UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

DATE: June 10, 1996

TO: John H. Austin, Chief
Performance Assessment and HLW Integration Branch
Division of Waste Management
Office of Nuclear Materials Safety and Safeguards

FROM: William Belke, Sr. On-Site Licensing Representative for
Quality Assurance and Engineered Systems

Chad Glenn, Sr. On-Site Licensing Representative for
Natural Systems and Total Systems

SUBJECT: U. S. NUCLEAR REGULATORY COMMISSION ON-SITE LICENSING REPRESENTATIVES' REPORT ON YUCCA MOUNTAIN PROJECT FOR APRIL AND MAY, 1996

INTRODUCTION

The principal purpose of the On-Site Representatives' (OR) reports is to alert NRC staff, managers and contractors to information of U. S. Department of Energy (DOE) programs for site characterization, repository design, performance assessment, and environmental studies that may be of use in fulfilling NRC's role during pre-licensing consultation. The principal focus of this and future OR reports will be on DOE's programs for the Exploratory Studies Facility (ESF), surface-based testing, performance assessment, data management systems and environmental studies. Relevant information includes new technical data, DOE's plans and schedules, and the status of activities to pursue site suitability and ESF development. In addition to communication of this information, any potential licensing concerns, or opinions raised in this report represent the views of the ORs and not that of NRC headquarters' staff.

QUALITY ASSURANCE, ENGINEERING, AND KEY TECHNICAL ISSUES

1. Based on recent observations of the U.S Geological Survey (USGS) the NRC OR is concerned about the lack of effectiveness of the USGS program, both from a quality assurance and technical perspective.

   During the course of the Yucca Mountain Quality Assurance Division (YMQAD) June 20-24, 1994, audit (YMP-94-06 Audit Report dated August 17, 1994) of USGS (observed by the NRC OR), ten deficiencies were identified resulting in the issuance of eight Corrective Action Requests (CARs). The audit team determined that implementation of quality assurance (QA) Program Elements 4.0 (Procurement), 7.0 (Purchased Items and Services), and 16.0 (Corrective Action) were unsatisfactory because of these deficiencies. NRC staff

NH03
102.7
WM-11

agreed with this conclusion as stated in its August 22, 1994, Audit Observation Report for this audit.

In the June 8-16, 1995, YMQAD audit, (YM-ARP-95-12 Audit Report dated July 25, 1995) of USGS (observed by the NRC OR), three deficiencies were identified which resulted in the issuance of two CARs. These deficiencies pertained to a USGS technical report that had been completed and submitted to the Yucca Mountain Site Characterization Office for review and approval, which contained numerous technical errors. Based on this finding, USGS withdrew this report. The other deficiencies identified were that there was no documented evidence that mandatory comments to technical documents are being resolved prior to approving the documents, and that technical comments were being identified as "nonmandatory" when they should have been "mandatory". Based on this audit and the related findings, the NRC staff recommended in its July 13, 1995, Audit Observation Report for this audit, that the YMQAD should investigate whether other participants are having similar problems. Shortly after this audit, DOE issued a September 27, 1995, letter to all participants recommending that technical staff and their direct management review the enclosure to this letter listing 13 good practices to follow in the preparation of technical reports and supporting activities.

As a result of the DOE September 6-15, 1995, audit (YM-ARP-95-20) of USGS, a CAR was issued and noted that another technical report was found to have deficiencies associated with documentation of activities, report review, training, and personnel qualification. In the October 3, 1995, NRC OR Report, based on the NRC observation of the YMQAD September 6-15, 1995, audit of USGS, the intention to list a repetitive condition observed on this audit as an Open Item was documented. The Open Item was formally documented as Enclosure 2 to the NRC Audit Observation Report QA-95-11, dated November 2, 1995, and will be tracked in the NRC Open Items Tracking System until satisfactorily resolved. The repetitive condition appears to be similar to the conditions reported in the CARs issued during the June 8-16, 1995, audit of USGS (YM-ARP-12). As a result of these two audits and the deficiencies identified for these technical reports, the NRC staff expressed concern that reviews conducted under the USGS QA program may not adequately verify the correctness, technical adequacy, completeness, accuracy, and compliance with established requirements of technical documents.

In the February 22, 1996, DOE Summary Report of the Office of Civilian Radioactive Waste Management QA Program Effectiveness for FY 1995, USGS is noted in Chart 1 as being "Marginal" for QA Program Elements 4.0, 7.0, and Supplement

III (Scientific Investigation). In the NRC April 10, 1996, OR Report, it is noted that the OR does not totally agree with this conclusion. In view of the USGS technical reports having significant deficiencies identified through the DOE audit process, it would appear that Supplement III would have at least been considered "indeterminate" or possibly "unsatisfactory" pending the outcome and results of the final review and corrective action taken to correct these outstanding deficiencies.

As a result of the March 25-29, 1996, YMQAD audit (YM-ARC-96-10 Audit Report dated May 3, 1996) of USGS, two CARs were issued during the course of this audit. The CARs identified deficiencies in QA Program Elements 4.0, 7.0, and 16.0. Implementation of these two QA Program Elements were noted by the audit team as being unsatisfactory. This is a repetitive condition for these areas being identified as unsatisfactory during the June 20-24, 1994, audit of USGS (see above). Therefore, it appears corrective action to prevent recurrences in these areas is ineffective.

Having reviewed the above information, it is the OR conclusion that not all of the USGS QA Program Elements are being effectively implemented. This conclusion is based on: 1) Observation of several DOE audits conducted during 1994, 1995, and 1996; 2) Failure to take corrective action to prevent repetitive recurrences; and 3) significant deficiencies being identified in a relatively small sample of technical reports in back to back audits. Based on the above rationale at this time, the OR does not have total confidence that USGS products could withstand the licensing process.

These concerns were briefly discussed by the OR at the May 28, 1996, meeting with the DOE Yucca Mountain Site Characterization Office (YMSCO) Project Manager and Assistant Managers (See Item 1 in "General" below). Also, a series of meetings between the OR, YMSCO Director of Quality Assurance, and DOE staff were scheduled to determine what corrective action is being pursued to assure that these apparent conditions adverse to quality are promptly and properly identified and corrected.

The DOE staff reviewed the audits and CARS initiated dating back to 1993. This review substantiated that based on the number of significant conditions identified, the USGS QA program has been found to be unsatisfactory in the areas of procurement and corrective action. The USGS QA program also appears to need a better system to identify adverse quality trends and repetitive conditions. There also appears to be problems associated with the technical review process and whether USGS implements adequate control over their contractors' activities in the areas of documentation, technical review, training, and personnel qualifications.

An April 10, 1996, letter from DOE to USGS issues CAR YMQAD-96-C004 which documents deficiencies relative to USGS' procurement of analytical, calibration, and/or other supplier services. This letter also states that a Stop Work Order is being considered as an option pending acceptable implementation of corrective action in the area of procurement. In the technical area, a May 24, 1996, DOE letter to USGS, requires resolution of comments associated with a technical review of 12 USGS technical reports. DOE is also considering stationing a full time QA representative at USGS in Denver, CO, in order to implement effective corrective action. Other possibilities will be considered and initiated by DOE as deemed necessary.

Consequently, DOE has recognized there are problems associated with the USGS QA program implementation and appears to be taking aggressive corrective action measures for this situation. The NRC OR intends to monitor these actions and provide feedback on its progress in future OR Reports.

At this time, it is not known what overall effect these QA problems will have on certain of the NRC Key Technical Issues.

EXPLORATORY STUDIES FACILITY (ESF)

As of May 31, 1996, the TBM advanced to station 55+58 meters (18,235 feet). Geologic mapping and sampling were completed to station 54+76 meters. The location of alcoves and preliminary tunnel stratigraphy is summarized in Enclosure 1.

ESF Testing:

<u>Alcove 1 (Upper Tiva Canyon Alcove)</u>
All planned testing in this alcove has been completed.

<u>Alcove 2 (Bow Ridge Fault Alcove)</u>
Testing in this alcove is designed to investigate the pneumatic and hydrologic properties of the Bow Ridge Fault. Scientists completed air-permeability testing and continue hydrochemistry (gas sampling) testing in radial boreholes.

<u>Alcove 3 (Upper Paintbrush Tuff [non-welded] Contact Alcove)</u>
Testing in this alcove is designed to investigate the pneumatic and hydrologic properties of the lithologic contact between the Tiva Canyon welded units and the Paintbrush bedded units. Over this reporting period, scientists completed air permeability

testing in one radial borehole (ESF-AL#3-RBT#1) and initiated air permeability testing in a second radial borehole (ESF-AL#3-RBT#4).

Alcove 4 (Lower Paintbrush Tuff [non-welded] Contact Alcove)
No further testing planned in this Alcove in FY96.

Alcove 5 (Thermal Testing Facility)
As of May 31, 1996, the excavation in the Access/Observation Drift (AOD) advanced to a depth of approximately 115 meters of its planned 130 meters. The Alpine Miner excavated the AOD to a depth of approximately 85 meters before it was moved to Alcove 6 to begin excavation. Excavation of Alcove 5 is now proceeding toward the drift-scale heater test area using the drill and blast method. The Thermomechanical Alcove (TMA), located approximately 40 meters down the AOD, has been excavated using the Alpine Miner. The TMA exposes a 10X13 meter block of rock that will be used for the single-hole heater test. The single-hole heater test is designed to test thermomechanical properties of rock in the potential repository horizon. A heater-hole and approximately 30 instrumentation holes that will monitor this test have been drilled in the TMA to depths ranging from 15 to 30 feet. The geologic features of this block have been mapped and video logs completed for all instrumentation holes. The single-hole heater test is scheduled to start in August 1996.

Alcove 6 and 7 (Northern and Southern Ghost Dance Fault Alcoves)
These alcoves are designed to test the pneumatic and hydrologic properties of the Ghost Dance Fault. Alcove 6 is located at ESF station 37+37. As of May 31, 1996, the excavation of this alcove advanced to approximately 11 meters. The location of Alcove 7 is tentatively planned at station 51+15 and excavation is scheduled to start in FY 97.

SURFACE BASED TESTING

Borehole Testing:
The location of boreholes referenced in this section is provided in Enclosure 2.

Borehole Pneumatic Testing
Scientists completed gas sampling in SD-12 in the unsaturated zone to establish in-situ rock-gas compositions. The Seamist liner system was installed in borehole UZ-6s to obtain gas samples and pneumatic data in the unsaturated zone. After completing gas sampling in UZ-6s, this system will be used to collect gas samples in UZ-14.

Pneumatic data recording continues at boreholes UZ-4, UZ-5, NRG-6, UZ-7a, SD-12, SD-7 and NRG 7a. Nye County continues to record data at boreholes NRG-4 and ONC-1.

G-2 Testing

On April 8, 1996, scientists initiated the second pump test at G-2 borehole. The pumping phase of this test was completed April 25, 1996. Water was pumped from G-2 at a rate of approximately 54 gallons per minute (gpm) from the zone above a borehole plug set at a depth of 2599 feet (same zone that was pumped in the first pump test). Scientists continue to monitor the water level recovery from this pump test. On May 29, 1996, the water level had recovered to within 15 feet of the level recorded at the beginning of the test. The purpose of testing at G-2 is to gather data that can be used to interpret the nature and origin of the high hydraulic gradient found at the north end of the site.

C-Hole Testing

Scientists released the conservative tracer pentaflurorobenzoic acid (PFBA) in the Bullfrog interval in C#2 on May 15, 1996 with partial recirculation of C#3 discharge water of 5 gpm. This is the second phase of tracer testing at the C-Holes. The amount of tracer injected was 225 gallons at a concentration of 8000 to 10000 parts per million. Conservative tracers are used as transport solutions for determining hydrologic properties, while reactive (sorbing) tracers are used to provide data for modeling groundwater travel times for radionuclides. Discharge water from C#3 was sampled automatically (every 1/2 to 1 hour) during this test to detect tracer breakthrough. Detection of PFBA in the discharge water occurred on May 18, 1996. The peak concentration of PFBA reached approximately 340 parts per billion on May 25, 1996 and has dropped steadily since that time. In this second phase of tracer testing, approximately 3.45 million gallons of water was pumped from the C-Hole complex into Fortymile Wash, 116,400 gallons of C-Hole discharge water re-injected into C#2, with approximately 28 percent of the 10 kilograms PFBA injected into C#2 recovered as of May 31, 1996. This phase of testing ended May 31, 1996, however scientists plan to continue pumping C#3 at a rate of 153 gpm with recirculation of discharge water into C#2 at 5 gpm until the start of the next phase of testing (expected early June 1996). Periodic samples will continue to be taken for analysis of PFBA content until the start of the next phase of testing.

In the next phase of testing, scientists plan to inject sodium iodide into C#1 to determine residence time and recoverable concentrations between C#1 and C#3. This testing will be followed by the simultaneous injection of reactive tracer and microspheres into the same borehole. Additional details on both the G-2 and C-Hole pump tests are provided in Enclosure 3.

OTHER ACTIVITIES

Reportable Geologic Condition

DOE's Yucca Mountain Site Characterization Office has recently invoked its procedure for the identification of a "Reportable Geologic Condition" in two different cases. This DOE procedure is a reporting tool used to advise interested parties that site characterization work has encountered some condition that was unexpected. The notice of a Reportable Geologic Condition includes an assessment of the technical significance of the condition, and outlines anticipated follow-up activities to evaluate this condition. A brief status of these conditions is provided below.

1. Elevated Levels of Chlorine-36 Detected in ESF:
On May 1, 1996, the DOE formally notified NRC of a reportable geologic condition at Yucca Mountain. Based on results of a draft report, it appears that scientists have detected bomb-pulse Chlorine-36 (Cl36) in a few distinct fractured and/or faulted zones in the ESF, indicating that there are a few fast pathways by which at least a small portion of water has flowed from the surface to the potential repository horizon in less than 50 years. DOE's notice of this condition indicates that DOE intends to "revisit the conceptual models that define the hydrology of the site and refine the testing program with regard to these findings". As the TBM advances, DOE plans to continue sampling for Cl36 and the presence of other bomb-pulse isotopes as corroborative evidence. DOE's refined testing strategy calls for additional sampling and analysis at smaller fracture features in the Paintbrush nonwelded (PTn), Topopah Spring welded, and the potential repository horizon. Samples will be collected from the boundary of PTn and through-going fractures in the PTn to better understand lateral diversion and conductive properties of this unit. Additional samples will also be collected where bomb-pulse Cl36 has already been observed to help establish the width of these zones. Finally, an effort will be made to predict future occurrences of bomb-pulse Cl36 based on site flow and transport models. The existing draft report will be updated to include the results of the ongoing sampling program and a final report is expected to be submitted to DOE in August 1996.

