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CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: International High-Level Radioactive Waste Management Conference
20-5702-151, 20-5702-191, 20-5702-221, 20-5702-222, 20-5702-421,
20-5702-422, 20-5702-425, 20-5702-426, 20-5702-451, 20-5702-523,
20-5702-541, 20-5702-623, 20-5702-641, 20-5702-642, 20-5702-712,
20-5702-722, 20-5702-723, 20-5704-023, 20-5704-039, 20-5704-053,
20-5704-064, 20-5704-193

DATE/PLACE: Mirage Hotel and Convention Center, Las Vegas, NV
May 22-27, 1994

AUTHORS: M. Ahola, A. Bagtzoglou, A. Chowdhury, R. Green, A. Gureghian,
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S. Mohanty, W. Murphy, P. Nair, W. Patrick, and B. Sagar

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PERSONS PRESENT: Over 1,300 people attended this year's conference, representing a wide
spectrum of interests, including: DOE, NRC, EPA, State of Nevada,
Indian Tribes, Academic Institutions, and other governmental and
nongovernmental entities

BACKGROUND AND PURPOSE OF TRIP:

The International High-Level Radioactive Waste Management Conference (IHLRWMC) is an annual conference where research and development activities pertaining to high-level [nuclear] waste (HLW) underground repository programs are presented and discussed. Of particular interest are the studies that relate to the Yucca Mountain program. Both Nuclear Regulatory Commission (NRC) and Center for Nuclear Waste Regulatory Analyses (CNWRA) staff participate and contribute to this conference by presenting technical papers, providing invited talks, and chairing various technical sessions. The conference provides early results of tests, data, and analyses performed by various U.S. Department of Energy (DOE) laboratories associated with the HLW repository program. The State of Nevada, Indian Tribes, and other interested parties also attend and participate in the deliberations of the conference. Opportunities to visit the Yucca Mountain repository site provide additional benefit to the staff involved in the repository licensing process.

SUMMARY OF PERTINENT POINTS:

The opening plenary session clearly drew lines of differences between the State of Nevada and DOE. Subsequent presentations in the Institutional Systems, Socioeconomic Impacts, Communication with the Public, Public Perception and Polling, Institutional Issues in Transportation, etc. expanded on this theme. Moreover, this polarity was further manifested in many of the more technical sessions. The dichotomy of view regarding the location of nuclear waste was expressed by foreign as well as U.S. speakers.

Plenary Sessions

In his opening remarks, Dr. J. C. Unrue, the Conference chairman, noted that disposal of HLW was a "global problem whose solution is manifestly local." As a result, the solutions posed must gain the public trust.

Commissioner Remick delineated NRC responsibility for regulatory oversight of licensees regarding disposal of low-level waste (LLW) and HLW based on historical perspective of deliberations, laws, regulations, societal pledge, and other considerations. He spoke to the important roles of a performance confirmation program of 50 years or longer and early and ongoing DOE/NRC interactions. Noting that there is no provision for separate licensing of a multi-purpose canister (MPC) for disposal, he stated that DOE must address the MPC in a repository licensing context. Finally, he cautioned against using a repository for a *de facto* monitored retrievable storage (MRS); legislative action and critical technical analysis are needed before long-term storage options at the repository can be considered.

Dr. D. Dreyfus, Director of the Office of Civilian Radioactive Waste Management (OCRWM), pointed out that the same issues exist today as in the late 1970s. However, permanent disposal in deep geologic media was still the preferred option. His main points were that (i) thousands of man years of study of the unsaturated zone and Yucca Mountain specifically suggested many positive factors that exist at Yucca Mountain, (ii) amendments of 1987 were made in recognition of the high cost of a multiple-site program and lack of progress, and (iii) site characterization efforts aim to confirm or revise the current policy and approach. He stated that the ultimate HLW repository decision will be made with or without scientists; scientists must focus on the most important issues and be responsive in providing answers; they must be careful not to "price the geologic repository out of the policy market place." In a somewhat paradoxical statement, he called on this same group to (i) identify "the best science that you can do" and (ii) be sure you are "doing the best science you can do."

