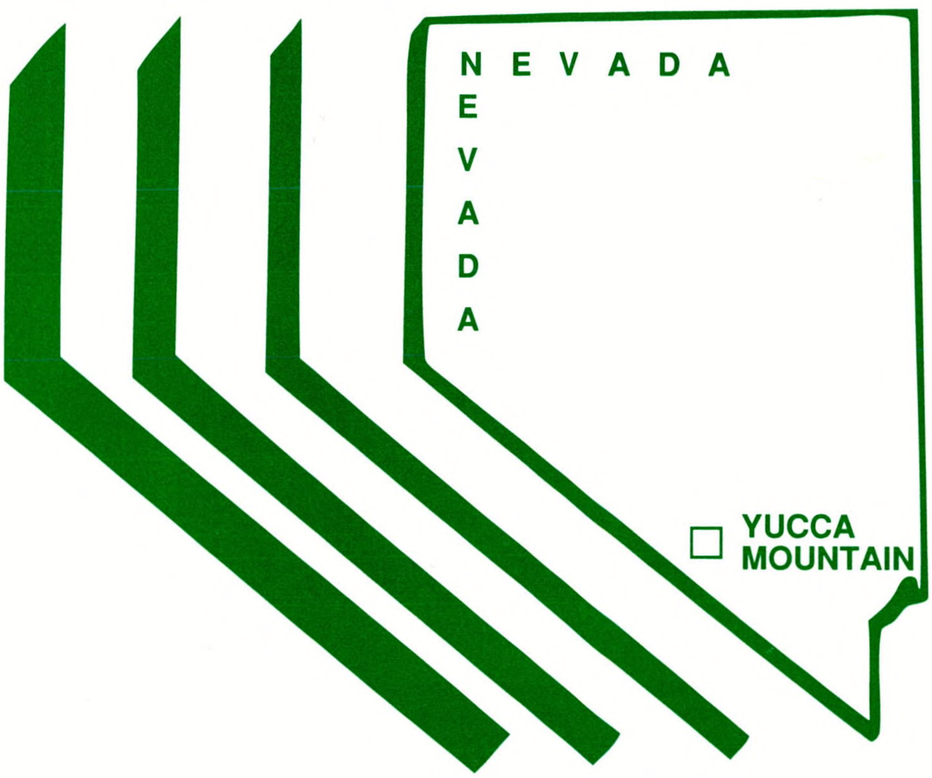
DOE/OSTI–3406(Suppl.2)
(DE90006793)
November 1990

Yucca Mountain Project Bibliography 1988–1989

United States Department of Energy



Civilian Radioactive Waste Management Program

Prepared for
Nevada Operations Office, Las Vegas, Nevada

Prepared by
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CONTENTS

FOREWORD

The Nuclear Waste Policy Act of 1982 (NWPA) established a national policy for the safe storage and permanent disposal of spent nuclear fuel and high-level radioactive waste. Congress assigned primary responsibility for development of a radioactive waste management system to the U.S. Department of Energy (DOE). The concept of a deep geologic repository was selected as the safest and most feasible method for permanent disposal of spent fuel from civilian reactors and high-level waste from national defense programs.

The DOE Office of Civilian Radioactive Waste Management (OCRWM) was formed in 1983 to administer the responsibilities delegated to the DOE by the NWPA. In February 1983, the DOE identified Yucca Mountain, in Nye County, Nevada, as one of nine potentially acceptable repository sites. The sites were evaluated to determine their suitability. In May 1986, the number of sites for further consideration was reduced to three: Yucca Mountain; the Hanford Reservation in Washington State; and a site in Deaf Smith County, Texas. At these sites, the DOE planned to conduct site characterization studies, that is, extensive surface-based and underground investigations. The Nuclear Waste Policy Amendments Act of 1987 suspended site studies in Washington and Texas and directed the DOE to characterize only the Yucca Mountain site.

The Yucca Mountain Project Office (formerly the Waste Management Project Office) in Las Vegas, Nevada, has local responsibility for the scientific investigations to determine if Yucca Mountain is a suitable repository site. The Yucca Mountain Project work force includes scientists from diverse disciplines as well as engineers and support personnel employed by the DOE, other government agencies, national laboratories, and private contractors. The major Yucca Mountain Project participants include the U.S. Geological Survey; Los Alamos National Laboratory; Sandia National Laboratories; Lawrence Livermore National Laboratory; Science Applications International Corporation; Holmes & Narver, Inc.; Fenix & Scisson of Nevada; MAC Technical Services; and Reynolds Electrical & Engineering Company, Inc.

Yucca Mountain is located about 100 miles northwest of Las Vegas on the Nevada Test Site's southwestern border. The property is administered by the Bureau of Land Management, the U.S. Air Force, and the DOE. The parcels of land designated for the proposed repository have been withdrawn from public use to prevent intrusions that might affect the quality of scientific data or future repository performance.

Yucca Mountain is a long, narrow ridge that runs north and south, with a steep western slope and a more gradual eastern slope. The ridge rises 1,000 to 1,200 feet above the surrounding alluvial flats. The mountain appears to possess several attributes that are desirable for a repository site: an arid environment, a deep static water table, slow hydrologic transport within the water table, and a volcanic tuff formation that would help retard radionuclide movement.

Preliminary data indicate Yucca Mountain is a favorable site, but adverse conditions may exist. Concerns have been raised about potential volcanic activity, faulting, earthquakes, and possible fluctuations in the water table.

Approximately ten more years of site characterization studies are necessary to analyze all factors that could affect the performance of a repository. If the site characterization studies are completed without discovery of any disqualifying conditions, the data gathered would be used to prepare a repository construction and operation application to the U.S. Nuclear Regulatory Commission (NRC). The NRC would then determine whether the proposed site meets strict federal regulations that prohibit a repository from posing a threat to the environment. If the Yucca Mountain site is deemed unsuitable, DOE must suspend site studies and report to Congress accordingly.

The Yucca Mountain Site Characterization Plan (SCP) is a 6,000-page document outlining numerous surface, underground, and climatological studies that must be performed to evaluate the site's suitability. The SCP contains a description of planned activities, information on their priority, and a general schedule for the site characterization program. Individual areas of study are presented in greater detail in separate SCP Study Plans. During site characterization, the DOE must also evaluate environmental and socioeconomic conditions.

Site characterization studies are divided into surface-based investigations and in situ testing. The surface-based program is a series of investigations designed to characterize the surface and subsurface environment through the proposed repository area. For in situ testing, an underground laboratory will be established at the proposed repository depth to study the processes and phenomena contributing to waste isolation performance and to evaluate how an engineered facility would affect the hydrogeologic environment.

All data gathered during the site characterization process must meet strict quality assurance (QA) requirements to be accepted for NRC licensing. While some of the site characterization activities will rely on advanced "cutting edge" technology and some of the country's top scientists to gather and analyze data, exemplary scientific work alone is not enough. Project staff and their contractors have to follow stringent QA procedures to ensure that all data are verifiable. The NRC will require traceability of all scientific samples; therefore, measures have been implemented to ensure that site characterization activities will produce valid data.

The site characterization phase is expected to last until early 2001. At that time, if the site proves to be suitable, the DOE would recommend construction of a repository at Yucca Mountain. If the President approves DOE's recommendation, a formal application for a repository construction license would be submitted to the NRC. Under the current repository development schedule, the Yucca Mountain repository would begin operations in 2010.

PROJECT HISTORY

FY 1988

Laboratory and field geologic and geomorphic studies at the Lathrop Wells and Sleeping Butte volcanic centers showed thin tephra layers interbedded with soil and aeolian material in the upper section of the scoria exposed in the cinder quarry. This suggests multiple, small-volume eruptions (polycyclic eruptions) from the main scoria cone; minor soil development on the cone slopes of the main scoria cone; and no apparent cone apron from the main scoria cone. The age determination of the Lathrop Wells volcanic center has been revised. The preferred age of the lava flow units of the center is 139,000 years before present.

Sampling and electron and proton beam analyses of basaltic ash deposits in trenches around Yucca Mountain show quartz saturation and considerable variability. In another group of samples that were analyzed for paleomagnetic pole position, data reveal the presence of two distinct pole populations consistent with previous interpretations of polycyclic volcanism at Lathrop Wells. However, the paleomagnetic pole positions are not completely consistent with eruptive sequence interpretations based on detailed field mapping of the Lathrop Wells volcanic center.

Work began on two facets of chloride sample preparation for accelerator mass spectrometric analyses of chlorine-36. The first facet is the leaching of USW UZ-1 cuttings. The second facet is development of a high-efficiency chloride extraction technique for smaller masses of tuff using a radio frequency induction furnace.

The objectives of the hydrothermal geochemistry tasks are, first, to produce a conceptual model and supporting data to explain the present distribution of minerals and water composition in Yucca Mountain and, second, to predict future mineralogy and water composition. A preliminary conceptual model was developed that stressed the factors controlling transformations and the time scale on which the transformations are likely to take place. The model suggests that mineral alteration would probably be minor during the lifetime of a repository in Yucca Mountain, but it also suggests that mineral reactions are currently occurring there.

On the basis of X-ray diffraction patterns, it has been determined that the solid isolated from the neptunium dioxide (NpO_2+) solution at 90 degrees Celsius and pH 5.9 in Well J-13 groundwater is neptunium pentoxide (Np_2O_5). Similarly, the neptunium solid isolated from the pH 7.2 solution at 90 degrees Celsius was found to contain some neptunium pentoxide. Infrared vibrational spectra were obtained for these neptunium solids and for the plutonium solids isolated from the 90 degrees Celsius experiments. The plutonium solids appear to be best characterized as carbonate-containing plutonium (Pu[IV]) colloid. Americium solids isolated from the 60 degrees Celsius, pH 5.9 solutions were assigned as americium hydroxycarbonates, which are isomorphous with the well-characterized neptunium hydroxycarbonates. Studies of the properties of Pu(IV) colloid have focused on three main areas: chemical oxidation of the colloid using cesium (Ce[IV]); electrochemical reduction and oxidation by voltammetry; and size determination by autocorrelated photon spectrometry.

Batch sorption experiments continuing from previous fiscal years were completed, and more mechanistic studies of sorption on single minerals were begun. Radiation detection measurements were performed with liquid scintillation counting techniques. Three different Yucca Mountain area groundwaters were studied along with four different Yucca Mountain tuff samples, including both vitric and zeolitic samples. The waters were from Wells J-13, H-3, and UE-25p#1, with the downgradient Well J-13 water from the Topopah Spring tuff used as a reference. The H-3 and UE-25p#1 waters represent the extremes in water compositions found at Yucca Mountain, each showing a higher cation concentration than the reference Well J-13 water.

The behavior of three colloids (0.10-, 0.91-, and 9.55-micrometer-diameter fluorescent carboxylated polystyrene spheres) was investigated during flow through a saturated column of densely welded fractured tuff from the Topopah Spring Member of the Paintbrush Tuff. The filtration coefficients for the fracture were about an order of magnitude less than predicted by the Tien and Payatakes formula. Based on this preliminary work, colloid transport may not be significant.

To study the ability of Yucca Mountain to act as a natural filter for particulate matter, plutonium colloids prepared under various conditions were characterized by autocorrelated photon spectrometry. The results showed that the largest colloid studied is only 30 nanometers in diameter. According to Hunt's filtration theory, particles smaller than a few micrometers migrating in porous media will be captured by the medium because of particle-medium collisions dominated by Brownian motion.

COVE2a benchmarking calculations were completed using the code TRACR3D. Twelve isothermal one-dimensional problems were considered—six steady and six nonsteady cases of flow through a vertical column of five fractured geologic layers. The computer codes FEHM and FEHMS, to be used to investigate the coupled effects of heat and stress on mass transport at Yucca Mountain, were modified to better represent processes that may occur.

Fracture network model (FRACNET) documentation and baselining continued. The random number generator, the normal random number generator, and the subroutine that calculates the inverse of the error function have been shown to perform properly. The code was altered to allow for tracer diffusion into the stagnant fluid in the rock matrix and adsorption in the rock matrix and on the fracture faces. The model was used to compute the connected node network, the pressure field, the flow field, and the response of a nonadsorbing, nondiffusing tracer.

A major mechanism by which microorganisms may influence the mobility of actinide elements is chelation. The purpose of the chelation study is to determine the effect of siderophores—chelating agents produced by microorganisms—on the movement of actinide elements away from the candidate repository. Siderophore production techniques are being modified continuously to increase yields for purification because large quantities of purified siderophores will be needed for the chelation study.

Core and selected cuttings from Well J-13 in the interval from a depth of 762 to 1,580 feet were examined, sampled, and analyzed to determine fracture mineralogy. The interval just above the vitrophyre is below the water table and contains only quartz and possibly a trace of mordenite. No heulandite was seen in any of the fractures. Comparison of Well J-13 with holes USW G-4, USW G-1, and UE-25a#1 suggests that where heulandite is found in fractures in nonzeolitic rock, that interval has not been below the water table since the formation of the heulandite. Analytical work was completed on the manganese oxide minerals in fractures in the Crater Flat Tuff from USW G-4. Abundant manganese-coated fractures appear to be correlated with the most densely welded intervals of that tuff.

The dehydration properties of the basal vitrophyre of the Topopah Spring Member were studied by dynamic thermogravimetric analysis and by long-term isothermal experiments. Preliminary results from the long-term isothermal heating experiments suggest that the first-stage loss of all but 1 percent of the perlite water may be a dehydration limit. Among the possible effects of perlite dehydration on repository performance are (1) changes in vitrophyre physical properties such as volume, strength, and permeability; (2) release of volatile constituents with attendant local changes in water or gas chemistry; and (3) production of dehydrated glasses that may rehydrate and retard water transmission below a repository.

Petrographic examination of silica-cemented breccia samples from Trench 14 and Busted Butte suggested that both the Topopah Spring Tuff at Busted Butte and the Tiva Canyon Tuff at Trench 13 suffered considerable brecciation very soon after deposition, possibly before devitrification. The breccia matrix consists entirely of finely crushed tuff. Later brecciation produced much less fine-grained matrix, and the spaces between breccia fragments were filled with silica and other secondary minerals.

The mineralogy of drill cuttings, core, and sidewall samples from drill hole UE-25p#1, which penetrates tuffs older than any volcanic units previously encountered in drill holes at Yucca Mountain, was examined using quantitative X-ray powder diffraction methods. The mineral distribution in the volcanic rocks in the hole is similar to that in the other drill holes examined at Yucca Mountain. The only significant mineralogic differences include the presence of dolomite in the Paleozoic carbonate rocks and the occurrence of up to 3 percent laumontite, a calcium-zeolite, in four samples of the Lithic Ridge Tuff. Tridymite occurs only near the surface, coexisting with cristobalite before disappearing.

Cristobalite disappears with the first appearance of zeolites, and opal-CT is a prominent phase coexisting with clinoptilolite. Analcime increases with depth, perhaps forming from clinoptilolite, but it coexists with clinoptilolite (or heulandite) to its deepest occurrence. Mordenite, a common zeolite in other Yucca Mountain drill holes, was identified in only 4 of 40 zeolite-bearing samples in UE-25p#1. Interstratified illite/smectites (I/S) are the most abundant clay minerals, and most samples examined contain two distinct I/S. The I/S with 60 to 75 percent collapsed layers are similar to that in drill holes USW G-1 and G-2 and is likely correlated with the ordered interstratifications in G-1 and G-2 that have potassium/strontium dates of approximately 11 My and are linked to Timber Mountain volcanism.

A preliminary analysis of flow in unsaturated tuff addressed modeling of vertical and lateral movement of partially saturated flow along the hydrogeologic contacts near fractures and faults. Numerical codes and procedures supporting performance assessment activities were successfully installed and verified on computer systems. Rigorous mathematical models, both analytical and numerical, were created to test the underlying assumptions in the simpler performance assessment models. Models were also formulated to describe the rate of release of radionuclides to the host rock at Yucca Mountain. A suggested structure for model validation was developed. A study of capillary-driven flow in a fracture located in a porous medium was also completed and documented. Instrument calibration was begun for experiments to validate models for flow in unsaturated media.

Water sampling was conducted to obtain the first hydrochemical samples from water table test wells UE-25 WT #12, #14, and #15. Two commercial mining companies were approached about gaining access to over 75 new boreholes that could provide potentiometric and hydrochemical data in key locations in the Amargosa Desert.

Streamflow measurement experiments were completed. Results from an imbibition experiment, which addressed the depth of water penetration resulting from drilling operations in a welded tuff matrix, were documented. The gamma-beam attenuation apparatus was modified to provide a measurement capability in a two-dimensional plane.

The physical and mathematical bases for the source term, hydrodynamic, and transport modules of the Total System Performance Assessment Code (TOSPAC) were documented. The logic of existing methods for screening disruptive events and processes and for constructing the complementary cumulative distribution function required by EPA standards (40 CFR Part 191) was clarified. A model spent fuel inventory and a model source term, both suitable for the total system performance assessment, were developed and incorporated in computer codes.

At G-Tunnel on the Nevada Test Site, 30 miles northeast of Yucca Mountain, underground drill holes in welded tuff were logged using a borehole video camera. Prototype test holes to depths of about 115 feet were completed, and completion activities were monitored. These holes will be used in the cross-hole prototype test. The results will eventually be compared with those from under Yucca Mountain.

Prototype drift wall mapping was also completed in G-Tunnel. This included surveying, wall-washing, and photographing the test area in tuff about 1400 feet below the surface. Prototype testing was performed. Drilling on the 150-foot horizontal borehole and 15-foot vertical borehole was completed, and geophysical logging was conducted. Core analyses were completed to determine matrix hydrologic and physical rock properties and how they were affected by the test.

Analyses of the thermomechanical loading cycles of the G-Tunnel heated block experiment were completed. Pressurized slot tests were performed in the Experiment Drift of the G-Tunnel Underground Facility. Based in part on the results of these tests, other methods are being developed for evaluating rock-mass response. A prototype heater test at G-Tunnel was begun. The heater was turned on in September and measurements were recorded with monitoring to continue during cooldown after heater turn-off. Instruments were calibrated, and techniques for calibrating humidity measuring instrumentation were developed and applied.

Prototype testing of the Engineered Barrier System Test techniques was undertaken. Grout and liner installation techniques were tested, and a procedure for borehole grouting was developed. Baseline measurements were obtained using neutron, gamma density, and high-frequency electromagnetic geotomography. Permeability, temperature, and humidity measurements were also obtained. After the baseline data were obtained, the heater was turned on and data collection commenced.

The impact of drilling techniques on the hydrologic characteristics being measured was analyzed. Numerical codes were developed having the capability of addressing moisture changes under thermal perturbation of partially saturated fractured porous welded tuff media. Codes were also developed to analyze the impacts of horizontal versus vertical emplacement modes. Reports were prepared to document the numerical codes for both thermal and hydrothermal analyses.

The 50- and 150-foot boreholes in G-Tunnel were successfully air cored. Dust samples collected from the drift during drilling indicated that the dust collection system installed at the borehole for air drilling did contain the dust; the respirable concentration was well below the safety limits. Data collection continued for the Exploratory Shaft prototype mineralogy–petrology test.

The pretest analysis of the canister-scale heater experiment was completed. The experiment procedure for the prototype thermal stress test was completed, and several pieces of equipment for the experiment were developed and tested. Results of the analysis led to redesign of the prototype thermal stress experiment.

Exploratory Shaft Facility design analyses of bulk properties (density and porosity), mechanical properties, and data for thermal conductivity, thermal expansion, and heat capacity were completed. A plan was completed for evaluating waste emplacement orientations with the goal of recommending a single configuration. The horizontal borehole liner installation study and the design of a machine to bore and line a long horizontal hole in tuff were completed.

A preliminary layout and procedures for testing Gemlink RF equipment were developed. The Gemlink equipment is part of a prototype microwave telemetry system for deep unsaturated zone (UZ) borehole monitoring. The system is called Prototype Integrated Data Acquisition System (PRIDAS). Two PRIDAS instrument shelters and associated equipment—including uninterrupted power supplies, generators, and special electronic lock systems—were procured and installed. The completed shelters will be located at USW UZ-1 and UZ-4 boreholes for field evaluations.

Experiments were completed that examined the interaction of aqueous fluids with vitric and vitrophyric tuffs. Waste package integrated testing studies focused on the near-field migration of radionuclides in tuff. These studies augmented previous experiments which included borosilicate glasses with experiments including actinide-doped aqueous solutions.

Numerical simulation techniques were developed that will accurately model the behavior of pore fluids in tuff in the vicinity of the waste packages. Particle tracking techniques were developed and are being considered for incorporation into reactive transport simulators. Modeling of the prototype experiments was conducted. Fluid flow and chemical transport models were developed for use in studying hydraulic, thermal, and chemical phenomena in the host rock around one or more waste packages. The TOUGH code was applied to model, under several surface infiltration scenarios, the transient thermal and hydraulic environment around a hypothetical, horizontally emplaced waste package.

Other experiments focused on studying a process known as "fracture healing" in which fractured rock samples actually become sealed when water flows through them at elevated temperatures. This phenomenon is considered to be quite important as it could mean that the host rock in the repository may become less permeable after being heated by the waste packages.

Unsaturated leach tests of target glass compositions continued. Experiments to determine the effects of vapor phase aging on the surface composition and mineralogy of borosilicate glasses and natural analogues were also conducted. A preliminary glass dissolution model was developed which uses the EQ3/6 geochemical code to determine secondary mineralogy and solution composition, and transition state theory to determine glass dissolution rates.

Spent fuel dissolution tests were continued on bare uranium dioxide fuel particles at 25 degrees Celsius in Well J-13 water. Another study determined stress corrosion cracking on C-rings fabricated from Zircaloy-4 spent fuel cladding. A scoping study to evaluate electrochemical corrosion of Zircaloy-4 cladding did not identify any type of corrosion in tuff-equilibrated Well J-13 water at 90 degrees Celsius.

Degradation modes that might affect container performance were surveyed. These degradation modes include various forms of aqueous corrosion, low-temperature oxidation, phase instability in the alloy, and the special problems associated with welded structures. A series of parametric studies was begun to provide necessary information to apply the selection criteria. Completion of these studies will allow direct comparison among the candidate materials. Work plans were developed for fabrication and closure tests on subscale waste package specimens. Three alloys were emphasized for process development: CDA 122, CDA 715, and Alloy 825. Thermal analyses were completed to evaluate near-field thermal effects on the waste package as a result of various fuel loading options. For deterministic modeling of waste package post-closure performance assessment, the PANDORA model of the waste package system was completed, as was the software version of the model. The software was partially verified and then used to perform preliminary analyses of the conceptual design waste package.

In probabilistic (uncertainty) modeling, a new methodology was devised for sampling from the system parameters. Known as "selected sampling," the methodology reduces the clustering of sample parameter values, a phenomenon which reduces the attractiveness of other similar methodologies, such as Latin Hypercube. Latin Hypercube sampling is widely used as a variance reduction technique, but until now it has been impractical to evaluate how much variance reduction is provided in each application. A new method developed this year has solved this problem.

An informal release of the EQ3/6 code package featured several code improvements not present in previously released versions of the code package, including an improved solid solution capability, modifications of the fixed fugacity option, and various code optimization features. The purpose of this release was to allow the community of EQ3/6 users to assist in testing the modeling codes and the thermodynamic database by applying them to modeling a wide variety of geochemical problems. This testing will help verify and partially validate the EQ3/6 models. An EQ3/6 option is being developed to allow more accurate calculations involving clay mineral (smectite) solid solutions.

Coding was completed on the first of eight modules for the Automatic Verification Library. Many database preprocessing functions were incorporated into the INGRESS database software.

The Repository Design Requirements (RDR) document was completed in draft form. The RDR presents the basic design criteria from which the design for a repository at Yucca Mountain will be developed. It states the functional and performance requirements for the repository subsystems and identifies constraints and interfaces affecting design.

Reference configuration drawings were prepared to guide the beginnings of Exploratory Shaft Facility design. Preliminary results of the parametric seismic loading analysis indicated shaft liners will survive, with only minor damage, a combination of geostatic, thermal, and seismic loading for loads up to 1.0 gravity. This value is well in excess of the 0.4 gravity specified as the design basis.

Work continued on the study plan to evaluate the location and recency of faulting near prospective surface facilities. Water requirements were specified, and the maximum probable flood control study was documented. The site-generated-waste treatment and disposal study report was issued, and a seismic design cost-benefit analysis was prepared. The preliminary seismic evaluation of repository site and subsurface facilities was documented. Fuel consolidation equipment and water requirements were identified.

The seismic design cost-benefit assessment for the surface facilities potentially important to safety was performed and documented. The costs and benefits of varying levels of both vibratory ground motion and permanent surface fault displacement were evaluated; both cost-benefit assessment and public radiological safety issues were considered.

Reports documenting the preclosure radiological safety analysis for normal conditions of the proposed Yucca Mountain repository, the preliminary criticality safety study, and a preclosure safety analysis of proposed repository facilities were completed. The Yucca Mountain design basis accident methodology was also documented. A preliminary approach for the decommissioning of the Yucca Mountain repository was drafted.

The Monitored Retrievable Storage (MRS) System Study is an OCRWM-sponsored study to determine the impact of having or not having an MRS facility in the waste management system. Nine repository surface and underground facility configurations (including life-cycle cost estimates, construction scenarios, and sensitivity studies) were developed for this study.

The Sample Management Facility (SMF) construction and renovations in Area 25 were completed. SMF capital equipment was purchased, installed, and operationally tested. Core samples were inventoried and transferred from the core library in Mercury to the SMF. Renovations were begun on the Technical Services Building in Area 25 to be used for laboratory facilities and for computer data gathering.

Several preliminary systems and management procedures and documents were developed and implemented. For example, several new and revised quality management procedures were issued and implemented throughout the Yucca Mountain Project. A Configuration Information System was begun by the development of the Draft Functional Description and the Draft Database Dictionary. A major accomplishment was development and issuance of the first baselined version of the Reference Information Base (RIB). In addition, a performance allocation study report was completed, and a Systems Engineering Management Plan was developed and issued. The Exploratory Shaft Facility Integrated Data System Title I, Preliminary Design, was added to the technical baseline. Finally, an updated version of the System Requirements document for the Yucca Mountain Mined Geologic Disposal System was completed in accordance with guidance from OCRWM.

The Site Characterization Plan (SCP) and the Site Characterization Plan–Conceptual Design Report (SCP–CDR) were completed in final draft form. The SCP–CDR contains a more detailed description of the design than is described in the SCP. This document included an expanded version of the surface and subsurface facilities designs with equipment layouts and descriptions and associated radiological safety aspects. It also provided a preliminary description of waste handling operations as well as descriptions of the equipment needed to perform those operations. The SCP–CDR includes a drawing portfolio to provide a preliminary engineering basis for the design description.

An unreviewed report entitled "Conceptual Considerations of the Death Valley Groundwater System With Special Emphasis on the Adequacy of This System to Accommodate the High-Level Nuclear Waste Repository," by J. S. Szymanski, was prematurely released to the State of Nevada. An internal review committee was established to review it, and the author was requested to further develop his concepts and address reviewer comments in a second draft of his report that would undergo internal and external peer review.

Additional new rail access routes were identified for consideration in providing railroad service to the Yucca Mountain site. Identification of these additional routes brings the total number of alternatives to nine routes.

The draft Environmental Regulatory Compliance Plan (ERCP) was transmitted to the State of Nevada on January 8, 1988. The ERCP identifies Federal, State, and local environmental regulatory requirements that must be addressed and provides a process for complying with those requirements. A draft Environmental Program Overview was written to describe the Project's comprehensive integrated plan for satisfying environmental policy and regulatory requirements. The draft Environmental Monitoring and Mitigation Plan was transmitted to the State of Nevada on January 8, 1988.

Environmental regulatory compliance approvals were granted for the Endangered Species Act, Farmland Protection Policy Act, Federal Land Policy and Management Act, and Executive Order 11990 (Protection of Wetlands). An Air Quality Surface Disturbance Permit application was filed with the Nevada Division of Environmental Protection (NDEP) on January 20, 1988. In response to comments received, additional information was provided to the NDEP. On May 4, 1988, the Project Office received notification from the NDEP that the additional information had been received and that the NDEP would begin processing the application.

The Water Appropriation Permit application was filed with the Nevada State Engineer in July 1988. Revisions to the map accompanying the application were made in September. The State Engineer indicated that the application would be given priority consideration; however, a decision to grant the permit has not been made. The air quality permit application was deemed complete by the NDEP. A decision to grant the permit is pending, and a public hearing may be required.

The Historic Preservation Programmatic Agreement, which formalizes the DOE's responsibilities under the National Historic Preservation Act (NHPA), was revised in March and returned to the Nevada Historic Preservation Officer for signature. In the absence of a response from that office, the agreement will be sent to the Advisory Council on Historic Preservation (ACHP) in October. Provisions in the agreement were implemented by the Project Office.

Pursuant to the draft guidelines of the ACHP for incorporating the American Indian Religious Freedom Act under Section 106 of the NHPA, local Native American Tribal Councils were consulted to identify traditional, cultural, and religious values in the Yucca Mountain area. As a result, several site tours were conducted, and the Tribal Councils made recommendations for minimizing adverse effects on cultural resources during site characterization.

An overall methodology was written to bring the Project's Quality Assurance Program in conformance with comments and guidance received by the NRC in accordance with NUREG-1318. The Yucca Mountain Site Characterization Plan–Consultative Draft (SCP–CD) was completed and made available to the NRC and the State of

Nevada. It was developed to familiarize the NRC, the State, and other interested parties with the contents of the SCP and to promote interactions that would enhance the quality of the SCP–CD. The Site Characterization Plan is required by Section 113(b)(1) of the Nuclear Waste Policy Act of 1982, as amended.

The Yucca Mountain Project Information Office located in Beatty, Nevada, began operation in March 20, 1988. The office was established to provide information about the Yucca Mountain Project and the DOE Civilian Radioactive Waste Management Program and to provide citizens with a place to ask questions about the DOE program. The information office provides visual display systems, a videotape viewing station, and printed information on various subjects pertaining to the DOE's overall high-level waste management program and the Yucca Mountain Project.

A draft copy of the Environmental Field Activity Plan (EFAP) for air quality was completed and transmitted to the State of Nevada. An EFAP for water resources was created to ensure maintenance of the integrity of water resources at and proximal to the Yucca Mountain site. To contribute to a habitat reclamation study, an EFAP for soils was started. Studies were conducted to assess potential impacts of site characterization activities on biological resources, leading to production of an EFAP for terrestrial ecosystems. The EFAP was transmitted to the State of Nevada. A Reclamation Feasibility Plan was also produced. This effort will help determine action necessary to reclaim the site after site characterization.

The EFAPs for cultural resources, consisting of an archaeological component and a native American component, were produced and transmitted to the State of Nevada. Studies were begun to assess potential impacts of site characterization on archaeological resources and native American beliefs and concerns. The Socioeconomic Monitoring and Mitigation Plan for Site Characterization (DOE/RW-0179), Revision 1, was completed. Other studies of native American aspects of the Yucca Mountain area were also completed.

An EFAP for radiological studies was produced and transmitted to the State of Nevada. This expanded field monitoring program allows Project participants to collect background radiological data for use in assessing the environmental impacts of site characterization and future repository development through potential radiological dose assessment analyses.

The Project Office submitted an application for a Right-of-Way Reservation (ROWR) and a Plan of Development to the Bureau of Land Management to secure access to public and Air Force land for site characterization activities. As a result, ROWR N-47748 was granted for the use of public lands.

The Final Nevada Nuclear Waste Storage Investigations (renamed the Yucca Mountain Project) Project Plan, Revision 1, was completed. All scheduled audits of Project participant quality assurance programs were completed; audit reports were issued to initiate appropriate corrective action. The NRC and the State of Nevada participated as observers in each of the audits.

The Records Management Plan was issued. The Records Center was reorganized to meet Project Records Management requirements, establishing a Local Records Center and a Project Central Records Facility. More than 20,000 Project records were indexed in the Automated Records System and standardized to conform to guidance from OCRWM.

Data collection for the Yucca Mountain Project Atlas was completed, and the Atlas of Field Activities was published. Copies of computer tapes containing Yucca Mountain and vicinity data from the seismologic database were transmitted to the State of Nevada.

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New surface-based drilling and coring technology was developed which will allow site characterization holes to be drilled and cored with dry air as the circulation medium. A prototype dry air drilling and coring test program was initiated to develop equipment, methods, and procedures for use at Yucca Mountain. Prototype work conducted at locations outside of the Yucca Mountain Site contributed to equipment development and essential personnel training in the methods and procedures that may be used for the drilling and coring program planned for the project.

A map of the lateral variations in lithology of the Tuffaceous Beds of Calico Hills was digitized. A mockup of the Bouguer gravity map of the Nevada Test Site (NTS) was completed. New regional and site base maps centered on Yucca Mountain were prepared at $1{:}10^6$ and $1{:}10^5$, respectively. New gravity and magnetic data plots at both scales were made as overlays on the new base maps. Fault and seismicity maps of the Pahute Mesa and Beatty $30 \times 60'$ quadrangles were compiled on the basis of data collected prior to March 1986.

Logs from 40 existing boreholes were organized in a database on a VAX-780 and are accessible with commercial logging software. A database was established of interpreted geoelectric soundings (depth-resistivity) in the vicinity of drill-hole resistivity logs on Yucca Mountain. Existing fault and seismicity map data were compiled for the NTS. The synthesis, reduction, and review of historic leveling data for the Southern Great Basin continued.

Significant progress was made in the organization and establishment of the sample testing program for core samples to be collected from deep and shallow boreholes and from infiltration plots during site characterization. A major effort has been concerned with the development of sample handling techniques necessary to ensure that measured hydrologic properties reflect in situ conditions of the core prior to drilling.

A program to calculate seismic travel time between an arbitrarily located source and any point in an extended, variable-velocity medium was completed for the Vertical Seismic Profiling activity. A program to plot the particle trajectory (hodogram) during the passage of a seismic wave also was completed. The components of recorded motion appear as a graphic plot, for visual polarization analysis.

Progress was made on the laboratory design of an electronic controller for the seismic recorders "SGR-III." Analysis and interpretation of seismic data continued. In an effort to better understand the deep seismic data previously collected, deep seismic data from central Nevada and Arizona have been examined. An attempt is being made to better understand the process of crustal extension in the Basin and Range, particularly as it applies to the Yucca Mountain site. Evidence is available to show that bright seismic reflections seen in the lower crust may be related to magmatic additions (intrusions) to the crust.

Work began on interpreting the seismic stratigraphy along reflection line AV-1 and integrating this interpretation with other geological and geophysical information along the seismic line.

Work continued on small-scale prototype testing in the Fran Ridge test pits, and detail line survey testing in the Fran Ridge test pits was started. Prototype equipment was developed and refined. The photo template holder was completed and tested, and prototype testing was done in the shaft test fixture. The geologic mapping computer program was further developed.

Approximately 18 months of 15-minute water-level data were obtained from Devil's Hole. The data show good correlation to earth tides. The geology in the vicinity was examined in preparation for a frequency analysis of the data. The water-level record at Devil's Hole was analyzed to see how the earth tide response is modified by faults. Historical data indicate that the water level responds frequently to seismic events. In 1982 alone, 14 underground nuclear explosions, 13 local-regional earthquakes, and 13 global earthquakes appear to be recorded in the water-level data. Analysis of water-level data from Devil's Hole based on the theoretical stress–strain relations for various fault orientations continues.

More than 75 well-test solutions were coded, tested, and validated; these were incorporated into a computer program that allows the user to select solutions based on the particular well or wells and flow-field boundary conditions. The well-test-analysis program will enable interactive well-test analysis from a wide choice of well-test solutions.

Deployment of the precipitation-monitoring network at Yucca Mountain to support the unsaturated zone infiltration, surface water, and regional meteorology studies was begun. In addition to the precipitation monitoring activities, other meteorological data were collected from five weather stations.

Monitoring of natural infiltration continues by neutron-moisture logging on and around Yucca Mountain. As part of this study, an analysis of infiltration in Pagany Wash was conducted. Infiltration data from a summer storm in 1984 was analyzed for the eight boreholes in Pagany Wash.

Significant storm activity occurred during the week of August 7–11, 1989. Tributaries to Topopah Wash from the southern part of the Calico Hills flowed on August 10 or 11; runoff from associated drainages was documented. Land-surface evidence of runoff in Crater Flat was photographed from an airliner on August 31. Evidence of some minor runoff and sediment transport was found at Wren Wash. All observed runoff on the east-facing slopes of Yucca Mountain was the product of sheet runoff, runoff from man-disturbed sites, or both. Runoff also occurred west and northwest of Yucca Mountain during the week of August 7–11, 1989.

Neutron logging was begun to determine the impacts on natural infiltration of the rainstorm. Preliminary indications are that all of the water was evaporated back into the atmosphere and did not have any influence at depth. One notable exception is the 5 feet of water that entered into UE-25 N2. It is most likely that fracture flow is responsible for this large volume of water.

All modern ostracode groundwater discharge samples from the Denver modern ostracode sample comparative collection were separated; locality by latitude and longitude was established and information was entered into a spreadsheet. Ostracode species and other physical and chemical parameters are being entered into this database.

All chrysophyte cyst and scale data available from USGS collections was organized into a single database to serve as a comparative base for both prototype testing collections and eventually detailed collections in southern Nevada.

Chloride leaching experiments were conducted on tuff samples from the central Nevada analog recharge sites to test the hypothesis that tuffs do not contribute a significant amount of chlorine to the chloride budget at the analog sites.

Processing of soil samples from the analog recharge sites for grain-size distribution analysis was completed and data reduction was begun. Spring and pond samples were collected for ostracode evaluation, and data and bibliographic references on modern surface water environments were compiled.

Strontium isotope analyses were completed on the prototype spring samples from Colorado. Results were encouraging as they support the hypothesis that the isotopic compositions in waters will reflect the geologic units through which the waters have flowed.

An operator variance test for modal point counts of the Topopah Spring Member of the Paintbrush Tuff was conducted and the results were published. Preliminary work began to identify trace minerals that could be important in retarding the movement of radionuclides (particularly actinides) in groundwater. Constituents of the high-density ($\rho > 2.77$) fraction included biotite, hematite, allanite, and an isometric oxide (possibly maghemite).

The fracture-coating minerals in the Topopah Spring Member and upper tuff of the Tuffaceous Beds of Calico Hills from drill hole J-13 were studied. Manganese-oxide minerals from fractures in the Crater Flat tuff in USW G-4 were examined using optical, scanning electron microscopic, electron microprobe, and X-ray powder diffraction methods to determine their distribution, mineralogy, and chemistry. Work continued on fractures in the Topopah Spring Member from drill holes USW G-1, G-2, and GU-3.

Authigenic mineral deposits and breccias along the Bow Ridge and other faults in the vicinity of Yucca Mountain were studied. Samples from Trench 14 have been analyzed by scanning electron microscope image analysis and by electron microprobe to determine the major modes of calcium, silicon, and magnesium elemental distributions resulting from authigenic mineral growth in the hydrogenic deposits. These three elements are most important because they are the major constituents in the only authigenic minerals (calcite, opal, and sepiolite) identified in abundance within Trench 14.

Potassium-argon age determinations were completed for 11 sample sites in the Yucca Mountain region including the 1.2 Ma volcanic centers of Crater Flat and the 3.7 Ma centers of southeast Crater Flat and Buckboard Mesa. The data were evaluated.

Rock-varnish studies have continued. The studies involved rock-varnish dating of geomorphic surfaces on and around Yucca Mountain (including alluvial fans, fluvial terraces, hillslope deposits, lava flows, and pediments) to determine the time of surface stabilization (since stable surfaces formed on lava flows) and to constrain the timing of geologic events that have formed, deformed, or modified these surfaces. Rock varnish studies supported not only the geochronology of volcanism studies but also the tectonic/neotectonic, erosion, paleoclimate, and paleoenvironment studies.

Batch sorption experiments were begun with neptunium, americium, and technetium on pure minerals. The minerals used included synthetic and natural calcite, hematite, goethite, cryptomelane, romanechite, montmorillonite, and clinoptilolite. The initial experiments showed strong absorption of neptunium onto the iron- and iron-manganese oxides and oxyhydroxides.

Sorption of nickel and neptunium in tuff was studied using groundwaters from Wells J-13, UE-25p#1, and USW H-3. The H-3 and UE-25p#1 waters represented extremes in water composition found at Yucca Mountain, each showing higher cation concentrations than does J-13 water. Sorption was least in the UE-25p#1 water, except for a devitrified sample; this finding is consistent with previously reported results for strontium, cesium, and barium. The sorption for nickel on the zeolitized samples was much less than that exhibited by strontium and barium. Sorption data were related to a 3-dimensional statistically produced mineralogic model of Yucca Mountain.

Experiments were completed to determine the solubility concentration limits for Np, Pu, and Nd^{3+}/Am at 25 degrees Celsius in UE 25p#1 groundwater. Solution species of NpO_2^+ and NpO_2CO_3 at pH 7 and all NpO_2CO_3 at pH 8.5 were identified.

The ability of Yucca Mountain tuff to act as a natural filter for particulate matter continued to be studied using Calico Hills and Topopah Spring solid rock columns. Two columns of the Calico Hills tuff USW G4-1502 and two columns of Topopah Spring tuff USW GU3-1119 were used. The elution of 0.09-micrometer fluorescent colloids through the columns continued, and the amount of colloid eluting was analyzed using quantitative fluorometric analysis. A calibration curve using standards with known concentrations of the 0.09-micrometer colloid was obtained.

Code development work was completed on FEHMN (Finite Element Heat–Mass) and FEHMSN (Finite Element Heat–Mass–Stress). For FEHMN, unsaturated zone flow and heat transfer capabilities were added and verified, a multiple tracer capability and a reactive tracer capability were added, a zoning capability that allows for irregularly shaped zones within the grid was added, and an adaptive solution strategy for multiple degree of freedom problems was developed. For FEHMSN, the fully coupled 2-dimensional stress and mass transport module were implemented and compared with analytic solutions of hydraulic fracturing.

A set of preliminary 3-dimensional forward calculations of the transport of technetium and cesium from the repository to below the water table was completed. The calculations were run with TRACRN using a grid with 30,870 zones. Transport was studied at three recharge rates—0.1 mm/yr, 0.5 mm/yr, and 4.5 mm/yr. The effects of dispersivity length scale on the calculated results was also studied. A nonvertical gravity vector option was added to TRACRN. This option simplifies the grid setup for systems with tilted beds or nonvertical boreholes.

Preliminary laboratory imbibition and evaporation studies were conducted on G-Tunnel welded and nonwelded tuff to aid in interpretation of water content and potential data collected from experiments. Laboratory tests were performed on core samples from the experiments. These tests were bulk density, porosity, and gravimetric water-content and volumetric water-content calculations. This information will be used in the calibration of the neutron logging probe for determining water content in the boreholes. Sampling began on axial fractures in welded tuff in the experimental drift. Phase 1 G-Tunnel testing was completed.

Several gas injection simulations were run using the TOUGH computer code. Simulations indicate that water is driven away from injection boreholes with increased gas pressure. Very little water is transported in the vapor phase. Most of the water movement occurs in the liquid phase. The amount of "drying" around the borehole due to gas injection varies depending upon the initial water saturation of the surrounding formation.

Work continued on the borehole grout question. The borehole grout in the prototype test borehole must be chemically and physically benign to the ambient conditions of the unsaturated zone. Three grouts are being considered: gypsum cement, portland cement, and a two-part epoxy.

Borehole PW-4 was drilled in the G-Tunnel Underground Facility. This borehole, in the welded, fractured, Grouse Canyon Member tuff, will be used in the prototype perched water test. Studies have shown that careful borehole TV camera surveys are superior to core analyses for identification of natural fractures.

Analyses of jointed-rock response in the vicinity of flatjacks placed in thin slots cut in the walls or floors of drifts continued. Two-dimensional finite element analyses were run of both plan and elevation views of a flatjack being pressurized in a vertical slot located in the wall of the drift with an imposed horizontal in situ stress. Solutions using an elastic rock-mass model and compliant-joint model were obtained.

A high-pressure flatjack test achieving 4,500 psi, the highest pressure achieved to date, was completed. A one-meter-deep slot was cut in the rib of the Demonstration Drift in densely welded tuff. This is the first successful slot cut in the densely welded tuff using a hydraulic control system. Work continued on the redesign of the one-meter and two-meter hydraulic chain saws. Redesign is required to increase the performance and reliability of the equipment for both present and future work.

Preliminary designs for flatjack, instrumentation anchors, and reaction frames were initiated for an in situ compression test as part of the Rock Mass Response Experiment. The G-Tunnel Data Acquisition System (DAS) was nearly completed. The DAS software was complete enough to allow data acquisition. Instrumentation spacing, orientation, and depths were selected for the prototype thermal stress experiment based on calculations from finite-element codes. An insulation support structure was designed. The rationale and layout for the thermal stress test were considered. It was concluded that there is value in performing such a thermal overdrive experiment above the roof of a drift, despite the considerable logistic difficulties.

The first Prototype Engineered Barrier System Field Test was conducted in a horizontal emplacement configuration in G-Tunnel. The measurements made included rock temperatures, changes in rock moisture content, air permeability of fractures intersecting the heater borehole, gas pressures, and rock-mass gas-phase humidity.

The test confirmed elements of the conceptual model of predicted environmental conditions. A dry zone develops around the heater borehole, and the degree of drying increases with proximity to the heater. A "halo" of increased saturation develops adjacent to the dry region and migrates away from the heater as rock temperatures increase. Some of the fractures intercepting the heater borehole accelerate the local penetration of hot-dry conditions into the rock mass. A buildup of pore gas pressure develops in rock regions where vigorous evaporation is occurring.

During the portions of the test when the heater power was gradually reduced (and eventually turned off), the dry region around the heater cooled off and slowly regained water. The rewetting rate is much slower than the initial drying rate. Measurements of air permeability made along the heater borehole before heating show that the fracture system exhibits a strong heterogeneity in fracture permeability. Measurements made after the heater was turned off show that there was a slight increase in air permeability for the rock adjacent to the heater.

Requirements for additional mining in G-Tunnel were clarified. Decisions were made on locations and geometries of new drifts. In particular, a location off the EV-6 incline above the laser drift was identified for the drift to house the thermal stress experiment. The strata in this location afforded the possibilities of a 20-foot-thick, structurally undisturbed block of welded tuff.

A study on emplacement orientation of the waste package concluded that a vertical emplacement orientation was preferred by a narrow margin over horizontal orientations. The drawing depicting the interfaces between the Exploratory Shaft Facility (ESF) and repository openings on the ESF main test level was completed. A design of the repository that will allow total construction by the use of mechanical mining was completed.

Alternative repository life-cycle cost estimates were prepared for all nine Monitored Retrievable Storage (MRS) systems cases. The alternative estimates were based on average container costs, derived by averaging the estimated costs for the metal barrier waste containers after excluding the costs associated with the stainless-steel waste containers. The repository receiving operations were modeled using the REPository SIMulation (REPSIM) code.

Two computer codes for underground radiologic conditions were completed, validated, and verified. The first code provides estimates of the radiologic conditions near the transporter cask. The second code estimates the dose rates near the borehole shield plug.

Computer products supporting activities such as site characterization, mapping and modeling, and underground facility layout and design were created. Several programs were written to enhance the ability of the Interactive Graphics Information System (IGIS) to utilize irregular terrain data. An effort was begun to model unsaturated flow as a free-moving boundary problem. A code was installed to correlate parameters in multivariate stochastic simulations. The sensitivity of groundwater travel time to assumptions about correlation structure was tested.

The time required for water in a simulated fracture to flow into surrounding unsaturated matrix material was investigated. Concepts for investigating water movement in fractures using the gamma beam attenuation technique were analyzed. Calculations were made concerning groundwater travel times for water or for nonreactive dissolved mass. A study of the validity of the radioactive decay model in the Total System Performance Assessment Code (TOSPAC) was also completed.

The elements of a model of volcanic events at the Yucca Mountain site were compiled. Some elements included in the model are (1) a detailed repository plan including orientation of repository, and the placement, orientation, size, and contents of the waste containers; (2) orientations of possible magmatic dikes; (3) existence and orientation of possible magma chambers; and (4) the time distribution of past volcanic events in the region surrounding Yucca Mountain.

The ESF Basis for Design document was developed from several iterations of the Systems Design Requirements Document and the Reference Information Base. Performance specifications were developed to support the procurement of two new hoists for use at the ESF.

A Preliminary Safety Analysis Report (PSAR) was completed for subsurface facilities for the ESF Title I Design. The PSAR analyzed the industrial safety of the ESF to show that adequate measures are included in the design to provide for protection of the health and safety of the public and the ESF work force.

Pretest analyses of the thermomechanical, hydrologic, and waste package environment tests planned for the ESF were reviewed. The zone of influence of each experiment (estimated from analysis results and other test plan documentation), along with other design considerations, was compared with the proposed design layout of the main test level of the ESF to ensure that the experiments do not significantly interfere with each other.

Drawings were prepared defining the physical interfaces between the repository and the ESF and identifying potential ESF locations for installing postclosure repository sealing features. Load-versus-time relationships were generated for the loads generated by the waste heating of the host rock at the ESF shaft and underground locations. Design basis seismic loads for the ESF shafts and underground openings were quantified, and criteria and design methodology were developed for ESF shaft design.

Reports were drafted on the verification system investigation; the preclosure radiological safety analysis for the ESF; the potential dropping of casks, containers, and fuel assemblies during waste-handling operations; material specifications; cask decontamination and maintenance; and storage vault passive ventilation. Other studies covered the physical characteristics of waste-handling equipment and the waste-handling building subsystem design.

The Waste Package Design Requirements document and the Mined Geologic Disposal System Requirements document were completed. Parametric studies continued on the effects of general corrosion and stress corrosion cracking on the six candidate materials, in both the presence and absence of a gamma radiation environment.

Spent fuel waste form tasks included model development and testing for dissolution rates, cladding degradation, and oxidation processes. The Series 3 spent fuel dissolution tests in J-13 well water at 85 degrees Celsius and 25 degrees Celsius were completed. Preliminary model development and testing to describe Zircaloy cladding degradation were begun. A preliminary model was completed to simulate the orientation of precipitated hydride platelets with respect to the nominal stress state in Zircaloy cladding. Experimental techniques were developed that measure the gaseous release of carbon-14 and tritium from Zircaloy cladding. With regard to other corrosion mechanisms, initial experiments have been completed that use a new technique to measure the rate of fluoride corrosion on Zircaloy cladding. The preliminary data show that fluoride-Zircaloy corrosion rates increase with increasing fluoride concentration, increasing temperature, and decreasing pH. Finally, the low-temperature oxidation testing of spent fuel continued.

Unsaturated leach testing continued on glasses from the West Valley Demonstration Project and Defense Waste Processing Facility. The preliminary testing of static leaching of vapor-phase aged glasses indicated that the contact of such glasses with liquid water can result in the enhanced release of radionuclides from the glass as colloids. The rate of glass dissolution is modeled using transition-state theory with experimentally determined rate constants. Results to date indicate that the rate constant is dependent upon pH, being lowest for neutral pH at a given temperature.

Experiments continued on the near-field migration of radionuclides by placing small tuff samples in uranium-doped solutions. Secondary ion-mass spectrometry analysis of the samples shows that a boundary layer of enhanced uranium (a few microns) concentrates on the tuff surface. The uranium concentration measurements also indicate that local permeability (porosity) variations lead to fast aqueous transport of uranium into tuff waters.

Studies were continued to determine how a steady-state tuff-water system responds to perturbations in fluid composition. Single-phase dissolution and precipitation kinetics experiments were expanded to include studies of kaolinite at 80 degrees Celsius and low pH, and dissolution and precipitation of gibbsite at low pH and 80 degrees Celsius. Studies were continued on the dissolution and precipitation kinetics of cristobalite at 200 degrees Celsius.

Enhancements were incorporated into the TOUGH code to improve the code's performance. Models were developed for both large and small diameter heaters in a vertical emplacement orientation and were used to simulate a time duration of two years after emplacement. A test version of an EQ3/6 geochemical modeling code verification program was completed. Improvements and corrections were made to DØOUT, the source code that generates the DATAØ data file from the thermodynamic database. Work was begun to develop a dictionary of DATAØ species with cross referencing between DATAØ versions.

The statutory Site Characterization Plan was issued in December 1988. The Systems Requirements document, the Technical Data Management Plan, the ESF Subsystem Design Requirements document, and the Repository Design Requirements document were developed. Also developed were the Surface-Based Investigation Plan and Integrated Performance Assessment Plan. The Configuration Management Plan was completed, and the Systems Engineering Management Plan was revised.

The Configuration Information System, the Project Information System, and the Project Telecommunications Plan were developed. Additional plans developed and implemented included the Project Management Plan; the Field Operation Management Plan; the Advanced Acquisition and Assistance Plan; and Volume II, Repository Siting and Design, Nuclear Waste Management Technology Series.

The Project Environmental Compliance and Monitoring Program was defined. Data collection was initiated for the air quality, meteorological, terrestrial, archaeological, and radiological studies. A land withdrawal application was filed with the Bureau of Land Management. Revision 2 of the Project Quality Assurance Plan was prepared and accepted by the Nuclear Regulatory Commission (NRC). The Project Records Management System was developed, and the ten Yucca Mountain Project participants were integrated into the records management system.

Yucca Mountain Project

U.S. DEPARTMENT OF ENERGY, YUCCA MOUNTAIN PROJECT OFFICE

1 (CONF-880601–30) **Assessment of seismic hazards at Yucca Mountain.** King, J.L.; Frazier, G.A.; Grant, T.A. Science Applications International Corp., Las Vegas, NV (USA). 1988. 5p. DOE Contract AC08-87NV10576. From American Nuclear Society annual meeting; San Diego, CA, US; June 12, 1988. Order Number DE88009010. Source: NTIS, PC A02/MF A01; GPO Dep.

During the preclosure time period (approximately 100 yr), the prospective geologic repository at Yucca Mountain must provide for public and worker radiological safety and retrievability of emplaced waste. During the postclosure period (10,000 yr), the repository must ensure that cumulative radionulclide releases to the accessible environment comply with EPA release limits. Substantially complete containment must be provided by the waste packages for 300-1000 yr. All of these functions must be maintained should a severe seismic event occur and must be achieved with reasonably available technology. The seismic phenomena of interest for the preclosure period are vibratory ground motion from a nearby earthquake or underground nuclear explosion (UNE), faulting beneath surface facilities that are important to safety, and faulting in underground areas of emplaced waste. For the postclosure period, earthquake ground motion, underground faulting, and seismically induced adverse changes in hydrologic conditions have been identified as the most important seismic phenomena to be characterized. The NNWSI Project Site Charcterization Plan describes a number of seismic parameters that are needed for repository design or performance assessment, along with tentative goals for each parameter. Key parameters, goals and current assessments, all subject to change as site characterization progresses, are summarized in this report. 4 refs.

2 (CONF-890207–33) **An assessment of issues related to determination of time periods required for isolation of high level waste.** Cohen, J.J. (Science Applications International Corp., Las Vegas, NV (USA)); Daer, G.R.; Smith, C.F.; Vogt, D.K.; Woolfolk, S.W. Science Applications International Corp., Las Vegas, NV (USA). 1989. 18p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC08-87NV10576. From Waste management '89; Tucson, Arizona, USA; 26 Feb - 2 mar 1989. Order Number DE89013090. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

A commonly held perception is that disposal of spent nuclear fuel or high-level waste presents a risk of unprecedented duration. The EPA requires that projected releases of radioactivity be limited for 10,000 years after disposal with the intent that risks from the disposal repository be no greater than those from the uranium ore deposit from which the nuclear fuel was originally extracted. This study reviews issues involved in assessing compliance with the requirement. The determination of compliance is assumption dependent primarily due to uncertainties in dosimetric data, and relative availability of the radioactivity for environmental transport and eventual assimilation by humans. A conclusion of this study is that, in time, a spent fuel disposal repository such as the projected Yucca Mountain Project Facility will become less hazardous than the original ore deposit. Only the time it takes to do so is in question. Depending upon the assumptions selected, this time period could range from a few centuries to hundreds of thousands of years considering only the inherent radiotoxicities. However, if it can be assumed that the spent fuel radioactivity emplaced in a waste repository is less than 1/10 as available for human assimilation than that in a uranium ore deposit, then even under the most pessimistic set of assumptions, the EPA criteria can be considered to be complied with. 24 refs., 5 figs., 2 tabs.

3 (CONF-891101–1) **Geology and hydrogeology of the proposed nuclear waste repository at Yucca Mountain, Nevada and the surrounding area.** Mattson, S.R. (Science Applications International Corp., Las Vegas, NV (USA)); Broxton, D.E.; Crowe, B.M.; Buono, A.; Orkild, P.P. Science Applications International Corp., Las Vegas, NV (USA). [1989]. 66p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC08-87NV10576. From Geological Society of America annual meeting; St. Louis, MO (USA); 6-9 Nov 1989. Order Number DE89014542. Source: NTIS, PC A04/MF A01; OSTI; INIS; GPO Dep.

In late 1987 Congress issued an amendment to the Nuclear Waste Policy Act of 1982 which directed the characterization of Yucca Mountain, Nevada as the only remaining potential site for the Nation's first underground high-level radioactive waste repository. The evaluation of a potential underground repository is guided and regulated by policy established by the Department of Energy (DOE), Nuclear Regulatory Commission (NRC), Environmental Protection Agency (EPA), Department of Transportation (DOT), and the US Congress. The Yucca Mountain Project is the responsibility of the DOE. The purpose of this field trip is to introduce the present state of geologic and hydrologic knowledge concerning this site. This report describes the field trip. 108 refs., 6 figs., 1 tab.

4 (DOE/NV/10270–14) **Preliminary site characterization radiological monitoring plan for the Nevada Nuclear Waste Storage Investigations Project, Yucca Mountain Site.** Science Applications International Corp., Las Vegas, NV (USA). Mar 1987. 81p. DOE Contract AC08-83NV10270. (SAIC–86/8007). Order Number DE88004208. Source: NTIS, PC A05/MF A01; GPO Dep.

The activities described in this plan occur in the early phases of site characterization. This document presents the Preliminary Site Characterization Radiological Monitoring Plan (PSCRMP) for collecting and evaluating data in support of the NNWSI Project. The PSCRMP defines and identifies control procedures for the monitoring activities. The PSCRMP activity will utilize integrating radon monitoring devices, a continuous radon monitor, and a particulate air sampler. These instruments will be used to establish the baseline radioactivity and/or radioactivity released due to early site characterization activities. The sections that follow provide a general project description, the specifics of the monitoring program, and the practices that will be employed to ensure the validity of the collected data by integrating quality assurance into all activities. Section 2 of this document describes the regulatory base of this document. Section 3 describes the site characterization activities which may lead to release of radioactivity. Section 4 provides a description of the potential sources of radioactivity that site characterization could generate. Section 5 summarizes the sampling and monitoring methodology, which will be used to monitor the potential sources of radioactivity. The network of sampling and monitoring equipment is described in Section 6, and Section 7 summarizes the systems operation activities. The data reporting activities are described in Section 8. Finally, a description of the Quality Assurance (QA) and Quality Control (QC) activities is provided in Section 9. Appendix A contains a summary of the procedures to be used in this program, and Appendix B contains technical specification on equipment and services. 20 refs., 11 figs., 2 tabs.

5 (DOE/NV/10322–19) **NNWSI [Nevada Nuclear Waste Storage Investigations] hole histories: USW G-1, USW G-2, USW G-3, USW G-4, USW GA-1, USW GU-3.** Fenix and Scisson, Inc., Mercury, NV (USA). Jun 1987. 187p. DOE Contract AC08-84NV10322. Order Number DE88004026. Source: NTIS, PC EE17/MF $33.95; GPO Dep.

Includes 75 sheets of 24x reduction microfiche.

This report is a compilation of data from six exploratory boreholes drilled to characterize the geologic, geophysical and hydrologic data for the Yucca Mountain block. The six boreholes were drilled adjacent to the Nevada Test Site (NTS). Information presented in this report include locations, daily activities, core records, mud records, reviews of hole condition, geophysical log listings, video tape listings, and microfiche copies of all geophysical logs run by the Fenix and Scisson, (F and S) subcontractors.

6 (DOE/NV/10322–25) **NNWSI [Nevada Nuclear Waste Storage Investigations] 51 seismic hole histories.** Fenix and Scisson, Inc., Tulsa, OK (USA). Sep 1987. 214p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC08-84NV10322. Order Number DE89013205. Source: NTIS, PC A10/MF A01 - OSTI; GPO Dep.

This report is a compilation of data from fifty-one shallow boreholes drilled within the Nevada Test Site (NTS) and the adjacent Bureau of Land Management (BLM) lands. The boreholes were drilled to determine the alluvial thickness and subsurface structure. Once drilled the boreholes were used to emplace explosive charges of three seismic refraction surveys conducted in 1981, 1983 and 1984. The information presented in this report includes location maps, daily activities and reviews of hole condition.

7 (DOE/NV/10322–35) **Impact analysis on ESF design for Calico Hills penetration and exploratory drift and tuff main extension to limits of the repository block.** Grenia, J.; Weyand, L. Fenix and Scisson, Inc., Las Vegas, NV (USA). 15 Nov 1988. 101p. DOE Contract AC08-84NV10322. Order Number DE89006930. Source: NTIS, PC A06/MF A01 - OSTI; GPO Dep.

The study covers the impacts on project costs, schedule, human resources and engineering designs caused by increases in site characterization activity consisting of penetration of the Calico Hills formation by ES-1 shaft with exploratory drifting to the Ghost Dance fault and/or drifting 10,000 feet southward from the MTL ESF test complex area to the end of the future repository block.

8 (DOE/NV/10576–17) **Native American interpretation of cultural resources in the area of Yucca Mountain, Nevada.** Stoffle, R.W.; Evans, M.J.; Harshbarger, C.L. Science Applications International Corp., Las Vegas, NV (USA); Michigan Univ., Ann Arbor, MI (USA). Inst. for Social Research. Mar 1989. 137p. DOE Contract AC08-87NV10576. (SAIC–88/8011). Order Number DE89009778. Source: NTIS, PC A07/MF A01 - OSTI; GPO Dep.

This report presents the location and interpretation of Native American cultural resources on or near Yucca Mountain, Nevada. This work builds on the archaeological reconnaissance and identifications of cultural resources by the Desert Research Institute (for a summary, see Pippin and Zerga, 1983; Pippin, 1984). Interpretations provided by Native American Indian people are not intended to refute other scientific studies, such as botanical, wildlife, and archaeological studies. Rather, they provide additional hypotheses for future studies, and they provide a more complete cultural understanding of the Yucca Mountain area. Representatives of sixteen American Indian tribes identified the cultural value of these resources as part of a consultation relationship with the US Department of Energy (DOE). This interim report is to be used to review research procedures and findings regarding initial consultation with the sixteen tribes, in-depth interviews with tribal elders, and findings from the first on-site visit with representatives of the sixteen tribes. As additional information is collected, it will be reviewed separately. An annual report will integrate all findings. 44 refs., 58 figs., 2 tabs.

9 (DOE/NV/10576–T1-Vol.1) **Yucca Mountain Project Site Atlas: Volume 1.** Science Applications International Corp., Las Vegas, NV (USA). Oct 1988. 556p. DOE Contract AC08-87NV10576. Order Number DE89003704. Source: NTIS, PC A24/MF A01 - OSTI; GPO Dep.

The Nevada Nuclear Waste Storage Investigations (NNWSI) Project Site Atlas is a reference document of field activities which have been, or are being, conducted by the US Department of Energy (DOE) to support investigations of Yucca Mountain as a potential site for an underground repository for high-level radioactive waste. These investigations, as well as future investigations, will yield geologic, geophysical, geochemical, geomechanical, hydrologic, volcanic, seismic, and environmental data necessary to characterize Yucca Mountain and its regional setting. This chapter summarizes the background of the NNWSI Project and the objective, scope, structure, and preparation of the Site Atlas. Chapter 2 describes in more detail the bibliography and map portfolio portions of the Atlas, which are presented in Chapter 4 and Volume 2, respectively. Chapter 3 describes how to use the Atlas. The objective of the Site Atlas is to create a management tool for the DOE Waste Management Project Office (WMPO) that will allow the WMPO to compile and disseminate information regarding the location of NNWSI Project field investigations, and document the permits acquired and the environmental, archaeological, and socioeconomic surveys conducted to support those investigations. The information contained in the Atlas will serve as a historical reference of site investigation field activities. A companion document to the Atlas is the NNWSI Project Surface Based Investigations Plan (SBIP).

10 (DOE/NV/10576–T1-Vol.2) **Nevada Nuclear Waste Storage Investigations atlas of field activities,**

Yucca Mountain, Nye County, Nevada: Volume II. Holmes and Narver, Inc., Las Vegas, NV (USA). Energy Support Div. [1988]. 74p. DOE Contract AC08-87NV10576. Order Number DE89003705. Source: NTIS, PC A04/MF A01 - OSTI; GPO Dep.

This document contains only engineering drawings that support text material in Volume I. (TEM)

11 (DOE/NV/10576–T2-Vol.1) **Surface-based investigations plan, Volume 1: Yucca Mountain Project.** USDOE Nevada Operations Office, Las Vegas, NV (USA). Yucca Mountain Project Office; Science Applications International Corp., Las Vegas, NV (USA). Dec 1988. 188p. DOE Contract AC08-87NV10576. (YMP–88-25-Vol.1). Order Number DE89009613. Source: NTIS, PC A09/MF A01 - OSTI; GPO Dep.

This document represents a detailed summary of design plans for surface-based investigations to be conducted for site characterization of the Yucca Mountain site. These plans are current as of December 1988. The description of surface-based site characterization activities contained in this document is intended to give all interested parties an understanding of the current plans for site characterization of Yucca Mountain.

12 (DOE/NV/10576–T2-Vol.2) **Surfaced-based investigations plan, Volume 2: Yucca Mountain Project.** USDOE Nevada Operations Office, Las Vegas, NV (USA). Yucca Mountain Project Office; Science Applications International Corp., Las Vegas, NV (USA). Dec 1988. 465p. DOE Contract AC08-87NV10576. (YMP–88-25-Vol.2). Order Number DE89009612. Source: NTIS, PC A20/MF A01 - OSTI; GPO Dep.

This document represents a detailed summary of design plans for surface-based investigations to be conducted for site characterization of the Yucca Mountain site. These plans are current as of December 1988. The description of surface-based site characterization activities contained in this document is intended to give all interested parties an understanding of the current plans for site characterization of Yucca Mountain. Volume 2 contains only additional data forms.

13 (DOE/NV/10576–T2-Vol.3) **Surfaced-based investigations plan, Volume 3: Yucca Mountain Project.** USDOE Nevada Operations Office, Las Vegas, NV (USA). Yucca Mountain Project Office; Science Applications International Corp., Las Vegas, NV (USA). Dec 1988. 172p. DOE Contract AC08-87NV10576. (YMP–88-25-Vol.3). Order Number DE89009614. Source: NTIS, PC A08/MF A01 - OSTI; GPO Dep.

This document represents a detailed summary of design plans for surface-based investigations to be conducted for site characterization of the Yucca Mountain site. These plans are current as of December 1988. The description of surface-based site characterization activities contained in this document is intended to give all interested parties an understanding of the current plans for site characterization of Yucca Mountain. Volume 3 contains only additional data sheets.

14 (DOE/NV/10576–T2-Vol.4) **Surfaced-based investigations plan, Volume 4: Yucca Mountain Project.** USDOE Nevada Operations Office, Las Vegas, NV (USA). Yucca Mountain Project Office; Science Applications International Corp., Las Vegas, NV (USA). Dec 1988. 47p. DOE Contract AC08-87NV10576. (YMP–88-25-Vol.4). Order Number DE89009615. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

This document represents a detailed summary of design plans for surface-based investigations to be conducted for site characterization of the Yucca Mountain site. These plans are current as of December 1988. The description of surface-based site characterization activities contained in this document is intended to give all interested parties an understanding of the current plans for site characterization of Yucca Mountain. The maps presented in Volume 4 are products of the Geographic Information System (GIS) being used by the Yucca Mountain Project. The ARC/INFO GIS software, developed by Environmental Systems Research Institute, was used to digitize and process these SBIP maps. The maps were prepared using existing US Geological Survey (USGS) maps as a planimetric base. Roads and other surface features were interpreted from a variety of sources and entered into the GIS. Sources include the USGS maps, 1976 USGS orthophotoquads and aerial photography, 1986 and 1987 aerial photography, surveyed coordinates of field sites, and a combination of various maps, figures, descriptions and approximate coordinates of proposed locations for future activities.

15 (DOE/NV/10576–T3) **Assessment of faulting and seismic hazards at Yucca Mountain.** King, J.L. (Science Applications International Corp., Las Vegas, NV (USA)); Frazier, G.A.; Grant, T.A. Science Applications International Corp., Las Vegas, NV (USA). 2 Jun 1989. 26p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC08-87NV10576. Order Number DE89016000. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Yucca Mountain is being evaluated for the nation's first high-level nuclear-waste repository. Local faults appear to be capable of moderate earthquakes at recurrence intervals of tens of thousands of years. The major issues identified for the preclosure phase ($<$100 yrs) are the location and seismic design of surface facilities for handling incoming waste. It is planned to address surface fault rupture by locating facilities where no discernible recent ($<$100,000 yrs) faulting has occurred and to base the ground motion design on hypothetical earthquakes, postulated on nearby faults, that represent 10,000 yrs of average cumulative displacement. The major tectonic issues identified for the postclosure phase (10,000 yrs) are volcanism (not addressed here) and potential changes to the hydrologic system resulting from a local faulting event which could trigger potential thermal, mechanical, and chemical interactions with the ground water. Extensive studies are planned for resolving these issues. 33 refs., 3 figs.

16 (DOE/OSTI–3406-Suppl.1-Add.1) **Yucca Mountain Project bibliography, January–June 1988: An update: Civilian Radioactive Waste Management Program.** Tamura, A.T.; Lorenz, J.J. (comps. USDOE Office of Scientific and Technical Information, Oak Ridge, TN. Oct 1988. 20p. Order Number DE88015230. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The Nevada Nuclear Waste Storage Investigations Project was renamed the Yucca Mountain Project on August 5, 1988. This update contains information that was added to the DOE Energy Data Base during the first six months of 1988. The update is categorized by principal project participating organizations, and items are arranged in chronological order. Participant-sponsored subcontractor reports, papers, and articles are included in the sponsoring organization's list. Previous information on this project can be found in the Nevada Nuclear Waste Storage Investigations bibliographies, DOE/TIC-3406 which covers the years 1977–1985, and DOE/OSTI-3406(Suppl.1) which covers 1986 and 1987. These bibliographies contain indexes for Corporate Author, Personal Author, Subject, Contract Number, Report Number, Order Number Correlation and Key Word in Context.

17 (DOE/OSTI–3406-Suppl.1-Add.2) **Yucca Mountain Project bibliography, July–December 1988: An update: Civilian Radioactive Waste Management Program.** Tamura, A.T. (USDOE Office of Scientific and Technical Information, Oak Ridge, TN (USA)); Lorenz, J.J. (comps. USDOE Office of Scientific and Technical Information, Oak Ridge, TN (USA). Apr 1989. 43p. Sponsored by U.S. DOE Radioactive Waste Management. Order Number DE89005394. Source: NTIS, PC A04/MF A01 - OSTI; GPO Dep.

This update contains information on the Yucca Mountain Project that was added to the Energy Data Base during the last six months of 1988. The update also includes a new section which provides information about publications on the Energy Data Base that were not sponsored by the project but have some relevance to it. This section covers the period 1977 to 1988. Prior to August 5, 1988, this project was called the Nevada Nuclear Waste Storage Investigations. The update is categorized by principal project participating organizations, and items are arranged in chronological order. Participant-sponsored subcontractor reports, meeting papers, and journal articles are included with sponsoring organization. Previous information on this project can be found in the Nevada Nuclear Waste Storage Investigations bibliographies: DOE/TIC-3406, which covers the years 1977 to 1985; DOE/OSTI-3406(Suppl.1), which covers 1986 and 1987; and the Yucca Mountain Project Bibliography, DOE/OSTI-3406(Suppl.1)(Add. 1), which covers the first six months of 1988. All entries in these publications are searchable on-line on the NNW data base file which can be accessed through the Integrated Technical Information System (ITIS) of the US Department of Energy (DOE).

18 (DOE/RW–0160-Vol.1) **Site characterization plan: Yucca Mountain site, Nevada research and development area, Nevada: Consultation draft, Nuclear Waste Policy Act: Volume 1.** Department of Energy, Washington, DC (USA). Office of Nuclear Waste Management. Jan 1988. 754p. DOE Contract AC08-87NV10576. Source: OSTI, PO Box 62, Oak Ridge, TN 37831.

The Yucca Mountain site in Nevada is one of three candidate sites for the first geologic repository for radioactive waste. On May 28, 1986, it was recommended for detailed study in a program of site characterization. This site characterization plan (SCP) has been prepared in acordance with the requirements of the Nuclear Waste Policy Act to summarize the information collected to date about the geologic conditions at the site;to describe the conceptual designs for the repository and the waste package and to present the plans for obtaining the geologic information necessary to demonstrate the suitability of the site for a repository, to design the repository and the waste package, to prepare an environmental impact statement, and to obtain from the US Nuclear Regulatory Commission (NRC) an authorization to construct the repository. This introduction begins with a brief section on the process for siting and eveloping a repository, followed by a discussion of the pertinent legislation and regulations. A description of site characterization is presented next;it describes the facilities to be constructed for the site characterization program and explains the principal activities to be conducted during the program. Finally, the purpose, content, organizing prinicples, and organization of this site characterization plan are outlined, and compliance with applicable regulations is discussed. 880 refs., 130 figs., 25 tabs.

19 (DOE/RW–0160-Vol.2) **Site characterization plan: Yucca Mountain site, Nevada research and development area, Nevada: Consultation draft, Nuclear Waste Policy Act: Volume 2.** USDOE Office of Civilian Radioactive Waste Management, Washington, DC (USA). Jan 1988. 588p. DOE Contract AC08-87NV10576. Source: OSTI, PO Box 62, Oak Ridge, TN 37831.