2. Identification of Fracture Zone at ESF Station 42+10:
On May 22, 1996, DOE formally notified NRC of an unexpected pattern of fractures in the ESF. Recent mapping in the ESF has revealed a pattern of fractures in the potential repository horizon trending N70W to N45W and dipping 75 to 85 degrees to SW. This fracture pattern begins at station 42+10, weakens between stations 45+00 to 46+70, intensifies between stations 46+70 to approximately 53+60, and then appears to weaken or terminate. There is a gradual clockwise rotation in the orientation of this fracture pattern going north to south in the ESF. These

fractures are normally closely spaced (several inches apart), smooth, and generally can be traced from tunnel invert to crown. Manganese oxide is a common mineral coating on fracture faces throughout this zone. This pattern of fractures is not evident based on surface mapping, however it has been identified in the downhole video log of SD-12 where it appears to be confined to Topopah Spring middle non-lithophysal unit. These fractures have had little impact on ESF construction as evidenced by the installation of Category 1 ground support over most of this interval. DOE will continue to evaluate this fracture system in an effort to determine the age, origin and relationship of these fractures to other structural features. The final evaluation of this condition is expected to be documented in FY97.

Synthesis Reports

In late FY 1996, DOE expects to complete a number of reports that will attempt to synthesize and document work conducted in various scientific areas. Enclosure 4 provides a listing of these reports, along with a preliminary outline and schedule for the submittal of each of these reports to DOE. Draft outlines of synthesis reports for Minerology/Petrology, Geotechnical Characterization of the Proposed Repository Site at Yucca Mountain, and the Near-Field Environment are omitted here since they were included in the April 10, 1996, OR report.

GENERAL

1. Meetings/Interactions

   - Attended the regularly scheduled meetings with W. Barnes (Yucca Mountain Site Characterization Office (YMSCO) Project Manager), Deputy Project Manager, YMSCO Assistant Managers, and the YMSCO QA Manager. See Enclosure 5 for the subject matter discussed at these meetings.

   - Attended the May 2, 1996, Licensing Support System Advisory Review Panel meeting in Las Vegas, NV. (Enclosure 6)

   - Attended the May 8, 1996, NRC/DOE management meeting. The purpose of this meeting was to present and discuss current activities and concerns.

   - Attended (Part time) the May 22-23, 1996, DOE Total System Performance Assessment '95 Technical Exchange held in Las Vegas, NV. The meeting proceeded in a very orderly professional manner with an open exchange of technical information and ideas.

2. Appendix 7 Site Interactions

- Conducted an April 26, 1996, site visit with the NRC Deputy Executive Director for Nuclear Materials Safety, Safeguards, and Operations Support (NMSS), the NMSS Office Director, and the Acting NMSS Deputy Office Director. The purpose of this visit was to provide information to these managers on the current site characterization technical activities being conducted at Yucca Mountain. There were no outstanding issues raised on this visit.

- Attended a May 7-8, 1996 interaction in which DOE and NRC staff and contractors met at the Southwest Research Institutes's facility in Texas to exchange information on various conceptual tectonic models applicable to Yucca Mountain. Representatives from the State of Nevada, Nuclear Waste Technical Review Board and ACNW also participated in this meeting. The purpose of this meeting was to review the range of models proposed in the literature and discuss the relevance of these models based on existing data. It was hoped that this discussion would lead to some consensus on the tectonic models relevant to Yucca Mountain. Twelve conceptual tectonic models were reviewed and discussed in this meeting. Based on these discussions, there was general agreement that half of these models could be eliminated. This meeting was useful in achieving a focus on the pertinent tectonic models to pursue.

- Conducted a May 3, 1996, site visit with the NRC Performance Assessment and High-Level Waste Integration Branch QA Section Leader and five representatives from the NRC Division of Waste Management technical staff. Part of this group visited the Amargosa Valley area. There were no outstanding issues raised on this visit

- Conducted a May 14, 1996, site visit with the NRC Performance Assessment and High-Level Waste Integration Branch Section Leader. This also included a visit to the Amargosa Valley area. There were no outstanding issues raised on this visit.

- Conducted a May 17, 1996, site visit with two members from the Center for Nuclear Waste Regulatory Analyses. There were no outstanding issues raised on this visit.

- Conducted a May 24, 1996, site visit with the NRC Engineering and Geosciences Chief, and five members from the Center for Nuclear Waste Regulatory Analyses. There were no outstanding issues raised on this visit.

3. Reports

Over this reporting period the following reports were received in the NRC Las Vegas office.

LAWRENCE LIVERMORE

UCRL-ID-121046 POTENTIAL LONG-TERM CHEMICAL EFFECTS OF DIESEL FUEL EMISSIONS ON A MINING ENVIRONMENT: A PRELIMINARY ASSESSMENT BASED ON DATA FROM A DEEP SUBSURFACE TUNNEL AT RAINER MESA, NEVADA TEST SITE
A. Meike, Editor, 9/95

LOS ALAMOS

LA-11023-MS SMECTITE DEHYDRATION AND STABILITY: APPLICATIONS TO RADIOACTIVE WASTE ISOLATION AT YUCCA MOUNTAIN, NEVADA (Duplicate)
D. Bish, 3/88

LA-11289-MS A PRELIMINARY COMPARISON OF MINERAL DEPOSITS IN FAULTS NEAR YUCCA MOUNTAIN, NEVADA, WITH POSSIBLE ANALOGS (Duplicate)
D. Vaniman, D. Bish, S. Chipera, 5/88

LA-11504-MS FRACTURE-COATING MINERALS IN THE TOPOPAH SPRING MEMBER AND UPPER TUFF OF CALICO HILLS FROM DRILL HOLE J-13 (Duplicate)
B. Carlos, 2/89

LA-11663-MS THE OCCURRENCE AND DISTRIBUTION OF ERIONITE AT YUCCA MOUNTAIN, NEVADA, (Duplicate)
S. Chipera, D. Bish, 9/89

LA-11787-MS MANGANESE-OXIDE MINERALS IN FRACTURES OF THE CRATER FLAT TUFF IN DRILL CORE USW G-4, YUCCA MOUNTAIN, NEVADA (Duplicate)
B. Carlos, D. Bish, S. Chipera, 7/90

LA-12803-MS FIELD GUIDE TO FRACTURE-LINING MINERALS AT YUCCA MOUNTAIN, NEVADA
B. Carlos, 12/94

LA-13012-MS REPORT ON NEPTUNIUM SPECIATION BY NMR AND OPTICAL SPECTROSCOPIES
C. Tait, P. Palmer, S. Ekberg, D. Clark, 11/95

LA-13043-MS FIELD DEPLOYMENT TEST OF LASER-INDUCED BREAKDOWN SPECTROSCOPY (LIBS) TECHNOLOGY AT THE YUCCA MOUNTAIN EXPLORATORY STUDIES FACILITY, TEST ALCOVE #1, MARCH 2-9, 1994: MILESTONE REPORT LA4047
J. Blacic, D. Pettit, D. Cremers, 1/96

LA-13068-SR LOS ALAMOS NATIONAL LABORATORY, YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT, 1994 QUALITY PROGRAM STATUS REPORT

LA-13113-MS GEOCHEMISTRY OF THE LATHROP WELLS VOLCANIC CENTER, F. Perry, K. Straub, 3/96

Papers & Reports

SURFACE-DISCHARGING HYDROTHERMAL SYSTEMS AT YUCCA MOUNTAIN-EXAMINING THE EVIDENCE, S. Levy (MRS Proceedings, 1993)

NATURAL GELS IN THE YUCCA MOUNTAIN AREA, NEVADA, USA, S. Levy, (1992 Reprint from Elsevier Science Publishers, Amsterdam)

ION EXCHANGE AND DEHYDRATION EFFECTS ON POTASSIUM AND ARGON CONTENTS OF CLINOPTILOLITE, G. Woldegabriel, S. Levy, (1996 Materials Research Society)

ALTERATION HISTORY STUDIES IN THE EXPLORAORY STUDIES FACILITY, YUCCA MOUNTAIN, NV, USA S. Levy, D. Norman, S. Chipera (1996 Materials Research Society)

EQUILIBRIUM MODELING OF THE FORMATION OF ZEOLITES IN FRACTURES AT YUCCA MOUNTAIN, NV, S. Chipera, D. Bish, B. Carlos (Copyright 1995)

QUANTITATIVE X-RAY DIFFRACTION ANALYSIS OF SOILS, D. Bish, 1994

THE IMPORTANCE OF ZEOLITES IN THE POTENTIAL HIGH-LEVEL RADIOACTIVE WASTE REPOSITORY AT YUCCA MOUNTAIN, D. Vaniman, D. Bish, (Copyright 1995)

DISTRIBUTION AND CHEMISTRY OF FRACTURE-LINING ZEOLITES AT YUCCA MOUNTAIN, NV, B. Carlos, S. Chipera, D. Bish, R. Raymond, (Copyright 1995)

USGS

OPEN-FILE REPORT 94-469 PROPOSED STRATIGRAPHIC NOMENCLATURE AND MACROSCOPIC IDENTIFICATION OF LITHOSTRATIGRAPHIC UNITS OF THE PAINTBRUSH GROUP EXPOSED AT YUCCA MOUNTAIN, NV, D. Buesch, R. Spengler, T. Moyer, J. Geslin, 1996

OPEN-FILE REPORT 95-287 DIGITAL ELEVATION MODEL (DEM) FILE OF TOPOGRAPHIC ELEVATIONS FOR THE DEATH VALLEY REGION OF SOUTHERN NEVADA AND SOUTHEASTERN CALIFORNIA PROCESSED FROM U.S. GEOLOGICAL SURVEY 1-DEGREE DIGITAL ELEVATION MODEL DATA FILES
K. Turner, F. D'Agnese, C. Faunt, 1996

OPEN-FILE REPORT 95-362 DIGITAL HYDROGRAPHIC, LAND USE/LAND COVER, AND HYDROLOGIC UNIT BOUNDARY FILES FOR THE DEATH VALLEY REGION OF SOUTHERN NEVADA AND SOUTHEASTERN CALIFORNIA PROCESSED FROM U.S. GEOLOGICAL SURVEY 1:100,000- AND 1:250,000-SCALE DIGITAL DATA FILES
A. Turner, F. D'Agnese, C Faunt, 1996

NUREGS

CR-6096 APACHE LEAP TUFF INTRAVAL EXPERIMENTS, Results and Lessons Learned
T. Rasmussen (Univ of GA); S. Rhodes, A. Guzman, S. Neuman, (Univ. of AZ), 3/96; T. Nicholson (NRC)

CR--6124 (PNL-8856) CHARACTERIZATION OF RADIONUCLIDE-CHELATING AGENT COMPLEXES FOUND IN LOW-LEVEL RADIOACTIVE DECONTAMINATION WASTE (Literature Review)
R. Serne, A. Felmy, K. Cantrell, K. Krupka, J. Campbell, H. Bolton, Jr., J. Fredrickson 3/96

CR-6230 (PNL-9444) RADIOANALYTICAL TECHNOLOGY FOR 10 CFR PART 61 AND OTHER SELECTED RADIONUCLIDES, (Literature Review)
C. Thomas, V. Thomas, D. Robertson

STATE OF NEVADA

EVALUATION OF THE GEOLOGIC RELATIONS AND SEISMOTECTONIC STABILITY OF THE YUCCA MOUNTAIN AREA NEVADA NUCLEAR WASTE SITE INVESTIGATION (NNWSI) PROGRESS REPORT, 9/30/95, UNIV OF NV, RENO

SENSITIVITY ANALYSIS ON SMITH'S AMRV MODEL
C. Ho, 10/18/95

NWPO-TR-023-95 INVESTIGATION OF THE IMPACT OF SPARSE DATA ON THE USE OF GEOSTATISTICAL APPROACHES
G. Lamorey, E. Jacobson, 10/95

NWPO-TR-024-95 THE ROLE OF FRACTURE COATINGS ON WATER IMBIBITION INTO UNSATURATED TUFF FROM YUCCA MOUNTAIN
V. Chekuri, S. Tyler, J. Fordham, 11/95

cc w/encs.:
R. Milner, DOE-OCRWM
R. Loux, State of Nevada
J. Meder, Nevada Legislative Counsel Bureau
W. Barnes, YMSCO
D. Horton, YMSCO
N. Chappell, M&O
H. Haghi, M&O
M. Murphy, Nye County, NV
M. Baughman, Lincoln County, NV
D. Bechtel, Clark County, NV
D. Weigel, GAO
P. Niedzielski-Eichner, Nye County, NV
B. Mettam, Inyo County, CA
V. Poe, Inyo County, CA
W. Cameron, White Pine County, NV
R. Williams, Lander County, NV
L. Fiorenzi, Eureka County, NV
J. Hoffman, Esmeralda County, NV
C. Schank, Churchill County, NV
L. Bradshaw, Nye County, NV
W. Barnard, NWTRB
R. Holden, NCAI
A. Melendez, NIEC
R. Arnold, Pahrump, NV
N. Stellavato, Nye County, NV
J. Greeves, NRC WA (T7J-9)
J. Thoma, NRC WA (T7F-1)
M. Bell, NRC WA (T7C-6)
M. Federline, NRC WA (T7J-9)
J. Spraul, NRC WA (T7F-1)
S. Wastler, NRC WA (T7F-1)
A. Garcia, NRC WA (T7J-9
C. Paperiello, NRC WA (T8A-23)
M. Knapp, NRC WA (T8A-23)
R. Irish, NRC WA (T-5D28)
W. Reamer, NRC WA (O15B-18)
W. Patrick, CNWRA (Center
R. Wallace, USGS, VA

ESF TUNNEL STRATIGRAPHY*

STATION	
0+00 to 0+99.5m	Tiva Canyon crystal poor upper lithophysal zone.
	Alcove #1 (centerline station intersection): 0+42.5
0+99.5 to 1+90m	Tiva Canyon crystal poor middle nonlithophysal zone
	Alcove #2 (centerline station intersection): 1+68.2
1+90 to 1+99.5m	Tiva Canyon crystal poor lower lithophysal zone.
1+99.5 to 2+02m	Bow Ridge fault zone (placing Pre-Ranier Mesa Tuff against Tiva Canyon Tuff)
2+02 to 2+20m	pre-Ranier Mesa Tuff
2+20	Fault (4.3m offset)***
2+20 to 2+63.5m	pre-Ranier Mesa Tuff
2+63.5 to 3+37m	Tuff "X"
3+37 to 3+49.5m	pre-Tuff "X"
3+49.5 to 3+59.5m	Tiva Canyon vitric zone
3+59.5 to 4+30m	Tiva Canyon crystal rich nonlithopysal zone
4+30m	Fault (~10m offset)***
4+30 to 4+34	Tiva Canyon crystal rich nonlithopysal zone
4+34 to 4+39m	Tiva Canyon crystal rich lithopysal zone
4+39 to 5+50m	Tiva Canyon crystal poor upper lithophysal zone
5+50m	Fault (~5m offset)***
5+50 to 5+53	Tiva Canyon crystal poor upper lithophysal zone
5+53 to 5+87m	Tiva Canyon crystal poor middle nonlithophysal zone

