GeoTrans

Specialists In Solving Ground-Water Problems

PDR
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August 8, 1984

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Mail Stop 623-SS
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Contract Number NRC-02-82-047
Hydrogeology of NTS, Project D
FIN No. B-7378-4
Trip Report for Data Review Session
Letter Number 58

Dear Jeff:

Please find enclosed the trip report for the data review session in Lakewood Colorado during the week of July 23, 1984. The three members of the GeoTrans' professional staff attending were James W. Mercer, David R. Buss, and B. Geoffrey Jones. This report includes information and observations related to the data review as well as the field site visit held during July 28 and 29, 1984.

Sincerely yours,

David R. Buss

David R. Buss
Hydrogeologist

DRB/ldm
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GEOTRANS TRIP REPORT

for

NNWSI DATA REVIEW SESSION

July 23-27, 1984

Lakewood, Colorado

Prepared by:

D.R. Buss
B. Geoffrey Jones
J.W. Mercer

August 8, 1984

1.0 INTRODUCTION

Three members of the GeoTrans' staff attended the data review session held between the U.S.G.S. personnel, and the NRC staff and consultants. James W. Mercer, David R. Buss, and B. Geoffrey Jones participated in the daily sessions during the week of July 23, 1984 at the offices of the nuclear hydrology program of the U.S.G.S. Water Resources Division in Lakewood, Colorado. Members of the staff were assigned specific tasks and responsibilities by Jeff Pohle, NRC, for conduction of the data review. Primarily, Mercer performed detailed reviews related to aquifer and well testing; Buss reviewed the water-level measurements data base, and Jones investigated the aspects of geochemistry related to ground waters and precipitation at Yucca Mountain.

The purpose of the data review session was fourfold: (1) to ascertain the objectives and purposes of collection of specific data, (2) to establish the types, amount, spatial location of this data for the NNWSI project, (3) to assess the reliability of this information through documentation of testing protocol and data collection techniques, and (4) to determine if adequate data are being collected to characterize the site conditions.

Auxiliary to the data review sessions; Mercer, Buss, and Jones travelled to the Mercury, Nevada area to participate in a field visit of the Yucca Mountain repository site and the surrounding area. The field visitation was conducted by Martin W. Mifflin, NRC consultant. The objective of the trip to Mercury and Southern Nevada was to observe: (1) the pertinent aspects of the regional carbonate and welded tuff flow system, which contains the proposed repository block, (2) the effects of both the present and Late Pleistocene climate on the regional physiography of the site, and (3) the local hydrogeologic conditions of the proposed repository site.

2.0 DATA REVIEW

2.1 Aquifer/Slug Tests

Data Reviewed - The data that GeoTrans reviewed included packer recovery tests, injection tests (slug tests), water levels, well construction details, pumping tests, and downhole temperatures surveys for well UE25p-1; injection tests for well USW H-1; and injection tests for both UE25c-1 and UE25b-1.

Summary and Comments - Most of the time was used to examine the injection tests, which are discussed first. Throughout the materials examined, the injection tests were referenced by different names, including slug tests, falling-head tests, and drillstem tests. For UE25p-1, the tests were conducted by packing off an interval, filling the tubing to some specified level with lithium-spiked water, releasing a valve at the end of the tubing, inside the packed zone, then measuring the water-level drop in terms of millivolts with a pressure transducer. As part of the tests, Kuster gauges were placed above and below the straddle packers in order to detect packer leakage. Detailed test procedures for other wells and other tests were not readily available. This type of information should include test well and drilling pad construction details, as well as procedures for conduction of a given test. The protocol for the chain-of-command and personnel in charge of conducting the test was also not evident from the files. The role of the U.S.G.S. personnel in the testing program is not clear.