Senator Dr. Titus from the State of Nevada spoke to the group on behalf of Governor Miller from multiple perspectives as professor, Las Vegas, and legislator. She made three key points: (i) scientists should not fall prey to the allure of discovery and forget the related human and ethical issues; (ii) science can never be neutral, value free, and separate from the politics associated with funding, yet staff must maintain scientific integrity; and (iii) Nevada politicians and the majority of Nevada citizens are against the Yucca Mountain project. Noting that these problems go beyond technical matters, she called for a panel discussion on ethics.

Dr. Barber (ANDRA) noted that in France, after difficulties with siting activities in the 1980s which led to a 1990 moratorium on work, the emphasis has turned to education of the public regarding HLW and the associated issues relating to technical, societal, and political factors. France now takes a phased approach to waste management. The phased approach begins with development of two underground research laboratories; four departments (states) have shown interest in hosting these facilities.

J. Lemley, Project Manager of the Chunnel Project, provided the keynote address. Citing three findings of a recent Nuclear Waste Technical Review Board (NWTRB) report, he noted that these three problems were also evident in the Superconducting Supercollider Project, which Congress canceled. His general theme was empowerment of management, and he used the Chunnel and Panama Canal as examples where decision-making authority was given to the field project managers. He urged the HLW program to adopt a proactive approach to decision making and not to "hide behind analyses, committees, and the so-called expert process."

There were plenary sessions dealing with technical topics, and these are discussed, as appropriate, in the Technical Sessions section of this report.

Regulatory Issues Sessions

Dr. D. Fehring (NWTRB) introduced the three-session sequence on Solving the Regulatory Conundrum. Stating that development of an environmental standard for application to a place like Yucca Mountain is the regulatory conundrum, he noted that the controversy is centered on (i) protection of population versus individuals, (ii) release versus dose, (iii) perception of over- or under-stringent requirements, and (iv) treatment of C^{14} release, which is specifically cited by many as being overly stringent.

S. Brocoum summarized DOE recommendations to the National Academy of Sciences (NAS) panel in the context of an issues framework. This framework, which they developed based on Section 801 of Energy Policy Act, delineates both the regulatory bases and means of demonstration of compliance. The six DOE recommendations to the NAS were (i) use a health-based standard; (ii) focus on protection of a population in the vicinity of the proposed Yucca Mountain site, using a single performance measure (he stated that NRC subsystem requirements are unnecessary); (iii) limit the quantitative standard to 10,000 years; (iv) impose a qualitative requirement for human intrusion; (v) describe the standard deterministically, but call for demonstrating compliance probabilistically; and (vi) while noting that an individual dose standard is appropriate (they stopped short of recommending this), be consistent with international standards and use average dose to a larger group rather than the maximum individual or group. There were many questions [including from the U.S. Environmental Protection Agency's (EPA) L. Weinstock] on the inconsistency of the DOE recommendations. It was specifically noted that while DOE called for regulatory clarity, they resorted to "mush" on the important issues of human intrusion and offered the confusing approach of probabilistic implementation of a deterministic standard. Brocoum's presentation and responses did not acknowledge why EPA and NRC standards have features such as subsystem requirements.

K. Bragg (AECB) posed the question: Can long term criteria be implemented? He argued that a critical distinction must be made between understanding the great complexities of reality, which is what scientists want, and demonstrating compliance with established limits, which is what is required in the regulatory-societal context. Using a series of case studies, he basically argued that nature provides analogs which help identify the components of a reasonable standard and build confidence in the repository system (again, in a regulatory-societal context). Key points included: (i) set a time frame of regulatory interest for containment based on achieving risk levels equivalent to orebodies; (ii) use regional hydrological gradients and permeability to bracket reasonable average flow velocities and times; (iii) employ solubility limit calculations to indicate level of protection needed beyond chemistry constraints; (iv) identify hydrological isolation based on consideration of permeability contrasts or dilution to obtain the required level of protection (e.g., 1 percent of solution gets to accessible environment). One example he cited for addressing matters at a qualitative/conceptual level is that uranium concentrations in nature range over 7 orders of magnitude at ground surface, 5 orders at repository depth, but are bounded by about 10^{-7} moles/litre; his data indicated that, in nature, there is no obvious correlation with pH, Eh, or bicarbonate. Rebutting Bragg's suggestion, L. Weinstock (EPA) noted that public comments on EPA Standard indicate that the U.S. public prefers the "bright line" of the standard; Bragg countered that a probabilistic standard does not provide a "bright line" and, furthermore, "no one understands what a CCDF is."