The Yucca Mountain site in Nevada is one of three candidate sites for the first geologic repository for radioactive waste. On May 28, 1986, it was recommended for detailed study in a program of site characterization. This site characterization plan (SCP) has been prepared in accordance with the requirements of the Nuclear Waste Policy Act to summarize the information collected to date about the geologic conditions at the site; to describe the conceptual designs for the repository and the waste package and to present the plans for obtaining the geologic information necessary to demonstrate the suitability of the site for a repository, to design the repository and the waste package, to prepare an environmental impact statement, and to obtain from the US Nuclear Regulatory Commission (NRC) an authorization to construct the repository. Chapter 3 summarizes present knowledge of the regional and site hydrologic systems. The purpose of the information presented is to (1) describe the hydrology based on available literature and preliminary site-exploration activities that have been or are being performed and (2) provide information to be used to develop the hydrologic aspects of the planned site characterization program. Chapter 4 contains geochemical information about the Yucca Mountain site. The chapter references plan for continued collection of geochemical data as a part of the site characterization program. Chapter 4 describes and evaluates data on the existing climate and site meterology, and outlines the suggested procedures to be used in developing and validating methods to predict future climatic variation. 534 refs., 100 figs., 72 tabs.

20 (DOE/RW–0160-Vol.3) **Site characterization plan: Yucca Mountain site, Nevada research and development area, Nevada: Consultation draft, Nuclear Waste Policy Act.** Department of Energy, Washington, DC (USA). Office of Nuclear Waste Management. Jan 1988. 638p. DOE Contract AC08-87NV10576. Source: OSTI, PO Box 62, Oak Ridge, TN 37831- H.

Chapter six describes the basis for facility design, the completed facility conceptual design, the completed analytical work relating to the resolution of design issues, and future design-related work. The basis for design and the conceptual design information presented in this chapter meet the requirements of the Nuclear Waste Policy Act of 1982, for a conceptual repository design that takes into account site-specific requirements. This information is presented to permit a critical evaluation of planned site characterization activities. Chapter seven describes waste package components, emplacement environment, design, and status of research and development that support the Nevada Nuclear Waste Storage Investigation (NNWSI) Project. The site characterization plan (SCP) discussion of waste package components is contained entirely within this chapter. The discussion of emplacement environment in this chapter is limited to considerations of the environment that influence, or which may influence, if perturbed, the waste packages and their performance (particularly hydrogeology, geochemistry, and borehole stability). The basis for conceptual waste package design as well as a description of the design is included in this chapter. The complete design will be reported in the advanced conceptual design (ACD) report and is not duplicated in the SCP. 367 refs., 173 figs., 68 tabs.

21 (DOE/RW–0160-Vol.4) **Site characterization plan: Yucca Mountain site, Nevada research and development area, Nevada: Consultation draft, Nuclear Waste Policy Act: Volume 4.** USDOE Office of Civilian Radioactive Waste Management, Washington, DC. Jan 1988. 854p. DOE Contract AC08-87NV10576.

The Yucca Mountain site in Nevada is one of three candidate sites for the first geologic repository for radioactive waste. On May 28, 1986, it was recommended and approved by the President for detailed study in a program of site characterization. This site characterization plan (SCP) has been prepared in accordance with the requirements of the Nuclear Waste Policy Act to summarize the information collected to date about the geologic conditions at the site; to describe the conceptual designs for the repository and the waste package; and to present the plans for obtaining the geologic information necessary to demonstate the suitability of the site for a repository, to desin the repository and the waste package, to prepare an environmental impact statement, and to obtain from the US Nuclear Regulatory Commission (NRC) an authorization to construct the repository. This introduction begins with a brief section on the process for siting and developing a repository, followed by a discussion of the pertinent legislation and regulations. A description of site characterization is presented next; it describes the facilities to be constructed for the site characterization program and explains the principal activities to be conducted during the program. Finally, the purpose, content, organizing principles, and organization of this site characterization plan are outlined, and compliance with applicable regulations is discussed.

22 (DOE/RW–0160-Vol.5) **Site characterization plan: Yucca Mountain site, Nevada research and development area, Nevada: Consultation draft, Nuclear Waste Policy Act.** Department of Energy, Washington, DC (USA). Office of Nuclear Waste Management. Jan 1988. 854p. DOE Contract AC08-87NV10576. Order Number DE88007746. Source: OSTI, PO Box 62, Oak Ridge, TN 37831.

The Yucca Mountain site in Nevada is one of three candidate sites for the first geologic repository for radioactive waste. On May 28, 1986, it was recommended by the Secretary of Energy and approved by the President for detailed study in a program of site characterization. This site characterization plan (SCP) has been prepared by the US Department of Energy (DOE) in accordance with the requirements of the Nulcear Waste Policy Act to summarize the information collected to date about the geologic conditions at the site;to describe the conceptual designs for the repository and the waste package;and to present the plans for obtaining the geologic information necessary to demonstrate the suitability of the site for a repository, to design the repository and the waste package, to prepare an environmental impact statement, and to obtain from the US Nuclear Regulatory Commission (NRC) an authorization to construct the repository. This introduction begins with a brief section on the process for siting and developing a repository, followed by a discussion of the pertinent legislation and regulations. A description of site characterization is presented next;it describes the facilities to be constructed for the site characterization program and explains the principal activities to be conducted during the program. Finally, the purpose, content, organizing principles, and organization of the site characterization plan are oulined, and compliance with applicable regulations is discussed.

23 (DOE/RW–0160-Vol.6) **Site characterization plan: Yucca Mountain site, Nevada research and development area, Nevada: Consultation draft, Nuclear Waste Policy Act: Volume 6.** USDOE Office of Civilian Radioactive Waste Management, Washington, DC. Jan 1988. 802p. DOE Contract AC08-87NV10576.

The Yucca Mountain site in Nevada is one of three candidate sites for the first geologic repository for radioactive waste. On May 28, 1986, it was recommended for detailed study in a program of site characterization. This site characterization plan (SCP) has been prepared in accordance with the requirements of the Nuclear Waste Policy Act to summarize the information collected to date about the geologic conditions at the site;to describe the conceptual designs for the repository and the waste package;and to present the plans for obtaining the geologic information necessary to demonstrate the suitability of the site for repository, to design the repository and the waste package, to prepare an environmental impact statement, and to obtain from the US Nuclear Regulatory Commission (NRC) an authorization to construct the repository. This introduction begins with a brief section on the process for siting and developing a repository, followed by a discussion of the pertinent legislation and regulations. A description of site characterization is presented next;it describes the facilities to be constructed for the site characterization program and explains the principal activities to be conducted during the program. Finally, the purpose, content, organizing principles, and organization of this site characterization plan are outlined, and compliance with applicable regulations is discussed.

24 (DOE/RW–0160-Vol.7) **Site characterization plan: Yucca Mountain site, Nevada research and development area, Nevada: Consultation draft, Nuclear Waste Policy Act: Volume 7.** USDOE Office of Civilian Radioactive Waste Management, Washington, DC. Jan 1988. 847p. DOE Contract AC08-87NV10576. Source: OSTI, PO Box 62, Oak Ridge, TN 37831.

The Yucca Mountain site in Neavada is one of three candidate sites for the first geologic repository for radioactive waste. On May 28, 1986, it was recommended and approved for detailed study in a program of site characterization. This site characterization plan (SCP) has been prepared in accordance with the requirements of the Nuclear Waste Policy Act to summarize the information collected to date about the geologic conditions at the site;to describe the conceptual designs for the repository and the waste package;and to present the plans for obtaining hte geologic information necessary to demonstrate the suitability of the site for a repository, to design the repository and the waste package, to prepare and environmental impact statement, and to obtain from the US Nuclear Regulatory Commission (NRC) an authorization to construct the repository. This introduction begins with a brief section on the process for siting and developing a repository, followed by a discussion of the pertinent legislation and regulations. A description of site characterization is presented next;it describes the facilities to be constructed for the site characterization program and explains the principal activities to be conducted during the program. Finally, the purpose, content, organizing principles, and organization of this site characterization plan are outlined, and compliance with applicable regulations is discussed.

25 (DOE/RW–0161) **Site characterization plan overview: Yucca Mountain Site, Nevada Research and Development Area, Nevada: Consultation Draft.** USDOE Office of Civilian Radioactive Waste Management, Washington, DC (USA). Jan 1988. 123p. Source: OSTI, PO Box 62, Oak Ridge, TN 37831.

The consultation draft of the site characterization plan is a lengthy document that describes in considerable detail the program that will be conducted to characterize the geologic, hydrologic, and other conditions relevant to the suitability of the site for a repository. The overview presented here consists of brief summaries of important topics covered in the consultation draft of the site-characterization plan; it is not a substitute for the site-characterization plan. The arrangement of the overview is similar to that of the plan itself, with brief descriptions of the disposal system – the site, the repository, and the waste package – preceding the discussion of the characterization program to be carried out at the Yucca Mountain site. It is intended primarily for the management staff of organizations involved in the DOE's repository program – staff who might wish to understand the general scope of the site-characterization program, the activities to be conducted, and the facilities to be constructed rather than the technical details of site characterization. 22 figs., 1 tab.

26 (DOE/RW–0176-Rev.1-Draft) **Environmental Monitoring and Mitigation Plan for site characterization.** USDOE Nevada Operations Office, Las Vegas. Jan 1988. 161p. DOE Contract AC08-87NV10576. Order Number DE88006888.

The DOE is committed to conduct its operations in an environmentally safe and sound manner, and will comply with the letter and the spirit of applicable environmental statues and regulations. This document - the NNWSI Project's Environmental Regulatory Compliance Plan (ERCP) - is one means of implementing the policy. The ERCP describes the plan by which the NNWSI Project Office will comply with applicable environmental statutes and regulations. The ERCP also discusses how DOE will address State and local environmental statues and regulations. To achieve the goals of DOE, the ERCP will be developed in phases. This version of the ERCP is the first phase in this development. It represents the NNWSI Project's understanding of environmental regulatory requirements for site characterization of Yucca Mountain. After consultation with appropriate Federal and State agencies, the ERCP will be updated to reflect the results of these consultations. 29 figs., 1 tab.

27 (DOE/RW–0177) **Environmental Regulatory Compliance Plan for site: Draft characterization of the Yucca Mountain site:Draft.** USDOE Nevada Operations Office, Las Vegas. Jan 1988. 231p. DOE Contract AC08-87NV10576. Source: OSTI, PO Box 62, Oak Ridge, TN 37831.

The objective of the EMMP is to document compliance with the NWPA. To do so, a summary description of site characterization activites is provided, based on the consultation draft of the SCP. Subsequent chpaters identify those technical areas having the potential to be impacted by site characterization activities and the monitoring plans proposed to identify whether those impacts acutally occur. Should monitoring confirm the potential for significant adverse impact, mitigative measures will be developed. In the context of site characterization, mitigation is defined as those changes in site characterization activities that serve to avoid or minimize, to the maximum extent practicle, any significant adverse environmental impacts. Although site characterization activies involve both surface and subsurface activities, it is the surface-based aspect of site characterization that is addressed in detailed by the EMMP. The schedule and duration of these activities is given in the consultation draft of the SCP. A breif summary of all proposed activities is given in the EMMP. 10 refs., 8 figs.

28 (DOE/RW–0179) **Socioeconomic monitoring and mitigation plan for site characterization: Revision 1.** USDOE Nevada Operations Office, Las Vegas. Jan 1988. 147p. DOE Contract AC08-87NV10576. Order Number DE88006890. Source: OSTI, PO Box 62, Oak Ridge, TN 37831.

The objective of the SMMP is to document compliance with the NWPA. In order to do so, a summary description of site characterization activities based on the consultation draft of the Site Characterization Plan and the final EA is provided. Subsequent chapters identify issues related to the potential for significant adverse impacts and the monitoring plans proposed to determine whether those impacts occur. Should monitoring confirm the potential for significant adverse impact, mitigative maesures will be developed. In the context of site characterization, mitigation is defined as those changes in site characterization activities that serve to avoid or minimize, to the maximum extent practicable, any significant adverse environmental impacts. Proposed site characterization activites involve a variety of surface and subsurface activities including site preparation, access road construction and improvment, exploratory drilling and testing, geophysical surveys, geological mapping, and construction of the exploratory shaft facility. It is not anticipated that any significant adverse socioeconomic impacts will result form any of the proposed site characterization activities. However, the assessment of impacts in the EA, especially impacts related to employment and population growth, was based on assumptions concerning activities and conditions during the site characterization phase.

29 (DOE/RW–0198) **Site characterization plan overview: Yucca Mountain site, Nevada Research and Development Area, Nevada.** USDOE Office of Civilian Radioactive Waste Management, Washington, DC. Dec 1988. 172p. Source: OSTI, PO Box 62, Oak Ridge, TN 37831.

To help the public better understand both the SCP and the site characterization program, the DOE has prepared this overview and the SCP Public Handbook. The overview presents summaries of selected topics covered in the SCP; it is not a substitute for the SCP. The organization of the overview is similar to that of the SCP itself, with brief descriptions of the Yucca Mountain site, the repository, and the containers in which the waste would be packaged, followed by a discussion of the characterization program to be carried out at the Yucca Mountain site. This overview is intended primarily for those persons who want to understand the general scope and basis of the site-characterization program, the activities to be conducted, and the facilities to be constructed without spending the time necessary to become familiar with all of the technical details presented in the

SCP. For the readers of the SCP, the overview will be useful as a general guide to the plan. The SCP Public Handbook is a short document that contains brief descriptions of the SCP process and the contents of the SCP. It also explains how the public can submit comments on the SCP and lists the libraries and reading rooms at which the SCP is available. 9 refs., 18 tabs.

30 (DOE/RW–0199-Vol.1-Pt.A) **Site characterization plan: Yucca Mountain Site, Nevada Research and Development Area, Nevada: Volume 1, Part A: Chapters 1 and 2.** USDOE Office of Civilian Radioactive Waste Management, Washington, DC (USA). Dec 1988. 759p. Source: OSTI, PO Box 62, Oak Ridge, TN 37831.

This site characterization plan (SCP) has been developed for the candidate repository site at Yucca Mountain in the State of Nevada. The SCP includes a description of the Yucca Mountain site (Chapters 1-5), a conceptual design for the repository (Chapter 6), a description of the packaging to be used for the waste to be emplaced in the repository (Chapter 7), and a description of the planned site characterization activities (Chapter 8). The schedules and milestones presented in Sections 8.3 and 8.5 of the SCP were developed to be consistent with the June 1988 draft Amendment to the DOE's Mission Plan for the Civilian Radioactive Waste Management Program. The five month delay in the scheduled start of exploratory shaft construction that was announced recently is not reflected in these schedules. 750 refs., 123 figs., 42 tabs.

31 (DOE/RW–0199-Vol.2-Pt.A) **Site characterization plan: Yucca Mountain Site, Nevada Research and Development Area, Nevada: Volume 2, Part A: Chapters 3, 4, and 5.** USDOE Office of Civilian Radioactive Waste Management, Washington, DC (USA). Dec 1988. 577p. Source: OSTI, PO Box 62, Oak Ridge, TN 37831.

This site characterization plan (SCP) has been developed for the candidate repository site at Yucca Mountain in the State of Nevada. The SCP includes a description of the Yucca Mountain site (Chapters 1–5), a conceptual design for the repository (Chapter 6), a description of the packaging to be used for the waste to be emplaced in the repository (Chapter 7), and a description of the planned site characterization activities (Chapter 8). The schedules and milestones presented in Sections 8.3 and 8.5 of the SCP were developed to be consistent with the June 1988 draft Amendment to the DOE's Mission Plan for the Civilian Radioactive Waste Management Program. The five month delay in the scheduled start of exploratory shaft construction that was announced recently is not reflected in these schedules. 575 refs., 84 figs., 68 tabs.

32 (DOE/RW–0199-Vol.3-Pt.A) **Site Characterization Plan: Yucca Mountain Site, Nevada Research and Development Area, Nevada: Volume 3, Part A: Chapters 6 and 7.** USDOE Office of Civilian Radioactive Waste Management, Washington, DC (USA). Dec 1988. 654p. Source: OSTI, PO Box 62, Oak Ridge, TN 37831.

This site characterization plan (SCP) has been developed for the candidate repository site at Yucca Mountain in the State of Nevada. The SCP includes a description of the Yucca Mountain site (Chapters 1-5), a conceptual design for the repository (Chapter 6), a description of the packaging to be used for the waste to be emplaced in the repository (Chapter 7), and a description of the planned site characterization activities (Chapter 8). The schedules and milestones presented in Sections 8.3 and 8.5 of the SCP were developed to be consistent with the June 1988 draft Amendment to the DOE's Mission Plan for the Civilian Radioactive Waste Management Program. The five month delay in the scheduled start of exploratory shaft construction that was announced recently is not reflected in these schedules. 218 figs., 50 tabs.

33 (DOE/RW–0199-Vol.4-Pt.B) **Site characterization plan: Yucca Mountain Site, Nevada Research and Development Area, Nevada: Volume 4, Part B: Chapter 8, Sections 8.0 through 8.3.1.4.** USDOE Office of Civilian Radioactive Waste Management, Washington, DC (USA). Dec 1988. 855p. Source: OSTI, PO Box 62, Oak Ridge, TN 37831.

This site characterization plan (SCP) has been developed for the candidate repository site at Yucca Mountain in the State of Nevada. The SCP includes a description of the Yucca Mountain site (Chapters 1-5), a conceptual design for the repository (Chapter 6), a description of the packaging to be used for the waste to be emplaced in the repository (Chapter 7), and a description of the planned site characterization activities (Chapter 8). The schedules and milestones presented in Sections 8.3 and 8.5 of the SCP were developed to be consistent with the June 1988 draft Amendment to the DOE's Mission Plan for the Civilian Radioactive Waste Management Program. The five month delay in the scheduled start of exploratory shaft construction that was announced recently is not reflected in these schedules. 74 figs., 32 tabs.

34 (DOE/RW–0199-Vol.5-Pt.B) **Site characterization plan: Yucca Mountain Site, Nevada Research and Development Area, Nevada: Volume 5, Part B: Chapter 8, Sections 8.3.1.5 through 8.3.1.17.** USDOE Office of Civilian Radioactive Waste Management, Washington, DC (USA). Dec 1988. 889p. Source: OSTI, PO Box 62, Oak Ridge, TN 37831.

This site characterization plan (SCP) has been developed for the candidate repository site at Yucca Mountain in the State of Nevada. The SCP includes a description of the Yucca Mountain site (Chapters 1-5), a conceptual design for the repository (Chapter 6), a description of the packaging to be used for the waste to be emplaced in the repository (Chapter 7), and a description of the planned site characterization activities (Chapter 8). The schedules and milestones presented in Sections 8.3 and 8.5 of the SCP were developed to be consistent with the June 1988 draft Amendment to the SOE's Mission Plan for the Civilian Radioactive Waste Management Program. The five month delay in the scheduled start of exploratory shaft construction that was announced recently is not reflected in these schedules.

35 (DOE/RW–0199-Vol.6-Pt.B) **Site characterization plan: Yucca Mountain Site, Nevada Research and Development Area, Nevada: Volume 6, Part B: Chapter 8, Sections 8.3.2 through 8.3.4.4.** USDOE Office of Civilian Radioactive Waste Management, Washington, DC (USA). Dec 1988. 553p. Source: OSTI, PO Box 62, Oak Ridge, TN 37831.

This site characterization plan (SCP) has been developed for the candidate repository site at Yucca Mountain in the State of Nevada. The SCP includes a description of the Yucca Mountain site (Chapters 1-5), a conceptual design for the repository (Chapter 6), a description of the packaging to be used for the waste to be emplaced in the repository

(Chapter 7), and a description of the planned site characterization activities (Chapter 8). The schedules and milestones presented in Sections 8.3 and 8.5 of the SCP were developed to be consistent with the June 1988 draft Amendment to the DOE's Mission Plan for the Civilian Radioactive Waste Management Program. The five month delay in the scheduled start of exploratory shaft construction that was announced recently is not reflected in these schedules. 35 figs., 70 tabs.

36 (DOE/RW–0199-Vol.7-Pt.B) **Site characterization plan: Yucca Mountain Site, Nevada Research and Development Area, Nevada: Volume 8, Part B: Chapter 8, Sections 8.3.5 through 8.3.5.20.** USDOE Office of Civilian Radioactive Waste Management, Washington, DC (USA). Dec 1988. 893p. Source: OSTI, PO Box 62, Oak Ridge, TN 37831.

This site characterization plan (SCP) has been developed for the candidate repository site at Yucca Mountain in the State of Nevada. The SCP includes a description of the Yucca Mountain site (Chapters 1-5), a conceptual design for the repository (Chapter 6), a description of the packaging to be used for the waste to be emplaced in the repository (Chapter 7), and a description of the planned site characterization activities (Chapter 8). The schedules and milestones presented in Sections 8.3 and 8.5 of the SCP were developed to be consistent with the June 1988 draft Amendment to the DOE's Mission Plan for the Civilian Radioactive Waste Management Program. The five month delay in the scheduled start of exploratory shaft construction that was announced recently is not reflected in these schedules. 68 figs., 102 tabs.

37 (DOE/RW–0199-Vol.8-Pt.B) **Site characterization plan: Yucca Mountain Site, Nevada Research and Development Area, Nevada: Volume 8, Part B: Chapter 8, Sections 8.4 through 8.7; Glossary and Acronyms.** USDOE Office of Civilian Radioactive Waste Management, Washington, DC (USA). Dec 1988. 713p. Source: OSTI, PO Box 62, Oak Ridge, TN 37831.

This site characterization plan (SCP) has been developed for the candidate repository site at Yucca Mountain in the State of Nevada. The SCP includes a description of the Yucca Mountain site (Chapters 1-5), a conceptual design for the repository (Chapter 6), a description of the packaging to be used for the waste to be emplaced in the repository (Chapter 7), and a description of the planned site characterization activities (Chapter 8). The schedules and milestones presented in Section 8.3 and 8.5 of the SCP were developed to be consistent with the June 1988 draft Amendment to the DOE's Mission Plan for the Civilian Radioactive Waste Management Program. The five month delay in the scheduled start of exploratory shaft construction that was announced recently is not reflected in these schedules. 88 figs., 42 tabs.

38 (DOE/RW–0199-Vol.9) **Site characterization plan: Yucca Mountain Site, Nevada Research and Development Area, Nevada: Volume 9, Index.** USDOE Office of Civilian Radioactive Waste Management, Washington, DC (USA). Dec 1988. 303p. Source: OSTI, PO Box 62, Oak Ridge, TN 37831.

This site characterization plan (SCP) has been developed for the candidate repository site at Yucca Mountain in the State of Nevada. The SCP includes a description of the Yucca Mountain site (Chapters 1-5), a conceptual design for the repository (Chapter 6), a description of the packaging to be used for the waste to be emplaced in the repository (Chapter 7), and a description of the planned site characterization activities (Chapter 8). The schedules and milestones presented in Sections 8.3 and 8.5 of the SCP were developed to be consistent with the June 1988 draft Amendment to the DOE's Mission Plan for the Civilian Radioactive Waste Management Program. The five month delay in the scheduled start of exploratory shaft construction that was announced recently is not reflected in these schedules.

39 (DOE/TIC–3406-Add.1) **Nevada Nuclear Waste Storage Investigations, 1986: A bibliography.** Tamura, A.T.; Lorenz, J.J. (comps. USDOE Office of Scientific and Technical Information, Oak Ridge, TN. Jan 1988. 36p. Order Number DE87012696. Source: NTIS, PC A03/MF A01; GPO Dep.

This update contains information on the Nevada Nuclear Waste Storage Investigations (NNWSI) that was added to the Department of Energy's Energy Data Base during 1986. The preceeding initial bibliography (DOE/TIC-3406) covered 1977 to 1985 with indexing for: Corporate Author, Personal Author, Subject, Contract Number, Report Number, Order Number Correlation, and Key Word in Context. Future updates will be prepared on a six-month basis without indexing but will be cumulated at two-year intervals with complete indexing. This update is categorized by principal NNWSI Project participating organization, and items are arranged in chronological order. Participant-sponsored subcontractor reports, papers, and articles are included in the sponsoring organization's bibliography list.

40 (DOE/TIC–3406-Add.2) **Nevada Nuclear Waste Storage Investigations, January-June 1987: An update.** Tamura, A.T.; Lorenz, J.J. (comps. USDOE Office of Scientific and Technical Information, Oak Ridge, TN. Mar 1988. 24p. Order Number DE88000455. Source: NTIS, PC A03/MF A01; GPO Dep.

This update contains information on the Nevada Nuclear Waste Storage Investigations (NNWSI) that was added to the DOE Energy Data Base during the first six months of 1987. The update is categorized by principal NNWSI Project participating organization, and items are arranged in chronological order. Participant-sponsored subcontractor reports, papers, and articles are included in the sponsoring organization's list. The publication following this update will be a supplement to the first bibliography (DOE/TIC-3406) and will include all information retrieved from January 1, 1986, to December 31, 1987. It will be a cumulation of all updates for this two-year interval and will include indexing for: Corporate Author, Personal Author, Subject, Contract Number, Report Number, Order Number Correlation, and Key Word in Context.

41 (EGG–10282-2111) **Nevada Nuclear Waste Storage Investigations: A review of requirements for biological information in federal, state, and local environmental laws and regulations.** Collins, E.; O'Farrell, T.P. EG and G Energy Measurements, Inc., Goleta, CA (USA). Santa Barbara Operations. Jan 1987. 35p. DOE Contract AC08-83NV10282. Order Number DE88003669. Source: NTIS, PC A03/MF A01; GPO Dep.

Biological information concerning Yucca Mountain collected since 1980 is evaluated to determine if it is sufficient to satisfy the requirements of the various federal, state, and local laws and regulations that pertain to environmental protection or to development of waste repositories. The pertinent requirements of each law are summarized, missing information is identified, and recommendations are made for studies to fill these gaps. 11 refs., 2 figs., 1 tab.

42 (NVO–326) **Exploratory shaft location documentation report.** Gnirk, P.; Hardin, E.; Voegele, M. RE/SPEC, Inc., Albuquerque, NM (USA); Science Applications International Corp., Las Vegas, NV (USA). 21 Dec 1988. 137p. Order Number DE89010665. Source: NTIS, PC A07/MF A01 - OSTI; GPO Dep.

The purpose of this report is to describe and document the process that involved locating, relocating, and designing the exploratory shafts for site characterization at the Yucca Mountain site. In a broad sense, the contents of the report have been developed to reflect several topics including the guidance provided by DOE-HQ to the NNWSI Project; the interaction between DOE-HQ and the NNWSI Project during the course of reaching major milestone decisions; the process and considerations that formed the basis for locating, relocating, and designing the ES(s), the review of those considerations, and the associated interface with quality assurance (QA); the interactions among DOE-HQ, the NNWSI Project, and the NRC that had impact on the location, function, and design of the ES and the exploratory shaft facility (ESF); and the impact of the course of events in the NWTS Program on the activities of the NNWSI Project since its inception in FY 1977.

43 **Development of a test series to determine in situ thermomechanical and transport properties.** Hardin, E.L. (Science Applications, Inc., 3349 S. Highland Dr., Suite 403, Las Vegas, NV 89109); Voegele, M.D.; Board, M.P.; Pratt, H.R. Measurement of rock properties at elevated pressures and temperatures. Pincus, H.J.; Hoskins, E.R. ASTM, (1985). pp. 128-148 (CONF-830605–: 24. symposium on rock mechanics, College Station, TX, US, June 20, 1983).

A small number of heated block tests have been performed, with the objective of determining the usefulness of large-scale field testing in site characterization for an underground nuclear waste repository. These tests have been research oriented, involving independent control of the state of stress and temperature in a specimen of rock having a volume of 8 m^3. The heated block test is a logical candidate to obtain information on repository design and licensing, particularly for validating predictive repository model performance. A description is given of the preparation, field work, and analysis that comprised the heated block tests at the Colorado School of Mines (CSM) experimental mine and G-tunnel on the Nevada test site. These demonstrations of the heated block test showed that additional refinement is possible and especially that the method was effective in gathering meaningful data not obtainable by any other means. Such data included the apparent coupling of the effects of independently controlled stress and temperature on the deformation behavior of jointed rock, and on the conductivity of a single fracture to injected water.

44 **Transportation of spent fuel to the Idaho National Engineering Laboratory.** Gertz, C.P. (Idaho National Engineering Lab., Dept. of Energy - Idaho Operations, Idaho Falls, ID 83402); Schoonen, D.H.; Wakeman, B.H. Waste management '87: Waste isolation in the US, technical programs, and public education. Post, R.G. University of Arizona Nuclear Engineering Dept., (1987). pp. 397-404 (CONF-870306–: Waste management '87, Tucson, AZ, US, March 1, 1987).

Spent fuel research and development demonstrations and associated transportation activities are being performed for the Department of Energy's (DOE) Office of Civilian Radioactive Waste Management (OCRWM) as a part of the storage cask performance testing programs at the Idaho National Engineering Laboratory (INEL). The shipment of spent fuel to the INEL from the Surry Power Station and the Nevada Test Site (NTS) required shipping plans and coordination between DOE, EG and G Idaho, Transnuclear, Inc., (the shipping cask supplier) and Virginia Power (VP) transportation personnel for the VP shipments; included Westinghouse Nevada Operations for the NTS shipments; as well as extensive communication with the corridor states. Similar extensive planning and coordination with DOE; Nuclear Regulatory Commission (NRC); General Public Utilities (GPU) Nuclear Corporation [owner and operator of Three Mile Island Unit 2 (TMI-2)]; EG and G Idaho, Inc.; two railroad companies; and state and city officials were required to initiate the shipments of core debris by railroad from TMI-2 to the INEL.

45 **Mineral resource evaluation.** Mattson, S.R. (Science Applications International Corp., 101 Convention Center Drive, Suite 407, Las Vegas, NY (US)). pp. 915-924 of Waste management '88. Post, R.G. University of Arizona Nuclear Engineering Dept., Tucson, AZ (1988). vp. of (CONF-880201–: Waste management '88: symposium on radioactive waste management, Tucson, AZ (USA), 28 Feb - 3 mar 1988).

The absence or presence of mineral resources can lead to a potentially favorable or unfavorable characteristic for a high-level nuclear waste repository. Regulatory compliance, in accordance with 10 CFR Part 60, involves satisfying two key elements that are aimed at assessing the likelihood of possible human intrusion or interference (e.g., drilling, mining, extraction), which could affect the functioning of a repository or lead to a loss of waste isolation. The first element is an evaluation, identification, and assessment of any known reserves or potentially economic resources. Defined reserves or potentially economic resources must be described by factors including grade or quality and by tonnage or other amount. The second element is an evaluation and assessment of the likelihood that a repository site is, or someday could be considered, a likely exploration target based on any site-specific geologic or geophysical evidence, by analogy with presently known mineralized areas, or through the perceived resource potential of the repository site in comparison to the local surrounding area.

46 **Yucca Mountain, Nevada.** Gertz, C.P. (Department of Energy, Las Vegas, NV (USA). Nevada Operations Office). *JNMM (Journal of Nuclear Materials Management) (USA),* 17(3): 10-13 (Apr 1989).

As mandated by Congress in the amended Nuclear Waste Policy Act, Yucca Mountain, Nevada is currently being studied by the U.S. Department of Energy to determine if it is a suitable location for the nation's first geologic repository for disposal of high-level radioactive waste and spent nuclear fuel. While the site has attributes that suggest it may be suitable, DOE must spent the next five to seven years and up to $2 billion to find out if the site would be able to isolate radioactive materials for 10,000 years. Site characterization studies are being conducted to determine the geologic, hydrologic and environmental characteristics of the Yucca Mountain site. The DOE is planning to start construction of an underground laboratory in 1989 and to implement an extensive surface-based study program. The next five to seven years of study will determine if Yucca Mountain can meet regulations for waste isolation and qualify for a

Nuclear Regulatory Commission license for repository construction and operation.

LOS ALAMOS NATIONAL LABORATORY

47 (CONF-8704112–, pp. 376-379) **Infiltration at Yucca Mountain, Nevada, traced by ^{36}Cl.** Norris, A.E. (Los Alamos National Lab., NM (USA)); Wolfsberg, K.; Gifford, S.K.; Bentley, H.W.; Elmore, D. Rochester Univ., NY (USA). 1987. From 4. international symposium on accelerator mass spectrometry; Ontario, CA; April 27, 1987. In *Accelerator mass spectrometry: Proceedings of the fourth international symposium on accelerator mass spectrometry.* 376-379p. Source: Elsevier Science Publishers Co. Inc., 52 Vanderbilt Ave., New York 10017.

Measurements of chloride and ^{36}Cl in soils from two locations near Yucca Mountain, Nevada, have been used to trace the infiltration of precipitation in this arid region. The results show that the ^{36}Cl fallout from nuclear-weapons testing formed a well-defined peak at one location, with a maximum ^{36}Cl/Cl ratio 0.5 m below the surface. The structure of the ^{36}Cl bomb pulse at the other location was much more complex, and the quantity of ^{36}Cl in the bomb pulse was $<$ 1% of the 6 x 10^{12} atoms ^{36}Cl/m^2 in the bomb pulse at the first location. The data indicate hydrologic activity subsequent to the ^{36}Cl bomb-pulse fallout at one location, but none at the other location.

48 (LA–10532-MS) **Two-dimensional numerical simulation of geochemical transport in Yucca Mountain.** Travis, B.J.; Nuttall, H.E. Los Alamos National Lab., NM (USA). Dec 1987. 69p. DOE Contract W-7405-ENG-36. Order Number DE88004435. Source: NTIS, PC A04/MF A01; GPO Dep.

Several physical and chemical processes can affect transport of radionuclides in Yucca Mountain. Geometric spreading and lateral flow will reduce the concentration of contaminated water reaching the accessible environment. Travel times to the water table are calculated to be at least several tens of thousands of years. Colloid transport can also enhance radionuclide transport, but will be important only if fracture flow is. Finally, the heat load from repository waste can alter the distribution of some naturally occurring minerals. In particular, dissolution and precipitation of SiO_2 should lead to a region of reduced permeability around waste canisters. 22 refs., 47 figs., 7 tabs.

49 (LA–10667-MS) **Evaluation of past and future alterations in tuff at Yucca Mountain, Nevada, based on the clay mineralogy of drill cores USW G-1, G-2, and G-3.** Bish, D.L. Los Alamos National Lab., NM (USA). Mar 1989. 41p. DOE Contract W-7405-ENG-36. Order Number DE89008317. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The tuffs at Yucca Mountain in south-central Nevada are being studied by the Yucca Mountain Project (YMP) to determine their suitability for a high-level radioactive waste repository. For predictive purposes, it is important to understand the alteration history of Yucca Mountain and to know how the minerals in Yucca Mountain tuffs respond to changing conditions such as elevated temperatures. The clay mineralogy of these tuffs has been examined using x-ray powder diffraction, and approximation temperatures of alteration have been determined using available clay mineral data and fluid inclusion analyses. Also, several illites from drill holes USW G-1 and G-2 have been dated using K/Ar techniques, yielding ages of about 11 Myr. The clay mineral in Yucca Mountain tuffs are predominantly interstratified illite/smectites, with minor amounts of chloride, kaolinite, and interstratified chlorite/smectite at depth in USW G-1 and G-2. The reactions observed for these illite/smectites are similar to those observed in pelitic rocks. With depths, the illite/smectites transform from random interstratifications (R = 0) through ordered intermediates (R = 1) to illite in USW G-2 and to Kalkberg (R $\geq$ 3) interstratifications in USW G-1. The illite/smectites in USW G-3 have not significantly transformed. It appears that the illites in deeper rock results from hydrothermal and diagenetic reactions of earlier-formed smectites. These data demonstrate that the rocks at depth in the northern end of Yucca Mountain were significantly altered about 11 Myr ago. Both clay mineralogy and fluid inclusions suggest that the rocks at depth in USW G-2 have been subjected to postdepositional temperatures of at least 275°C, those in USW G-1 have reached 200°C, and USW G-3 rocks probably have not exceeded 100°C. 64 refs., 9 figs., 3 tabs.

50 (LA–10952-MS) **Preliminary report on sorption modeling.** Fuentes, H.R.; Polzer, W.L.; Gruber, J.; Lauctes, B.; Essington, E.H. Los Alamos National Lab., NM (USA). Aug 1987. 353p. DOE Contract W-7405-ENG-36. Order Number DE88006874.

The generic objective of this study is to inventory and model batch sortpion data obtained for the Nevada Nuclear Waste Storage Investigations Projects by the Los Alamos National Laboratory. This report addresses the modeling by various isotherms of data sets inventoried from about 1500 data enetries, potential occurrence of precipitation in the sorption experiments, and evaluation of a computer code to study changes in chemical isolation caused by changes in the chemistry of the porous media. 20 refs., 4 figs., 31 tabs.

51 (LA–10960-MS) **Summary of sorption measurements performed with Yucca Mountain, Nevada, tuff samples and water from Well J-13.** Thomas, K.W. Los Alamos National Lab., NM (USA). Dec 1987. 101p. DOE Contract W-7405-ENG-36. Order Number DE88005707. Source: NTIS, PC A06/MF A01; GPO Dep.

The sorption studies undertaken from 1977 to 1985 by Los Alamos National Laboratory in support of the Nevada Nuclear Waste Storage Investigations project are summarized, and the data are tabulated in the Appendix. These studies of the sorptive behavior of Yucca Mountain, Nevada, area tuffs have been partly generic in nature (to understand the sorptive behavior of tuff as a function of many variables) and partly site specific (to obtain data for a possible repository site at Yucca Mountain). Sorption has been investigated as a function of mineralogy, temperature, particle size, waste-element concentration, water composition, sorption time, and other variables. The major elements studied were americium, cesium, neptunium, plutoniuim, thorium, uranium, strontium, technetium, tin, barium, radium, cerium, europium, and selenium. 24 refs., 2 figs., 10 tabs.

52 (LA–10987-PR) **Research by ESS Division for the Nevada Nuclear Waste Storage Investigations: Progress report, January-June 1985.** Vaniman, D. (comp.). Los Alamos National Lab., NM (USA). Oct 1987. 53p. DOE Contract W-7405-ENG-36. Order Number DE88001940. Source: NTIS, PC A04/MF A01; GPO Dep.

Petrographic research for the Nevada Nuclear Waste Storage Investigations focused on xenolithic variability in the

Topopah Spring Member and on variations of clinoptilolite composition at Yucca Mountain. Zeolite and smectite occurrences were considered in terms of their relation to a disturbed zone beneath the potential repository, and mineral stability experiments have produced a new clinoptilolite structure as a result of prolonged heating at low temperature. Limitations were defined on the abundance of erionite and of sulfur. X-ray diffraction studies lead to improved analytical methods. Progress was made in the comparative study of mineralogy in sand ramps and in faults. Geological modeling considered the differences of the diffusion of nonsorbing tracers in vertically and in horizontally fractured rock. Modeling also treated the diffusion of a nonsorbing tracer in devitrified and in zeolitized rock. The results of these experiments in all cases show relatively symmetrical two-dimensional diffusion patterns. Preliminary calculations compare the dispersion/diffusion of nonsorbing Tc with the dispersion/diffusion/sorption of U. 27 refs., 20 figs., 5 tabs.

53 (LA–11023-MS) **Smectite dehydration and stability: Applications to radioactive waste isolation at Yucca Mountain, Nevada.** Bish, D.L. Los Alamos National Lab., NM (USA). Mar 1988. 32p. DOE Contract W-7405-ENG-36. Order Number DE88007167.

Montmorillonite-beidellite smectites are present in amounts up to 50% in the rocks directly underlying the potential high-level radioactive waste repository horizon at Yucca Mountain, Nevada. The thermal reactions of concern include reversible collapse/expansion of the smectite layers due to loss/gain of interlayer water;irreversible collapse due to loss of interlayer water and migration of interlayer cations into the 2:1 silicate layers;irreversible reduction of the osmotic swelling ability through reaction in a steam atmosphere;and inhomogeneous transformation of the smectite into an interstratified illite/smectite. Reversible collapse should be of minor importance because any thermally driven collapse will be reversed when water is introduced and temperatures go down. The amounts of smectite in the potential repository horizon itself are probably insufficient to give rise to rock strength problems due to reversible collapse. The irreversible reduction of somotic selling capacity in a steam environment may be significant in the rocks near the repository horizon. This effect on naturally occurring Na-rich smectites would probably increase permeabilitie shut would also provide for increased cation exchange by the smectite. 60 refs., 9 figs.

54 (LA–11026-MS) **Assessment report on the kinetics of radionuclide adsorption on Yucca Mountain tuff.** Rundberg, R.S. Los Alamos National Lab., NM (USA). Jul 1987. 95p. DOE Contract W-7405-ENG-36. Order Number DE88006031. Source: NTIS, PC A05/MF A01; GPO Dep.

The kinetics of sorption was measured by observing the uptake of radionuclides by tuff wafers and crushed tuff as a function of time. In addition, the broadening of breakthrough curves for cations eluted through crushed-tuff columns was interpreted in terms of adsorption kinetics. The results of these measurements are consistent with a diffusion-limited adsorption mechanism for simple cations, such as strontium, cesium, and barium. The adsorption kinetics for these simple cations is sufficiently fast so that equilibrium can be assumed for the retardation of these chemical species in the groundwater velocities that would be reasonable for most release scenarios. The actinides, in particular plutonium, exhibited a slow time dependence for adsorption. 23 refs., 61 figs., 12 tabs.

55 (LA–11162-MS) **Methods for obtaining sorption data from uranium-series disequilibria.** Finnegan, D.L.; Bryant, E.A. Los Alamos National Lab., NM (USA). Dec 1987. 22p. DOE Contract W-7405-ENG-36. Order Number DE88002512. Source: NTIS, PC A03/MF A01; GPO Dep.

Two possible methods have been identified for obtaining in situ retardation factors from measurements of uranium-series disequilibria at Yucca Mountain. The first method would make use of the enhanced $^{234}U/^{238}U$ ratio in groundwater to derive a signature for exchangeable uranium sorbed on the rock; the exchangeable uranium would be leached and assayed. The second method would use the ratio of ^{222}Rn to ^{234}U in solution, corrected for weathering, to infer the retardation factor for uranium. Similar methods could be applied to thorium and radium.

56 (LA–11222-MS) **Preliminary survey of the stability of silica-rich cementitious mortars 82-22 and 84-12 with tuff.** Scheetz, B.E.; Roy, D.M. Los Alamos National Lab., NM (USA). Mar 1989. 55p. DOE Contract W-7405-ENG-36. Order Number DE89009692. Source: NTIS, PC A04/MF A01 - OSTI; GPO Dep.

Two cementitious formulations were prepared that contained mixtures of silica-adjusted cementitious binder and tuff of the Topopah Spring Member. Both formulations were developed to possess a bulk chemical composition that approached the bulk silica-to-alumina ratio of the tuff of the Topopah Spring Member. The two formulations represent examples of an expansive (82-22) and a nonexpansive (84-12) cementitious sealing material. The expansive grout relies on the formation of ettringite to generate the expansive forces. Phase characterization of the reaction products for the expansive grout revealed that the expansive agent, ettringite, was not stable above about 100°C. Tobermorite was observed at all temperatures, even at 300°C, well above its expected stability limit. The incorporation of Al into the tobermorite structure is postulated as contributing to the enhanced thermal stability. In the longer experiments, at 200 and 300°C, the Al-tobermorite partially reacted with excess SiO_2 to form truscottite, another calcium silicate hydrate. This observation is consistent with the solution analyses that suggest that the liquid phase in contact with the seal material is very nearly at equilibrium with respect to quartz at 150°C and slightly undersaturated with respect to quartz at 200°C. 12 refs., 11 figs., 12 tabs.

57 (LA–11246-MS) **Preliminary report on the statistical evaluation of sorption data: Sorption as a function of mineralogy, temperature, time, and particle size.** Beckman, R.; Thomas, K.; Crowe, B. Los Alamos National Lab., NM (USA). May 1988. 26p. DOE Contract W-7405-ENG-36. Order Number DE88009204. Source: NTIS, PC A03/MF A01; GPO Dep.

This report studies the transport of radionuclides from a repository to the environment by dissolution of the stored solid-waste form and subsequent transport in water. The sorption process may retard this movement of radionuclides from the repository to the accessible environment. A measure of this retardation process is the sorption ratio, R_D, where R_D = (activity in solid phase per unit mass of solid)(activity in solution per unit volume of solution). In this study, predictions of the R_D values for the elements barium, cerium, cesium, europium, and strontium are developed from linear regression techniques. An R_D value was obtained for numerous drill core samples. Additional data include the particle size of the rock, temperature condition during the experiment, concentration of the sorbing element, and length of the sorption experiment. Preliminary regression results based on these data show that the temperature and length of the experiment are the most significant factors influencing the R_D values. Particle size has a slight effect, and based on a small amount of data, it appears that concentration had no effect. The x-ray diffraction data are used to classify the samples by mineralogy, and regression techniques are used to develop estimates of the R_D values. Zeolite abundance of 10% or more with some addition of clay increases the sorption values significantly. 12 refs., 3 figs., 6 tabs.

58 (LA–11289-MS) **A preliminary comparison of mineral deposits in faults near Yucca Mountain, Nevada, with possible analogs.** Vaniman, D.T.; Bish, D.L.; Chipera, S. Los Alamos National Lab., NM (USA). May 1988. 59p. DOE Contract W-7405-ENG-36. Order Number DE88010486. Source: NTIS, PC A04/MF A01; GPO Dep.

Several faults near Yucca Mountain, Nevada, contain abundant calcite and opal-CT, with lesser amounts of opal-A and sepiolite or smectite. These secondary minerals are being studied to determine the directions, amounts, and timing of transport involved in their formation. Such information is important for evaluating the future performances of a potential high-level nuclear waste repository beneath Yucca Mountain. This report is a preliminary assessment of how those minerals were formed. Possible analog deposits from known hydrothermal veins, warm springs, cold springs or seeps, soils, and aeolian sands were studied by petrographic and x-ray diffraction methods for comparison with the minerals deposited in the faults; there are major mineralogic differences in all of these environments except in the aeolian sands and in some cold seeps. Preliminary conclusions are that the deposits in the faults and in the sand ramps are closely related, and that the process of deposition did not require upward transport from depth. 35 refs., 25 figs.

59 (LA–11292-MS) **Mineralogy of drill hole UE-25p#1 at Yucca Mountain, Nevada.** Chipera, S.J.; Bish, D.L. Los Alamos National Lab., NM (USA). May 1988. 25p. DOE Contract W-7405-ENG-36. Order Number DE88010487. Source: NTIS, PC A03/MF A01.

Drill hole UE-25p#1 is located east of the candidate repository block at Yucca Mountain, Nevada, and as such provides information on the geology of the accessible environment. The hole was drilled to a depth of 1807 m (5923 ft) and is unique in that it penetrates tuffs that are older than any volcanic units previously encountered in drill holes at Yucca Mountain. In addition, it is the only hole drilled to date that penetrates the base of the tuff sequence and enters the underlying Paleozoic dolomite basement. We have examined the mineralogy of drill cuttings, core, and sidewall samples from drill hole UE-25p#1 is similar to that in the other drill holes examined at Yucca Mountain. The only significant differences in mineralogy from other drill holes include the presence of dolomite in the Paleozoic carbonate rocks and the occurrence of up to 3% laumontite, a Ca-zeolite, in four samples of the Lithic Ridge Tuff. 15 refs., 5 figs., 4 tabs.

60 (LA–11293-MS) **Statistical guidelines for planning a limited drilling program.** Campbell, K. Los Alamos National Lab., NM (USA). Jun 1988. 51p. DOE Contract W-7405-ENG-36. Order Number DE88010488. Source: NTIS, PC A04/MF A01; GPO Dep.

Site characterization for potential nuclear waste repository at Yucca Mountain in south-central Nevada will include the construction of a limited number of new drill holes to depths below the repository horizon from which information about the properties of the surrounding and underlying tuffs can be obtained. Quantitative techniques to estimate the amount of information to be gained from a proposed drilling plan are developed. These estimates are to be compared with economic costs and with risk analysis requirements for the potential repository. In some cases the existing data, although extremely limited, are sufficient for preliminary application of these methods. 33 refs., 19 figs., 3 tabs.

61 (LA–11398-MS) **Nevada Nuclear Waste Storage Investigations: Exploratory Shaft Facility fluids and materials evaluation.** West, K.A. Los Alamos National Lab., NM (USA). Nov 1988. 155p. DOE Contract W-7405-ENG-36. Order Number DE89005292. Source: NTIS, PC A08/MF A01 - OSTI; GPO Dep.

The objective of this study was to determine if any fluids or materials used in the Exploratory Shaft Facility (ESF) of Yucca Mountain will make the mountain unsuitable for future construction of a nuclear waste repository. Yucca Mountain, an area on and adjacent to the Nevada Test Site in southern Nevada, USA, is a candidate site for permanent disposal of high-level radioactive waste from commercial nuclear power and defense nuclear activities. To properly characterize Yucca Mountain, it will be necessary to construct an underground test facility, in which in situ site characterization tests can be conducted. The candidate repository horizon at Yucca Mountain, however, could potentially be compromised by fluids and materials used in the site characterization tests. To minimize this possibility, Los Alamos National Laboratory was directed to evaluate the kinds of fluids and materials that will be used and their potential impacts on the site. A secondary objective was to identify fluids and materials, if any, that should be prohibited from, or controlled in, the underground. 56 refs., 19 figs., 11 tabs.

62 (LA–11443-PR) **Research and development related to the Nevada Nuclear Waste Storage Investigations: Progress report, October 1–December 31, 1984.** Thomas, K.W. (comp.). Los Alamos National Lab., NM (USA). Nov 1988. 93p. DOE Contract W-7405-ENG-36. Order Number DE89004539. Source: NTIS, PC A05/MF A01 - OSTI; GPO Dep.

This report summarizes some of the technical contributions by the Los Alamos National Laboratory to the Nevada Nuclear Waste Storage Investigations (NNWSI) Project from October 1 through December 31, 1984. The report is not a detailed technical document but does indicate the status of the investigations being performed at Los Alamos.

63 (LA–11452-MS) **Statistical test of reproducibility and operator variance in thin-section modal analysis of textures and phenocrysts in the Topopah Spring member, drill hole USW VH-2, Crater Flat, Nye County, Nevada.** Moore, L.M. (Los Alamos National Lab., NM (USA)); Byers, F.M. Jr.; Broxton, D.E. Los Alamos National Lab., NM (USA). Jun 1989. 47p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract W-7405-ENG-36. Order Number DE89015327. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

A thin-section operator-variance test was given to the 2 junior authors, petrographers, by the senior author, a statistician, using 16 thin sections cut from core plugs drilled by the US Geological Survey from drill hole USW VH-2 standard (HCQ) drill core. The thin sections are samples of Topopah Spring devitrified rhyolite tuff from four textural zones, in ascending order: (1) lower nonlithophysal, (2) lower lithopysal, (3) middle nonlithophysal, and (4) upper lithophysal. Drill hole USW-VH-2 is near the center of the Crater Flat, about 6 miles WSW of the Yucca Mountain in Exploration Block. The original thin-section labels were opaqued out with removable enamel and renumbered with alpha-numeric labels. The sliders were then given to the petrographer operators for quantitative thin-section modal (point-count) analysis of cryptocrystalline, spherulitic, granophyric, and void textures, as well as phenocryst minerals. Between operator variance was tested by giving the two petrographers the same slide, and within-operator variance was tested by the same operator the same slide to count in a second test set, administered at least three months after the first set. Both operators were unaware that they were receiving the same slide to recount. 14 figs., 6 tabs.

64 (LA–11497-MS) **Revised mineralogic summary of Yucca Mountain, Nevada.** Bish, D.L.; Chipera, S.J. Los Alamos National Lab., NM (USA). Mar 1989. 68p. DOE Contract W-7405-ENG-36. Order Number DE89008957. Source: NTIS, PC A04/MF A01 - OSTI; GPO Dep.

We have evaluated three-dimensional mineral distribution at Yucca Mountain, Nevada, using quantitative x-ray powder diffraction analysis. All data were obtained on core cuttings, or sidewall samples obtained from drill holes at and around Yucca Mountain. Previously published data are included with corrections, together with new data for several drill holes. The new data presented in this report used the internal standard method of quantitative analysis, which yields results of high precision for the phases commonly found in Yucca Mountain tuffs including opal-CT and glass. Mineralogical trends with depth previously noted are clearly shown by these new data. Glass occurrence is restricted almost without exception to above the present-day static water level (SWL), although glass has been identified below the SWL in partially zeolitized tuffs. Silica phases undergo well-defined transitions with depth, with tridymite and cristobalite occurring only above the SWL, opal-CT occurring with clinoptilolite-mordenite tuffs, and quartz most abundant below the SWL. Smectite occurs in small amounts in most samples but is enriched in two distinct zones. These zones are at the top of the vitric nonwelded base of the Tiva Canyon Member and at the top of the basal vitrophyre of the Topopah Spring Member. Our data support the presence of several zones of mordenite and clinoptilolite-heulandite as shown previously. New data on several deep clinoptililite-heulandite samples coexisting with analcime show that they are heulandite. Phillipsite has not been found in any Yucca Mountain samples, but erionite and chabazite have been found once in fractures. 21 refs., 17 figs.

65 (LA–11503-MS) **Petrography and phenocryst chemistry of volcanic units at Yucca Mountain, Nevada: A comparison of outcrop and drill hole samples.** Broxton, D.E.; Byers, F.M. Jr.; Warren, R.G. Los Alamos National Lab., NM (USA). Apr 1989. 69p. DOE Contract W-7405-ENG-36. Order Number DE89010550. Source: NTIS, PC A04/MF A01 - OSTI; GPO Dep.

This report is a compilation of petrographic and mineral chemical data for stratigraphic units at Yucca Mountain. It supports a possible peer review of Yucca Mountain drill core by summarizing the available data in a form that allows comparison of stratigraphic units in drill holes with surface outcrops of the same units. Petrographic and mineral chemical data can be used in conjunction with other geologic and geophysical information to determine if stratigraphic relations in Yucca Mountain drill core are geologically reasonable and compare well with relations known from extensive surface studies. This compilation of petrographic and mineral chemical data is complete enough for most stratigraphic units to be used in a peer review of Yucca Mountain drill core. Additional data must be collected for a few units to complete the characterization. Rock units at Yucca Mountain have unique petrographic and mineral chemical characteristics that can be used to make accurate stratigraphic assignments in drill core samples. Stratigraphic units can be differentiated on the basis of petrographic characteristics such as total phenocryst abundances, relative proportions of phenocryst minerals, and type and abundances of mafic and accessory minerals. The mineral chemistry of phenocrysts is also an important means of differentiating among stratigraphic units, especially when used in conjunction with the petrographic data. Sanidine phenocrysts and plagioclase rims have narrow compositional ranges for most units and often have well-defined dominant compositions. Biotite compositions are useful for identifying groups of related units (e.g., Paintbrush Tuff Members vs Crater Flat Tuff Members) and for providing an important check on the consistency of the data. 21 refs., 12 figs., 2 tabs.

66 (LA–11504-MS) **Fracture-coating minerals in the Topopah Spring Member and upper tuff of Calico Hills from drill hole J-13.** Carlos, B. Los Alamos National Lab., NM (USA). Feb 1989. 21p. DOE Contract W-7405-ENG-36. Order Number DE89007100. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Fracture-lining minerals from drill core in the Topopah Spring Member of the Paintbrush Tuff and the tuff of Calico Hills from water well J-13 were studied to identify the differences between these minerals and those seen in drill core USW G-4. In USW G-4 the static water level (SWL) occurs below the tuff of Calico Hills, but in J-13 the water table is fairly high in the Topopah Spring Member. There are some significant differences in fracture minerals between these two holes. In USW G-4 mordenite is a common fracture-lining mineral in the Topopah Spring Member, increasing in abundance with depth. Euhedral heulandite >0.1 mm in length occurs in fractures for about 20 m above the lower vitrophyre. In J-13, where the same stratigraphic intervals are below the water table, mordenite is uncommon and euhedral heulandite is not seen. The most abundant fracture coating in the Topopah Spring Member in J-13 is drusy quartz, which is totally absent in this interval in USW G-4. Though similar in appearance, the coatings in the vitrophyre have different mineralogy in the two holes. In USW G-4 the coatings are extremely fine grained heulandite and smectite. In J-13 the coatings are fine-grained heulandite, chabazite, and alkali feldspar. Chabazite has not been identified from any other hole in the Yucca Mountain area. Fractures in the tuff of Calico Hills have similar coatings in core from both holes. In J-13, as in USW G-4, the tuff matrix of the Topopah Spring Member is welded and devitrified and that of the tuff of Calico Hills is zeolitic. 11 refs., 10 figs., 5 tabs.

67 (LA–11527-MS) **Studies of ancient concrete as analogs of cementitious sealing materials for a repository in tuff.** Roy, D.M.; Langton, C.A. Los Alamos National Lab., NM (USA). Mar 1989. 106p. DOE Contract W-7405-ENG-36. Order Number DE89009687. Source: NTIS, PC A06/MF A01 - OSTI; GPO Dep.

The durability of ancient cementitious materials has been investigated to provide data applicable to determining the resistance to weathering of concrete materials for sealing a repository for storage of high-level radioactive waste. Because tuff and volcanic ash are used in the concretes in the vicinity of Rome, the results are especially applicable to a waste repository in tuff. Ancient mortars, plasters, and concretes collected from Rome, Ostia, and Cosa dating to the third century BC show remarkable durability. The aggregates used in the mortars, plasters, and concretes included basic volcanic and pyroclastic rocks (including tuff), terracotta, carbonates, sands, and volcanic ash. The matrices of ancient cementitious materials have been characterized and classified into four categories: (1) hydraulic hydrated lime and hydrated lime cements, (2) hydraulic aluminous and ferruginous hydrated lime cements (± siliceous components), (3) pozzolana/hydrated lime cements, and (4) gypsum cements. Most of the materials investigated are in category (3). The materials were characterized to elucidate aspects of the technology that produced them and their response to the environmental exposure throughout their centuries of existence. Their remarkable properties are the result of a combination of chemical, mineralogical, and microstructural factors. Their durability was found to be affected by the matrix mineralogy, particle size, and porosity; aggregate type, grading and proportioning; and the methodology of placement. 30 refs.

68 (LA–11532-MS) **Reactivity of a tuff-bearing concrete: CL-40 CON-14.** Scheetz, B.E.; Roy, D.M. Los Alamos National Lab., NM (USA). Apr 1989. 89p. DOE Contract W-7405-ENG-36. Order Number DE89010549. Source: NTIS, PC A05/MF A01 - OSTI; GPO Dep.

Samples of a tuff-bearing concrete have been altered in J-13 groundwater and in the vapor phase over deionized water at 200°C. Crushed and intact discs of the concrete have been studied. The glassy tuff component of the tuff was more extensively reacted than the welded devitrified tuff. The original concrete was formulated to be expansive on curing through the formation of the calcium aluminosulfate hydrate phase, ettringite. An x-ray diffraction examination of the altered crushed samples shows that the ettringite is no longer present. The original, poorly crystalline calcium-silicate-hydrate has recrystallized to tobermorite. In the rocking autoclave experiments with crushed material, which are the experiments expected to have the fastest reaction rates, the tobermorite has been replaced by a mineral of the gyrolite-truscottite group at the longer reaction times. The disc experiments in J-13 groundwater are characterized by prominent dissolution of the tuff aggregate. Alteration in the vapor phase experiments is primarily in the form of overgrowths on the discs. 10 refs., 27 figs., 12 tabs.

69 (LA–11605-MS) **Study plan for water movement test: Site Characterization Plan Study 8.3.1.2.2.2.** Norris, A.E. (Los Alamos National Lab., NM (USA)). Los Alamos National Lab., NM (USA). Sep 1989. 21p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract W-7405-ENG-36. Order Number DE89016019. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The water movement tracer test is designed to produce information derived from isotopic measurements of soil and tuff samples collected from Yucca Mountain that is pertinent for assessing the performance of a nuclear waste repository. Measurements of chlorine isotropic distributions will help characterize the percolation of precipitation into the unsaturated zone. The ^{36}Cl in the unsaturated zone occurs from atmospheric fallout of ^{36}Cl produced by cosmic-ray secondaries reacting with ^{40}Ar and, to a lesser extent, with ^{36}Ar. It also occurs as global fallout from high-yield nuclear weapons tests conducted at the Pacific Proving Grounds between 1952 and 1962. When chloride ions at the surface are washed underground by precipitation, the radioactive decay of the ^{36}Cl in the chloride can be used to time the rate of water movement. The ^{36}I half-life of 301,000 yr permits the detection of water movement in the range of approximately 50,000 to 2 million years. These data are part of the input for developing numerical models of ground water flow at this site. 5 refs., 4 figs., 4 tabs.

70 (LA–11663-MS) **The occurrence and distribution of erionite at Yucca Mountain, Nevada.** Chipera, S.J.; Bish, D.L. Los Alamos National Lab., NM (USA). Sep 1989. 20p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract W-7405-ENG-36. Order Number DE89017905. Source: NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

We have conducted an investigation to determine the occurrence and distribution of erionite, a potential carcinogen, at Yucca Mountain, Nevada. Using x-ray powder diffraction techniques yielding detection limits to below 0.05 wt %, we positively identified erionite in only 3 out of 76 bulk and 12 fracture samples investigated. The three erionite-bearing samples (J12-620/630, UE-25aNo.1-1296.2, and USW G4-1314) all occur above the static water level in clay/zeolite-rich horizons near the top of vitrophyres. Erionite occurs as trace amounts of less than 1 wt % in the whole rock, although it may occur locally in significant amounts as fracture fillings (e.g., UE-25aNo.1-1296.2 where it comprises approximately 45 wt % of the fracture filling material). All three occurrences appear to be extremely isolated cases since erionite was not detected in neighboring samples. Erionite at Yucca Mountain apparently formed only in localized microenvironments, possibly restricted to fractures. Since erionite occurs in trace amounts only in extremely isolated instances, it should pose little or no health hazard to workers in the potential repository at Yucca Mountain or to the public. The amounts of erionite liberated to the biosphere should be negligible, particularly when compared with the amounts of erionite occurring naturally at the surface in Nevada and surrounding states. 24 refs., 7 figs., 2 tabs.

71 (LA–11665-SR) **The Yucca Mountain Project Prototype Testing Program: 1989 Status report.** Los Alamos National Lab., NM (USA). Oct 1989. 32p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract W-7405-ENG-36. Order Number DE90000947. Source: NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

The Yucca Mountain Project is conducting a Prototype Testing Program to ensure that the Exploratory Shaft Facility (ESF) tests can be completed in the time available and to develop instruments, equipment, and procedures so the ESF tests can collect reliable and representative site characterization data. This report summarizes the prototype tests and their status and location and emphasizes prototype ESF and surface tests, which are required in the early stages of the ESF site characterization tests. 14 figs.

72 (LA–11669-MS) **Quantitative x-ray diffraction analyses of samples used for sorption studies by the Isotope and Nuclear Chemistry Division, Los Alamos National Laboratory.** Chipera, S.J.; Bish, D.L. Los Alamos National Lab., NM (USA). Sep 1989. 20p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract W-7405-ENG-36. Order Number DE89017906. Source: NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

Yucca Mountain, Nevada, is currently being investigated to determine its suitability to host our nation's first geologic high-level nuclear waste repository. As part of an effort to determine how radionuclides will interact with rocks at Yucca Mountain, the Isotope and Nuclear Chemistry (INC) Division of Los Alamos National Laboratory has conducted numerous batch sorption experiments using core samples from Yucca Mountain. In order to understand better the interaction between the rocks and radionuclides, we have analyzed the samples used by INC with quantitative x-ray diffraction methods. Our analytical methods accurately determine the presence or absence of major phases, but we have not identified phases present below ~1 wt %. These results should aid in understanding and predicting the potential interactions between radionuclides and the rocks at Yucca Mountain, although the mineralogic complexity of the samples and the lack of information on trace phases suggest that pure mineral studies may be necessary for a more complete understanding. 12 refs., 1 fig., 1 tab.

73 (LA-UR–86-556) **Kriging for interpolation of sparse and irregularly distributed geologic data.** Campbell, K. Los Alamos National Lab., NM (USA). 1986. 19p. DOE Contract W-7405-ENG-36. (CONF-8608125–4: American Statistical Association meeting, Chicago, IL, US, August 18, 1986). Order Number DE87013293. Source: NTIS, PC A02/MF A01; GPO Dep.

For many geologic problems, subsurface observations are available only from a small number of irregularly distributed locations, for example from a handful of drill holes in the region of interest. These observations will be interpolated one way or another, for example by hand-drawn stratigraphic cross-sections, by trend-fitting techniques, or by simple averaging which ignores spatial correlation. In this paper we consider an interpolation technique for such situations which provides, in addition to point estimates, the error estimates which are lacking from other ad hoc methods. The proposed estimator is like a kriging estimator in form, but because direct estimation of the spatial covariance function is not possible the parameters of the estimator are selected by cross-validation. Its use in estimating subsurface stratigraphy at a candidate site for geologic waste repository provides an example.

74 (LA-UR–87-3854) **Preliminary geochemical/geophysical model of Yucca Mountain.** Greenwade, L.E.; Cederberg, G.A. Los Alamos National Lab., NM (USA). 1987. 14p. DOE Contract W-7405-ENG-36. (CONF-8711100–1: Symposium on the scientific basis for nuclear waste management, Boston, MA, US, November 30, 1987). Order Number DE88003165. Source: NTIS, PC A03/MF A01; GPO Dep.

A comprehensive geochemical/geophysical model incorporates the current and relevant stratigraphic, petrologic, hydrogeologic, geochemical, and material data associated with a candidate repository at Yucca Mountain, Nevada. A geochemical/geophysical model will provide support and confidence to the Systems Performance calculations, determine whether the data collected as part of the site characterization provide the information needed by the design and performance assessment task, and provide the most accurate and referenced foundation on which to base the radionuclide transport calculations. In this report, the known repository data are compiled and unknown parameter values are estimated based on the available data. It is concluded that more data are needed before the geochemical/geophysical model of Yucca Mountain can be regarded as satisfactory and suitable base for multidimensional predicative flow and transport simulations. Recommendations for future studies concerning site characterization and data acquisition are presented. 36 refs., 1 fig., 2 tabs.

75 (LA-UR–88-4155) **Preliminary geologic map of the Lathrop Wells volcanic center.** Crowe, B.; Harrington, C.; McFadden, L.; Perry, F.; Wells, S.; Turrin, B.; Champion, D. Los Alamos National Lab., NM (USA). Dec 1988. 10p. DOE Contract W-7405-ENG-36. Order Number DE89008185. Source: NTIS, PC A02/MF A01 - OSTI; GPO Dep.

A preliminary geologic map has been compiled for the bedrock geology of the Lathrop Wells volcanic center. The map was completed through use of a combination of stereo photographic interpretation and field mapping on color aerial photographs. These photographs (scale 1:4000) were obtained from American Aerial Surveys, Inc. They were flown on August 18, 1987, at the request of the Yucca Mountain Project (then Nevada Nuclear Waste Storage Investigations). The photographs are the Lathrop Wells VC-Area 25 series, numbers 1–32. The original negatives for these photographs are on file with American Aerial Surveys, Inc. Copies of the negatives have been archived at the Los Alamos National Laboratory, Group N-5. The preliminary geologic map is a bedrock geologic map. It does not show alluvial deposits, eolian sands, or scoria fall deposits from the youngest eruptive events. The units will be compiled on separate maps when the geomorphic and soils studies are more advanced.

76 (LA-UR–89-781) **Volcanic hazard studies for the Yucca Mountain project.** Crowe, B.; Turrin, B.; Wells, S.; Perry, F.; McFadden, L.; Renault, C.E.; Champion, D.; Harrington, C. Los Alamos National Lab., NM (USA). 1989. 17p. DOE Contract W-7405-ENG-36. (CONF-890207–16: Waste management '89, Tucson, AZ, US, February 26, 1989). Order Number DE89009404. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Volcanic hazard studies are ongoing to evaluate the risk of future volcanism with respect to siting of a repository for disposal of high-level radioactive waste at the Yucca Mountain site. Seven Quaternary basaltic volcanic centers are located a minimum distance of 12 km and a maximum distance of 47 km from the outer boundary of the exploration block. The conditional probability of disruption of a repository by future basaltic volcanism is bounded by the range of 10^{-8} to 10^{-10} yr^{-1}. These values are currently being reexamined based on new developments in the understanding of the evaluation of small volume, basaltic volcanic centers including: (1) Many, perhaps most, of the volcanic centers exhibit brief periods of eruptive activity separated by longer periods of inactivity. (2) The centers may be active for time spans exceeding 10^5 yrs, (3) There is a decline in the volume of eruptions of the centers through time, and (4) Small volume eruptions occurred at two of the Quaternary centers during latest Pleistocene or Holocene time. We classify the basalt centers as polycyclic, and distinguish them from polygenetic volcanoes. Polycyclic volcanism is characterized by small volume, episodic eruptions of magma of uniform composition over time spans of 10^3 to 10^5 yrs. Magma eruption rates are low and the time between eruptions exceeds the cooling time of the magma volumes. 25 refs., 2 figs.

77 (LA-UR–89-2541) **Formation, characterization, and stability of plutonium (IV) colloid: A progress report.** Hobart, D.E. (Los Alamos National Lab., NM (USA));

Morris, D.E.; Palmer, P.D.; Newton, T.W. Los Alamos National Lab., NM (USA). 1989. 9p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract W-7405-ENG-36. (CONF-890928–1: Nuclear waste isolation in the unsaturated zone: FOCUS '89, Las Vegas, NV (USA), 18-21 Sep 1989). Order Number DE89015288. Source: NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Plutonium is expected to be a major component of the waste element package in any high-level nuclear waste repository. Plutonium(IV) is known to form colloids under chemical conditions similar to those found in typical groundwaters. In the event of a breach of a repository, these colloids represent a source of radionuclide transport to the far-field environment, in parallel with the transport of dissolved waste element species. In addition, the colloids may decompose or disaggregate into soluble ionic species. Thus, colloids represent an additional term in determining waste element solubility limits. A thorough characterization of the physical and chemical properties of these colloids under relevant conditions is essential to assess the concentration limits and transport mechanisms for the waste elements at the proposed Yucca Mountain Repository site. This report is concerned primarily with recent results obtained by the Yucca Mountain Project (YMP) Solubility Determination Task pertaining to the characterization of the structural and chemical properties of Pu(IV) colloid. Important results will be presented which provides further evidence that colloidal plutonium(IV) is structurally similar to plutonium dioxide and that colloidal plutonium(IV) is electrochemically reactive. 13 refs., 7 figs.

78 (LA-UR–89-2573) **The use of chlorine isotope measurements to trace water movements at Yucca Mountain.** Norris, A.E. (Los Alamos National Lab., NM (USA)). Los Alamos National Lab., NM (USA). 1989. 7p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract W-7405-ENG-36. (CONF-890928–2: Nuclear waste isolation in the unsaturated zone: FOCUS '89, Las Vegas, NV (USA), 18-21 Sep 1989). Order Number DE89015278. Source: NTIS, PC A02/MF A01 - OSTI; GPO Dep.

The rates of water movements in the tuffs at Yucca Mountain are important for assessing the performance of a potential high-level nuclear waste repository. Measurements of cosmogenic 3.0×10^5 yr ^{36}Cl in tuff from the unsaturated zone and in water from the saturated zone can provide information about water movements over times of 10^{15} to 10^6 years. The data derived from the analysis of cuttings from a dry-drilled hole at Yucca Mountain indicate the presence of a ^{36}Cl background that must be taken into account for proper interpretation of the ^{36}Cl interpretation of the ^{36}Cl results. Similarly, the ^{36}Cl measured in water from the saturated zone requires additional work for correct interpretation. Fallout of ^{36}Cl from nuclear weapons tests between 1952 and 1962 provided a tracer for an infiltration study. Measurements of the ^{36}Cl bomb pulse in tuffs from the unsaturated zone show potential for tracing recent water flow in faults and fractures. 5 refs.

79 (LA-UR–89-2952) **Mineralogy-petrology studies and natural barriers at Yucca Mountain, Nevada.** Bolivar, S.L. (Los Alamos National Lab., NM (USA)); Broxton, D.E.; Bish, D.L.; Byers, F.M.; Carlos, B.H.; Levy, S.S.; Vaniman, D.T.; Chipera, S.J. Los Alamos National Lab., NM (USA). [1989]. 10p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract W-7405-ENG-36. (CONF-890928–3: Nuclear waste isolation in the unsaturated zone: FOCUS '89, Las Vegas, NV (USA), 18-21 Sep 1989). Order Number DE89016778. Source: NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

Yucca Mountain is being studied as a potential site for an underground, high-level nuclear waste repository. The site is underlain by a thick sequence of lithologically variable pyroclastic rocks. The candidate host rock is a densely welded devitrified tuff, the Topopah Spring Member of the Paintbrush Tuff. The water table is about 200–400 m below the potential repository. The types, distributions, and abundances of both rock-matrix and fracture-lining minerals along potential transport pathways between the proposed repository and accessible environment are described. Our work emphasizes the distribution of secondary minerals such as zeolites, clays, and Fe and Mn oxides because of their ability to selectivity sorb or retard certain radionuclides. We are also examining both the conditions under which mineral assemblages form and their thermal stabilities. Mineralogic and petrologic studies of the candidate host rock and the underlying units will help establish whether these rock units will act as effective, long-term natural barriers to radionuclide transport. 28 refs., 4 figs., 1 tab.