ESF TUNNEL STRATIGRAPHY CONTINUED*

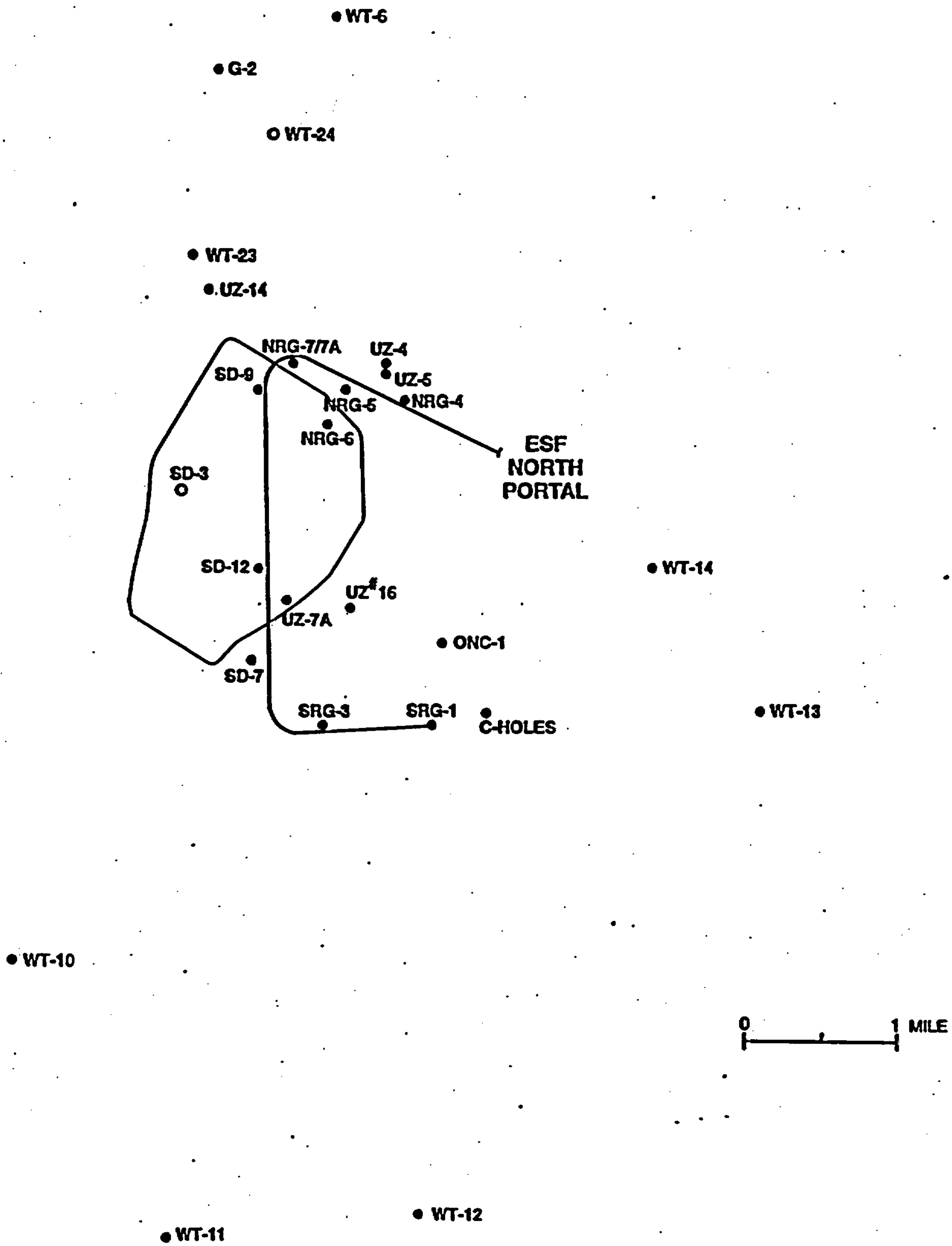
5+87 to 6+19m	Tiva Canyon crystal poor lower lithophysal zone
6+19 to 7+00m	Tiva Canyon crystal poor lower nonlithophysal zone
7+00m	Fault (~20m? offset)***
7+00 to 7+77m	Tiva Canyon crystal poor lower nonlithophysal zone.
	Alcove #3 (centerline station intersection): 7+54.
7+77 to 8+69m	Tiva Canyon crystal poor vitric zone
8+69 to 9+12m	Bedded tuffs (including thin Yucca Mountain member)
9+12 to 10+20m	Pah Canyon Member.
10+20 to 10+51.5m	Pre-Pah Canyon tuffs
	Alcove #4 (centerline station intersection): 10+27.8
10+51.5 to 11+93m	Topopah Spring crystal rich vitric zone
11+93 to 17+17m	Topopah Spring crystal rich nonlithophysal zone
17+17 to 17+97m	Topopah Spring crystal rich lithophysal zone
17+97 to 27+20m	Topopah Spring crystal poor upper lithophysal zone
27+20 to 35+93m	Topopah Spring crystal poor middle nonlithophysal zone
	Alcove #5 (centerline station intersection): 28+27
35+93m	Sundance fault (most prominent fault plane, minor fracturing reported between Stations 35+85 and 36+40)
35+93 to face	Topopah Spring crystal poor middle nonlithophysal zone

* All stations given are referenced to the right springline unless otherwise noted. Station 0+00 is located at coordinates N765352.7, E569814.4.

** Indicates that contact is preliminary and has not been verified.

*** Only faults with greater than 4 meters offset are noted on the table.

Selected Borehole Locations



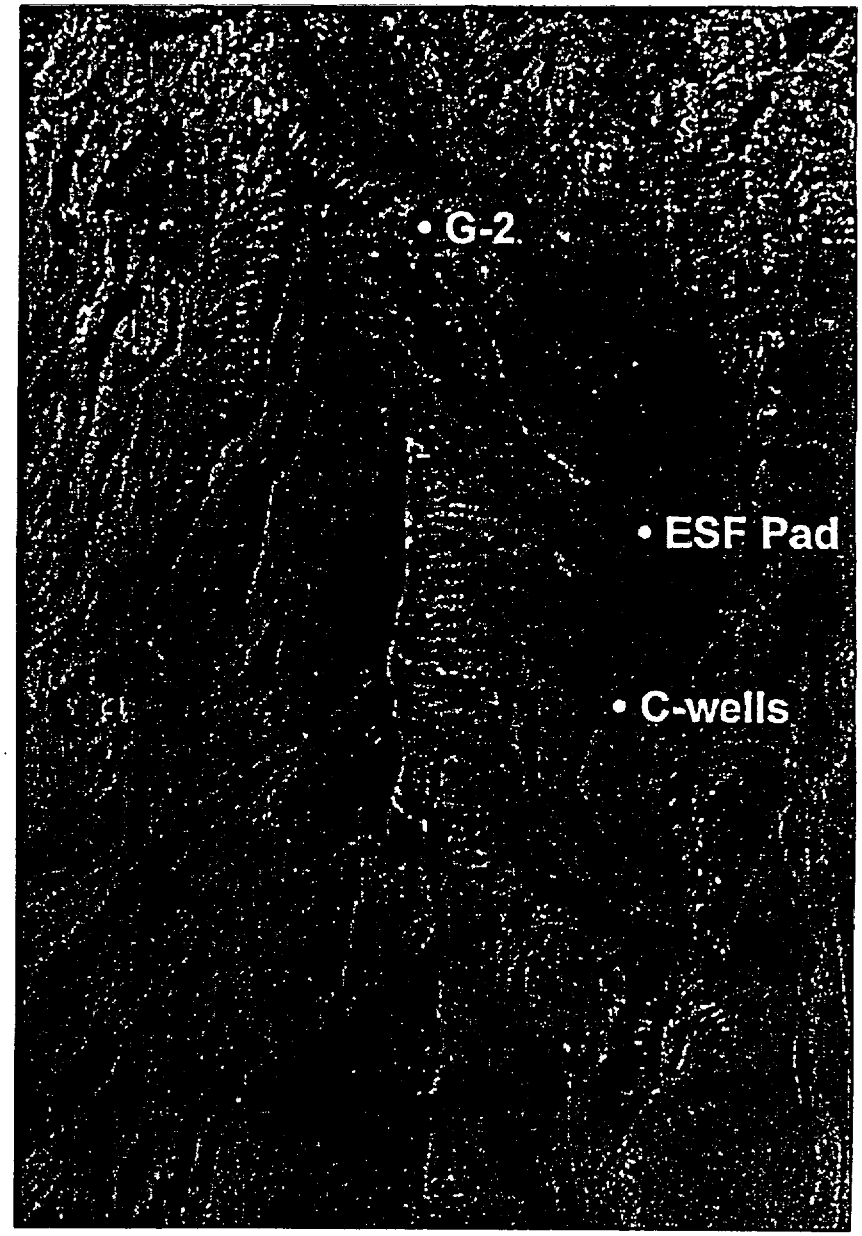
ENCLOSURE 2

Pump Tests at

UE-25c #1, #2, #3

and

USW G-2



PRELIMINARY DRAFT
INFORMATION ONLY

ENCLOSURE 3

C-Hole Complex Testing

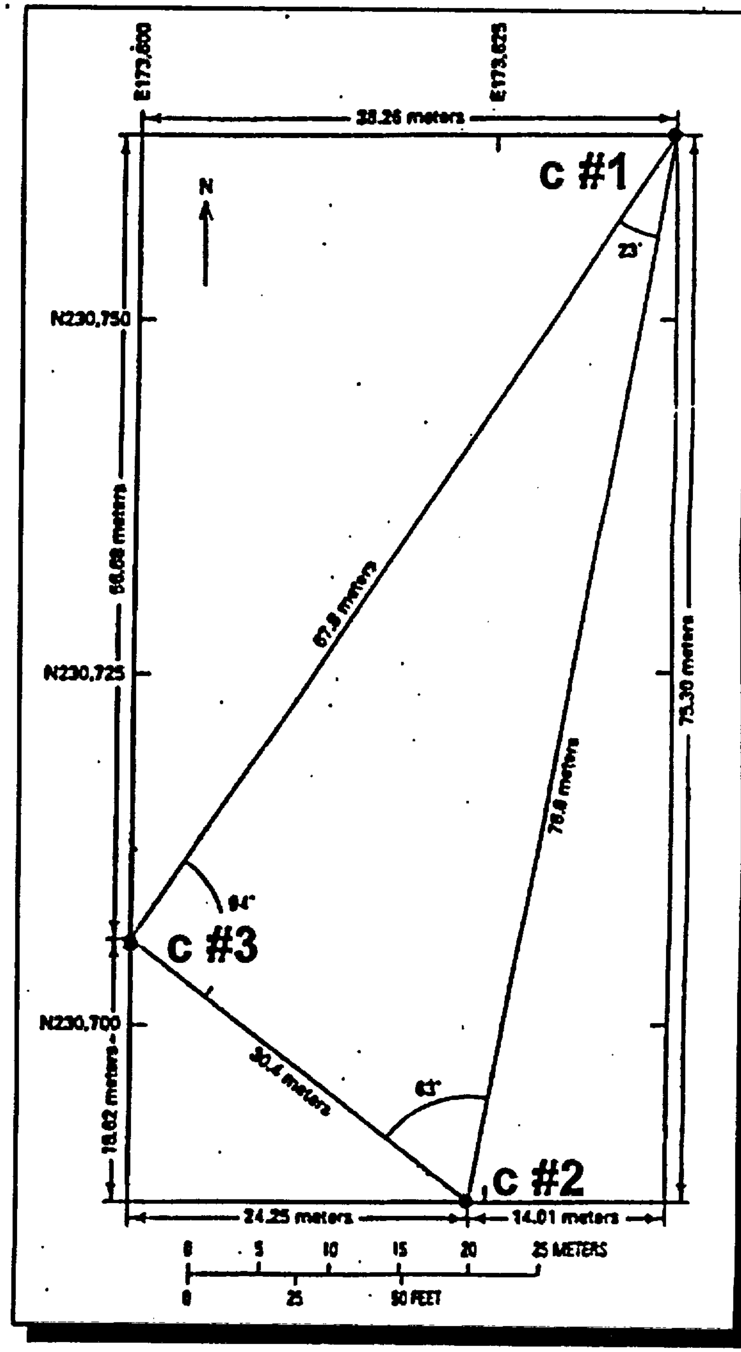
- **Purpose: Establish flow and transport field parameters for site SZ hydrologic models**
- **Method: Conduct conservative and reactive tracer tests between boreholes c #1, c #2, and c #3.**

C-Hole Complex Testing Status

- **Phase I - Conservative tracer testing (02/13/96 - 03/29/96)**
  - Sodium Iodide injection into c #2 @ 10,000 ppm
  - Entire Bullfrog test interval used (approx. 600 ft)
  - Response seen in 5 days at c #3
  - Good breakthrough curve developed with 100 ppb peak
  - Low peak concentration caused source term concern
- **Phase II (a) - Second conservative tracer test (05/15/96 - present)**
  - Pentaflourobenzoic acid injected into c #2 @10,000 ppm
  - Limited to 361 ft of Bullfrog (high flow zone)
  - Tracer flushed from borehole following injection
  - Response seen in 3 days at c #3
  - Peak estimated over weekend @ approx. 1,000 ppb