M. McGarry, III [Management and Operating contractor (M&O) legal counsel] provided a very insightful presentation on the Treatment of Uncertainty in the NRC Regulatory Process. Noting that the process does not require absolute knowledge, he highlighted the importance of subsystems in addressing uncertainty. He observed that the role of reasonable assurance is also well established as a legal standard, not a technical standard, and has been confirmed by the Supreme Court. Regarding expert judgment, he stated that (i) it should be used to fill in the gaps regarding data and principles; (ii) it should be used to complement, not replace, available data; (iii) its use was liberalized by the Daubert case to accommodate scientific breakthroughs that go beyond scientific consensus; and (iv) there are still issues with regard to the weight to be given to such judgments. He referred the audience to the Perkins case regarding Rn^{222} from mine/mill tailings and NUREG 1489 on NRC Use of Probabilistic Risk Assessment in the Licensing Process (March 1994). L. Weinstock noted that the EPA term "reasonable expectation" refers to the mean CCDF and, thus, is a lesser standard than NRC's reasonable assurance. J. Wolf (NRC-OGC) generally agreed with Weinstock, but clarified that NRC holds reasonable assurance to be a qualitative judgment, not a specific numerical confidence level.

D. Moeller [private consultant, formerly Chairman of the Advisory Committee on Nuclear Waste (ACNW)] summarized ACNW comments on the EPA Standard. His basic points were that the standard is (i) overly stringent, (ii) inconsistent with NCRP and ICRP guidelines on dose to population, (iii) inconsistent with EPA Standard on radon for indoor air by more than two orders of magnitude, and (iv) inconsistent with regard to C^{14} in the atmosphere and as released from reactors. [Note: ACNW comments are available in CNV, SA files for detailed assessment.]

M. Federline provided a comprehensive review of NRC staff views of EPA Standards. These are available in CNWRA files and are not repeated here.

A. Zurkinden (SNSI) summarized the Swiss guidelines on radioactive waste disposal, noting that while they are not legally binding, the regulatory authority imposes them and requires compliance as a matter of practice. Principal features of the Swiss guidelines are (i) one set of standards for all radioactive wastes; (ii) deterministic approach of calculating consequences of assumed events; (iii) allow probabilistic calculations to complement these; (iv) no *a priori* limit on time scale—continue the calculations at least until maximum effects are seen.

J. Kessler [Electric Power Research Institute (EPRI)] presented a paper on A Health Risk Based Approach for HLW Repository Environmental Protection Criteria. He summarized the results of EPRI analyses using the IMARC code, which uses a fault-tree approach with expert judgments of the estimated probabilities of occurrence of events rather than detailed analyses. It appears that EPRI favors a standard based on reasonable assurance of continued low dose over long times to an average individual in a local population group. Kessler noted that dose does not peak at 10,000 years, suggesting that calculations should extend to at least 100,000 years, but stated that EPRI believes 1,000 years may be the greatest period quantitative assessments will be able to be used in the regulatory process. He does not believe that technical agreement can be obtained beyond 1,000 years. It appears that EPRI is basing this conclusion on a higher standard of technical certainty, rather than the regulatory requirement for reasonable assurance. Kessler characterized the subsystem requirements as specious, based on the need for very long-term performance. For example, he argued that since all the containers are gone at 10,000 years, they do not affect 100,000-year performance.

There were several papers in the area of implementation of current regulations. T. Williamson (Duke Engineering) and A. Gil (DOE) who are involved in the MGDS Annotated Outline (AO) and Progress

Report development stressed that their efforts are focused on development of the AO, issue resolution, and interim licensability evaluations. They also stressed that they intend to implement the structure and guidance presented by the Format and Content Regulatory Guide (FCRG) and License Application Review Plan (LARP). The presentation also included an overall program schedule.