80 (LA-UR–89-3095) **Laboratory studies of radionuclide migration in tuff.** Rundberg, R.S.; Mitchell, A.J.; Ott, M.A.; Thompson, J.L.; Triay, I.R. Los Alamos National Lab., NM (USA). 1989. 16p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract W-7405-ENG-36. (CONF-890928–4: Nuclear waste isolation in the unsaturated zone: FOCUS '89, Las Vegas, NV (USA), 18-21 Sep 1989). Order Number DE90001834. Source: NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

The movement of selected radionuclides has been observed in crushed tuff, intact tuff, and fractured tuff columns. Retardation factors and dispersivities were determined from the elution profiles. Retardation factors have been compared with those predicted on the basis of batch sorption studies. This comparison forms a basis for either validating distribution coefficients or providing evidence of speciation, including colloid formation. Dispersivities measured as a function of velocity provide a means of determining the effect of sorption kinetics or mass transfer on radionuclide migration. Dispersion is also being studied in the context of scaling symmetry to develop a basis for extrapolating from the laboratory scale to the field. 21 refs., 6 figs., 2 tabs.

81 (LA-UR–89-3116) **Experiences of fitting isotherms to data from batch sorption experiments for radionuclides on tuffs.** Polzer, W.L. (Los Alamos National Lab., NM (USA)); Fuentes, H.R. Los Alamos National Lab., NM (USA). Nov 1989. 22p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract W-7405-ENG-36. (CONF-891120–2: Migration '89: 2nd international conference on chemistry and migration behavior of actinides and fission products in the geosphere, Monterey, CA (USA), 6-10 Nov 1989). Order Number DE90001830. Source: NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

Laboratory experiments have been performed on the sorption of radionuclides on tuff as site characterization information for the Yucca Mountain Project. This paper presents general observations on the results of curve-fitting of sorption data by isotherm equations and the effects of experimental variables on their regressional analysis. Observations are specific to the effectiveness and problems associated with fitting isotherms, the calculation and value of isotherm parameters, and the significance of experimental variables such as replication, particle size, mode of sorption, and mineralogy. These observations are important in the design of laboratory experiments to ensure that collected data are adequate for effectively characterizing sorption of radionuclides on tuffs or other materials. 13 refs., 2 figs., 4 tabs.

82 (LA-UR-89-3210) **Sorption of radionuclides on Yucca Mountain tuffs.** Meijer, A.; Triay, I.; Knight, S.; Cisneros, M. Los Alamos National Lab., NM (USA). [1989]. 6p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract W-7405-ENG-36. (CONF-890928-9: Nuclear waste isolation in the unsaturated zone: FOCUS '89, Las Vegas, NV (USA), 18-21 Sep 1989). Order Number DE90000198. Source: NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

A substantial database of sorption coefficients for important radionuclides on Yucca Mountain tuffs has been obtained by Los Alamos National Laboratory over the past ten years. Current sorption studies are focussed on validation questions and augmentation of the existing database. Validation questions concern the effects of the use of crushed instead of solid rock samples in the batch experiments, the use of oversaturated stock solutions, and variations in water/rock ratios. Sorption mechanisms are also being investigated. Database augmentation activities include determination of sorption coefficients for elements with low sorption potential, sorption on psuedocolloids, sorption on fracture lining minerals, and sorption kinetics. Sorption can provide an important barrier to the potential migration of radionuclides from the proposed repository within Yucca Mountain to the accessible environment. In order to quantify this barrier, sorption coefficients appropriate for the Yucca Mountain groundwater system must be obtained for each of the important radionuclides in nuclear waste. Los Alamos National Laboratories has conducted numerous batch (crushed-rock) sorption experiments over the past ten years to develop a sorption coefficient database for the Yucca Mountain site. In the present site characterization phase, the main goals of the sorption test program will be to validate critical sorption coefficients and to augment the existing database where important data are lacking. 11 refs., 1 fig., 3 tabs.

83 (LA-UR-89-3503) **Preliminary integrated calculation of radionuclide cation and anion transport at Yucca Mountain using a geochemical model.** Birdsell, K.H.; Campbell, K.; Eggert, K.G.; Travis, B.J. Los Alamos National Lab., NM (USA). [1989]. 21p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract W-7405-ENG-36. (CONF-890928-12: Nuclear waste isolation in the unsaturated zone: FOCUS '89, Las Vegas, NV (USA), 18-21 Sep 1989). Order Number DE90002402. Source: NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

This paper presents preliminary transport calculations for radionuclide movement at Yucca Mountain using preliminary data for mineral distributions, retardation parameter distributions, and hypothetical recharge scenarios. These calculations are not performance assessments, but are used to study the effectiveness of the geochemical barriers at the site at mechanistic level. The preliminary calculations presented have many shortcomings and should be viewed only as a demonstration of the modeling methodology. The simulations were run with TRACRN, a finite-difference porous flow and radionuclide transport code developed for the Yucca Mountain Project. Approximately 30,000 finite-difference nodes are used to represent the unsaturated and saturated zones underlying the repository in three dimensions. Sorption ratios for the radionuclides modeled are assumed to be functions of mineralogic assemblages of the underlying rock. These transport calculations present a representative radionuclide cation, ^{135}Cs and anion, ^{99}Tc. The effects on transport of many of the processes thought to be active at Yucca Mountain may be examined using this approach. The model provides a method for examining the integration of flow scenarios, transport, and retardation processes as currently understood for the site. It will also form the basis for estimates of the sensitivity of transport calculations to retardation processes. 11 refs., 17 figs., 1 tab.

84 (LA-UR-89-3702) **Size determinations of plutonium colloids using autocorrelation photon spectroscopy.** Triay, I.R.; Rundberg, R.S.; Mitchell, A.J.; Ott, M.A.; Hobart, D.E.; Palmer, P.D.; Newton, T.W.; Thompson, J.L. Los Alamos National Lab., NM (USA). [1989]. 15p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract W-7405-ENG-36. (CONF-891120-6: Migration '89: 2nd international conference on chemistry and migration behavior of actinides and fission products in the geosphere, Monterey, CA (USA), 6-10 Nov 1989). Order Number DE90003168. Source: NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

Autocorrelation Photon Spectroscopy (APS) is a light-scattering technique utilized to determine the size distribution of colloidal suspensions. The capabilities of the APS methodology have been assessed by analyzing colloids of known sizes. Plutonium(IV) colloid samples were prepared by a variety of methods including: dilution; peptization; and alpha-induced auto-oxidation of Pu(III). The size of theses Pu colloids was analyzed using APS. The sizes determined for the Pu colloids studied varied from 1 to 370 nanometers. 7 refs., 5 figs., 3 tabs.

85 (LBL-27156) **Letter report (T-418): Progress report on solubility measurements, October 1, 1987–September 30, 1988.** Nitsche, H. (Lawrence Berkeley Lab., CA (USA)). Lawrence Berkeley Lab., CA (USA). 21 Mar 1989. 16p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC03-76SF00098. Order Number DE89014889. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

This letter report describes the technical activities of the waste element solubility study during Fiscal Year (FY88, October 1, 1987 to September 30, 1988). This experimental waste element solubility study provides experimentally determined limits on radionuclide concentrations in groundwater from Yucca Mountain. Furthermore, the results of this study are essential for verifying the validity of radionuclide transport calculations, and for providing the maximum concentrations for the radionuclide sorption tests. Solubility is the source term for radionuclide transport calculations. The solubility in this study is controlled by fewer variables than are used in the multiparameter transport model. Therefore, modeling must be capable of predicting the results of this waste element solubility study. Agreement between the experimental result and the modeling predictions will validate the geochemical module of the transport model. 3 refs., 8 figs.

86 (LBL-27157) **Solubility and speciation studies of waste radionuclides pertinent to geologic disposal at Yucca Mountain: Results on neptunium, plutonium and**

americium in J-13 groundwater: Letter report (R707): Reporting period, October 1, 1985–September 30, 1987. Nitsche, H. (Lawrence Berkeley Lab., CA (USA)); Standifer, E.M.; Lee, S.C.; Gatti, R.C.; Tucker, D.B. Lawrence Berkeley Lab., CA (USA). Jan 1988. 70p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC03-76SF00098. Order Number DE89014896. Source: NTIS, PC A04/MF A01 - OSTI; GPO Dep.

We have studied the solubilities of neptunium, plutonium, and americium in J-13 groundwater from Yucca Mountain (Nevada) at three temperatures and hydrogen ion concentrations. They are 25°, 60°C, and 90°C and pH 5.9, 7.0, and 8.5. The results for 25°C are from a study which we did during FY 1984. We included these previous results in the tables to give more information on the solubility temperature dependence; they were, however, done at only one pH (7.0). The solubilities were studied from oversaturation. The nuclides were added at the beginning of each experiment as NpO_2^+, Pu^{4+}, and Am^{3+}. The neptunium solubility decreased with increasing temperature and with increasing pH. The soluble neptunium did not change oxidation state at steady state. The pentavalent neptunium was increasingly complexed by carbonate with increasing pH. All solids were crystalline and contained carbonate, except the solid formed at 90°C and pH 5.9. We identified this solid as crystalline Np_2P_5. The 25°C, pH 7 solid was $Na_3NpO_2(CO_3)_2 \cdot nH_2O$. Plutonium concentrations decreased with increasing temperature and showed no trend with pH. Pu(V) and Pu(VI) were the dominant oxidation states in the supernatant solution; as the amount of Pu(V) increased with pH, Pu(VI) decreed. The steady-state solids were mostly amorphous, although some contained a crystalline component. They contained Pu(IV) polymer and unknown carbonates.

87 Sorption of radionuclides in tuff using groundwaters of various compositions. Knight, S.D. (Los Alamos National Lab., NM (USA)); Thomas, K.W. 194th national meeting of the American Chemical Society, Division of Nuclear Chemistry and Technology. American Chemical Society, (1987). pp. 9 (CONF-8708244-: American Chemical Society Division of Nuclear Chemistry and Technology meeting, New Orleans, LA, US, August 30, 1987).

Three natural and several synthetic groundwaters were used to investigate the sorptive properties of a few selected radionuclides on tuff. The natural groundwaters were pumped from wells in the Yucca Mountain area that is being considered by the Nevada Nuclear Waste Storage Investigations Project as a possible site for a nuclear waste repository. The synthetic groundwaters were prepared to identify which components had the greatest effect in changing the sorptive behavior of the radionuclides studied. The tuff samples had various mineralogic compositions which were characteristic of the Yucca Mountain area. The radionuclides selected for this study were ^{85}Sr, ^{137}Cs, ^{133}Ba, ^{152}Eu, and ^{113}Sn, all at low concentration levels ($<10^{-7}$ M). Observed changes in sorptive behavior with the different groundwaters were element-dependent, and within the concentration ranges studied, no single ionic species appeared to exert a controlling influence on the sorption of these radionuclides.

88 Clinoptilolite compositions in diagenetically-altered tuffs at a potential nuclear waste repository, Yucca Mountain, Nevada. Broxton, D.E. (Los Alamos National Lab., NM (USA)). pp. 179-194 of Interface science and engineering '87. Hofmann, P.L. (ed.). Battelle Memorial Institute, Columbus, Ohio (1987). pp. 16

The compositions of Yucca Mountain clinoptilolites and their host tuffs are highly variable. Clinoptilolites and heulandites in fractures near the repository and in a thin, altered zone at the top of the Topopah Spring basal vitrophyre have consistent calcium-rich compositions. Below this level, clinoptilolites in thick zones of diagenetic alteration on the east side of Yucca Mountain have calcic-potassic compositions and become more calcium rich with depth. Clinoptilolites in stratigraphically equivalent tuffs to the west have sodic-potassic compositions and become more sodic with depth. Clinoptilolite properties important for repository performance assessment include thermal expansion/contraction behavior, hydration/dehydration behavior, and ion-exchange properties. These properties can be significantly affected by clinoptilolite compositions. The compositional variations for clinoptilolites found by this study suggest that the properties will vary vertically and laterally at Yucca Mountain. Used in conjunction with experimental data, the clinoptilolite compositions presented here can be used to model the behavior of clinoptilolites in the repository environment and along transport pathways.

89 Solute leaching from resin/tuff media in unsaturated flow: experiments and characterization. Fuentes, H.R. (Los Alamos National Lab., NM (USA)); Essington, E.H.; Polzer, W.L. *Radioactive Waste Management (Switzerland),* 10(4): 285-320 (Jun 1988).

Prediction of solute transport at shallow land burial facilities requires a knowledge of the rates of release of solutes (source term) from the buried wastes and of those processes affecting transport through the surrounding media. The leaching (removal) of lithium, strontium, and cesium from a resin/tuff mixture was conducted under unsaturated steady and unsteady (drainage) flow conditions in both laboratory columns and intermediate-scale field caissons to approximate the conditions of buried contaminated-waste resins. Lithium was leached most rapidly and strontium least rapidly. Stopping the flow for a period of 40 to 60 days to create drainage (unsteady flow) conditions had very little effect on the concentrations of solutes leached from the resin/tuff layer. Leaching of these solutes in laboratory columns simulated the large-scale (caisson) leaching very well. Thus, laboratory studies may be reasonable predictors of leaching under certain large-scale field conditions. Also, leaching appears to be a kinetics-controlled process that, for the experimental conditions of this study, may be represented by simple first-order kinetics. 18 refs.; 12 figs.; 8 tabs.

90 Actinide behavior on crushed rock columns. Thompson, J.L. (Los Alamos National Lab., NM (USA)). *Journal of Radioanalytical and Nuclear Chemistry (Switzerland),* 130(2): 353-364 (Apr 1989).

The interactions of dissolved or colloidal actinides with tuffaceous rock are being studied at Los Alamos National Laboratory. Small columns of crushed tuff were used to obtain information on the sorption of neptunium, plutonium and americium during short (<1 day) time spans. Data from these experiments supplement information obtained from longer term batch-type experiments and provide insight concerning sorption kinetics, speciation, and colloid migration. Np(V), Pu(VI) and Pu(V) are found to show limited sorption on crushed tuff. Pu(IV) polymer and Am(III) are largely retained by the tuff, with a small fraction of the input material moving through the column as colloids. (author) 9 refs.; 3 figs.

91 Use of a heterogeneity-based isotherm to interpret the transport of radionuclides in volcanic tuff media. Polzer, W.L. (Los Alamos National Lab. (LANL), NM (USA). Health Safety and Environmental Div.); Fuentes, H.R. *Radiochimica Acta (F.R. Germany),* 44/45(pt.2): 361-365 (1988). (CONF-870965–: International conference on chemistry and migration behaviour of actinides and fission products in the geosphere (Migration '87), Munich, DE, September 14, 1987).

The sorption of cesium and strontium has been modeled with a heterogeneity-based isotherm equation for various tuff materials including those within a sequence of geologic stratigraphic units. The theory of the isotherm foresees the relative retardation and the 'chemical dispersion' of the studied radionuclides during transport. The concepts of heterogeneity of sites and variability in the maximum number of sites available for sorption are incorporated into the model.

92 Infiltration at Yucca Mountain, Nevada, traced by ^{36}Cl. Norris, A.E. (Los Alamos National Lab., NM (USA)); Wolfsberg, K.; Gifford, S.K.; Bentley, H.W.; Elmore, D. *Nuclear Instruments and Methods in Physics Research, Section B: Beam Interactions with Materials and Atoms (Netherlands),* 29(1/2): 376-379 (Nov 1987). (CONF-8704112–: 4. international symposium on accelerator mass spectrometry, Ontario, CA, April 27, 1987).

Measurements of chloride and ^{36}Cl in soils from two locations near Yucca Mountain, Nevada, have been used to trace the infiltration of precipitation in this arid region. The results show that the ^{36}Cl fallout from nuclear-weapons testing formed a well-defined peak at one location, with a maximum ^{36}Cl/Cl ratio 0.5 m below the surface. The structure of the ^{36}Cl bomb pulse at the other location was much more complex, and the quantity of ^{36}Cl in the bomb pulse was $<$ 1% of the 6 x 10^{12} atoms ^{36}Cl/m^2 in the bomb pulse at the first location. The data indicate hydrologic activity subsequent to the ^{36}Cl bomb-pulse fallout at one location, but none at the other location.

93 Phenocryst abundances and glass and phenocryst compositions as indicators of magmatic environments of large-volume ash flow sheets in southwestern Nevada. Warren, R. G. (Los Alamos National Laboratory, Los Alamos, New Mexico(US)); Byers, F. M., Jr.; Broxton, D. E.; Freeman, S. H.; Hagan, R. C. *Journal of Geophysical Research (USA),* 94(B5): 5987-6020 (10 May 1989).

The Topopah Spring, Tiva Canyon, Rainier Mesa, and Ammonia Tanks tuffsare large-volume, silicic ash flow sheets that provide samples of fourmagmatic systems in southwestern Nevada. Successively erupted within a span of2 m.y. from the same source area, they allow comparison of the sequentialevolution of large-volume, mature Cordilleran magmatic systems. Each largesheet has a rhyolitic lower zone and quartz latitic upper zone. Coeval-basaltic andesite and basalt show petrochemical continuity with these sheetsand may represent mantle contributions that triggered eruptions of themidcrustal silicic portion. Abundance of phenocrysts and accessory phasesincrease upward with whole rock Fe (FeOt) from the base of all four sheets tomaximum values unique for each system. Although maximum abundances of eachmineral are unique for each sheet, each maximum occupies the same relativeposition within each sheet. High-temperature minerals such as plagioclaseincrease in abundance continuously with FeOt in each system, showing a decreasewith FeOt only within basaltic andesite at the base of the Rainier Mesasystem. Late crystallizing minerals such as quartz and sphene show maximumabundances at much lower FeOt, at or near the top of the rhyolitic zone.Minerals that normally form at intermediate stages of crystallization, such assanidine, show maxima at intermediate FeOt for each sheet. A continuum ofglass and phenocryst compositions occurs within the Topopah Spring andRainier Mesa sheets. Variations in phenocryst compositions with FeOt aregenerally consistent with those expected for crystallization within magmareservoirs characterized by vertical thermal and compositional gradients.However, simple fractional crystallization does not adequately explain theclose relationship in each sheet among the mineral chemistry, glass (magma)chemistry, and phase assemblages, which indicate a close approach to equilibriumwithin each magma system.

LAWRENCE LIVERMORE NATIONAL LABORATORY

94 (ANL–88-14) **The reaction of glass during gamma irradiation in a saturated tuff environment: Part 3, long-term experiments at 1 x 10^{4}rad/hour.** Abrajano, T.A. Jr.; Bates, J.K.; Gerding, T.J.; Ebert, W.L. Argonne National Lab., IL (USA). Feb 1988. 118p. DOE Contract W-31109-ENG-38. Order Number DE88012171. Source: NTIS, PC A06/MF A01; GPO Dep.

Savannah River Laboratory 165 type glass was leached with equilibrated J-13 groundwater at 90°C for times up to 182 days. These experiments were performed as part of an effort by the Nevada Nuclear Waste Storage Investigations Project to assess the importance of radiation effects on repository performance and waste glass corrosion. The gamma radiation field used in this work was 1. 0 +- 0.2 x 10^4 rad/h. Glass dissolution is notably incongruent throughout the entire experimental periods and normalized releases follow the sequence Li $\geq$ Na $\geq$ B $\simeq$ U $\geq$ Si. The normalized leach rates of these elements, as well as the measured growth rates of the reaction layers, decreased with time. The only significant variation observed in the abundance of anions is the systematic decrease in NO_3^-/NO_2^- ratio from the starting EJ-13 groundwater to the EJ-13 blank experiments to the tuff- and glass-containing experiments. A leaching model that is consistent with the observed solution data and depth profiles is presented. The applicability and limitation of the present results in predicting the actual interactions that may occur in the NNWSI repository are discussed. 35 refs., 30 figs., 12 tabs.

95 (ANL–89/14) **A review of degradation behavior of container materials for disposal of high-level nuclear waste in tuff and alternative repository environments.** Maiya, P.S. Argonne National Lab., IL (USA). Jun 1989. 83p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract W-31109-ENG-38. Order Number DE90000916. Source: NTIS, PC A05/MF A01; OSTI; INIS; GPO Dep.

Corrosion resistance of materials in aqueous system is reviewed from the perspective of their suitability as container materials for nuclear waste. A discussion of the chemistry and characterization of repository environments, namely, tuff and alternative environments (shale, limestone, and carbonate), is followed by a description of corrosion mechanisms. In this review, emphasis is placed on localized corrosion (e.g., stress corrosion cracking, crevice corrosion, and pitting) because localized corrosion is difficult to account for in design of components, but it is the life-limiting factor for many metallic and nonmetallic systems. The physical metallurgy and microstructure of the potential alloys are briefly described because they provide insight into both the mechanisms of various localized corrosion processes and possible solutions to corrosion problems. A survey of localized corrosion behavior of potential candidate materials as determined by both corrosion and mechanical test in a large number of repository-related environments is presented in order to determine the most promising materials for a given environment. These studies include the effects of various environmental factors (such as pH, temperature, and electrochemical potentials), as well as alloying elements and other microstructural parameters, on corrosion. The modifications of the environment induced by gamma radiation and the stability of the microstructure under gamma irradiation are also described. Although in the majority of cases the tests and the environments used are severe, they point out that metallic materials are generally more promising than nonmetallic materials (ceramic and polymeric materials). 122 refs., 61 figs., 19 tabs.

96 (BNL–52085) **Assumptions, uncertainties, and limitations in the predictive capabilities of models for sensitization in 304 stainless steels.** Schweitzer, D.G.; Sastre, C. Brookhaven National Lab., Upton, NY (USA). Jun 1987. 12p. DOE Contract AC02-76CH00016. Order Number DE88002818. Source: NTIS, PC A03/MF A01; GPO Dep.

A review of literature on sensitization in 304 stainless steels has been made from what we believe would be the regulatory framework evaluating the claim that there is reasonable assurance that predicts the absence of sensitization for the times (300 to 1000 years) and temperatures (below about 200^{0}C) associated with a high-level waste (HLW) repository at Yucca Mountain. We conclude that such a claim would be indefensible. 17 refs.

97 (CONF-871124–78) **The performance of actinide-containing SRL 165 type glass in unsaturated conditions.** Bates, J.K.; Gerding, T.J. Argonne National Lab., IL (USA). 1987. 12p. DOE Contract W-31109-ENG-38. From Fall meeting of the Materials Research Society; Boston, MA, US; November 30, 1987. Order Number DE88006000. Source: NTIS, PC A03/MF A01; GPO Dep.

As part of the effort by the Nevada Nuclear Waste Storage Investigations (NNWSI) Project to evaluate the volcanic tuff beds of Yucca Mountain, Nevada, as a repository for the permanent storage of high-level nuclear waste, the interaction of actinide-doped Savannah River Laboratory (SRL) 165 type glass with the unsaturated repository environment has been studied. The NNWSI Unsaturated Test method has been used, and the results from batch and continuous tests completed through 18 months demonstrate that several interactions are important for controlling both the reaction of the glass and the release of radionuclides. These interactions include (1) the reaction between the glass and moist air with interludes of liquid water contact, which results in the release of alkali metals from the glass; and (2) the reaction between standing water, glass, and presensitized 304 L type stainless steel which results in breakdown of the glass matrix and the release of radionuclides from the glass-metal assemblage. A comparison of the results of the Unsaturated Test with those of parametric experiments illustrates the importance of presensitized steel in enhancing the glass reaction, and demonstrates the applicability of the Unsaturated Test to those conditions anticipated to exist in the NNWSI repository horizon. 10 refs., 8 figs., 1 tab.

98 (CONF-871237–1) **Effect of ionizing radiation on moist air systems.** Reed, D.T.; Van Konynenburg, R.A. Argonne National Lab., IL (USA); Lawrence Livermore National Lab., CA (USA). 1987. 14p. DOE Contract W-31109-ENG-38. From Materials Research Society fall meeting; Boston, MA, US; December 1, 1987. Order Number DE88002897. Source: NTIS, PC A03/MF A01; GPO Dep.

The radiation chemistry of nitrogen/oxygen/water systems is reviewed. General radiolytic effects in dry nitrogen/oxygen systems are relatively well characterized. Irradiation results in the formation of steady state concentrations of ozone, nitrous oxide and nitrogen dioxide. In closed systems, the concentration observed depends on the total dose, temperature and initial gas composition. Only three studies have been published that focus on the radiation chemistry of nitrogen/oxygen/water homogeneous gas systems. Mixed phase work that is relevant to the gaseous system is also summarized. The presence of water vapor results in the formation of nitric acid and significantly changes the chemistry observed in dry air systems. Mechanistic evidence from the studies reviewed are summarized and discussed in relation to characterizing the gas phase during the containment period of a repository in tuff.

99 (CONF-890401–7) **Repository-relevant testing applied to the Yucca Mountain Project.** Bates, J.K.; Gerding, T.J.; Veleckis, E. Argonne National Lab., IL (USA). Apr 1989. 26p. DOE Contract W-31109-ENG-38. From 197. national meeting of the American Chemical Society; Dallas, TX, US; April 9, 1989. Order Number DE89010701. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

A repository environment poses a challenge to developing a testing program because of the diverse nature of conditions that may exist at a given time during the life of the repository. A starting point is to identify whether any potential waste-water contact modes are particularly deleterious to the waste form performance, and whether any interactions between materials present in the waste package environment need to be accounted for during modeling the waste form reaction. The Unsaturated Test method in one approach that has been developed by the Yucca Mountain Project (YMP) to investigate the above issues, and a description of results that have been obtained during the testing of glass and unirradiated UO_2 are the subject of this report. 10 refs., 7 figs., 4 tabs.

100 (CONF-890421–10) **The influence of penetrating gamma radiation on the reaction of simulated nuclear waste glass in tuff groundwater.** Ebert, W.L. (Argonne National Lab., IL (USA)); Bates, J.K.; Abrajano, T.A. Jr.; Gerding, T.J. Argonne National Lab., IL (USA). 1989. 19p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract W-31109-ENG-38. From 91. annual meeting of the American Ceramic Society; Indianapolis, Indiana, USA; 23-27 Apr 1989. Order Number DE89014671. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Static leaching experiments have been performed to determine the influence of penetrating gamma radiation on the reaction of simulated nuclear waste glass in tuff groundwater at 90°C. Both the leachates and the reacted glass monoliths were analyzed to characterize the reaction. Radiation was seen to acidify the leachates, but the high bicarbonate content of the groundwater prevented the pHs from dropping below 6.4. The glass reaction tended to raise the pH. Glass based on SRL 165 black frit and PNL 76-68 glass compositions were leached. The SRL 165 type glasses were quite durable and unaffected by radiation [NL(B) ~4 g/m^2 after 278 days at all exposure rates]. The PNL 76-68 glasses were much less durable, with the durability decreasing as the exposure rate was increased [NL(B) was about 20 g/m^2 after 278 days at 1×10^3 R/h for both ATM-1c and ATM-8 glasses]. 8 refs., 5 figs.

101 (CONF-890488–12) **The influence of penetrating gamma radiation on the reaction of simulated nuclear waste glass in tuff groundwater.** Ebert, W.L.; Bates, J.K.; Abrajano, T.A. Jr.; Gerding, T.J. Argonne National Lab., IL (USA). 1989. 27p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract W-31109-ENG-38. From 4. international symposium on ceramics in nuclear waste management; Indianapolis, IN (USA); 23-27 Apr 1989. Order Number DE90002257. Source: NTIS, PC A03/MF A01; OSTI; INIS.

Static leaching experiments have been performed to determine the influence of penetrating gamma radiation on the reaction of simulated nuclear waste glass in tuff groundwater at 90°C. Both the leachates and the reacted glass monoliths were analyzed to characterize the reaction. Radiation was seen to acidify the leachates, but the high bicarbonate content of the groundwater prevented the pH values from dropping below 6.4. The glass reaction tended to raise the pH. Glasses based on SRL 165 black frit and PNL 76-68 glass compositions were leached. The SRL 165 type glasses were quite durable (as measured by the elemental mass loss after constant reaction times) and were unaffected by radiation. The PNL 76-68 glasses were much less durable, with the durability decreasing (after constant reaction times) as the exposure rate was increased. The primary effect of radiation is a lowering of the leachate pH which then affects the glass leaching rate. 9 refs., 5 figs.

102 (CONF-891119–2) **Identification of secondary phases formed during unsaturated reaction of UO_2 with EJ-13 water.** Bates, J.K.; Tani, B.S.; Veleckis, E. Argonne National Lab., IL (USA). 1989. 7p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract W-31109-ENG-38. From Materials Research Society fall meeting; Boston, MA (USA); 27 Nov - 2 dec 1989. Order Number DE90001908. Source: NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

A set of experiments, wherein UO_2 has been contacted by dripping water, has been conducted over a period of 182.5 weeks. The experiments are being conducted to develop procedures to study spent fuel reaction under unsaturated conditions that are expected to exist over the lifetime of the proposed Yucca Mountain repository site. One half of the experiments have been terminated, while one half are ongoing. Analyses of solutions that have dripped from the reacted UO_2 have been performed for all experiments, while the reacted UO_2 surfaces have been examined for the terminated experiments. A pulse of uranium release from the UO_2 solid, combined with the formation of schoepite on the surface of the UO_2, was observed between 39 and 96 weeks of reaction. Thereafter, the uranium release decreased and a second set of secondary phases was observed. The latter phases incorporated cations from the EJ-13 water and included boltwoodite, uranophane, sklodowskite, compreignacite, and schoepite. The experiments are continuing to monitor whether additional changes in solution chemistry or secondary phase formation occurs. 6 refs., 2 figs., 2 tabs.

103 (CONF-891119–3) **Parametric effects of glass reaction under unsaturated conditions.** Bates, J.K.; Gerding, T.J.; Woodland, A.B. Argonne National Lab., IL (USA). [1989]. 8p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract W-31109-ENG-38. From Materials Research Society fall meeting; Boston, MA (USA); 27 Nov - 2 dec 1989. Order Number DE90002275. Source: NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

Eventual liquid water contact of high-level waste glass stored under the unsaturated conditions anticipated at the Yucca Mountain site will be by slow intrusion of water into a breached container/canister assembly. The water flow patterns under these unsaturated conditions will vary, and the Unsaturated Test method has been developed by the YMP to study glass reaction. The results from seven different sets of tests done to investigate the effect of systematically varying parameters, such as glass composition, composition and degree of sensitization of 304L stainless steel, water input volume, and the interval of water contact are discussed. Glass reaction has been monitored over a period of five years, and the parametric effects can result in up to a tenfold variance in the degree of glass reaction.

104 (HEDL-SA–3313-Rev.) **Microstructural characteristics of PWR [pressurized water reactor] spent fuel relative to its leaching behavior.** Wilson, C.N. Hanford Engineering Development Lab., Richland, WA (USA). Jan 1986. 34p. DOE Contract AC06-76FF02170. (CONF-850536–11-Rev.: American Ceramic Society annual meeting, Cincinnati, OH, US, May 5, 1985). Order Number DE88001465. Source: NTIS, PC A03/MF A01; GPO Dep.

Microstructural, compositional and thermochemical properties of spent nuclear fuel are discussed relative to its potential performance as a high-level waste form under proposed Nevada Nuclear Waste Storage Investigations Project tuff repository conditions. Pressurized water reactor spent fuel specimens with various artificially induced cladding defects were leach tested in deionized water and in a reference tuff groundwater under ambient hot cell air and temperature conditions. Greater fractional actinide release was observed with bare fuel than with clad fuel leached through a cladding defect. Congruent actinide release and preferential release of cesium and technetium were observed in both water types. Selected summary radionuclide release data are presented and correlated to pre- and post-test microstructural characterization data.

105 (HEDL-SA–3627) **Predicting spent fuel oxidation states in a tuff repository.** Einziger, R.E.; Woodley, R.E. Hanford Engineering Development Lab., Richland, WA (USA). 1987. 22p. DOE Contract AC06-76FF02170. (CONF-870437–3: Workshop on chemical reactivity of oxide fuel and fission product release, Gloucestershire, GB, April 6, 1987). Order Number DE88005708. Source: NTIS, PC A03/MF A01; GPO Dep.

Nevada Nuclear Waste Storage Investigations Project (NNWSI) is studying the suitability of the tuffaceous rocks at Yucca Mountain as a waste repository for spent fuel disposal. The oxidation state of the LWR spent fuel in the moist air environment of a tuff repository could be a significant factor in determining its leaching and dissolution characteristics. Predictions as to which oxidation states would be present are important in analyzing such a repository and thus the present study was undertaken. A set of TGA (thermogravimetric analysis) tests were conducted on well-controlled samples of irradiated PWR fuel with time and temperature as the only variables. The tests were conducted between 140 and 225°C for a duration up to 2200 hours. The weight gain curves were analyzed in terms of diffusion through a layer of U_3O_7, diffusion into the grains to form a solid solution, a simplified empirical representation of a combination of grain boundary diffusion and bulk grain oxidation. Reaction rate constants were determined in each case, but analysis of these data could not establish a definitive mechanism. 21 refs., 10 figs., 3 tabs.

106 (HEDL-TC–2562) **Zircaloy spent fuel cladding electrochemical corrosion-scoping experiment.** Smith, H.D. Hanford Engineering Development Lab., Richland, WA (USA). Dec 1984. 30p. DOE Contract AC06-76FF02170. Order Number DE87013632. Source: NTIS, PC A03/MF A01; GPO Dep.

This document describes the purpose and execution of the electrochemical corrosion scoping experiments. The design of the spent fuel cladding bundles that represent the loaded canister in the repository environment is reviewed. The experimental procedures and post-experiment cladding evaluation are described in detail.

107 (LBL–24254) **Preliminary results on the hydrolysis and carbonate complexation of dioxoplutonium(V).** Bennett, D.A.; Hoffman, D.C.; Nitsche, H.; Silva, R.J. Lawrence Berkeley Lab., CA (USA); Lawrence Livermore National Lab., CA (USA). Nov 1987. 22p. DOE Contract AC03-76SF00098. (CONF-870802–37: 194. American Chemical Society national meeting, New Orleans, LA, US, August 30, 1987). Order Number DE88004444. Source: NTIS, PC A03.

The hydrolysis and carbonate complexation reactions of dioxoplutonium (V) were studied in near neutral aqueous systems. These experiments involved the addition of hydroxide or carbonate to Pu(V) in a perchorate medium. Change in the electronic adsorption spectra provided information about the chemical properties of Pu(V). The results indicate the Pu(V) does not hydrolyze below pH 7.15. In the carbonate complexation studies, log β_{11} was measured to be 4.4 +- 0.7. 5 figs., 3 tabs.

108 (LBL–27778) **VSP [Vertical Seismic Profiling] and cross hole tomographic imaging for fracture characterization.** Majer, E.L.; Peterson, J.E.; Myer, L.R.; Karasaki, K.; Daley, T.M.; Long, J.C.S. Lawrence Berkeley Lab., CA (USA). Sep 1989. 10p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC03-76SF00098. (CONF-890928–13: Nuclear waste isolation in the unsaturated zone: FOCUS '89, Las Vegas, NV (USA), 18-21 Sep 1989). Order Number DE90002680. Source: NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

For the past several years LBL has been carrying out experiments at various fractured rock sites to determine the fundamental nature of the propagation of seismic waves in fractured media. These experiments have been utilizing high frequency (1000 to 10000 Hz.) signals in a cross-hole configuration at scales of several tens of meters. Three component sources and receivers are used to map fracture density, and orientation. The goal of the experiments has been to relate the seismological parameters to the hydrological parameters, if possible, in order to provide a more accurate description of a starting model for hydrological characterization. The work is ultimately aimed at the characterization and monitoring of the Yucca Mountain site for the storage of nuclear waste. In addition to these controlled experiments multicomponent VSP work has been carried out at several sites to determine fracture characteristics. The results to date indicate that both P-wave and S-wave can be used to map the location of fractures. In addition, fractures that are open and conductive are much more visible to seismic waves that non-conductive fractures. The results of these tests indicate direct use in an unsaturated environment. 12 refs., 10 figs.

109 (PNL–6427) **Test plan for long-term, low-temperature oxidation of BWR spent fuel.** Einziger, R.E. Pacific Northwest Lab., Richland, WA (USA). Dec 1988. 30p. DOE Contract AC06-76RL01830. Order Number DE89006387. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Preliminary studies indicated the need for more spent fuel oxidation data in order to determine the probable behavior of spent fuel in a tuff repository. Long-term, low-temperature testing was recommended in a comprehensive technical approach to (1) confirm the findings of the short-term thermogravimetric analysis tests; (2) evaluate the effects of variables such as burnup, atmospheric moisture,and fuel type on the oxidation rate; and (3) extend the oxidation data base to representative repository temperatures and better define the temperature dependence of the operative oxidation mechanisms. This document presents the test plan to study the effects of atmospheric moisture and temperature on oxidation rate and phase formation using a large number of boiling-water reactor fuel samples. Tests will run for up to two years, use characterized fragmented and pulverized fuel samples, cover a temperature range of 110°C to 175°C, and be conducted with an atmospheric moisture content ranging from <-55°C to $\sim$80°C dew point. After testing, the samples will be examined and made available for leaching testing. 15 refs., 2 figs., 2 tabs.

110 (PNL–6745) **Test plan for thermogravimetric analyses of BWR spent fuel oxidation.** Einziger, R.E. Pacific Northwest Lab., Richland, WA (USA). Dec 1988. 34p. DOE Contract AC06-76RL01830. Order Number DE89006389. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Preliminary studies indicated the need for additional low-temperature spent fuel oxidation data to determine the behavior of spent fuel as a waste form for a tuffy repository. Short-term thermogravimetric analysis tests were recommended in a comprehensive technical approach as the method for providing scoping data that could be used to (1) evaluate the effects of variables such as moisture and burnup on the oxidation rate, (2) determine operative mechanisms, and (3) guide long-term, low-temperature oxidation testing. The initial test series studied the temperature and moisture effects on pressurized water reactor fuel as a function of particle and grain size. This document presents the test matrix for studying the oxidation behavior of boiling water reactor fuel in the temperature range of 140 to 225°C. 17 refs., 7 figs., 3 tabs.

111 (PNL-SA–16734) **A sensitivity study of near-field thermomechanical conditions in tuff.** Johnson, K.I.; Voss, C.F.; Sherwood, D.J. Pacific Northwest Lab., Richland, WA (USA). Aug 1989. 11p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-76RL01830. (CONF-890928–14: Nuclear waste isolation in the unsaturated zone: FOCUS '89, Las Vegas, NV (USA), 18-21 Sep 1989). Order Number DE90002663. Source: NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

A study was conducted by the Pacific Northwest Laboratory to investigate the response of a discontinuous rock mass to the combined mechanical and thermal loads from the excavation of repository openings and decay heating of radioactive waste forms. The ANSYS finite element code was used to calculate temperatures and thermal stresses near an emplacement hole as a function of time. The UDEC distinct element code was used to simulate a discontinuous rock mass around the emplacement hole using the finite element stress results as boundary conditions. This approach differs from previous work in its approximation of the near-field geosphere as an assemblage of blocks that are free to slide and rotate relative to one another. The physical properties of the rock joints and fractures were explicitly included in the analysis. Earlier efforts have used continuum models that included the effects of discontinuities by adjusting material properties (reducing elastic modulus and rock strength) or using ubiquitous joints. A range of parameter values were used to represent the upper, lower, and expected conditions for the Yucca Mountain site. Assuming worst case conditions, the calculated displacements around the emplacement hole were only a small fraction of the design air gap between the waste package and the wall of the emplacement hole. Overall, the results confirm that the retrieval option and waste package lifetime will not be adversely affected by borehole instability and excessive rock loads. 8 refs., 6 figs., 4 tabs.

112 (PNL-SA–16832) **Studies on spent fuel dissolution behavior under Yucca Mountain repository conditions.** Wilson, C.N. (Pacific Northwest Lab., Richland, WA (USA)); Bruton, C.J. Pacific Northwest Lab., Richland, WA (USA). Jul 1989. 19p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC06-76RL01830 ;W-7405-ENG-48. (CONF-890421–11: 91. annual meeting of the American Ceramic Society, Indianapolis, IN (USA), 23-27 Apr 1989). Order Number DE89017242. Source: NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

Nuclide concentrations measured in laboratory tests with PWR spent fuel specimens in Nevada Test Site J-13 well water are compared to equilibrium concentrations calculated using the EQ3/6 geochemical modeling code. Actinide concentrations in the laboratory tests reach steady-state values lower than those required to meet Nuclear Regulatory Commission (NRC) release limits. Differences between measured and calculated actinide concentrations are discussed in terms of the effects of temperature (25°C to 90°C), sample filtration, oxygen fugacity, secondary phase precipitation, and the thermodynamic data in use. The concentrations of fission product radionuclides in the laboratory tests tend to increase continuously with time, in contrast to the behavior of the actinides. 11 refs., 5 figs., 4 tabs.

113 (UCID–20926) **Spent fuel performance data: An analysis of data relevant to the NNWSI Project.** Oversby, V.M.; Shaw, H.F. Lawrence Livermore National Lab., CA (USA). Aug 1987. 53p. DOE Contract W-7405-ENG-48. Order Number DE89006016. Source: NTIS, PC A04/MF A01 - OSTI; GPO Dep.

This paper summarizes the physical and chemical properties of spent light water reactor fuel that might influence its performance as a waste form under geologic disposal conditions at Yucca Mountain, Nevada. Results obtained on the dissolution testing of spent fuel conducted by the NNWSI Project are presented and discussed. Work published by other programs, in particular those of Canada and Sweden, are reviewed and compared with the NNWSI testing results. An attempt is made to relate all of the results to a common basis of presentation and to rationalize apparent conflicts between sets of results obtained under different experimental conditions.

114 (UCID–21044) **Progress report on the results of testing advanced conceptual design metal barrier materials under relevant environmental conditions for a tuff repository.** McCright, R.D.; Halsey, W.G.; Van Konynenburg, R.A. Lawrence Livermore National Lab., CA (USA). Dec 1987. 114p. DOE Contract W-7405-ENG-48. Order Number DE88005272. Source: NTIS, PC A06/MF A01; GPO Dep.

This report discusses the performance of candidate metallic materials envisioned for fabricating waste package containers for long-term disposal at a possible geological repository at Yucca Mountain, Nevada. Candidate materials include austenitic iron-base to nickel-base alloy (AISI 304L, AISI 316L, and Alloy 825), high-purity copper (CDA 102), and copper-base alloys (CDA 613 and CDA 715). Possible degradation modes affecting these container materials are identified in the context of anticipated environmental conditions at the repository site. Low-temperature oxidation is the dominant degradation mode over most of the time period of concern (minimum of 300 yr to a maximum of 1000 yr after repository closure), but various forms of aqueous corrosion will occur when water infiltrates into the near-package environment. The results of three years of experimental work in different repository-relevant environments are presented. Much of the work was performed in water taken from Well J-13, located near the repository, and some of the experiments included gamma irradiation of the water or vapor environment. The influence of metallurgical effects on the corrosion and oxidation resistance of the material is reviewed; these effects result from container fabrication, welding, and long-term aging at moderately elevated temperatures in the repository. The report indicates the need for mechanisms to understand the physical/chemical reactions that determine the nature and rate of the different degradation modes, and the subsequent need for models based on these mechanisms for projecting the long-term performance of the container from comparatively short-term laboratory data. 91 refs., 17 figs., 16 tabs.

115 (UCID–21099) **The PLUS family: A set of computer programs to evaluate analytical solutions of the diffusion equation and thermoelasticity.** Montan, D.N. Lawrence Livermore National Lab., CA (USA). Feb 1987. 101p. DOE Contract W-7405-ENG-48. Order Number DE89001283. Source: NTIS, PC A06/MF A01.

This report is intended to describe, document and provide instructions for the use of new versions of a set of computer programs commonly referred to as the PLUS family. These programs were originally designed to numerically evaluate simple analytical solutions of the diffusion equation. The new versions include linear thermo-elastic effects from thermal fields calculated by the diffusion equation. After the older versions of the PLUS family were documented a year ago, it was realized that the techniques employed in the programs were well suited to the addition of linear thermo-elastic phenomena. This has been implemented and this report describes the additions. 3 refs., 14 figs.

116 (UCID–21100) **Thermomechanical calculations pertaining to experiments in the Yucca Mountain exploratory shaft.** Montan, D.N. Lawrence Livermore National

Lab., CA (USA). Apr 1987. 35p. DOE Contract W-7405-ENG-48. Order Number DE89006015. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Waste Package Environment Tests are being planned for the NNWSI Exploratory Shaft to provide information about the near-field hydrological, thermal, and mechanical environment of the waste package for use in assessing the expected performance of the waste package subsystem. The rationale of the tests is driven by the need for this information, but is constrained by the measurement capabilities that can be applied in situ and by the ability of analytical and numerical models to use the data obtained with the measurements. A secondary purpose of the tests is to provide the option of testing certain components that might be part of the engineered barrier system. The Waste Package Environment Tests will be located in drifts at a depth of approximately 310 m (1020 ft) in the Exploratory Shaft. The tests will be separated from one another by at least 6.1 m (20 ft) based on the need to avoid interaction of the individual tests. This planned minimum separation will be refined as scoping and design calculations proceed. The actual test locations within the access drift will be dependent on local geology. 8 refs., 28 figs.

117 (UCID–21113) **Proton precession magnetometer.** Stager, R. Lawrence Livermore National Lab., CA (USA). Mar 1986. 30p. DOE Contract W-7405-ENG-48. Order Number DE88003707. Source: NTIS, PC A03/MF A01; GPO Dep.

The downhole proton precession magnetometer (DPPM) is designed to make total intensity magnetic field measurements in small bore exploratory wells. This manual describes the measurement procedure and discusses maintenance issues. The step-by-step description of the measurement procedure is suitable for use by an operator of the system, while the section on maintenance procedures and theory of operation is intended for use by someone with some experience in electronics. 7 figs.

118 (UCID–21190) **Plan for glass waste form testing for NNWSI [Nevada Nuclear Waste Storage Investigations].** Aines, R.D. Lawrence Livermore National Lab., CA (USA). Sep 1987. 33p. DOE Contract W-7405-ENG-48. Order Number DE88003266. Source: NTIS, PC A03/MF A01; GPO Dep.

The purpose of glass waste form testing is to determine the rate of release of radionuclides from breached glass waste containers. This information will be used to qualify glass waste forms with respect to the release requirements. It will be the basis of the source term from glass waste for repository performance assessment modeling. This information will also serve as part of the source term in the calculation of cumulative releases after 100,000 years in the site evaluation process. It will also serve as part of the source term input for calculation of cumulative releases to the accessible environment for 10,000 years after disposal, to determine compliance with EPA regulations. This investigation will provide data to resolve information needs. Information about the waste forms which is provided by the producer will be accumulated and evaluated; the waste form will be tested, properties determined, and mechanisms of degradation determined; and models providing long-term evaluation of release rates designed and tested. 23 refs.

119 (UCID–21249-Rev.1) **An experiment to determine drilling water imbibition by in situ densely welded tuff.** Daily, W.; Ramirez, A. Lawrence Livermore National Lab., CA (USA). Apr 1987. 8p. DOE Contract W-7405-ENG-48. Order Number DE89002427. Source: NTIS, PC A02/MF A01.

Experiments were performed to determine the extent of penetration of drill water into Grouse Canyon densely welded tuff during use of normal drilling practices. Core samples were examined from a borehole cored in a rib of the Rock Mechanics drift in G-tunnel at the Nevada Test Site, Nye County, Nevada. Methylene blue dye was added to the drill water to act as a tracer which stained the rock blue on contact. We found the rock stained blue only in a thin layer about 0.5 mm thick at the surface of the core. However we were concerned about the uniformity of penetration depth observed in the core and this prompted a simple experiment to test the ability of methylene blue to penetrate the matrix of densely welded tuff. We found that in the imbibition process, the dye and water separated such that the water penetrated the matrix to a much greater depth. This result meant that any interpretation of drill water imbibition in borehole core based on this dye as a tracer is unreliable. More important, however, is the conclusion that the presence of methylene blue dye on the rock indicates the presence of tracer water flow, but the absence of the dye does not rule out the presence of water flow. 6 refs.

120 (UCID–21262) **Plan for metal barrier selection and testing for NNWSI.** Halsey, W.G.; McCright, R.D. Lawrence Livermore National Lab., CA (USA). Dec 1987. 48p. DOE Contract W-7405-ENG-48. Order Number DE89000235. Source: NTIS, PC A03/MF A01.

The Department of Energy's Nevada Nuclear Waste Storage Investigations (NNWSI) Project is evaluating a site at Yucca Mountain in Nevada as a geological repository for the storage of high-level nuclear waste. The Nuclear Waste Management Projects (NWMP) at Lawrence Livermore National Laboratory (LLNL) has the responsibility for design, testing, and performance analysis of the NNWSI waste packages. One portion of this work is the selection and testing of the material for container construction. The anticipated container design is for this material to be a corrosion resistant metal called the metal barrier. This document is the publication version of the Scientific Investigation Plan (SIP) for the Metal Barrier Selection and Testing Task. The SIP serves as a formal planning document for the investigation and is used to assign quality assurance levels to the activities of the task. This document is an informal version for information distribution and has the sections on "Schedule and Milestones" and "Quality Assurance Level Assignment Sheets" removed.

121 (UCID–21272) **Plan for spent fuel waste form testing for NNWSI [Nevada Nuclear Waste Storage Investigations].** Shaw, H.F. Lawrence Livermore National Lab., CA (USA). Nov 1987. 36p. DOE Contract W-7405-ENG-48. Order Number DE88005802. Source: NTIS, PC A03/MF A01; GPO Dep.

The purpose of spent fuel waste form testing is to determine the rate of release of radionuclides from failed disposal containers holding spent fuel, under conditions appropriate to the Nevada Nuclear Waste Storage Investigations (NNWSI) Project tuff repository. The information gathered in the activities discussed in this document will be used: to assess the performance of the waste package and engineered barrier system (EBS) with respect to the containment and release rate requirements of the Nuclear Regulatory Commission, as the basis for the spent fuel waste form source term in repository-scale performance assessment modeling to calculate the cumulative releases to the accessible environment over 10,000 years to determine compliance with the Environmental Protection Agency, and as the basis for the spent fuel waste form source term in repository-scale performance assessment modeling to calculate cumulative releases over 100,000 years as required by the site evaluation process specified in the DOE siting guidelines. 34 refs.

122 (UCID–21274) **Plan for integrated testing for NNWSI [Nevada Nuclear Waste Storage Investigations] non EQ3/6 data base portion.** Oversby, V.M. Lawrence Livermore National Lab., CA (USA). 29 May 1987. 21p. DOE Contract W-7405-ENG-48. Order Number DE88006723.

The purposes of the Integrated Testing Task are to develop laboratory data on thermodynamic properties for actinide and fission product elements for use in the EQ3/6 geochemical modelling code; to determine the transport properties of radionuclides in the near-field environment; and develop and validate a model to describe the rate of release of radionuclides from the near-field environment. Activities to achieve the firs item have been described in the Scientific Investigation Plan for EQ3/6, where quality assurance levels were assigned to the acitivities. This Scientific Investigation Plan describes activities to achieve the second and third purposes. The information gathered in these activities will be used to assess compliance with the performance objective for the Engineered Barrier System (EBS) to control the rate of release of radionuclides if the repository license application includes part of the host rock; to provide a source term for release of radionuclides from the waste package near-field environment to the system performance assessment task for use in showing compliance with the Environmental Protection Agency requirements; and to provide a source term for release of radionculides from the waste package near-field environment to the system performance assessment task for use in doing calculations of cumulative releases of radionuclides from the repository over 100,000 years as required by the site evaluation process. 5 refs.

123 (UCID–21294) **Estimates of the hydrologic impact of drilling water on core samples taken from partially saturated densely welded tuff.** Buscheck, T.A.; Nitao, J.J. Lawrence Livermore National Lab., CA (USA). Sep 1987. 25p. DOE Contract W-7405-ENG-48. Order Number DE89003730. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The purpose of this work is to determine the extent to which drill water might be expected to be imbibed by core samples taken from densely welded tuff. In a related experimental study conducted in G-Tunnel, drill water imbibition by the core samples was observed to be minimal. Calculations were carried out with the TOUGH code with the intent of corroborating the imbibition observations. Due to the absence of hydrologic data pertaining directly to G-Tunnel welded tuff, it was necessary to apply data from a similar formation. Because the moisture retention curve was not available for imbibition conditions, the drainage curve was applied to the model. The poor agreement between the observed and calculated imbibition data is attributed primarily to the inappropriateness of the drainage curve. Also significant is the value of absolute permeability (k) assumed in the model. Provided that the semi-log plot of the drainage and imbibition moisture retention curves are parallel within the saturation range of interest, a simple relationship exists between the moisture retention curve, k, and porosity (ϕ) which are assumed in the model and their actual values. If k and ϕ are known, we define the hysteresis factor λ to be the ratio of the imbibition and drainage suction pressures for any saturation within the range of interest. If k and ϕ are unknown, λ also accounts for the uncertainties in their values. Both the experimental and modeling studies show that drill water imbibition by the core has a minimal effect on its saturation state. 22 refs., 6 figs., 2 tabs.

124 (UCID–21323) **Preliminary technique assessment for nondestructive evaluation certification of the NNWSI [Nevada Nuclear Waste Storage Investigations] disposal container closure.** Day, R.A. Lawrence Livermore National Lab., CA (USA). [1988]. 61p. DOE Contract W-7405-ENG-48. Order Number DE89000236. Source: NTIS, PC A04/MF A01.

Under the direction of the Department of Energy's (DOE) Office of Civilian Radioactive Waste Management (OCRWM) program, the Nevada Nuclear Waste Storage Investigations (NNWSI) project is evaluating a candidate repository site at Yucca Mountain, Nevada, for permanent disposal of high-level nuclear waste. The Lawrence Livermore National Laboratory (LLNL), a participant in the NNWSI project, is developing waste package designs to meet the NRC requirements. One aspect of this waste package is the nondestructive testing of the final closure of the waste container. The container closure weld can best be nondestructively examined (NDE) by a combination of ultrasonics and liquid penetrants. This combination can be applied remotely and can meet stringent quality control requirements common to nuclear applications. Further development in remote systems and inspection will be required to meet anticipated requirements for flaw detection reliability and sensitivity. New research is not required but might reduce cost or inspection time. Ultrasonic and liquid penetrant methods can examine all closure methods currently being considered, which include fusion welding and inertial welding, among others. These NDE methods also have a history of application in high radiation environments and a well developed technology base for remote operation that can be used to reduce development and design costs. 43 refs., 23 figs., 3 tabs.

125 (UCID–21326) **Plan for waste package environment for NNWSI [Nevada Nuclear Waste Storage Investigations].** Glassley, W.E. Lawrence Livermore National Lab., CA (USA). Feb 1988. 45p. DOE Contract W-7405-ENG-48. Order Number DE88010728. Source: NTIS, PC A03/MF A01; GPO Dep.

The purpose and objective of the Waste Package Environment task is to establish and characterize the environmental processes affecting the near-field repository host rock after waste package emplacement. These processes, which reflect the perturbation induces in the environment by engineering effects and by the waste package decay heat and radiation, will influence chemical, mineralogical and hydrological features of the environment. The thermal and radiation output of the waste packages will change with time, resulting in an environment in which the chemical, mineralogical and physical attributes may also change through time. To assure that waste package design considerations reflect the characteristics of this evolving environment, it is necessary to determine the range of conditions that may develop in the pre- and post-emplacement waste package environment. To assure that the emplacement configurations do not compromise the lifetime of the repository or the waste packages, the design of the emplacement configuration must also consider the environmental features. Recognition of these requirements resulted in the development of the issue an information needs. 20 refs.

126 (UCID–21347) **Plan for waste package design, fabrication and prototype testing for NNWSI [Nevada Nuclear Waste Storage Investigations].** Russell, E.W.; Nelson, T.A. Lawrence Livermore National Lab., CA (USA). Feb 1988. 18p. DOE Contract W-7405-ENG-48. Order Number DE88012448. Source: NTIS, PC A03/MF A01; GPO Dep.

The activities addressed in this Scientific Investigation Plan are directed toward planning and developing the design inputs that are necessary to design the NNWSI waste package. Scientific Investigations are configured to provide specific data for design inputs in the areas of parametric studies; requirements for the Advanced Conceptual Design phase; process development for disposal container fabrication, final closure, and nondestructive evaluation; and design validation through prototype testing. Studies that were undertaken prior to initiation of the work described herein have aided in scoping the current design task but are not discussed here.

127 (UCID–21414) **Thermal performance of a buried nuclear waste storage container storing a hybrid mix of PWR and BWR spent fuel rods.** Johnson, G.L. Lawrence Livermore National Lab., CA (USA). Sep 1988. 109p. DOE Contract W-7405-ENG-48. Order Number DE89006803. Source: NTIS, PC A06/MF A01 - OSTI; GPO Dep.

Lawrence Livermore National Laboratory will design, model, and test nuclear waste packages for use at the Nevada Nuclear Waste Storage Repository at Yucca Mountain, Nevada. One such package would store lightly packed spent fuel rods from both pressurized and boiling water reactors. The storage container provides the primary containment of the nuclear waste and the spent fuel rod cladding provides secondary containment. A series of transient conduction and radiation heat transfer analyses was run to determine for the first 1000 yr of storage if the temperature of the tuff at the borehole wall ever falls below 97°C and whether the cladding of the stored spent fuel ever exceeds 350°C. Limiting the borehole to temperatures of 97°C or greater helps minimize corrosion by assuring that no condensed water collects on the container. The 350°C cladding limit minimizes the possibility of creep-related failure in the spent fuel rod cladding. For a series of packages stored in a 8 x 30 m borehole grid where each package contains 10-yr-old spent fuel rods generating 4.74 kW or more, the borehole wall stays above 97°C for the full 1000-yr analysis period.

128 (UCID–21444) **Numerical modeling of the thermal and hydrological environment around a nuclear waste package using the equivalent continuum approximation: Horizontal emplacement.** Nitao, J.J. Lawrence Livermore National Lab., CA (USA). May 1988. 77p. DOE Contract W-7405-ENG-48. Order Number DE89006802. Source: NTIS, PC A05/MF A01 - OSTI; GPO Dep.

In support of the investigations for an underground high-level nuclear waste repository at Yucca Mountain, Nevada, we have performed computer simulations of the immediate thermal and hydrological environment around a nuclear waste package. Calculations of this type will be needed for waste package design, performance assessment, and radionuclide transport analyses. Two dimensional computer simulations using a modified version of the TOUGH code were run for an idealized configuration derived from the COVE3 benchmarking effort consisting of a single spent fuel waste package with laterally periodic boundary conditions. The model domain extended downward to the water table and upward to the ground level. Fluid behavior in the rock was modeled using the equivalent continuum approximation. Runs were made with surface water influx rates at the surface set to 0.1, 0.5, and 1.0 mm/yr. A significant amount of code modification and development was needed in order to develop the capability to run these types of problems out to the long time spans required. 26 refs., 59 figs.

129 (UCID–21472) **An annotated history of container candidate material selection.** McCright, R.D. Lawrence Livermore National Lab., CA (USA). Jul 1988. 62p. DOE Contract W-7405-ENG-48. Order Number DE89011340. Source: NTIS, PC A04/MF A01 - OSTI; GPO Dep.

This paper documents events in the Nevada Nuclear Waste Storage Investigations (NNWSI) Project that have influenced the selection of metals and alloys proposed for fabrication of waste package containers for permanent disposal of high-level nuclear waste in a repository at Yucca Mountain, Nevada. The time period from 1981 to 1988 is covered in this annotated history. The history traces the candidate materials that have been considered at different stages of site characterization planning activities. At present, six candidate materials are considered and described in the 1988 Consultation Draft of the NNWSI Site Characterization Plan (SCP). The six materials are grouped into two alloy families, copper-base materials and iron to nickel-base materials with an austenitic structure. The three austenitic candidates resulted from a 1983 survey of a longer list of candidate materials; the other three candidates resulted from a special request from DOE in 1984 to evaluate copper and copper-base alloys. 24 refs., 2 tabs.

130 (UCID–21571) **Preliminary scoping calculations of hydrothermal flow in variably saturated, fractured, welded tuff during the engineered barrier design test at the Yucca Mountain Exploratory Shaft Test Site.** Buscheck, T.A.; Nitao, J.J. Lawrence Livermore National Lab., CA (USA). Nov 1988. 31p. DOE Contract W-7405-ENG-48. Order Number DE89004982. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

We model a hydrothermal system as a discrete fracture/matrix system, using the integral finite difference code TOUGH and the best available data on the fracture and matrix properties of Topopah Spring densely welded tuff. These calculations will also be useful for the design of the underground facilities in the vicinity of the EBDT; e.g., in determining the volume of undisturbed rock required for each EBDT heater. After conceptualizing our model to be an infinitely long heater (either horizontal or vertical) which is orthogonally intersected by an infinite set of uniformly spaced fractures, we justify its applicability to both horizontal and vertical heater emplacement. The calculations show that by the end of the full-power heating stage ($t = 6$ months), boiling in the rock results in complete desaturation out to a radius of $r = 0.8$ m from the heater axis, with partial desaturation occurring out to $r = 1.8$ m. Water vapor which does not leave the system via the borehole (to the drift) moves radially outward to the condensation zone lying 1.8–4.0 m from the heater axis. Gas pressures build up considerably within the matrix due to the low matrix permeability, but remain close to ambient within the fracture due to the high fracture permeability. At the end of the cooling stage ($t = 24$ months), the saturation in the matrix is below ambient for $r < 3.0$ m. Maximum temperature changes (above ambient) are 252.6°C at the borehole wall, and 10.2°C at a radial distance of 10.0 m from the heater axis. 32 refs., 17 figs., 2 tabs.

131 (UCID–21579) **Estimates of the width of the wetting zone along a fracture subjected to an episodic infiltration event in variably saturated, densely welded tuff.** Buscheck, T.A.; Nitao, J.J. Lawrence Livermore National Lab., CA (USA). 31 May 1988. 58p. DOE Contract W-7405-ENG-48. Order Number DE89010281. Source: NTIS, PC A04/MF A01 - OSTI; GPO Dep.

A central issue to be addressed within the Nevada Nuclear Waste Storage Investigations (NNWSI) is the role which fractures will play as the variably saturated, fractured rock mass surrounding the waste package responds to heating, cooling, and episodic infiltration events. Understanding the role of fractures during such events will, in part, depend on our ability to make geophysical measurements of perturbations in the moisture distribution in the vicinity of fractures. In this study we first examine the details of the perturbation in the moisture distribution in and around a fracture subjected to an episodic infiltration event, and then integrate that behavior over the scale at which moisture measurements are likely to be made during the Engineered Barrier Design Test of the NNWSI project. To model this system we use the TOUGH hydrothermal code and fracture and matrix properties considered relevant to the welded ash flow tuff found in the Topopah Spring member at Yucca Mountain as well as in the Grouse Canyon member within G-Tunnel at the Nevada Test Site. Our calculations provide insight into the anticipated spatial and temporal resolution obtainable through the use of the geophysical techniques being considered. These calculations should prove useful both in planning the implementation of these methods as well as in the interpretation of their results. 41 refs., 28 figs.

132 (UCID–21700) **Yucca Mountain Project waste package design for MRS [Monitored Retrievable Storage] system studies.** Nelson, T.; Russell, E.; Johnson, G.L.; Morissette, R.; Stahl, D.; LaMonica, L.; Hertel, G. Lawrence Livermore National Lab., CA (USA). Apr 1989. 136p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract W-7405-ENG-48. Order Number DE89012806. Source: NTIS, PC A07/MF A01 - OSTI; GPO Dep.

This report, prepared by the Yucca Mountain Project, is the report for Task E of the MRS System Study. A number of assumptions were necessary prior to initiation of this system study. These assumptions have been defined in Section 2 for the packaging scenarios, the waste forms, and the waste package concepts and materials. Existing concepts were utilized because of schedule constraints. Section 3 provides a discussion of sensitivity considerations regarding the impact of different assumptions on the overall result of the system study. With the exception of rod consolidation considerations, the system study should not be sensitive to the parameters assumed for the waste package. The current reference waste package materials and concepts are presented in Section 4. Although stainless steel is assumed for this study, a container material has not yet been selected for Advanced Conceptual Design (ACD) from the six candidates currently under study. Section 5 discusses the current thinking for possible alternate waste package materials and concepts. These concepts are being considered in the event that the waste package emplacement environment is more severe than is currently anticipated. Task E also provides a concept in Section 6 for an MRS canister to contain consolidated fuel for storage at the MRS and eventual shipment to the repository. 5 refs., 14 figs., 10 tabs.

133 (UCRL–15991) **The reaction of glass in a gamma irradiated saturated tuff environment: Part 2, Data package for ATM-1c and ATM-8 glasses.** Bates, J.K.; Gerding, T.J.; Fischer, D.F.; Ebert, W.L. Lawrence Livermore National Lab., CA (USA). Nov 1987. 131p. DOE Contract W-7405-ENG-48. (SANL–610-008-11/87). Order Number DE88006239. Source: NTIS, PC A07/MF A01; GPO Dep.

A series of experiments have been performed in support of the Nevada Nuclear Waste Storage Investigations (NNWSI) project that investigate the efects of gamma radiation on groundwater and glass reaction. Experiments have been done in a gamma radiation field at exposure rates ranging between 2 x 10^5 and 0 R/h, and have been performed over a period of four years. All the data that have been generated during these experiments and which were used in writing the article are presented. The report consists of a series of Tables that provide the (1) groundwater compositions; (2) glass compositions; (3) experimental matrices and selected results; (4) cation analyses; (5) anion analyses; (6) Np and Pu analyses; (7) SEM/EDS analyses; and (8) SIMS analyses exposure rates of 2 x 10^5 (2R), 1 x 10^3 (1R), and 0 (OR) R/h. 2 refs., 7 figs., 16 tabs.

134 (UCRL–15993) **The influence of copper on Zircaloy spent fuel cladding degradation under a potential tuff repository condition.** Smith, H.D. Sandia National Labs., Albuquerque, NM (USA). Nevada Nuclear Waste Storage Investigations Projects Dept. Mar 1987. 26p. DOE Contract W-7405-ENG-48. (HEDL-SA–3583; CONF-870306–71:). Order Number DE88004366. Source: NTIS, PC A03/MF A01; GPO Dep.

This paper reports the results of an experiment designed to detect the influence of copper on Zircaloy spent fuel cladding degradation in one possible repository environment. Copper and copper alloys are being considered for use in a tuff repository. The compatibility of a copper waste package container and the Zircaloy cladding on spent fuel has been questioned essentially because copper ion has been observed to accelerate zirconium alloy corrosion in acid environments, as does ferric iron, and a phenomenon called "crud-induced localized corrosion" is observed in some Boiling Water Reactors where thorugh-the-wall corrosion pits develop beneath copper-rich crud deposits. 16 refs., 6 figs., 2 tabs.

135 (UCRL–21005) **Corrosion testing of type 304L stainless steel in tuff groundwater environments.** Westerman, R.E.; Pitman, S.G.; Haberman, J.H. Pacific Northwest Lab., Richland, WA (USA). Nov 1987. 69p. DOE Contract W-7405-ENG-48. (SANL–616-007; PNL–5829). Order Number DE88006242. Source: NTIS, PC A04/MF A01; GPO Dep.

The stress-corrosion cracking (SCC) resistance of Type 304L stainless steel (SS) to elevated temperatures in tuff rock and tuff groundwater environments was determined under irradiated and nonirradiated conditions using U-bend specimens and slow-strain-rate tests. The steel was tested both in the solution-annealed condition and after sensitization heat treatments. The material was found to be susceptible to SCC in both the solution-annealed and solution-annealed-and-sensitized conditions when exposed to an irradiated crushed tuff rock environment containing air and water vapor at 90°C. A similar exposure at 50°C did not result in failure after a 25-month test duration. Specimens of sensitized 304 SS conditioned with a variety of sensitization heat treatments resisted failure during a test of 1-year duration in which a nonirradiated environment of tuff rock and groundwater held at 200°C was allowed to boil to dryness on a cyclical basis. All specimens of sensitized 304 SS exposed to this environment failed. Slow-strain-rate studies were performed on 304L, 304, and 316L SS specimens. The 304L SS was tested in J-13 well water at 150°C, and the 316L SS at 95°C. Neither material showed evidence of SCC in these tests. Sensitized 304 SS did exhibit SCC in J-13 well water in tests conducted at 150°C. 12 refs., 27 figs., 13 tabs.

136 (UCRL–21013) **Summary of results from the Series 2 and Series 3 NNWSI [Nevada Nuclear Waste Storage Investigations] bare fuel dissolution tests.** Wilson, C.N. Pacific Northwest Lab., Richland, WA (USA); Westinghouse Hanford Co., Richland, WA (USA). Nov 1987. 15p. DOE Contract W-7405-ENG-48. (CONF-8711100–2: Symposium on the scientific basis for nuclear waste management, Boston, MA, US, November 30, 1987; PNL-SA–15207; HEDL-SA–3731A). Order Number DE88006030. Source: NTIS, PC A03/MF A01; GPO Dep.

The Nevada Nuclear Waste Storage Investigations (NNWSI) Project is studying dissolution and radionuclide release behavior of spent nuclear fuel in Nevada Test Site groundwater. Specimens were tested for multiple cycles in J-13 well water. The Series 2 tests were run in unsealed silica vessels under ambient hot cell air (25°C) for five cycles for a total of 34 months. The Series 3 tests were run in sealed stainless steel vessels at 25°C and 85°C for three cycles for a total of 15 months. Selected summary results from Series 2 and Series 3 tests with bare fuel specimens are reported. Uranium concentrations in later test cycles ranged from 1 to 2 μg/ml in the Series 2 Tests versus about 0.1 to 0.4 μg/ml in Series 3 with the lowest concentrations occurring in the 85°C tests. Preferential release of fission products Cs, I, Sr and Tc, and activation product C-14, was indicated relative to the actinides. Tc-99 and Cs-137 activities measured in solution after Cycle 1 increased linearly with time, with the rate of increase greater at 85°C than at 25°C. 8 refs., 8 figs., 3 tabs.

137 (UCRL–21019) **Recent results from NNWSI [Nevada Nuclear Waste Storage Investigations] spent fuel leaching/dissolution tests.** Wilson, C.N. Westinghouse Hanford Co., Richland, WA (USA). Apr 1987. 26p. DOE Contract AC06-76FF02170 ;W-7405-ENG-48. (SANL–622-027; HEDL-SA–3700-FP; CONF-870422–10:). Order Number DE88005727. Source: NTIS, PC A03/MF A01; GPO Dep.

The Nevada Nuclear Waste Storage Investigations (NNWSI) Project is studying dissolution and radionuclide release behavior of spent nuclear fuel in Nevada Test Site groundwater. Results from two-year extended testing of pressurized water reactor (PWR) spent fuel at 25°C in unsealed silica vessels are discussed. These results are compared to initial results from testing in sealed stainless steel vessels at 25°C and 85°C and to initial results from scoping experiments using oxidized spent fuel in unsealed silica vessels at 25°C.

138 (UCRL–21060-87-2) **NNWSI [Nevada Nuclear Waste Storage Investigation] waste form testing at Argonne National Laboratory: Semiannual report, July–December 1987.** Bates, J.K.; Gerding, T.J.; Ebert, W.L.; Mazer, J.J.; Biwer, B.M. Argonne National Lab., IL (USA). Jul 1988. 97p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract W-7405-ENG-48. Order Number DE89013174. Source: NTIS, PC A06/MF A01 - OSTI; GPO Dep.

Tests are ongoing at Argonne National Laboratory to examine the reaction of glass with water under conditions that may exist in the proposed repository at Yucca Mountain, Nevada. Examination of glass reaction using the Unsaturated Test method as applied to simulated defense glass (SRL 165 black frit based) and simulated West Valley glass (ATM-10) is ongoing. The tests on SRL 165 glass have been ongoing for 104 weeks with nonstoichiometric release of Li, Na, B, and actinide elements being observed throughout the test period. The tests on ATM-10 glass have been in progress for 26 weeks and it is too early in the test cycle to assess the glass reaction. The influence of penetrating gamma radiation on the reaction of synthetic nuclear waste glasses in tuff groundwater was also investigated. Modified MCC-1 static leaching experiments were performed under radiation exposures of 1×10^3 R/h and O R/h at 90°C. The groundwater was acidified by nitrous and nitric acids radiolytically produced in the air. The high bicarbonate ion concentration of the groundwater prevented the pH from dropping below 6.4, however. The glass reaction, as measured by the release of glass species and the thickness of an alteration layer formed on the glass surface, was not measurably affected by radiation. 24 refs., 34 figs., 20 tabs.

139 (UCRL–53645) **Hydrothermal interaction of solid wafers of Topopah Spring Tuff with J-13 water and distilled water at 90, 150, and 250°C, using Dickson-type, gold-bag rocking autoclaves.** Knauss, K.G.; Beiriger, W.J.; Peifer, D.W.; Piwinskii, A.J. Lawrence Livermore National Lab., CA (USA). Sep 1985. 57p. DOE Contract W-7405-ENG-48. Order Number DE88006145. Source: NTIS, PC EE05/MF A01; GPO Dep.

Includes 3 sheets of 24x reduction microfiche.

The Nevada Nuclear Waste Storage Investigations Project has conducted experiments to study the hydrothermal interaction of rock and water representative of a potential high-level waste repository at Yucca Mountain, Nevada. The results of these experiments help define the near-field repository environment during and shortly after the thermal period that results from the emplacement of nuclear waste. When considered in conjunction with results contained in companion reports, these results can be used to assess our ability to accelerate tests using the surface area/volume parameter and/or temperature. These rock-water interaction experiments were conducted with solid polished wafers cut from both drillcore and outcrop samples of Topopah tuff, using both a natural ground water and distilled water as the reacting fluid. Pre- and post-test characterization of the reacting materials was extensive. Post-test identification and chemical analysis of secondary phases resulting from the hydrothermal interactions were aided by using monoliths of tuff rather than crushed material. All experiments were run in Dickson-type, gold-bag rocking autoclaves that were periodically sampled at in situ conditions. A total of nine short-term (up to 66-day) experiments were run in this series; these experiments covered the range from 90 to 250°C and from 50 to 100 bar. The results obtained from the experiments have been used to evaluate the modeled results produced by calculations using the geochemical reaction process code EQ3/6. 31 refs., 37 figs., 7 tabs.