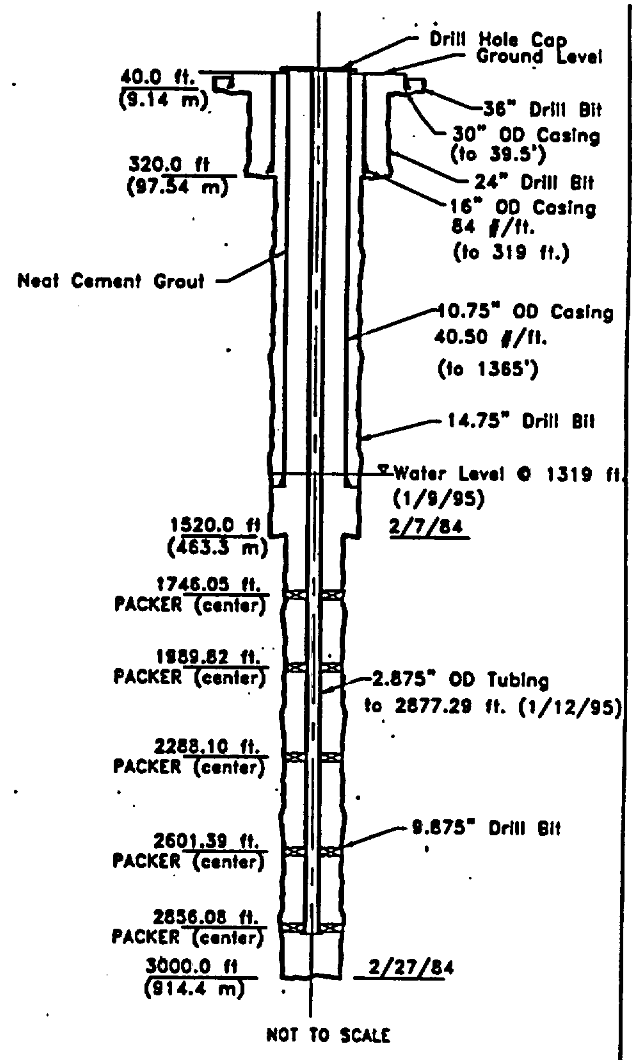
C-well Complex Borehole Orientation

- Phase I & phase II (a)
  - Injection in c #2
  - Withdrawal from c #3



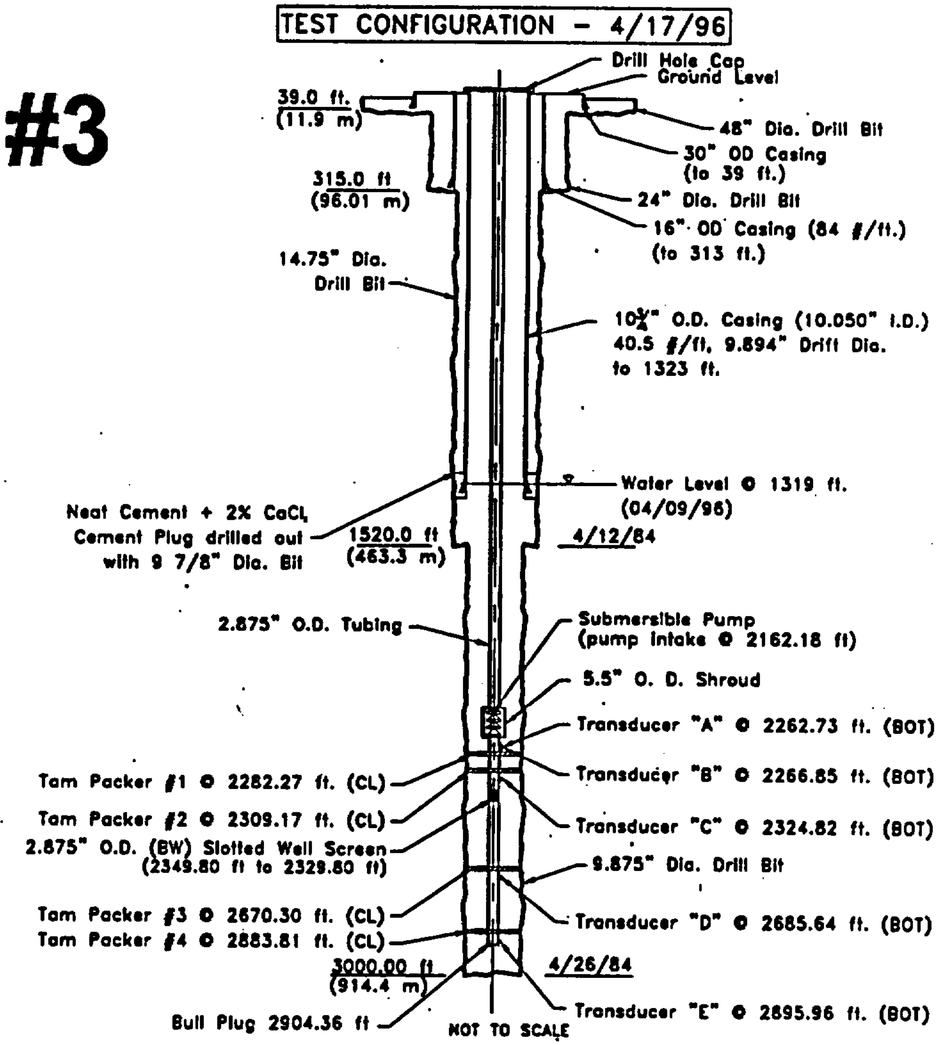
Borehole Configuration: c #2

- Packer depths:
  - 1,746.05 ft
  - 1,989.82 ft
  - 2,288.10 ft
  - 2,601.39 ft
  - 2,856.08 ft



Borehole Configuration: c #3

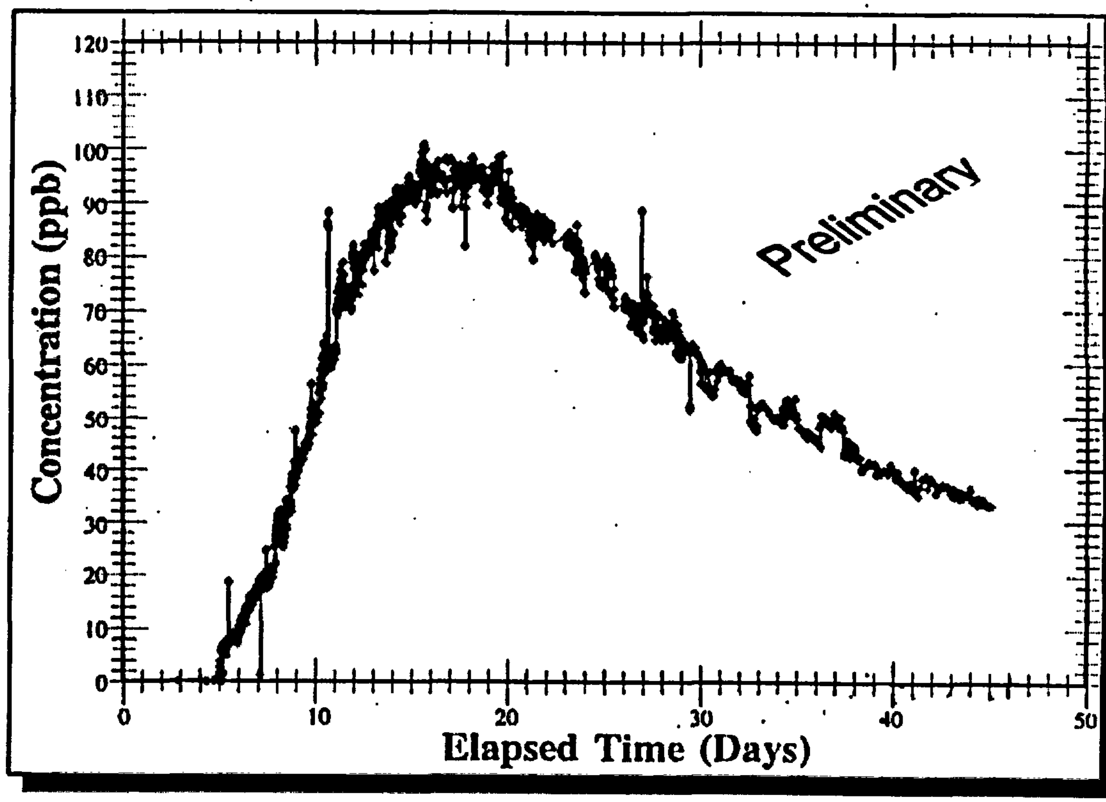
- Pump location (intake):
  - 2,162.18 ft
- Packer locations:
  - 2,282.27 ft
  - 2,309.17 ft
  - 2,670.30 ft
  - 2,883.81 ft



UE-25c #3
Hydrologic Test Hole

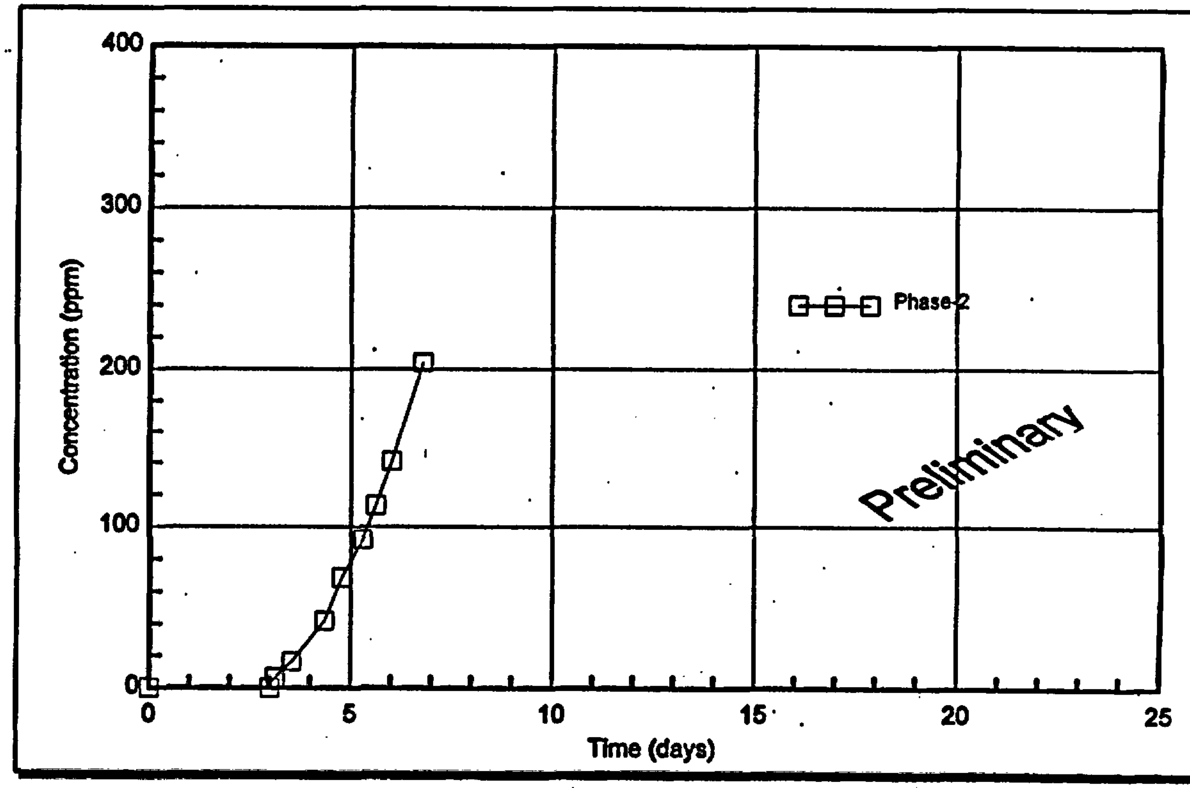
Phase-1 C-wells Tracer Tests

- 5 kg NaI tracer injected @ 10,000 ppm.
- Pumping duration: 46 days.
- Water volume pumped: 7,907,000 gallons.
- 23% of tracer recovered.
- Pumping terminated when characteristic portions of breakthrough curve observed.



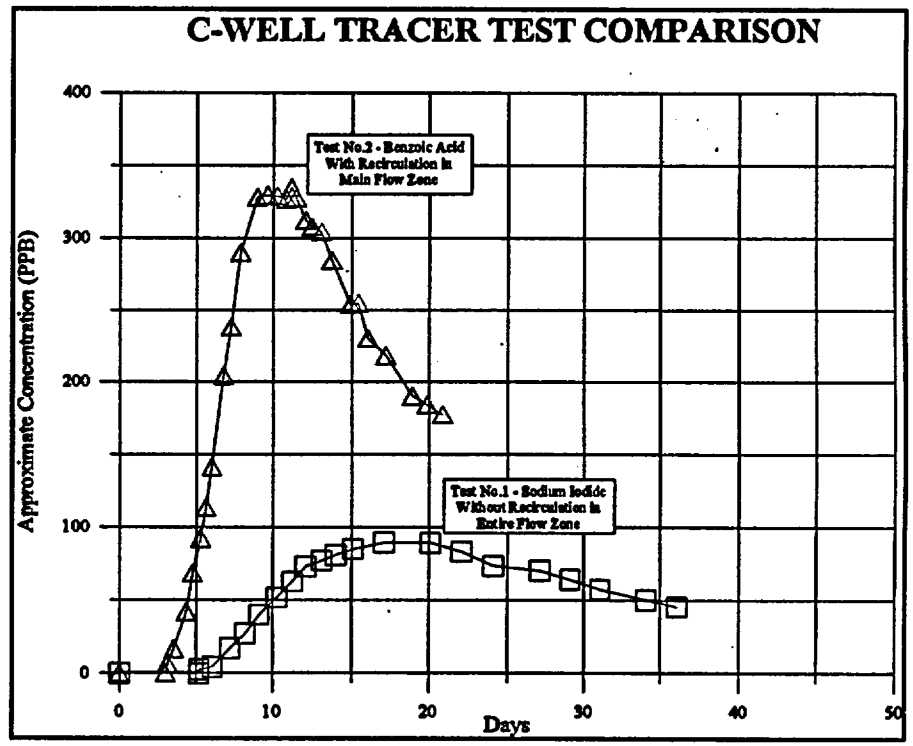
Phase-2 C-wells Tracer Test

- Test commenced on May 15, 1996.
- 3,079,620 gallons pumped as of May 22, 1996.
- Pump rate ~154 gpm.



C-Well Test Comparison

- **First test - Sodium Iodide**
  - No recirc. w/ low pump rate (+/- 100 GPM)
  - Entire zone tested (+/- 600 Ft)
  - Low peak (100 PPM)
  - Source term concern
- **Second test - Benzoic Acid**
  - Recirc. w/higher pump rate (150 GPM)
  - Only high flow interval tested (half of zone)
  - Peak higher but still less than 1000 PPB



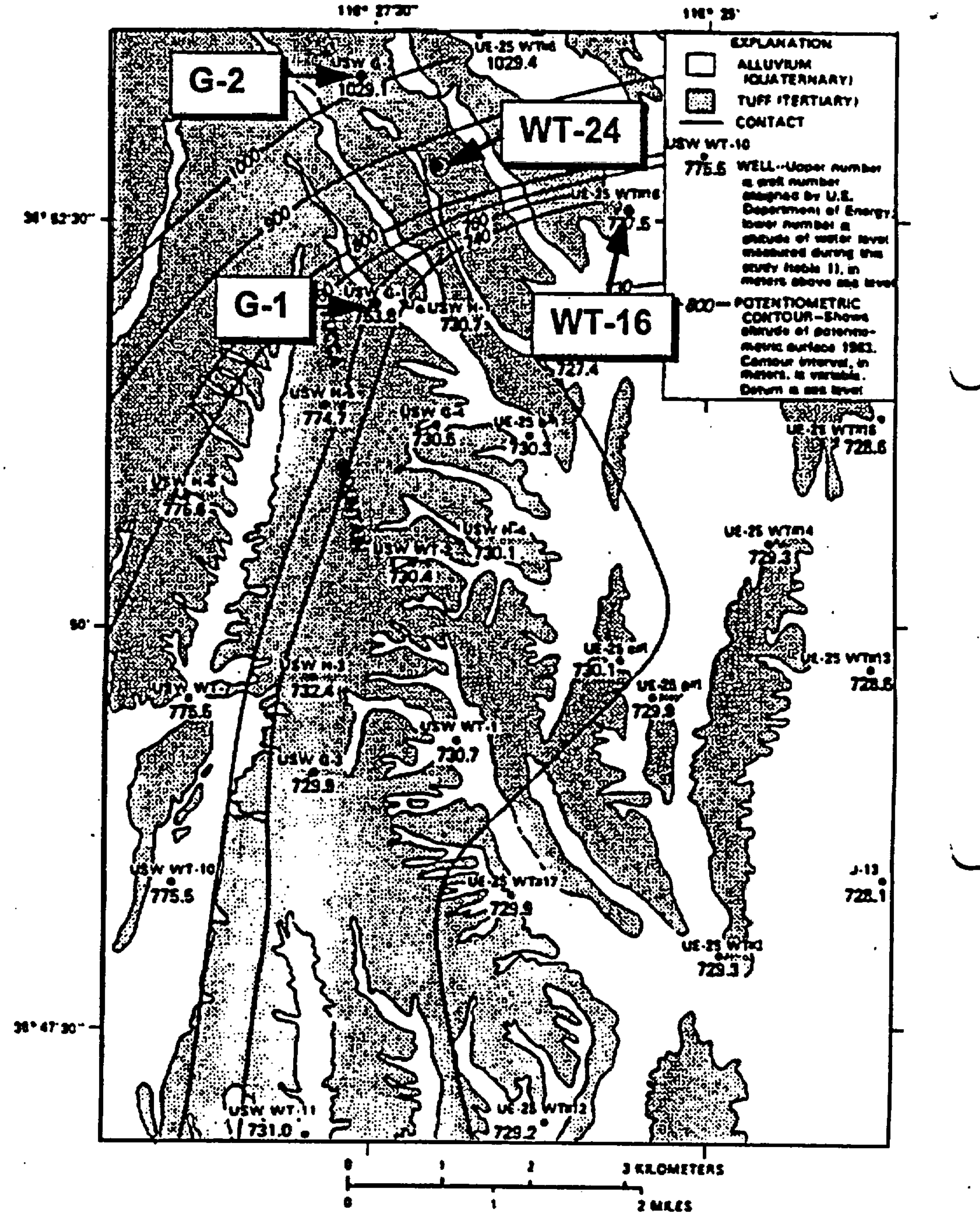
6/10/96 update (8A)

