that the NRC had approved the overall State of Nevada quality assurance program in 1988.

Charles Barker, USGS

Dr. Barker commenced his presentation by discussing the current program, which until recently was focused only on the characterization of the source rocks in eastern Nevada, but which now has been extended to the whole state. D. Barker indicated that the study was attempting to determine the richness of the source rocks, insofar as carbon and hydrogen are concerned, there would be oil or gas-prone source rocks, and to evaluate how far along the path of oil or gas generations these rocks have gone.

He noted that in Nevada there are two basic source rock series, the Eleana (Paleozoic) and the Tertiary series such as the Elko and Sheep Pass formations. The first formation addressed was the Tenneco Shingle Pass. The temperature of these rocks would produce oil in the later Paleozoic and early Mesozoic periods. However, these rocks have now lost all sources of oil. He noted that even at the deep explorations down to 3,500 feet there were inconsistencies in the results of their exploratory studies. It is believed that the material indicators are strongly controlled by the peak temperatures reached in the rocks and that probably time is a subsidiary to the peak temperature. Therefore, by estimating the peak burial temperature, one can have an idea as to the oil potential in that rock.

In the area of Yucca Mountain the temperatures indicate that there would be a very low potential for gas, whereas it appears that there is a higher potential for gas in the area of the Calico Hills. His conclusions are that the oil that was generated in the Pleozoic series has probably been destroyed either by cooling or by being cooked out. Also pointed out was that even though one may use organic carbon as an indicator of source rock potential, the hydrogen indices are very important. "You need hydrogen to make hydrocarbons."

John Grow, USGS

Dr. Grow then addressed his area of expertise, seismic reflection work and its integration with other potential data and structural data. He noted that in the late 1980's Tom Broker, USGS, experimented with a 480 channel reflection line in the Amargosa Valley. The results of that effort were encouraging. Should the results of further experimentation this coming spring be encouraging, then this approach may be used to better define the petroleum potential in the area. As a background note, it was noted that national assessments are underway to determine

undetermined onshore oil and gas reserves for the U.S. The next such assessment is due in 1995, but the 1988 study estimated that there could be possibly 300 million barrels of undiscovered oil in the Eastern Great Basin.

He then discussed a 1,024 channel line in Railroad Valley that crosses the Grant Canyon field and even a part of the White River Valley. He noted that the thrusting in the Yucca Mountain area, while it does not appear to be major, will undoubtedly be evaluated in the 1995 assessment. Gravity and magnetic mapping in the general area were also discussed, it being noted that the magnetic data suggest that the pluton underneath the Eastern River Valley and the Grant Range is quite extensive. Although, in summary, the data still do not provide a completely clear picture of the area, they do tend to reveal a slightly different story than the data currently published would tend to indicate. In conclusion, Dr. Grow stated that, although much of the data was preliminary and therefore there were no reports to provide, he trusted that his presentation, and that of his colleague, would provide an insight into the magnitude and types of research currently in progress.

In response to a query, he stated that without seismic data, he doubted that oil companies would bother exploring in the area. Dr. Corbett noted that in areas of difficult terrain there are other methods that could be used such as are being used in New Guinea.

Mr. Johnson stated that although the presentation was interesting, he did not hear any indication of a schedule nor of the use of alternatives to the seismic surveys, if they are not successful. This leads him to the question whether an adequate resource assessment can be conducted within the time constraints imposed upon the project. Dr. Berquist indicated that they would do what they could in the time that they have been allotted.

Following up on that comment, Dr. Jennings noted that it would be useful to know how much data were required to satisfy the regulations. Dr. Price suggested that one deep hole would perhaps provide an answer to a lot of questions. Some discussion ensued as to "deep", with a general feeling that a hole 10,000 feet or more, properly located, would perhaps be of the right order.

Mr. Miklas stated that it would be valuable to know whether there will be human or inadvertent intrusion at Yucca Mountain. Dr. J. Boak, DOE, responded, noting that in his perception all data provide input into the performance assessment effort. He noted that there are two extremes in the assumptions that one can use: either a probability of zero for no intrusion or a probability of one, which would assume that at some time there will be intrusion. DOEs' latest performance assessment for the proposed

site (which had just been transmitted to the Committee) assumed the most conservative position-and still resulted in a CCDF calculation that was satisfactory.

3. Concluding comments by Dr. W. J. Hinze, Working Group Chairman

Dr. Hinze noted that the presentations were most interesting and informative. He requested that the Committee Members and consultants mull over the plethora of information provided and inform him as to any guidance they might care to provide, either as far as what was presented or insofar as future needs. Following those remarks, the working group meeting was adjourned.