140 (UCRL–53722) **Hydrothermal interaction of solid wafers of Topopah Spring Tuff with J-13 water at**

90 and 150°C using Dickson-type, gold-bag rocking autoclaves: Long-term experiments. Knauss, K.G.; Beiriger, W.J.; Peifer, D.W. Lawrence Livermore National Lab., CA (USA). May 1987. 23p. DOE Contract W-7405-ENG-48. Order Number DE88005709. Source: NTIS, PC A03/MF A01; GPO Dep.

The Nevada Nuclear Waste Storage Investigations Project conducted long-term experiments to study the hydrothermal interaction of rock and water representative of a potential high-level waste repository at Yucca Mountain, Nevada. The results of these experiments complement those obtained previously in short-term experiments at similar and higher temperatures. These long-term experiments also help in assessing the effects of kinetic inhibition in the precipitation of secondary minerals at the lower temperatures and allow a more complete determination of the approach of the fluid toward a steady-state composition. Considered collectively, the results of both short- and long-term experiments provide information useful in defining the near-field repository environment during and shortly after the thermal period caused by the emplacement of nuclear waste. These long-term experiments were conducted using solid wafers cut from drillcore samples of Topopah Spring tuff. A natural ground water was used as the reacting fluid. Analytical techniques for determining the composition of fluids and solids were similar to those used in previous short-term experiments. All experiments were run in Dickson-type, gold-bag rocking autoclaves that were periodically sampled under in situ conditions. Two long-term (304-day) experiments were run at temperatures of 90 and 150°C and 50-bar pressure. 21 refs., 8 figs., 5 tabs.

141 (UCRL–53795) **Reaction of vitric Topopah Spring Tuff and J-13 ground water under hydrothermal conditions using Dickson-type, gold-bag rocking autoclaves.** Knauss, K.G.; Peifer, D.W. Lawrence Livermore National Lab., CA (USA). Nov 1986. 42p. DOE Contract W-7405-ENG-48. Order Number DE88005234. Source: NTIS, PC A03/MF A01; GPO Dep.

In support of the Nevada Nuclear Waste Storage Investigations Project, we conducted experiments to study the effects of repository-generated heat on glassy tuff present at Yucca Mountain, Nevada. Solid wafers of glassy tuff were reacted with a dilute ground water for several months at 250, 150, and 90°C at 100 bar pressure in Dickson-type, gold-bag rocking autoclaves. The in-situ chemistry of the hydrothermal fluids was modeled; and the chemical affinities for all possible mineral precipitation reactions for species contained within the database were calculated using the EQ3/6 program. For the 250°C experiment, the calculations predicted the precipitation of a zeolite mineral. Analyses of the run products showed that the wafer had been extensivley corroded, the glass shards were replaced by clinoptilolite (a zeolite), and pure clinoptilolite precipitated directly from solution. Modeling of the 150°C experiment indicated that, although clay minerals were thermodynamically more highly supersaturated than zeolites in the first half of the experiment, by the end of the run a zeolite mineral was also predicted to precipitate. Analyses of the run products showed that no well-crystallized secondary minerals (clays or zeolites) had formed. In the 90°C experiment, the degree of superstaturation for both clays and zeolites was lower than at either of the higher temperatures. The relative change in super-saturation for any one mineral was also lower as the run progressed. At the lower temperature (90 and 150°C), slow precipitation kinetics may preclude the formation of the zeolite within the time span of these experiments. In general, the actual observations are in relatively good agreement with the geochemical model calculations made at each temperature.

142 (UCRL–95330) **Geophysical tomography for imaging water movement in welded tuff.** Daily, W.D.; Ramirez, A.L. Lawrence Livermore National Lab., CA (USA). Sep 1986. 5p. DOE Contract W-7405-ENG-48. (CONF-8609350–1: 2. international conference on nuclear waste management, Winnipeg, CA, September, 1986). Order Number DE87013108. Source: NTIS, PC A02.

Alterant tomography has been evaluated for its ability to delineate in-situ water flow paths in a fractured welded-tuff rock mass. The evaluation involved a field experiment in which tomographs of electromagnetic attenuation factor (or attenuation rate) at 300 MHz were made before, during, and after the introduction to the rock of two different water-based tracers: a plain water and dye solution, and salt water and dye. Alterant tomographs were constructed by subtracting, cell by cell, the attenuation factors derived from measurements before each tracer was added to the rock mass from the attenuation factors derived after each tracer was added. The alterant tomographs were compared with other evidence of water movement in the rock: borescope logs of fractures, and post experiment cores used to locate the dye tracer on the fractured surfaces. These comparisons indicate that alterant tomography is suitable for mapping water flow through fractures and that it may be useful in inferring which of the fractures are hydrologically connected in the image plane. The technique appears to be sensitive enough to delineate flow through a single fracture and to define fractures with a spatial resolution of about 10 cm on an imaging scale of a few meters. 9 refs., 3 figs.

143 (UCRL–95539-Rev.1) **Influence of stress-induced deformations on observed water flow in fractures at the Climax granitic stock.** Wilder, D.G. Lawrence Livermore National Lab., CA (USA). Jun 1987. 9p. DOE Contract W-7405-ENG-48. (CONF-870625–19-Rev.1: 28. U.S. symposium on rock mechanics, Tucson, AZ, US, June 29, 1987). Order Number DE88008342. Source: NTIS, PC A02/MF A01; GPO Dep.

Three examples of stress-induced displacement influence on fracture-dominated hydrology were noted in drifts 1400 ft below surface in granite. Seepage into drifts was limited to portions of shears near a fault zone. No water entered the drifts from the fault itself, although its orientation relative to Basin and Range extension is favorable for fracture opening. Localization of seepage appears to result from excavation block motion that increased apertures of the shear zones in contrast to the fault where asperities had been destroyed by earlier shearing thus minimizing aperture increases. Seepage was also noted, in an adjoining drift, from a set of shallow-dip healed fractures that intersected the rib, and from vertical fractures that increased the crown. The restricted location of this seepage apparently was a result of shear opening of the joints that occurred because of cantilevered support of tabular rock between joints. Interpretation of paleostresses based on joint chronologies and orientations indicates that sets subjected to shear stresses at a time when normal stresses were low contained mineral infilling. Sets subjected to shear stresses at a time when the normal stresses were significant had minimal mineral infilling. 8 refs., 7 figs.

144 (UCRL–96702) **Geochemical simulation of reaction between spent fuel waste form and J-13 water at 25^0 and 90^{0}C.** Bruton, C.J.; Shaw, H.F. Lawrence Livermore National Lab., CA (USA). Nov 1987. 12p. DOE Contract W-7405-ENG-48. (CONF-8711100–4: Symposium on the scientific basis for nuclear waste management, Boston, MA, US, November 30, 1987). Order Number DE88005724. Source: NTIS, PC A03/MF A01; GPO Dep.

Geochemical simulations of the degradation of spent fuel waste form in the presence of groundwater at the candidate Yucca Mountain, Nevada repository have been carried out to attempt to predict elemental concentrations in solution and to identity potential radionuclide-bearing precipitates. Spent fuel was assumed to dissolve congruently into a static mass of J-13 groundwater at 25^{0}C and 90^{0}C. Simulation results inidcate that haiweeite, soddyite, $Na_2U_2O_7(c)$ and schoepite are potential U-bearing precipitates. $Na_2U_2O_7(c)$ is only predicted to occur at 90^{0}C. U concentrations in solution and the identity of the U-bearing precipitate depend on the activity of $SiO_2(aq)$ in solution. U concentrations are limited to $<$ 1 mg/kg when sufficient $SiO_2(aq)$ exists in solution to precipitate uranyl silicates. Depletion of $SiO_2(aq)$ in solution by the precipitation of silicates results in predicted increases of U concentrations to 87 and 619 mg/kg at 25^{0}C and 90^{0}C, respectively. Subsequent reaction and precipitation of schoepite cause U concentrations to decrease. Radionuclide other than U commonly precipitate as oxides in the simulations. The precipitation of solid phases appears to be extremely effective in limiting the concentrations of some radionuclides, such as Pu and Th, in solution. Increasing the temperature from 25^{0}C to 90^{0}C does not impact greatly the identify of precipitated phases or solution composition, except in the case of U. 7 refs., 7 figs., 2 tabs.

145 (UCRL–96703) **Geochemical simulation of dissolution of West Valley and DWPF [Defense Waste Product Facility] glasses in J-13 water at 90^{0}C.** Bruton, C.J. Lawrence Livermore National Lab., CA (USA). Nov 1987. 14p. DOE Contract W-7405-ENG-48. (CONF-871124–67: Fall meeting of the Materials Research Society, Boston, MA, US, November 30, 1987). Order Number DE88005619. Source: NTIS, PC A03/MF A01; GPO Dep.

Dissolution of West Valley and Defense Waste Product Facility (DWPF) glasses in J-13 water at 90^{0}C at the candidate Yucca Mountain, Nevada repository was simulated using the EQ3/6 computer code package. The objectives of the study were to attempt to predict the concentrations of radionuclides and other glass components in solution resulting from glass dissolution, and to identify potential precipitates that sequester glass components. Modified projected inventories of 10,000 year-old West Valley and DWPF SRL-165 frit glasses were used as starting glass compositions. J-13 water was considered to be representative of groundwater at Yucca Mountain. A total of 10 grams of each glass was assumed to dissolve congruently into a kilogram of J-13 water in a closed system. No inhibitions to precipitation, except for crystalline SiO_2 polymorphs, were assumed to exist. Radiolysis and materials interactions were not considered. Simulation results predict that radionuclides and other glass components precipitate predominantly in the form of oxides and hydroxides, together with carbonates, silicates and phosphates. Precipitates appear to be effective in limiting the concentrations of radionuclides and other elements in solution. The general compositional trends in precipitates and solution chemistry are the same in the West Valley and DWPF simulations, except for variations arising from differences in glass chemistry. 20 refs., 7 figs., 3 tabs.

146 (UCRL–97562) **Impact of phase stability on the corrosion behavior of the austenitic candidate materials for NNWSI [Nevada Nuclear Waste Storage Investigations].** Bullen, D.B.; Gdowski, G.E.; McCright, R.D. Science and Engineering Associates, Inc., Pleasanton, CA (USA); Lawrence Livermore National Lab., CA (USA). Oct 1987. 12p. DOE Contract W-7405-ENG-48. (CONF-8711100–3: Symposium on the scientific basis for nuclear waste management, Boston, MA, US, November 30, 1987). Order Number DE88006243. Source: NTIS, PC A03/MF A01; GPO Dep.

The Nuclear Waste Management Program at Lawrence Livermore National Laboratory is responsible for the development of the waste package design to meet the Nuclear Regulatory Commission licensing requirements for the Nevada Nuclear Waste Storage Investigations (NNWSI) Project. The metallic container component of the waste package is required to assist in providing substantially complete containment of the waste for a period of up to 1000 years. Long term phase stability of the austenitic candidate materials (304L and 316L stainless steels and alloy 825) over this time period at moderate temperatures (100-250^{0}C) can impact the mechanical and corrosion behavior of the metal barrier. A review of the technical literature with respect to phase stability of 304L, 316L and 825 is presented. The impact of martensitic transformations, carbide precipitation and intermediate (σ, chi, and eta) phase formation on the mechanical properties and corrosion behavior of these alloys at repository relevant conditions is discussed. The effect of sensitization on intergranular stress corrosion cracking (IGSCC) of each alloy is also addressed. A summary of the impact of phase stability on the degradation of each alloy in the proposed repository environment is included. 32 refs., 6 figs.

147 (UCRL–98029) **Assessment of engineered barrier system and design of waste packages.** Ramspott, L.D. (Lawrence Livermore National Lab., CA (USA)). Lawrence Livermore National Lab., CA (USA). Jun 1988. 14p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract W-7405-ENG-48. (CONF-880601–53: American Nuclear Society annual meeting, San Diego, CA, US, 12-16 Jun 1988). Order Number DE89012289. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The US Nuclear Regulatory Commission has established two post closure performance objectives for the Engineered Barrier System (EBS) in a geologic repository. These require containment of the waste followed by controlled release. The EBS for a repository in unsaturated tuff at Yucca Mountain is designed to meet these performance objectives. The major components are the waste form, container, air gap, and borehole liner. Assessment of post-closure performance of the EBS is based on allocating performance for various components toward meeting overall design objectives. Because of the unprecedented time periods considered, 1000 to 10,000 years, computer modeling is essential and will be used in conjunction with testing to assess whether the performance allocations are met. 7 refs., 1 tab.

148 (UCRL–99734) **Uranium transport in Topopah Spring tuff: An ion-microscope investigation.** McKeegan, K.D.; Phinney, D.; Oversby, V.M.; Buchholtz-ten Brink, M.; Smith, D.K. Lawrence Livermore National Lab., CA (USA). Oct 1988. 9p. DOE Contract W-7405-ENG-48.

(CONF-881066–3: 12. international symposium on the scientific basis for nuclear waste management, Berlin, DE, October 10, 1988). Order Number DE89004778. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

We investigated the effect of different methods of surface preparation on ion-microscope profiles of uranium concentration (added to the sample by diffusion from an aqueous solution) vs depth in a welded, devitrified, tuffaceous rock from Yucca Mountain. The concentration profiles were used to study transport of uranium in the tuff. Four wafers of rock were prepared from primary drill core material and finished by polishing with increasingly finer abrasive material. Final polishes were made with 400 grit SiC, 600 grit SiC, 0.3 um alumina, and 0.05 um alumina. The polished tuff wafers were exposed for eight hours to a solution of groundwater doped with 2 ppM 235-U. The wafers were then examined by SEM and the ion microscope was used to measure the lateral and depth distributions of 235-U and other isotopes in the wafer. No systematic correlation of the measured 235-U concentration- vs-depth profiles with the degree of surface finish was observed, indicating that the polishing does not affect the measurable transport of U in the tuff. A zone of enhanced 235-U concentration was observed in the upper few microns, which we attribute to sorption onto surfaces of exposed pores. Concentrations of 235-U were elevated above background to depths >15 um, indicating that rapid transport paths exist. When the uranium distribution near the surface of the wafer was modelled by an error function, an upper limit for a slower transport path was defined by an apparent diffusion coefficient of approximately 10^{-13} cm^2/s. 5 refs., 5 figs., 1 tab.

149 (UCRL–100601) **Waste package for Yucca Mountain repository: Strategy for regulatory compliance.** Cloninger, M.; Short, D.; Stahl, D. Lawrence Livermore National Lab., CA (USA). Feb 1989. 12p. DOE Contract W-7405-ENG-48. (CONF-890207–24: Waste management '89, Tucson, AZ, US, February 26, 1989). Order Number DE89009960. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

This document summarizes the strategy given in the Site Characterization Plan (1) for demonstrating compliance with the post closure performance objectives for the waste package and the Engineered Barrier System (EBS) contained in the Code of Federal Regulations. The strategy consists of the development of a conservative waste package design that will meet the regulatory requirements with sufficient margin for uncertainty using a multi-barrier approach that takes advantage of the unsaturated nature of the Yucca Mountain site. This strategy involves an iterative process designed to achieve compliance with the requirements for substantially complete containment and EBS release. The strategy will be implemented in such a manner that sufficient evidence will be provided for presentation to the Nuclear Regulatory Commission (NRC) so that it may make a finding that there is “reasonable assurance” that these performance requirements will indeed be met. In implementing the strategy, DOE recognizes four fundamental goals: (1) protect public health and safety; (2) minimize financial and other resource commitments; (3) comply with applicable laws and regulations; and (4) maintain an aggressive schedule. The strategy is intended to be a reasonable balance of these competing goals. 7 refs., 3 figs., 1 tab.

150 (UCRL–100603) **Evaluation of the post-emplacement environment of high level radioactive waste packages at Yucca Mountain, Nevada.** Glassley, W. (Sandia National Labs., Albuquerque, NM (USA)). Lawrence Livermore National Lab., CA (USA). Mar 1989. 16p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract W-7405-ENG-48. (CONF-8903112–5: Waste management '89, Tucson, AZ (USA), 1 Mar 1989). Order Number DE90002816. Source: NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

Evaluation of the post-emplacement environment around high level radioactive waste containers is required by federal regulations. The information derived from this evaluation will be used to determine the service performance of the waste containers, the chemical and hydrological conditions that may influence radionuclide release and transport if containers are breached, and retrievability of the waste containers prior to closure of the repository. Laboratory studies, numerical simulations, and field experiments and tests are used to provide data necessary for this evaluation. Results obtained to date demonstrate that the post-emplacement environment in the welded tuff at Yucca Mountain, Nevada maintains relatively benign chemical features (i.e., near neutral pH, low concentrations of dissolved species) for most scenarios. The hydrological environment appears to be one of low flow volume and rates for the expected condition of an unsaturated medium. Emplacement borehole stability will be a function of fracture density and orientation, which may be influenced by microcrack development. Field studies and numerical simulations are in progress that will extend the results of laboratory studies to long time periods. The extent to which chemical, hydrological and mechanical processes can be adequately coupled through numerical simulations remains a matter of concern. 18 refs., 4 figs., 1 tab.

151 (WHC-EP–0065) **Electrochemical corrosion-scoping experiments: An evaluation of the results.** Smith, H.D. Westinghouse Hanford Co., Richland, WA (USA). Sep 1988. 56p. DOE Contract AC06-87RL10930. Order Number DE89000691. Source: NTIS, PC A04/MF A01.

Prior to emplacement in a nuclear waste repository, each waste form must be well characterized with respect to its behavior in the environments expected to develop in the repository. This scoping study was designed to obtain a qualitative idea of how spent fuel cladding would respond to a hot water environment that could develop in a tuff repository at a time when temperatures have cooled to ~95°C and hot liquid water has infiltrated the repository horizon. That information would then be used to establish more definitive tests on cladding behavior in a tuff repository. For this study bundles of spent fuel cladding held together with a 304 stainless steel (SS) wrap were constructed which simulate the geometries and materials associations in a breached 304L SS container. They were exposed to 90°C tuff-equilibrated Well J-13 water for periods of 2, 6, and 12 mo. During the experiments, the water level, temperature, conductivity, and pH were monitored on a regular basis. The water was also checked periodically for carbon (organic, inorganic, and later in the experiment Carbon-14) and zirconium. More extensive water analyses were carried out at the midpoint and completion of the experiments. 12 refs., 16 figs., 5 tabs.

152 (WHC-EP–0070) **Long-term, low-temperature oxidation of PWR spent fuel: Interim transition report.** Einziger, R.E.; Buchanan, H.C. Westinghouse Hanford Co., Richland, WA (USA). May 1988. 84p. DOE Contract AC06-87RL10930. Order Number DE88013497. Source: NTIS, PC A05/MF A01; GPO Dep.

Since some of the fuel rods will be breached and eventually most of the cladding will corrode, exposing fuel, one factor influencing the ability of spent fuel to retain radionuclides is its oxidation state in the expected moist air atmosphere. Oxidation of the fuel could split the cladding, exposing additional fuel and changing the leaching characteristics. Thermodynamically, there is no reason why UO_2 should not oxidize completely to UO_3 at repository temperatures. The underlying uncertainty is the rate of oxidation. Extrapolation of higher temperature data indicates that insufficient oxidation to convert all of the fuel to U_3O_8 will occur during the first 10,000 years. However, lower oxidation states, such as U_4O_9 and U_3O_7, might form. To date, the tests have run between 3200 and 4100 hours out of a planned 16,000-hour duration. Some preliminary conclusions can be drawn: (1) Moisture content of the air has no significant effect on oxidation rate, (2) the data have an uncertainty of 15 to 20%, which must be accounted for in the interpretation of single sample tests, and (3) below 175°C, the oxidation rate is dependent on the particle size in the sample. The smaller particles oxidize more rapidly. 19 refs., 23 figs., 7 tabs.

153 (WHC-EP–0096) **Initial report on stress-corrosion-cracking experiments using Zircaloy-4 spent fuel cladding C-rings.** Smith, H.D. Westinghouse Hanford Co., Richland, WA (USA). Sep 1988. 69p. DOE Contract AC06-87RL10930. Order Number DE89000692. Source: NTIS, PC A04/MF A01.

The Nevada Nuclear Waste Storage Investigations (NNWSI) Project is sponsoring C-ring stress corrosion cracking scoping experiments as a first step in evaluating the potential for stress corrosion cracking of spent fuel cladding in a potential tuff repository environment. The objective is to scope the approximate behavior so that more precise pressurized tube testing can be performed over an appropriate range of stress, without expanding the long-term effort needlessly. The experiment consists of stressing, by compression with a dead weight load, C-rings fabricated from spent fuel cladding exposed to an environment of Well J-13 water held at 90°C. The results indicate that stress corrosion cracking occurs at the high stress levels employed in the experiments. The cladding C-rings, tested at 90% of the stress at which elastic behavior is obtained in these specimens, broke in 25 to 64 d when tested in water. This was about one third of the time required for control tests to break in air. This is apparently the first observation of stress corrosion under the test conditions of relatively low temperature, benign environment but very high stress. The 150 ksi test stress could be applied as a result of the particular specimen geometry. By comparison, the uniaxial tensile yield stress is about 100 to 120 ksi and the ultimate stress is about 150 ksi. When a general model that fits the high stress results is extrapolated to lower stress levels, it indicates that the C-rings in experiments now running at ~80% of the yield strength should take 200 to 225 d to break. 21 refs., 24 figs., 5 tabs.

154 Electromagnetic experiment to map in situ water in heated welded tuff: Preliminary results. Ramirez, A.L. (Lawrence Livermore National Lab., CA); Daily, W.D. Rock mechanics: Proceedings of the 28th U.S. symposium. Farmer, I.W.; Daemen, J.J.K.; Desai, C.S.; Glass, C.E.; Neuman, S.P. A.A. Balkema Publishers, (1987). pp. 37-46 DOE Contract W-7405-ENG-48. (CONF-870625–: 28. U.S. symposium on rock mechanics, Tucson, AZ, US, June 29, 1987).

The results of an experiment conducted in Tunnel Complex G at the Nevada Test Site to evaluate geotomography as a possible candidate for in situ monitoring of hydrology in the near field of a heater placed in densely welded tuff are given. The experiment is described. The linear character of many tomographic features and their spatial correlation with fractures mapped in boreholes are evidence that drying was most rapid along some fractures. The interpretation of the tomographs is preliminary until they can be processed without the restrictive assumption of straight ray paths for the signals through the highly heterogeneous rock mass.

155 Estimates of radionuclide release from glass waste forms in a tuff repository and the effects on regulatory compliance. Aines, R.D. (Nevada Nuclear Waste Storage Investigations Project, Lawrence Livermore National Lab., Livermore, CA (US)). pp. 91-98 of Nuclear waste management II. Passchier, W.F.; Bosnjakovic, B.F.M. American Ceramic Society Inc., Westerville, OK (1986). vp. of (CONF-8608225–: 3. international symposium on ceramics in nuclear waste management, Chicago, IL, US, 28-30 Aug 1986).

Radionuclide release from glass waste forms in a tuff repository would be limited by the small amounts of water available. One scenario allowing release is that in which the headspace of a DWPF can fills with water. The parameters associated with this scenario and an estimate of the release under these conditions using a simplified model are presented.

156 The behavior of type 304L stainless steel in tuff repository conditions. Juhas, M.C. (Lawrence Livermore National Lab., Livermore, CA (US)); McCright, R.D.; Garrison, R.E. pp. 38 of Corrosion '85. National Assoc. of Corrosion Engineers, Houston, TX (1985). v.v of (CONF-850311–: National Association of Corrosion Engineers annual meeting and materials performance and corrosion show, Boston, Massachusetts, USA, 25-29 Mar 1985).

The Lawrence Livermore National Laboratory is developing containment for high-level nuclear waste as part of the Nevada Nuclear Waste Storage Investigations project. Paper presents results of preliminary findings of sensitization and its effects on the corrosion behavior of the reference material. Type 304L stainless steel. Also discussed are the results of irradiation effects.

157 Influence of stress-induced deformations on observed water flow in fractures of the Climax Granitic Stock. Wilder, D.G. (Lawrence Livermore National Lab.). Rock mechanics: Proceedings of the 28th U.S. symposium. Farmer, I.W.; Daemen, J.J.K.; Desai, C.S.; Glass, C.E.; Neuman, S.P. A.A. Balkema Publishers, (1987). pp. 491-500 DOE Contract W-7405-ENG-48. (CONF-870625–: 28. U.S. symposium on rock mechanics, Tucson, AZ, US, June 29, 1987).

Three examples of stress induced influence on fracture dominated hydrology were noted in drifts 1400 ft below surface in granite. Seepage into portions of shears near a fault zone and an adjoining drift, and mineralization of the joints were the three indicators of shear stress. Interpretation of these results are given.

158 The influence of copper on zircaloy spent fuel cladding degradation under a potential tuff repository condition. Smith, H.D. (Westinghouse Hanford Co., P.O. Box 1970, Richland, WA 99352 (US)). Waste management '87: Waste isolation in the US, technical programs, and public education. Post, R.G. University of Arizona Nuclear Engineering Dept., (1987). pp. 471-476 (CONF-870306–: Waste management '87, Tucson, AZ, US, March 1, 1987).

The purpose of this paper is to report the results of an experiment designed to detect the influence of copper on zircaloy spent fuel cladding degradation in a tuff repository environment. The results show that there are no indications of discrete copper-containing phases forming as part of a developing oxide film on the zircaloy and that it is estimated that it would take more than 30,000 years to penetrate the cladding by oxidation. Both metallography and the scanning electron microscope suggest that the effects of corrosion due to exposure to the model repository environment are not significant.

159 Performance of actinide-containing SRL 165 type glass in unsaturated conditions. Bates, J.K. (Argonne National Lab., IL (USA)); Gerding, T.J. Scientific basis for nuclear waste management 11: Volume 112: Proceedings. Apted, M.J.; Westerman, R.E. (eds. Materials Research Society, (1987). pp. 651-662 (CONF-8711100-: Symposium on the scientific basis for nuclear waste management, Boston, MA, US, November 30, 1987).

As part of the effort by the Nevada Nuclear Waste Storage Investigations (NNWSI) Project to evaluate the volcanic tuff beds of Yucca Mountain, Nevada, as a repository for the permanent storage of high-level nuclear waste, the interaction of actinide-doped Savannah River Laboratory (SRL) 165 type glass with the unsaturated repository environment has been studied. The NNWSI Unsaturated Test method has been used, and the results from batch and continuous tests completed through 18 months demonstrate that several interactions are important for controlling both the reaction of the glass and the release of radionuclides. These interactions include (1) the reaction between the glass and moist air with interludes of liquid water contact, which results in the release of alkali metals from the glass; and (2) the reaction between standing water, glass, and presensitized 304 L type stainless steel which results in breakdown of the glass matrix and the release of radionuclides from the glass-metal assemblage. A comparison of the results of the Unsaturated Test with those of parametric experiments illustrates the importance of presensitized steel in enhancing the glass reaction, and demonstrates the applicability of the Unsaturated Test to those conditions anticipated to exist in the NNWSI repository horizon. 10 references.

160 Geochemical simulation of dissolution of West Valley and DWPF glasses in J-13 water at 90C. Bruton, C.J. (Lawrence Livermore National Lab., CA (USA)). Scientific basis for nuclear waste management 11: Volume 112: Proceedings. Apted, M.J.; Westerman, R.E. (eds. Materials Research Society, (1987). pp. 607-619 DOE Contract W-7405-ENG-48. (CONF-8711100-: Symposium on the scientific basis for nuclear waste management, Boston, MA, US, November 30, 1987).

Dissolution was simulated using the EQ3/6 computer code package. The objectives of the study were to attempt to predict the concentrations of radionuclides and other glass components in solution resulting from glass dissolution, and to identify potential precipitates that sequester glass components. Simulation results predict that radionuclides and other glass components precipitate predominantly in the form of oxides and hydroxides, together with carbonates, silicates and phosphates. Precipitates appear to be effective in limiting the concentrations of radionuclides and other elements in solution. Concentrations of elements released from glass increase until the solution reaches saturation with respect to solids that contain these elements. Elemental concentrations are then predicted to remain constant, increase or decrease depending on: (1) whether the reaction between the dominant aqueous species of the element in solution and its precipitate is pH and/or Eh-dependent; (2) whether the species distribution of the element in solution changes significantly in response to changes in pH, Eh, or other factors; and (3) the competition with other phases for elements required to form the precipitate. pH increases from 7.3 to 9.8 and from 7.2 to 10 in the West Valley and DWPF simulations, respectively. Eh decreases abruptly from about 0.5 to 0.3 volts after dissolution of 3.4 and 5.8 grams of glass in the West Valley and DWPF simulations, respectively, because of depletion of dissolved oxygen in solution. Complexing of aqueous species has a significant impact on radionuclide concentrations in solution; predicted concentrations of U in solution, for example, are controlled by the presence or absence of P in solution because H_2PO_4 is an extremely effective complexing agent for U. 20 references.

161 Leaching fully radioactive SRP nuclear waste glass in tuff ground water in stainless steel vessels. Bibler, N.E. (E.I. du Pont de Nemours and Co., Savannah River Lab., Aiken, SC (US)). Nuclear waste management II. Passchier, W.F.; Bosnjakovic, B.F.M. American Ceramic Society Inc., Westerville, OK (1986). pp. 619-626 (CONF-8608225-: 3. international symposium on ceramics in nuclear waste management, Chicago, IL, US, August 28, 1986).

SRP glass containing actual radioactive waste was leached in static tests at 90^{0}C in a tuffaceous ground water at an SA/V ratio of 100 m^{-1} in 316 stainless steel vessels. Tests were performed for up to 134 days. Normalized mass losses were calculated for ^{137}Cs, ^{90}Sr, and ^{238}Pu. The ^{137}Cs in the leachate appeared to reach a steady value of $\approx$3 g/m^2, corresponding to steady state concentration of only 1.0 ppb for total cesium. The mass losses based on ^{90}Sr and ^{238}Pu appearing in solution were low ($<$0.3 and $<$0.01, respectively), because of their low solubilities. However, significant amounts of these radionuclides had deposited on the steel vessel, while the amount of deposited ^{137}Cs was negligible. During the leach tests, the pH changed $<$0.4 units and the only significant effect of radiolysis was reduction of NO_3^- ions in solution to NO_2^-. When compared to earlier tests, the results confirm that leach rates in the earlier tests with radioactive glass in Teflon vessels were high due to radiolysis of the Teflon. The results also indicate that radioactive and nonradioactive glasses of comparable composition and surface finish leach essentially identically.

162 The effect of gamma radiation on ground-water chemistry and glass leaching as related to the NNWSI repository site. Abrajano, T. (Argonne National Lab., Chemical Technology Div., Argonne, IL (US)); Bates, J.; Ebert, W.; Gerding, T. Nuclear waste management II. Passchier, W.F.; Bosnjakovic, B.F.M. American Ceramic Society Inc., Westerville, OK (1986). pp. 609-618 (CONF-8608225-: 3. international symposium on ceramics in nuclear waste management, Chicago, IL, US, August 28, 1986).

This paper presents an overview of the results of leaching experiments performed on Savannah River Laboratory 165 type glass under a gamma radiation field of 1.0 +- 0.2 x 10^4 rad/h with emphasis on describing the effect of ionizing radiation on ground-water chemistry and waste form durability. These experiments were performed for 14, 28, 56, 91 and 182 days at 90^{0}C using tuff-equilibrated J-13 ground water (EJ-13) as the leachant. Acidification of EJ-13 solution from radiolytic production of nitric acid was buffered by adequate levels of dissolved bicarbonate and, in the presence of glass, by alkali leaching. Compared to similar experiments in the absence of radiation, the net effect of this interaction is to retard glass dissolution. However, the integrated release of actinides and other glass components that are more soluble below neutral pH may be relatively enhanced by this acidification.

163 Test concept for waste package environment tests at Yucca Mountain. Yow, J.L. Jr. (Lawrence Livermore National Lab., CA). Rock mechanics: Proceedings of the 28th U.S. symposium. Farmer, I.W.; Daemen, J.J.K.; Desai, C.S.; Glass, C.E.; Neuman, S.P. A.A. Balkema Publishers, (1987). pp. 1035-1042 DOE Contract W-7405-ENG-48. (CONF-870625–: 28. U.S. symposium on rock mechanics, Tucson, AZ, US, June 29, 1987).

The Nevada Nuclear Waste Storage Investigations Project is characterizing a tuffaceous rock unit at Yucca Mountain, Nevada to evaluate its suitability for a repository for high level radioactive waste. The candidate repository horizon is a welded, devitrified tuff bed located at a depth of about 300 m in the unsaturated zone, over 100 m above the water table. Waste package environment tests are being conducted in an exploratory shaft test facility at Yucca Mountain. The status and development of these tests are described in this article.

164 Dissolution kinetics of quartz as a function of pH and time at 70°C. Knauss, K.G. (Lawrence Livermore National Lab., CA (USA)); Wolery, T.J. *Geochimica et Cosmochimica Acta (USA),* 52(1): 43-53 (Jan 1988). DOE Contract W-7405-ENG-48.

A single-pass, flow-through apparatus was used to determine the dissolution rate of quartz at 70°C as a function of pH and time. Dissolution rate data were obtained over the pH range 1.4 to 11.8 in nine separate experiments each lasting 50 days. The quartz dissolution rates were defined by the silica release rate to solution. Speciation-solubility calculations using the geochemical modeling code EQ36 indicate that the fluid was maintained far from equilibrium with respect to quartz and well-undersaturated with respect to all possible secondary minerals in all runs. The dissolution rates were independent of pH at values ($10^{-15.3}$ molcm^2 x s) consistent with the data of Rimstidt and Barnes (1980) up to approximately pH 6, but at higher pH the rates increased with increasing pH, proportional to $a_{H^+}{}^{-0.5}$, being almost four orders of magnitude higher at pH 11.8. The rate constants for quartz dissolution at 70°C were $10^{-15.3}$ molcm^2 x s in the pH-independent region extending from acid through neutral solutions, and $10^{-17.8}$ molcm^2 x s in more alkaline solutions. Etch pits were strongly developed in the runs with the more alkaline solutions (pH $>$ 8), in which the rates were the highest. This appears consistent with a surface reaction-controlled dissolution mechanism.

165 Important radionuclides in high level nuclear waste disposal: Determination using a comparison of the U.S. EPA and NRC regulations. Oversby, V.M. (Earth Sciences Dept., Lawrence Livermore National Lab., Livermore, CA). *Nuclear and Chemical Waste Management (USA),* 7(2): 149-162 (1987). DOE Contract W-7405-ENG-48.

The performance objective for the engineered barrier system given in the NRC regulations (10CFR60) is used to determine a maximum release rate for each significant radionuclide for a generic repository containing PWR spent fuel. This release rate, integrated over the times during which release would occur, is then compared to the U.S. EPA requirements on limitation of total releases to the accessible environment. The amount by which the releases allowed under the NRC regulations exceeds the U.S. EPA requirements is an indication of the importance of the radionuclide for performance assessment purposes. Americium and plutonium are by far the most important. The other actinides, carbon, and nickel are also important. If the assumption of congruent dissolution is imposed, with a 1% rapid release spike for cesium, iodine, carbon, and technetium, the list of elements reduces to 13, with iodine, cesium, selenium, and palladium being eliminated from the list. The importance of americium is greatly reduced in this case and plutonium becomes the most important element. A final analysis, which assumed a congruent dissolution rate of one part in 1,000,000 per year, results in a list of at most seven important elements.

166 Reaction of reference commercial nuclear waste glasses during gamma irradiation in a saturated tuff environment. Bates, J.K. (Chemical Technology Division, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois 60439-4837); Ebert, W.L.; Fischer, D.F.; Gerding, T.J. *Journal of Materials Research (USA),* 3(3): 576-597 (May 1988). DOE Contract W-31-109-ENG-38.

The effects of gamma irradiation on groundwater and the reaction between groundwater and glass have been investigated at radiation exposure rates of 2 x 10^5 , 1 x 10^3 , and 0 R/h. These experiments, which bound the conditions that may occur in a high-level nuclear waste repository located in tuff, have been performed using the actinide-containing glasses ATM-1c and ATM-8, and have been performed for time periods up to 278 days. The experimental results indicate that when only the repository groundwater is present, the pH of the system remains near-neutral, regardless of the radiation field, due to the buffering capacity of the solution. When glass is added to the system, the subsequent reaction is governed by the solution chemistry, which results from a complex interaction between radiolysis products, glass reaction products, and groundwater components. While no long-term reaction trends have been extracted from the current data, it is noted that there are no outstanding differences in the reaction of the glasses as measured by the release of the soluble components B, Mo, and Na, as a function of radiation exposure rate. However, there is a marked difference in the amount of U, Np, and Pu released from the glasses as a function of radiation exposure rate. This difference can be correlated with the pH values of the leachate, with more basic solutions resulting in lower actinide release.

167 Effectiveness of Geologic Characterization techniques, Climax Granitic Stock, Nevada Test Site. Wilder, D.G. (Lawrence Livermore National Laboratory, P.O. Box 808, L-204, Livermore, CA 94550 (USA)); Yow, J.L. Jr. *Bulletin of the Association of Engineering Geologists (USA),* 24(4): 537-548 (Jan 1986). DOE Contract W-7405-ENG-48.

Also available as Lawrence Livermore National Laboratory Report UCRL-92687.

Several different techniques were used to characterize the structural geology of the quartz monzonite unit of the Climax Stock. This study examined major geologic structural features and yielded detailed data on over 1,500 fractures. The data were used to identify joint sets, faults and shear zones as well as to statistically analyze joint frequencies and spacings. Eight joint sets, three major shear sets, and a fault zone were studied. The results of previous geologic characterization work performed by many other investigators were compared with the results of our studies. These data provided the basis for evaluating how effective various techniques were in describing the structural geology of the Climax Stock. The specific techniques that were evaluated included the use of unoriented diiamond drilled core, mappoing of only major fractures within the drifts, detailed mapping using modified scan-line techniques, data reduction techniques to account for orientation biases, and surface trench mapping. The results of this study identified several issues for consideration during characterization studies. Firstly, geologic structural features that are often assumed to be uniform and continuous were shown to change characteristics within very short distances. Secondly, we demonstrated that when applied properly to an adequate data set, orientation bias correction techniques were effective in identifying all fracture sets. Thirdly, we demonstrate that unless three nearly equal length orthogonal surfaces are mapped, interpretations of spacing or of joint prevalence can be misleading. Finally, we demonstrate the usefulness of mapping only isolated and limited sized areas in detail with more general or reconnaissance mapping of the entire facility to tie the detailed map sections together and to identify major features. 10 refs., 23 figs., 2 tabs.

168 Evidence for dynamic withdrawal from a layered magma body: The Topopah Spring Tuff, southwestern Nevada. Schuraytz, B. C. (Department of Geological Sciences, Michigan State University, East Lansing(US)); Vogel, T. A.; Younker, L. W. *Journal of Geophysical Research (USA),* 94(B5): 5925-5942 (10 May 1989).

The Topopah Spring Tuff is a classic example of a compositionally zoned ash flow sheet resulting from eruption of a compositionally zoned magma body. Geochemical and petrographic analyses of whole rock tuff samples indicate that the base of the ash flow sheet and the predominant volume of erupted material consist of crystal-poor high-silica rhyolite, with agradational transition into overlying crystal-rich quartz latite. However, major and trace element analyses of glassy pumice lumps and microprobe analyses of their silicate and oxide phenocrysts provide closer approximations of the chemical and thermal gradients within the magma body. The gradients inferred from these data indicate that the transition from high-silica rhyolitic to quartz latitic magma within the chamber was abrupt, rather than gradational, with a distinct liquid-liquid interface separating the contrasting magma layers. Compositionally and texturally distinct pumice lumps are present throughout the ash flow sheet. The degree of heterogeneity within and among pumice lumps increases with stratigraphic height, becoming most pronounced in the uppermost quartz latite, where the chemical variability among pumice lumps is as great as that of the entire ash flow sheet. These observations are consistent with fluid dynamic models in which the velocity field developed near the entrance region of the vent(s) results in simultaneous withdrawal of magma from all points of a continuously expanding lateral and vertical region within the chamber. The abrupt transition to chemically bimodal pumice types near the top of the ash flowsheet, dominated by those of quartz latitic composition, implies that the interface between the magma layers remained relatively stable until drawdown breached the interface and preferentially erupted hotter, more mafic magma along with lesser amounts of remaining high-silica rhyolitic magma.

SANDIA NATIONAL LABORATORIES

169 (LBL–25547) **Numerical modeling of multiphase and nonisothermal flow in fractured media.** Pruess, K.; Narasimhan, T.N. Lawrence Berkeley Lab., CA (USA). Jul 1988. 22p. DOE Contract AC03-76SF00098. (CONF-880583–3: International conference on fluid flow in fractured rocks, Atlanta, GA, US, May 15, 1988). Order Number DE88014855. Source: NTIS, PC A03/MF A01; GPO Dep.

Approaches for modeling of coupled multiphase fluid and heat flow in fractured media include "explicit" modeling of fractures, which are represented as domains with small spatial scale and large permeability: effective continuum approximations, in which one attempts to model the composite behavior of a fractured porous medium in terms of a single effective continuum; and "hybrid" models such as double- or multiple-porosity techniques which combine features of the explicit fracture and effective continuum approaches. We present examples of each of these approaches. The explicit fracture approach has been applied to investigate thermohydrologic conditions near high-level nuclear waste packages emplaced in partially saturated fractured tuffs. Besides providing some useful insight into multiphase flow processes this approach substantiates an effective continuum approximation, which leads to a drastic simplification in the modeling of fractured flow systems. A consideration of diffusive processes in rock matrix and fractures provides criteria for the validity of the effective continuum approximation; these have been verified by means of numerical experiments. Flow studies using the method of "multiple interacting continua" have demonstrated how effects of global flow tend to diminish sensitivity to individual matrix block response in enhanced oil recovery and in heat mining in geothermal systems. In some cases simple semi-analytical techniques are found to provide an adequate approximation to the complexities of multiple-continua behavior. 25 refs., 4 figs., 4 tabs.

170 (LBL–27578) **Semi-analytical solutions for flow problems in unsaturated porous media.** Zimmerman, R.W.; Bodvarsson, G.S. Lawrence Berkeley Lab., CA (USA). Aug 1989. 24p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC03-76SF00098. (CONF-891208–20: Winter annual meeting of the American Society of Mechanical Engineers, San Francisco, CA (USA), 10-15 Dec 1989). Order Number DE90000556. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Semi-analytical solutions are developed for two unsaturated flow problems that are relevant to characterizing the hydrological behavior of Yucca Mountain, the site of a proposed nuclear waste repository. The "integral" or "boundary-layer" approach is used to find a closed-form approximate solution for absorption of water from a saturated fracture into an unsaturated semi-infinite formation. This solution is then programmed into a numerical code as a source/sink term for fracture elements, and used to study the problem of flow along a fracture with transverse leakage to the rock matrix. 21 refs., 7 figs.

171 (SAND–84-0307) **A technique for the geometric modeling of underground surfaces: Nevada Nuclear Waste Storage Investigations Project.** Williams, R.L. Sandia National Labs., Albuquerque, NM (USA). Mar 1988. 84p. DOE Contract AC04-76DP00789. Order Number DE88009792. Source: NTIS, PC A05/MF A01.

There is a need within the Nevada Nuclear Waste Storage Investigation (NNWSI) project to develop three-dimensional surface definitions for the subterranean stratigraphies at Yucca Mountain, Nevada. The nature of the data samples available to the project require an interpolation technique that can perform well with sparse and irregularly spaced data. Following an evaluation of the relevant existing methods, a new technique, Multi-Kernel Modulation (MKM), is presented. MKM interpolates sparse and irregularly spaced data by modulating a polynomial trend surface with a linear summation of regular surfaces (kernels). A perspective discussion of MKM, Kriging, and Multiquadric Analysis reveals that MKM has the advantage of simplicity and efficiency when used with sparse samples. An example of the use of MKM to model a complex topography is presented. 24 refs., 6 figs., 2 tabs.

172 (SAND–84-0468) **Experimental plan for investigating water movement through fractures: Yucca Mountain Project.** Klavetter, E.A.; Peters, R.R.; Schwartz, B.M. Sandia National Labs., Albuquerque, NM (USA). Mar 1989. 113p. DOE Contract AC04-76DP00789. Order Number DE89010539. Source: NTIS, PC A06/MF A01 - OSTI; GPO Dep.

The Yucca Mountain site in southern Nevada is being investigated by the Nevada Nuclear Waste Storage Investigations (NNWSI) project as a possible site for a nuclear waste repository. The manner in which the water flows downward from the repository through the unsaturated zone to the water table can affect the transport of radionuclides. The travel time of water across a rock unit is considerably shorter if the flow is predominantly through fractures than if it is predominantly through the rock matrix. Current data and postulated physical models indicate that there is little or no significant flow through fractures in the unsaturated zone at Yucca Mountain. Fracture data are required to increase confidence in this conclusion and would be used qualitatively to increase understanding and quantitatively in modeling. The evaluation of water flow in fractures is also necessary for abnormal scenarios where significant fracture flow may occur because of future climatic conditions. An experimental system is described for the purpose of investigating the movement of water through fractures. The system will be used to perform the tests described in this report. 14 refs., 11 figs., 3 tabs.

173 (SAND–84-1697) **Capillary-driven flow in a fracture located in a porous medium.** Martinez, M.J. Sandia National Labs., Albuquerque, NM (USA). Sep 1988. 52p. DOE Contract AC04-76DP00789. Order Number DE89001055. Source: NTIS, PC A04/MF A01.

Capillary-driven immiscible displacement of air by water along an isolated fracture located in a permeable medium is induced by an abrupt change in water saturation at the fracture inlet. The fracture is idealized as either a smooth slot with permeable walls or a high-permeability later. The penetration distance of moisture in the fracture permeability ratio and length scales for the problem. The models are applied to materials representative of the Yucca Mountain region of the Nevada Test Site. Fracture moisture-penetration histories are predicted for several units in Yucca Mountain and for representative fracture apertures. 18 refs., 20 figs., 6 tabs.

174 (SAND–84-1895) **Technical basis for performance goals, design requirements, and material recommendations for the NNWSI [Nevada Nuclear Waste Storage Investigations] Repository Sealing Program.** Fernandez, J.A.; Kelsall, P.C.; Case, J.B.; Meyer, D. Sandia National Labs., Albuquerque, NM (USA); IT Corp., Albuquerque, NM (USA). Sep 1987. 355p. DOE Contract AC04-76DP00789. Order Number DE88003269. Source: NTIS, PC A16/MF A01; GPO Dep.

The objectives are to develop performance goals, to assess the need for seals, to define design requirements, and to recommend potential sealing materials for the sealing system. Performance goals are the allowable amounts of water that can enter the waste disposal areas directly from the rock mass above the repository and indirectly from shafts and ramps connecting to the underground facility. These goals are developed using a numerical model that calculates radionuclide releases. To determine the need for sealing, estimates of water flow into shafts, ramps, and the underground facility under anticipated conditions are developed and are compared with the performance goals. It is concluded that limited sealing measures, such as emplacement of shaft fill, are sufficient to properly isolate the radioactive waste in the repository. A broad range of sealing design options and associated hydrologic design requirements are proposed to provide a greater degree of assurance that the hydrologic performance goals can be met even if unanticipated hydrologic flows enter the waste disposal areas. The hydrologic design requirements are specific, hydraulic conductivity values selected for specific, seal design options to achieve the performance goals. Using these hydrologic design requirements and additional design requirements, preferred materials are identified for continued design and laboratory analyses. In arriving at these preferred materials, results from previous laboratory testing are briefly discussed. 96 refs., 48 figs., 28 tabs.

175 (SAND–84-2641-Vol.1) **Site characterization plan: Conceptual design report, Volume 1: Chapters 1-3.** MacDougall, H.R.; Scully, L.W.; Tillerson, J.R. (comps. Sandia National Labs., Albuquerque, NM (USA); Bechtel National, Inc., San Francisco, CA (USA); Parsons, Brinckerhoff, Quade and Douglas, Inc., San Francisco, CA (USA). Sep 1987. 277p. DOE Contract AC04-76DP00789. Order Number DE88003720. Source: NTIS, PC A13/MF A01; GPO Dep.

The site for the prospective repository is located at Yucca Mountain in southwestern Nevada, and the waste emplacement area will be constructed in the underlying volcanic tuffs. The target horizon for waste emplacement is a sloping bed of densely welded tuff more than 650 ft below the surface and typically more than 600 ft above the water table. The conceptual design described in this report is unique among repository designs in that it uses ramps in addition to shafts to gain access to the underground facility, the emplacement horizon is located above the water table, and it is possible that 300- to 400-ft-long horizontal waste emplacement boreholes will be used. This report summarizes the design bases (site and properties of the waste package), design and performance criteria, and the design analyses performed. The current status of meeting the preclosure performance objectives for licensing and of resolving the repository design and preclosure issues is presented. The repository design presented in this report will be expanded and refined during the advanced conceptual design, the license application design, and the final procurement and construction design phases.

176 (SAND–84-2641-Vol.2) **Site characterization plan: Conceptual design report, Volume 2: Chapters 4-9: Nevada Nuclear Waste Storage Investigations**

Project. MacDougall, H.R.; Scully, L.W.; Tillerson, J.R. (comps. Sandia National Labs., Albuquerque, NM (USA); Bechtel National, Inc., San Francisco, CA (USA); Parsons, Brinckerhoff, Quade and Douglas, Inc., San Francisco, CA (USA). Sep 1987. 537p. DOE Contract AC04-76DP00789. Order Number DE88003619. Source: NTIS, PC A23.

This document presents a description of a prospective geologic repository for high-level radioactive waste to support the development of the Site Characterization Plan for the Yucca Mountain site. The target horizon for waste emplacement is a sloping bed of densely welded tuff more than 650 ft below the surface and typically more than 600 ft above the water table. The conceptual design described in this report is unique among repository designs in that it uses ramps in addition to shafts to gain access to the underground facility, the emplacement horizon is located above the water table, and it is possible that 300- to 400-ft-long horizontal waste emplacement boreholes will be used. This report summarizes the design bases (site and properties of the waste package), design and performance criteria, and the design analyses performed. The current status of meeting the preclosure performance objectives for licensing and of resolving the repository design and preclosure issues is presented. The repository design presented in this report will be expanded and refined during the advanced conceptual design, the license application design, and the final procurement and construction design phases. 147 refs., 145 figs., 83 tabs.

177 (SAND–84-2641-Vol.3) **Site characterization plan: Conceptual design report, Volume 3: Appendices A-E: Nevada Nuclear Waste Storage Investigations Project.** MacDougall, H.R.; Scully, L.W.; Tillerson, J.R. (comps. Sandia National Labs., Albuquerque, NM (USA); Bechtel National, Inc., San Francisco, CA (USA); Parsons, Brinckerhoff, Quade and Douglas, Inc., San Francisco, CA (USA). Sep 1987. 553p. DOE Contract AC04-76DP00789. Order Number DE88004779. Source: NTIS, PC A24.

This document presents a description of a prospective geologic repository for high-level radioactive waste to support the development of the Site Characterization Plan for the Yucca Mountain site. The site for the prospective repository is located at Yucca Mountain in southwestern Nevada, and the waste emplacement area will be constructed in the underlying volcanic tuffs. The target horizon for waste emplacement is a sloping bed of densely welded tuff more than 650 ft below the surface and typically more than 600 ft above the water table. The conceptual design described in this report is unique among repository designs in that it uses ramps in addition to shafts to gain access to the underground facility, the emplacement horizon is located above the water table, and it is possible that 300- to 400-ft-long horizontal waste emplacement boreholes will be used. This report summarizes the design bases, design and performance criteria, and the design analyses performed. The current status of meeting the preclosure performance objectives for licensing and of resolving the repository design and preclosure issues is presented. Volume 3 contains Appendices A through E.

178 (SAND–84-2641-Vol.4) **Site characterization plan: Conceptual design report: Volume 4, Appendices F-O: Nevada Nuclear Waste Storage Investigations Project.** MacDougall, H.R.; Scully, L.W.; Tillerson, J.R. (comps. Sandia National Labs., Albuquerque, NM (USA); Bechtel National, Inc., San Francisco, CA (USA); Parsons, Brinckerhoff, Quade and Douglas, Inc., San Francisco, CA (USA). Sep 1987. 817p. DOE Contract AC04-76DP00789. Order Number DE88004780. Source: NTIS, PC A99.

The site for the prospective repository is located at Yucca Mountain in southwestern Nevada, and the waste emplacement area will be constructed in the underlying volcanic tuffs. The target horizon for waste emplacement is a sloping bed of densely welded tuff more than 650 ft below the surface and typically more than 600 ft above the water table. The conceptual design described in this report is unique among repository designs in that it uses ramps in addition to shafts to gain access to the underground facility, the emplacement horizon is located above the water table, and it is possible that 300- to 400-ft-long horizontal waste emplacement boreholes will be used. This report summarizes the design bases, design and performance criteria, and the design analyses performed. The current status of meeting the preclosure performance objectives for licensing and of resolving the repository design and preclosure issues is presented. The repository design presented in this report will be expanded and refined during the advanced conceptual design, the license application design, and the final procurement and construction design phases. Volume 4 contains Appendices F to O.

179 (SAND–84-2641-Vol.5) **Site characterization plan: Conceptual design report: Volume 5, Appendices P-R: Nevada Nuclear Waste Storage Investigations Project.** MacDougall, H.R.; Scully, L.W.; Tillerson, J.R. (comps. Sandia National Labs., Albuquerque, NM (USA); Bechtel National, Inc., San Francisco, CA (USA); Parsons, Brinckerhoff, Quade and Douglas, Inc., San Francisco, CA (USA). Sep 1987. 789p. DOE Contract AC04-76DP00789. Order Number DE88004781. Source: NTIS, PC A99/MF A01; GPO Dep.

The site for the prospective respository is located at Yucca Mountain in southwestern Nevada, and the waste emplacement area will be constructed in the underlying volcanic tuffs. The target horizon for waste emplacement is a sloping bed of densely welded tuff more than 650 ft below the surface and typically more than 600 ft above the water table. The conceptual design described in this report is unique among repository designs in that it uses ramps in addition to shafts to gain access to the underground facility, the emplacement horizon is located above the water table, and it is possible that 300- to 400-ft-long horizontal waste emplacement boreholes will be used. This report summarizes the design bases, design and performance criteria, and the design analyses performed. The current status of meeting the preclosure performance objectives for licensing and of resolving the repository design and preclosure issues is presented. The repository design presented in this report will be expanded and refined during the advanced conceptual design, the license application design, and the final procurement and construction design phases. Volume 5 contains appendices P through R.

180 (SAND–84-2641-Vol.6) **Site characterization plan: Conceptual design report: Volume 6, Drawing portfolio: Nevada Nuclear Waste Storage Investigations Project.** MacDougall, H.R.; Scully, L.W.; Tillerson, J.R. (comps. Sandia National Labs., Albuquerque, NM (USA); Bechtel National, Inc., San Francisco, CA (USA); Parsons, Brinckerhoff, Quade and Douglas, Inc., San Francisco, CA (USA). Sep 1987. 247p. DOE Contract AC04-76DP00789. Order Number DE88004782. Source: NTIS, PC A11.

This document presents a description of a prospective geologic repository for high-level radioactive waste to support the development of the Site Characterization Plan for the Yucca Mountain site. The site for the prospective repository is located at Yucca Mountain in southwestern Nevada, and the waste emplacement area will be constructed in the underlying volcanic tuffs. The target horizon for waste emplacement is a sloping bed of densely welded tuff more than 650 ft below the surface and typically more than 600 ft above the water table. The conceptual design described in this report is unique among repository designs in that it uses ramps in addition to shafts to gain access to the underground facility, the emplacement horizon is located above the water table, and it is possible that 300- to 400-ft-long horizontal waste emplacement boreholes will be used. This report summarizes the design bases, design and performance criteria, and the design analyses performed. The current status of meeting the preclosure performance objectives for licensing and of resolving the repository design and preclosure issues is presented. The repository design presented in this report will be expanded and refined during the advanced conceptual design, the license application design, and the final procurement and construction design phases. Volume 6 contains drawings. 114 figs.

181 (SAND–84-7130) **Spent-fuel consolidation system: Nevada Nuclear Waste Storage Investigations Project.** Townes, G.A.; Godfrey, W.L.; Anderson, K.J. BE, Inc., Barnwell, SC (USA); Sandia National Labs., Albuquerque, NM (USA). Sep 1987. 189p. DOE Contract AC04-76DP00789. Order Number DE88001787. Source: NTIS, PC A09/MF A01; GPO Dep.

This document describes a developmental study of equipment and operations for disassembling and packaging commercially generated light water reactor spent fuel. This fuel-consolidation study supports the conceptual design activities of the Nevada Nuclear Waste Storage Investigations project for the development of facilities at Yucca Mountain, Nevada, a candidate site for the disposal of radioactive waste. The study includes a review of current technology and existing equipment that potentially applies to a spent-fuel consolidation system. It generates a definition of the design bases for a consolidation system; provides recommendations for and descriptions of equipment and operations; and presents a design rationale, a staffing plan, and partial life-cycle cost estimates. 3 refs.

182 (SAND–85-0002) **Total System Performance Assessment Code (TOSPAC): Volume 1, Physical and mathematical bases: Yucca Mountain Project.** Dudley, A.L.; Peters, R.R.; Gauthier, J.H.; Wilson, M.L.; Tierney, M.S.; Klavetter, E.A. Sandia National Labs., Albuquerque, NM (USA). Dec 1988. 204p. DOE Contract AC04-76DP00789. Order Number DE89006312. Source: NTIS, PC A10/MF A01 - OSTI; GPO Dep.

TOSPAC is a computer program designed to simulate water flow and transport of soluble waste materials along ground water pathways through fractures, porous rock formations similar to those at Yucca Mountain, Nevada, a candidate site for a high-level nuclear-waste repository. The physical models and simplifying assumptions used are described, along with their mathematical formulation and the numerical techniques used to implement them. Example problems demonstrating the capabilities of the code are presented. 64 refs., 101 figs., 9 tabs.

183 (SAND–85-0598) **Selected analyses to evaluate the effect of the exploratory shafts on repository performance at Yucca Mountain: Yucca Mountain Project.** Fernandez, J.A.; Hinkebein, T.E.; Case, J.B. Sandia National Labs., Albuquerque, NM (USA). Jan 1989. 270p. DOE Contract AC04-76DP00789. Order Number DE89010528. Source: NTIS, PC A12/MF A01 - OSTI; GPO Dep.

This report presents a number of analyses to determine whether the construction of two shafts associated with the exploratory shaft facility can significantly influence the long-term isolation capabilities of a high-level nuclear waste repository at Yucca Mountain, on and adjacent to the Nevada Test Site. Both shafts are planned to be located predominantly in fractured, welded tuff within the unsaturated zone. The calculational effort, using analytical solutions, focuses primarily on the potential influence of the shaft liner and the zone of increased rock damage around the shaft (termed in this paper the modified permeability zone, MPZ). Two mechanisms are considered in determining whether the MPZ can significantly enhance radionuclide releases. These mechanisms include water flow entering the exploratory shafts from both realistic and improbable scenarios and airflow exiting the shaft as a result of convective and barometric forces. The influence of the liner on the performance of the repository is determined by evaluating the potential chemical interaction between ground water and the concrete liner and the subsequent potential for precipitates to deposit within the MPZ and the shaft fill. It is concluded from these calculations and the current knowledge of the hydrology of the unsaturated zone at Yucca Mountain that the presence of the shafts and the associated MPZ and shaft liner do not significantly impact the long-term isolation capability of the repository. 68 refs., 54 figs., 12 tabs.

184 (SAND–85-7111) **Installation of steel liner in blind hole study.** Kenny Construction Co., Wheeling, IL (USA); Sandia National Labs., Albuquerque, NM (USA). Sep 1987. 42p. DOE Contract AC04-76DP00789. Order Number DE88001316. Source: NTIS, PC A03/MF A01; GPO Dep.

Lining of horizontally bored, waste-emplacement holes has been studied for possible use in underground nuclear waste repositories. This study developed and evaluated a technically feasible concept for installing a steel liner in a 37-in.-diameter borehole up to 700 ft in length. This report reviews the history of jacking such lines in place, surveys existing equipment, reviews the cost estimate for this procedure, examines welding technology for the application, and concludes with a critical review of the construction risk. 9 figs., 1 tab.

185 (SAND–85-7117) **A first survey of disruption scenarios for a high-level-waste repository at Yucca Mountain, Nevada: Nevada Nuclear Waste Storage Investigations Project.** Ross, B. Disposal Safety, Inc., Washington, DC (USA). Dec 1987. 147p. DOE Contract AC04-76DP00789. Order Number DE88004144. Source: NTIS, PC A07/MF A01; GPO Dep.

A high-level-waste repository located in unsaturated welded tuff at Yucca Mountain, Nevada, would rely on six different, although not entirely independent, barriers to prevent escape of radioactivity. These barriers are the waste canister, fuel cladding, dissolution of the spent fuel itself, and movement of released contaminants in the unsaturated Topopah Spring welded tuff unit, the unsaturated Calico Hills nonwelded tuff unit, and the saturated tuff aquifer. Fifty-eight processes and events that might affect such a repository were examined. Eighty-four different sequences were identified by which these processes and events could lead to failure of one or more barriers. Sequences that had similar consequences were grouped into 17 categories: direct release, repository flooding, colloid formation, increased water flux through the repository, accelerated fracture flow, water diverted toward the waste package, accelerated dissolution mechanisms, accelerated cladding corrosion mechanisms, accelerated canister corrosion mechanisms, canister breakage, fracture flow in the Topopah Spring welded unit without increased moisture flux, reduced sorption in the Topopah Spring welded unit, water table rise above the Calico Hills nonwelded unit, fracture flow in the Calico Hills nonwelded unit, new discharge points, and faster flow in the saturated zone. 52 refs., 6 figs., 1 tab.

186 (SAND–86-0940) **Transport of solutes through unsaturated fractured media: Nevada Nuclear Waste Storage Investigations Project.** Dykhuizen, R.C. Sandia National Labs., Albuquerque, NM (USA). Mar 1988. 16p. DOE Contract AC04-76DP00789. Order Number DE88014700. Source: NTIS, PC A03/MF A01; GPO Dep.

A numerical model is presented to represent the transport of solutes through a highly fractured unsaturated, porous medium. To accomplish this, the solute is tracked separately in two flow systems a matrix pore flow system and a fracture network, with interaction terms. Compatible hydraulic equations for such a dual system are also presented to enable solution of the solute trasport. The hydraulic equations chosen use the equivlaent porous media concept. These equations can also be applied to a saturated medium without modification. However, many of the transport terms will be negligible for such an application. A brief sample calculation illustates the method. 11 refs., 4 figs.

187 (SAND–86-1580C) **Modeling of multiphase flow in permeable media: (1) Mathematical model; (2) Analysis of imbibition and drying experiments.** Bixler, N.E.; Eaton, R.R. Sandia National Labs., Albuquerque, NM (USA). 1986. 16p. DOE Contract AC04-76DP00789. (CONF-8607358–1: Gordon research conference on modelling of flow in permeable media, Andover, NH, US, July 28, 1986). Order Number DE88002423. Source: NTIS, PC A03/MF A01; GPO Dep.

Calculating multiphase flow of water through fractured porous media, such as volcanic tuff, is a numerically challenging problem because of the highly nonlinear material characteristics of permeability and saturation which describe liquid and gas transport. Typically, the permeability of the fractured host rock being investigated for an underground nuclear waste repository at Yucca Mountain, Nevada increases by 15 orders of magnitude as the rock becomes saturated. Furthermore, permeability may vary by five orders of magnitude between geologic strata. Other nonlinear mechanisms - Knudsen diffusion, binary diffusion, vapor pressure lowering, and adsorption of vapor onto pore walls - may also strongly affect liquid and gas transport. In Part I of the presentation, the mathematical model and its computer implementation are presented. The application of these equations and solution procedures to problems related to underground waste repositories are addressed in Part II. Predicted results will be compared with the results of laboratory experiments in which a core of volcanic tuff has first undergone controlled imbibition, then drying. The importance of the various transport mechanisms is demonstrated by examining the predicted results. 14 figs.

188 (SAND–86-1955) **Proposed preliminary definition of the disturbed-zone boundary appropriate for a repository at Yucca Mountain.** Langkopf, B.S. Sandia National Labs., Albuquerque, NM (USA). Dec 1987. 112p. DOE Contract AC04-76DP00789. Order Number DE88005248. Source: NTIS, PC A06/MF A01; GPO Dep.

Some of the calculations that support the licensing of a repository for high-level radioactive waste will use the regulatory concept of a disturbed zone. The Nevada Nuclear Waste Storage Investigations (NNWSI) project must determine the location of the boundary of the disturbed zone for use in these calculations. This paper summarizes results of computer analyses and laboratory experiments and suggests a preliminary definition for the boundary of the disturbed zone for the unsaturated environment at Yucca Mountain. Although the intent of this paper is to define the boundary of the disturbed zone at the edge of significant changes in intrinsic hydrologic properties, there is no evidence of changes in intrinsic hydrologic properties that could significantly change the groundwater travel time from the repository to the water table. Such a result suggests that the disturbed zone at Yucca Mountain is of minimal extent. Because the analyses and experiments reviewed here indicate that there are a variety of changes near the waste package and because the results are subject to uncertainty, the preliminary suggestion for the extent of the disturbed zone is a value larger than the results themselves would suggest: the boundary is proposed to be a plane 10 m below the lower boundary of the waste packages. 88 refs., 12 figs., 5 tabs.

189 (SAND–86-2157) **Definitions of reference boundaries for the proposed geologic repository at Yucca Mountain, Nevada.** Rautman, C.A.; Whittet, B.C.; South, D.L. Sandia National Labs., Albuquerque, NM (USA). Nov 1987. 52p. DOE Contract AC04-76DP00789. Order Number DE88004148. Source: NTIS, PC A04/MF A01; GPO Dep.

Reference locations are proposed for six boundaries or regions specified by federal regulations related to a proposed high-level nuclear waste repository at Yucca Mountain in southern Nevada. These proposed boundaries establish the limits and extent of the underground facilities; the disturbed zone around those underground faciltiies; the geologic repository operations area, the restricted area for preclosure radiation protection, the controlled area, and the accessible environment. For each boundary, discussion of the underlying regulations is followed by a description of the proposed location of that boundary. A section describes the rationale for choosing that particular, site-specific location in relationship to the generic regulatory definition. 21 refs., 11 figs.

190 (SAND–86-2178C) **Estimates of cumulative releases of radionuclides to the water table from a repository at Yucca Mountain, Nevada.** Tierney, M.S.; Bingham, F.W. Sandia National Labs., Albuquerque, NM (USA). 1986. 13p. DOE Contract AC04-76DP00789. (CONF-860911–31-Summ.: 192. American Chemical Society national meeting, Anaheim, CA, US, September 7, 1986). Order Number DE88002422. Source: NTIS, PC A03.

Expected cumulative releases of radioactivity to the water table under a nuclear waste repository at Yucca Mountain, Nevada, are estimated for a period of 10,000 years after closure of the repository using a simple mathematical model, a ground-water travel time distribution based on a hydrologic model of the site's unsaturated zone, and measured sorption ratios of the radionuclide species in Yucca Mountain water chemistry. Only non-sorbing species, C-14, I-129 and Tc-99, are released to the water table in the 10,000-year period from a repository containing 70,000 MTU of spent fuel; the cumulative release is estimated to be about one ten-millionth of the release limit allowed in the applicable standard governing long-term containment of nuclear wastes in a geologic repository. 3 refs., 7 figs.

191 (SAND–86-2533) **Meteorological tower data for the Yucca Alluvial (YA) site and Yucca Ridge (YR) site: Final data report, July 1983-October 1984.** Church, H.W.; Freeman, D.L.; Boro, K.; Egami, R.T. Sandia National Labs., Albuquerque, NM (USA); Nevada Univ., Reno (USA). Desert Research Inst. Nov 1987. 63p. DOE Contract AC04-76DP00789. Order Number DE88004638. Source: NTIS, PC EE05/MF A01; GPO Dep.

Includes 2 sheets of 48x reduction microfiche.

The purpose of the NNWSI meteorological data collection program was to support environmental evaluations of site suitability for a nuclear waste repository. This is the last of a series of data summaries for the NNWSI Alluvial and Ridge Sites in southern Nevada. 3 refs., 3 figs., 6 tabs.

192 (SAND–86-7000) **Effective continuum approximation for modeling fluid and heat flow in fractured porous tuff: Nevada Nuclear Waste Storage Investigations Project.** Pruess, K.; Wang, J.S.Y.; Tsang, Y.W. Lawrence Berkeley Lab., CA (USA). May 1988. 100p. DOE Contract AC04-76DP00789. Order Number DE88010969. Source: NTIS, PC A06/MF A01; GPO Dep.

Fluid and heat flow in fractured porous media can be of great complexity, and a quantitative description requires the development of simplified mathematical and numerical methods. This report presents a detailed formulation, and partial evaluation, of an "effective continuum approximation" for non-isothermal multi-phase flow, which had been introduced previously only in a heuristic fashion. The key concept on which the effective continuum approach must rely is (approximate) local thermodynamic equilibrium between fractures and rock matrix. The applicability of this approximation is discussed and studied by means of numerical simulations for emplacement of high-level waste packages in partially saturated fractured tuff. The simulations demonstrate that the validity of the effective continuum approximation cannot be ascertained in general terms. The approximation will break down for rapid transients in flow systems with low matrix permeability and/or large fracture spacing, so that its applicability needs to be carefully evaluated for the specific processes and conditions under study. The effective continuum approximation has been applied for a preliminary study of fluid and heat flow near a high-level nuclear waste repository on a regional scale, employing a highly simplified strtatigraphic description. It was found that substantial gas phase convection was taking place, with convection velocities being sensitive to permeability, porosity, and tortuosity of the fracture network. 18 refs., 27 figs., 7 tabs.

193 (SAND–86-7004) **Design of a machine to bore and line a long horizontal hole in tuff: Nevada Nuclear Waste Storage Investigations Project.** Friant, J.E.; Dowden, P.B. Robbins Co., Kent, WA (USA). Sep 1987. 146p. DOE Contract AC04-76DP00789. Order Number DE88003618. Source: NTIS, PC A07/MF A01; GPO Dep.

This report describes an engineering design for equipment capable of simultaneously drilling and lining deep horizontal bore holes. The ultimate use of the equipment is to bore up to 600 ft long, 3 ft diameter emplacement holes for a nuclear waste repository. The specific system designed is referred to as a Development Prototype Boring Machine (DPBM) which will be used to demonstrate the drilling/lining capability in field development tests. The system utilizes as in-hole electric drive and a vacuum chip removal and handling system. The drilling unit is capable of active directional control and uses laser-type alignment equipment. The system combines the features of a small steerable tunnel boring machine, combined with a horizontally-oriented raise drill, thereby utilizing current technology. All elements of the system are compact and mobile as required for a shaft entry, underground mining environment. 3 refs., 35 figs., 1 tab.

194 (SAND–86-7014C) **Design methodology to develop a conceptual underground facility for the disposal of high-level nuclear waste at Yucca Mountain, Nevada.** Zerga, D.P.; Badie, A. Parsons-Brinckerhoff, New York (USA). 1986. 13p. DOE Contract AC04-76DP00789. (CONF-8609177–1-Vugraphs: Structures congress '86: symposium on super and parallel computers and their impact on civil engineering, New Orleans, LA, US, September 15, 1986). Order Number DE88002350. Source: NTIS, PC A03/MF A01; GPO Dep.

This paper examines the design methodology employed to develop conceptual underground layouts for a prospective high level nuclear waste repository at Yucca Mountain, Nevada. This study is in conjunction with the Nevada Nuclear Waste Storage Investigations (NNWSI), project studying the disposal of high level waste in densely welded tuff. The fundamental design effort concentraes on the effects of the heat released from the decaying waste forms and the impact of this heat on ventilation, waste emplacement configurations, and rock stability. This effort will perfect the design of the waste emplacement layout including emplacement hole spacing, emplacement drift spacing, and the areal power density (APD) for the installed waste. This paper contains only viewgraphs. 11 figs.

195 (SAND–86-7136) **Site-generated waste treatment and disposal study.** Jardine, L.J.; Lipps, D.J.; Miller, D.D. Bechtel National, Inc., San Francisco, CA (USA); Sandia National Labs., Albuquerque, NM (USA). Oct 1987. 225p. DOE Contract AC04-76DP00789. Order Number DE88001932. Source: NTIS, PC A10/MF A01; GPO Dep.

Secondary radioactive wastes will be generated during the normal operation of the Yucca Mountain Nuclear Waste Repository. The sources, quantities, and characteristics of these site-generated radioactive wastes are estimated, and available waste treatment and disposal technologies are evaluated. Technical and economic comparisons are performed for 10 waste treatment options. Recommendations are given for the preferred waste treatment and disposal options based on these comparisons of the various alternatives. 42 refs., 38 figs., 23 tabs.

196 (SAND–87-0293C) **Drying of an initially saturated fractured volcanic tuff.** Russo, A.J.; Reda, D.C. Sandia National Labs., Albuquerque, NM (USA). 14 Apr 1987. 25p. DOE Contract AC04-76DP00789. (CONF-871234–1: ASME winter meeting, Boston, MA, US, December 13, 1987). Order Number DE88002325. Source: NTIS, PC A03/MF A01; GPO Dep.

The isothermal drying of an initially saturated welded tuffaceous rock was studied experimentally. Gamma-beam densitometry was used to measure the material's effective porosity distribution prior to the drying experiment. It was then used to measure liquid saturation distributions during a 1400 hour drying period. The core selected for study was taken from the Busted Butte outcrop at the Nevada Test

Site, part of the Topopah Spring Member of Paintbrush tuff. This specimen contained several microfractures transversely oriented to the direction of the water or vapor migration. These fractures were found to be regions of rapid dryout or low saturation even though they were displaced from the surface over which dry nitrogen was flowing. An imbibition experiment was performed earlier on the same core. In the imbibition experiment the presence of most of these microfractures was detected by discontinuities in the measured saturation curves, which indicated a delay in liquid transport past the microfractures. The mechanism for this inside out drying is believed to be capillary action that removes water from the larger-pore fracture zone. Vapor pressure lowering in the fine pore region, which would result in transport by evaporation, diffusion and condensation, is thought not to be important at room temperatures. Modeling of this dryout experiment reproduced some of the overall features of the experiment but underpredicted the saturation near the drying surfaces. 8 refs., 11 figs.