Two presentations, one by M. Delligatti (NRC) and the other by R. Johnson (NRC), provided excellent summaries of the status and direction of NRC's program. Significant interest was generated in attendees representing the DOE and M&O in that they seem eager to obtain information concerning the NRC program as it becomes available.

In the area of Decision and System Analysis, papers focused on the experience gained in implementing the methodologies to the repository system. D. Shelor (DOE) and R. Langton (TRW) summarized an actual effort using stakeholders in decision making and using a modified multi-attribute utility analysis. This effort, in which a "Value Framework and Process" were developed was an interesting example of how use of formal "systems" methods can most often be modified to fit the particular constraints and circumstances of an actual problem. S. Rindskopf (TRW) and D. Royer (DOE) highlighted the difficulties which DOE has in integrating requirements with design. The requirements document hierarchy is complex (the viewgraphs were so cluttered as to be unreadable by the audience) and seems to require a full-time effort for its maintenance. This document structure is to guide design efforts to ensure that all requirements and specifications are accounted for. The nature of comments defined by an NRC/CNWRA review of the exploratory studies facility (ESF) design package 2C in the time period immediately prior to the conference indicates that there is a serious disconnect between the requirements documents and the design process.

Nuclear Waste Issues in Indian Country was addressed in a session. R. Jim (Yakima Indian Nation) stated the Indian people have a culture and a religion which require a stable and clean environment. He emphasized that this society needs to clean up and not cover up things and leave them. F. Peso (Mescalero Apache Nation) emphasized that the Mescalero's are "business-minded people" and believe they have a service to provide (storage of spent nuclear fuel) to many potential clients (currently 33 utilities). He emphasized that the Mescalero's were the first to respond to the Nuclear Waste Negotiator's invitation to participate in the siting of a Federal MRS and that they should be "first in line" should that program be revived. He closed by acknowledging that many legislators and environmentalists will try to block the siting of a MRS in New Mexico, yet he was optimistic that the Mescalero's and their utility partners would be successful.

Technical Sessions

One of the highlights of this year's meeting was the emphasis on MPC. Presentations in various technical sessions included all aspects of the new concept, including materials selection, heat loading (related to burnup credit), design/welding, interim storage, transportation, and schedules for completing various milestones towards licensing the MPC.

Plenary speaker, R. Bernero (NRC) pointed out that there are three functional issues related to the MPC: (i) storage, (ii) transport, and (iii) disposal. The operating environment for the first and third issue is static; while, for the second, it is dynamic. The time frames of these functions are: storage (0-100 yrs), transport (N-100 yrs), and disposal (10,000+ yrs). According to Mr. Bernero, the licensing concerns related to the first two functional issues for MPC can be resolved now, while the third one will have to wait pending further investigations and studies by the DOE.

D. Wilder [Lawrence Livermore National Laboratory (LLNL)] summarized anticipated concerns in the near-field environment, identifying a wide range of heterogeneities in the geologic system and its interactions with the engineered components of the system. He recognized that dripping could occur on a localized basis, due to matrix saturation, periodic fracture flow, and condensate reflux. The focus appears to be to determine the maximum corrosion conditions based on temperature, relative humidity, microbiological activity, etc. Surprisingly, he argued that H₂O chemistry in the vicinity of the waste package will be benign. This study gave a rather superficial treatment of the hypothesized evaporation-concentration process.

W. O'Connell (LLNL) provided an overview of the PANDORA model. A general description of code capabilities with some sensitivity analysis was provided. Their approach simulates a single waste package with various wetting models. The code is not fully developed yet, but parts of it are operational.

J. Gansemer (LLNL) spoke on the Yucca Mountain Integrated Model (YMIM), which evaluates a composite or collection of packages by probabilistically treating the spatial distribution of environmental conditions; this leads to time-varying failures. This analysis used extreme value statistics on pitting to determine failure based on through-wall penetration. YMIM is written in the C++ language.