The well data are provided to the U.S.G.S. as part of the Drillstem Test Report produced by TAM International (for UE25p-1 and UE25c-1). As part of the Drillstem Test Report, TAM provided a preliminary analysis of the injection test data using a method described by Ramey, Agarwal, and Martin (1975). The U.S.G.S. analysis of the data appears to ignore this initial TAM analysis. The U.S.G.S. employed one of three methods described by Cooper, Bredehoeft, and Papadopulos (1967), Papadopulos, Bredehoeft, and Cooper (1973), and Bredehoeft and Papadopulos (1980). Tests, where measurements indicate that the packers leaked, are not considered in their analysis. In order to use the Bredehoeft and Papadopulos method, the initial head difference between the tubing and the formation, H_0, needs to be known. From the material reviewed, it was not clear how H_0 was determined or if it was determined in a consistent fashion among holes and/or tests on the same hole.

Test results showed several different types of behavior. Some tests, for example, would follow a pressure decay curve in early time, then shift to a different decay curve in later time. It was speculated that the large head increase produced by the injection test increased the fracture apertures. As the apertures decreased to their original values, the first decay curve was produced. After that time, the second decay curve was produced, supposedly being more representative of the formation. This idea was supported in part when the test was reportly repeated with a smaller head increase and only one decay curve was produced. The data to support this, however, was not actually observed by the NRC review team.

A final note for USW H-1, some of the tests in the data files were not included in the H1 published reports. In some cases, the reason is obvious, but in others, e.g., shut-in tests, the reason is not clear. The procedure for determining what data should be published as part of a data report is unclear.

Pumping tests that were conducted also displayed a variety of responses to the pumping stress. Some tests in USW H-1, for example, behaved as if the aquifer tested was confined. Deeper zones tested in USW H-1 displayed leaky confined behavior, which could be produced by leakage from overlying or underlying lower-permeability layers, or by leakage from porous blocks into the fracture system. Reports on well J-13, on the other hand, show pump test results that are indicative of water-table or unconfined conditions, demonstrating delayed yield in early time. Finally, data on UE25b-1 indicated confined behavior in early time, with delayed yield in later time. This result could occur in an unconfined fractured system where delayed yield in the fractures would occur so fast that it is not observed, producing typical confined results in early time. In later time, when the porous blocks begin to drain, a second delayed yield is produced that can be observed. From the plot alone, these delayed yield effects could also be interpreted as a barrier boundary.

During some pump tests, observation wells demonstrated barometric pressure responses. Although this may be indicative of a confined system, McWhorter and Sunada (1977, p. 45) point out that barometric effects can also occur in deep unconfined aquifers where the air above the water table is confined and does not communicate readily with the atmosphere.

In fractured media, a variety of responses to well tests are observed. These responses depend on the local nature of the fractured/porous system. Also, test interpretation as well as assessments of test validity are extremely difficult to analyze. It appears as though a conceptual model needs to be developed for utilization in conduction of aquifer test and analysis of their associated data. Some effort in this area has recently been published by Moench (1984).

Downhole temperatures were also measured in several wells. In UE25p-1, for example, temperatures exhibit an approximate range of 20 C°, reaching a high just below a depth of 1200 feet at the Tertiary-Paleozoic contact. In general, temperature effects are not considered in water-level interpretations, UE25p-1 being an exception. Water-level data in UE25p-1 shows a trend similar to the temperature profile.

Data Requested - The additional data and/or information that we would like to see includes:

(1) detailed information on drillhole site selection rationale, and drilling pad and borehole specifications and construction.

(2) detailed descriptions of tests, including design, objectives, implementation, and chain of command.

(3) protocols for selecting data to be included in a published data report.

(4) reasons for not considering the TAM drillstem test interpretations.

(5) methods and basis for determining H_0 for the slug injection test method of Bredehoeft and Papadopulos.

2.2 Water-Table Series Test ·les

Data Review - The hydrogeologic information reviewed included representative water-level measurements taken on a periodic basis in piezometers and open boreholes in the H and W-T series test holes. Certain geologic and hydrogeologic information related to the water-level measurements was also reviewed. Not all available information for each of the test holes was reviewed; only selected representative examples as chosen by the NRC consultants were examined.