197 (SAND–87-1176) **Description of ground motion data processing codes: Volume 1: Nevada Nuclear Waste Storage Investigations Project.** Sanders, M.L. Sandia National Labs., Albuquerque, NM (USA). Feb 1988. 207p. DOE Contract AC04-76DP00789. Order Number DE88009239.

Data processing codes developed to process ground motion at the Nevada Test Site for the Weapons Test Seismic Investigations Project are used today as part of the program to process ground motion records for the Nevada Nuclear Waste Storage Investigations Project. The work contained in this report documents and lists these codes and verifies the "PSRV" code.

198 (SAND–87-1176-Vol.2) **Description of ground motion data processing codes: Volume 2.** Sanders, M.L. Sandia National Labs., Albuquerque, NM (USA). Feb 1988. 422p. DOE Contract AC04-76DP00789. Order Number DE88007137. Source: NTIS, PC A18/MF A01; GPO Dep.

Data processing codes developed to process ground motion at the Nevada Test Site for the Weapons Test Seismic Investigations Project are used today as part of the program to process ground motion records for the Nevada Nuclear Waste Investigations Project. The work contained in this report documents and lists these codes and verifies the "PSRV" code. Volume I, which contains the program specifications for the scientific and engineering software, consists of the following programs: "SPECTRA" calculates the power density spectrum of digitized time histories from underground nuclear explosions (UNEs); "FILTER" designs optimum finite impulse response filters and then filters UNE ground motion data; and "PSRV" calculates the pseudo relative velocity response spectrum for UNE ground motions. Volume II contains the following program specifications for the auxiliary software. "ACCESS" allows the user to scan, update, delete, or add records contained in the Weapons Test Seismic Investigations data base. "SCAN" produces an inventory of the time histories contained in a large data file. "PLOT" plots the data files; "ROTATE" converts data in the horizontal plane into a UNE specific coordinate system; and "VECTOR" calculates the magnitude versus time of the 2-D (horizontal components) and 3-D (vertical andl horizontal components) vectors. Volume III comprises the users' manuals for each of the programs described in Volumes I and II.

199 (SAND–87-1176-Vol.3) **Description of ground motion data processing codes: Volume 3.** Sanders, M.L. Sandia National Labs., Albuquerque, NM (USA). Feb 1988. 182p. DOE Contract AC04-76DP00789. Source: NTIS, PC A09/MF A01; GPO Dep.

Data processing codes developed to process ground motion at the Nevada Test Site for the Weapons Test Seismic Investigations Project are used today as part of the program to process ground motion records for the Nevada Nuclear Waste Storage Investigations Project. The work contained in this report documents and lists codes and verifies the "PSRV" code. 39 figs.

200 (SAND–87-1245) **Repository waste-handling equipment development plan: Nevada Nuclear Waste Storage Investigations Project.** Glowka, D.A. Sandia National Labs., Albuquerque, NM (USA). Nov 1987. 96p. DOE Contract AC04-76DP00789. Order Number DE88003229. Source: NTIS, PC A05/MF A01; GPO Dep.

This report presents a plan for developing equipment for emplacing and, if necessary, retrieving high-level nuclear waste at the proposed Yucca Mountain repository in Nevada. A 7-year development program is proposed, prior to repository license application. Costs and manpower requirements are estimated for each of 133 separate tasks and are integrated on a monthly, annual, and program-life basis. The program is structured to provide critical information needed to select a waste emplacement configuration, and the effects of the selection on subsequent equipment development and demonstration costs are estimated. The total program costs are estimated to be approximately $23.4 to 26.8 million if a vertical waste emplacement configuration is selected in FY 1990. If a horizontal waste emplacement configuration is selected at that time, total program costs would be appoximately $25.4 to 31.3 million. 15 refs., 18 figs., 5 tabs.

201 (SAND–87-1433) **G-Tunnel Welded Tuff Mining experiment evaluations.** Zimmerman, R.M. (Sandia National Labs., Albuquerque, NM (USA)); Bellman, R.A. Jr.; Mann, K.L.; Zerga, D.P.; Fowler, M.; Johnson, J.R. Sandia National Labs., Albuquerque, NM (USA). Dec 1988. 100p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC04-76DP00789. Order Number DE89014378. Source: NTIS, PC A05/MF A01 - OSTI; GPO Dep.

Designers and analysts of radioactive waste repositories must be able to predict the mechanical behavior of the host rock. Sandia National Laboratories elected to conduct a mine-by in welded tuff so that predictive-type information could be obtained regarding the response of the rock to a drill and blast excavation process, where smooth blasting techniques were used. This report describes the results of the mining processes and presents and discusses the rock mass responses to the mining and ground support activities. 37 refs., 20 figs., 7 tabs.

202 (SAND–87-1575) **Preliminary analyses of the excavation investigation experiments proposed for the exploratory shaft at Yucca Mountain, Nevada Test Site.** Costin, L.S. (Sandia National Labs., Albuquerque, NM (USA)); Bauer, S.J. Sandia National Labs., Albuquerque, NM (USA). Dec 1988. 202p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC04-76DP00789. Order Number DE89012872. Source: NTIS, PC A10/MF A01 - OSTI; GPO Dep.

The Yucca Mountain Project (YMP), is examining the feasibility of siting a repository for high-level nuclear waste at Yucca Mountain on and adjacent to the Nevada Test Site.

Three excavation experiments, Shaft Convergence, Demonstration Breakout Rooms, and Sequential Drift Mining, will provide some of the data required to (1) assess the mechanical behavior of repository-size openings and (2) validate numerical models that may be used in the repository design process. In this report, the results of preliminary analyses of the three excavation experiments are presented. The major objective of these analyses was to provide some guidance to the experiment planners regarding the expected displacements and stresses near the experimental drifts so that selection and placement of instrumentation could be optimized. Further, successful completion of these analyses demonstrates the ability to model the experiments, given the simplifying assumptions presented. Limitations of the analyses performed and the experiments as currently designed are also discussed. Finally, the results of these analyses provided some indication of how the variation of some key geometric and material parameters would affect the predicted results. Once the experiment design is finalized and site-specific material data are collected, pretest predictive analyses will be conducted using the mechanical and material models that require validation. 15 refs., 123 figs., 13 tabs.

203 (SAND–87-1685) **Preliminary evaluation of the exploratory shaft representativeness for the Yucca Mountain Project.** Nimick, F.B.; Shephard, L.E.; Blejwas, T.E. Sandia National Labs., Albuquerque, NM (USA). Dec 1988. 134p. DOE Contract AC04-76DP00789. Order Number DE89005298. Source: NTIS, PC A07/MF A01 - OSTI; GPO Dep.

Experiments planned in the Exploratory Shaft (ES) play an integral role in the site-characterization effort to provide the necessary information for evaluating the Yucca Mountain site as a potential high-level waste repository. An important part of the planning process for the ES is to evaluate the representativeness of the data and information to be obtained in the ES relative to the remainder of the area and environs. This evaluation is based on evolving interpretations of a limited suite of data, many of which were obtained adjacent to or outside the designated boundaries of the primary area. The representativeness of information scheduled to be obtained in the ES has been evaluated for a number of technical disciplines including geology, mineralogy, rock mechanics, hydrology, waste package and repository design, and performance assessment. The representativeness in some areas is considered in greater detail than in other areas because of the disparity in the amount of data available and the level of confidence in the data analysis and interpretation. Results of this evaluation indicate that most data obtained in the ES are expected to be representative of the primary area at Yucca Mountain. The conclusion also is drawn that the selected location of the ES is at least as good as any other single location within the primary area. 37 refs., 56 figs., 5 tabs.

204 (SAND–87-1915C) **Seismic design of the waste-handling building at the prospective Yucca Mountain nuclear waste repository.** Subramanian, C.V.; Wu, C.L.; DeGabriele, C.D. Sandia National Labs., Albuquerque, NM (USA). 1988. 7p. DOE Contract AC04-76DP00789. (CONF-880903–10: Spectrum '88: international topical meeting on nuclear and hazardous waste management, Pasco, WA, US, September 11, 1988). Order Number DE88011092. Source: NTIS, PC A02/MF A01; GPO Dep.

The site for the first prospective high-level nuclear waste repository is located in Yucca Mountain at the southwest corner of the Nevada Test Site in Nye County, Nevada. The preliminary site investigation and seismic hazard evaluation indicate that the design ground acceleration in the horizontal direction of 0.40 g (with a vertical acceleration equal to two-thirds the horizontal) has a recurrence interval of 2000 years. The site evaluation also indicates a potential for some fault displacement on the geologic faults near the site. Proposed facilities at the prospective repository includes a waste handling building (WHB), the primary facility used for handling radioactive waste materials. This paper summarizes the structural behavior of the WHB resulting from the seismic loads. This summary includes a preliminary seismic evaluation of the WHB, and includes estimates of the seismic design margin, building performance, and the amount of fault displacement that the WHB can accommodate without structural yield failure. 9 refs.

205 (SAND–87-1937C) **Evaluation of site-generated radioactive waste treatment and disposal methods for the Yucca Mountain repository.** Subramanian, C.V. (Sandia National Labs., Livermore, CA (USA)); Jardine, L.J. Sandia National Labs., Livermore, CA (USA). 1989. 9p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC04-76DR00789. (CONF-890855–22: 10. international conference on Structural Mechanics in Reactor Technology (SMIRT), Anaheim, CA (USA), 14-18 Aug 1989). Order Number DE89010742. Source: NTIS, PC A02/MF A01 - OSTI; GPO Dep.

This study identifies the sources of radioactive wastes that may be generated at the proposed high level waste (HLW) repository at Yucca Mountain, Nevada, estimates the waste quantities and characteristics, compares various technologies that are available for waste treatment and disposal, and develops recommended concepts for site-generated waste treatment and disposal. The scope of this study is limited to the repository operations during the emplacement phase, in which 70,000 MTU of high-level waste will be received and emplaced at the proposed repository. The evaluations consider all radioactive wastes generated during normal operations in surface and underground facilities. Wastes generated as a result of accidents are not addressed because accidents that could result in large quantities of radioactive waste are expected to occur very infrequently so that temporary, portable systems could be used for cleanup, if necessary. The results of this study can be used to develop more definitive plans for managing the site-generated wastes and to serve as a basis for the design of associated facilities at the proposed repository. 8 refs., 1 tab.

206 (SAND–87-1938C) **An analysis of the G-Tunnel Heated Block Experiment using a compliant-joint rock-mass model.** Costin, L.S.; Chen, E.P. Sandia National Labs., Albuquerque, NM (USA). Jan 1988. 16p. DOE Contract AC04-76DP00789. (CONF-880654–6: 29. U.S. symposium on rock mechanics, Minneapolis, MN, US, June 13, 1988). Order Number DE88004694. Source: NTIS, PC A03/MF A01 - 02/MF A01; GPO Dep.

A key question in the analytical and numerical modeling of rock structures is how to account for the effects of joints, faults and other natural discontinuities on the deformation of the rock mass. In this paper, we address this question by using a continuum rock-mass model to simulate the response of a large block of jointed rock subjected to mechanical loading. The purpose of this effort is to evaluate the validity of the continuum approach to rock-mass modeling and, thus, provide at least a partial answer to the question posed above. The results of two-dimensional finite element analyses of the G-Tunnel Heated Block Experiment (Zimmerman, et al., 1986) are presented. Good quantitative agreement between the experimental and numerical results were obtained in most cases. 10 refs., 3 figs., 2 tabs.

207 (SAND–87-2070C) **Preliminary preclosure radiological safety analysis for normal operations of a prospective Yucca Mountain repository.** Jardine, L.J.; Ma, C.W.; Hartman, D.J.; Sit, R.C.; Zavoshy, S.J.; Laub, T.W. Sandia National Labs., Albuquerque, NM (USA). 1988. 18p. DOE Contract AC04-76DP00789. (CONF-880903–47: Spectrum '88: international topical meeting on nuclear and hazardous waste management, Pasco, WA, US, September 11, 1988). Order Number DE89005208. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

A preliminary radiological safety analysis was performed for the normal operating conditions during the preclosure period at the prospective Yucca Mountain repository. Since the repository is designed to accommodate spent fuel and defense high-level waste (DHLW), an estimate was made of the offsite doses and onsite occupational doses from (1) anticipated routine releases of airborne radioactive materials and from (2) the handling of the spent fuels and DHLW. This paper summarizes the methodology and calculated offsite doses resulting from the postulated routine releases of airborne radioactive materials from the waste-handling building through inhalation and immersion pathways. The calculated onsite occupational doses from the inhalation, immersion, and direct exposure pathways will be reported elsewhere at a later date. 15 refs. , 4 tabs.

208 (SAND–87-2073) **Additional underground test data required for Yucca Mountain repository characterization: Nevada Nuclear Waste Storage Investigations Project.** Easterling, R.G.; Hall, I.J. Sandia National Labs., Albuquerque, NM (USA). Apr 1988. 22p. DOE Contract AC04-76DP00789. Order Number DE88009788. Source: NTIS, PC A03/MF A01.

Predicted ground motion at the proposed Yucca Mountain nuclear waste repository, due to underground nuclear explosions at the Nevada Test Site, is one aspect of the Yucca Mountain site characterization. The data used in such predictions must be Quality Category I, but existing data and the resulting predictions are not. Thus, it will be necessary to collect additional Quality Category I data to validate predictions based on historical data. This report presents results that can be used to determine how many instrumented tests are required. In particular, the sample size required to have a specified probability of detecting a given bias in the historical data is derived and tabulated. 3 refs., 2 figs., 4 tabs.

209 (SAND–87-2699) **An analysis of the G-Tunnel heated block thermomechanical response using a compliant-joint rock-mass model: Yucca Mountain Project.** Costin, L.S. (Sandia National Labs., Albuquerque, NM (USA)); Chen, E.P. Sandia National Labs., Albuquerque, NM (USA). Dec 1988. 76p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC04-76DP00789. Order Number DE89013997. Source: NTIS, PC A05/MF A01 - OSTI; GPO Dep.

The results of two-dimensional finite element analyses of several thermal and mechanical loading cycles of the G-Tunnel heated block experiment are presented. The deformations of the block resulting from biaxial and uniaxial loading as well as thermal loading under constant biaxial stress were determined using a recently developed compliant-joint rock-mass model. The results of the finite element calculations were compared to experimental results. Good quantitative agreement between the experimental and numerical results were obtained in most cases. The notable exception was in the analysis of the thermal loading cycles. In some calculations, key model parameters were varied in order to assess the sensitivity of the solution to variation of these parameters. In addition to comparison of numerical and experimental results a major purpose of these analyses was to assess the methods used in the heated block experiment and their impact on the use of such an experiment for thermomechanical model validation. The results of this evaluation are discussed and recommendations regarding the design of future experiments are made. 15 refs., 49 figs.

210 (SAND–87-7070) **Hydrologic modeling of vertical and lateral movement of partially saturated fluid flow near a fault zone at Yucca mountain.** Wang, J.S.Y.; Narasimhan, T.N. Sandia National Labs., Albuquerque, NM (USA); Lawrence Berkeley Lab., CA (USA). Aug 1988. 76p. DOE Contract AC04-76DP00789. Order Number DE89000667. Source: NTIS, PC A05.

Distribution of fluid flow is governed by the balance between gravity and capillary forces. The objective of this work is to assess fluid flow in the partially saturated, fractured, porous tuff formations at Yucca Mountain. The effects of eastern tilting of the units at Yucca Mountain on fluid flow has been studied using two-dimensional models. Ghost Dance Fault has been modeled as a seepage face. Under the expected flux conditions, saturation increased just to the west of the fault, but the water did not enter the fault. Tuff matrix and fracture data have been compared to the limited model parameters of the fault; and correlations between saturated conductivity and unsaturated parameters for tuff matrix, fracture, and fault are discussed. 26 refs., 33 figs., 5 tabs.

211 (SAND–87-7076C) **An analysis of air cooling prior to re-entering a drift containing emplaced commercial nuclear waste.** Wallace, K.G. Jr.; Zerga, D.P. Mine Ventilation Services, Inc., Lafayette, CA (USA); Parsons, Brinckerhoff, Quade and Douglas, Inc., San Francisco, CA (USA). Jan 1988. 29p. DOE Contract AC04-76DP00789. (CONF-880126–1: TMS-AIME/ASM symposium on high temperature mechanical properties of ordered intermetallics, Phoenix, AZ, US, January 25, 1988). Order Number DE88005170. Source: NTIS, PC A03.

This paper describes an analysis performed to determine the cool-down time of drifts in the prospective commercial nuclear waste repository in volcanic tuff at Yucca Mountain, Nevada. Two emplacement methods are currently being considered at Yucca Mountain. The reference configuration stores the high-level waste in short vertical boreholes, and the alternative configuration stores the waste in long horizontal boreholes. After emplacement operations for each emplacement drift are complete, the drift will be closed off from continuous ventilation. Given time, the radioactive decay of high-level waste will increase the rock temperature around access and emplacement drifts. Air cooling may be required to reenter these drifts. The paper discusses the analysis procedure and computer programs used to evaluate the time to cool a drift to acceptable environmental conditions 50 years after emplacement of high-level waste. Key assumptions to the analysis are presented. The results of the study show that cooling either vertical or horizontal configuration emplacement drifts is possible in a reasonable period of time. 4 refs., 5 figs., 2 tabs.

212 (SAND–87-7077C) **Repository design integration.** Monsees, J.E.; Streeter, W.S. Parsons, Brinckerhoff, Quade and Douglas, Inc., San Francisco, CA (USA); Sandia National Labs., Albuquerque, NM (USA). 1987. 22p. DOE Contract AC04-76DP00789. (CONF-870948–4: American Nuclear Society topical meeting on the integrated spent fuel and HLW management system, Albuquerque, NM, US, September 27, 1987). Order Number DE88000600. Source: NTIS, PC A02/MF A01; GPO Dep.

Because the repository is the final component in the waste management system, the interactions tend to flow in one direction only, i.e., from reactor through to the repository. Therefore, the design of the repository must provide flexibility to respond to changes in program guidance, to variability in geologic characteristics, and to site specific requirements. Programmatic issues affecting design include waste type, quantity, burnup, and age; the existence of other system elements such as a monitored retrieval storage facility; consolidation of fuel elements; emplacement of other waste types; and schedule for first and second repository. In addition to programmatic decisions, site specific decisions such as waste emplacement geometry affect repository design. The approach has been to develop initial designs that provide flexibility and consider the program and design issues listed above. The next step in the program must be to resolve programmatic and site specific issues and thereby reduce the multiplicity of design efforts. 12 refs., 2 figs., 2 tabs.

213 (SAND–88-0001C) **A conceptual design for a nuclear waste repository at the Yucca Mountain site.** Hunter, T.O.; Tillerson, J.R.; Stevens, A.L. Sandia National Labs., Albuquerque, NM (USA). 1988. 5p. DOE Contract AC04-76DP00789. (CONF-880601–5: American Nuclear Society annual meeting, San Diego, CA, US, June 12, 1988). Order Number DE88004126. Source: NTIS, PC A; 02/MF A01; GPO Dep.

The NNWSI Project of the U.S. Department of Enrgy has recently completed a conceptual design for a nuclear waste repository at the Yucca Mountain site. This conceptual design supports the site characterization program by defining a reference description of surface and underground facilities. This reference description would provide a basis for identifying design-related issues and determining the appropriate site characterization activities to obtain needed information about the site. 2 figs.

214 (SAND–88-0027C) **Preliminary estimates of groundwater travel time at Yucca Mountain.** Sinnock, S.; Lin, T. Sandia National Labs., Albuquerque, NM (USA). 1988. 9p. DOE Contract AC04-76DP00789. (CONF-881280–1: American Nuclear Society meeting, San Diego, CA, US, December 17, 1988). Order Number DE89010038. Source: NTIS, PC A02/MF A01 - OSTI; GPO Dep.

This report presents the assumptions, methods, and results of a probabilistic approach to the calculation of groundwater travel times to the water table below Yucca Mountain, Nevada. Data to support the analyses were abstracted from formal and informal reports generated by the staff of several organizations participating in the Nevada Nuclear Waste Storage Investigations (NNWSI) Project activities. Because flow in the portion of the unsaturated zone below the proposed repository is probably nearly steady state and vertical, the hydraulic gradient was assumed to equal minus one (-1) in our model. This means that the flow was assumed to be driven vertically downward solely by elevation head along the direction of gravity. On the basis of this assumption, a reasonable approximation of the velocity of water through the unsaturated zone was obtained by dividing the flux by an effective porosity. 3 refs., 2 figs.

215 (SAND–88-0035C) **Effect of material nonhomogeneities on equivalent conductivities in unsaturated porous media flow.** Eaton, R.R.; Dykhuizen, R.C. Sandia National Labs., Albuquerque, NM (USA). Apr 1988. 16p. DOE Contract AC04-76DP00789. (CONF-880582–1: Validation of flow and transport models for the unsaturated zone meeting, Ruidoso, NM, US, May 23, 1988). Order Number DE88005470.

Deterministic calculations of the flow of water through partially saturated, geologic materials are complicated by the heterogeneous nature of the geologic media and the uncertainty of material properties. Consequently, there is a trend toward the development of stochastic solution procedures and equivalent material property concepts for use in predicting bounds on water motion and particle travel times. A numerical investigation of the effect of material heterogeneities on two-dimensional deterministic calculations of water flow and particle travel times is presented. Upper and lower bounds on the infiltration rates for Dirichlet boundary conditions are defined as a function of the degree of material heterogeneity. These calculations are an extension of earlier work in which parallel and series circuit concepts were used to define limiting flow conditions for flow in saturated media. Because of the nonlinear nature of flow in partially saturated media, the techniques applicable for determining the bounds for saturated flows do not apply. 4 refs., 8 figs., 2 tabs.

216 (SAND–88-0077C) **A "top-level" strategy to guide the characterization of Yucca Mountain.** Bingham, F.W. Sandia National Labs., Albuquerque, NM (USA). 1988. 11p. DOE Contract AC04-76DP00789. (CONF-880601–52: American Nuclear Society annual meeting, San Diego, CA, US, June 12, 1988). Order Number DE89007037. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The basis for plans to characterize the Yucca Mountain site is a detailed strategy for collecting the data that the US Department of Energy (DOE) expects to use in assessing compliance with regulations. At its highest, least detailed level, the strategy rests simply on a few fundamental expectations about the behavior of a repository system at Yucca Mountain. This top level of the strategy shows how the detailed strategy was formulated and points out the features of the site on which those fundamental expectations are based. In developing the top-level strategy, the DOE chose the elements of the repository system that are to be relied on: the unsaturated rock units above and below the repository, the saturated rock below the units, and the engineered-barrier system. For guiding the site-characterization work, the DOE also constructed quantitative expressions that explain the reliance the DOE expects to put on each element.

217 (SAND–88-0324C) **Comparison of strongly heat-driven flow codes for unsaturated media.** Updegraff, C.D.; Bonano, E.J. GRAM, Inc., Albuquerque, NM (USA); Sandia National Labs., Albuquerque, NM (USA). 1988. 14p. DOE Contract AC04-76DP00789. (CONF-880582–3: Validation of flow and transport models for the unsaturated zone meeting, Ruidoso, NM, US, May 23, 1988; CONF-880582–). Order Number DE88010526. Source: NTIS, PC A03/MF A01.

SNLA evaluated three strongly heat-driven flow codes, TOUGH, NORIA, PETROS, for simulating unsaturated ground-water flow near a high-level radioactive waste (HLW) repository. The purpose of the evaluation was to ascertain whether one or more of these codes could be useful in the development of a performance assessment methodology for disposal of HLW in welded tuff. The results of this study suggest the need for thorough investigations of the impact of heat on the flow field in the vicinity of an unsaturated HLW repository. Recommendations are to develop a new flow code combining the best features of these three codes and eliminating the worst ones and to find test problems representative of conditions around an HLW repository.

218 (SAND–88-0418C) **Excavation effects on tuff: Recent findings and plans for investigations at Yucca Mountain.** Blejwas, T.E.; Zimmerman, R.M.; Shephard, L.E. Sandia National Labs., Albuquerque, NM (USA); Sandia National Labs., Albuquerque, NM (USA); Sandia National Labs., Albuquerque, NM (USA). 1988. 18p. DOE Contract AC04-76DP00789. (CONF-880497–1: Workshop on excavation effects on the engineering design and safety performance of an underground repository for radioactive waste, Winnipeg, CA, April 26, 1988). Order Number DE88008672. Source: NTIS, PC A03/MF A01.

Plans for site-characterization testing and constructing an exploratory shaft facility (ESF) at Yucca Mountain, Nevada, have been influenced by the construction and monitoring of stable openings in G-Tunnel on the Nevada Test Site. G-Tunnel provides access for testing in a thin bed of unsaturated welded tuff that is similar to that at Yucca Mountain. The data from the experiments in the ESF will be used to validate analytical methods for predicting the response of underground openings to the excavation process and to the heat generated by the waste. 13 refs., 8 figs.

219 (SAND–88-0453C) **Thermal/mechanical analyses of G-Tunnel field experiments at Rainier Mesa, Nevada.** Bauer, S.J.; Costin, L.S.; Chen, E.P.; Tillerson, J.R. Sandia National Labs., Albuquerque, NM (USA). 1988. 20p. DOE Contract AC04-76DP00789. (CONF-880497–2: Workshop on excavation effects on the engineering design and safety performance of an underground repository for radioactive waste, Winnipeg, CA, April 26, 1988). Order Number DE88008801. Source: NTIS, PC A03.

Analysis methods (models) are currently being developed to support thermal, mechanical, and thermomechanical aspects of repository design and performance assessment of the candidate Yucca Mountain high-level nuclear waste site. Credibility of these models, and therefore of design and performance analyses, will in part be determined through comparison of calculated and measured response (validation) for large-scale field experiments. This paper discusses the models being developed, the rationale behind the model development, and analyses of experiments performed at G-Tunnel and planned as part of site characterization at Yucca Mountain. 25 refs., 21 figs.

220 (SAND–88-0624) **Thermal-conductivity data for tuffs from the unsaturated zone at Yucca Mountain, Nevada: Yucca Mountain Project.** Nimick, F.B. (Sandia National Labs., Albuquerque, NM (USA)). Sandia National Labs., Albuquerque, NM (USA). Jun 1989. 85p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC04-76DP00789. Order Number DE89014594. Source: NTIS, PC A05/MF A01 - OSTI; GPO Dep.

This report is primarily a means of transmitting thermal-conductivity data to the Yucca Mountain Project properties data base. As such, the majority of the report is a compilation of these data for 45 samples of tuffaceous rocks from Yucca Mountain, Nevada; some of the data have been published previously. Brief discussions of the experiment technique (transient-line-source) and experiment uncertainties also are included. The accuracy of the thermal-conductivity data cannot be assessed at present; precision (repeatability) has been determined to be better than { + } 2%, in most cases. 15 refs., 5 figs., 1 tab.

221 (SAND–88-0660) **Compliance and strength of artificial joints in Topopah Spring tuff: Yucca Mountain Project.** Olsson, W.A. Sandia National Labs., Albuquerque, NM (USA). Dec 1988. 121p. DOE Contract AC04-76DP00789. Order Number DE89009001. Source: NTIS, PC A06/MF A01 - OSTI; GPO Dep.

Capabilities for predicting the response of rock masses to thermomechanical loadings are being developed under the Yucca Mountain Project (YMP) for the design of an underground nuclear waste repository at Yucca Mountain on the Nevada Test Site (NTS). An important ingredient in the computer codes being used is the constitutive description of the mechanical discontinuities (mostly joints, but also bedding planes and faults). This report summarizes preliminary laboratory experimental data on the compliance and the friction stress of artificial joints in Topopah Spring tuff in the air-dry, room-temperature condition. Also, data for a laboratory-induced, clean tensile fracture are given. Details of the analysis of the results are discussed in earlier reports. Therefore, the reader is urged to judiciously use data in this report, consulting the earlier documents when necessary. This report is primarily a catalogue of experiments and a summary of results; hence, little further analysis is given. Because of the exploratory nature of the investigation, a systematic data base was not developed for the variables (such as sliding velocity, amount of slip, and normal stress history) studied. The results suggest guidelines for further, more systematic, experimentation on fracture properties. It is critical to clearly understand the nature of the data and their implication; therefore, in the next section the constitutive relations for a joint are defined and the methods for their determination are explained. 15 refs., 89 figs.

222 (SAND–88-1600) **Preliminary seismic design cost-benefit assessment of the tuff repository waste-handling facilities.** Subramanian, C.V.; Abrahamson, N.; Hadjian, A.H.; Jardine, L.J.; Kemp, J.B.; Kiciman, O.K.; Ma, C.W.; King, J.; Andrews, W.; Kennedy, R.P. Sandia National Labs., Albuquerque, NM (USA). Feb 1989. 217p. DOE Contract AC04-76DP00789. Order Number DE89008994. Source: NTIS, PC A10/MF A01 - OSTI; GPO Dep.

This report presents a preliminary assessment of the costs and benefits associated with changes in the seismic design basis of waste-handling facilities. The objectives of the study are to understand the capability of the current seismic design of the waste-handling facilities to mitigate seismic hazards, evaluate how different design levels and design measures might be used toward mitigating seismic hazards, assess the costs and benefits of alternative seismic design levels, and develop recommendations for possible modifications to the seismic design basis. This preliminary assessment is based primarily on expert judgment solicited in an interdisciplinary workshop environment. The estimated costs for individual attributes and the assumptions underlying these cost estimates (seismic hazard levels, fragilities, radioactive-release scenarios, etc.) are subject to large uncertainties, which are generally identified but not treated explicitly in this preliminary analysis. The major conclusions of the report do not appear to be very sensitive to these uncertainties. 41 refs., 51 figs., 35 tabs.

223 (SAND–88-1931C) **Cost-benefit assessment methodology for seismic design of high-level waste repository facilities.** Subramanian, C.V. (Sandia National Labs., Livermore, CA (USA)); Hadjian, A.H. Sandia National Labs., Livermore, CA (USA). 1989. 8p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC04-76DR00789. (CONF-890855–30: 10. international conference on Structural Mechanics in Reactor Technology (SMIRT), Anaheim, CA, USA, 14-18 Aug 1989). Order Number DE89011540. Source: NTIS, PC A02/MF A01 - OSTI; GPO Dep.

This paper summarizes a methodology for performing a cost-benefit assessment of the seismic design of the surface facilities associated with the prospective high-level waste repository at Yucca Mountain, NV. The methodology described will develop the costs and benefits of varying design levels for vibratory ground motion and surface fault displacements for structures, components, and equipment in the repository facilities. 2 refs., 1 fig.

224 (SAND–88-2247C) **Modeling the uncertainties in the parameter values of a layered, variably saturated column of volcanic tuff using the beta probability distribution.** Kaplan, P.G.; Yarrington, L. Sandia National Labs., Albuquerque, NM (USA). 1989. 19p. DOE Contract AC04-76DP00789. (CONF-890262–1: 4. international conference on solving ground water problems with models, Indianapolis, IN, US, February 7, 1989). Order Number DE89006233. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The geologic formations in the unsaturated zone at Yucca Mountain, Nevada, on and adjacent to the Nevada Test Site, are being investigated as the proposed site of a repository for the disposal of high-level radioactive waste. The Department of Energy is conducting studies of this site through the Yucca Mountain Project. The numerical and conceptual tools that will be used to analyze the site are currently under development. This paper reports the status of a probability model that has recently been implemented to address uncertainties in quantitative predictions of parameter values. The model can also be used to quantify the changes in uncertainty that occur as more information is obtained. Sparse sampling data, unknown errors in measurement, and the inherent variability of natural materials give rise to uncertainties in the choice of appropriate parameter values to represent those materials in models. The beta probability distribution is used to quantify the uncertainties associated with the parameter values and can be used to test the consequences of the analyst's subjective judgment on the density function of the input parameters. 24 refs., 3 figs., 6 tabs.

225 (SAND–88-2294) **A synopsis of analyses (1981–87) performed to assess the stability of underground excavations at Yucca Mountain: Yucca Mountain Project.** Ehgartner, B.L. (Sandia National Labs., Albuquerque, NM (USA)); Kalinski, R.C. Sandia National Labs., Albuquerque, NM (USA). Dec 1988. 60p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC04-76DP00789. Order Number DE89014596. Source: NTIS, PC A04/MF A01 - OSTI; GPO Dep.

This paper reviews 14 analyses that were performed by 10 different investigators during the course of 7 yr to assess the preclosure (up to 100 yr) stability of underground excavations for a potential nuclear waste repository located at Yucca Mountain, Nevada. The analyses were primarily based on thermomechanical models of the conceptual design of shafts and drifts. The material properties, codes, and design configurations used in the analyses varied because of the acquisition of additional data and refinement in codes and design over that period of time. However, all the analyses indicate that shafts and drifts can be constructed and will remain stable with minimum ground support through decommissioning of the repository. This information supports the feasibility of constructing a safe exploratory shaft facility and the expectation that it will remain stable should repository construction and waste emplacement follow. 63 refs., 2 tabs.

226 (SAND–88-2486C) **Stability of underground openings in the Yucca Mountain repository.** Blejwas, T.E. (Sandia National Labs., Albuquerque, NM (USA)). Sandia National Labs., Albuquerque, NM (USA). 1989. 9p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC04-76DP00789. (CONF-890855–4: 10. international conference on Structural Mechanics in Reactor Technology (SMIRT), Anaheim, CA (USA), 14-18 Aug 1989). Order Number DE89009378. Source: NTIS, PC A02/MF A01 - OSTI; GPO Dep.

The licensing of a repository for high-level radioactive waste will require assurances that underground openings do not experience frequent major instabilities, which are defined here as sudden movements of blocks of rock that limit the functions of the openings. Although the design of nuclear power plant structures is controlled by strict adherence to building or professional-engineering codes, this approach is not practical for the structural design of underground facilities because the design must accommodate a varied and partially defined geologic setting. However, regulations require the reduction of the potential for deleterious rock movement and the design of openings to maintain the option to retrieve waste. The present plans for meeting these requirements for a repository at Yucca Mountain, Nevada, include a program of state-of-the-art analyses and modified forms of existing empirically based design methods. An extensive experimental program is required to provide confidence in the results of the design-analysis process. 7 refs., 1 fig.

227 (SAND–88-2521C) **Relevance of partial saturation to the mechanical behavior of tuffs.** Nimick, F.B. (Sandia National Labs., Albuquerque, NM (USA)); Peters, R.R. Sandia National Labs., Albuquerque, NM (USA). 1989. 10p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC04-76DP00789. (CONF-890628–10: 30. US symposium on rock mechanics, Morgantown, West Virginia, USA, 19-22 Jun 1989). Order Number DE89010435. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

In this paper, equivalent confining pressures are estimated for samples of tuff using an expression that relates capillary pressure and effective confining pressure to the saturation state of the pores. These confining pressures are compared to the pressures calculated from strain measurements during drying; the calculations use elasticity theory. It is found that stresses and strains are caused by capillary forces in certain partially saturated rocks. This phenomenon has a direct impact on experiments that rely on strain measurements to calculate a rock property. Specific problem areas are the performance of unconfined mechanical tests, calculation of elastic parameters from laboratory data on unjacketed samples, and determination of in situ stress by any method involving stress relaxation.

228 (SAND–88-2626C) **Predicting flow through low-permeability, partially saturated, fractured rock: A review of modeling and experimental efforts at Yucca Mountain.** Eaton, R.R.; Bixler, N.E.; Glass, R.J. Sandia National Labs., Albuquerque, NM (USA). [1989]. 39p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC04-76DP00789. (CONF-890702–4: 28. international geological congress, Washington, DC (USA), 9-19 Jul 1989). Order Number DE90002884. Source: NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

Current interest in storing high-level nuclear waste in underground repositories has resulted in an increased effort to understand the physics of water flow through low-permeability rock. The US Department of Energy is investigating a prospective repository site located in volcanic ash (tuff) hundreds of meters above the water table at Yucca Mountain, Nevada. Consequently, mathematical models and experimental procedures are being developed to provide a better understanding of the hydrology of this low-permeability, partially saturated, fractured rock. Modeling water flow in the vadose zone in soils and in relatively permeable rocks such as sandstone has received considerable attention for many years. The treatment of flow (including nonisothermal conditions) through materials such as the Yucca Mountain tuffs, however, has not received the same level of attention, primarily because it is outside the domain of agricultural and petroleum technology. This paper reviews the status of modeling and experimentation currently being used to understand and predict water flow at the proposed repository site. Several areas of research needs emphasized by the review are outlined. The extremely nonlinear hydraulic properties of these tuffs in combination with their heterogeneous nature makes it a challenging and unique problem from a computational and experimental view point. 101 refs., 14 figs., 1 tab.

229 (SAND–88-2650C) **Experiments in rock mechanics for the site characterization of Yucca Mountain.** Blejwas, T.E. (Sandia National Labs., Albuquerque, NM (USA)). Sandia National Labs., Albuquerque, NM (USA). 1989. 12p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC04-76DP00789. (CONF-890628–2: 30. US symposium on rock mechanics, Morgantown, West Virginia, USA, 19-22 Jun 1989). Order Number DE89005607. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The site characterization of Yucca Mountain, candidate site for a repository for high-level radioactive waste, will include an experimental program in rock mechanics that presents a challenge beyond common experience. To obtain the necessary levels of confidence in results and conclusions that will support licensing of a repository, numerous carefully controlled and documented experiments are required. Data from the experiments will be used to validate advanced analytical methods, expand the database for empirical approaches, demonstrate rock-mass behavior under simulated repository conditions, and provide input for repository performance assessments. Although some experiments are relatively straight forward, others will require development or modification of state-of-the-art techniques, equipment, or instruments. 5 refs., 4 figs.

230 (SAND–88-2784) **Hydrologic technical correspondence in support of the site characterization plan.** Peters, R.R. Sandia National Labs., Albuquerque, NM (USA). Dec 1988. 224p. DOE Contract AC04-76DP00789. Order Number DE89007918. Source: NTIS, PC A10/MF A01 - OSTI; GPO Dep.

This document is composed of five technical memoranda containing information that has been used in preparing the plan to characterize the site of a prospective high-level radioactive waste repository at Yucca Mountain, Nevada. The Yucca Mountain Project is investigating the feasibility of emplacing high-level waste in unsaturated tuff at this site. The information in this report pertains to (1) how the use of water during construction may affect the surrounding site conditions and consequently affect estimates of the in situ hydrologic parameters and water movement in fractured tuff, (2) calculations concerning the response of a fractured tuff column to changes in vertical flux, and (3) changes in groundwater travel-time that may result from water redistribution caused by repository heating, (4) some potential effects of seismicity on water movement and radionuclide transport in the unsaturated zone, and (5) the rate at which a tuff column returns to steady-state conditions after being saturated by a fluctuating water table.

231 (SAND–88-2785) **Preliminary analyses in support of in situ thermomechanical investigations.** Bauer, S.J. (Sandia National Labs., Albuquerque, NM (USA)); Costin, L.S.; Holland, J.F. Sandia National Labs., Albuquerque, NM (USA). Dec 1988. 139p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC04-76DP00789. Order Number DE89014616. Source: NTIS, PC A07/MF A01 - OSTI; GPO Dep.

The Yucca Mountain Project, managed by the Nevada Operations Office of the US Department of Energy, is examining the feasibility of siting a repository for high-level nuclear waste at Yucca Mountain on and adjacent to the Nevada Test Site. As part of the site characterization, a series of in situ thermomechanical experiments have been proposed, which are to be conducted in the exploratory shaft test facility. Three of the experiments, Canister-Scale Heater, Thermal Stress, and Heated Room, will provide some of the data required to (1) assess the thermomechanical response of tuff rock masses at several scales and (2) validate numerical models that may be used in the repository design process. In this report, the results of preliminary analyses of three in situ thermomechanical experiments are presented. The major objective of these analyses has been to provide some guidance to the experiment planners regarding the expected temperatures, displacements, and stresses with regard to time and position based on the very preliminary stage of the experiment design. The analyses will assist in selection and placement of instrumentation. Further, successful completion of these analyses demonstrates the ability to model the experiments, given the simplifying assumptions presented. Limitations of the analyses performed and the experiments as currently designed are also discussed. 13 refs., 72 figs., 4 tabs.

232 (SAND–88-2868C) **Approaches to groundwater travel time.** Kaplan, P.; Klavetter, E.; Peters, R. Sandia National Labs., Albuquerque, NM (USA). 1989. 6p. DOE Contract AC04-76DP00789. (CONF-8903112–1: Waste management '89, Tucson, AZ, US, March 1, 1989). Order Number DE89010686. Source: NTIS, PC A02/MF A01 - OSTI; GPO Dep.

One of the objectives of performance assessment for the Yucca Mountain Project is to estimate the groundwater travel time at Yucca Mountain, Nevada, to determine whether the site complies with the criteria specified in the Code of Federal Regulations. The numerical standard for performance in these criteria is based on the groundwater travel time along the fastest path of likely radionuclide transport from the disturbed zone to the accessible environment. The concept of groundwater travel time, as proposed in the regulations, does not have a unique mathematical statement. The purpose of this paper is to discuss (1) the ambiguities associated with the regulatory specification of groundwater travel time, (2) two different interpretations of groundwater travel time, and (3) the effect of the two interpretations on estimates of the groundwater travel time. 3 refs., 2 figs., 2 tabs.

233 (SAND–88-2936) **Technical correspondence in support of an evaluation of the hydrologic effects of exploratory shaft facility construction at Yucca Mountain.** Peterson, A.C.; Eaton, R.R.; Russo, A.J.; Lewin, J.A. Sandia National Labs., Albuquerque, NM (USA). Dec 1988. 119p. DOE Contract AC04-76DP00789. Order Number DE89008319. Source: NTIS, PC A06/MF A01 - OSTI; GPO Dep.

This document comprises four letter reports containing information that has been used in preparing the plan to characterize the site of the prospective repository at Yucca Mountain. The Yucca Mountain Project is studying the feasibility of constructing a high-level nuclear waste repository in the Topopah Spring Unit of the Paintbrush Tuff. One activity of site characterization is the construction of two exploratory shafts. The information in this report pertains to (1) engineering calculations of the potential distribution of residual water from constructing the exploratory shafts and drifts, (2) numerical calculations predicting the movement of the residual construction water from the shaft walls into the rock, (3) numerical calculations of the movement of the residual water and how the movement is affected by ventilation, and (4) measurement of the movement of water into a welded tuff core when a pulse of water pressure is applied to a laboratory test sample for a short time (100 min).

234 (SAND–88-3410C) **Results of pressurized-slot measurements in the G-Tunnel underground facility.** Zimmerman, R.M. (Sandia National Labs., Albuquerque, NM (USA)); Mann, K.L.; Dodds, D.J. Sandia National Labs., Albuquerque, NM (USA). 1989. 9p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC04-76DP00789. (CONF-890628–3: 30. US symposium on rock mechanics, Morgantown, West Virginia, USA, 19-22 Jun 1989). Order Number DE89005597. Source: NTIS, PC A02/MF A01 - OSTI; GPO Dep.

A rock-mechanics field-testing program is underway at Sandia National Laboratories (SNL) as part of the YMP. SNL has the responsibility for assessing the repository design and performance as well as characterizing the geomechanical behavior of the rock. SNL has conducted field experiments in G-Tunnel in Rainier Mesa at the NTS, where tuffs similar to those at Yucca Mountain, the potential repository site, are found. Later experiments are planned as part of the YMP Exploratory Shaft investigations at Yucca Mountain. Major geomechanical factors in repository developments are determinations of the stress state and the deformability of the rock mass (described by the modulus of deformation). One feature of SNL's rock-mechanics program was the development of a testing program for cutting thin slots in a jointed welded tuff and utilizing flatjacks for pressurizing these thin-slots on a relatively, large scale. Objectives in the pressurized-slot testing in G-Tunnel have been to apply and possibly improve methods for (1) utilizing the flatjack cancellation (FC) method for measuring stresses normal to the slot and (2) measuring the modulus of deformation of the jointed rock surrounding the slot. This paper discusses the results of field measurements in and around a single slot and evaluates potential applications and limitations. 10 refs., 1 fig., 4 tabs.

235 (SAND–88-7067C) **A probabilistic estimate of seismic damage to the waste-handling building of a repository located at Yucca Mountain, Nevada.** Kiciman, O.K. (Bechtel National, Inc., San Francisco, CA (USA)); Abrahamson, N.A. Sandia National Labs., Albuquerque, NM (USA). 1989. 12p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC04-76DP00789. (CONF-890855–31: 10. international conference on Structural Mechanics in Reactor Technology (SMIRT), Anaheim, CA (USA), 14-18 Aug 1989). Order Number DE89011396. Source: NTIS, PC A03/MF A01 - OSTI.

The waste-handling building (WHB) at the Yucca Mountain repository is a reinforced concrete structure with massive shear walls whose thicknesses are established by shielding requirements. The probabilities of seismic damage to the WHB are calculated in this paper. To determine these probabilities seismic hazard curves for the site and fragility curves for the building were developed and combined. The details of this work are found in SNL (1988). The seismic hazard analysis considers both ground acceleration at the WHB site and vertical ground rupture under the WHB. Standard methods (McGuire, 1976; 1978) were used to estimate the acceleration hazard assuming that there is not ground rupture under the WHB. The ground rupture hazard from unknown faults was estimated using a conservative approach developed in this study. The acceleration hazard associated with ground rupture under the WHB was also computed. 7 refs., 16 figs.

236 (SAND–88-7120C) **A proposed concrete shaft liner design method for an underground nuclear waste repository.** Richardson, A.M. (Parsons, Brinckerhoff, Quade and Douglas, Inc., San Francisco, CA (USA)); Schmidt, B.; St. John, C.M.; Stinebaugh, R.E. Sandia National Labs., Albuquerque, NM (USA). 1989. 8p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC04-76DP00789. (CONF-890855–47: 10. international conference on Structural Mechanics in Reactor Technology (SMIRT), Anaheim, CA, USA, 14-18 Aug 1989). Order Number DE89014707. Source: NTIS, PC A02/MF A01 - OSTI; GPO Dep.

General requirements and performance objectives for nuclear waste repository shafts (operational safety and waste retrievability) are defined in 10 CFR 60.133 (NRC, 1988). The Generic Requirements Document (DOE, 1986) interprets and expands these requirements into more specific functional requirements for liners of these shafts, including structural integrity, provisions for attaching shaft fittings, and water control. These requirements also apply to the exploratory shafts used for site characterization because they may later be used in the repository. Cast-in-place concrete liners are excellent for vertical shafts, providing security from rockfalls, convenient attachment of shaft equipment, low resistance to ventilation airflow, and protection of the wall rock from weathering. Concrete-lined shafts are planned for the proposed waste repository in Nevada. To meet repository licensing requirements, a design methodology for liners must be developed that considers the effects of induced thermal and seismic loads on the liner in the context of repository performance requirements. The major steps of a proposed methodology are outlined in this paper. 8 refs., 2 figs.

237 (SAND–89-0165C) **Systems performance assessment for a Yucca Mountain repository.** Hunter, T.O.; Bingham, F.W. Sandia National Labs., Albuquerque, NM (USA). 1989. 10p. DOE Contract AC04-76DP00789. (CONF-890207–28: Waste management '89, Tucson, AZ, US, February 26, 1989). Order Number DE89011510. Source: NTIS, PC A02/MF A01 - OSTI; GPO Dep.

The development of a geologic repository must include evaluations to determine whether the repository system can satisfy the regulatory requirements for postclosure waste isolation. The Yucca Mountain Project of the US DOE includes a performance-assessment program as part of this evaluation. This program focuses on developing and applying methods to determine the isolation potential of the unsaturated tuff at Yucca Mountain. The methods must be based on an understanding of the fundamental concepts of fluid flow, radionuclide releases from the engineered-barrier system, and radionuclide transport in unsaturated, fractured rock. They must be capable of addressing both expected site conditions and unexpected potentially disruptive conditions. They must ultimately be efficient enough to accommodate numerous parameters and their associated uncertainties in the development of the statistical representations that are necessary to satisfy regulatory criteria. The existing methods are based on the current information about the site but will ultimately be supported by data to be obtained during site characterization. 4 refs.

238 (SAND–89-1196) **The effect of strain rate on the compressive strength of dry and saturated tuff.** Olsson, W.A. Sandia National Labs., Albuquerque, NM (USA). Sep 1989. 14p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC04-76DP00789. Order Number DE90000854. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

The uniaxial compressive strength of air-dry and water-saturated ashfall tuff from the Nevada Test Site was measured as a function of strain rate from 10^{-6} to 10^{3} s^{-1}. Two different testing devices were used to achieve this wide range in rate, an electro-hydraulic, servo-controlled load frame, and a Kolsky bar. Critical strain rates of 82 s^{-1} and 22^{-1} were found for dry and saturated tuffs, respectively. Below the critical rate the strength is a weak function of strain rate and above the critical rate strength varies as the cube root of strain rate. The strengths of the dry and saturated tuff are the same above the critical rate. At slower rates, the saturated tuff is weaker at all rates and shows a slightly stronger strain-rate sensitivity. 26 refs., 5 figs.

239 (SAND–89-1285C) **Uncertainties in sealing a nuclear waste repository in partially saturated tuff.** Tillerson, J.R. (Sandia National Labs., Albuquerque, NM (USA)); Fernandez, J.A.; Hinkebein, T.E. Sandia National Labs., Albuquerque, NM (USA). 1989. 14p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC04-76DP00789. (CONF-8905136–2: Joint NEA/CEC workshop on sealing of radioactive waste repositories, Braunschweig, Germany, F.R., 22-25 May 1989). Order Number DE89012637. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Sealing a nuclear waste repository in partially saturated tuff presents unique challenges to assuring performance of sealing components. Design and performance of components for sealing shafts, ramps, drifts, and exploratory boreholes depend on specific features of both the repository design and the site; of particular importance is the hydrologic environment in the unsaturated zone, including the role of fracture flow. Repository design features important to sealing of a repository include the size and location of shaft and ramp accesses, excavation methods, and the underground layout features such as grade (drainage direction) and location relative to geologic structure. Uncertainties about seal components relate to the postclosure environment for the seals, the emplacement methods, the material properties, and the potential performance of the components. An approach has been developed to reduce uncertainties and to increase confidence in seal performance; it includes gathering extensive site characterization data, establishing conservative design requirements, testing seal components in laboratory and field environments, and refining designs of both the seals and the repository before seals are installed. 9 refs., 5 figs., 2 tabs.

240 (SAND–89-1915C) **A sensitivity analysis of flow through layered, fractured tuff: Implications for performance allocation and performance assessment modeling.** Prindle, R.W. Sandia National Labs., Albuquerque, NM (USA). [1989]. 3p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC04-76DP00789. (CONF-890928–5: Nuclear waste isolation in the unsaturated zone: FOCUS '89, Las Vegas, NV (USA), 18-21 Sep 1989). Order Number DE90001172. Source: NTIS, PC A02/MF A01 - OSTI; GPO Dep.

We have recently completed a sensitivity study of unsaturated flow through a system of layered, fractured tuffs. This study was defined and performed for the International Hydrologic Code Intercomparison Project (HYDROCOIN). The modeled system was highly constrained and simplified but was loosely based on conditions though to exist at Yucca Mountain. The proposed paper will cover: a brief description of the system modeled, the mathematical model used, and the analyses performed for this study; a summary of the major conclusions drawn regarding the important types of flow behavior that were observed, and a discussion of the implications of the different types of flow behavior for performance allocation and for performance assessment using simplified models.

241 (SAND–89-2135C) **A description and status of the Yucca Mountain Project repository sealing program.** Fernandez, J.A.; Hinkebein, T.E. Sandia National Labs., Albuquerque, NM (USA). [1989]. 7p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC04-76DP00789. (CONF-8904272–1: International high-level radioactive waste management conference, Las Vegas, NV (USA), 18-21 Apr 1989). Order Number DE90000665. Source: NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

Yucca Mountain is being characterized to determine its suitability as a site for a high-level nuclear waste repository. The repository would be located in the unsaturated zone in fractured, welded tuff. Sealing of the repository is one element of the Yucca Mountain Project (YMP). This paper presents a description of the repository sealing program including the sealing design options, design requirements, design constraints, and the identification of the proposed sealing materials and field tests. Design options for the shafts include anchor-to-bedrock seals, shaft fill, and settlement plugs; in the underground facility options include drift seals, drainage channels, sumps, and bulkheads. Design requirements are those quantitative requirements imposed on the sealing design options to achieve a desired level of performance. Constraints are restrictions placed on the repository design by the sealing design. As (1) additional hydrogeologic data are obtained through site characterization, (2) approaches to allocating performance to various subsystems within the YMP are refined, and (3) the exploratory shafts and the associated testing results are developed, the design requirements and constraints may be modified and used in developing the License Application Design. 1 ref., 1 fig.

242 (SAND–89-7003C) **Offsite radiation doses resulting from seismic events at the Yucca Mountain repository.** Ma, C.W. (Bechtel National, Inc., San Francisco, CA (USA)); Jardine, L.J. Sandia National Labs., Albuquerque, NM (USA). 1989. 13p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC04-76DP00789. (CONF-890855–45: 10. international conference on Structural Mechanics in Reactor Technology (SMIRT), Anaheim, CA (USA), 14-18 Aug 1989). Order Number DE89014690. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

This paper describes a preliminary study to evaluate the offsite doses resulting from seismic events postulated to occur during the preclosure period at the proposed Yucca Mountain repository. The work reported here is part of a larger preliminary study of the costs and benefits of designing the waste-handling building (WHB) at the repository for seismic events of varying severity. During an earthquake, the quantity of radiological releases is dependent on the damage state of the structure or facility under construction. For the purpose of this study, four damage states are used: light, moderate, heavy, and total. These damage states are characterized by various degrees of spalling of concrete pieces from the walls and cracking of the walls. The spalling concrete may hit the spent fuel assemblies and cause radiological releases. An estimate of the maximum total radionuclide inventory in the WHB is made in Section 2.0. In Section 3.0, the quantities of radioactive material released for each damage state are evaluated. The offsite doses resulting from these releases are calculated in Section 4.0. Section 5.0 presents the conclusions.

243 **Drying of an initially saturated fractured volcanic tuff.** Multiphase transport in porous media. Eaton, R. (Sandia National Labs., Albuquerque, NM (US)); Udell, K.S.; Kaviany, M. American Society of Mechanical Engineers, (1988). pp. 55-60 (CONF-871234–: ASME winter meeting, Boston, MA, US, December 13, 1987).

The isothermal drying of an initially saturated welded tuffaceous rock was studied experimentally. Gamma-beam densitometry was used to measure the material's effective porosity distribution prior to the drying experiment. It was then used to measure liquid saturation distributions during a 1400 hour drying period. The core selected for study was taken from the Busted Butte outcrop at the Nevada Test Site, part of the Topopah Spring Member of Paintbursh tuff. This specimen contained several microfractures transversely oriented to the direction of the water or vapor migration. These fractures were found to be regions of rapid dryout or low saturation even though they were displaced from the surface over which dry nitrogen was flowing. An imbibition experiment was performed earlier on the same core. In the imbibition experiment the presence of most of these microfractures was detected by discontinuities in the measured saturation curves, which indicated a delay in liquid transport past the microfractures.

244 **Modeling multiphase heat and mass transfer in consolidated, fractured, porous media.** Bixler, N.E. (Fluid and Thermal Sciences Dept., Sandia National Labs., Albuquerque, NM 87185 (USA)); Eaton, R.R. Proceedings of the 4th Miami international symposium on multi-phase transport particulate phenomena (condensed papers). Veziroglu, T.N. University of Miami, (1987). pp. 1 (CONF-861204–: 4. Miami international symposium on multi-phase transport and particulate phenomena, Miami Beach, FL, US, December 15, 1986).

A number of potential transport mechanisms are considered in this paper: Darcy flow due to pressure and density gradients in the liquid and gas phases; Knudsen diffusion in the gas phase; binary diffusion in the gas phase; heat conduction; energy convection; and evaporation/condensation and its associated latent heat effects. Most of these mechanisms are highly nonlinear, especially Darcy flow, where relative permeabilities often vary by orders of magnitude depending on local saturation, and evaporation/condensation, which depends strongly on local temperature, gas pressure, and saturation. As a consequence of the nonlinearities, it is essential to employ numerical methods if realistic modeling is to be performed. Here, the numerical model is of the standard Galerkin/finite element variety, which is convenient for handling irregular domains and a wide variety of boundary conditions. This numerical model is used to examine the relative effectiveness of each of the transport mechanisms in several one-dimensional and simple two-dimensional multiphase flows in fractured and unfractured porous materials. The importance of fracture orientation is also studied. Predictions are compared with experimental measurements for imbibition and drying of fractured volcanic tuff.

245 **Excavation effects on tuff - recent findings and plans for investigations at Yucca Mountain.** Blejwas, T.E. (Sandia National Lab., Albuquerque, NM (US)); Zimmerman, R.M.; Shephard, L.E. pp. 175-186 of Excavation response in geological repositories for radioactive waste. Proceedings of an NEA Workshop. Organisation for Economic Co-0peration and Development, Paris, FR (1989). v. of (CONF-880497–: Workshop on excavation effects on the engineering design and safety performance of an underground repository for radioactive waste, Winnipeg, Canada, 26-28 Apr 1988).

Plans for site-characterization testing and constructing an exploratory shaft facility (ESF) at Yucca Mountain, Nevada, have been influenced by the construction and monitoring of stable openings in G-Tunnel on the Nevada Test Site. G-Tunnel provides access for testing in a thin bed of unsaturated welded tuff that is similar to that at Yucca Mountain. The data from the experiments in the ESF will be used to validate analytical methods for predicting the response of underground openings to the excavation process and to the heat generated by the waste.

246 **Thermal/mechanical analyses of G-Tunnel field experiments at Rainier Mesa, Nevada.** Bauer, S.J. (Sandia National Lab., Albuquerque, NM (US)); Costin, L.S.; Chen, E.P.; Tillerson, J.R. pp. 187-206 of Excavation response in geological repositories for radioactive waste. Proceedings of an NEA Workshop. Organisation for Economic Co-0peration and Development, Paris, FR (1989). v. of (CONF-880497–: Workshop on excavation effects on the engineering design and safety performance of an underground repository for radioactive waste, Winnipeg, Canada, 26-28 Apr 1988).

Analysis methods (models) are currently being developed to support thermal, mechanical, and thermomechanical aspects of repository design and performance assessment of the candidate Yucca Mountain high-level nuclear waste site. Credibility of these models, and therefore of design and performance analyses, will in part be determined through comparison of calculated and measured response (validation) for large-scale field experiments. This paper discusses the models being developed, the rationale behind the model development, and analyses of experiments performed at G-Tunnel and planned as part of site characterization at Yucca Mountain.

247 Elastic properties of dry, highly porous tuffs. Butcher, B.M. (Sandia National Labs., Albuquerque, NM). Rock mechanics: Proceedings of the 28th U.S. symposium. Farmer, I.W.; Daemen, J.J.K.; Desai, C.S.; Glass, C.E.; Neuman, S.P. A.A. Balkema Publishers, (1987). pp. 181-188 DOE Contract AC04-76DP00789. (CONF-870625–: 28. U.S. symposium on rock mechanics, Tucson, AZ, US, June 29, 1987).

A functional relationship between values for the elastic constants and porosity has been developed for tuffs with various degrees of welding. This correlation defines the change in elastic constants with inelastic compaction for wave propagation analysis and also can be used to estimate elastic properties of tuffs with different initial porosity. The ability to relate stress induced changes to unstressed states with different porosity values is new and eliminates the need for a large, costly testing program every time the site changes.

248 Initial Q-list for the prospective Yucca Mountain repository based on items important to safety and waste isolation. Laub, T.W. (Sandia National Labs., Div. 6311, Nuclear Waste Engineering Projects, Albuquerque, NM 87185); Jardine, L.J. Waste management '87: Waste isolation in the US, technical programs, and public education. Post, R.G. University of Arizona Nuclear Engineering Dept., (1987). pp. 293-300 DOE Contract AC04-76DP00789. (CONF-870306–: Waste management '87, Tucson, AZ, US, March 1, 1987).

A method for identifying items important to safety based on a probabilistic risk assessment approach was developed and implemented for the conceptual design of the Yucca Mountain repository. No items were classified as important to safety; however, six items were classified as potentially important to safety. These were the shipping cask, the cranes and the truck or rail-care vehicle stops in the cask receiving and preparation area, the hot cell structure of the waste packaging hot cells, the cranes in the waste packaging hot cells, and the waste-handling building fire protection system. In addition, a method for identifying items important to waste isolation was developed and implemented. Two hydrogeologic units of the Yucca Mountain site were classified as important to waste isolation: the Calico Hills nonwelded zeolitic unit and the Calico Hills nonwelded vitric unit. The preliminary Q-list for the Yucca Mountain repository is comprised of the two units of the site classified as important to waste isolation and contains no items important to safety.

249 Preliminary preclosure safety analysis for a prospective Yucca mountain repository. Jardine, L.J. (Bechtel National Inc., Advanced Technology, San Francisco, CA 94119); Ma, C.W.; Sit, R.C.; Donahue, R.J. Waste management '87: Waste isolation in the US, technical programs, and public education. Post, R.G. University of Arizona Nuclear Engineering Dept., (1987). pp. 645-650 (CONF-870306–: Waste management '87, Tucson, AZ, US, March 1, 1987).

A quantitative probabilistic safety assessment was performed for the reference conceptual repository design being used as the basis for the development of the Yucca Mountain Site Characterization Plan. A new methodology to quantify radioactive source terms for the air pathways was also developed and applied in the assessment. The assessment identified 21 potential initiating internal and external events applicable to the prospective site for which 149 potential accident scenarios were defined with event tree analysis. Of these accident scenarios, 13 occurred with probabilities ranging between 10^{-6} to 10^{-9} per year and with estimated offsite 50-year dose commitment consequences ranging from 110 to 1,100 mrem, respectively. These 13 reference accident scenarios represent the most severe consequences identified that the operation of a repository could initiate. The remaining scenarios had either probabilities of occurrence of less than 5×10^{-9} per year or offsite dose consequences of less than 50 mrem.

250 Analysis of in situ stress at Yucca Mountain. Bauer, S.J. (Sandia National Labs., Albuquerque, NM); Holland, J.F. Rock mechanics: Proceedings of the 28th U.S. symposium. Farmer, I.W.; Daemen, J.J.K.; Desai, C.S.; Glass, C.E.; Neuman, S.P. A.A. Balkema Publishers, (1987). pp. 707-714 DOE Contract AC04-76DP00789. (CONF-870625–: 28. U.S. symposium on rock mechanics, Tucson, AZ, US, June 29, 1987).

A method has been developed utilizing far-field finite element models such that the measured in situ stress state appears to be reproduced well. The method includes use of the mechanical stratigraphy, effective and total stresses, gravity loading, a horizontal compressive component of stress, and use of a compliant-joint rock model to calculate the mechanical response. Topographic effects and effects related to the vertical variation in mechanical properties are predicted for repository depths (– 300 m). Gravity loading with a small horizontal compression are used to calculate a minimum horizontal total stress similar in magnitude to that measured in situ.

251 Analysis of drift convergence phenomena from G-Tunnel welded tuff mining evaluations. Zimmerman, R. (Sandia National Labs., Albuquerque, NM); Bellman, R.A. Jr.; Mann, K.L. Rock mechanics: Proceedings of the 28th U.S. symposium. Farmer, I.W.; Daemen, J.J.K.; Desai, C.S.; Glass, C.E.; Neuman, S.P. A.A. Balkema Publishers, (1987). pp. 831-842 DOE Contract AC04-76DP00789. (CONF-870625–: 28. U.S. symposium on rock mechanics, Tucson, AZ, US, June 29, 1987).

This paper discusses the results of vertical and horizontal drift convergence measurements taken during the mining of a repository-sized drift in welded tuff in G-Tunnel on the Nevada Test Site. Results are quantified in terms of drift convergence magnitudes and rates that relate to drift stability.

252 Development of diamond-tipped chain saws for slot cutting in welded tuff. Zimmerman, R.M. (NNWSI Geotechnical Projects Div., Sandia National Labs., Albuquerque, NM); Finley, R.E.; Schuch, R.L.; Dodds, D.J. Rock mechanics: Proceedings of the 28th U.S. symposium. Farmer, I.W.; Daemen, J.J.K.; Desai, C.S.; Glass, C.E.; Neuman, S.P. A.A. Balkema Publishers, (1987). pp. 963-972 DOE Contract AC04-76DP00789. (CONF-870625–: 28. U.S. symposium on rock mechanics, Tucson, AZ, US, June 29, 1987).

This paper describes the development and performance evaluations of two chain saws, one with a 1.1-m bar and the other with a 2.1-m bar, that were used to cut thin (less than 15 mm) planar slots in a jointed, welded tuff in G-tunnel on the Nevada Test Site as part of the Nevada Nuclear Waste Storage Investigations Project.

253 Planning a program in experimental rock mechanics for the Nevada Nuclear Waste Storage Investigations Project. Blejwas, T.E. (Sandia National Labs., Albuquerque, NM). Rock mechanics: Proceedings of the 28th U.S. symposium. Farmer, I.W.; Daemen, J.J.K.; Desai, C.S.; Glass, C.E.; Neuman, S.P. A.A. Balkema Publishers, (1987). pp. 1043-1052 DOE Contract AC04-76DP00789. (CONF-870625–: 28. U.S. symposium on rock mechanics, Tucson, AZ, US, June 29, 1987).

The next phase of the Nevada Nuclear Waste Storage Investigations (NNWSI) Project is the characterization of Yucca Mountain, a possible site for a high-level nuclear-waste repository. Site characterization includes experimental programs in many technical fields, including rock mechanics. The planning approach includes performance allocation, an interactive process by which the data needs for design and performance assessment of the repository are used to determine the direction and magnitude of the experimental programs.

254 Continuum model for water movement in an unsaturated fractured rock mass. Peters, R.R. (Sandia National Labs., Albuquerque, NM (USA)); Klavetter, E.A. *Water Resources Research (USA),* 24(3): 416-430 (Mar 1988). DOE Contract AC04-76DP00789.

The movement of fluids in a fractured, porous medium has been the subject of considerable study. This paper presents a continuum model that may be used to evaluate the isothermal movement of water in an unsaturated, fractured, porous medium under slowly changing conditions. This continuum model was developed for use in evaluating the unsaturated zone at the Yucca Mountain site as a potential repository for high-level nuclear waste. Thus its development has been influenced by the conditions thought to be present at Yucca Mountain. A macroscopic approach and a microscopic approach are used to develop a continuum model to evaluate water movement in a fractured rock mass. Both approaches assume that the pressure head in the fractures and the matrix are identical in a plane perpendicular to flow. Both approaches lead to a single-flow equation for a fractured rock mass. The two approaches are used to calculate unsaturated hydrologic properties, i.e., relative permeability and saturation as a function of pressure head, for several types of tuff underlying Yucca Mountain, using the best available hydrologic data for the matrix and the fractures. Rock mass properties calculated by both approaches are similar.

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255 (LBL–25073) **Preliminary calculations of the effects of air and liquid water-drilling on moisture conditions in unsaturated rocks.** Bodvarsson, G.S.; Niemi, A.; Spencer, A.; Attanayake, M.P. Lawrence Berkeley Lab., CA (USA). Nov 1988. 68p. DOE Contract AC03-76SF00098 ;AI08-78ET44802. Order Number DE89010666. Source: NTIS, PC A04/MF A01 - OSTI; GPO Dep.

Numerical simulation studies are performed to investigate the effects of air and liquid water drilling on the time-dependent moisture conditions in nearby fractures and rock matrix blocks. The results obtained suggest that drilling with liquid water will increase the liquid saturation in the matrix by one or two percentage points after one year of recovery. For the characteristic curves used, this corresponds to a 10 to 20 percent increase in the relative permeability of the liquid phase. The results also indicate that air drilling has negligible effects on the moisture conditions within the matrix blocks. 15 refs., 38 figs.

256 (USGS-BULL–1777) **Distribution, characterization, and genesis of mordenite in Miocene silicic tufts at Yucca Mountain, Nye County, Nevada.** Sheppard, R.A.; Gude, A.J. III; Fitzpatrick, J.J. Geological Survey, Denver, CO (USA). [1988]. 22p. DOE Contract AI08-78ET44802. Order Number DE89003673. Source: NTIS, PC A03/MF A01 - OSTI - US Geological Survey, Federal Center, Box 25425, Denver, CO 80225.

Tuffs at Yucca Mountain in the southwestern Nevada volcanic field are being investigated as a possible deep repository for high-level radioactive wastes. A sequence, as much as about 3000 meters thick, of Miocene silicic ash-flow tuffs, bedded tuffs, lavas, and flow breccias was derived chiefly from the Timber Mountain-Oasis Valley caldera complex. Previous studies by others of core from several drill holes have shown that much of the original vitric material of the volcanic and volcaniclastic rocks was altered during diagenesis to clay minerals, silica minerals, zeolites, and feldspars. Unaltered glass still persists in the upper part of the sequence, but zones characterized by clinoptilolite and mordenite, analcime, and albite follow in succession with depth. 28 refs., 16 figs., 5 tabs.

257 (USGS-BULL–1790) **Geologic and hydrologic investigations of a potential nuclear waste disposal site at Yucca Mountain, southern Nevada.** Carr, M.D.; Yount, J.C. (eds. Geological Survey, Denver, CO (USA). 1988. 152p. DOE Contract AI08-78ET44802. Source: NTIS, PC A07/MF A01 - USGS Federal Center, Box 25425, Denver, CO 80225.

Yucca Mountain in southern Nye County, Nevada, has been selected by the United States Department of Energy as one of three potential sites for the nation's first high-level nuclear waste repository. Its deep water table, closed-basin ground-water flow, potentially favorable host rock, and sparse population have made the Yucca Mountain area a viable candidate during the search for a nuclear waste disposal site. Yucca Mountain, however, lies within the southern Great Basin, a region of known contemporary tectonism and young volcanic activity, and the characterization of tectonism and volcanism remains as a fundamental problem for the Yucca Mountain site. The United States Geological Survey has been conducting extensive studies to evaluate the geologic setting of Yucca Mountain, as well as the timing and rates of tectonic and volcanic activity in the region. A workshop was convened by the Geologic Survey in Denver, Colorado, on August 19, 20, and 21, 1985, to review the scientific progress and direction of these studies. Considerable debate resulted. This collection of papers represents the results of some of the studies presented at the workshop, but by no means covers all of the scientific results and viewpoints presented. Rather, the volume is meant to serve as a progress report on some of the studies within the Geological Survey's continuing research program toward characterizing the tectonic framework of Yucca Mountain. Individual papers were processed separately for the data base.

258 (USGS/MAP/I–1767) **Geologic map of the quaternary and tertiary deposits of the Big Dune quadrangle, Nye County, Nevada, and Inyo County, California.** Swadley, W.C.; Carr, W.J. Geological Survey, Denver, CO (USA). 1987. 20p. DOE Contract AI08-78ET44802. Order Number DE88010834. Source: NTIS, PC A03.

CALIFORNIA/geologic deposits; CALIFORNIA/geology; CALIFORNIA/maps; NEVADA/geologic deposits; NEVADA/geology; NEVADA/maps; CALIFORNIA; GEOLOGY; MAPS; NEVADA; QUATERNARY PERIOD; SANDSTONES; SILTSTONES, TERTIARY PERIOD, TUFF

259 (USGS/MAP/I–1826) **Surficial geologic map of the Bare Mountain quadrangle, Nye County, Nevada.** Swadley, W.C.; Parrish, L.D. Geological Survey, Denver, CO (USA). 1988. 13p. DOE Contract AI08-78ET44802. Source: USGS.

NEVADA/geology; NEVADA/maps; NEVADA; GEOLOGY; MAPS

260 (USGS/MAP/I–2018) **Geologic map of the surficial deposits of the Topopah Spring Quadrangle, Nye County, Nevada.** Swadley, W.C.; Hoover, D.L. Geological Survey, Denver, CO (USA). 1989. 16p. DOE Contract AI08-78ET44802. Source: US Geological Survey, Map Distribution, Federal Center, Box 25286, Denver, CO 80225.

This document consists of a single map without supporting text. (TEM)

261 (USGS-OFR–87-199) **A reconnaissance assessment of probabilistic earthquake accelerations at the Nevada Test Site.** Perkins, D.M.; Thenhaus, P.C.; Hanson, S.L.; Algermissen, S.T. Geological Survey, Denver, CO (USA). 1986. 29p. DOE Contract AI08-78ET44802. Order Number DE88002166. Source: NTIS, PC A03/MF A01; GPO Dep.

We have made two interim assessments of the probabilistic ground-motion hazard for the potential nuclear-waste disposal facility at the Nevada Test Site (NTS). The first assessment used historical seismicity and generalized source zones and source faults in the immediate vicinity of the facility. This model produced relatively high probabilistic ground motions, comparable to the higher of two earlier estimates, which was obtained by averaging seismicity in a 400-km-radius circle around the site. The high ground-motion values appear to be caused in part by nuclear-explosion aftershocks remaining in the catalog even after the explosions themselves have been removed. The second assessment used particularized source zones and source faults in a region substantially larger than NTS to provide a broad context of probabilistic ground motion estimates at other locations of the study region. Source faults are mapped or inferred faults having lengths of 5 km or more. Source zones are defined by boundaries separating fault groups on the basis of direction and density. For this assessment, earthquake recurrence has been estimated primarily from historic seismicity prior to nuclear testing. Long-term recurrence for large-magnitude events is constrained by geological estimates of recurrence in a regime in which the large-magnitude earthquakes would occur with predominately normal mechanisms. 4 refs., 10 figs.

262 (USGS-OFR–87-408) **Evaluation of the seismicity of the southern Great Basin and its relationship to the tectonic framework of the region.** Rogers, A.M.; Harmsen, S.C.; Meremonte, M.E. Geological Survey, Denver, CO (USA). 1987. 196p. DOE Contract AI08-78ET44802. Order Number DE88900471.