A session chaired by M. Federline and N. Eisenberg was devoted to the NRC IPA Phase II results. R. Wescott, J. Park, T. McCartin, R. Codell, and V. Colten-Bradley described, respectively, the components of IPA II, the total system code development, flow and transport modeling, source-term modeling, and sensitivity analyses. It was notable that presenters emphasized aspects of the geologic and repository system that could have a significant effect on performances but were absent from the IPA model. Such aspects include focused infiltration, the capacity of the failed waste package to inhibit radionuclide release, and retardation of radionuclide migration in fractures. IPA can provide guidance for future work through insights concerning processes absent from the models, as well as through numerical results.

The Sandia second iteration performance assessment results were summarized and compared to first iteration results by M. Wilson. It was notable that in several cases the second iteration results showed poorer repository performance (based on the CCDF) than first iteration results. This pattern seems to violate the underpinning philosophy of iterative performance assessment that with successive, more realistic and less conservative iterations, the performance measure should improve.

W. Lin (LLNL) presented the current status on the large block test (LBT) designed to test and calibrate some of the coupled thermal-mechanical-hydrological-chemical (TMHC) process model concepts. The main motivation in conducting a large block test (as opposed to a natural analog or pilot test) lies in using this as a natural extension of the small- or medium-block test conducted in the laboratory environment where the boundary conditions are controlled. Lin et al. emphasized that the block can be characterized before and after the test; whereas, this cannot be done in ESF testing, and that the LBT does not intend to simulate ESF or repository conditions. The location of the LBT site was selected based on Chestnut's suggestion that the location has, on the average, one fracture per foot. Ten percent of the fractures may not contribute to the flow. The decision was taken on the basis that at least one fracture is present that will allow flow. The fracture maps are available to the public for analysis purposes. Question was raised by A. Flint as to whether water will flow at all in the matrix. Lin et al. replied that water would flow at 50% water saturation. A. Flint responded by saying that it would take over 100 years to saturate the rock matrix to that level. Lin et al. also pointed out that the temperature distribution is insensitive to the permeability and that the heat flow would be mostly conduction dominated. To prevent heat losses, a

panel of heaters will be used on the four exposed vertical faces. The temperatures of individual heaters will be controlled independently.

H. Kalia presented test results from a simulated waste package test to determine the effect of heat produced by the decay of HLW on the migration of brine moisture, thermomechanical response of salt, corrosion on waste package container material, and generation of gases. The test consisted of central 5 m-long heater boreholes surrounded radially by 8 guard-heater boreholes and 3 thermocouples. The heat produced by the decay of Cobalt 60 source was considered in applying the electric load to heat the salt. It seems that the investigator intended to maintain the guard heaters at the central borehole temperature. Past experience indicates that guard heaters could be unreliable in maintaining the desired temperatures. Hence, the data from such tests need to be adequately scrutinized.

Z. Bieniawski pointed out that there could still be considerable improvement in DOE's design methodology and concepts for the repository design. The design methodology linking the decisions made for the ESF construction with those based on a conceptual repository design were apparently still unclear. This was based on a review of a representative sample of DOE's design documents by an outside group of students/engineers.

C. Menges (USGS) in the Faulting and Seismic Issues-II session, regarding detailed mapping along the route of the ESF, suggested the likely presence of many more faults than previously suspected. Menges believes that the ESF may go in and out of the selected repository formation several times rather than be contained within it as proposed by DOE. If this belief is substantiated, earthquake and faulting risks for the repository could be higher than anticipated, and the NRC/CNWRA may be required to evaluate and/or independently calculate probabilities for these events.

N. Trask [United States Geological Society (USGS)], in The Likelihood of Human Intrusion and Impact from Terrestrial Bodies session, suggested that risk from meteorite impact to a waste repository could be as high as 10^{-4} per year and for a high-mass high-velocity body from outside our solar system, 10^{-6} per year. Trask pointed out that this estimate is higher than DOE's estimate for volcanic disruption of the repository. He stated that a deep and consolidated burial of waste would reduce the total risk of exposure caused by this hazard. He argues for underground disposal rather than keeping material in spent fuel pools or in on-site dry storage at several nuclear power plants. Previous meteorite hazard estimates that have been noted were on the order of 10^{-8} per year and were generally considered below regulatory concern.