The available information includes: (1) well construction details of the test hole and the semi-permanent packer installations, (2) a typical suite of geophysical logs, (3) geologic descriptions of formations penetrated by the holes, (4) discussions concerning instrumentation set-up to continuously monitor water levels in wells and piezometers, and (5) costs of drilling and testing operations, test procedures, test methods, and their objectives.

Summary and Comments - Each water-table series hole could be potentially utilized in one of four principal ways: (1) heat flow measurements, (2) stress determinations in the unsaturated zone, (3) water sampling program, or (4) continuous water-level monitoring. The continuous water-level monitoring program is designed for up to 25 observation points. Test holes USW H-4 and UE25b-1 presently contain a single packer with an access standpipe. Thus, potential measurements in two isolated zones can be compared. These packer installations are advantageous because they are not permanently grouted or cemented in place. A string of 2.9- inch pipe with a 6-10 foot inflatable packer is set at the desired depth. A second string of 1.9-inch pipe is run to just below the water table. The standpipes are outfitted with screened wellpoints that are 4-6 feet in length. The continuous water-level monitoring device is a pressure transducer. No detailed specifications on the construction details were reviewed.

Time series plots of water-level measurements for piezometers and open boreholes were reviewed. The average water-level fluctuation for 24 test holes was approximately 0.5 meters. The range in water levels for an individual observation point was from 0.3 to over 2.0 meters. It appears as though the water-level measurements exhibit systematic variations with time. The data base for any given well consists of approximately biweekly measurements taken by an "iron horse" or other water-level measuring device for a several month interval. It is difficult to explain the observed variations in water levels. With the observed average fluctuation approximately 0.5 meters, various cyclic mechanisms might be responsible for these changes (i.e. earth tides, barometric effects). With the installation of continuous monitoring devices, a more complete record will be established. The records of water levels in piezometers to date show many holes where the lower most intervals possess the highest potential level.

An updated potentiometric surface map was reviewed. This map exhibited the same general trend as established before this review session. That is, a relatively flat gradient across the site with an elevated surface (200 meters higher) located across the northern and western limits of the area. A refinement on the nature and/or location of this apparent discontinuity in the potentiometric surface has still not been established. The role of these so-called "flow barriers" needs to be thoroughly investigated and their importance documented.

On the average a 4,000 ft H-series test hole costs between $1.8 to 2.0 million including drilling, logging and hydrologic testing; a W-T series test hole, approximately 1,500 to 2,000 feet, $300,000 to $400,000. These prices are comparable to off-shore drilling rates. Based on hole descriptions, it was not clear why the costs are so high. From a pragmatic view point, given a limited budget, excessive drilling costs will limit the amount of data that can be collected and the detail of site characterization.

Data requested - The following items related to water-level measurement data base are requested:

(1) Periodic water-level and piezometric-level measurements for all W-T and H-series test holes.

(2) Geologic logs and descriptions of formations penetrated by the water-table series holes.

(3) Test-hole construction details of water-table series holes including drilling fluid losses.

(4) Construction details of packer installation and piezometer settings for all test holes.

(5) Regional water-level map and or measurements for all observation points.

2.3 Geochemistry

Data Reviewed - The GeoTrans' staff examined various hydrochemical data. This included precipitation data, well sampling data, computer data base printouts, a regional isotope map, the Franklin Lake discharge study area data, and some paleoclimatic data.

Summary and Comments - Records concerning the collection and analysis of precipitation data in the Yucca Mountain area were examined. Collection records show the installation and locations of eleven sampling stations. The four oldest stations were installed on Yucca Mountain in July 1983 and additional stations have been installed since January 1984. Records indicated the collection of samples from various sites for 16 precipitation events between August 8, 1983 and February 15, 1984. Collection of samples appears to have been completed within two days of precipitation events.

Precipitation analyses examined included δD and $\delta^{18}O$ values for at least some sample locations for all dates noted in the collection logs.