Seismograph network recordings of local and regional earthquakes are being collected in the southern Great Basin to aid in the evaluation of the seismic hazard at a potential high-level radioactie waste repository site at Yucca Mountain in the southwestern Nevada Test Site. Data for 1522 earthquakes for the calendar years 1982 and 1983 are reported herein. In the period August, 1978 through December, 1983, 2800 earthquakes were located within and adjacent to the southern Great Basin seismograph network. Earthquake hypocenters, selected focal mechanisms, and other inferred seismicity characteristics are presented and discussed in relation to the local and regional geologic framework. 105 refs., 94 figs., 8 tabs.

263 (USGS-OFR–87-409) **Photogeologic study of small-scale linear features near a potential nuclear-waste repository site at Yucca Mountain, southern Nye County, Nevada.** Throckmorton, C.K. Geological Survey, Denver, CO (USA). 1987. 56p. DOE Contract AI08-78ET44802. Order Number DE88005001. Source: NTIS, PC A04/MF A01; GPO Dep.

Linear features were mapped from 1:2400-scale aerial photographs of the northern half of the potential underground nuclear-waste repository site at Yucca Mountain by means of a Kern PG 2 stereoplotter. These features were thought to be the expression of fractures at the ground surface (fracture traces), and were mapped in the caprock, upper lithophysal, undifferentiated lower lithophysal and hackly units of the Tiva Canyon Member of the Miocene Paintbrush Tuff. To determine if the linear features corresponded to fracture traces observed in the field, stations (areas) were selected on the map where the traces were both abundant and located solely within one unit. These areas were visited in the field, where fracture-trace bearings and fracture-trace lengths were recorded. Additional data on fracture-trace length and fracture abundance, obtained from ground-based studies of cleared pavements located within the study area were used to help evaluate data collected for this study. 16 refs., 4 figs., 2 tabs.

264 (USGS-OFR–87-506) **Complete Bouguer gravity map of the Nevada Test Site and vicinity, Nevada.** Healey, D.L.; Harris, R.N.; Ponce, D.A.; Oliver, H.W. Geological Survey, Menlo Park, CA (USA). 1987. 20p. DOE Contract AI08-78ET44802. Source: OSTI - USGS-OFR, Open File Service, Box 25425, Denver Federal Center, Denver, CO 80225.

About 15,000 gravity stations were used to create the gravity map. Gravity studies at the Nevada Test Site were undertaken to help locate geologically favorable areas for underground nuclear tests and to help characterize potential high-level nuclear waste storage sites. 48 refs. (TEM)

265 (USGS-OFR–87-596) **Earthquake location data for the southern Great Basin of Nevada and California: 1984 through 1986.** Harmsen, S.C.; Rogers, A.M. Geological Survey, Denver, CO (USA). 1987. 96p. DOE Contract AI08-78ET44802. Order Number DE88007077. Source: NTIS, PC A; Q 05/MF A01;1; GPO Dep.

This report presents data in map and table form for earthquake parameters such as hypocentral coordinates and magnitudes for earthquakes located by the southern Great Basin Seismic network for the time period January 1, 1984, through December 31, 1986. These maps show concentrations of earthquakes in regions previously noted to be seismically active, including the Pahranagat Shear Zone, Pahroc Mountains, southern Nevada Test Site, Timber Mountain, Black Mountain, Gold Mountain, Montezuma Range, and Grapevine Mountains. A concentration of earthquake activity in the Reveille Range was observed in 1986, in a previously inactive area. The northern Nevada Test Site had fewer earthquakes than a comparable area of the southern Nevada Test Site, indicating that the low-yield nuclear testing program is not currently triggering significant numbers of aftershocks. Eight microearthquakes occurred at Yucca Mountain during the 1984-1986 monitoring period. Depths of focus for well-located earthquakes continue to indicate a bimodal distribution, with peaks at 1 to 2 and 8 to 9 km below sea-level and a local minimum at 4 to 5 km. Focal mechanisms range from strike slip to normal slip. No dependence of slip mode on depth or magnitude is evident. 8 refs., 46 figs., 5 tabs.

266 (USGS-OFR–87-617) **Late Cenozoic evolution of the upper Amargosa River drainage system, southwestern Great Basin, Nevada and California.** Huber, N.K. Geological Survey, Menlo Park, CA (USA). 1988. 26p. DOE Contract AI08-78ET44802. Order Number DE88010306. Source: NTIS, PC A03/MF A01; GPO Dep.

A major part of the upper Amargosa River drainage system is centered on Timber Mountain, a high central area within a volcanic caldera northeast of Beatty, Nevada, on the west margin of the Nevada Test Site. The basic drainage pattern in this area was established soon after caldera collapse and resurgent dome formation about 11 million years ago. The gross drainage pattern has changed little since then, although subsequent volcanic activity has temporarily blocked drainage channels. As there have been no significant changes in subbasin geometry, general tectonic stability of the region during this time is implied. A major change in alluvial regimen occurred with the end of major alluvial-fan construction within the drainage system and the beginning of fanhead erosion that formed incised washes. The size and shape of incised channels differ, but they show a similar relation to the geomorphic parameters of their respective drainage basins—including such diverse-appearing washes as the deep Fortymile Wash and the wide, shallow wash on the Amargosa River downstream from Beatty. If the subbasin drainages have not changed appreciably during the Quaternary, then the forcing mechanism for the change in alluvial regimen is most likely either climatic or tectonic. Because this change appears to have occurred at about the same time throughout the upper Amargosa River drainage system, a climatic cause is preferred; its nature and timing are still speculative, but probably was increasing aridity that reached a threshold in the middle Pleistocene. This analysis also concludes that a postulated Pleistocene drainage capture by the Fortymile Canyon drainage system did not occur and that a large Pliocene lake in the Amargosa Desert, the postulated “Lake Amargosa”, is equivocal.

267 (USGS-OFR–87-649) **Temperature, thermal conductivity, and heat flow near Yucca Mountain, Nevada: Some tectonic and hydrologic implications.** Sass, J.H.; Lachenbruch, A.H.; Dudley, W.W. Jr.; Priest, S.S.; Munroe, R.J. Geological Survey, Reston, VA (USA). 1988. 118p. DOE Contract AI08-78ET44802. Order Number DE89002697. Source: NTIS, PC A06/MF A01.

Repeated temperature logs were obtained in 18 geologic and hydrologic test wells near Yucca Mountain, Nevada. Single logs were also obtained (using a specially designed sonde with fast response in air) in the air column of 17 wells drilled to monitor water level below and around Yucca Mountain. The temperature data suggest that the thermal regimes of both the saturated and unsaturated zones are strongly influenced by a complex hydrologic regime in the saturated tuffs and underlying Paleozoic carbonate rocks. Temperature gradients in the unsaturated zone (UZ) appear primarily conductive, but they range from about 15°C km^{-1} to nearly 60°C km_{-1}. However, one profile indicates rapid penetration to a depth of 150 m beneath a major channel by water from run-off following a local heavy rain. From the water table (which ranges in depth from about 300 m to over 700 m) to depths of 1 km or more, the temperature gradient in the saturated zone (SZ) typically is very irregular with evidence for locally controlled water movement in the Tertiary volcanic rocks, laterally and both up and down vertically. Vertical seepage velocities inferred from one-dimensional hydrologic models range from a few millimeters to 100 millimeters or more per year. Below depths of 1 km, temperature profiles are linear, suggesting conductive heat flow, but as in the case of the UZ, the gradients are quite variable, suggesting that the heat flux here is being controlled by fluid flow in the Paleozoic carbonate aquifer that underlies Yucca Mountain. 26 refs., 18 figs., 6 tabs.

268 (USGS-OFR–88-233) **Instructions for the soil development index template: Lotus 1-2-3.** Taylor, E.M. Geological Survey, Denver, CO (USA). 1988. 27p. DOE Contract AI08-78ET44802. Order Number DE88009779. Source: NTIS, PC A03.

The soil development index to quantify field properties of soils has proven to be a successful method to study rates of soil development and provides a means to quantitatively compare soil development in different climatic regimes. Three Lotus 1-2-3 templates have been designed to simplify the transition from field descriptions to the calculation of the soil development index. The first two are optional bookkeeping templates to record field description of soils; the third template calculates the soil development index. The field descriptions may be copied into the index template. Data can easily be added, changed, and compared. 12 refs., 1 tab.

269 (USGS-OFR–88-242) **Preliminary results of absolute and high-precision gravity measurements at the Nevada Test Site and vicinity, Nevada.** Zumberge, M.A.; Harris, R.N.; Oliver, H.W.; Sasagawa, G.S.; Ponce, D.A. Geological Survey, Menlo Park, CA (USA). 1988. 31p. DOE Contract AI08-78ET44802. Order Number DE89003459. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Absolute gravity measurements were made at 4 sites in southern Nevada using the absolute gravity free-fall apparatus. Three of the sites are located on the Nevada Test Site at Mercury, Yucca Pass, and in northern Jackass Flats. The fourth site is at Kyle Canyon ranger station near Charleston Park where observed gravity is 216.19 mGal lower than at Mercury. Although there is an uncertainty of about 0.02 mGal in the absolute measured values, their gravity differences are considered accurate to about 0.03 mGal. Therefore, the absolute measurements should provide local control for the calibration of gravity meters between Mercury and Kyle Canyon ranger station to about 1 to 2 parts in 10,000. The average gravity differences between Mercury and Kyle Canyon obtained using LaCoste and Romberg gravity meters is 216.13 mGal, 0.06 mGal lower, or 3 parts in 10,000 lower than using the absolute gravity meter. Because of the discrepancy between the comparison of the absolute and relative gravity meters, more absolute and relative gravity control in southern Nevada, as well as the Mt.

Hamilton area where the LaCoste and Romberg instruments were calibrated, is needed. Multiple gravity meter ties were also made between each of the four absolute stations to nearby base stations located on bedrock. These stations were established to help monitor possible real changes in gravity at the absolute sites that could result from seasonal variations in the depth to the water table or other local mass changes. 8 refs., 16 figs., 7 tabs.

270 (USGS-OFR--88-243) **High-precision gravity network to monitor temporal variations in gravity across Yucca Mountain, Nevada.** Harris, R.N.; Ponce, D.A. Geological Survey, Menlo Park, CA (USA). 1988. 19p. DOE Contract AI08-78ET44802. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Repeatable high-precision gravity surveys provide a method of monitoring temporal variations in the gravity field. Fluctuations in the gravity field may indicate water table changes, crustal deformation, or precursors to volcanism and earthquakes. This report describes a high-precision gravity loop which has been established across Yucca Mountain, Nevada in support of the Nevada Nuclear Waste Storage Investigations (NNWSI) program. The purpose of this gravity loop is to monitor temporal variations in gravity across Yucca Mountain in an effort to interpret and predict the stability of the tectonic framework and changes in the subsurface density field. Studies of the tectonic framework which include volcanic hazard seismicity, and faulting studies are in progress. Repeat high-precision gravity surveys are less expensive and can be made more rapidly than a corresponding leveling survey. High-precision gravity surveys are capable of detecting elevation changes of 3 to 5 cm, and thus can be employed as an efficient tool for monitoring vertical crustal movements while supplementing or partially replacing leveling data. The Yucca Mountain gravity network has been tied to absolute gravity measurements established in southern Nevada. These ties provide an absolute datum for comparing repeat occupations of the gravity network, and provide a method of monitoring broad-scale changes in gravity. Absolute gravity measurements were also made at the bottom and top of the Charleston Peak calibration loop in southern Nevada. These absolute gravity measurements provide local control of calibrating gravity meters over the gravity ranges observed at Yucca Mountain. 13 refs., 7 figs., 3 tabs.

271 (USGS-OFR--88-468) **Water levels in periodically measured wells in the Yucca Mountain area, Nevada, 1981-1987.** Robison, J.H.; Stephens, D.M.; Luckey, R.R.; Baldwin, D.A. Geological Survey, Denver, CO (USA). 1988. 136p. DOE Contract AI08-78ET44802. Order Number DE89006256. Source: NTIS, PC A07/MF A01 - OSTI; GPO Dep.

This report presents water-level data for 28 wells that have been periodically measured in the Yucca Mountain area, Nevada. The report includes discussions of the methods used and corrections applied to obtain water-level depths and altitudes from onsite measurements. Water levels for each well are presented in tabular and graphical (hydrograph) form. The altitude of the water level in the upper part of the saturated zone is about 775 meters above sea level to the west of and along part of the crest of Yucca Mountain; along the eastern edge and southern end of Yucca Mountain, the water level is nearly horizontal and is 728 to 730 meters above sea level. The water-level data were obtained in cooperation with the US Department of Energy to help evaluate the suitability of the area for storing high-level nuclear waste. 38 refs., 3 figs., 2 tabs.

272 (USGS-OFR--88-560) **Location refinement of earthquakes in the southwestern Great Basin, 1931-1974, and seismotectonic characteristics of some of the important events.** Gawthrop, W.H.; Carr, W.J. Geological Survey, Denver, CO (USA). 1988. 74p. DOE Contract AI08-78ET44802. Order Number DE89006764. Source: NTIS, PC A04/MF A01 - OSTI; GPO Dep.

Seismological records for the period 1931-1974 were examined and analyzed by modern techniques, including velocity structure inversion and application of station-phase corrections. Epicenter confidence ellipses and fault plane solutions were determined for many events. In the past, epicenters of earthquakes in the southwestern Great Basin have been mislocated by as much as 100 kilometers, or even more in one case. Improved locations for foreshocks and aftershocks, with relative errors of about 5 to 10 kilometers and absolute errors of perhaps 15 to 25 kilometers, permit closer inspection of possible relationships or coupling between some major events in the Nevada portion of the Nevada-California seismic zone. 28 refs., 27 figs.

273 (USGS-OFR--89-92) **Fractures in outcrops in the vicinity of drill hole USW G-4, Yucca Mountain, Nevada: Data analysis and compilation.** Barton, C.C.; Page, W.R.; Morgan, T.L. Geological Survey, Denver, CO (USA). 1989. 133p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AI08-78ET44802. Order Number DE89017523. Source: NTIS, PC A07/MF A01; OSTI; INIS; GPO Dep.

Fractures on outcrops in the vicinity of drill hole USW G-4, Yucca Mountain, Nevada, were studied in order to contribute to characterization of fractures for hydrologic, geomechanical, and tectonic modeling of the Yucca Mountain block and to characterize fractures prior to the excavation of a proposed exploratory shaft located near USW G-4. Yucca Mountain is a prospective site for the construction of an underground repository for high-level nuclear waste. Measurements were taken and recorded on 5000 fractures at 50 outcrop stations primarily in the upper lithophysal unit of the Tiva Canyon Member of the Miocene Paintbrush Tuff. Fracture orientation and surface roughness were recorded for each fracture. Additionally, notes were taken on fracture abutting, crossing, and offsetting relations, swarming, curvature, brecciation, slickensides, and fracture fillings. Frequency distributions of orientation and roughness were plotted and analyzed. Fractures with low roughness coefficients (0-4) group tightly into two sets based on orientation. We conclude that such fractures are cooling joints and that all other fractures are tectonic. The development of small-scale fractures adjacent, subparallel, and possibly related to the Ghost Dance fault has been addressed in a preliminary way based on data collected in this study. Such sympathetic fractures are abundant in the upper cliff unit but not in the upper lithophysal unit. 14 refs., 6 figs., 1 tab.

274 (USGS-OFR--89-359) **Preliminary description of quaternary and late pliocene surficial deposits at Yucca Mountain and vicinity, Nye County, Nevada.** Hoover, D.L. Colorado Geological Survey, Denver, CO (USA). 1989. 48p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AI08-78ET44802. Order Number DE90001382. Source: NTIS, PC A03/MF A01 - GPO; OSTI; INIS; GPO Dep.

The Yucca Mountain area, in the south-central part of the Great Basin, is in the drainage basin of the Amargosa River. The mountain consists of several fault blocks of volcanic rocks that are typical of the Basin and Range province. Yucca Mountain is dissected by steep-sided valleys of consequent drainage systems that are tributary on the east side to Fortymile Wash and on the west side to an unnamed wash that drains Crater Flat. Most of the major washes near Yucca Mountain are not integrated with the Amargosa River, but have distributary channels on the piedmont above the river. Landforms in the Yucca Mountain area include rock pediments, ballenas, alluvial pediments, alluvial fans, stream terraces, and playas. Early Holocene and older alluvial fan deposits have been smoothed by pedimentation. The semiconical shape of alluvial fans is apparent at the junction of tributaries with major washes and where washes cross fault and terrace scarps. Playas are present in the eastern and southern ends of the Amargosa Desert. 39 refs., 9 figs., 1 tab.

275 (USGS/WRI–88-4189) **Triaxial-compression extraction of pore water from unsaturated tuff, Yucca Mountain, Nevada.** Yang, I.C.; Turner, A.K.; Sayre, T.M.; Montazer, P. Geological Survey, Denver, CO (USA). 1988. 68p. DOE Contract AI08-78ET44802. Order Number DE89006464. Source: NTIS, PC A04/MF A01 - OSTI; GPO Dep.

The purpose of this experiment was to design and validate methods for extracting uncontaminated pore water from nonwelded parts of this tuff. Pore water is needed for chemical analysis to help characterize the local hydrologic system. A standard Hoek-Franklin triaxial cell was modified to create a chemically inert pore-water-extraction system. Experimentation was designed to determine the optimum stress and duration of triaxial compression for efficient extraction of uncontaminated pore water. Experimental stress paths consisted of a series of increasing stress levels. Trial axial stress levels ranged from 41 to 190 megapascals with lateral confining stresses of 34 to 69 megapascals. The duration of compression at any given stress level lasted from 10 minutes to 15 hours. A total of 40 experimental extraction trials were made. Tuff samples used in these tests were collected from drill-hole core from the Paintbrush nonwelded unit at Yucca Mountain. Pore water was extracted from tuff samples that had a water content greater than 13 percent by weight. Two stress paths have been determined to be applicable for future pore-water extraction from nonwelded tuff at Yucca Mountain. The initial water content of a sample affects the selection of an appropriate period of compression. 39 refs., 55 figs.

276 (USGS/WRIR–86-4015) **Geohydrology of rocks penetrated by test well USW G-4, Yucca Mountain, Nye County, Nevada.** Lobmeyer, D.H. Geological Survey, Lakewood, CO (USA). 1986. 42p. DOE Contract AI08-78ET44802. Order Number DE88003304. Source: NTIS, PC A03/MF A01; GPO Dep.

Test well USW G-4 was drilled to a depth of 915 meters on the eastern flank of Yucca Mountain, near the southwestern part of the Nevada Test Site. The wellsite is near the site proposed for an exploratory shaft that would aid site-characterization efforts. Hydrologic tests were conducted on the saturated part of the section, which is entirely within the Miocene Crater Flat Tuff. Two pumping tests were run. Transmissivity for the entire saturated section is about 600 meters squared per day. A flow survey conducted during the second pumping test indicated that most of the water came from a zone about 10 meters thick below a depth of 892 meters. Packer-injection tests indicated that the transmissivity of the interval above 850 meters was about 7 meters squared per day. A sample collected during the first pumping test was sodium bicarbonate type water, typical of the Yucca Mountain area. Radiocarbon dating gave an apparent age of 12,160 years before present. The water level at the end of testing was 540.3 meters below land surface. 31 refs., 17 figs., 4 tabs.

277 (USGS/WRIR–89-4006) **Climatic changes inferred from analyses of lake-sediment cores, Walker Lake, Nevada.** Yang, In Che. Geological Survey, Denver, ÇO (USA). 1989. 20p. DOE Contract AI08-78ET44802. Order Number DE89010740. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Organic and inorganic fractions of sediment collected from the bottom of Walker Lake, Nevada, have been dated by carbon-14 techniques. Sedimentation rates and the organic-carbon content of the sediment were correlated with climatic change. The cold climate between 25,000 and 21,000 years ago caused little runoff, snow accumulation on the mountains, and rapid substantial glacial advances; this period of cold climate resulted in a slow sedimentation rate (0.20 millimeter per year) and in a small organic-carbon content in the sediment. Also, organic-carbon accumulation rates in the lake during this period were slow. The most recent period of slow sedimentation rate and small organic-carbon content occurred between 10,000 and 5500 years ago, indicative of low lake stage and dry climatic conditions. This period of dry climate also was evidenced by dry conditions for Lake Lahontan in Nevada and Searles Lake in California, as cited in the literature. Walker Lake filled rapidly with water between 5500 and 4500 years ago. The data published in this report was not produced under an approved Site Investigation Plan (SIP) or Study Plan (SP) and will not be used in the licensing process. 10 refs., 3 figs., 2 tabs.

278 Characterization of the subregional ground-water flow system of a potential site for a high-level nuclear waste repository. Czarnecki, J.B. Thesis (Ph. D.). 359p. Univ. of Minnesota, Minneapolis, MN (US) (1988). Source: University Microfilms, PO Box 1764, Ann Arbor, MI 48106, Order No.88-15,271.

A study was performed to characterize the subregional ground-water flow system that includes Yucca Mountain, Nevada, the potential site of a high-level nuclear-waste repository. The study consisted of three parts: (1) The development of a finite-element parameter-estimation model of ground-water flow, from which sensitivity analyses of model variables were performed; (2) the characterization of the geohydrology and evapotranspiration at Franklin Lake playa; and (3) the simulation of the ground-water flow system under conditions of increased recharge. Evapotranspiration at Franklin Lake playa was determined to be the most sensitive of the discharge boundary conditions in the model. On-site estimates of evapotranspiration at Franklin Lake playa, estimated as a residual of the energy-balance equation ranged from 0.1 to 0.3 centimeters per day throughout the year, with an annual average of 0.16 centimeters per day. These estimates were compared with evapotranspiration estimates using: (1) Empirical relations of meteorological data to estimate potential evapotranspiration; (2) temporal variations in soil-moisture content in the unsaturated zone; (3) estimates of evapotranspiration by phreatophytes in climatically similar Owens and Santa Ana Valleys; (4) temperature profiles for the saturated zone; (5) a saturated-zone vertical gradients; and (6) a one-dimensional finite-difference model of vertical ground-water flow from the water table to land surface. Simulations of increased recharge showed a rise in water-table altitude of about 130 meters near the primary repository area at Yucca Mountain under conditions involving a 100-percent increase in precipitation compared to modern-day conditions. Despite the water-table rise, no flooding of the potential repository would occur at its current proposed location.

RELATED INFORMATION

279 (BMI/ONWI/C–28) **Salt repository project close-out status report.** Battelle Memorial Inst., Columbus, OH (USA). Office of Nuclear Waste Isolation. Jun 1988. 285p. DOE Contract AC02-87CH10290. Source: OSTI, PO Box 62, Oak Ridge, TN 37831.

This report provides an overview of the scope and status of the US Department of Energy (DOE's) Salt Repository Project (SRP) at the time when the project was terminated by the Nuclear Waste Policy Amendments Act of 1987. The report reviews the 10-year program of siting a geologic repository for high-level nuclear waste in rock salt formations. Its purpose is to aid persons interested in the information developed during the course of this effort. Each area is briefly described and the major items of information are noted. This report, the three salt Environmental Assessments, and the Site Characterization Plan are the suggested starting points for any search of the literature and information developed by the program participants. Prior to termination, DOE was preparing to characterize three candidate sites for the first mined geologic repository for the permanent disposal of high-level nuclear waste. The sites were in Nevada, a site in volcanic tuff; Texas, a site in bedded salt (halite); and Washington, a site in basalt. These sites, identified by the screening process described in Chapter 3, were selected from the nine potentially acceptable sites shown on Figure I-1. These sites were identified in accordance with provisions of the Nuclear Waste Policy Act of 1982. 196 refs., 21 figs., 11 tabs.

280 (CONF-881054–Vol.2, pp. 435-446) **The diffusion of $^{14}CO_2$ through engineered barrier media.** Bauer, L.R. (Purdue Univ., Lafayette, IN (USA)); Landolt, R.R. Martin Marietta Energy Systems, Inc., Oak Ridge, TN (USA); Analysas Corp., Oak Ridge, TN (USA). 1988. From 4. annual DOE model conference; Oak Ridge, TN (USA); 3-7 Oct 1988. In *1988 DOE model conference proceedings. Volume 2.* 292p. Order Number DE89014701. Source: NTIS, PC A13/MF A01.

The diffusion of $^{14}CO_2$ through crushed tuff, bentonite and a crushed tuff/bentonite mixture was measured for two diffusion lengths. The ability of $^{14}CO_2$ to penetrate a microsilica-containing cement proposed for repository use was also examined. The specimens were subjected to uniaxially-applied compressive loads prior to the diffusion tests to simulate the onset of environmentally-induced microcracks. The results suggest that the presence of a tuff- or bentonite-based backfill would not significantly affect $^{14}CO_2$ release rates from a repository. Conversely, $^{14}CO_2$ diffusion through simulated cement seals can apparently only occur after severe physical damage has been induced. These results may have implications for the ability of a repository to comply with the applicable regulatory release limits for C-14.

281 (DOE/CH/10290–T1) **Interface management for the Yucca Mountain Project.** Battelle Memorial Inst., Columbus, OH (USA). Project Management Div. Dec 1988. 106p. DOE Contract AC02-87CH10290. Order Number DE89005005. Source: NTIS, PC A06/MF A01 - OSTI; GPO Dep.

The subject of this report is selection of that portion of physical and informational interfaces that need to be controlled on the Yucca Mountain Project (YMP). Physical interfaces are interactions between physical elements of the mined geologic disposal system; for example, the repository shafts will interface with the shafts in the Exploratory Shaft Facility (ESF), because the ESF shafts will eventually be absorbed into the repository as additional repository shafts. Informational interfaces are interactions involving an exchange of information between organizations working on the mined geologic disposal system; for example, the in situ testing contractor will interact with the site performance assessment contractor and will supply information regarding host rock behavior. This report describes the physical system interfaces that can be identified from analysis of a physical system structure. A discussion of informational interfaces can be found elsewhere. 30 refs., 8 figs., 3 tabs.

282 (DOE/ET/44802–T22) **Aeromagnetic map of Nevada: Caliente sheet.** Saltus, R.W.; Snyder, D.B. Nevada Bureau of Mines and Geology, Reno, NV (USA); Nevada Univ., Reno, NV (USA). Mackay School of Mines; Nevada Univ., Reno, NV (USA). 1986. 13p. DOE Contract AI08-78ET44802. Order Number DE88008625. Source: NTIS, PC A03.

Two maps are presented, one at 1:250,000 displaying the residual magnetic field for four separate surveys, and one at 1:1,000,000 adjusting the datums to a common elevation and merging the surveys. (ACR).

283 (DOE/IG–0253) **Integration of defense waste into the Civilian Repository Program.** Department of Energy, Washington, DC (USA). Office of Inspector General. 24 Mar 1988. 14p. Source: OSTI, PO Box 62, Oak Ridge, TN 37831.

Report to The Secretary.

The purpose of this audit was to determine whether the fee calculation method proposed by Waste Management would result in an accurate and fair allocation of costs to both civilian and defense owners of nuclear waste. We reviewed Waste Management's proposed cost allocation plans to be used in calculating fees for defense waste disposal. We also evaluated Waste Management's actions toward developing a defense waste fee payment schedule. Our examination was made in accordance with generally accepted government auditing standards which included tests of internal controls and compliance with laws and regulations to the extent necessary to satisfy the scope of the audit.

284 (DOE/NV/10322–33) **Selected stratigraphic contacts for drill holes in LANL use areas of Yucca Flat, NTS.** Drellack, S.L. Jr. Fenix and Scisson, Inc., Mercury, NV (USA). Jul 1988. 55p. DOE Contract AC08-84NV10322. Order Number DE89003805. Source: NTIS, PC A04/MF A01 - OSTI; GPO Dep.

This report is a compilation of selected stratigraphic contacts in drill holes of Yucca Flat, Nevada Test Site (NTS), used by the Los Alamos National Laboratory (LANL). This is the product of an ongoing effort to establish and maintain the most up-to-date database of formation tops in LANL use areas of Yucca Flat. Figure 1 is an index map showing areas of the NTS covered in this report. A drill hole planning map showing hole locations is in the rear pocket. Data presented for each drill hole include drill hole name; year drill hole completed; ground level elevations, above mean sea level (MSL), at drill hole site; total depth (TD) of drill hole at completion of drilling; and depth below surface to selected stratigraphic contacts. The geologic data presented here was generated by numerous individuals. Published references, from which most of these data originated, are listed on page 54 of this report. Information regarding other drill hole statistics can be found in the NTS Drilling and Mining Summary ("The Redbook") compiled by the Technical Support Division of Fenix and Scisson, Inc. We continue the "revised" stratigraphic nomenclature for the bedded tuffs between the Rainier Mesa Member of the Timber Mountain Tuff and the Grouse Canyon Member of the Belted Range Tuff (formerly the "Paintbrush Tuff"). Confidence in these stratigraphic assignments for these bedded tuffs is consolidating. 13 refs., 4 figs., 2 tabs.

285 (DOE/NV/10322–34) **Shaft drilling at the Nevada Test Site.** Schwichtenberg, D.R. Fenix and Scisson, Inc., Mercury, NV (USA). Oct 1988. 39p. DOE Contract AC08-84NV10322. (CONF-8810214–1: Shaft drilling short course, Golden, CO, US, October 12, 1988). Order Number DE89002287. Source: NTIS, PC A03/MF A01.

Numerous areas of shaft drilling equipment, practices, and ideas are discussed, based primarily on drilling operations as carried on under the general management of the US Department of Energy at the Nevada Test Site (NTS). The organizational structure for drilling work at the Test Site is presented. The geological formations, in general terms, of those areas of the Test Site in which shafts are drilled on a 24-hour-per-day basis, are examined. Some of the history of shaft drilling development at the Test Site is reviewed, and current shaft drilling machinery and techniques are addressed. Several current ideas for improvements in shaft drilling are presented. Some of these innovations will likely produce only a few percentage points increase in shaft drilling efficiency, while one of them could eventually prove to be a quantum jump in shaft drilling technology, especially for those engaged in drilling shafts in the harder rock formations. 19 figs.

286 (DOE/NV/10327–36) **Cross-index to DOE-prescribed occupational safety codes and standards.** Reynolds Electrical and Engineering Co., Inc., Las Vegas, NV (USA). Occupational Safety. Mar 1988. 661p. DOE Contract AC08-84NV10327. Order Number DE88010553. Source: NTIS, PC A99/MF A01.

This Cross-Index volume is the 1986 compilation of detailed information from more than four hundred and seventy DOE-prescribed or OSHA-referenced occupational safety codes, transportation safety codes, and fire protection codes and standards. The compilation of this material was conceived and initiated in 1973 by Reynolds Electrical & Engineering Company's (REECo) Occupational Safety organization, and is revised yearly to provide information from current codes.

287 (DOE/NV/10327–T3) **A contribution of groundwater to Mojave Desert shrub transpiration.** Hunter, R.B. California Univ., Mercury, NV (USA). Lab. for Biomedical and Environmental Sciences. 1988. 8p. DOE Contract AC08-84NV10327. Order Number DE88017320. Source: NTIS, PC A02/MF A01.

Soil moisture was measured to 1-m depths in the northern Mojave Desert on two plots, one of which was denuded of shrubs. The pattern of wetting-drying near the surface and below the depth wet by rainfall suggested roughly 2 mm per month of transpired water was supplied by percolation upward from below the root zone. This deep moisture built up during fall and winter and depleted in spring and summer, which correlates well with local shrub phenology. 10 refs., 3 figs.

288 (DOE/NV/10384–17) **Review of soil moisture flux studies at the Nevada Test Site, Nye County, Nevada.** Tyler, S.W. Nevada Univ., Las Vegas (USA). Water Resources Center. Apr 1987. 56p. DOE Contract AC08-85NV10384. Order Number DE87014485. Source: NTIS, PC A04/MF A01; GPO Dep.

This report documents almost 30 years of research on soil moisture movement and recharge at the Department of Energy, Nevada Test Site. Although data is scarce, three distinct topographic zones are represented: alluvial valleys, inundated terrains, and upland terrain. Recharge in alluvial valleys was found to be very small or negligible. Ponded areas such as playas and subsidence craters showed significant amounts of recharge. Data in the upland terrains is very scarce but one area, Rainier Mesa, shows active recharge of up to three percent of the annual average precipitation in fractured volcanic tuff. The report summarizes the results.

289 (DOE/NV/10384–18) **Effects of the length of record on estimates of annual and seasonal precipitation at the Nevada Test Site, Nevada.** French, R.H. Nevada Univ., Las Vegas (USA). Desert Research Inst. Jun 1987. 50p. DOE Contract AC08-85NV10384. Order Number DE88005454. Source: NTIS, PC A03/MF A01; GPO Dep.

The goal was to examine, in some detail, the effect of the period of record available for analysis on estimates of annual and seasonal precipitation, examine the effect of changing estimates of annual precipitation on estimates of regional groundwater recharge, and to discuss the possibility of a period of severe erosion occurring on the Nevada Test Site in the near future. The conclusions were resonably large changes in the calculated annual and seasonal precipitation must be expected as the period of record available for analysis lengthens; there appears to be a positive trend in the calculated annual precipitation at six of the eleven precipitation stations examined in this study; and in the case of annual precipitation, the variability of precipitation has increased at some stations and has decreased at others as the period of record has lengthened. In the case of seasonal precipitation, the variability of the precipitation has increased at ten of the eleven stations for the summer season and decreased at all stations for the winter season.

290 (DOE/NV/10461–T1-Vol.1) **Environmental program planning for the proposed high-level nuclear waste repository at Yucca Mountain, Nevada: Volume 1.** Nevada Nuclear Waste Project Office, Carson City, NV (USA). Aug 1987. 135p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract FG08-85NV10461. (NWPO-TR-001-87). Order Number DE89012958. Source: NTIS, PC A07/MF A01 - OSTI; GPO Dep.

Environmental protection during the course of siting and constructing a repository is mandated by NWPA in conjunction with various phases of repository siting and development. However, DOE has issued no comprehensive, integrated plan for environmental protection. Consequently, it is unclear how DOE will accomplish environmental assessment, monitoring, impact mitigation, and site reclamation. DOE should, therefore, defer further implementation of its current characterization program until a comprehensive environmental protection plan is available. To fulfill its oversight responsibilities the State of Nevada has proposed a comprehensive environmental program for the Yucca Mountain site that includes immediately undertaking studies to establish a 12-month baseline of environmental information at the site; adopting the DOE Site Characterization Plan (SCP) and the engineering design plans it will contain as the basis for defining the impact potential of site characterization activities; using the environmental baseline and the SCP to evaluate the efficacy of the preliminary impact analyses reported by DOE in the EA; using the SCP as the basis for discussions with federal, state, and local regulatory authorities to decide which environmental requirements apply and how they can be complied with; using the SCP, the EA impact review, and the compliance requirements to determine the scope of reclamation measures needed; and developing environmental monitoring and impact mitigation plans based on the EA impact review, compliance requirements, and anticipated reclamation needs.

291 (DOE/NV/10461–T1-Vol.2) **Physics and chemistry of the transition of glass to authigenic minerals: State of Nevada, agency for nuclear projects/nuclear waste project office.** Morgenstein, M.E. Nevada Nuclear Waste Project Office, Carson City, NV (USA). Nov 1984. 72p. DOE Contract FG08-85NV10461. (NWPO-TR–002-87). Order Number DE89011489. Source: NTIS, PC A04 - OSTI.

The purpose of this paper is to provide a basic review of the topic of volcanic-glass hydration and the diagenetic formation of authigenic minerals from the hydrated-glass products. The Yucca Mountain Draft Environmental Assessment (DEA) of December 1984 indicates that: most of the available glass in the proximity of the repository horizon has been already hydrated and authigenic minerals which could form have already done so, zeolites could form from as yet unreacted glass during transport of water exiting from the repository, and the zeolites and other authigenic minerals provide sorptive barriers to radionuclide migration. This document surveys the available literature and concludes that the topic appears more complex than as it is treated in the DEA. It is concluded that an insufficient quantity of raw data exists. This paucity of information does not allow the determination of which authigenic minerals (if any) may form from the alteration of volcanic glass in Yucca Mountain; and consequently, radionuclide retardation leading from this reaction process is undeterminable. Appendix A and B contain a critical review of this publication. 29 refs., 6 tabs.

292 (DOE/NV/10461–T1-Vol.3) **Two-dimensional steady-state model of ground-water flow, Nevada test site and vicinity Nevada-California: State of Nevada, agency for nuclear projects/nuclear waste project office.** Waddell, R.K. Nevada Nuclear Waste Project Office, Carson City, NV (USA). Oct 1986. 12p. DOE Contract FG08-85NV10461. (NWPO-TR–003-87). Order Number DE89011488. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

A two-dimensional, steady-state, finite-element model of the ground-water flow system of the Nevada Test Site and vicinity in Nye and Clark Counties, Nevada, and Inyo County, California, was developed using parameter-estimation techniques. The model simulates flow in an area underlain by clastic and carbonate rocks of Precambrian and Paleozoic age, and volcanic rocks and alluvial deposits of Tertiary and Quaternary age. Normal Basin-and-Range faulting and both right- and left-lateral strike-slip faults have caused the juxtaposition of rocks of differing hydraulic conductivities. Characteristics of the flow system are principally determined by locations of low-hydraulic-conductivity rocks (barriers); by amounts of recharge originating in the Spring Mountains, Pahranaget, Timpahute, and Sheep Ranges, and in Pahute Mesa; and by amount in flow into the study area from Gold Flat and Kawich Valley. Discharge areas (Ash Meadows, Oasis Valley, Alkali Flat, and Furnace Creek Ranch) are upgradient from barriers. Analyses of sensitivity of hydraulic head with respect to model-parameter variations indicate that the flux terms having the greatest impact on model output are recharge on Pahute Mesa, underflow from Cold Flat and Kawich Valley, and discharge at Ash Meadows. The most important transmissivity terms are those for rocks underlying the Amargosa Desert (exclusive of Amargosa Flat area), the Eleana Formation along the west side of Yucca Flat, and the Precambrian and Cambrian clastic rocks underlying the Groom Range.

293 (DOE/NV/10461–T1-Vol.4) **Review of modeling efforts associated with Yucca Mountain, Nevada: State of Nevada, agency for nuclear projects/nuclear waste project office.** Nevada Nuclear Waste Project Office, Carson City, NV (USA). Sep 1986. 24p. DOE Contract FG08-85NV10461. (NWPO-TR–004-87). Order Number DE89011487. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Detailed comments are presented on five modeling investigations related to the NNWSI at Yucca Mountain, Nevada. In general, the quality assurance/quality control (QA/QC) procedures of the modeling efforts are considered to be poor. The reports reviewed indicate model documentation and verification/validation is lacking. Many of the technical assumptions underpinning the theory of the models are not supported by observed field conditions and may be inappropriate for application to the Yucca Mountain flow system. Much of the data is assumed and not field measured. Many of the problems simulated have insufficient information provided to allow reproduction of the computed results. Finally, the accuracy of some of the results is questionable, and lack confidence because good QA/QC procedures, such as mass balance calculations, are not performed or reported with the computational results. The review of these five reports underscores the apparent lack of coordination between field investigations and the overall modeling efforts which will be used to support the licensing proceedings via travel time calculations. 8 refs.

294 (DOE/NV/10461–T1-Vol.5) **Characterization of infiltration into fractured, welded tuff using small borehole data collection technique: State of Nevada, agency for nuclear projects/nuclear waste project office.** Linderfelt, W. Nevada Nuclear Waste Project Office, Carson City, NV (USA). Oct 1986. 34p. DOE Contract FG08-85NV10461. (NWPO-TR–005-87). Order Number DE89011486. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Knowledge of all aspects of the hydrologic cycle is required for consideration of Yucca mountain as a high level radioactive waste site. Surface processes are especially important in controlling the quantity and quality of water infiltrating into the unsaturated zone, available for recharging the aquifer. The investigation reported herein uses small bore drill holes to access the near surface fractured rock environment. The study was conducted in northern Nevada at the north end of the Pah Rah range, east of Pyramid Lake as an analog to Yucca Mountain. The results of this study will be used to better understand the chemistry and flow of the near surface flow regime of Yucca Mountain and to evaluate proposed techniques for use in future investigations. 7 refs., 6 figs., 3 tabs.

295 (DOE/NV/10461–T1-Vol.6) **Chemistry of groundwater in tuffaceous rocks, central Nevada: State of Nevada, agency for nuclear projects/nuclear waste project office.** Baker, S.L.; Jacobson, R.L. Nevada Nuclear Waste Project Office, Carson City, NV (USA). Jan 1987. 117p. DOE Contract FG08-85NV10461. (NWPO-TR–006-87). Order Number DE89011485. Source: NTIS, PC A06/MF A01 - OSTI; GPO Dep.

A flow path chemical model in tuffaceous rocks was developed using statistical, graphical, and computer methods. Forty-nine springs which discharged from glassy, devitrified, and variably altered silicic rocks represent early stage recharge chemistry. Chemical analyses from Pahute Mesa and Yucca Mountain wells penetrating similar rock type and representing further chemically evolved waters, were compared. Common traits included pH, SO_4, HCO_3, SiO_2, TDS, and mineral saturation and stability. The trace elements (Fe, Mn, F, Li, and Sr), Cl, and cation concentrations, and temperature distinguished the two end member groundwaters. The difference in cation proportion between the Ca-HCO_3 type recharge chemistry and the Na-HCO_3 type well chemistry may reflect a decrease in divalent ions upon secondary mineral formation and/or ion exchange with clay and zeolite minerals (chiefly smectite and clinoptilolite).

296 (DOE/NV/10461–T1-Vol.7) **Inventory of numerical codes available for high-level nuclear waste repository performance modeling at Yucca Mountain, Nevada.** Panahi, Z. Nevada Nuclear Waste Project Office, Carson City, NV (USA); Nevada Univ., Reno, NV (USA). Water Resources Center. Jun 1987. 152p. DOE Contract FG08-85NV10461. (NWPO-TR–007-87). Order Number DE89011490. Source: NTIS, PC A08/MF A01 - OSTI; GPO Dep.

The purpose of this study is to generally characterize the numerical codes and to broadly identify background information on current modeling capabilities as applied to nuclear waste repository sites, particularly to Yucca Mountain geologic formation. No attempt was made to establish in-depth evaluation of each code in terms of reliability and utility for the environment at hand. This report may be updated periodically as new codes are developed by DOE contractors or others, specifically to address the recognized complexities of the unsaturated, fractured tuffs. 204 refs.

297 (DOE/NV/10461–T1-Vol.8) **A role in environmental compliance for the state of Nevada during site characterization of the proposed high-level nuclear waste repository site at Yucca Mountain, Nevada.** Nevada Nuclear Waste Project Office, Carson City, NV (USA). Jan 1988. 83p. DOE Contract FG08-85NV10461. (NWPO-TR–008-88). Order Number DE89011493. Source: NTIS, PC A05/MF A01 - OSTI; GPO Dep.

The present report results from an analysis of the regulatory requirements in light of draft plans for site characterization and environmental compliance prepared by DOE and an evaluation of the past record of the Agency in matters of environmental protection. A perspective thereby was gained on how regulatory compliance is likely to be carried out by DOE for the Yucca Mountain project and the corresponding oversight role for the State of Nevada can provide oversight. 55 refs.

298 (DOE/NV/10461–T2-Vol.1) **Yucca Mountain Project: A summary of technical support activities, January 1987–June 1988: Volume 1.** Nevada Nuclear Waste Project Office, Carson City, NV (USA); Mifflin and Associates, Inc., Las Vegas, NV (USA). May 1989. 273p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract FG08-85NV10461. Order Number DE90004711. Source: NTIS, PC A12/MF A01; OSTI; INIS.

This report is a summary of the technical support activities of Mifflin & Associates, Inc., during the 18-month period beginning 01 January 1987 and ending on 30 June 1988. It covers the following topics: Vadose zone drilling site selection, permits and quality assurance (QA) procedures; climate change; geochemistry, mineralogy; disturbed zone; hydrogeology; and review of technical documents. The report is organized by generally discussing each topic from the following perspectives: issue(s), objective(s) of activity, finding(s), interpretation of finding(s), additional work needed, recommended program, and existing program.

299 (DOE/NV/10461–T2-Vol.2) **Yucca Mountain Project: A summary of technical support activities, January 1987–June 1988: Volume 2.** Nevada Nuclear Waste Project Office, Carson City, NV (USA); Mifflin and Associates, Inc., Las Vegas, NV (USA). May 1989. 283p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract FG08-85NV10461. Order Number DE90004736. Source: NTIS, PC A13/MF A01; OSTI; INIS.

The activities in the Geochemistry and Mineralogy section of our program support three independent and interrelated subject areas which are: Geochemical retardation/transport of radionuclides to the accessible environment, site-specific mineralogy and geophysical studies to establish the hydrogeology of the vadose zone, and past climate and related genesis of authigenic desert carbonates and silicates.

300 (DOE/NV/10461–T3) **Retirement migration and military retirement.** Nevada Nuclear Waste Project Office, Carson City, NV (USA). Jun 1988. 131p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract FG08-85NV10461. Order Number DE90004712. Source: NTIS, PC A07/MF A01; OSTI; INIS.

This report addresses questions relevant to a socioeconomic assessment system for southern Nevada. They point to an understanding of the magnitude of impacts which may occur if the Yucca Mountain Project were to affect the decision-making process which leads these groups to migrate to southern Nevada. This is an important but somewhat elusive topic lacking in standard data sources. However, the topic may be addressed and analyzed systematically. This report presents the results of efforts to develop a data base and begin development of a model to address the migration, income and expenditure dimensions of these groups. 1 fig., 62 tabs.

301 (DOE/NV/10461–T4) **Characteristics of the Las Vegas/Clark County visitor economy.** Nevada Nuclear Waste Project Office, Carson City, NV (USA); Planning Information Corp., Denver, CO (USA). Jun 1988. 135p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract FG08-85NV10461. Order Number DE90004713. Source: NTIS, PC A07/MF A01; OSTI; INIS.

The purpose of this report is to present the results of a review of the Clark County visitor economy and the Clark

County visitor. The review, undertaken in support of NWPO's two objectives mentioned above, addressed a number of topics including performance of the Clark County visitor economy as a generator of employment, earnings and tax base; importance of the Clark County visitor economy to the Nevada economy as a whole; elements of the Clark County visitor economy outside the Las Vegas strip and downtown areas; current trends in the Clark County visitor industry; and indirect economic effects of Clark County casino/hotel purchases.

302 (DOE/NV/10461–T5) **Current target industry analysis: Las Vegas Metropolitan Area.** Boyle, M.R. (Growth Strategies Organization, Reston, VA (USA)). Nevada Nuclear Waste Project Office, Carson City, NV (USA); Growth Strategies Organization, Reston, VA (USA). Jun 1988. 15p. Sponsored by U.S. DOE Defense Programs. DOE Contract FG08-85NV10461. Order Number DE90004714. Source: NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

This is the second of three reports dealing with the Las Vegas MSA's economic development potential in support of an overall effort to prepare an environmental impact statement for the proposed underground nuclear waste storage facility at Yucca Mountain. The first report provides an assessment of the MSA current business climate for economic growth. This second report draws on that business climate assessment to evaluate the Las Vegas MSA's competitive posture in pursuing business investment in the "primary" sector of the economy – businesses which sell their products or services outside the local marketplace and bring new money back into the area and businesses serving local customers who would otherwise import these products or services from suppliers outside the area. GSO has developed an analytic tool which attempts to model the decision process used by businesses in selecting locations for new or expanded business investment. This computer based model reflects variations in site selection decision making among industries and ownership and management types. The underlying premise of the GSO locational compatibility index (LCI) model is that locational decisions are based more on a process of elimination that on a process of selection. There are many factors, some essential and some desirable, which influence any site selection decision. Multivariate comparative analyses narrow the geographic field to a region, then a group of states, then a state, then a sub-state region, then a community and finally to a specific site. Sometimes these analyses are rational and quantitative. More often, they are at least partially random and intuitive. 2 tabs.

303 (DOE/NV/10461–T6) **Business profile of metropolitan Las Vegas.** Boyle, M.R. (Growth Strategies Organization, Reston, VA (USA)). Nevada Nuclear Waste Project Office, Carson City, NV (USA); Growth Strategies Organization, Reston, VA (USA). Jun 1988. 46p. Sponsored by U.S. DOE Defense Programs. DOE Contract FG08-85NV10461. Order Number DE90004715. Source: NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

This first report describes the present makeup of the Las Vegas metropolitan statistical area (MSA) economy and analyzes the climate for business expansion. The second report contains an assessment of the competitiveness of the area as a location for new or expanded facilities investment by companies in approximately 600 business groups. The third report projects Las Vegas' competitiveness at the start of the next century in the absence of a nuclear waste storage facility and then evaluates the potential impacts of siting that facility near Las Vegas on its ability to attract and retain business investment. The primary purpose of these reports is to contribute to the overall assessment of the environmental impact of the US Department of Energy's proposed action to build and operate an underground nuclear waste storage facility at Yucca Mountain. The first two reports also serve a second purpose – they can be used by economic development organizations in the Las Vegas metropolitan area in their ongoing efforts to attract new business investment. Information contained in the business climate analysis found in this first report can be incorporated into marketing materials. The competitiveness assessment contained in the second report can be used by these organizations in identifying targets they wish to pursue.

304 (DOE/NV/10461–T8) **Nevada local government revenues analysis.** Nevada Nuclear Waste Project Office, Carson City, NV (USA); Planning Information Corp., Denver, CO (USA). Jun 1988. 111p. Sponsored by U.S. DOE Defense Programs. DOE Contract FG08-85NV10461. Order Number DE90004717. Source: NTIS, PC A06/MF A01; OSTI; INIS; GPO Dep.

This report analyzes the major sources of revenue for Nevada local government for purposes of estimating the impacts associated with the siting of a nuclear waste repository at Yucca Mountain. Each major revenue source is analyzed separately to identify relationships between the economic or demographic base, the revenue base and the revenues generated. Trends and changes in the rates and/or base are highlighted. A model is developed for each component to allow impact estimation. This report is a companion to the report Nevada State Revenues Analysis.

305 (DOE/NV/10461–T9) **The effects of human reliability in the transportation of spent nuclear fuel.** Tuler, S. (Clark Univ., Worcester, MA (USA). Center for Technology, Environment, and Development); Kasperson, R.E.; Ratick, S. Nevada Nuclear Waste Project Office, Carson City, NV (USA); Clark Univ., Worcester, MA (USA). Center for Technology, Environment, and Development. Jun 1988. 247p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract FG08-85NV10461. Order Number DE90004718. Source: NTIS, PC A11/MF A01; OSTI; INIS.

Despite the evident importance of the subject, no comprehensive analysis of human factors in spent fuel transportation has occurred. A reason for this may be the assumption that potential human contributions to spent fuel transportation risks are negligible [Nuclear Regulatory Commission 1980]. There are several characteristics of spent fuel and other high-level radioactive waste transport, however, that suggest that human actions may indeed contribute significantly to both actual and perceived risk of the system. 52 refs.

306 (DOE/NV/10461–T10) **Risk management and organizational systems for high-level radioactive waste disposal: Issues and priorities.** Emel, J. (Clark Univ., Worcester, MA (USA). Center for Technology, Environment, and Development); Cook, B.; Kasperson, R.; Brown, H.; Guble, R.; Himmelberger, J.; Tuller, S. Nevada Nuclear Waste Project Office, Carson City, NV (USA); Clark Univ., Worcester, MA (USA). Center for Technology, Environment, and Development. Sep 1988. 87p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract FG08-85NV10461. Order Number DE90004719. Source: NTIS, PC A05/MF A01; OSTI; INIS.

The discussion to follow explores the nature of the high-level radioactive waste disposal tasks and their implications for the design and organizational structure of effective risk management systems. We organize this discussion in a set of interrelated tasks that draw upon both relevant theory and accumulated experience. Specifically these tasks are to assess the management implications of the high levels of technical and social uncertainty that characterize the technology and mission; to identify the elements of organizational theory that bear upon risk management system design; to explore these theoretical issues in the context of two hypothetical risk scenarios associated with radioactive waste disposal; to consider the appropriate role of engineered and geological barriers; to examine briefly issues implicit in DOE's past waste management performance, with special attention to the Hanford facility; and to suggest findings and recommendations that require further attention. 74 refs.

307 (DOE/NV/10461–T11) **Distributional equity problems at the proposed Yucca Mountain facility.** Kasperson, R.E. (Clark Univ., Worcester, MA (USA). Center for Technology, Environment, and Development); Abdollahzadeh, S. Nevada Nuclear Waste Project Office, Carson City, NV (USA); Clark Univ., Worcester, MA (USA). Center for Technology, Environment, and Development. Jul 1988. 26p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract FG08-85NV10461. Order Number DE90004720. Source: NTIS, PC A03/MF A01; OSTI; INIS.

This paper addresses one quite specific part of this broad range of issues – the distribution of impacts to the state of Nevada and to the nation likely to be associated with the proposed Yucca Mountain repository. As such, it is one of four needed analyses of the overall equity problems and needs to be read in conjunction with our proposed overall framework for equity studies. The objective of this report is to consider how an analysis might be made of the distribution of projected outcomes between the state and nation. At the same time, it needs to be clear that no attempt will be made actually to implement the analysis that is proposed. What follows is a conceptual statement that identifies the analytical issues and pro poses an approach for overcoming them. Significantly, it must also be noted that this report will not address procedural equity issues between the state and nation for this is the subject of a separate analysis. 14 refs., 8 figs., 3 tabs.

308 (DOE/NV/10461–T12) **Potential retrieval of radioactive wastes at the proposed Yucca Mountain repository: A preliminary review of risk issues.** Goble, R. (Clark Univ., Worcester, MA (USA). Center for Technology, Environment, and Development); Golding, D.; Kasperson, R.E. Nevada Nuclear Waste Project Office, Carson City, NV (USA); Clark Univ., Worcester, MA (USA). Center for Technology, Environment, and Development. Jun 1988. 44p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract FG08-85NV10461. Order Number DE90004721. Source: NTIS, PC A03/MF A01; OSTI; INIS.

The absence of risk-based criteria for retrieval planning does not mean, of course, that DOE has been unconcerned about the risks of a retrieval operation or that pertinent information has not been generated. On the other hand, it is worrisome that there has not yet been a systematic identification and assessment of the potential risks. The goals of this preliminary review are: to explore the nature of the risks associated with a retrieval operation; to assess the adequacy of DOE's evaluation of these risks; to identify unresolved issues requiring further attention, and to examine implications for the state of Nevada.

309 (DOE/NV/10461–T13) **Postclosure risks at the proposed Yucca Mountain repository: A review of methodological and technical issues.** Emel, J. (Clark Univ., Worcester, MA (USA). Center for Technology, Environment, and Development); Kasperson, R.E.; Goble, R.; Renn, O. Nevada Nuclear Waste Project Office, Carson City, NV (USA); Clark Univ., Worcester, MA (USA). Center for Technology, Environment, and Development. Jun 1988. 55p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract FG08-85NV10461. Order Number DE90004722. Source: NTIS, PC A04/MF A01; OSTI; INIS.

Accordingly, the first section of the report provides an overview and critique of the risk analysis methodology proposed by the US Department of Energy (DOE 1988) in the Draft Site Characterization Plan (SCP) and related documents. The second section addresses specific technical problems associated with the site. Each section considers the significance or implications of the issues for the successful long-term isolation of radioactive wastes from the biosphere. We conclude with overall observations on the adequacy of current understandings and approaches in the waste disposal program and implications for the State of Nevada.

310 (DOE/NV/10461–T14) **The accident at Gorleben: A case study of risk communication and risk amplification in the Federal Republic of Germany.** Peters, H.P. (Clark Univ., Worcester, MA (USA). Center for Technology, Environment, and Development); Hennen, L. Nevada Nuclear Waste Project Office, Carson City, NV (USA); Clark Univ., Worcester, MA (USA). Center for Technology, Environment, and Development. Jul 1988. 59p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract FG08-85NV10461. Order Number DE90004723. Source: NTIS, PC A04/MF A01; OSTI; INIS.

On May 12, 1987 an accident happened in the "pilot mine" at Gorleben in the Federal Republic of Germany where the feasibility of a repository or high-radioactive nuclear waste is currently being investigated. A miner was killed during that accident and two others were severely injured. Although this accident happened during conventional mining work and had nothing to do with radioactive waste, this event received much public attention and news coverage and had a strong impact on the political debate on the Gorleben project of a repository mine for radioactive waste and even on the nuclear power controversy in general. This study does not aim to evaluate the accident that happened in the Gorleben pilot mine from a geological point of view nor does it aim to evaluate the West German waste disposal concept. All information given in chapter 2 on these aspects should be considered as background information, useful in understanding the subject of this case study: the risk communication concerning the Gorleben project in general and the accident in the shaft in particular.

311 (DOE/NV/10461–T15) **New Mexico Waste Isolation Pilot Project (WIPP): An historical overview.** Cummings, R.G. (New Mexico Univ., Albuquerque, NM (USA)). Nevada Nuclear Waste Project Office, Carson City, NV (USA); New Mexico Univ., Albuquerque, NM (USA). Jun 1988. 46p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract FG08-85NV10461. Order Number DE90004724. Source: NTIS, PC A03/MF A01; OSTI; INIS.

Given the WIPP's position as the nation's first nuclear waste repository many aspects of its evolution and development may be of interest. For the purpose of this study attention is to be focused on the subset of these aspects which relate to the socioeconomic impacts–anticipated and realized–of the WIPP. In these regards, attention is first given, in section II, to some of the major technical issues, and issues related to public confidence in the DOE, which have been raised to date during the site characterization and construction phases of the WIPP. In section III, our focus is on the patterns of public reactions to the WIPP project, and the successes/failures of the state and the DOE in dealing with these reactions. Section IV compares the promise of economic benefits projected for the WIPP with WIPP's performance in generating such benefits.

312 (DOE/NV/10461–T16) **The US Department of Energy's attempt to site the Monitored Retrievable Storage Facility (MRS) in Tennessee, 1985–1987.** Fitzgerald, M.R. (Tennessee Univ., Knoxville, TN (USA). Energy, Environment and Resources Center); McCabe, A.S. Nevada Nuclear Waste Project Office, Carson City, NV (USA); Tennessee Univ., Knoxville, TN (USA). Energy, Environment and Resources Center. May 1988. 80p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract FG08-85NV10461. Order Number DE90004725. Source: NTIS, PC A05/MF A01; OSTI; INIS.

This report is concerned with how America's public sector is handling the challenge of implementing a technical, environmental policy, that of managing the nation's high-level nuclear waste, as reflected in the attempt of the US Department of Energy (DOE) to site a Monitored Retrievable Storage Facility (MRS) for high-level radioactive waste in Tennessee. It has been observed that "radioactive wastes present some of societies' most complex and vexing choices." There is deep and abiding disagreement about almost every aspect of radioactive waste management (RWM).

313 (DOE/NV/10461–T17) **Goiania incident case study.** Petterson, J.S. (Impact Assessment, Inc., La Jolla, CA (USA)). Nevada Nuclear Waste Project Office, Carson City, NV (USA); Impact Assessment, Inc., La Jolla, CA (USA). Jun 1988. 82p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract FG08-85NV10461. Order Number DE90004726. Source: NTIS, PC A05/MF A01; OSTI; INIS.

The reasons for wanting to document this case study and present the findings are simple. According to USDOE technical risk assessments (and our own initial work on the Hanford socioeconomic study), the likelihood of a major accident involving exposure to radioactive materials in the process of site characterization, construction, operation, and closure of a high-level waste repository is extremely remote. Most would agree, however, that there is a relatively high probability that a minor accident involving radiological contamination will occur sometime during the lifetime of the repository – for example, during transport, at an MRS site or at the permanent site itself during repacking and deposition. Thus, one of the major concerns of the Yucca Mountain Socioeconomic Study is the potential impact of a relatively minor radiation-related accident. A large number of potential impact of a relatively minor radiation-related accident. A large number of potential accident scenarios have been under consideration (such as a transportation or other surface accident which results in a significant decline in tourism, the number of conventions, or the selection of Nevada as a retirement residence). The results of the work in Goiania make it clear, however, that such a significant shift in established social patterns and trends is not likely to occur as a direct outcome of a single nuclear-related accident (even, perhaps, a relatively major one), but rather, are likely to occur as a result of the enduring social interpretations of such an accident – that is, as a result of the process of understanding, communicating, and socially sustaining a particular set of associations with respect to the initial incident.

314 (DOE/NV/10461–T18) **Assessment of the impact of a nuclear waste repository at Yucca Mountain on the economic development potential of Las Vegas, Clark County, and the surrounding area.** Boyle, M.R. (Growth Strategies Organization, Reston, VA (USA)). Nevada Nuclear Waste Project Office, Carson City, NV (USA); Growth Strategies Organization, Reston, VA (USA). Jan 1989. 13p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract FG08-85NV10461. Order Number DE90004727. Source: NTIS, PC A03/MF A01; OSTI; INIS.

Growth Strategies Organization has completed an assessment of the Las Vegas MSA's competitiveness in the attraction of new business facilities to the area. That report found that under current business climate conditions and in the present economic development market place, the region is a competitive site for about one hundred of the six hundred types of primary businesses studied. It is almost competitive as a location for another 80 to 90 types of businesses and is a marginal choice for another 200 business groups. In other words, Clark County, as is, fully satisfies the basic requirements of almost a sixth of the businesses in this study. With minor improvements in areas such as the skill mix of its work force and the quality of its educational facilities and with an effective campaign to improve the area's image, the Las Vegas area could become a competitive location for about two-thirds of all business groups – a very large shift in marketability. The proposed nuclear waste repository that he Federal government has proposed for siting at Yucca Mountain more than a hundred miles from Las Vegas would become operational after the turn of the century, more than fifteen years from now. Its influence on business investment decisions would be felt in the mid- to late-1990s if the final decision were made and announced. To measure that impact it would be desirable to establish a baseline that reflects Clark County's competitiveness as a business facility location in the middle of the next decade. In constructing that baseline, several variables could be considered – changes in business climate conditions in the area other than the nuclear waste repository; and changes in the location decision process itself resulting from changes in technology and in market pressures.

315 (DOE/NV/10461–T19) **Summary of background fiscal data and analysis for the Nevada socioeconomic impact assessment study to date.** Nevada Nuclear Waste Project Office, Carson City, NV (USA); Planning Information Corp., Denver, CO (USA). Jan 1989. 118p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract FG08-85NV10461. Order Number DE90004728. Source: NTIS, PC A06/MF A01; OSTI; INIS.

This study has developed models to assess the fiscal implications of a projected economic and demographic future for the State of Nevada and for its three southern countries, Clark, Lincoln and Nye. The models analyze the fiscal implications of an economic and demographic future for the

State General Fund, the State Highway Fund, local government general funds, local capital requirements, the State Distributive Fund and local school districts.

316 (DOE/NV/10461–T20) **Assessing the state/nation distributional equity issues associated with the proposed Yucca Mountain repository: A conceptual approach.** Kasperson, R.E. (Clark Univ., Worcester, MA (USA). Center for Technology, Environment, and Development); Ratick, S.; Renn, O. Nevada Nuclear Waste Project Office, Carson City, NV (USA); Clark Univ., Worcester, MA (USA). Center for Technology, Environment, and Development. Jun 1988. 22p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract FG08-85NV10461. Order Number DE90004729. Source: NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

This paper addresses one quite specific part of this broad range of issues – the distribution of impacts to the state of Nevada and to the nation likely to be associated with the proposed Yucca Mountain repository. As such, it is one of four analyses of the overall equity problems and needs to be read in conjunction with our proposed overall framework for the equity studies and the several other specific analyses. The objective of this report is to consider how an analysis might be made of the distribution of projected outcomes between the state and nation. At the same time, it needs to be clear that no attempt will be made actually to implement the analysis that is proposed. What follows is a conceptual statement that identifies the analytical issues and problems and proposes an approach for overcoming them. Significantly, it must be remembered that this report will not address procedural equity issues between the state and nation for this is the subject of a separate analysis. 10 refs., 2 figs.

317 (DOE/NV/10461–T21) **A framework for analyzing and responding to the equity problems involved in high-level radioactive waste disposal.** Kasperson, R.E. (Clark Univ., Worcester, MA (USA). Center for Technology, Environment, and Development); Ratick, S.; Renn, O. Nevada Nuclear Waste Project Office, Carson City, NV (USA); Clark Univ., Worcester, MA (USA). Center for Technology, Environment, and Development. Jun 1988. 17p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract FG08-85NV10461. Order Number DE90004730. Source: NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

As used in the discussion that follows, and in our research papers treating equity in the Yucca Mountain Socioeconomic Impact Study, equity refers to the fairness of the process or results of a particular activity or development on the various affected groups or individuals. The proper role for equity analyses, in our view, is not to provide final answers for the difficult issues involved. Any such solutions would require absolute values to which all interested and affected parties would subscribe. They would also require agreement as to the meaning of "harm," "benefit," and "burden" as well as how these factors should most appropriately be measured and valued. Such absolute values and social consensus is not realistic. So no overall quantitative expression of the amount of inequity can be definitively calculated or stated.

318 (DOE/NV/10461–T22) **Nevada state and local government comments on the US Department of Energy's report to Congress pursuant to Section 175 of the Nuclear Waste Policy Act, as amended.** Nevada Nuclear Waste Project Office, Carson City, NV (USA). Mar 1989. 72p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract FG08-85NV10461. Order Number DE90004731. Source: NTIS, PC A04/MF A01; OSTI; INIS.

The State of Nevada and affected local governments and Indian Tribes recognize the difficulties Department of Energy (DOE) encountered in attempting to compile a meaningful report on possible repository-related impacts in the relatively short amount of time available for the task. Overall, the Section 175 Report represents a positive beginning in what must, necessarily, be a much more thorough and detailed impact assessment effort. Although the current Report Does not identify the full range of repository impacts, nor seek to quantify them, it is useful as a framework or scoping document which, when supplemented with information on the specifics of impacts and costs/strategies for mitigation, may be useful in understanding the effects a repository will have upon the State of Nevada and affected communities. Subsequent socioeconomic analyses should follow-up this positive beginning and specify in greater detail the areas where undefined impacts may occur. Such analyses should expand the geographic scope of the Report, address transportation impacts along potential high-level waste routes, complete the project description (i.e., uncertainties with regard to labor force, materials requirements, etc.) used in forecasting effects within various categories of impacts, refine the section on impact mitigation strategies, and give fuller treatment to tourism and economic development impacts.

319 (DOE/NV/10461–T23) **The convention planning process: Potential impact of a high-level Nuclear Waste Repository in Nevada.** Kunreuther, H. (Pennsylvania Univ., Philadelphia, PA (USA). Center for Risk and Decision Processes); Easterling, D.; Kleindorfer, P. Nevada Nuclear Waste Project Office, Carson City, NV (USA); Pennsylvania Univ., Philadelphia, PA (USA). Center for Risk and Decision Processes. Sep 1988. 182p. Sponsored by U.S. DOE Defense Programs. DOE Contract FG08-85NV10461. Order Number DE90004732. Source: NTIS, PC A09/MF A01; OSTI; INIS.

This report presents results from two studies that test whether a high level nuclear waste repository sites at Yucca Mountain, Nevada will diminish the willingness of meeting planners to schedule conventions, trade shows, and other meetings in Las Vegas. The first study, a focus group interview with nine meeting planners from the Philadelphia area, found little evidence that planners' selection decisions would be influenced by environmental hazards (e.g., earthquakes, pollution), unless planners were led to believe that these hazards would have a direct impact on convention delegates and the planner could conceivably be held personally responsible for any such impacts. Participants did point out that they would be sensitive to continued media coverage of a negative event, as this might stigmatize the city in the eyes of delegates. The results from the focus group guided the development of a larger and more formal questionnaire survey of meeting planners who were known to have selected Las Vegas for a meeting. Of the 153 planners recruited, 114 had a future meeting scheduled and 39 had arranged a meeting that was recently held in the city. Subjects first answered a number of questions that described the process by which they chose Las Vegas among the possible convention cities. They were then instructed to reconsider their decision in light of seven different scenarios pertaining to the repository at Yucca Mountain.

320 (DOE/NV/10461–T24) **Yucca Mountain socioeconomic project: An interim report on the State of**

Nevada socioeconomic studies. Nevada Nuclear Waste Project Office, Carson City, NV (USA); Mountain West Research, Las Vegas, NV (USA). Jun 1989. 255p. Sponsored by U.S. DOE Defense Programs. DOE Contract FG08-85NV10461. Order Number DE90004733. Source: NTIS, PC A12/MF A01; OSTI; INIS; GPO Dep.

The State of Nevada formally initiated a study of the socioeconomic impacts of a proposed high-level nuclear waste repository at Yucca Mountain in southern Nevada in 1986 after the Nevada site had been chosen as a potential waste disposal site. The State and affected local governments that participated in the development of the study recognized that the effort would need to go well beyond what is traditionally considered adequate for socioeconomic impact assessment because of the unique nature of the repository project. This Interim Report is a report on work in progress and presents findings from the research to date on the potential consequences of a repository for the citizens of Nevada. The research and findings in the Report have been subjected to rigorous peer review as part of the state's effort to insure independent, objective analysis that meets the highest professional standards. The basic research effort will continue through June 1990 and will enable the state to refine and clarify the findings presented in this Interim Report.

321 (DOE/NV/10461–T25) **Perceived risk, stigma, and potential economic impacts of a high-level nuclear waste repository in Nevada.** Slovic, P. (Decision Research, Eugene, OR (USA)); Layman, M.; Kraus, N.N.; Chalmers, J.; Gesel, G.; Flynn, J. Nevada Nuclear Waste Project Office, Carson City, NV (USA); Decision Research, Eugene, OR (USA); Mountain West Research, Las Vegas, NV (USA). Jul 1989. 58p. Sponsored by U.S. DOE Defense Programs. DOE Contract FG08-85NV10461. Order Number DE90004734. Source: NTIS, PC A04/MF A01; OSTI; INIS; GPO Dep.

This paper describes a program of research designed to assess the potential impacts of a high-level nuclear waste repository at Yucca Mountain, Nevada, upon tourism, retirement and job-related migration, and business development in Las Vegas and the state. Adverse economic impacts may be expected to result from two related social processes. One has to do with perceptions of risk and socially amplified reactions to "unfortunate events" associated with the repository (major and minor accidents, discoveries of radiation releases, evidence of mismanagement, attempts to sabotage or disrupt the facility, etc.). The second process that may trigger significant adverse impacts is that of stigmatization. The conceptual underpinnings of risk perception, social amplification, and stigmatization are discussed in this paper and empirical data are presented to demonstrate how nuclear images associated with Las Vegas and the State of Nevada might trigger adverse effects on tourism, migration, and business development.

322 (DOE/NV/10461–T26) **An interim report on the State of Nevada socioeconomic studies: Executive summary: Yucca Mountain socioeconomic project.** Nevada Nuclear Waste Project Office, Carson City, NV (USA); Mountain West Research, Las Vegas, NV (USA). Jun 1989. 15p. Sponsored by U.S. DOE Defense Programs. DOE Contract FG08-85NV10461. Order Number DE90004735. Source: NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

This Interim Report is a report on work in progress and presents findings from the research to date on the potential consequences of a repository for the citizens of Nevada. The research and findings in the Report have been subjected to rigorous peer review as part of the state's effort to insure independent, objective analysis that meets the highest professional standards. The basic research effort will continue through June 1990 and will enable the state to refine and clarify the findings presented in this Interim Report.

323 (DOE/NV/10461–T27) **Yucca Mountain program summary of research, site monitoring and technical review activities (January 1987–June 1988).** Nevada Nuclear Waste Project Office, Carson City, NV (USA); Nevada Univ., Las Vegas, NV (USA). Desert Research Inst.; Nevada Univ., Reno, NV (USA). Desert Research Inst. Dec 1988. 124p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract FG08-85NV10461. Order Number DE90004742. Source: NTIS, PC A07/MF A01; OSTI; INIS; GPO Dep.

Although studies of orbital mechanics provide speculative notions of future climatic trends, they cannot predict how these trends will manifest themselves in the immediate area around Yucca Mountain. The generally accepted approach to this question is to consider the climatic variations that have occurred during the last 10,000 years, and use these as a guide to the likely range of future variation in climate. However, because climatic studies around the world indicate that we are potentially on the verge of another ice age, we should also consider the conditions that predominated during the Pleistocene. The specific aim of this project is to derive the climatic history of Yucca Mountain during the last 20,000 years from the vegetation history. By integrating data obtained from pollen records, woodrat dens (middens), and tree-ring sequences from the Nevada Test Site (NTS) area, a regional climatic record is being generated that can be correlated to data obtained at Yucca Mountain to formulate a local climatic sequence there. This will then be used to determine the magnitude and frequency of climatic variation that have occurred during that time at Yucca Mountain. These data can then be used by other researchers to provide estimates of rainfall, recharge and soil chemical changes for modeling the past hydrology of Yucca Mountain.

324 (DOE/NV/10461–T28) **Regional importance of post-6 M.Y. old vocanism in the southern Great Basin: Implications for risk assessment of volcanism at the proposed Nuclear Waste Repository at Yucca Mountain, Nevada: Annual report No. 10, July 1, 1987–June 30, 1988.** Nevada Univ., Las Vegas, NV (USA). Center for Volcanic and Tectonic Studies. 1 Sep 1988. 79p. Sponsored by U.S. DOE Defense Programs. DOE Contract FG08-85NV10461. Order Number DE90004741. Source: NTIS, PC A05/MF A01; OSTI; INIS; GPO Dep.