R. Spengler (USGS) provided an overview of what is known about the Sundance Fault. Of particular interest was his observation that the fault is clearly evident in the 1987 low sun-angle photographs of the area. He characterized the Sundance Fault as (i) a series of parallel features several hundred feet wide with a main fault in the center of the fractured area; (ii) 0.5 to 5 miles long, with a probable length of 2 miles; and (iii) 170 feet of lateral separation. He cited the earlier work of Whitefield (1984) and Waddell (1985), which suggested fabric along the Sundance alignment, and C. Barton's pavement mapping which was along the trend of the Sundance Fault.

J. Quade described the paleospring deposits in the Yucca Mountain region. The deposits record discharge areas and the increase in the water table level during periods of wetter climate. The greatest water table rise noted (115 m) was at the site closest to Yucca Mountain (in Crater Flat).

In a paper by E. Roedder, J. Whelan, and D. Vaniyan, fluid inclusion data from calcites at Yucca Mountain were interpreted to indicate crystallization under low temperature (e.g., ambient) and hydrologically unsaturated conditions. Previous indications that the inclusion data indicated elevated temperature conditions were dispelled.

In a paper by V. Chekuri, S. Tyler, and J. Fordham, experiments were described in which the sorptivity ($\text{cm sec}^{-1/2}$) of rock samples was measured. Samples of Tiva Canyon tuff taken from the surface outcrops at Yucca Mountain generally showed greater sorptivity across mineralized fracture surfaces than across unmineralized surfaces. In the same session, a paper by R. Glass et al. described experimental and numerical studies of fracture-matrix interactions using an artificially cut block of Topopah Spring Tuff for the experiments and TOUGH2 for the modeling. While significant advances are being made, studies are still a long way from addressing natural fracture-matrix interactions.

W. Murphy served as co-chair and invited speaker in a plenary session titled Time and Complexity: Natural Analogs in Radioactive Waste Management. His presentation described CNWRA natural analog research at Peña Blanca and Santolani. Other speakers in this session were J. Smellie who described several international natural analog studies, D. Curtis who focused on the use of natural analog information in the context of other types of investigations, W. Glassley who described work at the Wairake geothermal field including studies of the alteration of engineering materials, and C. McCombie who spoke particularly of the use of natural analogs in conveying public confidence in geologic disposal of nuclear waste. Following this session, a 50-minute video on natural analogs was shown. It was prepared with international support primarily as a public education medium. The video repeatedly emphasized the utility of impermeable clay barriers and chemically reducing conditions in preserving natural and archaeological materials for long periods of time.

Wang et al. [Lawrence Berkeley Laboratory (LBL)] conducted numerical transient flow experiments along the identified fast path using single rock joint profile data from Stripa and Dixie valley fracture specimens. Their joint characterization data was presented at the 1993 IHLRWMC. They had obtained fractal dimension from the surface area to volume ratio. The aperture variation increased with scale but anisotropy ratio remained the same (i.e., independent of the scale). The saturated flow experiment showed that the total flow at a given time does not vary much between the two specimens (factor of 2) even if the fields are completely different. They expanded their data to conduct a simulation using a 110×110 mesh over 5×5 m surface and yet assumed that the surface had the same fracture aperture pattern as had been observed on a 22×22 mm spot on the Dixie valley anisotropic fault sample (a binary image). Their main interest was to evaluate the effect of matrix imbibition on fracture percolation (i.e., sorptivity experiment on the fracture). Although they used a simple model, they concluded that the fingering patterns are sensitive to the scaling of the average aperture value and the node size. If the average aperture increases, the finger moves down to the outlet end easily. Large nodes also enhance percolation. The effect of geometric anisotropy on percolation through fingers is substantial. The transient percolation and fingering into an initially dry fracture is very sensitive to anisotropy. The corresponding channeling pattern in saturated conditions is also sensitive to anisotropy, while the steady flow rates are less sensitive to anisotropy. They neglected the interface effects from the gas phase on liquid movement. They are planning to improve their quasi-1-D flow path model with 2-D simulation over the same aperture field. The CNWRA staff should further review the test parameters and identify the rigor needed in characterizing scaling parameters.