G-2 Aquifer Test

- Purpose - characterize large hydraulic gradient north of site
- Method - Investigation of potential perched water effects while pumping from Calico Hills
- Status -
  - First pump test (2/6/96-2/8/96): Planned 72 hour test
    - » Test interrupted: Power failure after 55 hours
    - » 55 ft. drawdown achieved
    - » Recovery occurred in 45 days
    - » Results inconclusive
  - Second pump test (4/8/96-4/25/96)
    - » pumped 1,379,779 gallons in 408 hrs.
    - » 124 feet of drawdown achieved
    - » recovery as of 5/20/96 = 21.26 ft. below pretest level
      - Estimate approx. 60 days more to recovery

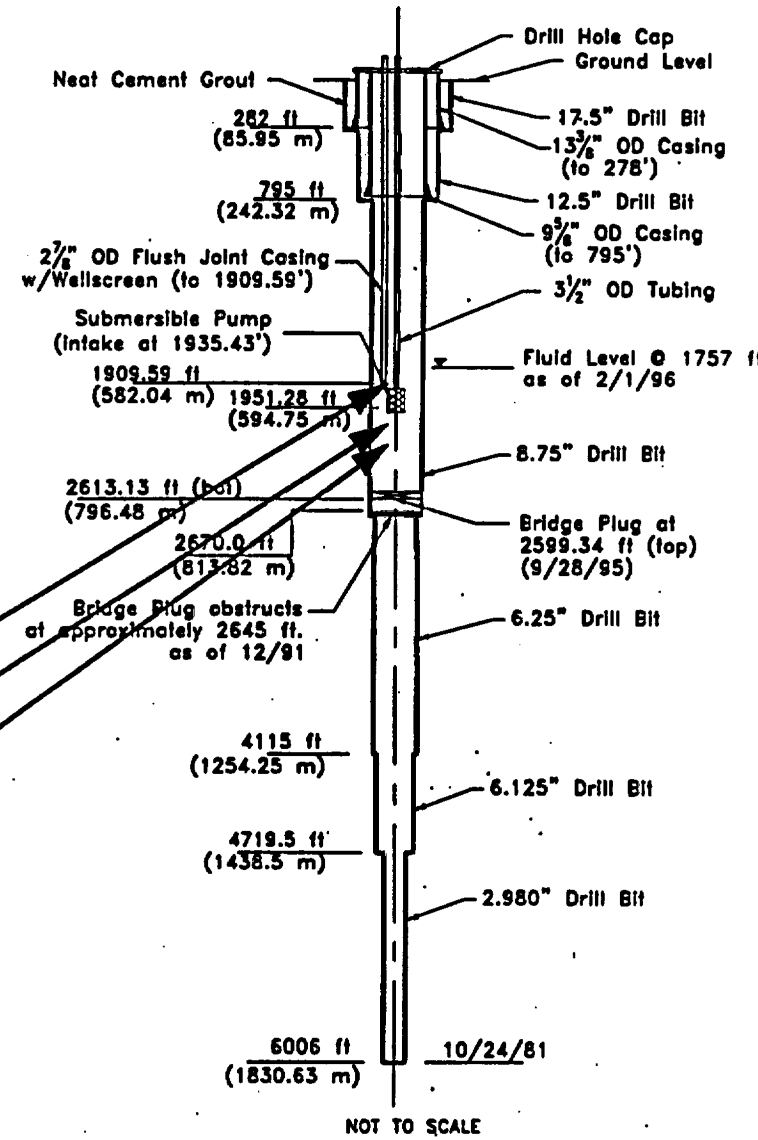
G-2 Location Relative to Potentiometric Surface

- Existing boreholes
- ◉ Proposed borehole
- —— Equipotential lines

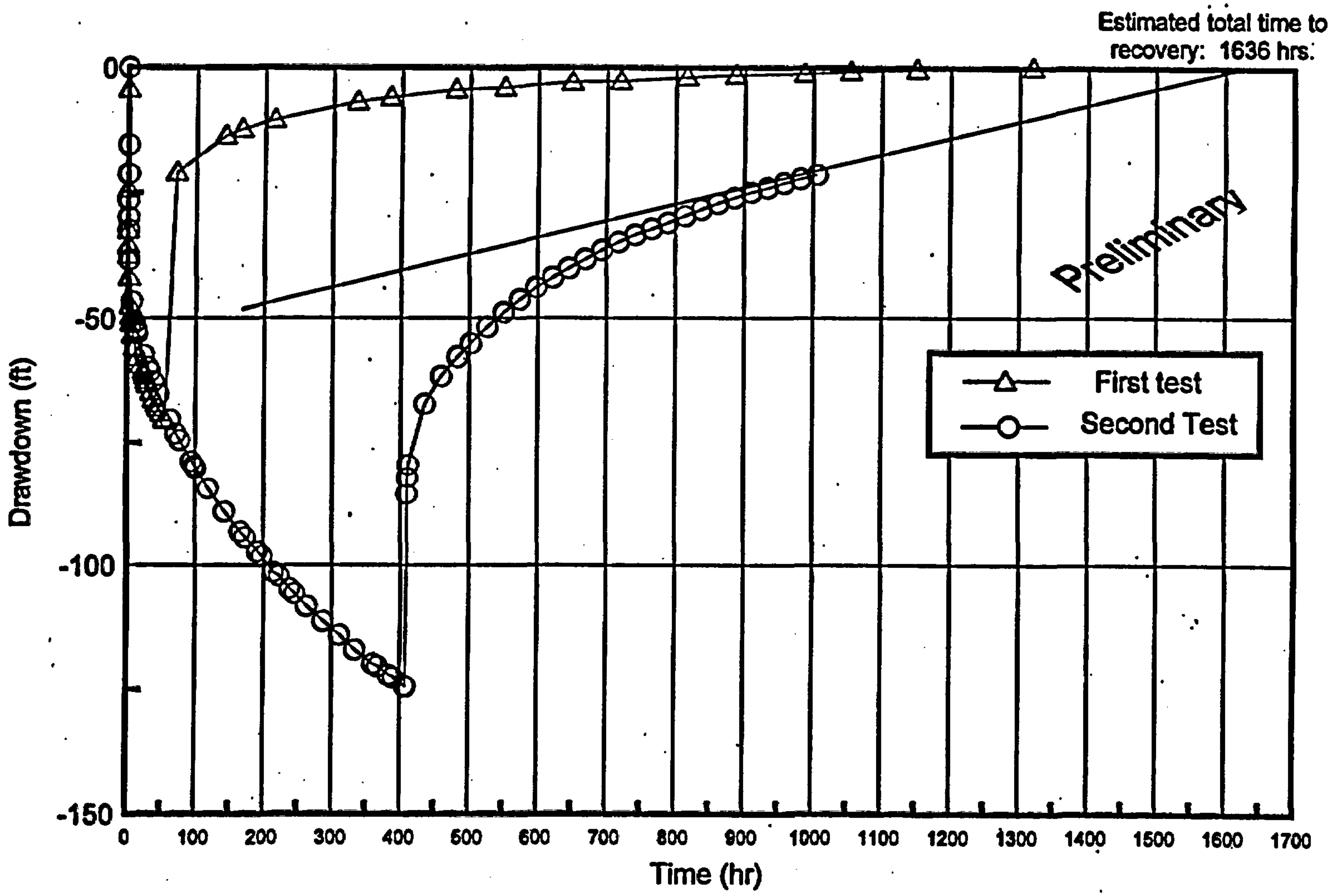


G-2 Pump Test #1 Configuration

- Pump location (intake):
  - 1,935.43
- Fracture interval depths:
  - 1,812' - 1,864'
  - 1,982' - 2,008'
  - 2,068' - 2,126'



G-2 Pump Tests



5/28/96

SYNTHESIS REPORTS SCHEDULED FOR FY96

WBS #	*Part.*	*Deliverable #*	*Title*	*Baseline*	*Forecast*
1.2.3.2.1.1.1	M&O	3665	Synthesis of Mineralogy/Petrology Studies	01-Aug-96	30-Aug-96
~~1.2.3.2.2.1.1~~	~~USGS~~	~~3GGU102M~~	~~Stratigraphy, Structure, and Rock Properties of Yucca Mountain~~	~~30-Aug-96~~	~~30-Aug-96~~
1.2.3.2.5.1.1	M&O	3781M	Synthesis of Volcanism Studies	30-Aug-96	30-Aug-96
1.2.3.2.7.4	M&O	OS32741D1	Site Geotechnical Report	02-Sep-96	03-Sep-96
1.2.3.2.8.3.6	USGS	3GSH100M	Seismotectonic Framework for Yucca Mountain	01-Aug-96	01-Aug-9
1.2.3.4.1.2.1	M&O	3784M	Summary & Synthesis Report on Radionuclide Retardation	31-Aug-96	30-Aug-96
1.2.3.3.1.2.7	USGS	3GUH607M	Synthesis Report on UZ Hydrochemistry at Yucca Mountain	30-Aug-96	30-Aug-96
1.2.3.6.2.1.5	USGS	3GCA102M	Synthesis Quaternary Rsp YM Unsaturated & Saturated Zone Hydrologic Climate Changes	30-Aug-96	30-Aug-96
1.2.3.11.2	M&O	OB05M	Borehole and Surface Geophysics Synthesis Report	01-Aug-96	29-Aug-96
1.2.3.12.1	M&O	MOL305	Revision 1 of Vol II of the Near Field Environment Report Preparation	30-Aug-96	30-Aug-96

Note: Synthesis Report on Stratigraphy, Structure, + Rock Properties cancelled because this information to be presented in 1997 PISA. DOE added Synthesis Report on "Characterization of Fractures at Yucca Mountain" due 8/30/96

PRELIMINARY DRAFT
INFORMATION ONLY

ENCLOSURE 4

M&O SYNTHESIS REPORT LEVEL 3 MILESTONES

Synthesis of Mineralogy/Petrology Studies: Milestone 3665 ✓ 01 Aug 96

This deliverable consists of a report that will describe the distribution, occurrence, and origin of important minerals in both fractures and matrix, the occurrence and distribution of erionite and associated health effects, the existing three-dimensional mineralogical model of Yucca Mountain and a description of existing mineral assemblages that are favorable for radionuclide retardation.

Stratigraphy Structure and Rock Properties of Yucca Mountain: Milestone 3GGU102M ✓
Deleted for FY96 per change request 30 Aug 96

The deliverable consists of a synthesis report, based primarily on data available at the end of FY1995, describing the current level of understanding on the stratigraphy, structural geology, and rock properties of the site area.

Synthesis of Volcanism Studies: Milestone 3781M ✓ 30 Aug 96

This deliverable will include but not be limited to: Revision of estimates of the annual probability of a magmatic event affecting the repository using various structural models for volcanism in the Yucca Mountain region. This work will provide a mature evaluation of the probability of disruption of the repository area due to direct and indirect volcanic effects, and thereby the importance of the hazard to the site due to renewed igneous activity.

Site Geotechnical Report: Milestone 0S32741D1 ✓ 02 Sep 96

The deliverable will contain a synthesis of the geology, hydrology, geochemistry, geomechanics, Exploratory Studies Facility Observations, Seismic Design Basis, Engineering Geology of the North Ramp, Seals, and Appendices. In this report, various types or groups of data will be interpreted in the context of other related and relevant information and end use.

Seismotectonic Framework for Yucca Mountain: Milestone 3GSH100M ✓ 01 Aug 96

This deliverable will summarize and synthesize the available seismotectonic information for Yucca mountain and will contain the results of field studies of Quaternary faults, both at the site and in the region surrounding Yucca Mountain, with emphasis on their potential as seismic sources. This summary will include an assessment of the recency of displacement and Quaternary history of studied faults, including final results for the Ghost Dance fault, Rock Valley fault, and Crater Flat fault.

Summary and Synthesis Report on Radionuclide Retardation; Milestone 3784M ✓ 31 Aug 96

This deliverable will consist of the assembly of summary and synthesis activities of laboratory and modeling studies that investigate mechanisms by which radionuclide transport is retarded

PRELIMINARY DRAFT
INFORMATION ONLY

or enhanced by sorption, diffusion, microbial activity, solubility limits, and colloid transport. Results of analysis will be discussed with regard to quality/reliability of results, site characterization, current conceptual models and hypotheses, and recommended input to subsequent modeling efforts and performance assessment.

Report on UZ Hydrochemistry at Yucca Mountain: Milestone 3GUH607M — 30 Aug 96

This deliverable will consist of analyses of water obtained from existing core samples from the Calico Hills and Paintbrush nonwelded units in selected boreholes, and these data will be compared to previously reported data will be compared to previously reported data from other boreholes. The synthesis also will include the results of past and ongoing rock-gas sampling from selected boreholes at the Yucca Mountain Site.

Synthesis Quaternary Response of Yucca Mountain Unsaturated and Saturated Zone Hydrol. to Climate Change: Milestone 3GCA102M — 30 Aug 96

This deliverable will incorporate information from Terrestrial Paleoecology, lakes, playas, and marshes, Paleoenvironmental History, and Quaternary Regional Hydrology into a single report. The report will provide an initial assessment of local and regional climate change and the resulting response of infiltration, percolation, rise in water-table elevation within and past-discharge on, or near Yucca Mountain.