This report summarizes our activities during the period July 1, 1987 to June 30, 1988. Our goal was to develop an understanding of late-Miocene and Pliocene volcanism in the Great Basin by studying late-Tertiary volcanic rocks to the north and south of the Nevada Test Site (Figure 1). We especially concentrated on detailed stratigraphic studies and geochemistry to determine the nature of chemical changes during the lifetime of a volcanic field, and on structural studies to determine the nature of the structures that control vent location. Also, K-Ar age dating provided important new information on the duration of activity at a single volcanic center. Geologic studies were concentrated in the Fortification basalt field in southern Nevada and in the Reveille Range in central Nevada. Our studies provide three important conclusions that have implications for volcanism about the proposed Nuclear Waste Repository at Yucca Mountain. There are no easily recognized geochemical characteristics that signify the termination of volcanism. The location of vent areas of basaltic volcanoes are not necessarily controlled by pre-existing structures. Volcanism at an individual basaltic center may last as long as 500,000 years. 32 refs., 34 figs., 6 tabs.

325 (DOE/NV/10461–T29) **Physical and chemical properties of zeolite minerals occurring at the Yucca Mountain Site.** Smyth, J.R. (Colorado Univ., Boulder, CO (USA). Dept. of Geological Sciences). Mifflin and Associates, Inc., Las Vegas, NV (USA); Colorado Univ., Boulder, CO (USA). Dept. of Geological Sciences. 1 Aug 1988. 19p. Sponsored by U.S. DOE Defense Programs. DOE Contract FG08-85NV10461. Order Number DE90004740. Source: NTIS, PC A03/MF A01; OSTI; INIS.

Silica tuffs at Yucca Mountain, Nevada, are under investigation as potential host rocks for isolation of high and intermediate level radioactive wastes from commercial nuclear power generation. Non- welded and partially welded tuffs at this site may contain major amounts (up to 90%) of the zeolite minerals clinoptilolite, mordenite, and analcime. Densely welded tuffs which form the proposed repository horizon and some of the minor basaltic dikes at the site contain clinoptilolite or heulandite as fracture filling which limits the permeability of these rocks. The cation exchange properties of these zeolites allow them to form a natural sorptive barrier to the migration of radionuclides that may move as soluble cationic species in ground water. However, these zeolites are unstable at elevated temperatures and may breakdown either by dehydration at low water-vapor pressures or by mineralogical reaction to more stable phases at higher water-vapor pressures and at relatively low temperatures (80–100°C). All the breakdown reactions occurring with increasing temperature result in significant volume reductions and evolution of fluids. Thus they may provide a pathway (shrinkage fractures) and a driving force (fluid pressure) for release of radionuclides to the biosphere if heat-generating wastes are emplaced in zeolite-rich horizons. The breakdown reactions and the sorptive properties both vary strongly with zeolite crystal chemistry, and for any given structure, with the exchangeable cations present in that structure. Thus an improved knowledge of the crystal chemistry of these zeolites, particularly clinoptilolite which has not been thoroughly studied due to a scarcity of adequate crystals, will allow improved models of radionuclide migration and a better evaluation of any potential hazards posed by breakdown of these highly temperature-sensitive minerals at the Yucca Mountain site. 38 refs., 5 figs., 2 tabs.

326 (DOE/NV/10461–T30) **Report of the State of Nevada Commission on Nuclear Projects.** Nevada Commission on Nuclear Projects, Carson City, NV (USA). Nov 1988. 78p. Sponsored by U.S. DOE Defense Programs. DOE Contract FG08-85NV10461. Order Number DE90004739. Source: NTIS, PC A05/MF A01; OSTI; INIS; GPO Dep.

Chapter One of the report presents a brief overview of the commission's functions and statutory charges. It also contains a summary of developments which have affected the overall nuclear waste disposal issue since the last Commission report was published. This chapter summarizes the Nuclear Waste Policy Amendments Act of 1987 (NWPAA), which significantly modified federal waste disposal policy and identified Nevada's Yucca Mountain as the only site to be evaluated for suitability as a nuclear waste repository. Chapter Two contains a synthesis of Commission activities and reports on the findings of the Commission relative to the geotechnical, environmental, socioeconomic, transportation, intergovernmental and legal aspects of federal and state nuclear waste program efforts. Chapter Three of the report presents recommendations which the Commission is making to the 1989 Nevada Legislature, the governor, and others concerned with matters surrounding the proposed high-level nuclear waste repository at Yucca Mountain and with repository-related activities, such as the transportation of radioactive materials.

327 (DOE/NV/10461–T31) **Report of the Nevada Commission on Nuclear Projects.** Nevada Commission on Nuclear Projects, Carson City, NV (USA). Nov 1986. 140p. Sponsored by U.S. DOE Defense Programs. DOE Contract FG08-85NV10461. Order Number DE90004738. Source: NTIS, PC A07/MF A01; OSTI; INIS.

This summary represents the major conclusions reached by the Commission on Nuclear Projects. They reflect the Commission's experience with the high-level nuclear waste disposal program since 1985 and are the result of the Commission's scrutiny of both State and federal repository-related activities.

328 (DOE/NV/10461–T32) **A report on high-level nuclear transportation: Prepared pursuant to assembly concurrent Resolution No. 8 of the 1987 Nevada Legislature.** Nevada Nuclear Waste Project Office, Carson City, NV (USA). Dec 1988. 162p. Sponsored by U.S. DOE Defense Programs. DOE Contract FG08-85NV10461. Order Number DE90004737. Source: NTIS, PC A08/MF A01; OSTI; INIS; GPO Dep.

The report is divided into three major sections, each of which addresses one of three directives cited above. Section 1.0 provides a review of DOE's statutory requirements, its repository transportation program and plans, the major policy, programmatic, technical and institutional issues and specific areas of concern for the State of Nevada. Section 2.0 contains a description of the current federal, state and tribal transportation regulatory environment within which nuclear waste is shipped and a discussion of regulatory issues which must be resolved in order for the State to minimize risks and adverse impacts to its citizens. Among other issues, this section addresses emergency management, liability for accidents, state permitting and fees, and consistency of State and local regulation with federal law. Section 3.0 contains the NWPO plan for the study and management of repository-related transporation. The plan addresses four areas, including policy and program management, regulatory studies, technical reviews and studies and institutional relationships. A fourth section provides recommendations for consideration by State and local officials which would assist the State in meeting the objectives of the plan.

329 (DOE/NV/10461–T33) **Review and comment on the US Department of Energy Site Characterization Plan Conceptual Design report.** Nevada Nuclear Waste Project Office, Carson City, NV (USA); Thompson (H. Platt) Engineering Co., Inc., Houston, TX (USA). Oct 1988. 214p. Sponsored by U.S. DOE Defense Programs. DOE Contract FG08-85NV10461. Order Number DE90004745. Source: NTIS, PC A10/MF A01; OSTI; INIS.

The "Site Characterization Plan Conceptual Design Report," as prepared by the United States Department of Energy and its contractors, depicts the conceptual designs being proposed for the Yucca Mountain, Nevada High-Level

Waste Repository. Much of the report is comprised of designs based on large assumptions that lead to inconclusiveness in terms of technical integrity and reasonableness. As a result, the likely success of the designs proposed within the report is highly questionable from a technical and even constructibility standpoint. Grave deficiencies have been found throughout the report ranging from the oversimplification of the geologic and geohydrologic setting to the incorrect determination of the repository horizon's host rock strength. All of these deficiencies found within the report relate directly to the probable outcome of the site characterization of Yucca Mountain and the possible design and construction of a high-level waste repository at the site. It does not appear that a concerted effort has been put forth to develop many of the concepts within the report to a reasonable level of engineering and scientific integrity that would be suitable to meet the needs of and provide the results to the Nation's High-Level Waste Program.

330 (DOE/NV/10461–T34) **Ground-water sampling of the NNWSI [Nevada Nuclear Waste Storage Investigation] water table test wells surrounding Yucca Mountain, Nevada.** Matuska, N.A. (Nevada Univ., Reno, NV (USA). Water Resources Center). Nevada Nuclear Waste Project Office, Carson City, NV (USA); Nevada Univ., Reno, NV (USA). Water Resources Center. Dec 1988. 20p. Sponsored by U.S. DOE Defense Programs. DOE Contract FG08-85NV10461. Order Number DE90004744. Source: NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

The US Geological Survey (USGS), as part of the Nevada Nuclear Waste Storage Investigation (NNWSI) study of the water table in the vicinity of Yucca Mountain, completed 16 test holes on the Nevada Test Site and Bureau of Land Management-administered lands surrounding Yucca Mountain. These 16 wells are monitored by the USGS for water-level data; however, they had not been sampled for ground-water chemistry or isotropic composition. As part of the review of the proposed Yucca Mountain high-level nuclear waste repository, the Desert Research Institute (DRI) sampled six of these wells. The goal of this sampling program was to measure field-dependent parameters of the water such as electrical conductivity, pH, temperature and dissolved oxygen, and to collect samples for major and minor element chemistry and isotopic analysis. This information will be used as part of a program to geochemically model the flow direction between the volcanic tuff aquifers and the underlying regional carbonate aquifer.

331 (DOE/NV/10461–T37-Vol.2) **Evaluation of the geologic relations and seismotectonic stability of the Yucca Mountain area, Nevada Nuclear Waste Site Investigation (NNWSI): Final report: Volume 2.** Nevada Nuclear Waste Project Office, Carson City, NV (USA); Nevada Univ., Reno, NV (USA). Center for Neotectonic Studies. Oct 1988. 254p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract FG08-85NV10461. Order Number DE90004747. Source: NTIS, PC A12/MF A01; OSTI; INIS.

This document describes activities for the year ending 30 June 1988 by staff members of the Seismological Laboratory in support of the Yucca Mountain site assessment program. Participants include James N. Brune, Director, John Anderson, William Peppin, Keith Priestley, Martha Savage, and Ute Vetter. Activities during the year centered largely around acquisition of equipment to be used for site characterization plan for Yucca Mountain. Due to modifications in the scheduling and level of funding, this work has not progressed as originally anticipated. The report describes progress in seven areas, listed in approximate order of significance to the Yucca Mountain project. These are: (1) equipment acquisition, (2) review of the draft site characterization plan, (3) studies of earthquake sequence related to the tectonic problems at Yucca Mountain, (4) a review of the work of Szymanski in relation to Task 4 concerns, (5) coordination meetings with USGS, DOE and NRC personnel, (6) studies related to Yucca Mountain and (7) other studies.

332 (DOE/NV/10461–T38) **Comments on US Department of Energy, Office of Civilian Radioactive Waste Mangement "Draft 1988 Mission Plan Amendment" (DOE/RW-0187, June 1988).** Nevada Nuclear Waste Project Office, Carson City, NV (USA). 30 Sep 1988. 45p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract FG08-85NV10461. Order Number DE90005481. Source: NTIS, PC A03/MF A01; OSTI; INIS.

The State of Nevada has reviewed the DOE Office of Civilian Radioactive Waste Management "Draft 1988 Mission Plan Amendment" (DMPA), and their comments are included in this document.

333 (DOE/NV/10461–T39-Vol.1) **State of Nevada comments on the US Department of Energy consultation draft site characterization plan, Yucca Mountain site, Nevada research and development area, Nevada: Volume 1.** Nevada Nuclear Waste Project Office, Carson City, NV (USA). Sep 1988. 247p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract FG08-85NV10461. Order Number DE90005482. Source: NTIS, PC A15/MF A01; OSTI; INIS.

The comments presented here represent a review effort by the Nevada Agency for Nuclear Projects and its Technical Support Contractors and advisors. Part I presents an overview of the comments contained in the document. The overview takes the form of general concerns and comments organized by specific areas of concern. The overview does not follow the format of the CD-SCP. Part II contains specific comments of the Nevada Agency for Nuclear Projects. These comments respond to specifics of the CD-SCP and do so in relation to the organizational format employed in the CD-SCP. Because of the way it is organized, the CD-SCP encouraged a certain degree of redundancy in our response. Part III of this document contains verbatim comments received from the Agency's Technical Contractors and advisors. These comments address issues and contain information not contained in Parts I and II. As such, these comments should be viewed as important in their own right – not as appendices to the State's comment document.

334 (DOE/NV/10461–T39-Vol.2) **State of Nevada comments on the US Department of Energy consultation draft site characterization plan, Yucca Mountain site, Nevada research and development area, Nevada: Volume 2.** Nevada Nuclear Waste Project Office, Carson City, NV (USA). Sep 1988. 247p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract FG08-85NV10461. Order Number DE90005483. Source: NTIS, PC A16/MF A01; OSTI; INIS.

The SCPCD has identified a number of key issues that need to be addressed for characterization of the Yucca Mountain site. A variety of complex experiments have been proposed in an attempt to address these issues. Although a lot of time, money and effort has been spent on characterizing the Yucca Mountain area to date, there are still many unresolved technical issues. Since many of the experiments proposed in the SCPCD have never been done in an unsaturated fractured media, it is impossible to tell if they will be successful. Results of these experiments may indicate that new test designs or data collection procedures are needed to address the issues. Our approach to reviewing the SCPCD has been to first identify key technical issues which have not been resolved and to make specific comments associated with the hydrologic experiments proposed.

335 (DOE/NV/10461–T40-Vol.1) **State of Nevada comments on the US Department of Energy Site Characterization Plan, Yucca Mountain site, Nevada: Volume 1.** Nevada Nuclear Waste Project Office, Carson City, NV (USA). Sep 1989. 409p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract FG08-85NV10461. Order Number DE90005484. Source: NTIS, PC A18/MF A01; OSTI; INIS.

One of the most important systems to understand is the hydrologic system at Yucca Mountain. This system probably contains the most likely pathways for radionuclide escape from the repository to the accessible environment. The hydrology of the unsaturated highly-fractured tuffs, in which the proposed repository would be constructed, is poorly understood because very little scientific study of this type of hydrogeologic system had been made prior to the selection of Yucca Mountain as a potential repository. The major concerns are of: (1) the time limitations for conducting the necessary investigations; (2) the great uncertainty regarding the hydrologic processes, especially fracture flow, in the unsaturated zone; (3) the inadequate consideration of various hydrogeologic and hydrologic factors, including coupled flow processes, recharge and discharge, and perched water zones; (4) the inadequate conceptual and numerical models of the saturated and unsaturated zones, and development of scenarios; (5) the flaws in the design and monitoring of observation wells; (6) the uncertainties in estimating infiltration, ground water travel time, the extent of the disturbed zone, and waste package integrity; and (7) the overall biased approach of the SCP. This report consists of a summary of these concerns, followed by specific comments on portions of Chapters 3 and 8 of the SCP.

336 (DOE/NV/10461–T40-Vol.2) **State of Nevada comments on the US Department of Energy site characterization plan, Yucca Mountain site, Nevada: Volume 2.** Nevada Nuclear Waste Project Office, Carson City, NV (USA). 1989. 428p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract FG08-85NV10461. Order Number DE90005485. Source: NTIS, PC A19/MF A01; OSTI; INIS; GPO Dep.

We find the Site Characterization Plan: Yucca Mountain Site, Nevada Research and Development Area (DOE/RW-0160) seriously deficient, in terms of establishing an investigative program to confidently characterize hydrogeologic and closely related aspects of the proposed repository, in the vadose zone at Yucca Mountain. Most hydrogeological licensing criteria indirectly measure waste isolation provided by the geologic environment during pre- and post-closure conditions. We believe the Site Characterization Plan (SCP) generally fails to establish scientifically sound and feasible programs of investigation that will, in a timely and confident manner, resolve most of the hydrogeologic and geochemical licensing issues that have been recognized since the vadose-zone repository was first proposed at this location in 1982. The SCP generally fails in its responsibility because it does not objectively set aside the DOE conceptual model of a "dry" repository environment with extremely slow flow of water confined to the rock matrix. In the SCP, the DOE fails to establish a scientifically sound investigative program that seriously tests for hydrogeologic conditions based on the range of existing data and general knowledge. Rather, the DOE builds a probabilistic program upon a preconceived conceptual model, without designing a field-data collection program with the power to test the validity of the conceptual model. This is unacceptable in that the DOE program, as described in the SCP, plans to build numerical model after numerical model upon untested conceptual models, in attempts to "resolve" the fundamental licensing issues of waste isolation by the geologic barrier. If executed as planned, these analyses will have only a series of assumptions of their foundation and, therefore, can not resolve licensing issues. 12 refs., 3 figs.

337 (DOE/NV/10461–T40-Vol.3) **State of Nevada comments on the US Department of Energy site characterization plan, Yucca Mountain site, Nevada: Volume 3.** Nevada Nuclear Waste Project Office, Carson City, NV (USA). Sep 1989. 527p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract FG08-85NV10461. Order Number DE90005486. Source: NTIS, PC A23/MF A01; OSTI; INIS; GPO Dep.

In December 1988, the US Department of Energy issued a Site Characterization Plan (SCP) for the Yucca Mountain site, as required by Section 113 of the Nuclear Waste Policy Act of 1982 (NWPA). The purpose of site characterization is to develop sufficient information to support a determination of the suitability, or lack of suitability of the site to safely isolate high-level radioactive waste with reasonable certainty for thousands of years. The purpose of the Site Characterization Plan is to describe plans for obtaining sufficient information about the site, plans for mitigation of any adverse impacts occurring from site characterization activities, and plans for decontamination and decommissioning of the site if it is determined not to be suitable for a repository. Part I presents an overview of the State's comments. The overview takes the form of general concerns and comments organized by specific areas of concern. The overview does not follow the format of the SCP.

338 (DOE/NV/10461–T40-Vol.4) **State of Nevada comments on the US Department of Energy site characterization plan, Yucca Mountain site, Nevada: Volume 4.** Nevada Nuclear Waste Project Office, Carson City, NV (USA). Sep 1989. 494p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract FG08-85NV10461. Order Number DE90005487. Source: NTIS, PC A21/MF A01; OSTI; INIS.

The following document comprises a critical evaluation of the DOE's Site Characterization Plan (SCP). The comments address a number of issues related to the scientific methods involved in the proposed procedures of site characterization, the suitability and integration of the methods, and the valid ity of the approach taken by the DOE in the context of the NRC regulations. The SCP contains many improvements of the Draft Environmental Assessment (DEA) and the Environmental Assessment (EA), and fewer improvements of the SCP Consultation Draft. An obvious attempt has been made to address topics that were regarded in these previous reviews as deficiencies in the study program. For example, the activity and seismogenic potential of the Quaternary faults at Yucca Mountain are treated much more realistically than orignally proposed by the DOE, even though published data has not increased significantly since the DEA and EA were released. Water is now recognized as a resource, and faults and fault breccias are recognized as potential hosts for epithermal mineralization. There has, in addition, been considerable effort to incorporate a number of alternative conceptual models (involving both cross sections of Yucca Mountain and regional tectonic models) into the realm of tectonic hypotheses. There is a little doubt that the SCP proposes an exhaustive and wide-ranging scope of investigations for the purpose of site characterization, and that many of these investigations have been included by the DOE in response to critical reviews by external groups (such as the NRC and various State of Nevada agencies).

339 (DOE/NV/10461–T41-Vol.2) **State of Nevada comments on the US Department of Energy draft environmental assessment for the proposed high-level nuclear waste site at Yucca Mountain: Volume 2.** Nevada Nuclear Waste Project Office, Carson City, NV (USA). Mar 1985. 375p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract FG08-85NV10461. Order Number DE90006176. Source: NTIS, PC A16/MF A01; OSTI; INIS; GPO Dep.

A page by page review of the geologic and mineral-resources considerations in DOE's Yucca Mountain EA is included. This review does not cover geohydrological or earthquake/faulting considerations in any detail, as they are being reviewed in detail by others. Other, non-geologic errors of fact are also pointed out. It appears that the process of evaluation has been done backwards—possible sites have been selected for nongeologic reasons, then efforts made to make the geologic settings (for example: rock type) appear favorable. Additional, more detailed studies need to be made by organizations other than DOE or the US Geological Survey to cross-check the accuracy, completeness, and conclusions of existing studies.

340 (DOE/OR/00033–T419) **Gas phase migration of C-14 through barrier materials applicable for use in a high-level nuclear waste repository located in tuff.** Bauer, L.R. Purdue Univ., Lafayette, IN (USA). Dec 1988. 127p. DOE Contract AC05-76OR00033. Order Number DE89010158. Source: NTIS, PC A07/MF A01 - OSTI; GPO Dep.

A study of the movement of $^{14}CO_2$ through proposed barrier media has been conducted. Diffusion coefficients for crushed tuff, bentonite and a 90:10% by wt. mixture of crushed tuff and bentonite were measured for two diffusion lengths. The ability of $^{14}CO_2$ to penetrate a microsilica-containing portland cement mortar proposed for repository use was also examined. The specimens were subjected to uniaxially-applied compressive loads prior to the diffusion tests to simulate the onset of environmentally-induced microcracks. 91 refs., 14 figs., 15 tabs.

341 (DOE/RW–0188) **Office of Civilian Radioactive Waste Management quarterly report on program cost and schedule, first quarter FY 1988.** USDOE Office of Civilian Radioactive Waste Management, Washington, DC. 1988. 32p.

This report is intended to provide a summary of the cost and schedule performance for the civilian radioactive waste management program. Performance data are presented for each of the major program elements. Also included in this report is the status of the Nuclear waste Fund revenues and disbursement. This report includes performance data through December 1987. In December 1987, Congress passed the Nuclear Waste Policy Amendments Act of 1987 which changed the near-term activities of the program. Specifically, This Act required that the tuff site in Nevada be characterized for the first repository and that site-specific activities at the other two first repository sites (the salt site in Texas and the basalt site in Washington) be terminated within 90 days of enactment. The Act also requires the phase-out of all second repository activities designed to evaluate the suitability of crystalline rock as a potential host rock for a repository. The new legislation impacts the contents of this report by focusing the first repository program on the activities of the tuff project and phasing-out the activities for the salt, basalt and second repository projects.

342 (DOE/RW–0189) **Office of Civilian Radioactive Waste Management annual report to Congress.** USDOE Office of Civilian Radioactive Waste Management, Washington, DC (USA). Aug 1988. 65p. Source: OSTI, PO Box 62, Oak Ridge, TN 37831.

This is the fifth Annual Report to Congress by the Office of Civilian Radioactive Waste Management (OCRWM). The report covers the activities and expenditures of OCRWM during fiscal year 1987, which ended on September 30, 1987. The activities and accomplishments of OCRWM during fiscal year 1987 are discussed in chapters 1 through 9 of this report. The audited financial statements of the Nuclear Waste Fund are provided in chapter 10. Since the close of the fiscal year, a number of significant events have occurred. Foremost among them was the passage of the Nuclear Waste Policy Amendments Act of 1987 (Amendments Act) on December 21, 1987, nearly 3 months after the end of the fiscal year covered by this report. As a result, some of the plans and activities discussed in chapters 1 through 9 are currently undergoing significant change or are being discontinued. Most prominent among the provisions of the Amendments Act is the designation of Yucca Mountain, Nevada, as the only candidate first repository site to be characterized. Therefore, the site characterization plans for Deaf Smith, Texas, and Hanford, Washington, discussed in chapter 3, will not be issued. The refocusing of the waste management program under the Amendments Act is highlighted in the epilogue, chapter 11. 68 refs., 7 figs., 7 tabs.

343 (DOE/RW–0205) **Section 175 report: Secretary of Energy report to the Congress pursuant to Section 175 of the Nuclear Waste Policy Act, as amended.** USDOE Office of Civilian Radioactive Waste Management, Washington, DC. Dec 1988. 138p. Source: OSTI, PO Box 62, Oak Ridge, TN 37831.

This report contributes to, but does not supplant, ongoing studies being conducted by DOE to ensure that potentially significant adverse effects that may result from the repository program are minimized to the maximum extent practicable. As indicated in the Environmental Assessment for the Yucca Mountain site (US DOE, 1986) DOE does not believe significant adverse effects will result from site characterization activities. Nevertheless, DOE is conducting a variety of studies to determine if this conclusion is valid. These studies include, but are not limited to, monitoring of air and water quality and other environmental factors; monitoring the number of immigrating repository program workers and their residential locations; identifying cultural resources in the Yucca Mountain area and traditional culture and religious values of American Indian people associated with those resources; evaluating possible rail access routes to the Yucca Mountain site; and evaluating possible highway routes. These studies have been implemented after consultation with affected parties in Nevada. As part of the determination of suitability, and Environmental Impact Statement will be written and will include an analysis of potential impacts associated with constructing, operating, closing, and decommissioning a repository at Yucca Mountain, Nevada. 59 refs., 33 figs., 12 tabs.

344 (DOE/RW–0206) **Site characterization plan: Public Handbook, Yucca Mountain, Nevada.** USDOE Office of Civilian Radioactive Waste Management, Washington, DC (USA). Jan 1989. 28p. Sponsored by U.S. DOE Radioactive Waste Management. Source: OSTI.

The Yucca Mountain site in Nevada has been designated by the Nuclear Waste Policy Act of 1982, as amended, for detailed study as the candidate site for the first US geologic repository for spent nuclear fuel and high-level radioactive waste. The detailed study — called "site characterization" — will be conducted by the Department of Energy (DOE) to determine the suitability of the site for a repository and, if the site is suitable, to obtain from the Nuclear Regulatory Commission authorization to construct the repository. As part of the site characterization study, DOE has prepared a Site Characterization Plan (SCP) for the Yucca Mountain site. The Site Characterization Plan is a nine-volume document, approximately 6300 pages in length, which describes the activities that will be conducted to characterize the geologic, hydrologic, and other conditions relevant to the suitability of the site for a repository. Part 1 of this Handbook explains what site characterization is and how the Site Characterization Plan (Plan) relates to it. Part 2 tells how to locate subjects covered in the Plan. Another major purpose of this Handbook is to identify opportunities for public involement in the review of the Site Characterization Plan. DOE wants to be sure that the public has adequate opportunities to learn about the Plan and review the results of the subsequent technical studies. 14 refs.

345 (DOE/RW–0221) **1988 Bulletin compilation and index.** USDOE Office of Civilian Radioactive Waste Management, Washington, DC. Feb 1989. 70p. Source: OSTI, PO Box 62, Oak Ridge, TN 37831.

This document is published to provide current information about the national program for managing spent fuel and high-level radioactive waste. This document is a compilation of issues from the 1988 calendar year. A table of contents and one index have been provided to assist in finding information.

346 (DOE/RW–0225) **Quarterly report on program cost and schedule: First quarter FY 1989.** USDOE Office of Civilian Radioactive Waste Management, Washington, DC (USA). 1989. 37p. Sponsored by U.S. DOE Radioactive Waste Management. Source: OSTI.

This report is intended to provide a summary of the cost and schedule performance for the Civilian Radioactive Waste Management Program. Performance data are presented for each of the major program elements. Also included in this report is the status of the Nuclear Waste Fund revenues and disbursements. This report includes performance data through December 1988.

347 (DOE/RW–0225-1) **Quarterly report on program cost and schedule.** USDOE Office of Civilian Radioactive Waste Management, Washington, DC (USA). Jul 1989. 35p. Sponsored by U.S. DOE Radioactive Waste Management. Source: OSTI.

This report is intended to provide a summary of the cost and schedule performance for the Civilian Radioactive Waste Management Program. Performance data are presented for each of the major program elements. Also included in this report is the status of the Nuclear Waste Fund revenues and disbursements. This report includes project performance data reported through March 1989.

348 (DOE/RW–0225-2) **Quarterly report on program cost and schedule: Third quarter FY 1989.** USDOE Office of Civilian Radioactive Waste Management, Washington, DC (USA). [1989]. 35p. Sponsored by U.S. DOE Radioactive Waste Management. Source: OSTI; INIS.

This report is intended to provide a summary of the cost and schedule performance for the Civilian Radioactive Waste Management Program. Performance data are presented for each of the major program elements. Also included in this report is the status of the Nuclear Waste Fund revenues and disbursements. This report includes cost and schedule data through June 1989.

349 (DOE/RW–0234) **Telecommunications Network Plan.** USDOE Office of Civilian Radioactive Waste Management, Washington, DC (USA). May 1989. 33p. Sponsored by U.S. DOE Radioactive Waste Management. Source: OSTI.

The Office of Civilian Radioactive Waste Management (OCRWM) must, among other things, be equipped to readily produce, file, store, access, retrieve, and transfer a wide variety of technical and institutional data and information. The data and information regularly produced by members of the OCRWM Program supports, and will continue to support, a wide range of program activities. Some of the more important of these information communication-related activities include: supporting the preparation, submittal, and review of a license application to the Nuclear Regulatory Commission (NRC) to authorize the construction of a geologic repository; responding to requests for information from parties affected by and/or interested in the program; and providing evidence of compliance with all relevant Federal, State, local, and Indian Tribe regulations, statutes, and/or treaties. The OCRWM Telecommunications Network Plan (TNP) is intended to identify, as well as to present the current strategy for satisfying, the telecommunications requirements of the civilian radioactive waste management program. The TNP will set forth the plan for integrating OCRWM's information resources among major program sites. Specifically, this plan will introduce a telecommunications network designed to establish communication linkages across the program's Washington, DC; Chicago, Illinois; and Las Vegas, Nevada, sites. The linkages across these and associated sites will comprise Phase I of the proposed OCRWM telecommunications network. The second phase will focus on the modification and expansion of the Phase I network to fully accommodate access to the OCRWM Licensing Support System (LSS). The primary components of the proposed OCRWM telecommunications network include local area networks; extended local area networks; and remote extended (wide) area networks. 10 refs., 6 figs.

350 (DOE/RW–0236) **Analysis of the total system life cycle cost for the Civilian Radioactive Waste Management Program.** USDOE Office of Civilian Radioactive Waste Management, Washington, DC (USA). May 1989. 190p. Sponsored by U.S. DOE Radioactive Waste Management. Source: OSTI.

The total-system life-cycle cost (TSLCC) analysis for the Department of Energy's (DOE) Civilian Radioactive Waste Management Program is an ongoing activity that helps determine whether the revenue-producing mechanism established by the Nuclear Waste Policy Act of 1982 – a fee levied on electricity generated in commercial nuclear power plants – is sufficient to cover the cost of the program. This report provides cost estimates for the sixth annual evaluation of the adequacy of the fee and is consistent with the program strategy and plans contained in the DOE's Draft 1988 Mission Plan Amendment. The total-system cost for the system with a repository at Yucca Mountain, Nevada, a facility for monitored retrievable storage (MRS), and a transportation system is estimated at $24 billion (expressed in constant 1988 dollars). In the event that a second repository is required and is authorized by the Congress, the total-system cost is estimated at $31 to $33 billion, depending on the quantity of spent fuel to be disposed of. The $7 billion cost savings for the single-repository system in comparison with the two-repository system is due to the elimination of $3 billion for second-repository development and $7 billion for the second-repository facility. These savings are offset by $2 billion in additional costs at the first repository and $1 billion in combined higher costs for the MRS facility and transportation. 55 refs., 2 figs., 24 tabs.

351 (DOE/RW–0244) **Draft reclamation program plan for site characterization: Yucca Mountain project.** USDOE Office of Civilian Radioactive Waste Management, Washington, DC (USA). Aug 1989. 37p. Sponsored by U.S. DOE Radioactive Waste Management. Source: OSTI.

As part of its obligations under the Nuclear Waste Policy Act, as amended, the US Department of Energy (DOE) has developed an environmental program that is to be implemented during site characterization at the Yucca Mountain site. This site is proposed for the location of the nation's first high-level radioactive waste repository. A program for the reclamation of areas disturbed by site characterization is part of the overall environmental program for that site. This Reclamation Program Plan (RPP) describes the reclamation policy of the DOE for the Yucca Mountain site and presents an overview of the reclamation program. The RPP also provides an overview of the reclamation needs relative to site characterization; a review of legislation and requirements pertinent to reclamation; and a review of previous commitments made by the DOE to certain types of reclamation activities. The objective of the DOE reclamation program at Yucca Mountain is to return land disturbed by site-characterization activities to a stable ecological state with a form and productivity similar to the predisturbance state. The DOE will take all reasonable and necessary steps to achieve this objective. 19 refs., 2 tabs.

352 (DOE/RWM–88/1) **Radioactive Waste Management: Current abstracts.** Ringe, A.C. (ed.). USDOE Office of Scientific and Technical Information, Oak Ridge, TN (USA). Jan 1988. 47p. Order Number DE88008253. Source: NTIS, PC A03/MF A01.

Radioactive Waste Management (RWM) announces on a monthly basis the current worldwide information available on the critical topics of spent-fuel transport and storage, radioactive effluents from nuclear facilities, techniques of processing radioactive wastes, their storage, and ultimate disposal. Information on remedial actions and other environmental aspects is also included. This publication contains the abstracts of DOE reports, journal articles, conference papers, patents, theses, and monographs added to the Energy Data Base (EDB) during the past month. Also included are other U.S. information obtained through acquisition programs or interagency agreements and international information obtained through the International Energy Agency's Energy Technology Data Exchange, the International Atomic Energy Agency's International Nuclear Information System or government-to-government agreements.

353 (DP-MS–87-70) **Leaching Tc-99 from SRP glass in simulated tuff and salt groundwaters.** Bibler, N.E.; Jurgensen, A.R. Savannah River Lab., Aiken, SC (USA). 1987. 9p. DOE Contract AC09-76SR00001. (CONF-871124–52: Fall meeting of the Materials Research Society, Boston, MA, US, November 30, 1987). Order Number DE88004740. Source: NTIS, PC A02/MF A01; GPO Dep.

Results of leach tests with Tc-99 doped SRP borosilicate waste glass are presented. The glass was prepared by melting a mixture of SRP 165 powdered frit doped with a carrier free solution of Tc-99 at 1150^{0}C. Dissolution of portions of the resulting glass indicated that the Tc-99 was distributed homogeneously throughout the glass. Static leach tests up to 90 days were performed at 90^{0}C in J-13 tuff groundwater or WIPP brine A at a SA/V of 100m^{-1}. Normalized mass losses were calculated for Tc-99 as well as all the major elements in the glass. Results indicated that under ambient oxidizing conditions Tc-99 leached no faster than the glass-forming elements of the glass. In J-13 water, Tc-99 leached congruently with B. In WIPP brine A, it leached congruently with Si. Leach rates for Li were higher in both groundwaters, probably due to a contribution from an ion exchange mechanism. Leach tests were performed under reducing conditions in J-13 water by adding Zn/Hg amalgam to the leachate. In these tests the pH increased significantly, probably because of the reaction of the amalgam with the water. In a 21-day test, the pH increased to 13 and leach rates for the glass were very high. Even though there was signifcant dissolution of the glass, the normalized mass loss based on Tc-99 was only 0.02g/m^2. This result and the fact that reducing conditions at normal pH values do not significantly affect the dissolution of the glass, indicate that the low concentrations for Tc-99 obtained under reducing conditions are due to is solubility and not due to an increased durability of the glass. 14 refs., 2 figs., 5 tabs.

354 (DPST–87-225) **NNWSI [Nevada Nuclear Waste Storage Investigation] strategy for repository licensing.** Plodinec, M.J. Savannah River Lab., Aiken, SC (USA). 16 Jan 1987. 5p. DOE Contract AC09-76SR00001. Order Number DE88017209. Source: NTIS, PC A02/MF A01.

The Nevada Nuclear Waste Storage Investigation (NNWSI) has developed a strategy to license a nuclear waste repository in tuff. This strategy, which is currently circulating in draft form within the Department of Energy's Office of Civilian Radioactive Waste Management, has important implications for DWPF waste form qualification activities, design of the DWPF process, and DWPF operations. In this report, the strategy and its implications for the DWPF are presented. 2 refs.

355 **Direct disposal of spent nuclear fuel.** Radioactive Waste Management Series. Bechthold, W.; Closs, K.D.; Knapp, U.; Papp, R. 197p. Graham & Trotman Ltd., (1987).

This book describes current technologies and political approaches to the disposal at spent nuclear fuels in Europe. The eight chapters include discussions of the characterization of spent fuels; spent fuel conditioning, transport and disposal, foreign site characterization, and special topics.

356 (GAO/RCED–86-206FS) **Nuclear waste: Quarterly report on DOE's nuclear waste program as of June 30, 1986.** General Accounting Office, Washington, DC

(USA). 1986. 22p. Source: General Accounting Office, PO Box 6015, Gaithersburg, MD 20877.

The Department of Energy's status of nuclear waste program activities for the quarter ending June 30, 1986 included (1) final environmental assessments for first repository sites and recommendations for sites in Nevada, Texas, and Washington for site characterization; (2) postponement of any site-specific work on a second repository; and (3) collection of over $166 million in fees and investment income.

357 (GAO/RCED–88-163BR) **Nuclear waste: Quarterly report on DOE's nuclear waste program as of March 31, 1988.** General Accounting Office, Washington, DC (USA). Resources, Community and Economic Development Div. 1988. 17p. Source: General Accounting Office, PO Box 6015, Gaithersburg, MD 20877.

As part of the Department of Energy's implementation of the Nuclear Waste Policy Act of 1982, DOE is required to investigate a site at Yucca Mountain, Nevada and, if it determines that the site is suitable, recommend to the President its selection for a nuclear waste repository. The Nuclear Regulatory Commission, in considering development of the plan, issued five objections, one of which is DOE's failure to recognize the range of alternative conceptual models of the Yucca Mountain site that can be supported by the limited existing technical data. At the end of the quarter DOE directed its project offices in Washington and Texas to begin an orderly phase-out of all site-specific repository activities. Costs for this phase-out are $53 million of the Deaf Smith site and $85 million for the Hanford site.

358 (LA–11223-PR) **Laboratory and field studies related to the Radionuclide Migration project: Progress report, October 1, 1986-September 30, 1987.** Thompson, J.L. (comp.). Los Alamos National Lab., NM (USA). Feb 1988. 29p. DOE Contract W-7405-ENG-36. Order Number DE88006027. Source: NTIS, PC A03/MF A01; GPO Dep.

In this report we describe the research done by personnel of the Los Alamos National Laboratory in support of the Radionuclide Migration project during FY 1987. We are engaged in collecting data concerning the movement of radionuclides at three locations on the Nevada Test Site. We continue to monitor the elution of tritium and krypton from the RNM-2S well at the Cambric site and have described in detail the elution of ^{36}Cl from the same well. The data from this field study provide us with the opportunity to test the validity of several models of solute transport through geologic media. We have detected tritium and fission products in a water sample from the hole UE20n #1, which was drilled this year at the Cheshire site on Pahute Mesa. We are also continuing our efforts to learn how radionuclides have moved in test areas 3 and 4 near the Aleman site. Our laboratory work this year includes (1) a characterization of the size and density of two stable plutonium(IV) colloid suspensions prepared by different techniques and (2) a study of the transmission of colloidal-size polystyrene beads through crushed-rock columns. 18 refs., 7 figs., 9 tabs.

359 (LA-UR–88-3961) **Application of rock melting to construction of storage holes for nuclear waste.** Neudecker, J.W. Jr. Los Alamos National Lab., NM (USA). 1988. 3p. DOE Contract W-7405-ENG-36. (CONF-890238–1: Annual meeting and exhibit of the Society of Mining Engineers, Inc., Las Vegas, NV, US, February 27, 1989). Order Number DE89003603. Source: NTIS, PC A02/MF A01 - OSTI; GPO Dep.

Rock melting technology can provide in-situ glass liners in nuclear waste package emplacement holes to reduce permeability and increase borehole stability. Reduction of permeability would reduce the time and probability of groundwater contacting the waste packages. Increasing the stability of the storage boreholes would enhance the retrievability of the nuclear waste packages. The rock melting hole forming technology has already been tested in volcanic tuff similar to the geology at the proposed nuclear waste repository at Yucca Mountain, Nevada. 6 refs., 5 figs., 2 tabs.

360 (LA-UR–89-3701) **Radionuclide migration studies at the Nevada Test Site.** Thompson, J.L. Los Alamos National Lab., NM (USA). [1989]. 12p. Sponsored by U.S. DOE Management & Administration. DOE Contract W-7405-ENG-36. (CONF-891206–4: International chemical congress of Pacific Basin Society symposium on polymer rheology and processing (PACIFICHEM '89), Honolulu, HI (USA), 17-22 Dec 1989). Order Number DE90003169. Source: NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.

The United States government routinely tests nuclear devices at the Nevada Test Site (NTS) in southern Nevada. A significant amount of radioactive material exists underground at the NTS with no containers or engineered barriers to inhibit its subsequent migration. The Department of Energy has sponsored for many years a research program on radionuclide movement in the geologic media at this location. Goals of this research program are to measure the extent of movement of radionuclides away from underground explosion sites and to determine the mechanisms by which such movement occurs. This program has acquired significance in another aspect of nuclear waste management because of the Yucca Mountain Project. Yucca Mountain at the NTS is being intensively studied as the possible site for a mined repository for high level nuclear waste. The NTS provides a unique setting for field studies concerning radionuclide migration; there is the potential for greatly increasing our knowledge of the behavior of radioactive materials in volcanogenic media. This review summarizes some of the significant findings made under this research program at the NTS and identifies reports in which the details of the research may be found. 36 refs., 4 figs.

361 (LBL–22559) **Coupled processes in single fractures, double fractures and fractured porous media.** Tsang, C.F. Lawrence Berkeley Lab., CA (USA). Dec 1986. 20p. DOE Contract AC03-76SF00098. (CONF-861246–1: Workshop on numerical modeling for radioactive waste repositories, Madrid, ES, December 10, 1986). Order Number DE87004477. Source: NTIS, PC A02/MF A01; GPO Dep.

The emplacement of a nuclear waste repository in a fractured porous medium provides a heat source of large dimensions over an extended period of time. It also creates a large cavity in the rock mass, changing significantly the stress field. Such major changes induce various coupled thermohydraulic, hydromechanic and hydrochemical transport processes in the environment around a nuclear waste repository. The present paper gives, first, a general overview of the coupled processes involving thermal, mechanical, hydrological and chemical effects. Then investigations of a number of specific coupled processes are described in the context of fluid flow and transport in a single fracture, two intersecting fractures and a fractured porous medium near a nuclear waste repository. The results are presented and discussed.

362 (LBL–23689) **Near-field mass transfer in geologic disposal systems: A review.** Pigford, T.H.; Chambre, P.L. Lawrence Berkeley Lab., CA (USA). Nov 1987. 20p. DOE Contract AC03-76SF00098. (CONF-8711100–8: Symposium on the scientific basis for nuclear waste management, Boston, MA, US, November 30, 1987; UCB-NE–4106). Order Number DE88007416.

A primary purpose of performance assessment of geologic repositories for radioactive waste is to predict the extent to which radioactive species are released from the waste solids and are transported through geologic media to the environment. Reliable quantitative predictions must be made of rates of release of radionuclides from the waste into the rock, transport through the geologic media, cumulative release to the accessible environment, and maximum concentrations in ground water and surface water. Here we review theoretical approaches to making the predictions of near-field release from buried waste solids, which provide the source terms for far-field release. The extent to which approaches and issues depend on the rock media and on regulatory criteria is discussed. 53 refs., 2 figs.

363 (LBL–24200) **Earth Sciences Division annual report, 1987.** Lawrence Berkeley Lab., CA (USA). Sep 1988. 249p. DOE Contract AC03-76SF00098. Order Number DE89008836. Source: NTIS, PC A11/MF A01 - OSTI; GPO Dep.

This report summarizes the activities for 1987. Much of the Division's research deals with the physical and chemical properties and processes in the Earth's crust, from the partially saturated, low-temperature near-surface environment to the high-temperature environments characteristic of regions where magmatic-hydrothermal processes are active. Strengths in laboratory and field instrumentation, numerical modeling, and in situ measurement allow study of the transport of mass and heat through geologic media—studies that now include the appropriate chemical reactions and the hydraulic-mechanical complexities of fractured rock systems. Related and parallel laboratory and field investigations address the effects of temperature, pressure, stresses, pore fluids, and fractures on the elastic and electrical properties of rock masses. These studies are concerned with rock behavior in the brittle and ductile crustal regimes, and they drive the development of improved geomechanical and geophysical tools and techniques for mapping and characterizing heterogeneity in the subsurface. The Division has increased its emphasis on the application of fluid transport modeling and subsurface imaging methods to problems related to discovery and recovery of petroleum. Each of the 166 individual reports is presented in a publication format and contains significant new information.

364 (LBL–24599) **Mass transfer and transport in geologic repositories: Analytical studies and applications.** Pigford, T.H.; Chambre, P.L.; Lee, W.W.L. Lawrence Berkeley Lab., CA (USA). Jan 1988. 8p. DOE Contract AC03-76SF00098. (UCB-NE–4120; CONF-880601–19: ; CONF-880601–). Order Number DE88006349.

Assessing the long-term performance of geologic repositories for radioactive waste requires reliable quantitative predictions of rates of release of radionuclides from the waste into the rock, transport through the geologic media, cumulative release to the accessible environment, and maximum concentrations in ground water and surface water. Here we review theoretical approaches to making these predictions and issues that require resolution. 27 refs.

365 (LBL–25505) **Critical parameters and measurement methods for post closure monitoring: A review of the state of the art and recommendations for further studies.** Morrison, H.F.; Majer, E.L.; Tsang, C.F. Lawrence Berkeley Lab., CA (USA). May 1987. 60p. DOE Contract AC03-76SF00098. Order Number DE89008416. Source: NTIS, PC A04/MF A01 - OSTI; GPO Dep.

Both NRC and EPA regulations require programs of post closure monitoring to detect substantial and detrimental deviations from expected performance. The unexpected in this case would involve anomalous stress changes that might rupture the canisters or changes in the hydrologic regime that might accelerate corrosion. In the event of leakage brought about by any means transport of radionuclides to the accessible environment could occur through unexpected changes in the hydrologic flow regime caused either by the long term effects of the thermal loading by the waste or by changes in regional stress or hydrology. Studies of performance confirmation have identified six parameters or conditions that should be monitored that are associated with the thermal, mechanical and hydrologic phenomena introduced by the waste heat: temperature, stress, displacement, pore pressure, groundwater velocity and permeability. Since it is the thermal load that continues to increase after decommissioning, and which continues to alter the stress field and the hydrological regime, these same six parameters remain the critical ones in post closure monitoring. At two of the repository sites fractures have been clearly shown to be critical in modelling and performance confirmation; at the tuff site fluid saturation is also a critical parameter and for all the sites estimates of the groundwater velocity through the site are very important. Changes in fracture properties, saturation and fluid flow are thus of continuing importance in post closure monitoring. 14 refs., 19 figs.

366 (LBL–26827) **Analytical models for C-14 transport in a partially saturated, fractured, porous media.** Light, W.B. (California Univ., Berkeley, CA (USA). Dept. of Nuclear Engineering); Pigford, T.H.; Chambre, P.L.; Lee, W.W.-L. Lawrence Berkeley Lab., CA (USA). Feb 1989. 9p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC03-76SF00098. (CONF-890928–16: Nuclear waste isolation in the unsaturated zone: FOCUS '89, Las Vegas, NV (USA), 18-21 Sep 1989). Order Number DE90003079. Source: NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.

Interaction between fractures and rock matrix is considered in developing a criterion for treating fractured rock as a porous medium for the purpose of transport calculations. The value of a modified Peclet number determines the suitability of the equivalent porous medium approach. Using a porous medium mode, underground concentrations of $^{14}CO_2$ are predicted for the proposed nuclear waste repository at Yucca Mountain, Nevada. Maximum concentrations near the ground surface are comparable to the USNRC limit for unrestricted areas; travel times are predicted to be hundreds to thousands of years for the assumed parameter values. 8 refs., 7 figs.

367 (LBL–26828) **Release rates of soluble species at Yucca Mountain.** Lee, W.W.-L.; Pigford, T.H. Lawrence Berkeley Lab., CA (USA). Feb 1989. 7p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC03-76SF00098. (CONF-890928–15: Nuclear waste isolation in the unsaturated zone: FOCUS '89, Las Vegas, NV (USA), 18-21 Sep 1989). Order Number DE90003267. Source: NTIS, PC A02/MF A01; OSTI; INIS.

Experimental leaching of spent fuel shows that some fission product species are preferentially released upon contact with water. We analyze the conservative case of bare spent fuel in contact with saturated tuff using diffusional mass transfer analysis. For the parameter values used, the US-NRC release rate limit is not exceeded, except for ^{99}Tc. The presence of a container and the distribution of water contact over time will assist in meeting this criterion. 6 figs., 2 tabs.

368 (NUREG–1347) **NRC staff site characterization analysis of the Department of Energy's Site Characterization Plan, Yucca Mountain Site, Nevada.** Nuclear Regulatory Commission, Washington, DC (USA). Div. of High-Level Waste Management. Aug 1989. 217p. Sponsored by Nuclear Regulatory Commission. Source: NTIS, PC A11/MF A01 - GPO - OSTI.

This Site Characterization Analysis (SCA) documents the NRC staff's concerns resulting from its review of the US Department of Energy's (DOE's) Site Characterization Plan (SCP) for the Yucca Mountain site in southern Nevada, which is the candidate site selected for characterization as the nation's first geologic repository for high-level radioactive waste. DOE's SCP explains how DOE plans to obtain the information necessary to determine the suitability of the Yucca Mountain site for a repository. NRC's specific objections related to the SCP, and major comments and recommendations on the various parts of DOE's program, are presented in SCA Section 2, Director's Comments and Recommendations. Section 3 contains summaries of the NRC staff's concerns for each specific program, and Section 4 contains NRC staff point papers which set forth in greater detail particular staff concerns regarding DOE's program. Appendix A presents NRC staff evaluations of those NRC staff Consultation Draft SCP concerns that NRC considers resolved on the basis of the SCP. This SCA fulfills NRC's responsibilities with respect to DOE's SCP as specified by the Nuclear Waste Policy Act (NWPA) and 10 CFR 60.18. 192 refs., 2 tabs.

369 (NUREG/CR–4134-R2) **Repository environmental parameters and models/methodologies relevant to assessing the performance of high-level waste packages in basalt, tuff, and salt.** Claiborne, H.C.; Croff, A.G.; Griess, J.C.; Smith, F.J. Oak Ridge National Lab., TN (USA). Sep 1987. 244p. DOE Contract AC05-84OR21400. (ORNL/TM–9522-R2). Source: NTIS, PC A11/MF A01 - GPO.

This document provides specifications for models/methodologies that could be employed in determining post-closure repository environmental parameters relevant to the performance of high-level waste packages for the Basalt Waste Isolation Project (BWIP) at Richland, Washington, the tuff at Yucca Mountain by the Nevada Test Site, and the bedded salt in Deaf Smith County, Texas. Guidance is provided on the identify of the relevant repository environmental parameters; the models/methodologies employed to determine the parameters, and the input data base for the models/methodologies. Supporting studies included are an analysis of potential waste package failure modes leading to identification of the relevant repository environmental parameters, an evaluation of the credible range of the repository environmental parameters, and a summary of the review of existing models/methodologies currently employed in determining repository environmental parameters relevant to waste package performance. 327 refs., 26 figs., 19 tabs.

370 (NUREG/CR–4708-Vol.2) **Progress in evaluation of radionuclide geochemical information developed by DOE high-level nuclear waste repository site projects: Report for April 1986–September 1987.** Meyer, R.E.; Arnold, W.D.; Blencoe, J.G.; O'Kelley, G.D.; Land, J.F. Nuclear Regulatory Commission, Washington, DC (USA). Div. of Waste Management; Oak Ridge National Lab., TN (USA). Jul 1988. 65p. DOE Contract AC05-84OR21400. (ORNL/TM–10147-Vol.2). Source: NTIS, PC A04/MF A01 - GPO.

During this report period, all experiments were conducted with tuff from the proposed high-level nuclear waste site at Yucca Mountain, Nevada. Batch sorption ratio determinations were conducted for strontium, cesium, uranium, and technetium onto samples of tuff using real and synthetic groundwater J-13. There were no significant differences in sorption ratios in experiments with real and synthetic groundwater. Columns were tested by determination of elution curves in J-13 containing tritium and technetium as the TcO_4^- ion. For strontium and cesium, fairly good correlation between values of the sorption ratio obtained by the two methods was observed. Little technetium sorption was observed with either method. The elution peaks obtained with neptunium and uranium were asymmetrical and the shapes were often complex, observations which suggest irreversibilities in the sorption reaction. Synthetic groundwater J-13 was slowly dripped onto a slab of tuff maintained at 95–100°C, and the result was a thin encrustation of solids on the slab as the water evaporated. Fresh J-13 groundwater was then allowed to contact the encrustation in a vessel maintained at 90°C. The principal result of the experiment was a significant loss of calcium and magnesium from the fresh J-13 groundwater. 13 refs. 25 figs., 9 tabs.

371 (NUREG/CR–4708-Vol.3) **Progress in evaluation of radionuclide geochemical information developed by DOE high-level nuclear waste repository site projects: Report for October 1987–June 1989.** Meyer, R.E. (Oak Ridge National Lab., TN (USA)); Arnold, W.D.; O'Kelley, G.D.; Case, F.I.; Land, J.F. Nuclear Regulatory Commission, Washington, DC (USA). Div. of Waste Management; Oak Ridge National Lab., TN (USA). Aug 1989. 53p. Sponsored by Nuclear Regulatory Commission. DOE Contract AC05-84OR21400. (ORNL/TM–10147/V3). Source: NTIS, PC A04/MF A01 - GPO; OSTI; INIS.

Information that is being developed by projects within the Department of Energy (DOE) pertinent to the potential geochemical behavior of radionuclides at candidate sites for a high-level radioactive waste repository is being evaluated by Oak Ridge National Laboratory (ORNL) for the Nuclear Regulatory Commission (NRC). During this report period, all experiments were conducted with tuff from the proposed high-level nuclear waste site at Yucca Mountain, Nevada. The principal emphasis in this report period was on column studies of migration of uranium and technetium in water from well J-13 at the Yucca Mountain site. Columns 1 cm in diameter and about 5 cm long were constructed and carefully packed with ground tuff. The characteristics of the columns were tested by determination of elution curves of tritium and TcO_4^-. Elution peaks obtained in past studies with uranium were asymmetrical and the shapes were often complex, observations that suggested irreversibilities in the sorption reaction. To try to understand these observations, the effects of flow rate and temperature on uranium migration were studied in detail. Sorption ratios calculated from the elution peaks became larger as the flow rate decreased and as the temperature increased. These observations support the conclusion that the sorption of uranium is kinetically hindered. To confirm this, batch sorption ratio experiments were completed for uranium as a function of time for a variety of conditions.

372 (NUREG/CR–4735-Vol.2) **Evaluation and compilation of DOE waste package test data: Biannual report, August 1986-January 1987.** Interrante, C.; Escalante, E.; Fraker, A.; Harrison, S.; Shull, R.; Linzer, M.; Ricker, R.; Ruspi, J. National Bureau of Standards, Washington, DC (USA). Metallurgy Div.; Nuclear Regulatory Commission, Washington, DC (USA). Div. of High-Level Nuclear Waste Management. Oct 1987. 136p. Source: NTIS, PC A07/MF A01 - GPO.

This report summarizes results of the National Bureau of Standards (NBS) evaluations of Department of Energy (DOE) activities on waste packages designed for containment of radioactive high-level nuclear waste (HLW). The waste package is a proposed engineered barrier that is part of a permanent repository for HLW. Metal alloys are the principal barriers within the engineered system. Technical discussions are given for the corrosion of metals proposed for the canister, particularly carbon and stainless steels, and copper. In the section on tuff, the current level of understanding of several canister materials is questioned. Within the Basalt Waste Isolation Project (BWIP) section, discussions are given on problems concerning groundwater, materials for use in the metallic overpack, and diffusion through the packing. For the proposed salt site, questions are raised on the work on both ASTM A216 Steel and Ti-Code 12. NBS work related to the vitrification of HLW borosilicate glass at the West Valley Demonstration Project (WVDP) and the Defense Waste Processing Facility (DWPF) is covered. NBS reviews of selected DOE technical reports and a summary of current waste-package activities of the Materials Characterization Center (MCC) is presented. Using a database management system, a computerized database for storage and retrieval of reviews and evaluations of HLW data has been developed and is described. 17 refs., 2 figs., 2 tabs.

373 (NUREG/CR–4735-Vol.3) **Evaluation and compilation of DOE waste package test data: Biannual report, February 1987–July 1987.** Interrante, C.; Escalante, E.; Fraker, A.; Hall, D.; Harrison, S.; Liggett, W.; Linzer, M.; Ricker, R.; Ruspi, J.; Shull, R. National Bureau of Standards, Washington, DC (USA). Metallurgy Div. May 1988. 159p. Source: NTIS, PC A08/MF A01 - GPO.

The waste package is a proposed engineering barrier that is part of a permanent repository for HLW. Metal alloys are the principal barriers within the engineered system. Technical discussions are given for the corrosion of metals proposed for the canister, particularly carbon steels, stainless steels, and copper. The current level of understanding of several canister materials is questioned for the candidate repository in tuff. Three issues are addressed, the possibility of the stress-induced failure of Zircaloy, the possible corrosion of copper and copper alloys, and the lack of site-specific characterization data. Discussions are given on problems concerning localized corrosion and environmentally assisted cracking of AISI 1020 steel at elevated temperatures (150°C). For the proposed salt site, the importance of the duration of corrosion tests and some of the conditions that may preclude prompt initiation of needed long-term testing are two issues that are discussed. 31 refs., 5 figs.

374 (NUREG/CR–4735-Vol.4) **Evaluation and compilation of DOE waste package test data: Biannual report, August 1987–January 1988.** Interrante, C.; Escalante, E.; Fraker, A.; Ondik, H.; Plante, E.; Ricker, R.; Ruspi, J. Nuclear Regulatory Commission, Washington, DC (USA). Office of Nuclear Material Safety and Safeguards; National Bureau of Standards, Washington, DC (USA). Aug 1988. 181p. Source: NTIS, PC A09/MF A01 - GPO.

This report summarizes results of the National Bureau of Standards (NBS) evaluations on waste packages designed for containment of radioactive high-level nuclear waste (HLW). The waste package is a proposed engineered barrier that is part of a permanent repository for HLW. Metal alloys are the principal barriers within the engineered system. Since enactment of the Budget Reconciliation Act for Fiscal Year 1988, the Yucca Mountain, Nevada, site (in which tuff is the geologic medium) is the only site that will be characterized for use as high-level nuclear waste repository. During the reporting period of August 1987 to January 1988, five reviews were completed for tuff, and these were grouped into the categories: ferrous alloys, copper, groundwater chemistry, and glass. Two issues are identified for the Yucca Mountain site: the approach used to calculate corrosion rates for ferrous alloys, and crevice corrosion was observed in a copper-nickel alloy. Plutonium can form pseudo-colloids that may facilitate transport. NBS work related to the vitrification of HLW borosilicate glass at the West Valley Demonstration Project (WVDP) and the Defense Waste Processing Facility (DWPF) and activities of the DOE Materials Characterization Center (MCC) for the 6-month reporting period are also included. 27 refs., 3 figs.

375 (NUREG/CR–4735-Vol.5) **Evaluation and compilation of DOE [Department of Energy] waste package test data: Biannual report, February 1988–July 1988.** Interrante, C.; Escalante, E.; Fraker, A.; Plante, E. Nuclear Regulatory Commission, Washington, DC (USA). Div. of High-Level Waste Management; National Inst. of Standards and Technology, Gaithersburg, MD (USA). Metallurgy Div. Oct 1989. 156p. Sponsored by Nuclear Regulatory Commission. Source: NTIS, PC A08/MF A01 - GPO; OSTI; INIS.

This report summarizes evaluations by the National Institute of Standards and Technology (NIST) of Department of Energy (DOE) activities on waste packages designed for containment of radioactive high-level nuclear waste (HLW) for the six month period February 1988 through July 1988. Activities for the DOE Materials Characterization Center are reviewed for the period January 1988 through June 1988. A summary is given of the Yucca Mountain, Nevada disposal site activities. Short discussions relating to the reviewed publications are given and complete reviews and evaluations are included. 20 refs., 1 fig., 1 tab.

376 (NUREG/CR–5092) **Progress in evaluation of radionuclide geochemical information developed by DOE high-level nuclear waste repository site projects: Report for April 1986-September 1987.** Meyer, R.E.; Arnold, W.D.; Blencoe, J.G.; O'Kelley, G.D.; Land, J.F. Nuclear Regulatory Commission, Washington, DC (USA). Div. of Waste Management; Oak Ridge National Lab., TN (USA). Feb 1988. 64p. DOE Contract AC05-84OR21400. (ORNL/TM–10707). Source: NTIS, PC A04/MF A01 - GPO.

Experiments were conducted with tuff from the proposed high-level nuclear waste site at Yucca Mountain, Nevada. Batch sorption ratio determinations were conducted for strontium, cesium, uranium, and technetium onto samples of tuff using real and synthetic groundwater J-13. There were no significant differences in sorption ratios in experiments with real and synthetic groundwater. Columns 1 cm in diameter and about 5 cm long were constructed, and experiments were conducted with the objective of correlating the results of batch and the column experiments. The characteristics of the columns were tested by determination of elution curves in J-13 containing tritium and technetium as the TcO_4^- ion. For strontium and cesium, fairly good correlation between values of the sorption ratio obtained by the two methods was observed. Little or no technetium sorption was observed with either method. The elution peaks obtained with neptunium and uranium were asymmetrical and the shapes were often complex, observations which suggest irreversibilities in the sorption reaction. An experiment was performed to provide information on the compositions of the first groundwaters that will contact waste canisters in a tuff-hosted repository after very near field temperatures have cooled to below 100°C. Synthetic groundwater J-13 was slowly dripped onto a slab of tuff maintained at 95-100°C, and the result was a thin encrustation of solids on the slab as the water evaporated. Fresh J-13 groundwater was then allowed to contact the encrustation in a vessel maintained at 90°C. The principal result of the experiment was a significant loss of calcium and magnesium from the fresh J-13 groundwater.

377 (NUREG/CR–5255) **Stable isotopes of authigenic minerals in variably-saturated fractured tuff.** Weber, D.S.; Evans, D.D. Nuclear Regulatory Commission, Washington, DC (USA). Div. of Engineering; Arizona Univ., Tucson, AZ (USA). Dept. of Hydrology and Water Resources. Nov 1988. 71p. Source: NTIS, PC A05/MF A01 - GPO.

Identifying stable isotope variation and mineralogical changes in fractured rock may help establish the history of climatic and geomorphological processes that might affect the isolation properties of a waste repository site. This study examines the use of the stable isotope ratios of oxygen ($^{18}O/^{16}O$) and carbon ($^{13}C/^{12}C$) in authigenic minerals as hydrogeochemical tools tracing low-temperature rock-water interaction in variably-saturated fractured stuff. Isotopic compositions of fracture-filling and rock matrix minerals in the Apache Leap tuff, near Superior, Arizona were concordant with geothermal temperatures and in equilibrium with water isotopically similar to present-day meteoric water and groundwater. Oxygen and carbon isotope ratios of fracture-filling, in unsaturated fractured tuff, displayed an isotopic gradient believed to result from near-surface isotopic enrichment due to evaporation rather than the effects of rock-water interaction. Oxygen isotope ratios of rock matrix opal samples exhibited an isotopic gradient believed to result from, leaching and reprecipitation of silica at depth. Methods and results can be used to further define primary flowpaths and the movement of water in variably-saturated fractured rock. 71 refs., 23 figs., 3 tabs.

378 (NUREG/CR–5335) **Stability of disposal rooms during waste retrieval.** Brandshaug, T. Nuclear Regulatory Commission, Washington, DC (USA). Div. of High-Level Waste Management; Itasca Consulting Group, Inc., Minneapolis, MN (USA). Mar 1989. 100p. Source: NTIS, PC A05/MF A01 - GPO - OSTI.

This report presents the results of a numerical analysis to determine the stability of waste disposal rooms for vertical and horizontal emplacement during the period of waste retrieval. It is assumed that waste retrieval starts 50 years after the initial emplacement of the waste, and that access to and retrieval of the waste containers take place through the disposal rooms. It is further assumed that the disposal rooms are not back-filled. Convective cooling of the disposal rooms in preparation for waste retrieval is included in the analysis. Conditions and parameters used were taken from the Nevada Nuclear Waste Storage Investigation (NNWSI) Project Site Characterization Plan Conceptual Design Report (MacDougall et al., 1987). Thermal results are presented which illustrate the heat transfer response of the rock adjacent to the disposal rooms. Mechanical results are presented which illustrate the predicted distribution of stress, joint slip, and room deformations for the period of time investigated. Under the assumption that the host rock can be classified as "fair to good" using the Geomechanics Classification System (Bieniawski, 1974), only light ground support would appear to be necessary for the disposal rooms to remain stable. 23 refs., 28 figs., 2 tabs.

379 (NUREG/CR–5336) **Sensitivity of the stability of a waste emplacement drift to variation in assumed rock joint parameters in welded tuff.** Christianson, M. Nuclear Regulatory Commission, Washington, DC (USA). Div. of High-Level Waste Management; Itasca Consulting Group, Inc., Minneapolis, MN (USA). Apr 1989. 215p. Source: NTIS, PC A10/MF A01 - GPO - OSTI.

This report presents the results of a numerical analysis to determine the effects of variation of rock joint parameters on stability of waste disposal rooms for vertical emplacement. Conditions and parameters used were taken from the Nevada Nuclear Waste Storage Investigation (NNWSI) Project Site Characterization Plan Conceptual Design report (MacDougall et al., 1987). Mechanical results are presented which illustrate the predicted distribution of stress, joint slip, and room deformations for times of initial excavation and after 50 years heating. 82 refs., 93 figs.

380 (NUREG/CR–5367) **Comparison of strongly heat-driven flow codes for unsaturated media.** Updegraff, C.D. (GRAM, Inc., Albuquerque, NM (USA)). Nuclear Regulatory Commission, Washington, DC (USA). Div. of Engineering; Sandia National Labs., Albuquerque, NM (USA); GRAM, Inc., Albuquerque, NM (USA). Aug 1989. 102p. Sponsored by Nuclear Regulatory Commission. DOE Contract AC04-76DP00789. (SAND–88-7145). Source: NTIS, PC A06/MF A01 - GPO - OSTI.

Under the sponsorship of the US Nuclear Regulatory Commission, Sandia National Laboratories (SNL) is developing a performance assessment methodology for the analysis of long-term disposal of high-level radioactive waste (HLW) in unsaturated welded tuff. As part of this effort, SNL evaluated existing strongly heat-driven flow computer codes for simulating ground-water flow in unsaturated media. The three codes tested, NORIA, PETROS, and TOUGH, were compared against a suite of problems for which analytical and numerical solutions or experimental results exist. The problems were selected to test the abilities of the codes to simulate situations ranging from simple, uncoupled processes, such as two-phase flow or heat transfer, to fully coupled processes, such as vaporization caused by high temperatures. In general, all three codes were found to be difficult to use because of (1) built-in time stepping criteria, (2) the treatment of boundary conditions, and (3) handling of evaporation/condensation problems. A drawback of the study was that adequate problems related to expected repository conditions were not available in the literature. Nevertheless, the results of this study suggest the need for thorough investigations of the impact of heat on the flow field in the vicinity of an unsaturated HLW repository.

Recommendations are to develop a new flow code combining the best features of these three codes and eliminating the worst ones. 19 refs., 49 figs.

381 (NUREG/CR–5390) **Rock mass modification around a nuclear waste repository in welded tuff.** Mack, M.G. (Itasca Consulting Group, Inc., Minneapolis, MN (USA)); Brandshaug, T.; Brady, B.H. Nuclear Regulatory Commission, Washington, DC (USA). Div. of High-Level Waste Management; Itasca Consulting Group, Inc., Minneapolis, MN (USA). Aug 1989. 90p. Sponsored by Nuclear Regulatory Commission. Source: NTIS, PC A06/MF A01 - GPO; OSTI; INIS.

This report presents the results of numerical analyses to estimate the extent of rock mass modification resulting from the presence of a High Level Waste (HLW) repository. Changes in rock mass considered are stresses and joint deformations resulting from disposal room excavation and thermal efffects induced by the heat generated by nuclear waste. rock properties and site conditions are taken from the Site Characterization Plan Conceptual Design Report for the potential repository site at Yucca Mountain, Nevada. Analyses were conducted using boundary element and distinct element methods. Room-scale models and repository-scale models were investigated for up to 500 years after waste emplacement. Results of room-scale analyses based on the thermoelastic boundary element model indicate that a zone of modified rock develops around the disposal rooms for both vertical and horizontal waste emplacement. This zone is estimated to extend a distance of roughly two room diameters from the room surface. Results from the repository-scale model, which are based on the thermoelastic boundary element model and the distinct element model, indicate a zone with modified rock mass properties starting approximately 100 m above and below the repository, with a thickness of approximately 200 m above and 150 m below the repository. Slip-prone subhorizontal features are shown to have a substantial effect on rock mass response. The estimates of rock mass modification reflect uncertainties and simplifying assumptions in the models. 32 refs., 57 figs., 1 tab.

382 (NUREG/CR–5400) **Basis for in-situ geomechanical testing at the Yucca Mountain site.** Board, M. (Itasca Consulting Group, Inc., Minneapolis, MN (USA)). Nuclear Regulatory Commission, Washington, DC (USA). Div. of High-Level Waste Management; Itasca Consulting Group, Inc., Minneapolis, MN (USA). Jul 1989. 112p. Sponsored by Nuclear Regulatory Commission. Source: NTIS, PC A06/MF A01 - GPO - OSTI.

This report presents an analysis of the in-situ geomechanical testing needs for the Exploratory Shaft (ES) test facility at the Yucca Mountain site in Nevada. The testing needs are derived from 10CFR60 regulations and simple thermomechanical canister- and room-scale numerical studies. The testing approach suggested is based on an "iterative" procedure of full-scale testing combined with numerical and empirical modeling. The testing suggested is based heavily on demonstration of excavation and thermal loading of full-scale repository excavations. Numerical and/or empirical models are compared to the full-scale response, allowing for adjustment of the model and evaluation of confidence in their predictive ability. Additional testing may be specified if confidence in prediction of the rock mass response is low. It is suggested that extensive drifting be conducted within the proposed repository area, including exploration of the bounding Drill Hole Wash and Imbricate fault structures, as well as the Ghost Dance fault. This approach is opposed to an a priori statistical specification of a number of "point" tests which attempt to measure a given property at a specific location. 40 refs., 49 figs., 6 tabs.

383 (NUREG/CR–5426) **Examination of the use of continuum versus discontinuum models for design and performance assessment for the Yucca Mountain site.** Board, M. (Itasca Consulting Group, Inc., Minneapolis, MN (USA)). Nuclear Regulatory Commission, Washington, DC (USA). Div. of High-Level Waste Management; Itasca Consulting Group, Inc., Minneapolis, MN (USA). Aug 1989. 70p. Sponsored by Nuclear Regulatory Commission. Source: NTIS, PC A05/MF A01 - GPO; OSTI; INIS.

This report examines the use of continuum and discontinuum numerical methods for analysis of the thermomechanical response of the rock mass at Yucca Mountain. Continuum numerical methods consider the rock to be a solid, unfractured body, whereas the discontinuum method is formulated specifically to account for the effects of discrete fractures. The fractures within the rock introduce overall non-linear material response due to slip and separation of rock blocks. Continuum models attempt to simulate this response through the use of non-linear constitutive laws. Discontinuum methods attempt to simulate the true response of the rock mass by correctly modeling the behavior of the joints as well as the deformability of the intact rock blocks. It is shown that, as the joint spacing, s, becomes small with respect to the size of the excavations, the behavior of the jointed rock approaches that of a solid with a form of elasto-plastic constitutive behavior. It is concluded that a continuum model with a form of "ubiquitous" or "compliant joint" plasticity law is probably sufficient for analysis of the thermomechanical response of excavations in welded tuff. However, one of the questions concerning Yucca Mountain which remains is the effect of fault structures on the stability performance of the repository, particularly under thermal and dynamic loads. Here, a true discontinuum approach seems necessary. 45 refs., 42 figs., 4 tabs.

384 (NUREG/CR–5427) **Analysis of emplacement borehole rock and liner behavior for a repository at Yucca Mountain.** Lorig, L.J. (Itasca Consulting Group, Inc., Minneapolis, MN (USA)); Dasgupta, B. Nuclear Regulatory Commission, Washington, DC (USA). Div. of High-Level Waste Management; Itasca Consulting Group, Inc., Minneapolis, MN (USA). Sep 1989. 137p. Sponsored by Nuclear Regulatory Commission. Source: NTIS, PC A07/MF A01 - GPO; OSTI; INIS.

This report presents the results of studies aimed at assessing the quasi-static behavior of both the rock surrounding an emplacement borehole and the lining within an emplacement borehole for a nuclear waste repository in tuff. Two-dimensional thermomechanical analyses of conditions similar to those representative of the horizontal emplacement option were performed using a distinct element code. Three different behavior models (equivalent continuum, wedge, and parallel joint) were used to investigate the state of deformation at 0 and 100 years following waste emplacement. Three different rock strength assumptions were studied corresponding to "design," "recommended" and "limit" values given in the Nevada Nuclear Waste Storage Investigation (NNWSI) Project Site Characterization Plan Conceptual Design Report (MacDougall et al., 1987). The ground reaction curve concept is introduced to study the potential liner loading resulting from thermally induced borehole closure. The report concludes that for the conditions and parameters assumed, liners may not be significantly loaded by borehole closure, because predicted closures will likely be less than tolerances required to install the lining. The report also concludes that gravity loading of linings by blocks which fall from the surrounding rock should not overstress the lining. 25 refs., 51 figs., 14 tabs.

385 (NUREG/CR–5428) **Variation of heat loading for a repository at Yucca Mountain.** Brandshaug, T. (Itasca Consulting Group, Inc., Minneapolis, MN (USA)). Nuclear Regulatory Commission, Washington, DC (USA). Div. of High-Level Waste Management; Itasca Consulting Group, Inc., Minneapolis, MN (USA). Sep 1989. 57p. Sponsored by Nuclear Regulatory Commission. Source: NTIS, PC A04/MF A01 - GPO; OSTI; INIS.