Pruess et al. (LBL) emphasized the possibility of two-phase flow in the repository environment because of the generation of gas due to corrosion, radiolysis, microbial activity, and gas flow. They presented

their data from laboratory multiphase flow experiments using replicas of joint surfaces. They reported experiencing great difficulties in reaching steady state due to the pressure constraints and gas fluttering. They pointed out that from an experimental point of view, instead of injecting both phases (air and water) at a constant rate, it may be practical to inject one fluid at constant pressure while injecting the other fluid at constant rate. This may explain some of the difficulties we are experiencing at the preliminary stage of the two-phase flow experiment being conducted at the CNWRA laboratory.

Rautman et al. [Sandia National Laboratory (SNL)] used indicator geostatistical techniques to produce a number of fully 3-D stochastic simulations of large-scale lithologic categories at the Yucca Mountain site. They conditioned their numerical hydraulic conductivity field generation to wellbore data. Variations among the simulated models collectively represent uncertainty in the lithology at an unsampled location. Many of the apparent discrepancies between the simulated data and general geology of Yucca Mountain represents characterization uncertainty and can be traced to the sparse site data used to condition the simulation. This certainly highlights the need for more data. Moreover, the indicator technique was arbitrarily chosen for convenience rather than relying on critical analysis of all available models. Because they have used the Stanford geostatistical software package, there is concern that the indicator technique had difficulties reproducing the assigned correlation lengths as interpreted from the imposed semivariograms of hydraulic conductivity distribution. At the time of the presentation, they had not tested the reproducibility of the imposed correlation length.

C. Ho (SNL) attempted to match the results from TOUGH2 simulation of water infiltration into tuff matrix from a saturated vertical fracture with the experimental results. Zimmerman from LBL questioned the use of a 2-D model as opposed to a 1-D model along a cross section perpendicular to the fracture plane if the purpose was to study matrix imbibition. Ho replied that the heterogeneity in the matrix might influence the imbibition rate. He also agreed that it would be more realistic to treat an advancing water-air front in the fracture rather than assuming full saturation of the matrix. It should be pointed out that a recent CNWRA report presents a semi-analytical solution to such an advancing front on a single fracture surface that is easily extendable to joint surfaces if a smooth fracture planes assumption is made, as has been done in Ho's approach.

Papers related to source term provided information on oxidation characteristics of spent fuel in a dry repository environment and spent fuel characteristics that are considered important from a long-term repository performance point of view. Modeling of fuel cladding life in a container environment was described. The model assumed creep rupture and hydride reorientation to be the life-limiting mechanisms for fuel cladding in a sealed container environment.

A session on Waste Package Systems and Performance presented papers recommending the need for additional Approved Testing Materials (ATMs) for obtaining materials properties characterization data for a majority of the spent fuel that is anticipated to go into the repository. Current ATMs bound only a small fraction of the spent fuels. Preliminary results of leaching tests on spent fuel indicate that there could be differences in long-term performance of spent fuel in a repository environment depending on the fuel source characteristics (burnup, BWR or PWR, etc.). Long-term tests are underway at Argonne National Laboratory (ANL) which will provide additional information in the future. The paper on actinide-doped vitrified wasteform indicated that a large fraction of actinide releases from glass could be associated with colloids.

Idaho National Engineering Laboratory (INEL) is continuing to develop a glass-ceramic wasteform that is considered more appropriate for the INEL calcined waste than borosilicate glass.

Several CNWRA staff participated in the DOE tour of Yucca Mountain.

The proceedings of the conference were issued in four volumes. For additional information on any paper discussed in this report or any other paper presented at the conference, the reader is directed to the four-volume publication. Copies of the conference proceedings are available from the authors.

PAPERS PRESENTED BY CNWRA STAFF:

"Comparison of Coupled Thermal-Mechanical-Hydrological Analyses of a Fractured Rock Mass," by M.P. Ahola (CNWRA), A.H. Chowdhury (CNWRA), S.M. Hsiung (CNWRA), and J. Philip (Nuclear Regulatory Commission), *Proceedings of Fifth International Conference on High-Level Radioactive Waste Management*, Vol(4):2492-2499, Las Vegas, NV, May 1994.