Tritium values were observed for only two analyses and no complete chemical analyses were observed. Of note in examining the analyses were the expected strong seasonal differences in the isotopic compositions and the unusually high values of the few observed apparent tritium concentrations. The comparative δD and $\delta^{18}O$ values appear to place the precipitation waters generally on the meteoric water line.

Ground-water chemistries of the Franklin Lake region and their locations on associated maps were examined. The nine sample points which were observed included both springs and very shallow wells. Noted was the increased occurrence of the springs in the eastern and northern lakes areas. There was some indication that the samples were taken from specific depths but associated depth values were not observed. The observed analyses of the ground-water samples included major element, some trace element, and some isotopic values. The isotopic analyses observed included $\delta^{18}O$ and δD, but not $\delta^{13}C$ or $\delta^{14}C$. The δD and $\delta^{18}O$ values indicate a fairly linear relationship placing the waters on an evaporation line with a slope much less then the meteoric water line. The intersection of the evaporation line with the meteroic water line indicates a possible source water somewhat similar to other waters that have been observed in the Yucca Mountain area. The relative degree of evaporation indicated by the isotopic data for the various samples correlates with the relative quantities of chloride and total dissolved solids. For some of the analyses the total dissolved values were notably high.

Three different computer printouts of water sample analyses were examined in whole or part. Examined in whole was a regional data base that contained more than 315 analyses related to 11 different areas. The areas included Yucca Mountain and associated possible discharge areas: Ash Meadows, Oasis Valley, Death Valley, and Armagosa Desert. Both published and unpublished data were observed. Noticeable as unpublished data were a group of analyses from the Oasis Valley area and a group of analyses from the previously discussed Franklin Lake area. Associated with the regional data base was a large map showing the areal distribution of isotopic values. Included on the map were δD, $\delta^{18}O$, and $\delta^{14}C$ values. The map indicated areal groups of similar values whose interrelations were not clear. Important areas of little or no data were observed including Timber Mountain and the Armagosa Desert south of Crater Flat. Examined in part was a computer printout of water analyses apparently dumped from the EPA STORET data base through the Reston, Virginia U.S.G.S. Amdohl computer on November 18, 1983. This data base contained analyses of samples from a broad area covering much of southern Nevada. For many of the sample locations, for example at well UE25b-1, sample analyses at various times were observed.

Records concerning .. collection and analysis of ground-water samples taken from individual wells were examined. Collection records were only obtainable for post-September 1983 which indicated the collection of samples and determination of field pH for well p1, c1, c2, c3, H3, H6. Well c2 was sampled four times on three dates and well H6 was sampled at two different depth intervals on two dates. The depth intervals sampled in H6 correlate with the higher flow intervals on the borehole flow survey. Well p1 samples were taken from both the packed-off Paleozoic section and the Tertiary section of the borehole. The borehole flow survey for the Tertiary section of the well indicated that some leakage through the packer occurred. The borehole flow survey and downhole head distribution for p1 were also observed. Noticeable is that the Paleozoic-Tertiary contact zone seems to have the greatest flow and the highest head.

Unpublished well sample analyses observed included: the two analyses for well p1, a drilling fluid contaminated and uncontaminated sample for well H3, and three analyses at well H1 on different dates. Unobserved were water analyses for any of the other newly drilled wells or analyses of the perched water which was discovered when drilling H1. Although some plans may exist for further sampling, the data base on water quality seems divided among the well testing, modeling, and paleoclimate projects.

Little paleoclimate information was observed because much of the paleoclimate data does not reside at the Denver offices visited, and the primary paleoclimate researcher who is located in Denver was not present. A partial log book for the paleolacustrine project of drilling a core into Walker Lake was examined. The log indicated the collection of cores and sulfur samples. Other data examined included published U.S.G.S. reports concerning paleoflooding and recharge-precipitation relationships in another study area.

Data Requested - The GeoTrans' staff would like to examine the all-encompassing water analyses data base, the regional isotope map, the map and analysis of Franklin Lake samples, and the location and analyses of the precipitation samples.