This report presents the results of numerical analyses to determine the range in container pitch (i.e., the spacing between vertically emplaced containers), disposal room extraction ratio, and waste stand-off distance that will satisfy design criteria expressed for a repository at Yucca Mountain. Effects are investigated for a range in thermal properties of the rock represented by the "saturated" and "dry" conditions expressed in Chapter 2 of the SCPCDR. A number of heat transfer analyses were performed for a time period of 50 years after initial waste emplacement. Within this period, temperatures have peaked in the vicinity of the waste containers. The analyses included three-dimensional heat transfer models that account for the explicit interaction of single waste containers emplaced in a repository panel. Vertical and horizontal waste emplacement concepts of commingled SF and DHLW were investigated. The analyses indicate that the configuration of container boreholes and extraction ratio, as well as the stand-off distance to waste proposed in the SCPCDR, Chapter 4, could result in the development of temperatures that exceed design goals currently expressed in the SCP and the SCPCDR. 8 refs., 25 figs., 3 tabs.

386 (PNL–6329) **Spent nuclear fuel as a waste form for geologic disposal: Assessment and recommendations on data and modeling needs.** Van Luik, A.E.; Apted, M.J.; Bailey, W.J.; Haberman, J.H.; Shade, J.S.; Guenther, R.E.; Serne, R.J.; Gilbert, E.R.; Peters, R.; Williford, R.E. Pacific Northwest Lab., Richland, WA (USA). Sep 1987. 271p. DOE Contract AC06-76RL01830. Order Number DE88001692. Source: NTIS, PC A12/MF A01; GPO Dep.

This study assesses the status of knowledge pertinent to evaluating the behavior of spent nuclear fuel as a waste form in geologic disposal systems and provides background information that can be used by the DOE to address the information needs that pertain to compliance with applicable standards and regulations. To achieve this objective, applicable federal regulations were reviewed, expected disposal environments were described, the status of spent-fuel modeling was summarized, and information regarding the characteristics and behavior of spent fuel was compiled. This compiled information was then evaluated from a performance modeling perspective to identify further information needs. A number of recommendations were made concerning information still needed to enhance understanding of spent-fuel behavior as a waste form in geologic repositories. 335 refs., 22 figs., 44 tabs.

387 (PNL-SA–15538) **Gas-water-rock interactions during isothermal boiling in partially saturated tuff at 100°C and 0.1 MPa.** Arthur, R.C.; Murphy, W.M. Pacific Northwest Lab., Richland, WA (USA). Jun 1988. 34p. DOE Contract AC06-76RL01830. (CONF-8807129–1: 1. international symposium on the thermodynamics of natural processes, Strasbourg, FR, July 25, 1988). Order Number DE89003137. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

Mass-transfer calculations using the Rayleigh distillation equation and EQ3/6 show that porewaters in the candidate high-level nuclear waste repository at Yucca Mountain, Nevada, will be strongly affected by open-system boiling at 100°C and 0.1 MPa. Variations in pH range from +1 to +4 units, and are caused by volatile weak electrolyte interactions as $Co_2(g)$ exsolves from the aqueous phase. Protolysis of H_4SiO_4 and mineral-solution reactions can moderate the increase in pH initially, but are not effective when boiling vaporizes more than approximately 0.2 wt % of the water. The host rocks will be affected by boiling because differences in the chemical potentials of components in the aqueous phase and minerals are created by the increases in pH. Experiments using carbonated solutions in closed systems are inappropriate for simulating water-rock interactions in this repository at temperatures greater than 100°C. 25 refs., 6 figs., 2 tabs.

388 (PNL-SA–15624) **Performance assessment for spent fuel waste packages at the candidate Nevada repository site.** Reimus, P.W.; Liebetrau, A.M.; Apted, M.J.; Engel, D.W. Pacific Northwest Lab., Richland, WA (USA). Oct 1988. 6p. DOE Contract AC06-76RL01830. (CONF-880903–36: Spectrum '88: international topical meeting on nuclear and hazardous waste management, Pasco, WA, US, September 11, 1988). Order Number DE89001513. Source: NTIS, PC A02/MF A01.

The Analytical Repository Source-Term (AREST) code is being developed for the US Department of Energy (DOE) as a preliminary performance assessment tool for evaluating waste package behavior in various geologic repository settings. In response to the 1987 amendments to the Nuclear Waste Policy Act of 1982, the code is being enhanced to provide specific assessments of waste package performance in the hydrologically unsaturated welded tuff geology of the candidate repository site at Yucca Mountain, Nevada. Modifications to the code are being made in each of three major functional areas: near-field environment modeling, waste package containment modeling, and waste package release modeling. This paper focuses specifically on the third of these, enhancements to radionuclide release modeling for spent fuel waste packages. 7 refs., 1 fig.

389 (SAND–86-2357) **OGR [Office of Geologic Repositories] repository-specific rod consolidation study: Effect on costs, schedules, and operations at the Yucca Mountain repository.** O'Brien, P.D. (Sandia National Labs., Albuquerque, NM (USA)). Sandia National Labs., Albuquerque, NM (USA). Dec 1988. 123p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AC04-76DP00789. Order Number DE89012947. Source: NTIS, PC A06/MF A01 - OSTI; GPO Dep.

This report compares repository life-cycle costs and assesses operational trade-offs for waste management scenarios with and without spent fuel rod consolidation. The study is specific to a geologic repository being considered for location in the tuff formations at Yucca Mountain, on and near the Nevada Test Site in southern Nevada. Four cases are considered. In Cases 1 and 2, intact spent fuel is received directly from the nuclear utilities; and in Cases 3 and 4, most of the fuel is received from a Monitored Retrievable

Storage (MRS) facility. Case 1 features at-repository consolidation, whereas in Case 2 the fuel is packaged and emplaced as intact fuel assemblies. Case 3 assumes at-MRS consolidation, and Case 4 assumes no consolidation either at the MRS or at the repository. The total life-cycle cost for the Case 1 (reference) repository is about $6.6 billion (in 1986 dollars). In Case 2, "intact" disposal saves $0.5 billion and offers a number of operational advantages. The presence of an MRS in the waste management system reduces repository costs, with or without at-MRS consolidation. Life-cycle costs for Cases 3 and 4 are, respectively, $1.2 billion and $1.0 billion less than the Case 1 cost; thus, consolidation at the MRS reduces the repository cost by $0.2 billion. Operationally, the MRS is advantageous in that it eliminates–or, rather, transfers to the MRS–the most difficult and complex operations in the preparation of spent fuel for disposal. 9 refs., 27 figs., 15 tabs.

390 (SAND–87-7171) **Optimization of mechanical/corrosion properties of TI-CODE 12 plate and sheet: Part 2, Thermomechanical processing effects.** Schultz, R.W.; Hall, J.A. Titanium Metals Corp. of America, Henderson, NV (USA). Henderson Technical Lab. Jan 1988. 114p. DOE Contract AC04-76DP00789. Order Number DE88007493. Source: NTIS, PC A06/MF A01; GPO Dep.

In an effort to determine and subsequently optimize mechanical and corrosion properties of the TI-CODE 12 alloy for DHLW container application, a two-stage study was conducted. Stage I was directed toward evaluation of the effect of compositional variations, within ASTM specification limits, on specific mechanical and corrosion properties of TI-CODE 12. Compositional variables investigated were weight percent molybdenum, nickel, oxygen, and iron. Compositional ranges of TI-CODE 12 were identified which correspond to select combinations of desirable properties. Stage II program objectives include evaluation of five distinct thermomechanical processes with respect to TI-CODE 12 0.25 inch (6.35mm) plate and 0.070 inch (1.78mm) sheet corrosion and mechanical propreties, with subsequent selection of a process route which achieves optimum properties. In addition to addressing effects of intermediate recrystallization and cross-rolling steps for reduction of property directionality, the influence of final product anneal is examined. In particular, the influence of a conventional mill anneal at 1450°F (788°C) is compared to that of the sub-eutectoid 1250°F (677°C) annual which is known to facilitate precipitation of nickel-rich intermetallic compound in TI-CODE 12. sup (18,19,20). Specific alloy properties considered include tensile strength and ductility, bend ductility, slow strain rate fracture toughness, creep strength, and general and crevice corrosion resistance. 24 refs., 25 figs., 24 tabs.

391 (SAND–88-0437C) **The importance of scenario development in meeting 40 CFR Part 191.** Hunter, R.L. Sandia National Labs., Albuquerque, NM (USA). 1988. 7p. DOE Contract AC04-76DP00789. (CONF-880201–10: Waste management '88: symposium on radioactive waste management, Tucson, AZ, US, February 26, 1988). Order Number DE88006105. Source: NTIS, PC A02/MF A01; GPO Dep.

Scenario development and screening is a fundamental part of performance assessment, but its importance in satisfying a standard is sometimes underestimated. The first step in scenario development in support of performance assessment for the standard's containment requirements is to identify a set of potentially disruptive events and processes. This set must be broad enough to allow the identification, as required by the standard, of those processes and events that might affect the disposal system; data can then be collected on the scenarios identified in this step. The standard also requires that releases be estimated for all significant processes and events; thus the final step in scenario development is systematically screening the scenarios, on the basis of their probabilities and consequences, to select those that are important enough to be modeled in detail. In general, a few hundred scenarios for the release of radionuclides from a nuclear-waste repository can be identified, but only a few of these can or should be modeled in detail. Without a description of the broad suite of scenarios that were originally considered, the regulator and the public would have difficulty in determining whether consequence modeling has been carried out for the appropriate processes and events. 17 refs.

392 (SAND–88-1507C) **Generalized simulation system for repository design.** Griesmeyer, J.M. Sandia National Labs., Albuquerque, NM (USA). May 1988. 5p. DOE Contract AC04-76DP00789. (CONF-890304–1: 3. topical meeting on robotics and remote systems, Charleston, SC, US, March 13, 1989). Order Number DE88011202. Source: NTIS, PC A02/MF A01 - OSTI; GPO Dep.

An object oriented, discrete event simulation system has been developed for evaluation of radioactive waste repository design and operations. A flexible modeling system is required because many of the requirements for the waste repository at Yucca Mountain in Nevada have not been determined. For example, shipping cask designs are currently being developed, the decisions as to whether and where fuel assemblies would be consolidated or buried intact have not been made, and the split between rail and truck shipments to the repository has not been determined. The simulation system is being used to investigate the impact of using advanced handling equipment, such as robotic systems, as well as other options on repository operations. 1 fig.

393 (UCRL–21055) **Thermochemistry of uranium compounds: XVI, Calorimetric determination of the standard molar enthalpy of formation at 298.15 K, low-temperature heat capacity, and high-temperature enthalpy increments of $UO_2(OH)_2 \cdot H_2O$ (schoepite).** Tasker, I.R.; O'Hare, P.A.G.; Lewis, B.M.; Johnson, G.K.; Cordfunke, E.H.P. Lawrence Livermore National Lab., CA (USA); Argonne National Lab., IL (USA). Aug 1987. 17p. DOE Contract W-7405-ENG-48. Order Number DE88010715. Source: NTIS, PC A03/MF A01; GPO Dep.

Three precise calorimetric methods, viz., low-temperature adiabatic, high-temperatuare drop, and solution-reaction, have been used to determine as a function of temperature the key chemical thermodynamic properties of a pure sample of schoepite, $UO_2(OH)_2 \cdot H_2O$. The following results have been obtained at the standard reference temperature T = 298.15 K:standard molar enthalpy of formation $\Delta_f H^0_m(T)$ = −1825.4 +- 2.1 kJ mol^{-1}; molar heat capacity $C^0_{p.m}(T)$ = 172.07 +- 0.34 JK^{-1}; and the standard molar entropy $S^0_m(T)$ = 188.54 +- 0.38 JK^{-1} mol^{-1}. The molar enthalpy increments relative to 298.15 K and the molar heat capacity are given by the polynomials: $\{H^0_m(T) - H^0_m(298.15\ K)\}/(J\ mol^{-1})$ = −38209.0 + 84.2375 (T/K) + 0.1472958 $(T/K)^2$ and $C^0_{p.m}(T)/(JK^{-1}\ mol^{-1})$ = 84.238 + 0.294592 (T/K), where 298.15 K $<$ T $<$ 400 K. The present result for $\Delta^f H^0_m$ at 298.15 K has been combined with three other closely-agreeing values from the literature to give a recommended weighted mean $\Delta_f H^0_m$ = −1826.4 +- 1.7 kJ mol^{-1}, from which is calculated the standard Gibbs energy of formation $\Delta_f G^0_m$ = −1637.0 +- 1.7 kJ mol^{-1} at 298.15 K. Complete thermodynamic properties of schoepite are tabulated from 298.15 to 423.15 K. 19 refs., 6 tabs.

394 (UCRL–53615-86, pp. 43-46) **Nuclear waste management.** Lawrence Livermore National Lab., CA (USA). Jul 1987. In *Earth sciences annual report, 1986.* 43-46p. Order Number DE88000821. Source: NTIS, PC A04/MF A01.

The Nuclear Waste Management Group's primary mission is to manage projects sponsored by the DOE Office of Civilian Radioactive Waste Management (OCRWM) through the Nevada Nuclear Waste Storage Investigations, Salt Repository Project, Repository Technology Program and Basalt Waste Isolation Program offices. The technical activities are carried out jointly with other groups in the Earth Sciences Department, with other divisions and departments at LLNL, and with contractors. The OCRWM program at LLNL comprises three major activities plus support to the DOE in additional areas. These activities are the design and evaluation of a waste package for a tuff repository; the improvement, use and maintenance of the geochemical code, EQ 3/6; and the Spent Fuel Test - Climax. This paper describes activities in waste package research and development, geochemical modeling, the Spent Fuel Test-Climax, and Canadian cooperative technology. A list of recent publications is given. 32 references.

395 (UCRL–53615-86, pp. 37-42) **Experimental geophysics.** Lawrence Livermore National Lab., CA (USA). Jul 1987. In *Earth sciences annual report, 1986.* 37-42p. Order Number DE88000821. Source: NTIS, PC A04/MF A01.

The Experimental Geophysics Group conducts research in rock properties, magma rheology, high-pressure physics using the diamond-anvil cell, and crystal growth. In 1986 the group measured the physical properties of materials ranging from ice to rock to xenon to magma over an extremely wide range of pressures and temperatures. This work, conducted in support of the Laboratory's energy, defense, and research programs, deepened the understanding of the physics of the earth and planets as well as the physics of phase transformations at high pressures. This paper discusses rock properties, crystal growth and electrical conductivity, high pressure studies, ice mechanics, stress gauge development effect of nonhydrostatic stress on chemical potential, and magma rheology. A list of recent publications is given. 29 references.

396 (UCRL–102033) **Hydrology and radionuclide migration at the Nevada Test Site.** Buddemeier, R.W.; Finkel, R.C.; Marsh, K.V.; Ruggieri, M.R.; Rego, J.H.; Silva, R.J. Lawrence Livermore National Lab., CA (USA). Oct 1989. 27p. Sponsored by U.S. DOE Defense Programs. DOE Contract W-7405-ENG-48. (CONF-891120–4: Migration '89: 2nd international conference on chemistry and migration behavior of actinides and fission products in the geosphere, Monterey, CA (USA), 6-10 Nov 1989). Order Number DE90002225. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

We have compared the transport behavior in various environments of radionuclides originating from underground nuclear tests at the Nevada Test Site (NTS). Under saturated conditions in both alluvium and fractured volcanic rock, ^{36}Cl, ^{129}I, and ^{3}H exhibit mutually consistent and presumably conservative behavior during saturated flow. At the saturated fractured rock site, ^{99}Tc was conservative under most conditions, but was not present in samples containing high levels of iron oxyhydroxides formed in the well water. ^{125}Sb and ^{137}Cs transport was observed in fracture flow, but concentrations of Sb were somewhat attenuated and Cs was strongly retarded. Total activity levels of these nonconservative nuclides were not affected by the particulate phenomena that reduced ^{99}Tc levels. Studies of transport in unsaturated alluvium showed that neither ^{36}Cl nor ^{129}I were conservative relative to tritium. Observations of the relative transport behavior of the radionuclides as functions of both time and distance permit deductions about the nature of their source terms. 11 refs., 9 figs.

397 (USGS-BULL–1831) **Index of granitic rock masses in the state of Nevada: A compilation of data on 205 areas of exposed granitic rock masses in Nevada.** Geological Survey, Denver, CO (USA). 1988. 81p. Sponsored by U.S. DOE Radioactive Waste Management. DOE Contract AI08-78ET44802. Order Number DE89014818. Source: NTIS, PC A06/MF A01; OSTI - USGS, Federal Center, Box 25425, Denver, CO 80225; GPO Dep.

The compilation of 205 areas of exposed granitic rock in Nevada was undertaken for the US Department of Energy. The purpose was to obtain data for evaluating granitic rock masses as potential underground nuclear waste repositories. Information, compiled by county for areas of granitic rock exposure, includes general location, coordinates, land classification, areal extent, accessibility, composition, age, rocks intruded, aeromagnetic expression, mining activity, and selected references. 49 refs., 18 figs., 3 tabs.

398 (USGS-OFR–88-366) **Bibliography of reports by US Geological Survey personnel on studies at the Nevada Test Site, released between January 1 and December 31, 1986.** Glanzman, V.M. Geological Survey, Denver, CO (USA). 1988. 18p. DOE Contract AI08-86NV10583. Order Number DE88013210. Source: NTIS, PC A03/MF A01; GPO Dep.

Reports listed in this bibliography include information on underground nuclear testing and waste management projects at the Nevada Test Site (NTS). The bibliography is divided into reports regarding underground nuclear testing, and waste management studies for the Nevada Nuclear Waste Storage Investigations Project (NNWSI). Reports are listed in each category by publication outlet and number. The USS-474- series report pertain to underground nuclear testing studies, and are cross referenced to administrative (or in-house) series. The administrative series numbers are used to break down the USGS-474- series for more specific area identification.

399 (WHC-SA–0102) **An introduction to technical issues important to geologic repository preclosure safety.** Babad, H.; Dukelow, J.S. Jr. Westinghouse Hanford Co., Richland, WA (USA). Feb 1988. 10p. DOE Contract AC06-87RL10930. (CONF-880354–9: Waste management '88, Tucson, AZ, US, March 1, 1988). Order Number DE88013581. Source: NTIS, PC A02/MF A01; GPO Dep.

Preclosure safety assessment for construction, operation, caretaking, and decommissioning is required by the US Nuclear Regulatory Commission (NC) regulations as part of a license application for nuclear waste repositories. This paper will present a variety of design and safety analysis issues addressed as part of the preclosure safety analysis of nuclear waste repositories. The definition of the issues and suggested approaches to resolving the issues will be presented. These technical issues arose during the process of defining site-specific issue resolution strategies related to design and preclosure safety (Key Issue 2) in the Office of Geologic Repositories Issues Hierarchy. These issue resolution strategies are described in the Basalt Waste Isolation Project (BWIP) Site Characterization Plan. Participation in the US Department of Energy (DOE) Preclosure Risk Assessment Methodology (PRAM) Working Group has also helped to define the open technical issues. 9 refs.

400 (WSRC-RP–89-547-Rev.1) **Recommended changes to waste acceptance preliminary specifications: Revision 1.** Ramsey, A.M.; Plodinec, M.J. Westinghouse Savannah River Co., Aiken, SC (USA). 11 Jul 1989. 36p. Sponsored by U.S. DOE Defense Programs. DOE Contract AC09-89SR18035. Order Number DE90000589. Source: NTIS, PC A03/MF A01 - OSTI; GPO Dep.

SRL, in conjunction with the DWPF, has been developing the detailed evidence that the DWPF product will be able to comply with the repository's Waste Acceptance Preliminary Specifications (WAPS) for the DWPF product. Based on this effort, as well as the subsequent publication of the Yucca Mountain Project's Site Characterization Plan (SCP), revisions to three of the WAPS are recommended. These include: substitution of the DWPF Product Consistency Test for the MCC-1 leach test in the radionuclide release specification; a change of the canister leaktightness specification from a gas leaktightness basis to a water leaktightness basis; and a clarification of the canister handling specification to avoid redesign of the DWPF grapple. 3 figs., 4 tabs.

401 (Y/OWI–9, pp. 39-52) **Nevada Test Site.** Laughon, R.B. Union Carbide Corp., Oak Ridge, TN (USA). Office of Waste Isolation. Apr 1978. DOE Contract AC05-84OS21400. In *National Waste Terminal Storage Program: Progress report, October 1, 1976-September 30, 1977.* 39-52p. Source: NTIS, PC A18/MF A01.

Results of investigations of the geology and hydrology of the Nevada Test Site are reported. The projects described are being carried out by several branches of the Geologic Division and by the Water Resources Division of the USGS. A small part of the effort in Geologic Investigations of the Eleana Formation is in support of heater experiments being operated by Sandia Laboratories. In addition, some of the FY 1977 activities at the Climax stock were in support of Lawrence Livermore Laboratory's heater experiment.

402 **Nuclear Waste Policy Act Amendments Act of 1987. Introduced in the United States Senate, One Hundredth Congress, First Session, September 1, 1987.** Report 100-152. 223p. Government Printing Office, (1987).

The purpose of the bill is to redirect the program for the management and disposal of spent nuclear fuel and high-level radioactive waste under the Nuclear Waste Policy Act of 1982 (NWPA) to provide for: (1) sequential characterization of candidate sites for a geologic repository for disposal of nuclear waste; (2) construction of a monitored retrievable storage facility for spent nuclear fuel as part of an integrated nuclear waste management system; and (3) benefits payments with respect to a repository or a monitored retrievable storage facility to States, Indian tribes and units of local government as appropriate. Section-by-section changes are noted in the Summary of major provisions. The following statements are included: John S. Herrington, Secretary of Energy, January 29, 1987; Ben C. Rusche, Director, Office of Civilian Radioactive Waste Management, DOE, April 28, 1987; Donald L. Vieth, Waste Management Project Office, Nevada Operations Office, DOE, June 29, 1987; John H. Anttonen, Basalt Waste Isolation Project, Richland Operations Office, DOE, June 29, 1987; Ben C. Rusche, July 16, 1987; Hugh L. Thompson, Office of Nuclear Material Safety and Safeguards, US NRC, April 28, 1987; and Robert Borneo, same office, US NRC, June 29, 1987. Also included is a report by Elizabeth Peelle, Energy Division, Oak Ridge National Lab., The MRS Task Force: Economic and Non-economic Incentives for Local Public Acceptance of a Proposed Nuclear Waste Packaging and Storage Facility.

403 **Scientific basis for nuclear waste management VIII. Volume 44.** Jantzen, C.M.; Stone, J.A.; Ewing, R.C. 991p. Materials Research Society, Pittsburgh, PA (1989).

This book is a compilation of 117 papers presented at a symposium that emphasized the performance of radioactive waste package materials under simulated repository hydrogeochemical conditions. The volume will be of interest especially to geochemists, hydrologists, and materials scientists and engineers, and to numerical modelers of the complex flow and transport systems that have radioactive components. Advances in the understanding of leaching of glass and concrete, radiation damage to solids, and radioactive waste processing technology are emphasized and are based largely on lab experiments and simulations. Geologists, geochemists, and hydrologists will find the papers bearing on aspects of basalt, tuff, and salt a useful adjunct to book VII.

404 **Scientific basis for nuclear waste management VII. Volume 26.** McVay, G.L. 1099p. Materials Research Society, Elsevier, NY (1983).

This volume is a compilation of 122 papers presented at a 1983 symposium that emphasized high-level radioactive waste disposal investigations. This is a valuable collection of scientific and engineering studies and program summaries made by field and laboratory geoscientists, materials engineers, and their managers. The book will be of interest especially to geologists, hydrologists, geochemists, materials scientists and engineers, and numerical modelers concerned with rock/mineral/glass-ground-water radionuclide-thermal interactions in natural settings and simulations for time periods of thousands of years. Worldwide site investigations discussed in this volume concentrate on basalt (Columbia River basalt in Washington), tuff (ash-flow tuff in southern Nevada), bedded salt (New Mexico, Texas, Utah), domal salt (Mississippi, Germany), and granitic rocks (throughout the US, Sweden). This compendium provides readers the flavor of advances in the understanding of groundwater flow and radionuclide transport in deep geologic settings, of waste package corrosion, and of the effects that certain combinations of water-rock characteristics and processes might have on an underground waste repository. It is also valuable as a source book of data and references related to high-level radioactive waste disposal in underground repositories.

405 **Role of geostatistical, sensitivity, and uncertainty analysis in performance assessment.** Brandstetter, A. (Battelle Office of Waste Technology Development, Willowbrook, IL (USA)); Buxton, B.E. pp. 89-110 of Geostatistical, sensitivity, and uncertainty methods for ground-water flow and radionuclide transport modeling. Proceedings. Buxton, B.E. (ed.). Battelle Memorial Institute, Columbus, OH (1989). pp. 658 (CONF-870971–: Geostatistical sensitivity and uncertainty methods for groundwater flow and radionuclide transport modeling conference, San Francisco, CA (USA), 15-17 Sep 1987).

The overall US Civilian Radioactive Waste Management Program is briefly described for the benefit of participants not familiar with the program or recent developments. The Nuclear Waste Policy Act of 1982 is summarized. A status report is given on the selection of the Texas, Nevada, and State of Washington sites for site characterization leading to the recommendation of a site for a first repository. The current activities of the second repository project are then described, and the relationship between the first and second repository projects is defined. The regulatory basis for performance assessment is identified, covering descriptions of the numerical standards imbedded in 40 CFR Part 191, 10 CFR Part 60, and 10 CFR Part 960. The requirements for considering uncertainties stated in these regulations and draft technical positions of the US Nuclear Regulatory Commission are summarized. The importance of geostatistical, sensitivity, and uncertainty analyses and their relative merits are pointed out. The sources of uncertainties are identified, and current methods for geostatistical, sensitivity, and uncertainty analyses are reviewed.

406 Chemical and textural surface features of pyroclasts from hydrovolcanic eruption sequences. Wohletz, K.H. (Los Alamos National Lab. (US)). Clastic particles: Scanning electron microscopy and shape analysis of sedimentary and volcanic clasts. Marshall, J.R. Van Nostrand Reinhold Co. Inc., (1987). pp. 79-97

The purpose of this paper is to examine the vertical textural variations observed in stratigraphic sections of ash and show how these can be related to the eruptive history of volcanic vents. Samples were systematically taken from near-vent localities in vertical sequences of ash layers. Both size distributions and petrologic (chemical) constraints are among the features used in interpretation of textural features of the ash samples. The samples studied in this report were taken from four small (less than 2 km diameter) volcanoes: Crater Elegante and Cerro Colorado in Sonora, Mexico, and Panum Crater and Obsidian Dome, California. All four are typical volcanoes formed by hydrovolcanic eruptions. Crater Elegante is a basaltic tuff ring and Cerro Colorado is a tuff cone. The California examples are rhyolitic tuff rings. All are less than 10^5 years old. The significance of selecting these four volcanoes is that their pyroclasts have been formed by explosive mixing of meteoric water with magma as it approached the surface.

407 Learning from nuclear waste repository design: the ground-control plan. Schmidt, B. (Parsons, Brinckerhoff, San Francisco, CA (USA)). pp. 11-19 of VI Australian tunnelling conference. Volume 1. Australasian Institute of Mining and Metallurgy, Parkville, Australia (1987). pp. 358 (CONF-8703300–: 6. Australian tunnelling conference, Melbourne (Australia), Mar 1987).

With mining development on hold and other underground works in a slowdown, the development of nuclear waste repositories takes center stage on the American rock engineering scene. Three repositories for commercial spent fuel - in salt, tuff, and basalt - are in the phase of site characterization and conceptual design, and one pilot project for defense high-level waste in salt is under construction. A repository design for crystalline rock has recently been postponed. Because of strict quality assurance requirements throughout design and construction, and because of the need to predict and ascertain in advance the satisfactory performance of the underground openings, much intellectual energy has been expended to analyze underground openings in the usual circumstances of the repository environment. In the long term, these efforts will lead to an improved understanding of rock behavior and improved methods of underground analysis and design. For the shorter term, a formalised ground control plan was developed, the principles of which may be applied to other types of projects. This paper summarizes the status of underground design and construction for nuclear waste repositories and presents some details of the ground control plan and its individual elements. 6 figs.

408 Risk perception and intended behavior. Mushkatel, A. (School of Public Affairs, Arizona State Univ., Tempe, AZ (US)); Nigg, J.; Pijawka, D. pp. 103-110 of Waste management '88. Post, R.G. University of Arizona Nuclear Engineering Dept., Tucson, AZ (1988). vp. of (CONF-880201–: Waste management '88: symposium on radioactive waste management, Tucson, AZ (USA), 28 Feb - 3 mar 1988).

This paper reviews the approach taken to assess the social impacts of the proposed high-level nuclear waste repository at Yucca Mountain, Nevada on residents in the closest metropolitan area, Las Vegas. The purpose of this portion of the assessment is to investigate the effects of the repository on the future well-being and behavior of Las Vegas residents under different operational futures of the repository. To investigate these effects, a research design and conceptual framework were developed to collect data from a random sample of Las Vegas metropolitan area residents. The design allows for the collection of both baseline data (to determine current risk perceptions and behaviors) and projected effects of the repository under four different operational futures.

409 Measurement of thermal conductivity and thermal expansion at elevated temperatures and pressures. Van Buskirk, R. (Terra Tek, Inc., University Research Park, 420 Wakara Way, Salt Lake City, UT 84108); Enniss, D.; Schatz, J. Measurement of rock properties at elevated pressures and temperatures. Pincus, H.J.; Hoskins, E.R. ASTM, (1985). pp. 108-127 (CONF-830605–: 24. symposium on rock mechanics, College Station, TX, US, June 20, 1983).

Laboratory procedures and equipment have been developed to measure thermal response of rock under a simulated in situ environment of overburden stress, pore fluid pressure, and temperature. Routine tests are conducted up to 250^{0}C, with stress levels to 100 MPa, on basalt, shale, tuff, and sandstone. High-pressure high-temperature use of the transient "needle-probe" heat source technique for the measurement of thermal conductivity is discussed. Considerations in the design of the thermal apparatus, which maximize stability and minimize error, are included. Laboratory procedures used, calibration techniques, and overall accuracy of the testing are reviewed. Thermal conductivity and thermal expansion are measured on equipment calibrated by using fused quartz as a standard. Uncertainty of calibrations caused by some inconsistency in published values for fused quartz is discussed. Methodical specimen preparation, frequent calibrations and computer test control, and data reduction allow accuracy to be maximized and relatively long-term tests to be conducted with a high degree of repeatability. Where possible, results of the tests are compared with previously published values. A suite of data obtained in support of studies on a potential nuclear waste repository in tuff is examined. Comparisons of theoretical thermal conductivities and expansions, derived from the behavior of the mineral constituents of the rock, and the measured responses are made. The advantages of these systems lie in the relative ease by which specimens may be tested at elevated temperatures and pressures, and the repeatability of the results. The accuracies (which are dependent upon calibration accuracies) are well within the range of engineering investigations.

410 Fracture system characterization for unsaturated rock. Evans, D.D. (Univ. of Arizona, Tucson, AZ 85721 (USA)); Rasmussen, T.C.; Nicholson, T.J. Waste management '87: Waste isolation in the US, technical programs, and public education. Post, R.G. University of Arizona Nuclear Engineering Dept., (1987). pp. 209-212 (CONF-870306–: Waste management '87, Tucson, AZ, US, March 1, 1987).

Techniques for estimating fluid flow through fractured volcanic tuffs are presented. The techniques include water infiltration and air flow tests on exposed rock surfaces, cross-hole borehole air flow tests along fracture planes, and fluid losses from a slanted borehole in the unsaturated zone. The methods demonstrate that methodologies are available for characterizing fracture flow through saturated fractures. The ability to characterize flow and solute transport through partially-saturated fracture networks has not been demonstrated.

411 Monitoring of heat and moisture migration from radioactive waste disposed in an augered shaft. Williams, R.E. (Reynolds Electrical and Engineering Co., Inc., P.O. Box 14400, Las Vegas, NV 89114); Mc Grath, D.A.; Boland, J.R. Waste management '87: Waste isolation in the US, technical programs, and public education. Post, R.G. University of Arizona Nuclear Engineering Dept., (1987). pp. 381-386 (CONF-870306–: Waste management '87, Tucson, AZ, US, March 1, 1987).

Soil temperature and moisture data have been collected for the past 4 years at the Greater Confinement Disposal Test (GCDT) being conducted at the Nevada Test Site. High-specific-activity radioactive waste with a thermal output of 3.4 kW was buried at a depth of 30 m in tuffaceous alluvium. Prior to waste emplacement the ambient subsurface temperature was about 17^{0}C and the volumetric soil moisture content was 10-12%. Two years after waste emplacement the soil temperature exceeded 100^{0}C and the soil moisture content dropped below 4% at a radius of approximately 3 m from the thermal waste. Drying of the soil has occurred as the high temperature radiating from the thermal sources propels water vapor from the waste zone to a zone where dew-point temperatures are reached. The temperature and moisture data will be used in combination with data from gaseous tracer release tests in predicting and appraising the long-term performance of the GCDT.

412 Dispute resolution in the nuclear waste repository program. Creighton, J.L. (Creighton and Creighton, Inc., Palo Alto, CA (US)); Shorett, A.J. pp. 447-452 of Waste management '88. Post, R.G. University of Arizona Nuclear Engineering Dept., Tucson, AZ (1988). vp. of (CONF-880201–: Waste management '88: symposium on radioactive waste management, Tucson, AZ (USA), 28 Feb - 3 mar 1988).

During 1987 a seven-person team addressed just that question for the State of Washington, as part of the studies of the socioeconomic impacts of a possible nuclear waste repository site at the Hanford site. The authors were, respectively, the Mitigation/Compensation team leader and the conflict resolution specialist within the team. While the studies were terminated when Congress selected the Nevada site, the conclusions may still have value for the State of Nevada, or for other controversial federal projects.

413 Feasibility assessment of copper-base waste package container materials in nuclear waste repositories sited in basalt and tuff. Gause, E.P. (Roy F. Weston, Inc., 955 L'Enfant Plaza, SW, Washington, DC 20024 (US)); Abraham, N. Waste management '87: Waste isolation in the US, technical programs, and public education. Post, R.G. University of Arizona Nuclear Engineering Dept., (1987). pp. 501-508 (CONF-870306–: Waste management '87, Tucson, AZ, US, March 1, 1987).

In early 1984, the United States Department of Energy Office of Civilian Radioactive Waste Management (DOE-OCRWM) established a two-year program (FY 1985 and FY 1986) to evaluate the use of copper and copper alloys in basalt and tuff repository environments in accordance with Congressional directive. The Basalt Waste Isolation Project (BWIP) and the Nevada Nuclear Waste Storage Investigation (NNWSI) Project concluded that copper-base materials are feasible as candidate container materials in a repository sited in a basalt or tuff environment. The feasibility of using copper materials in containers was qualitatively assessed using the following criteria: 1) container design and development; 2) preclosure safety (e.g., fabrication or emplacement risks); 3) repository interfaces (e.g., handling of containers); 4) retrievability considerations; 5) containment (mainly corrosion considerations); 6) radionuclide release (container/waste interactions); and 7) cost and availability. Weighting factors were not used and no comparison to other candidate disposal container materials was made. This paper details the results of testing, literature reviews, and evaluations that were performed for each of the seven criteria on each of the three conceptual container designs. The designs were as follows: A thick-walled Cupronickel 90-10 pressure vessel (BWIP); a copper monolith made by the HIP (hot isostatic pressing) process (BWIP); and a thin-walled aluminum bronze or Cupronickel 70-30 pressure vessel (NNWSI Project). A brief discussion of future plans to evaluate copper-base materials is presented for the BWIP and NNWSI Project.

414 Evaluation of disposal site geochemical performance using a containment factor. Lerman, A. (Dept. of Geological Sciences, Northwestern Univ., Evanston, IL (US)); Domenico, P.A.; Bartlett, J.W. pp. 633-638 of Waste management '88. Post, R.G. University of Arizona Nuclear Engineering Dept., Tucson, AZ (1988). vp. of (CONF-880201–: Waste management '88: symposium on radioactive waste management, Tucson, AZ (USA), 28 Feb - 3 mar 1988).

The containment factor is a measure of retention by geologic setting of wastes released from a repository. The factor is alternatively defined either in terms of several measurable hydrological and geochemical parameters, or in terms of amounts of waste components that may be released to the geologic setting and, subsequently, to the environment. Containment factors for individual waste components in a given geologic setting are functions of groundwater to rock volume ratios, sorption or exchange characteristics of the rocks, and containment time to groundwater travel time ratios. For high-level radioactive wastes, containment factors based on the NRC and EPA limit values for cumulative releases from waste and to the environment provide a measure of the geochemical performance of the geologic setting in tuff, basalt, and salt. The containment factor values for individual nuclides from high-level wastes indicate that for some of the nuclides containment may be achieved by groundwater travel time along. For other nuclides, additional performance functions need to be allocated to geochemical retention by such processes as sorption, ion-exchange or precipitation.

415 Surface reactions of natural glasses. White, A.F. (Univ. of California, Lawrence Berkeley Lab., Berkeley, CA (US)). pp. 713-722 of Nuclear waste management II. Passchier, W.F.; Bosnjakovic, B.F.M. American Ceramic Society Inc., Westerville, OK (1986). v.v of (CONF-8608225–: 3. international symposium on ceramics in nuclear waste management, Chicago, IL, USA, 28-30 Aug 1986).

Reactions at natural glass surfaces are important in studies involving nuclear waste transport due to chemical control on ground water in host rocks such as basalt and tuff, to potential diffusion into natural hydrated glass surfaces and as natural analogs for waste glass stability. Dissolution kinetics can be described by linear surface reaction coupled with cation interdiffusion with resulting rates similar to those of synthetic silicate glasses. Rates of Cs diffusion into hydrated obsidian surfaces between 25^0 and 75^0C were determined by XPS depth profiles and loss rates from aqueous solutions. Calculated diffusion coefficients were ten others of magnitude more rapid than predicted from an Arrhenius extrapolation of high temperature tracer diffusion data due to surface hydration reactions.

416 Disposal of spent nuclear fuel and high-level waste: design and technical/economic analysis. Roglans-Ribas, J. Thesis (Ph. D.). 269p. Iowa State Univ., (1987). Source: University Microfilms, PO Box 1764, Ann Arbor, MI 48106, Order No. 87-21,927.

An economic model for the back end of the nuclear fuel cycle was developed for a once-through cycle, a standard reprocessing cycle, and a reprocessing cycle with fractionation of Cs and St. A parametric thermal analysis was performed for waste emplaced in five different geologic formations: salt, granite, basalt, shallow tuff, and deep tuff. The results of the thermal analysis, in the form of maximum permissible loadings, were incorporated into the economic model. The economic analysis was performed for a variety of situations in order to compare the five possible repository host rocks, the three different back end cycles, and different locations of the Monitored Retrievable Storage Facility (MRS). The maximum permissible thermal loadings in granite and tuff were relatively high, whereas for basalt the thermal loadings are very restricted for both spent fuel and reprocessed waste and for salt the loadings are very restricted for spent fuel only. A repository in basalt always resulted in higher costs than in any other rock; the other repository media yield comparable costs, except in the case of spent fuel disposal in salt, where the costs are higher. Co-location of the MRS with the repository results in a lower system cost. The regular reprocessing cycle present the lower storage plus disposal costs among the three cycles studied, and disposal of spent fuel has the highest costs associated. The model proved to be very sensitive to variations of the discount rate, the storage facility capital cost, and the delay of repository backfilling after waste emplacement. Lower waste storage plus disposal costs can be obtained by delaying disposal in the fractionation waste cycle in any rock or disposal of any waste form in basalt. In the other cases, aging the waste before disposal does not reduce, in general, the total cost.

417 Nevada's predicament: public perceptions of risk from the proposed nuclear waste repository. Kunreuther, H. (Univ. of Pennsylvania, Pittsburgh (USA)); Desvousges, W.H.; Slovic, P. *Environment (USA),* 30(8): 17-18 (Oct 1988).

After fifteen years of vigorous national debate about a possible site for storing high-level radioactive waste from commercial power plants in the United States, the US Congress on 22 December 1987 amended the Nuclear Waste Policy Act of 1982 and authorized the Department of Energy (DOE) to determine whether Yucca Mountain, Nevada, is a geologically sound and technically feasible site. If this site passes a set of prescribed technical criteria, a repository will be constructed 2000 feet below ground in which nuclear waste shipped in casks from power plants all over the United States will be permanently stored. The state of Nevada is currently attempting to disqualify the Yucca Mountain site on the grounds that the storage of nuclear wastes at the site and the transportation of waste to Nevada pose unacceptable risks to the state's population. There is also concern that the addition of a repository to an area that already houses a nuclear weapons testing site may create an image of Nevada as a nuclear wasteland. Elected officials appear to be skeptical of the merits of the siting process and are concerned that the repository could stigmatize Nevada, thus affecting economic activity. These concerns provide a rational for investigating public attitudes toward the siting of a high-level nuclear waste repository in Nevada or elsewhere. In order to address this issue, we conducted two telephone surveys; a national sample of 1201 US households and a sample of 1001 residents of Nevada. These surveys are part of a larger study commissioned by the Nuclear Waste Project Office in the state of Nevada to determine the potential socioeconomic effects of the construction there of a high-level waste repository.

418 Wasting of Nevada. Davis, J.A. *Sierra (USA),* 73(4): 31-35 (Jul 1988).

Congress has chosen Yucca Mountain, Nevada as the nation's only permanent repository for high-level radioactive wastes. In an opinion poll conducted among 1200 residents in December, 74% said the state should do everything in its power to stop the development of the repository. The governor of Nevada feels that the state should not be forced to accept something it does not want. The Nuclear Waste Policy Act of 1982 established the process of siting a high-level radioactive waste repository. It also gives states the right to evaluate the siting process independently, and authorizes federal grants to help them do so. The state of Nevada received an $11-million grant last year, which it will use to marshal the expertise it will need to evaluate and respond to DOE studies.

419 Learning from nuclear waste repository design: The ground-control plan. Schmidt, B. (Parsons, Brinckerhoff, Quade and Douglas, Inc., San Francisco, CA (USA)). *AIMM Bulletin Proceedings (Australia),* 293(4): 67-73 (Jun 1988).

With mining development on hold and other underground works in a slowdown, the development of nuclear waste repositories takes centre stage on the American rock engineering scene. Three repositories for commercial spent fuel - in salt, tuff, and basalt-are in the phase of site characterisation and conceptual design, and one pilot project for defense high-level waste in salt is under construction. A repository design for crystal line rock has recently been postponed. Because of strict quality assurance requirements throughout design and construction, and because of the need to predict and ascertain in advance the satisfactory performance of the underground openings, underground openings have been analysed in the usual circumstances of the repository environment. These efforts will lead to an improved understanding of rock behaviour and improved methods of underground analysis and design. A formalised ground control plan was developed. This paper summarises the status of underground design and construction for nuclear waste repositories and presents some details of the ground control plan and its individual elements.

420 **Nevada wins the nuclear waste lottery.** Marshell, E. *Science (Washington, D.C.) (USA),* 239: 15 (1 Jan 1988).

A new law has been attached to the budget reconciliation bill for 1988. It directs the Department of Energy (DOE) to stop exploratory work at two of three sites already chosen as candidates for a waste repository. From now on, the investigation is to focus exclusively on a third site at Yucca Mountain, a desert area of volcanic tuff about 110 miles from Las Vegas. It will become the national burial ground for all spent reactor fuel, unless researchers find in the next 5 to 7 years that it is not environmentally fit. If the Nevada site fails to measure up, the secretary of energy is directed to return to Congress for further instructions.

421 **Politics and promises of nuclear waste disposal: the view from Nevada.** Bryan, R.H. *Environment (USA),* 29(8): 14-17, 32-38 (Oct 1987).

DOE's betrayal of the principles and standards of the Nuclear Waste Policy Act (NWPA) has distorted the agency's repository-siting decisions. Leadership is needed to make midcourse corrections and to return to the promise of state-federal cooperation on which the act was built. NWPA managed to incorporate the interests of diverse factions into a decision-making process that was viewed as an equitable and workable solution to the nation's nuclear waste disposal dilemma. The House of Representatives subcommittees report documents conclusively a substantial and pervasive bias in favor of the selection of sites at Yucca Mountain and Hanford and a politization of the siting process.

422 **Sorption of $^{106}RuO_4$ vapours on natural tuff with mordenite admixture.** Kepak, F. (Ustav Jaderneho Vyzkumu CSKAE, Rez, Czechoslovakia); Kanka, J.; Koutova, S. *Jaderna Energie (Czechoslovakia),* 33(4): 139-142 (Apr 1987). (In Czech).

The dependence was determined of the sorption of $^{106}RuO_4$ vapours on natural tuff with an admixture of mordenite. Studied were the effects of temperature, the length of the sorption packing, the sorbent grain size, the flow rate of the gas of the sorption packing and other parameters. The lowest passage of $^{106}RuO_4$ (ca 0.07%) through the sorption packing was achieved at a temperature of 300 degC, a gas flow rate through the sorbent of 4.7 $cm.s^{-1}$ and a packing length of 10 cm. (author) 5 tabs., 5 figs., 10 refs.

423 **Survey of ^{14}C literature relevant to a geologic nuclear waste repository.** Liepins, L.Z.; Thomas, K.W. *Radioactive Waste Management (Switzerland),* 10(4): 357-380 (Jun 1988).

An overview of information available in the open literature relevant to the disposal and potential release of carbon-14 from a high level waste repository is presented. Estimates of carbon-14 releases from hypothetical repositories taken from, or based on referenced material are presented. 81 refs.; 1 figure; 7 tabs.

424 **Distribution of calcium carbonate in desert soils: A model.** Mayer, L.; McFadden, L.D.; Harden, J.W. *Geology (USA),* 16: 303-306 (Apr 1988).

A model that describes the distribution of calcium carbonate in desert soils as a function of dust flux, time, climate, and other soil-forming factors shows which factors most strongly influence the accumulation of carbonate and can be used to evaluate carbonate-based soil age estimates or paleoclimatic reconstructions. Models for late Holocene soils have produced carbonate distributions that are very similar to those of well-dated soils in New Mexico and southern California. These results suggest that (1) present climate is a fair representation of late Holocene climate, (2) carbonate dust flux can be approximated by its Holocene rate, and (3) changes in climate and/or dust flux at the end of the Pleistocene effected profound and complex changes in soil carbonate distributions. Both higher carbonate dust flux and greater effective precipitation are required during the latest Pleistocene-early Holocene to explain carbonate distributions in latest Pleistocene soils. 21 refs., 4 figs., 1 tab.

425 **Nevada v. Herrington: an ineffective check on the DOE.** Karkut, J.E. *Journal of Energy Law and Policy (USA),* 8(2): 301-318 (1988).

In this decision, the United States Court of Appeals for the Ninth Circuit held that Nevada was entitled to Department of Energy (DOE) funding for certain hydrologic and geologic studies of the Yucca Mountain site. This site is located in Nye County, Nevada and could be selected as America's first high-level nuclear-waste repository. The studies' purpose is to provide independent state examination of the area's repository suitability. The court applied statutory construction principles to the Nuclear Waste Policy Act of 1982 (NWPA) to reach its decision. The decision has significance for its support of states' pre-site characterization funding rights, for the manner in which the court determined that DOE was not acting within the scope of the NWPA, and for underlying concerns left unaddressed. This Note provides background for and analysis of this decision. Factors necessitating the NWPA's passage are outlined, followed by a sketch of the events leading to this lawsuit. The court's review standard and NWPA analysis based on the statute's language and underlying congressional intent are explained. The decision is then analyzed and critiqued. Finally, a perspective viewing DOE as dangerously out of touch with NWPA statutory mandates and unrestrained in the repository selection process is expressed.

426 **Evaluating the risk of climate change to nuclear waste disposal.** Craig, R.G. (Kent State Univ., OH (USA)). *Journal of the International Association for Mathematical Geology (USA),* 20(5): 567-588 (Jul 1988).

A hierarchy of models is being developed to represent the changes in climate that could occur in the next 10,000 years at proposed nuclear waste repository sites in the US. Three levels of modeling of the global aspects of climate change are included. At the broadest level a multitude of theoretical representations are being considered, most based upon the Milankovitch theory. A set of at least 150 situations will be examined, and those of concern for site stability will be screened for more thorough analysis at the next level of detail. The screening criteria include estimation of the probability of the event; the level of probability which must be considered (0.0001) requires use of the most detailed paleoclimatic records available. Uncertainty in the results will be evaluated by comparison of model reconstructions to the paleoclimatic record and by Monte Carlo analyses.

427 Fe-oxide microcrystals in welded tuff from southern Nevada: origin of remanence carriers by precipitation in volcanic glass. Schlinger, C.M. (Univ. of Utah, Salt Lake City (USA)); Rosenbaum, J.G.; Veblen, D.R. *Geology (USA),* 16(6): 556-559 (Jun 1988).

Although it is widely recognized that remanent magnetism in ash-flow tuffs is carried by fine-grained Fe oxides, the origin, mineralogy, and significance of such magnetic carriers are not well understood. The authors have obtained transmission electron microscope images of distinctive Fe-oxide microcrystals in rhyolitic samples located 3.8, 7.6, and 18.5 m above the base of a 110-m-thick section of the Miocene Tiva Canyon Member of the Paintbrush Tuff. The Fe-oxide microcrystals are lath shaped and increase in size from 20 x 140 nm in the lowermost sample (near base of the member) to 120 x 800 nm in the uppermost sample (within the flow interior). Microcrystals in this size range are within or close to the range of single-domain grain size for magnetite. Electron diffraction and analytical X-ray data indicate that the microcrystals in the lower two samples are cubic Fe-oxides (magnetite/maghemite), with less than 10 mol% Ti end member, and that those in the uppermost sample are manganiferous hematite. Systematic variations in magnetic properties are consistent with the observed variations in size and mineralogy of the microcrystals. These microcrystals are morphologically distinct from grains that the authors interpret to be fragments of phenocrysts. The morphology and spatial distribution of the microcrystals as well as their increase in grain size, from the rapidly cooled base of the ash-flow sheet into the flow interior, are consistent with an origin by nucleation and growth from volcanic glass at elevated temperature, subsequent to emplacement.

428 Geologic repositories for radioactive waste: the nuclear regulatory commission geologic comments on the environmental assessment. Justus, P.S. (Nuclear Regulatory Commission, Washington, DC (USA)); Trapp, J.S.; Westbrook, K.B.; Lee, R.; Blackford, M.B.; Rice, B. *Geological Society of America, Abstracts with Programs (USA),* 17: 621 (1985). (CONF-8510489–: 98. annual meeting of the Geological Society of America, Orlando, FL, US, October 28, 1985).

The NRC staff completed its review of the Environmental Assessments (EAs) issued by the Department of Energy (DOE) in December, 1984, in support of the site selection processes established by the Nuclear Waste Policy Act of 1982 (NWPA). The EAs contain geologic information on nine sites that DOE has identified as potentially acceptable for the first geologic repository in accordance with the requirements of NWPA. The media for the sites vary from basalt at Hanford, Washington, tuff at Yucca Mountain, Nevada, bedded salt in the Palo Duro Basin, Texas and Paradox Basin, Utah, to salt domes in Mississippi and Louisiana. Despite the diversity in media there are common areas of concern for all sites. These include; structural framework and pattern, rates of tectonic and seismic activity, characterization of subsurface features, and stratigraphic thickness, continuity and homogeneity. Site-specific geologic concerns include: potential volcanic and hydrothermal activity at Yucca Mountain, potential hydrocarbon targets and deep basalt and sub-basalt structure at Hanford, and potential dissolution at all salt sites. The NRC comments were influenced by the performance objectives and siting criteria of 10 CFR Part 60 and the environmental protection criteria in 40 CFR Part 191, the applicable standards proposed by EPA. In its review the NRC identified several areas of geologic concern that it recommended DOE re-examine to determine if alternative or modified conclusions are appropriate.

429 Nevada may lose nuclear waste funds. Marshall, E. *Science (Washington, D.C.) (USA),* 240: 1727 (24 Jun 1988).

The people of Nevada are concerned that a cut in DOE funding for a nuclear waste repository at Yucca Mountain, Nevada will result in cuts in the state monitoring program, e.g. dropping a seismic monitoring network and a sophisticated drilling program. Economic and social impact studies will be curtailed. Even though a provision to curtail local research forbids duplication of DOE's work and would limit the ability of Nevada to go out and collect its own data, Nevada State University at Las Vegas would receive a nice plum, a top-of-the-line supercomputer known as the ETA-10 costing almost $30 million financed by DOE.

Corporate Author Index

This index lists the corporate authors responsible for issuing the documents in this publication which are identified primarily by report number. The corporate names are entered in standardized forms as defined in *DOE Energy Data Base: Corporate Author Entries* (DOE/TIC-4585). Each entry under a corporate name includes the document title and citation number. Three items of information may appear in parentheses: (1) an abbreviation to identify the document type, such as a report; (2) the country of publication, also abbreviated; and (3) the language of the document if non-English (R;US;In French). Author affiliations are not listed in this index.

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Personal Author Index

Authors' surnames are indexed in the form appearing in the publication cited; given names generally have been reduced to initials. For documents with multiple authors, each author name is indexed. The entry for a primary author (first author listed on an abstracted document) includes the full document title and citation number. Entries for other authors provide a cross-reference to the primary author. Also included is information on the document type, country of publication, and the document language listed in parentheses in the format (J;FR;In French and English). Accent marks are not input because of computer alphabetization. Spelling and transliteration follow standard conventions.

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Subject Index

This index is arranged by subject descriptors selected from those assigned to each citation in this publication. Subject descriptors are selected from a controlled thesaurus of terms, *EDB Subject Thesaurus* (DOE/OSTI-7000). In order to enhance indexing, subject descriptor entries generally consist of a pair of descriptors: a main term and a qualifier term. Each entry includes the full title (which may be followed by supplementary descriptive information in parentheses) and the citation number. Additional information given in parentheses indicates the document type (an abbreviation such as B for book), the country of publication (such as DE for Federal Republic of Germany), and the language if non-English.

See references guide users from synonymous terms to the descriptors selected for the concept. *See also* references indicate subject concepts that are more specific than a particular descriptor. To gain complete subject coverage, all such terms should be reviewed.

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Contract Number Index

Numbers assigned to DOE contracts announced in documents in this publication are listed. Contract numbers are sorted alphanumerically and list the primary corporate author of the document cited, the citation number, and the report number or other document identification.

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Report Number Index

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35	89:7	NTIS, PC A06/MF A01 - OSTI	E 1.99:	DE89006930	MF-70
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36	89:286	NTIS, PC A99/MF A01		DE88010553	MF-707
T3	89:287	NTIS, PC A02/MF A01		DE88017320	MF-702
DOE/NV/10384–					
17	89:288	NTIS, PC A04/MF A01	E 1.99:	DE87014485	MF-11
18	89:289	NTIS, PC A03/MF A01	E 1.99:	DE88005454	MF-11
DOE/NV/10461–					
T1-Vol.1	89:290	NTIS, PC A07/MF A01 - OSTI; GPO Dep.	E 1.99:	DE89012958	MF-721; MF-702
T1-Vol.2	89:291	NTIS, PC A04 - OSTI		DE89011489	MF-721

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T1-Vol.3	89:292	NTIS, PC A03/MF A01 - OSTI	E 1.99:	DE89011488	MF-721
T1-Vol.4	89:293	NTIS, PC A03/MF A01 - OSTI	E 1.99:	DE89011487	MF-721
T1-Vol.5	89:294	NTIS, PC A03/MF A01 - OSTI	E 1.99:	DE89011486	MF-721
T1-Vol.6	89:295	NTIS, PC A06/MF A01 - OSTI	E 1.99:	DE89011485	MF-721
T1-Vol.7	89:296	NTIS, PC A08/MF A01 - OSTI	E 1.99:	DE89011490	MF-70
T1-Vol.8	89:297	NTIS, PC A05/MF A01 - OSTI	E 1.99:	DE89011493	MF-721
T10	89:306	NTIS, PC A05/MF A01; OSTI; INIS		DE90004719	MF-814
T11	89:307	NTIS, PC A03/MF A01; OSTI; INIS		DE90004720	MF-814
T12	89:308	NTIS, PC A03/MF A01; OSTI; INIS		DE90004721	MF-814
T13	89:309	NTIS, PC A04/MF A01; OSTI; INIS		DE90004722	MF-814
T14	89:310	NTIS, PC A04/MF A01; OSTI; INIS		DE90004723	MF-814
T15	89:311	NTIS, PC A03/MF A01; OSTI; INIS		DE90004724	MF-815
T16	89:312	NTIS, PC A05/MF A01; OSTI; INIS		DE90004725	MF-812
T17	89:313	NTIS, PC A05/MF A01; OSTI; INIS		DE90004726	MF-814
T18	89:314	NTIS, PC A03/MF A01; OSTI; INIS		DE90004727	MF-814
T19	89:315	NTIS, PC A06/MF A01; OSTI; INIS		DE90004728	MF-814
T2-Vol.1	89:298	NTIS, PC A12/MF A01; OSTI; INIS		DE90004711	MF-814
T2-Vol.2	89:299	NTIS, PC A13/MF A01; OSTI; INIS		DE90004736	MF-814
T20	89:316	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004729	MF-814
T21	89:317	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004730	MF-814
T22	89:318	NTIS, PC A04/MF A01; OSTI; INIS		DE90004731	MF-814
T23	89:319	NTIS, PC A09/MF A01; OSTI; INIS		DE90004732	MF-700; MF-721
T24	89:320	NTIS, PC A12/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004733	MF-700; MF-721
T25	89:321	NTIS, PC A04/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004734	MF-700; MF-721
T26	89:322	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004735	MF-700; MF-721
T27	89:323	NTIS, PC A07/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004742	MF-814
T28	89:324	NTIS, PC A05/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004741	MF-721; MF-703
T29	89:325	NTIS, PC A03/MF A01; OSTI; INIS		DE90004740	MF-721; MF-703
T3	89:300	NTIS, PC A07/MF A01; OSTI; INIS		DE90004712	MF-814
T30	89:326	NTIS, PC A05/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004739	MF-721
T31	89:327	NTIS, PC A07/MF A01; OSTI; INIS		DE90004738	MF-721
T32	89:328	NTIS, PC A08/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004737	MF-721
T33	89:329	NTIS, PC A10/MF A01; OSTI; INIS		DE90004745	MF-721
T34	89:330	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004744	MF-721; MF-702
T37-Vol.2	89:331	NTIS, PC A12/MF A01; OSTI; INIS		DE90004747	MF-814
T38	89:332	NTIS, PC A03/MF A01; OSTI; INIS		DE90005481	MF-814
T39-Vol.1	89:333	NTIS, PC A15/MF A01; OSTI; INIS		DE90005482	MF-814
T39-Vol.2	89:334	NTIS, PC A16/MF A01; OSTI; INIS		DE90005483	MF-814
T4	89:301	NTIS, PC A07/MF A01; OSTI; INIS		DE90004713	MF-814
T40-Vol.1	89:335	NTIS, PC A18/MF A01; OSTI; INIS		DE90005484	MF-814
T40-Vol.2	89:336	NTIS, PC A19/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90005485	MF-814
T40-Vol.3	89:337	NTIS, PC A23/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90005486	MF-814
T40-Vol.4	89:338	NTIS, PC A21/MF A01; OSTI; INIS		DE90005487	MF-814
T41-Vol.2	89:339	NTIS, PC A16/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90006176	MF-814
T5	89:302	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004714	MF-700; MF-721
T6	89:303	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004715	MF-700; MF-721
T8	89:304	NTIS, PC A06/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90004717	MF-700; MF-721
T9	89:305	NTIS, PC A11/MF A01; OSTI; INIS		DE90004718	MF-814
DOE/NV/10576–					
17	89:8	NTIS, PC A07/MF A01 - OSTI	E 1.99:	DE89009778	MF-70
T1-Vol.1	89:9	NTIS, PC A24/MF A01 - OSTI	E 1.99:	DE89003704	MF-70
T1-Vol.2	89:10	NTIS, PC A04/MF A01 - OSTI	E 1.99:	DE89003705	MF-70
T2-Vol.1	89:11	NTIS, PC A09/MF A01 - OSTI	E 1.99:	DE89009613	MF-70
T2-Vol.2	89:12	NTIS, PC A20/MF A01 - OSTI	E 1.99:	DE89009612	MF-70
T2-Vol.3	89:13	NTIS, PC A08/MF A01 - OSTI	E 1.99:	DE89009614	MF-70
T2-Vol.4	89:14	NTIS, PC A03/MF A01 - OSTI	E 1.99:	DE89009615	MF-70
T3	89:15	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE89016000	MF-814
DOE/OR/00033–					
T419	89:340	NTIS, PC A07/MF A01 - OSTI	E 1.99:	DE89010158	MF-400

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DOE/OSTI–					
3406-Suppl.1-Add.1	89:16	NTIS, PC A03/MF A01 - OSTI	E 1.99:	DE88015230	PC-70
3406-Suppl.1-Add.2	89:17	NTIS, PC A04/MF A01 - OSTI; GPO Dep.	E 1.99:	DE89005394	PC-70
DOE/RW–					
0160-Vol.1	89:18	OSTI, PO Box 62, Oak Ridge, TN 37831	N:	TI88007742	MF-70
0160-Vol.2	89:19	OSTI, PO Box 62, Oak Ridge, TN 37831		TI88007743	MF-70
0160-Vol.3	89:20	OSTI, PO Box 62, Oak Ridge, TN 37831- H	N:	TI88007744	MF-70
0160-Vol.4	89:21		N:	TI88007745	MF-70
0160-Vol.5	89:22	OSTI, PO Box 62, Oak Ridge, TN 37831	N:	DE88007746	MF-70
0160-Vol.6	89:23		N:	TI88007747	MF-70
0160-Vol.7	89:24	OSTI, PO Box 62, Oak Ridge, TN 37831	N:	TI88007748	MF-70
0161	89:25	OSTI, PO Box 62, Oak Ridge, TN 37831		TI89012574	MF-70
0176-Rev.1-Draft	89:26		N:	DE88006888	MF-70
0177	89:27	OSTI, PO Box 62, Oak Ridge, TN 37831	N:	TI88006889	MF-70
0179	89:28	OSTI, PO Box 62, Oak Ridge, TN 37831	N:	DE88006890	MF-70
0188	89:341		N:	TI88008075	MF-70
0189	89:342	OSTI, PO Box 62, Oak Ridge, TN 37831		TI88016123	PC-70
0198	89:29	OSTI, PO Box 62, Oak Ridge, TN 37831		TI89004612	MF-70
0199-Vol.1-Pt.A	89:30	OSTI, PO Box 62, Oak Ridge, TN 37831		TI89011312	MF-70
0199-Vol.2-Pt.A	89:31	OSTI, PO Box 62, Oak Ridge, TN 37831		TI89011311	MF-70
0199-Vol.3-Pt.A	89:32	OSTI, PO Box 62, Oak Ridge, TN 37831		TI89011313	MF-70
0199-Vol.4-Pt.B	89:33	OSTI, PO Box 62, Oak Ridge, TN 37831		TI89011314	MF-70
0199-Vol.5-Pt.B	89:34	OSTI, PO Box 62, Oak Ridge, TN 37831		TI89011310	MF-70
0199-Vol.6-Pt.B	89:35	OSTI, PO Box 62, Oak Ridge, TN 37831		TI89011309	MF-70
0199-Vol.7-Pt.B	89:36	OSTI, PO Box 62, Oak Ridge, TN 37831		TI89011301	MF-70
0199-Vol.8-Pt.B	89:37	OSTI, PO Box 62, Oak Ridge, TN 37831		TI89011316	MF-70
0199-Vol.9	89:38	OSTI, PO Box 62, Oak Ridge, TN 37831		TI89011315	MF-70
0205	89:343	OSTI, PO Box 62, Oak Ridge, TN 37831		TI89004438	MF-70
0206	89:344	OSTI		TI89012573	MF-70
0221	89:345	OSTI, PO Box 62, Oak Ridge, TN 37831		TI89007053	MF-70
0225	89:346	OSTI		TI89014824	MF-810
0225-1	89:347	OSTI		TI89015573	MF-800
0225-2	89:348	OSTI; INIS		TI90000855	MF-800
0234	89:349	OSTI		TI89011304	MF-70
0236	89:350	OSTI		TI89012865	MF-800
0244	89:351	OSTI		TI89015572	MF-814
DOE/RWM–					
88/1	89:352	NTIS, PC A03/MF A01		DE88008253	MF-70
DOE/TIC–					
3406-Add.1	89:39	NTIS, PC A03/MF A01	E 1.99:	DE87012696	PC-70
3406-Add.2	89:40	NTIS, PC A03/MF A01	E 1.99:	DE88000455	PC-70
DP-MS–					
87-70	89:353	NTIS, PC A02/MF A01	E 1.99:	DE88004740	MF-70
DPST–					
87-225	89:354	NTIS, PC A02/MF A01		DE88017209	MF-721
EGG–					
10282-2111	89:41	NTIS, PC A03/MF A01	E 1.99:	DE88003669	MF-70
EUR–					
11268	89:355	NTIS (US Sales Only), PC A09			
GAO/RCED–					
86-206FS	89:356	General Accounting Office, PO Box 6015, Gaithersburg, MD 20877			
88-163BR	89:357	General Accounting Office, PO Box 6015, Gaithersburg, MD 20877			
HEDL-SA–					
3313-Rev.	89:104	NTIS, PC A03/MF A01	E 1.99:	DE88001465	MF-78
3583	89:134	*See* UCRL–15993			
3627	89:105	NTIS, PC A03/MF A01	E 1.99:	DE88005708	MF-510
3700-FP	89:137	*See* UCRL–21019			
3731A	89:136	*See* UCRL–21013			
HEDL-TC–					
2562	89:106	NTIS, PC A03/MF A01	E 1.99:	DE87013632	MF-70
LA–					
10532-MS	89:48	NTIS, PC A04/MF A01	E 1.99:	DE88004435	MF-70
10667-MS	89:49	NTIS, PC A03/MF A01 - OSTI	E 1.99:	DE89008317	MF-70
10952-MS	89:50		E 1.99:	DE88006874	MF-70
10960-MS	89:51	NTIS, PC A06/MF A01	E 1.99:	DE88005707	PC-70
10987-PR	89:52	NTIS, PC A04/MF A01	E 1.99:	DE88001940	PC-70
11023-MS	89:53		E 1.99:	DE88007167	PC-70
11026-MS	89:54	NTIS, PC A05/MF A01	E 1.99:	DE88006031	MF-70

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11162-MS	89:55	NTIS, PC A03/MF A01	E 1.99:	DE88002512	MF-70
11222-MS	89:56	NTIS, PC A04/MF A01 - OSTI	E 1.99:	DE89009692	MF-721
11223-PR	89:358	NTIS, PC A03/MF A01	E 1.99:	DE88006027	MF-70
11246-MS	89:57	NTIS, PC A03/MF A01	Y:	DE88009204	MF-70
11289-MS	89:58	NTIS, PC A04/MF A01	E 1.99:	DE88010486	PC-70
11292-MS	89:59	NTIS, PC A03/MF A01		DE88010487	PC-70
11293-MS	89:60	NTIS, PC A04/MF A01	Y:	DE88010488	PC-70
11398-MS	89:61	NTIS, PC A08/MF A01 - OSTI	E 1.99:	DE89005292	MF-721
11443-PR	89:62	NTIS, PC A05/MF A01 - OSTI	E 1.99:	DE89004539	MF-510
11452-MS	89:63	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE89015327	MF-814
11497-MS	89:64	NTIS, PC A04/MF A01 - OSTI	E 1.99:	DE89008957	MF-70
11503-MS	89:65	NTIS, PC A04/MF A01 - OSTI	E 1.99:	DE89010550	MF-70
11504-MS	89:66	NTIS, PC A03/MF A01 - OSTI	E 1.99:	DE89007100	MF-70
11527-MS	89:67	NTIS, PC A06/MF A01 - OSTI	E 1.99:	DE89009687	MF-721
11532-MS	89:68	NTIS, PC A05/MF A01 - OSTI	E 1.99:	DE89010549	MF-70
11605-MS	89:69	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE89016019	MF-814
11663-MS	89:70	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE89017905	MF-814
11665-SR	89:71	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90000947	PC-810
11669-MS	89:72	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE89017906	MF-802
LA-UR–					
86-556	89:73	NTIS, PC A02/MF A01	E 1.99:	DE87013293	MF-70
87-3854	89:74	NTIS, PC A03/MF A01	E 1.99:	DE88003165	MF-70
88-3961	89:359	NTIS, PC A02/MF A01 - OSTI	E 1.99:	DE89003603	MF-721
88-4155	89:75	NTIS, PC A02/MF A01 - OSTI	E 1.99:	DE89008185	MF-70
89-2541	89:77	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE89015288	MF-814; MF-401
89-2573	89:78	NTIS, PC A02/MF A01 - OSTI; GPO Dep.	E 1.99:	DE89015278	MF-814
89-2952	89:79	NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE89016778	MF-802
89-3095	89:80	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90001834	MF-814
89-3116	89:81	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90001830	MF-814
89-3210	89:82	NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90000198	MF-814
89-3503	89:83	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90002402	MF-802
89-3701	89:360	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003169	MF-940
89-3702	89:84	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003168	MF-810
89-781	89:76	NTIS, PC A03/MF A01 - OSTI	E 1.99:	DE89009404	MF-721
LBL–					
22559	89:361	NTIS, PC A02/MF A01	E 1.99:	DE87004477	MF-70
23689	89:362		Y:	DE88007416	MF-403
24200	89:363	NTIS, PC A11/MF A01 - OSTI	E 1.99:	DE89008836	PC-403
24254	89:107	NTIS, PC A03		DE88004444	MF-401
24599	89:364		Y:	DE88006349	MF-70
25073	89:255	NTIS, PC A04/MF A01 - OSTI	E 1.99:	DE89010666	MF-403
25505	89:365	NTIS, PC A04/MF A01 - OSTI	E 1.99:	DE89008416	MF-11
25547	89:169	NTIS, PC A03/MF A01	E 1.99:	DE88014855	MF-403
26827	89:366	NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90003079	MF-814
26828	89:367	NTIS, PC A02/MF A01; OSTI; INIS		DE90003267	MF-814
27156	89:85	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE89014889	MF-814
27157	89:86	NTIS, PC A04/MF A01 - OSTI; GPO Dep.	E 1.99:	DE89014896	MF-802
27578	89:170	NTIS, PC A03/MF A01 - OSTI; GPO Dep.	E 1.99:	DE90000556	MF-403
27778	89:108	NTIS, PC A02/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90002680	MF-810
NUREG–					
1347	89:368	NTIS, PC A11/MF A01 - GPO - OSTI		TI89017556	
NUREG/CR–					
4134-R2	89:369	NTIS, PC A11/MF A01 - GPO		TI87013729	MF-70
4708-Vol.2	89:370	NTIS, PC A04/MF A01 - GPO		TI88015467	
4708-Vol.3	89:371	NTIS, PC A04/MF A01 - GPO; OSTI; INIS		TI89017590	
4735-Vol.2	89:372	NTIS, PC A07/MF A01 - GPO		TI88900155	MF-70
4735-Vol.3	89:373	NTIS, PC A08/MF A01 - GPO		TI88011119	
4735-Vol.4	89:374	NTIS, PC A09/MF A01 - GPO		TI88015610	
4735-Vol.5	89:375	NTIS, PC A08/MF A01 - GPO; OSTI; INIS		TI90001583	
5092	89:376	NTIS, PC A04/MF A01 - GPO		TI88015648	
5255	89:377	NTIS, PC A05/MF A01 - GPO		TI89002740	
5335	89:378	NTIS, PC A05/MF A01 - GPO - OSTI		TI89009562	
5336	89:379	NTIS, PC A10/MF A01 - GPO - OSTI		TI89010127	
5367	89:380	NTIS, PC A06/MF A01 - GPO - OSTI		TI89016246	
5390	89:381	NTIS, PC A06/MF A01 - GPO; OSTI; INIS		TI89017593	
5400	89:382	NTIS, PC A06/MF A01 - GPO - OSTI		TI89015123	
5426	89:383	NTIS, PC A05/MF A01 - GPO; OSTI; INIS		TI89016813	
5427	89:384	NTIS, PC A07/MF A01 - GPO; OSTI; INIS		TI90000039	
5428	89:385	NTIS, PC A04/MF A01 - GPO; OSTI; INIS		TI90000040	

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NVO–					
326	89:42	NTIS, PC A07/MF A01 - OSTI	E 1.99:	DE89010665	MF-70
NWPO-TR–					
001-87	89:290	*See* DOE/NV/10461–T1-Vol.1			
002-87	89:291	*See* DOE/NV/10461–T1-Vol.2			
003-87	89:292	*See* DOE/NV/10461–T1-Vol.3			
004-87	89:293	*See* DOE/NV/10461–T1-Vol.4			
005-87	89:294	*See* DOE/NV/10461–T1-Vol.5			
006-87	89:295	*See* DOE/NV/10461–T1-Vol.6			
007-87	89:296	*See* DOE/NV/10461–T1-Vol.7			
008-88	89:297	*See* DOE/NV/10461–T1-Vol.8			
ORNL/TM–					
10147-Vol.2	89:370	*See* NUREG/CR–4708-Vol.2			
10147/V3	89:371	*See* NUREG/CR–4708-Vol.3			
10707	89:376	*See* NUREG/CR–5092			
9522-R2	89:369	*See* NUREG/CR–4134-R2			
PNL–					
5829	89:135	*See* UCRL–21005			
6329	89:386	NTIS, PC A12/MF A01	E 1.99:	DE88001692	MF-70
6427	89:109	NTIS, PC A03/MF A01 - OSTI	E 1.99:	DE89006387	MF-523
6745	89:110	NTIS, PC A03/MF A01 - OSTI	E 1.99:	DE89006389	MF-523
PNL-SA–					
15207	89:136	*See* UCRL–21013			
15538	89:387	NTIS, PC A03/MF A01 - OSTI	E 1.99:	DE89003137	MF-70
15624	89:388	NTIS, PC A02/MF A01		DE89001513	MF-70
16734	89:111	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE90002663	MF-814
16832	89:112	NTIS, PC A03/MF A01; OSTI; INIS; GPO Dep.	E 1.99:	DE89017242	MF-814
SAIC–					
86/8007	89:4	*See* DOE/NV/10270–14			
88/8011	89:8	*See* DOE/NV/10576–17			
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