Borehole and Surface Geophysics Synthesis Report: 0BC5M — 01 Aug 96

This deliverable will describe the geologic setting of Yucca Mountain and vicinity as determined from an interpretation and integration of surface-based and borehole geophysical data. Analysis of seismic data will include seismic reflection profiles across the Rock Valley fault and vertical seismic profile data collected to provide velocity information in support of seismic hazard assessment.

Revision 1 of Volume II of the Near Field Environment Report Prep.: Milestone MOL305 — 30 Aug 96

This deliverable will include appropriate updates of the existing Near-Field Environment Report and any new or additional information that has been developed, in addition to new chapter(s) covering the Altered Zone.

Characteristics of Fractures at Yucca Mountain, Nevada

1. Abstract

2. Introduction
   a. Rationale - role of fracture studies in site characterization
   b. Historical summary of fracture studies at Yucca Mountain

3. Geologic Setting - Stratigraphy and Structure

4. Data Collection Methodology
   a. Types of data
      i. Borehole data
      ii. Cleared exposures
      iii. Outcrop observation
      iv. Detailed line survey
      v. Close-range photogrammetry

5. Results
   a. Comparisons of observations from individual studies
   b. Strengths and weakness of different data
   c. Data integration methodology and database construction

6. Discussion
   a. Analysis of the entire database
      i. Number and orientation of fracture sets
         (1) cooling joints versus tectonic fractures
         (2) trace-length distributions
         (3) fracture intensity measures
         (4) fracture connectivity
      ii. Paleostress evolution and timing of fracture development
      iii. Characterization of stratigraphic control of fracture networks
      iv. Areal distribution of fracture characteristics

7. Interpretations
   a. Fractures and structures
      i. Changes in fracture style/intensity near fault zones
      ii. Links between discontinuous faults and the fracture network
   b. Evaluation of ability to predict fracture distribution at depth from surface studies
   c. Geologic models for predicting fracture characteristics
   d. Implications for hydrologic models

8. Summary

9. References

10. Appendices

c:\work\mail\steve.vol

APPENDIX

Synthesis of Volcanism Studies

outline (***For information purposes only. The outline does not reflect contracted workscope and may not be used to judge suitability/acceptibility of the report***)

I. **Abstract**

II. **Introduction to the volcanism issue (chapter 1)**

A. Summary of major conclusions
B. Introduction to major issues regarding volcansim
   1. Risk vs. hazard
   2. Uncertainty and difficulties of predictions for Yucca Mountain
   3. Description of the contents of succeeding chapters

III. **Geologic setting of basaltic volcanism (chapter 2)**

A. Summary of geologic setting
B. Introduction
   1. Regional geologic setting at a variety of scales
C. Basaltic volcanism of the Yucca Mountain region
   1. Basalt of the silicic episode (>11 Ma)
   2. Post-caldera basalt (<11 Ma)
      a. Older post-caldera basalts (9-6.3 Ma)
      b. Younger post-caldera basalts (<4.8 Ma)

IV. **Tectonic setting of Yucca Mountain and its relationship to basaltic volcanism (chapter 3)**

A. Summary of the tectonic setting
B. Introduction to tectonic issues
C. Tectonics of the southern Great Basin
D. Tectonics of the Yucca Mountain region
E. Tectonics and the time-space distribution of basaltic volcanism
F. Summary of geophysical studies in the Yucca Mountain region
   1. Seismic studies (natural seismicity)
   2. Gravity studies
   3. Magnetic studies
   4. Geodetic studies
   5. Seismic studies (reflection, refraction, teleseismic)
G. Tectonic models of basaltic volcanism

V. Petrologic and geochemical constraints on basaltic volcanism (chapter 4)

A. Summary of petrologic and geochemical constraints
B. Introduction to petrologic and geochemical constraints
C. Time-space-composition trends in basaltic volcansim from the western US
D. Mantle source components for volcanism
E. Evolution of basaltic volcanic fields
F. Geochemical evidence for polygenetic volcanism in the Yucca Mountain region

VI. 3. Magma System Dynamics (Chapter 5)

A. Summary of literature review
B. Recommendations for future research.

VII Eruptive Effects (chapter 6)

A. Description of analog eruptive centers in New Mexico and Arizona
B. Lithic data
   1. Measurement techniques
   2. Uncertainty
   3. Lithic data for different eruptive mechanisms
   4. Statistical treatment of lithic data
C. Implications for eruptive effects on a repository.

VIII. Subsurface Effects (chapter 7)

A. Controls on shallow intrusion geometry
   1. Desription of Paiute Ridge intrusion geometries
   2. Interpretation of emplacement mechanisms
   3. Implications for intrusions near repository.
B. Hydrothermal alteration of silicic tuffs around shallow basaltic intrusions.
   1. Paiute Ridge analog site
      a. Field descriptions
      b. Chemical and mineralogical data
      c. Interpretation of alteration processes
   2. Grants Ridge analog site
      a. Field descriptions
      b. Chemical and mineralogical data
      c. Interpretation of alteration processes
   3. Implcations for hydrothermal effects on repository.
C. Summary of theoretical and modeling studies of hydrothermal processes.

Intrusive effects

A. Temporal and spatial scale of disruption to a repository system
   1. Field studies
   2. Modeling studies

B. Anticipated contribution to releases

IX. History of volcanism studies (chapter 8)

A. Summary of volcanism studies
B. Introduction to volcanism studies
C. Progress before the site characterization plan (by year since 1979)
D. Progress since the site characterization plan (by year since 1988)

X. Probabilistic volcanic hazard assessment (PVHA; chapter 9)

A. Summary of PVHA
B. Introduction to PVHA
C. The probability models
D. Stragtegy for implementing PVHA at Yucca Mountain
E Revised probability calculations
   1. Definition of a volcanic event
   2. Temporal treatment of models
   3. Spatial and structural treatment of models
   4. Treatment of possible polygenetic volcanism
   5. Treatement of event distributions for various volcanic centers/clusters
   6. Recurrence rate calculations
   7. Estimates of the probability of disruption of the repository system
F. Comparison of probability calculations to those of the PVHA expert panel and others
   1. Comparisions of probability distributions
   2. Source and significance of differences in probability distributions

XI. Current status and recommendations for further needed work (Chapter 10)

XII Summary of conclusions from chapters 1 through 10 (chapter 11)

10/25/95 VERSION

Seismotectonic Framework of Yucca Mountain

A Synthesis Report by the

U.S. Geological Survey Tectonics Team

Executive Summary

Introduction

Define purpose and scope of this synthesis report.
Present a history of the tectonics program.
Discuss relevant regulatory and design issues
Discuss relevant technical issues and how they have been approached in this report
Limitations of present work

1 Geologic Setting

- Miocene volcanic history
- Physiographic and climatic setting
- Evolution of the Great Basin

2 Neogene tectonic evolution of Yucca Mountain

- Pre-Neogene structural configuration
- Volcanotectonic evolution; calderas history and renewed volcanism (recurrent basaltic cones)
- Origin of major faults and other structures on Yucca Mountain
    - Discussion of faults on Yucca Mtn central block

PRELIMINARY DRAFT
INFORMATION ONLY

Alternative tectonic models
- Tectonic domains
- Structural models and cross-sections
- Interpretation of geophysical data sets
  - seismic reflection, gravity, aeromagnetics, etc
- Vertical and horizontal deformation
- Discussion of coupled processes
- Discussion of regional and local stresses

3 Quaternary faulting in the Yucca Mountain Region

Distribution of Quaternary faults within 100 km
Brief description of all potential regional seismic sources
- Complete descriptions presented in an Appendix

Death Valley-Furnace Creek Fault System
Bare Mountain Fault System
Rock Valley Fault System

Modern deformation from so Great Basin GPS network

4 Quaternary faulting and paleoseismology at Yucca Mtn

Distribution of Quaternary deposits
- Quaternary stratigraphy

Geochronology of Quaternary sediments
- Dating paleo surface ruptures

Distribution of Quaternary faults and scarps at Yucca Mountain
- Relationship to Miocene structures
- Fault bifurcations and intersections
- Presence of basaltic ash in fault planes
- Scarp enhancement by erosion

Summary of Midway Valley Studies

Ghost Dance Fault Evaluation

Synthesis of paleoseismic studies of eight local faults
- (Detailed summaries in an Appendix)
- Displacements per events
- Recurrence intervals
- Fault slip rates: Quaternary through Neogene

5 Earthquake magnitude and recurrence at Yucca Mountain

- Fault segmentation models
- Distributed faulting scenarios
- Paleo-magnitude from displacement per event, fault length, and down-dip width
- Earthquake recurrence models

6 Seismotectonic models of Yucca Mountain faults

- Synthesis of faulting style, geometry, and dynamics
  - Critique tectonic models:
    - detachment
    - concealed detachment or strike-slip
    - high-angle planar or branching
    - volcanic
    - slide block
- Boundary element models of local faults (in cross-section and plan view)

7 Seismicity in the Great Basin

- Historical earthquake catalog (scrubbed version)
- Seismicity from 1978-1995
- Little Skull Mountain Earthquake of 1993
  - Discussion of triggered events
- Recent earthquakes in Rock Valley and near Yucca Mountain
- Precarious rock studies
- Background source zones in the Great Basin

8 Fault rupture hazard analysis: A summary of issues and information

- Empirical data from Great Basin and global earthquakes
  - Contrast regional data with Yucca Mtn data
- Minimum magnitude for surface rupture in the Great Basin
- Maximum background earthquake in the Great Basin
- Alternative approaches for assessing fault rupture hazard

9 Ground motion hazard analysis: A summary of issues and information

- Source Modeling studies and Scenario Earthquakes at Yucca Mountain
- Ground motion attenuation
  - Empirical relationships from California earthquakes in the western U.S.
  - Empirical relationships from normal faulting earthquakes
- Ground motion Site Response

10 Relevant earthquake sources

- Define type I vs. relevant and potentially relevant sources)
  - Distinguish relevancy to fault rupture vs. ground motion hazards
- Seismic source characterization analysis
  - Table of relevant and potentially relevant sources:
    - use new empirical ground motion relationship

11 Discussion of the state of knowledge of tectonics of Yucca Mountain (?)

- Discussion of studies that may increase confidence in the data and interpretations

c:\work\mail\steve.vol

OUTLINE OF SYNTHESIS REPORT FOR RADIONUCLIDE RETARDATION

Chapter on: GROUNDWATER CHEMISTRY MODEL

Chapter on: SORPTION AND SORPTION MODELING STUDIES

I. Groundwater Chemistry (and its effects sorption)
II. Mineralogy Variability (and its effects on sorption)
III Sorption Data (determined by batch experiments)
   A. Sorption of Simple Cations
   B. Sorption of Simple Anions
IV Sorption of Actinides
V. Models that can explain the measured sorption data
   A. Ion Exchange
   B Surface Complexation
VI Recommended sorption data for PA

Chapter on: SOLUBILITY STUDIES

I. **Introduction**

   A. Solubility's Role in Multi-Barrier Approach
   B. Focus on Np, Pu, and Am
   C. Focus on OH- and CO32- Ligands
   D. Goals of Study: Short, Intermediate, and Long Term

II. **Neptunium**

   A. Summary of Bulk Solubility Experiments
   B. Summary of Solution Speciation
      1. Check on Consistency of Data Using SIT Analysis
   C. Summary of Solubility Limiting Solids
   D. Status of Solubility Modeling

III. **Plutonium**

   A. Summary of Bulk Solubility Experiments
   B. Summary of Solution Speciation
      1. Check on Consistency of Data Using SIT Analysis
   C. Summary of Solubility Limiting Solids
   D. Status of Solubility Modeling

PRELIMINARY DRAFT
INFORMATION ONLY

c:\work\mail\steve.vol

IV. Americium

A. Summary of Bulk Solubility Experiments
B. Summary of Solution Speciation
   1 Check on Consistency of Data Using SIT Analysis
C. Summary of Solubility Limiting Solids
D. Status of Solubility Modeling

Chapter on: DYNAMIC TRANSPORT STUDIES

I. Assessment of Validity of Kd under Advective Conditions

A. Crushed Rock Columns
   1. Using Water from the J-13 Well
      a. Vitric Tuff
      b. Zeolitic Tuff
      c. Devitrified Tuff
   2. Using Water from the UE-25 p# 1 Well
      a.. Vitric Tuff
      b. Zeolitic Tuff
      c. Devitrified Tuff
B. Saturated Solid Rock Columns
   1. Using Water from the J-13 Well
   2. Using Water from the UE-25 p# 1 Well
C. Unsaturated Solid Rock Columns
   1. Zeolitic Tuff
   2. Devitrified Tuff

II. Radionuclide Transport through Fractures

A. Conservative Radionuclides (tritium and pertechnetate)
B. Sorbing Radionuclides

III. Colloid-Facilitated Radionuclide Transport

A. Colloid Stability in Natural Groundwaters
B. Sorption of Radionuclides onto Colloids
C. Elution of Colloids through Fractures
   1. Saturated Systems
   2. Unsaturated Systems

c:\work\mail\steve.vol

Chapter on: DIFFUSION STUDIES

I. Diffusion of Conservative Radionuclides through Saturated Tuff

A. Tritiated Water
   1. Diffusion Cells
   2. Rock Beakers
B. Pertechnetate
   1. Diffusion Cells
   2. Rock Beakers

II. Diffusion of Sorbing Radionuclides through Saturated Tuff

A. Tuff Wafers
B. Diffusion Cells
C. Rock Beakers

III Diffusion of Radionuclides through Unsaturated Tuff

Chapter on: BIOLOGICAL SORPTION AND TRANSPORT

I. INTRODUCTION

A. This will discuss subsurface microbiology and microbial effects on transport of radioactive wastes. This will reference pertinent literature and recent reviews including:
   1. Pedersen and Karlsson. 1995. Investigations of subterranean Microorganisms: Their importance for performance assessment of radioactive waste disposal. SKB Technical Report.
   2. Bachofen et al. 1990. Microorganisms in nuclear waste disposal. Experientia 46 and 47 (multi author review in two issues).
   3. Horn and Meike. 1995. Microbial activity in Yucca Mountain. LLNL report UCRL-ID-122256
   4. Hersman. 1996. Microbial activity in Yucca Mountain: Effects on radioactive transport. in "Subsurface microbiology". Holdeman and Amy, eds. CRC Press, Boca Raton, FL. in preparation.

II. MATERIALS AND METHODS

A. Describe the ESF and sampling techniques.
B. Describe sample collection methods, sample replication, and distribution to participating labs

C. Describe the materials and methods of each of the analysis performed at each of the participating labs:
   1. UNLV - CTC heterotrophs, nutrient limitations (PO4, S, carbohydrates), AODC counts, autotrophs (Fe, S, NH4 oxidizers), percent moisture.
   2. NM Tech - 14CO2 heterotrophs, nutrient limitations (amino acids, carbohydrates), AODC counts, water activity effects.
   3. U. Oklahoma - total anaerobes, MPN for SO4, NO3 reducers, methanogens.
   4. U. Tennessee - phospholipid fatty acid (PLFA) analysis which includes: 11 normal structure, 7 terminally branched saturates, 4 mid-branched saturates, 10 monoenoics, 2 branched monoenoics, and 1 polyenoic fatty acid analyses.