3.0 FIELD TRIP - SOUTHERN NEVADA, YUCCA MOUNTAIN

The field visitation was held on July 28 and 29, 1984. A total of five stops were made on Saturday, July 28, 1984, while travelling from Las Vegas to Tonopah, Nevada. The majority of the first day was spent observing the regional carbonate flow system associated with the White

River Valley. Table 1 exhibits a list and description of locations visited on July 28, 1984.

Table 1. Field Stop Locations for Saturday July 28, 1984.

STOP NUMBER	LOCATIONS	FEATURES OBSERVED
1	Glendale, Nevada	Regional carbonate springs of the lower White River Flow System.
2	Coyote Springs Valley	Alluvial fan with thick caliche development.
3	Pahranagat Valley	Regional carbonate springs; Controls on their location.
4	White River Canyon	Typical sequence of welded tuff.
5	Sunnyside Wildlife Area	Regional carbonate spring of deep flow path.

The discharge springs of the lower White River Flow System (STOP 1) exemplify the long interbasin flow possible in this carbonate terrane. These regional flow systems are the result of repeated structural deformation and the development of an integrated secondary permeability and porosity. The flow system observed at any given point in time and space will be characterized by extremely heterogeneous fluid potentials and variation in water chemistry, but an integrated view over the system exhibits a systematic and consistent progression from recharge to discharge areas in water levels and chemical constituents. Mifflin (1968), through indirect evidence contained in water chemistry, fluid potentials, and tritium content, was able to characterize the ground-water flow regime on a regional scale. Regional carbonate flow systems exhibit interbasin flow (long flow path) with local systems "feeding" this regional system. The chemical nature of waters at discharge points exhibits relatively high concentrations of Na, K, Cl, and SO_4 with elevated temperatures (80 to 90°F) suggesting circulation at depth, and waters lighter in C^{14} and H^3. The springs of regional flow systems exhibit large discharges (several thousand gpm) and very little seasonal fluctuation.

Throughout the two-day field trip, Mifflin pointed out the uncertainties associated with the delineation of regional flow system boundaries. This is especially true with those basins that exhibit interbasin flow, including those of southern Nevada near Yucca Mountain. Mifflin (1968) states" ... delineation of flow systems in this region is believed subject to major error, and truly confident delineation awaits the proof provided by carefully collected fluid potential - from deep boreholes in key areas ...". The boundary between NTS-Armagosa Desert Flow System and the Las Vegas Flow System, as defined by Mifflin, lies just to the North of Yucca Mountain. The location of this divide is subject to change.

In the Coyote Springs Valley (STOP 2), the development of several distinct geomorphologic surfaces was observed. A rather thick caliche (several feet) has developed on elevated alluvial fan surfaces. These thick caliche deposits suggest the occurrence of an arid climate for an extended period. At lower elevations, thiner caliche had developed, representing a more recent late-Pleistocene incision. Additionally, light-colored calcareous, fine-grained sediments that appear similar to those of a high-water table/perched water zones such as marshes/swamps are present throughout the region. According to one hypothesis these deposits were formed by ground-water discharging at land surface. The distribution of these deposits are at elevations above the modern day discharge areas, and may give indirect evidence of ancestral flow system discharge. These deposits could represent former regional discharge areas much like those currently observed. These deposits may represent a means for mapping paleohydrologic systems. Future investigations and research into other developed hypotheses are warranted to verify the role of these deposits.

It appears that the regional setting of the Yucca Mountain Repository does show a strong hydrologic response to climatic environment. The thick caliche development, the fine-grained light colored marsh deposits, and evidence of pluvial lakes as investigated by Mifflin and Wheat (1979) are relics of past climatological processes. An integrated study of the composition, distribution, and geometry of these deposits/features will provide a more regional assessment of paleohydrology for the repository.