"Pressure Driven Gas Flow in Heated, Partially Saturated Porous Media," by F.T. Dodge (SwRI) and R.T. Green (CNWRA), *Proceedings of Fifth International Conference on High-Level Radioactive Waste Management*, Vol(4):2217-2227, Las Vegas, NV, May 1994.

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"Stochastic Analysis of Unsaturated Flow and Transport with the SUFLAT Executive Numerical Code," by A.C. Bagtzoglou (CNWRA), M.R. Islam (Washington State University), and M. Muller (SwRI), *Proceedings of Fifth International Conference on High-Level Radioactive Waste Management*, Vol(4):2669-2677, sponsored by the American Nuclear Society and American Society of Civil Engineers, May 1994.

"Effective Unsaturated Hydraulic Property Determination with the Renormalization Group Approach: Methodology," by S. Mohanty (CNWRA) and A.C. Bagtzoglou (CNWRA), *Proceedings of Fifth International Conference on High-Level Radioactive Waste Management, Vol(4):2660-2668*, sponsored by the American Nuclear Society and American Society of Civil Engineers, May 1994.

"Comparison of Published Attenuation Functions to 6/29/1992 Little Skull Mountain Earthquake Strong Motion," by R.B. Hofmann (CNWRA) and A.K. Ibrahim (Nuclear Regulatory Commission), *Proceedings of Fifth International Conference on High-Level Radioactive Waste Management, Vol(4):2402-2408*, sponsored by the American Nuclear Society and American Society of Civil Engineers, May 1994.

PROBLEM AREAS:

None to report.

IMPRESSIONS & CONCLUSIONS:

- Dreyfus' somewhat paradoxical charge to the group that (i) scientists and engineers must focus on the most important issues and be responsive in providing answers, being careful not to "price the geologic repository out of the policy market place," on the one hand, and (ii) identifying "the best science that you can do" and being sure you are "doing the best science you can do," on the other hand must be reconciled in practice. Management must play an important role in achieving balance between these goals.
- The diversity of views regarding the HLW standard underscores the need for continued in-depth involvement of CNWRA and NRC staff in the ongoing NAS deliberations and EPA promulgation of a standard.
- Preliminary data and interpretations suggest that the Yucca Mountain block may be more highly faulted than initially thought. There are potential consequences for CNWRA's PFD&SHA and hydrologic analyses as well as total system performance assessment.
- There is a sense among DOE and M&O staff that there is a positive movement in the overall HLW program with the initiation of the ESF and the opportunities with the endorsement of the MPC concept by the Secretary of Energy. However, there is concern within the technical community that schedule expediencies may compromise the necessary technical investigations.

PENDING ACTION ITEMS:

- Follow-up discussions are needed with W. Reamer (NRC-OGC) regarding further interactions with CNWRA staff concerning the licensing process. This was discussed during the IHLRWMC, particularly in the context of the extremely informative presentation by M. McGarry III concerning the Treatment of Uncertainty in the NRC Regulatory Process.
- Copies of documentation on the use of expert judgement in the Perkins case regarding Rn^{222} from mine/mill tailings and NUREG 1489 on NRC Use of Probabilistic Risk

Assessment in the Licensing Process (March 1994) should be obtained and read by appropriate CNWRA staff.

RECOMMENDATIONS:

- The subject of radionuclide release via colloids appeared in question-and-answer periods in a number of presentations. There appears to be relatively little or no effort in current DOE performance assessment in accounting for colloids. It appears appropriate to consider suggesting that NRC arrange a DOE/NRC technical exchange to discuss the role of colloids in the release and transport of radionuclides in a repository environment.

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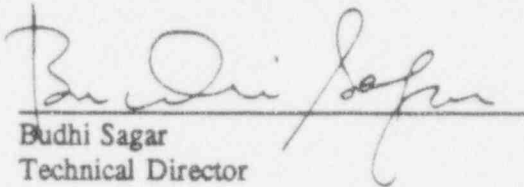


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