D. Describe the materials and methods of each of the analyses performed at Los Alamos - sorption of 239Pu(IV) by micro's, chelation of 239Pu(IV) by micro's produced siderophores, effects of micro's on colloidal agglomeration rates, siderophore/Fe(III) transport rates through unsaturated tuff columns, microbial dissolution of metal oxides.

E. Discuss correlation and regression analyses of the above experiments.

III. RESULTS

A. Figures and Tables.

B. Describe the results of each of the above experiments. Because of the volume of data, only significant results will be described (however, every data set will be mentioned).

IV. DISCUSSION

A. The significance of the data will be discussed. This discussion will also compare all of the experiments to one another, for example PLFA vs. total anaerobes. Significant correlations and regressions will be discussed. Performance assessment. The ESF and Los Alamos data will be combined to predict the microbial effect on transport.

V. LITERATURE CITED

Report Outline for Level 3 Milestone 3GUH607M:
Synthesis of UZ Hydrochemistry at Yucca Mountain
March 22, 1996
Revised May 15, 1996

INTERPRETATIONS OF CHEMICAL AND ISOTOPIC COMPOSITIONS AND GEOCHEMICAL MODELING (NETPATH) IN THE UNSATURATED ZONE, YUCCA MOUNTAIN, NEVADA, By Albert I.C. Yang

I. Introduction

This report will present new chemical and isotopic data obtained in FY 96 from boreholes SD-7, SD-9, SD-12, UZ-14, NRG-6, and NRG-7a. Data will be interpreted with respect to gaseous- and aqueous-phases residence times, flow paths, and flow types (matrix versus fracture flow). In addition, results of investigations on stable isotopic compositions (δD and $\delta^{18}O$) of pore water from UZ-14 with respect to water-extraction methods and significance of the isotopic data will be presented and discussed. Further, the results of geochemical modeling using the program NETPATH will be documented. Geochemical modeling will be used to evaluate chemical evolution of perched water and to correct ^{14}C ages of perched water.

II. Chemical and radioactive-isotopic compositions (^{3}H and ^{14}C) of pore water from unsaturated-zone cores

A. Boreholes from which data were collected

B. Sample collection and analysis
(Note: This section will be brief; reference to FY 95 milestone 3GUH105M.)

1. Gas samples from UZ-14 and SD-12
(CO_2, $^{14}CO_2$, and $^{13}CO_2$)

2. Pore-water samples from SD-7, -9, -12 and NRG-6, -7a
(Chemical compositions, ^{3}H and ^{14}C)

3. Gas and water sample analyses

C. Interpretations of chemical and isotopic data

1. Spatial variabilities in chemical and isotopic data

2. ^{3}H profiles in boreholes (limited samples; may not intercept all fast-flow paths)

3. Residence times of gaseous-phase $^{14}CO_2$ and pore water

4. Flux (qualitative) attributed to matrix or fracture flows.

III. Stable isotopic compositions (δD and $\delta^{18}O$) of pore water from UZ-14 (None of these data are in FY 95 milestone report)

A. Methods of pore-water extraction and analysis for δD and $\delta^{18}O$

1. Toluene distillation

2. Vacuum distillation

3. Compression extraction

4. Water analyses

B. Inconsistency in δD and $\delta^{18}O$ data with different extraction methods

1. Reviews of studies published in literature

2. Results of current studies

a. Isotopic data from toluene-azeotropic distillation

b. Comparison of vacuum distillation and compression-extraction methods

C. Laboratory tests

1. Imbibing dry core with known isotopic-composition water: imbibing test

a. Extracting imbibed water by vacuum distillation

b. Extracting imbibed water by compression

2. Exchange ability of matrix water with environmental water: column test

D. Applicability of the extraction methods to Yucca Mountain cores

1. Pah Canyon and Topopah Spring Tuffs: vacuum distillation method

2. Bedded tuff and Calico Hills Formation: Compression method

E. Interpretations of the stable-isotopic data

1. Source and nature of infiltrating water in UZ

(Note: UZ pore water in relation to precipitation water, perched water, and saturated-zone water)

2. Interactions of old matrix water with younger environmental water

3. Preglacial (>10,000 years) or postglacial (<10,000 years) pore water in Topopah Spring Tuff.
(Note: ^{14}C data were not obtainable from Topopah Spring Tuff because no water can be extracted by compression. However, water can be extracted by distillation. Distilled water is a pure water which contains no salts or carbon element for ^{14}C dating. But hydrogen and oxygen isotopes (δD and $\delta^{18}O$) can be measured on the pure water because hydrogen and oxygen are parts of the water molecule itself.)

IV. Geochemical modeling (NETPATH)

A. Modeling chemical evolution of perched water

1. Chemical speciation and mineral saturation of unsaturated-zone water

2. Conceptual model for water and mineral chemistry at YM

3. Selection of chemical-element constraints and mineral phases

4. NETPATH results

B. Models of ^{14}C age corrections on perched water

1. Various model performances

2. Sensitivity of isotopic input data to the corrected ^{14}C ages

3. Corrected ^{14}C ages of perched water

V. Summary and Conclusions

VI. References

CLIMATE AND QUATERNARY HYDROLOGY SYNTHESIS REPORT FY 96
(3GCA102M)

ABSTRACT

Climate cycles are 400 ky in duration. Those cycles are tied to changes in the earth's orbit which result in changes in the amount of heat (insolation) received by earth. Changes in insolation are well correlated with the major features of global climate change such as the waxing and waning of continental ice sheets. The well-dated record from Devils Hole shows southern Nevada climate changed in concert with those on the rest of earth. Long sedimentary records from basins such as Owens Lake provide an estimation of the magnitude and frequency of local climate change and therefore link changes in insolation to a climate response in the Yucca Mountain area. That linkage provides a way of using calculated changes in insolation over the next 100 ky or longer to estimate future-climate boundary conditions.

Sedimentary deposits from former wetlands and springs found in valleys near Yucca Mountain provide records of ground-water discharge during the last major wet-climate period. In particular deposits down the flow gradient from Yucca Mountain at Site 199 on Crater Flats, at the Lathrop Wells Diatomite, and at paleowetland sites near the Amargosa River show that discharge was initiated about 40 ka and persisted to about 8 ka. That discharge, at least in part, came from the regional aquifer when the water table rose a maximum of about 115m. Interpretation of plant macrofossils found in packrat middens suggest
mean annual precipitation (MAP) varied during the latter wet period, but exceeded modern levels by 200 to 300 percent. In particular, episodes with white fir and no limber pine likely had MAP levels above 25 inches,
whereas white fir and limber together likely had MAP levels between 20 to 25 inches and limber only indicate MAP levels below 20 inches.

Dating, isotopic, geochemical, and petrographic studies of calcite and opal minerals precipitated in fractures within Yucca Mountain provide a direct means of comparing regional climate changes to changes in hydrology within the unsaturated and saturated zones. Calcite and opal mineral precipitation within the unsaturated zone appears to have occurred throughout the period from more than 400 ka to about 100 ka.
During much, but not all of this time, regional climate records show an intermediate MAP level between the very dry modern condition and the wettest phases between 160 to 140 ka and between 40 to 8 ka. The few
minerals in both the ESF and drill holes dating from the wettest past climate phases, if upheld by new data, may indicate that the flow of water within Yucca Mountain may have changed in some fundamental way such as being dispersed along other fracture paths or passing through the mountain without leaving a mineral record, or, maybe the higher precipitation never gets into the mountain.

I. INTRODUCTION.

General comments will describe the linkages between climate and hydrology. Discuss the climate of the region and note that climate is not constant.

Link past synthesis reports to this one.

II. EXECUTIVE SUMMARY

This section will characterize Yucca Mountain paleoclimate and the response of paleohydrology to climate change.

The data will be placed within the framework of long (400 ky) climate cycles. In two areas deal with the long records spanning the entire 400 ky cycle and the high resolution records from the last 50 ky within the vicinity of the mountain.

III. CENTRAL HYPOTHESIS

The future climate patterns at Yucca Mountain can be projected by looking for patterns in the past that link climate and hydrological change to the cyclical change in the earth's insolation; the only parameter that can be reasonably estimated for the future. The hydrologic behavior of the mountain during the next 100 kY or more years should be similar to that which occurred for correspondingly similar insolation patterns in the past.

This section will also discuss the central problem of examining the hydrologic characteristics of Yucca Mountain during the current brief and unusually dry period in the region's climate history and relating these characteristics to those that are likely to occur in the future.

DATA COLLECTION, ANALYSES, AND INTERPRETATIONS

Paleoclimate data comes primarily from fossils of plants and animals that lived in aquatic and terrestrial environments as well as isotopic evidence derived from the fossils and other material. Site paleohydrology data comes primarily from the isotopes, geochemistry, and petrography of calcite and opal within the mountain and from deposits (including fossils) along the ground-water flow paths of Yucca Mountain. Additional paleohydrologic data comes from alluvial, fluvial, eolian, pedogenic, and related deposits on and near the mountain.

IV. CAUSATION OF CLIMATE AND HYDROLOGICAL CHANGE IN SOUTHERN NEVADA

A. THE NATURE OF THE CLIMATE SYSTEM

1. Modern climate varies due to factors such as the ENSO phenomena, ocean circulation, solar variability, volcanic eruptions, and so on. Those factors that produce climate variability operate within the climate boundary conditions established by the orbital parameters and commonly expressed in terms of insolation. As insolation changes on a millenial time scale the climate boundary conditions change and so does the average climate about which the variation and the degree of variation occurs.

2. The nature of climate when the insolation boundary conditions change will be discussed. What is the nature of insolation, how does it arise, what happens when it changes on a global scale? Key orbital parameters will be described; eccentricity (the shape of earth's orbit) and thus its distance from the sun; the obliquity (the tilt of the earth's axis towards or away from the sun); and precession (the relative wobble of earth on its axis) resulting in the orientation of the earth toward or away from the sun during northern hemisphere seasons. These orbital parameters vary in cyclic and predictable ways and hence their status for the next 100 k or more years is easily determined. Changes in orbital parameters produce changes in earth's upper atmospheric insolation. Insolation changes may or may not exhibit linear covariance with the tropospheric expression of climate. Note oceanic record of orbital changes represents a measure of the size of the earth's ice caps and that determines the position of the storm tracks relative to yucca mountain.

3. Discuss the Devils Hole record in the context of showing how this long, continuous, and well dated climate record shows that climate change in southern Nevada is closely

correlated with global climate change as recorded by, for example, stable isotopes of water from polar ice cores or from marine biogenic carbonate in oceanographic cores.

4. Orbital Parameters in the future.--Discuss orbital style and resulting insolation for the next 100 k. Identify orbital analogs from the past, noting for example, that the period from about 400 to 300 ka is in orbital terms nearly identical to the next 100 k years.

V. CLIMATE HISTORY OF YUCCA MOUNTAIN REGION

A. COMPARE ORBITAL RECORDS WITH THOSE FROM DEVIL'S HOLE--Discuss relationships between the two records, noting that the Devil's Hole record stops about 20 ka. Local climate records substitute for the gap in the Devil's Hole record.

B. LONG RECORDS-REGIONAL--Compare available lacustrine records from last 500 ky with orbital and insolation records. Note general response of lacustrine records with orbital parameters,especially eccentricity. Establish preliminary linkages between past and future orbital parameters
and response of lacustrine records.

(The information content from this comparison is dependent on technical assistance needed to assemble components of the database. Available samples need to be analyzed and the resulting data incorporated in the synthesis report.)

C. HIGH RESOLUTION RECORDS-LOCAL

1. Lakes, Playas, and Marshes--describe history of wetland development in Las Vegas Valley using new radiocarbon age data with the changes in insolation at 30 degrees north latitude. Data include ostracodes, mollusks, stable isotopes, radiocarbon, and stratigraphic components. Place resulting discussion in an orbital parameter context.

If available discuss middle and late Holocene climate history from the cores taken in Pahranagat Lake. (Detail of this comparison will be dependent on available technical assistance to assemble an adequate database for diatoms and ostracodes.) Pahranagat data from aquatic fossils, stable isotopes, and pollen provide a good estimate of climate variability within the present climate state.

2. Terrestrial Records--describe history of vegetation change revealed by the packrat midden data available from the literature and from the data collected over the last several years and interpreted by DRI. Place an emphasis on estimating the magnitude of past climate change. Compare
history of vegetation change with insolation at 30 degrees north latitude and place in orbital context.

3. Comparison of Aquatic and Terrestrial Records. Compare and contrast the local history of changes in surface and shallow ground water with those of the major vegetation types.

D. SITE RECORDS--Forty Mile Wash, Midway Valley--use field data of surficial deposits from map unit deposits associated with fluvial or ground-water discharge activity on or near the mountain as a record of surface water availability and local recharge sources. Estimations of ages by available techniques will allow assembly of the history of stream activity and shallow infiltration over the last 100 millennia. Compare
eolian history with site records of surface-water hydrology.

VI. QUATERNARY HYDROLOGY

A. OVERVIEW OF PRESENT-DAY REGIONAL HYDROLOGY--Discuss major features within the present-day hydrologic system, including hydrogeologic units, recharge areas, discharge areas, and ground-water flowpaths.

B. STABLE ISOTOPE AND MINERALOGY--UZ Place isotope and mineralogical datasets in a context of long term infiltration, percolation, and recharge history within yucca mountain. Discuss isotope data set from minerals with respect to thermal gradient and with respect to the possible range of del o18 values for input waters--considering arctic to subtropical air mass sources and minerals precipitated at temperatures consistent with the modern thermal gradient. If dataset permits recognition of general air mass sources, align those with long lacustrine records and orbital data.

B. RADIOGENIC ISOTOPE (STRONTIUM AND URANIUM) TRACER STUDIES--UZ--SZ Use strontium and uranium isotope data sets to identify solute sources for secondary minerals in fracture flow paths (paleohydrologic implications) and present-day ground waters (perched and SZ) within Yucca Mountain. Combine strontium and stable isotope data sets in an attempt to link air mass sources with flow paths within Yucca Mountain in order to identify linkage between orbital parameters and depth or path of percolation or recharge. Characterization of climate-controlled parameters is particuarly important for sub-surface materials dated by radiocarbon or uranium-series disequilibrium.

If data are available, consider using strontium isotope data from Devil's Hole record to describe changes in the elevation of the Devil's Hole recharge area as a function of climate change.

C. GEOCHRONOLOGIC STUDIES OF SUBSURFACE SECONDARY

MATERIALS--UZ--SZ Discuss the available uranium-series disequilibrium age estimates from vein and fracture-filling materials within Yucca Mountain in order to establish a preliminary subsurface history of past
hydrology. Place particular importance on paleohydrologic records obtained from ESF in repository block horizon to place constraints on values of paleo water flux of and near the present-day potentiometric surface to determine height of paleowater table fluctuations. Discuss any linkages between age and aqueous saturation information for secondary minerals to make a preliminary estimate of past water flux. Age
frequencies from dated materials will also be compared to regional and orbital climate framework to evaluate links between climate and paleohydrology. Ultimately, results will be synthesized as models of UZ aqueous flow that leave mineral precipitation as well as episodes of undersaturated water flux that leave no mineralogical record.