The carbonate springs observed in Pahranagat Valley (STOP 3) are illustrative of the factors controlling the location of regional points of discharge. Collectively, these spring discharge over 15,000 gpm from Devonian limestone and dolomite. For the most part, structure at depth forces the upward movement into the alluvial cover of the deeper flow systems. This is done by creating "ground water dams" and other similar large-scale features with large permeability contrast. The alluvium exerts a secondary influence on discharge location. The permeability characteristics of the alluvium will restrict upward leakage (due to the higher horizontal transmissivity as well as interbedded clay lenses). The alluvium can act as a confining bed resulting in regional springs being located at quite variable elevations within the same valley discharge area. Crystal Spring is a rather unique example of the control of deformation on discharge location. The alluvium near this spring consists of fine-grained silts and clays; faulting has upthrust a block of carbonate rocks from depth. Crystal Spring discharges over 5,300 gpm at the surface contact between the alluvium and the upthrusted carbonate fault block.

The White River Canyon (STOP 4) provided the opportunity to observe a typical welded tuff sequence with simple cooling history. A variation in the degree of welding was illustrated by the sequence from nonwelded to densely welded tuffs. A dense vitrophyre was sandwiched between successive units of less dense welding character. All units were characterized by vertical and horizontal fractures. As expected, the degree of vertical fracturing was a function of welding character. The distribution of fractures observed in this outcrop suggested a greater degree of horizontal interconnection than has been described in the U.S.G.S. test hole reports. A concentrated zone of fractured broken tuff could be traced horizontally for several hundred feet along the extent of this outcrop. Other important features observed included mylonitic-like fracture filling and lithophysae zones within discrete intervals. This outcrop portrayed the anisotropic permeability distribution that is present in the welded tuffs at depths below Yucca Mountain.

The last stop (5) of the first day was at the Sunnyside Wildlife Management Area. This is the location of a regional carbonate spring discharge which has experienced a rather deep flow path. This spring exhibited elevated water temperatures (approximately 90°F) with an associated higher total dissolved solids content and a discharge of several thousand gpm. The dissolved constituents exhibit equivalent parts per millon (epm) concentrations of Na+K = 1.0, Ca+Mg = 4.0, and $Cl+SO_4$ = 1.0. This water chemistry is typical of waters that have experienced a long flow path permitting an extensive contact time with the aquifer materials. The flow path also must be one with depth to permit warming of ground waters in deeper portions of these structural basins which contain residual thermal energy.

The later portions of the first day were spent traveling southwest from the northern portions of the White River Flow System to Tonopah, Nevada. Following Route 6, the regional carbonate terrane changed to a stratigraphic section dominated by Tertiary volcanics and welded tuffs. Some dry valleys of no regional discharge were observed suggesting interbasin flow. For example, Alkali Spring Valley exhibits no discharge area. The regional flow from this valley goes through to Clifton Valley, with regional discharges occurring in the Lithium Mining District.

The second day of the field trip was spent observing regional discharge springs near Beatty and Ash Meadows. A majority of time was consumed visiting drill sites, well locations, and other pertinent features on the NNWSI project area near Mercury, Nevada. Table 2 contains a description of the field trip stops on July 29, 1984.

Table 2. Field Stop Locations for Sunday, July 29, 1984.

STOP NUMBER	LOCATIONS	FEATURES OBSERVED
1	Beatty, Nevada	Regional discharge springs of welded tuff, Oasis Valley.
2	NNWSI, J-13	Well head pump station, Forty-Mile Canyon
3	NNWSI, UZ-6	Active drilling operations, Overlook Solitario Canyon.
4	NNWSI, H-5	Wellhead piezometer installation, Overlook G-1, UZ-1.
5	NNWSI, Precipitation Collection Station	Typical precipitation collector.
6	NNWSI, G-3, GU-3	Wellhead piezometers, associated borrow pit near site.
7	NNWSI, Welded Tuff	Tiva Canyon, Upper Clastic Unit, Upper Topopah Springs.
8	NNWSI, G-4	Wellhead and proposed exploratory shaft.
9	Ash Meadows	Regional discharge area Devil's Hole and Springs.