Use radiocarbon data to establish the fracture flow history in Yucca Mountain during the last hydrological cycle (40 to 20 ka). Compare radiocarbon data with insolation data in order to establish history of saturated versus unsaturated water flux.

D. PAST DISCHARGE--ISOTOPE AND PALEONTOLOGICAL STUDIES Utilize available data from stable and radiogenic isotopes, geochronology (thermoluminescence, radiocarbon, uranium-series disequilibrium), and fossils to describe the hydrologic origins (regional and or perched aquifers) and discharge history of ground-water deposits occurring down-gradient from Yucca Mountain. Synthesize discharge history into a climate framework that links surface-water availability determined from playa and terrestrial records to a ground-water fluctuation response. Determine if discharge history can be placed in an orbital context, so that likelihood of such discharge in the future can be assessed.

VII. DISCUSSION

A. CURRENT INTERPRETATIONS Integrate the implications of the data discussed above into current understanding of how climate has changed and what that change has meant to the hydrology in the mountain. Link ages of opal and calcite from within the moutain to climate outside the mountain. Describe the linkage of climate and past discharge during the last climate cycle. Suggest how the discharge from the regional aquifer down gradient from Yucca Mountain may have played out in earlier cycles. How many wet cycles may exist and, therefore, how frequently and for how long might discharge be similar to that of the last cycle.

B. SUPPORT FOR INTERPRETATION Describe similarity or dissimilarity of various climate proxies. Explain relationship or lack of relationship between hydrologic response and climate proxies, e.g. does discharge from regional aquifers occur during times when climate proxies say its wet, especially during the last climate hydrological cycle when we have the benifit of large well dated climate and hydrological datasets?

Do changes in insolation parameters serve as a good predictor of past climate and hydrological change. What other datasets are needed? What existing datasets need to be expanded??

How might climate vary in the future using insolation values as a predictor?? How might global warming affect the natural system?? Sustained or enhanced aridity? or acceleration of a glacial advance??

C. ALTERNATIVE HYPOTHESES How might changes in the Quaternary Geology of the mountain alter the climate hydrology couplets? Have the wet cycles during the past 200 ky changed the capacity of the mountain to receive infiltration?

Do the calcite-opal studies suggest climate related percolation pathways--e.g. fast paths during very wet climates, multiple paths during intermediate wet climates, and sporadic paths during dry climates?

Is the orbital insolation explaination for climate change the only mechanism--would others lead to a different view of future climate and hydrological change?

Others that arise.

VIII. ISSUES

Discuss adequacy of datasets, adequacy of understanding, ground-water travel time (GWTT), UZ-flux etc. The data sets noted above are in different stages of maturity. Some are nearly complete, while others are in their infancy. Further, whereas a general understanding now exists as to how the system behaves in climate and hydrological terms, the particulars, such as GWTT or UZ-flux, need to be sorted out and evaluated with existing or new data sets, and by presentation of interpretations in the project as well as general scientific arena.

IX. CONCLUSIONS

What do we know now and what do we need to know to support or refute the central or alternative hypostheses.

Draft Outline
Geophysics Synthesis Report

- E.L. Majer, LBNL -

I. Introduction

A. Scope and Purpose of Report (1 page)

B. Background (5-10 pages)

(a) Review of Status of Geophysical Information Prior to FY 1995

C. Objective of Recent (FY 1995) Geophysical Work (1-3 pages)

II. Regional Geophysics

A. Potential Methods

(a) Earth field "depth to basement" results from gravity/magnetic data
(b) Gravity results along regional seismic lines 2 & 3
(c) Magnetic results along regional seismic lines 2 &3
(d) Magnetotellurics (Midway Valley)

B. Seismic Methods

(a) Reflection (lines 2 & 3. Rock Valley)
(b) Refraction Amorgosa Desert lines
(c) P & S wave delay models (if available)

C. Presentation of Interpreted Model

(a) Cross-sections (where available and appropriate)
(b) Map view (where appropriate and available)

Note: Data will be presented at various scales depending upon resolution of data, spacing of data points and methods.

III. Repository Geophysics

A. Seismic Reflection — YMP-1, 2, 3, 4, 5, 6, 7, 8, 9, 12, HR-1, HR-2, 13, 14, Line 1 (1994), Line 2 (1994).

B. VSP — WT-2, NRG-6, UZ-16 (if available) SD-12, G-4, G-2.

C. Magnetic Data — YMP-1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12.

D. Gravity Data — YMP-1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12.

E. MT Data — YMP-3.

IV. Integration of Well-Log Data
(Note: This section is not intended to replace the well-logging synthesis report being developed by Bud Thompson)

A. Description of logs used and information derived from the logs. (UZ 16, G 2, ONC-1, UZ-14, UZ-4, UZ-5, UZ-7a, SD-7, SD-9, SD-12, WT-2, WT-10, WT-12, G-4, G-3, GU-3, G-1)

B. Use of statagraphic tops for correlation of well-log data with surface geophysics

C. Synthetic VSP and surface reflection results

D. Find input and constraints placed on models based on well-log data.

V. Synthesis of Geophysical Data

A. Models derived from each geophysical method. Presentation format will be in cross-section and map at scale dependent upon data type and resolution. However, efforts will be made to have a consistent scale and scales compatible with geologic and other information.

(a) Seismic - 2D cross-section
(b) Gravity - 3D model, residual and final interpretation of geologic structures
(c) Magnetic - 2D (hopefully 3D if provided by USGS)
(d) MT - 2D cross-section
(e) Well-logs 3D sections

B. Integrated Model - Presentations of alternative models derived from combined interpretations of the various geophysical data types. For example, depth to basement derived from seismic/gravity, Topopah top from well log, VSP, seismic, etc. The objective is to provide several plausible alternative repository block and regional models based on the available data and within the scope of the report.

VI. Conclusions and Recommendations

A. Final conclusions and interpretations of models

B. Discussion of "confidence intervals" of models and reliability of results

C. Recommendations for future work, priorities for work and recommendations on further integration activities

PRELIMINARY

SYNTHESIS REPORT ON BOREHOLE GEOPHYSICS
PROPOSED TABLE OF CONTENTS

CHAPTER	EST NO OF TEXT PAGES
Descriptive Abstract	1
Abstract (Executive Summary)	1
Area Map	1
Introduction	3 - 5
Purpose	
Scope (technical and aerial)	
Summary of Results	3 -8*
Core-to-log relationships	
Comparison to results from other methods	
Conclusions and Recommendations	5 -10
Observations derived from borehole geophysics	
Conclusions (With appropriate QA qualification status)	
Confidence in analytical models	
Recommendations for future work	
Borehole Geophysical Methods	8 - 15*
Field Methods	
Logging in empty boreholes	
Logging in volcanic rock environments	
Borehole geophysical measurements - (A generic description of the major measurements used. NOTE: This will not be a tutorial on geophysical logging!) NOTE: Investigations classified as prototype will not be discussed in detailed, that discussion will be included in the subsequent Log Analysis Report.	
Data Reduction and Analysis[1]	
Data Verification	
Forensic Evaluation	
Analytical Methods	
Porosity Evaluation	
Water Saturation Evaluation	
Fracture Evaluation	
Etc., Etc..	

[1] This section will be a brief overview and include reference to the detailed Log Analysis Report (a level four deliverable) which will be in production at the time this synthesis report is issued)

*These chapters will generate a significant number of additional pages of supporting tables, diagrams, charts, logplots, plates, maps, etc.

Proposed Table of Contents - Synthesis Report on Borehole Geophysics Jan 30, 1996

*These chapters will generate a significant number of additional pages of supporting tables, diagrams, charts, logplots, plates, maps, etc.

Cross Sections (discussion) 5 - 10*

Cross sections showing the spatial distribution of several boreholes will be presented as figures and discussed. To the extent the data set of acquired and developed data will provide support, the sections will contain:

Reference to map location, i.e., surface expression of section
Two or more boreholes showing some acquired and developed data in the form of log traces.
Stratigraphy and structure along the line(s) of section

Maps (discussion) 3 -10*

Planar maps of developed data will be included in the report. To the extent the data set of acquired and developed log data, fault data, outcrop data, and topography will provide support, we can supply the following for any group or subgroup of boreholes:

Structure maps on any selected horizon (surface)
Paleo topographic maps on any selected time horizon (surface)
Major stress/strain relationships
Isopach maps on any mappable parameter over any correlative interval
Isopach maps on differences or derivatives between two mappable parameters

3-D Perspective Drawings (discussion) 3 - 5*

Rotatable slices of pertinent parts of the mountain from any perspective based on any 3-D surface available through the data base.

Programmatic Issues Affecting Borehole Geophysics 5 - 10

SCP "Planned" activity vs. actual work that was done
Development of historical and modern borehole sets
QA pedigree for acquired and developed logging data
Qualification status of inputs and outputs
Qualification status of software employed

Traceability, Reproducibility, Genealogy 5 - 10*

This section will document the QA:L pedigree for the borehole geophysics synthesis report, and show the traceable, logical flow of acquired and developed data used as inputs and the development of data for outputs for the synthesis report. It will depend heavily on simply cross referencing similar sections in previous M&O Geophysics reports.

*These chapters will generate a significant number of additional pages of supporting tables, diagrams, charts, logplots, plates, maps, etc.

*These chapters will generate a significant number of additional pages of supporting tables, diagrams, charts, logplots, plates, maps, etc.

AGENDA FOR 4/2/96 W. BARNES-OR MEETING

- o State of Nevada comments on intent of EIS (12/1/95 Loux to Dixon Ltr.)

- o DOE Update on Surface-based testing:
  - C-Well testing
  - G-2 pump testing

- o OR update on NRC KTI Activities

- o Upcoming site visits:
  - April 12, 1996, Director General for Finnish Center for Radiation and Nuclear Safety visiting Yucca Mt.
  - April 21, 1996, two CENTER geologists visiting Crater Flat and Tolicha Peak areas
  - April 26, 1996, NRC Deputy Executive Director for Nuclear Materials Safety, Safeguards & Operations; NRC Director NMSS, and NRC Director DWM visiting Yucca Mt.
  - May 3, 1996, seven members of NRC DWM staff visiting Yucca Mt.

- o DOE feedback on 82th ACNW meeting and March 13-14th Appendix 7 interaction

- o Upcoming Appendix 7 Interactions:
  - Tectonic Models with emphasis on Crater Flat/Yucca Mt
  - Response to NRC comments on Seismic Topical Report II

- o DOE status on TBM and recent ventilation problems

- o Any DOE feedback on pending issues

ENCLOSURE 5

AGENDA FOR 4/23/96 W. BARNES MEETING

- o NRC requests from DOE for H. Thompson, C. Paperiello, and J. Greeves 4/26/96 site visit (Bill/Chad)
- o NRC staff 5/3/96 site visit-info only (Chad/Bill)
- o CNWRA 4/23/96 &5/7-8/96 visits-info only (Chad)
- o Waste Isolation Strategy Document status-when expected to be released final-will NRC review be requested? (Bill)
- o Results of OR review/comments on DOE 1994 Program Plan (Bill/Chad)
- o Status of christobelite condition (Bill)
- o NRC progress on Summerlin move (Chad)
- o 3rd TBM Consultant's meeting date (Bill)
- o Status NRC KTI's-provide handout of NRC Team leads-members-assignments (Chad/Bill)
- o NRC OR's receiving documents and information in a timely manner (Bill/Chad)
- o OR's request copy of DOE 4/30-5/1/96 NWTRB meeting handouts when finalized either prior to or after meeting (Bill)
- o 10CFR960 rule status (S. Brocum)
- o DOE plan for follow-up on 3/29/96 LANL draft report on CL 36 levels (Chad)
- o DOE response (if any) on Peer Review Recommendations for Thermohydrologic Modeling and Test program (Chad)
- o OR feedback on NRC Thermohydrologic modeling (Chad)
- o DOE plan for elevating effect of ventilation on ESF testing (Chad)
- o DOE mechanism for documenting concerns with respect to viability assessment or licensing (Chad)
- o Any other feedback from DOE on pending issues

AGENDA FOR 5/28/96 W. BARNES MEETING

- o NRC requests status of:
  1) CL36 issue
  2) Possible Reportable Geologic Condition for ESF Faulting

- o NRC discussion of USGS QA problems

- o NRC request - EIS; how much of information will be used from NTS EIS for Yucca Mountain EIS?

- o NRC discussion:
  1) Status NRC KTI's-provide handout (again) of NRC Team leads-members-assignments
  2) Status of OITS
  3) Who will DOE designate as KTI contacts? (OKs have been requested to give KTIs priority and assist in obtaining information leading towards resolution)

- o NRC requests DOE to discuss what is agreement between DOE, OSHA, MSHA. Does DOE use their standards? Are there any enforceability aspects? Are there any written agreements between these parties?

- o NRC feed back on Appendix 7 interaction on Tectonic Models

- o NRC requested copy of final ESF Safety Team report discussed at March 19,1996, DOE Stand Down meeting. Requested from R.Dyer/W. Barnes shortly after this meeting, and documented in March OR Report) What is status of report?

- o NRC OR computer connection - How does NRC ORs obtain access to DOE lotus notes?

- o Value of meetings with W. Barnes. Should NRC meet with just W. Barnes or just AMs or both? Should just policy issues be discussed or problems that only W. Barnes should be informed of?

- o NRC feedback from:
  - 4/26/96 H. Thompson, C. Paperiello, and J. Greeves site visit
  - 5/3/96 J.Thoma, N. Eisenburg et. al. site visit
  - 5/21/96 K. McConnel site visit
  - 5/24/96 M. Bell site visit

- o NRC progress on Summerlin move (Chad)

- o Any other feedback from DOE on pending issues

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

OFFICE OF THE
SECRETARY

April 17, 1996

NOTE FOR LSSARP MEMBERS

FROM: John Hoyle

SUBJECT: MAY 2-3 LSSARP MEETING IN LAS VEGAS

The LSS Advisory Review Panel will hold its next meeting in Las Vegas, NV, on May 2 and 3, 1996. Dennis Bechtel has arranged for our use of a conference room in the new Clark County Government Center at 500 Grand Central Parkway (see enclosed maps). We will meet in the Pueblo Room (#1119).

The meeting will be from 8:30 am to 4:00 pm on Thursday, May 2; and will continue, as needed, from 8:30 am to 10:00 am on Friday, May 3. Our agenda will be as follows:

1. LSS Administrator's Report

2. DOE Activity Report
   a. Schedule for LSS Development
   b. Availability of Records Information System (RIS) and Demonstration

3. NRC's LSS Senior Management Team Report
   a. Topical Guidelines Publication
   b. Assessment of Licensing Support Technology/Options
   c. Decision Capture Process and Procedure

I am looking forward to seeing you on May 2.

Attachment:
Ltr from Dennis Bechtel with maps

ENCLOSURE 6