The regional discharges of Oasis Valley (STOP 1) are an excellent example of the controlling influence that alluvium exerts on spring location. The combined spring discharges in this area are estimated at over 2,000 gpm from a rather uncertain drainage basin area. The springs exhibit water chemistry of the regional flow system type but are located at various elevations. This suggests that the alluvium is acting as a confining bed and the flow system is discharging waters through low permeability units. The recharge area for these spring systems could be, in part, northern Yucca Mountain.

Access on the Nevada Test Site and the NNWSI area was gained through the Mercury, Nevada area. From the most recent precipitation events during the week of July 23-27, 1984, Forty Mile Wash and Canyon exhibited signs of surface runoff. Route 95 south of the project area near Lathrop Wells, Nevada was temporarily closed due to flooding and sediment transport across the roadway. At the U.S.G.S. gaging station near well J-13 (STOP 2), a high water survey recently completed, exhibited a maximum water depth between 36 and 43 inches. Considerable erosion and sediment transport was observed on service roads to drill site locations on the top of Yucca Mountain as well as the road leading to Drill Hole and Abandoned Wash.

At the drill site location, UZ-6, (STOP 3), drill rig and operations area were observed. Test hole UZ-6 is being drilled by a dry air rotary method for the purpose of documenting hydrogeologic conditions in the unsaturated zone. The drilling operations have encountered much difficulty in the highly fractured Tiva Canyon Member. It appeared as though cementing operations had been completed on casing or unstable portions of the drillhole. The effects that cementing operations will have on hole saturation conditions is uncertain. Although cementing was performed above the "upper clastic unit" in the Tiva Canyon, this confining bed was observed to be fractured in localities on the NNWSI area. Several observations were made near this drilling operation that may effect unsaturated zone monitoring in this borehole. First, western portions of the drill pad prepared by the drilling contractor contained exposed fractured bedrock where regolith had been removed and the exposed welded tuff blasted to provide rock fill for drill pad preparation. The effect this exposed bedrock has on local recharge is uncertain. Some open blast holes were also observed. A tank truck vehicle was parked on site. This truck had supposedly been utilized to water the fill and fine-grained materials that were compacted on top of the rock fill. It was reported that three tanks/day had been applied to this fill material during drill pad preparation. The effect of this water application on the unsaturated zone is also uncertain. A good vantage view of Solitario Canyon was seen just west of the UZ-6 location. In the canyon drill sites USW H-6 and WT-7 were observed. Most recently, a long-term pumping test was conducted on H-6 for which over 23 acre-feet of water was discharged to the surface near the well. This test hole is only approximately 3200 feet horizontally, 700 feet vertically from UZ-6. Again how this might influence the unsaturated zone near UZ-6 is uncertain.

At USW H-5 (STOP 4), finished well head conditions were observed. This borehole contains an inflatable packer set at an unknown depth with piezometer tubes installed through and above the packer. Periodic water levels are being taken at this installation. Considerable regolith had been removed from this area to provide fine-grained fill for the drill pad at the site. It was noted that a collapse of the fill material about the well head had occurred. Both the regolith removal and the collapse features provide direct infiltration access for precipitation and/or surface runoff. Overlooking to the east from the H-5 location, an appreciation is gained for the close proximity of UZ-1 and USW G-1 locations. Test hole G-1 was drilled with mud and water and was reported to have lost 58,181 barrels of circulation fluids. Completion of UZ-1 was difficult and the hole had to be cemented in its lower most portion. Presently, UZ-1 has water ponded on its cement plug. This water could represent perched water, vertically percolating recharge, drilling fluids from G-1, or water from drill site preparation.

Near USW H-5 and other localities, U.S.G.S. precipitation collection stations were observed. There were varying amounts of precipitation in the collectors. At the data review, the NRC staff and its consultants had learned that collection of samples occurred within a very short time period of each event. It was suggested that the collection stations were built such that a very small surface area was exposed to evaporative processes. At the site, collectors had standing water and a circular area of several inches exposed for potential evaporation. Additionally, a filter device was observed at a station near test hole USW H-5. The purpose of this device is unknown.

Wellhead piezometers and installations were observed at test hole G-3. Caution signs for a radiation area were observed. It appears as though a radioactive logging tool was left downhole at a depth of 1300 feet. Additionally, a separate offset small diameter boring designated as GU-3 was observed. It was not clear to the NRC consultants present as to the purpose of this borehole. A "borrow pit" area to the southeast of the testhole G-3 was viewed. A considerable amount of regolith removal and subsequent erosion on the sloped haul roads was observed. It appears as though a thicker accumulation of regolith developed in a downslope area from the crest of Yucca Mountain. This could be due to the natural colluviation processes; however, the thicker portions of the deposit excavated also coincide with the trace of a fault zone.

A stratigraphic sequence of the Tiva Canyon, Upper Clastic Unit, and the Upper Topopah Spring Member was observed at STOP 7. The Tiva

Canyon appeared moderately welded and had the associated high degree of fracturing. Below, the nonwelded to partially welded Upper Clastic Zone exhibited a less fractured appearance but distinct fractures were present. The upper portions of the Topopah Spring, as expected, were more fractured and more densely welded than the Upper Clastic Unit. Fractures were coated with secondary minerals suggesting remobilization of siliceous material.

From the elevated ground of the proposed repository block, a trip upgradient from Forty Mile Wash to the proposed exploratory shaft was taken. Proceeding upgradient from J-13, evidence of a high volume of discharge was observed. The main paved road going up Drillhole Wash had recently experienced, in several locations of several feet, erosion and washout. High water marks at UE-25a-6 appeared to cover the top of the wellhead. The drill pad at USW G-4 experienced some erosion. Although the exact location of the exploratory shaft was not determined; the vicinity of its approximate location was obviously close to some major discharge volumes that occurred during the most recent precipitation event.

The last stop of the day was in the Ash Meadows area. The U.S.G.S. has mapped this area as a major discharge for the flow system containing the repository block. These regional discharge springs are emanating from a joint carbonate, welded tuff system.

4.0 OBSERVATIONS, CONCERNS, AND SUMMARY

During the one week data review session and the subsequent field trip on the weekend to the Yucca Mountain site, the following observations and concerns were realized by the GeoTrans' review team.

(1) Potentiometric surface data being gathered in piezometers suggests a more widespread area in which the lower stratigraphic units possess a higher potential than the upper portions of the saturated zone.

(2) The relationship of the fault zones to the subregional flow system and their possible influence on the discontinuities observed in the potentiometric surface has not been documented. In order to assess the sub-regional ground-water flow system, the fault zone hydrology must be investigated. The planned testing program at the c-wells will not completely answer this question.

(3) No attempt has been made to areally integrate hydraulic property testing, fracture orientation and distribution and its role in controlling ground-water flow, and delineation of areally important hydrostratigraphic units.

(4) Few multiple well tests have been designed and implemented to intentionally document or verify the parameters such as hydraulic conductivity, specific storage, and other "flow and velocity" dependent variables. The multiple well tests planned for the tracer testing program are directed at the evaluation of "transport" parameters such as effective porosity, dispersivity, and retardation/attenuation. The U.S.G.S. appears to be relying on single-well tests for flow-dependent parameters. Using single well tests for determination of hydraulic parameters has some limitations. In a fractured media, a large percentage of the observed drawdown in a pumping well can be attributed to well loss.

This well loss drawdown overestimates the drawdown in the formation due to the applied pumping stress. Subsequent determination of transmissivity with the test data through a Jacob Straight Line Method or a specific capacity approach underestimates the transmissivity value. In standard porous media, step drawdown tests can be performed to determine well loss constants and observed drawdown can be corrected to represent the true formation drawdown. To date only the test hole report for J-13 has attempted determination of well loss constant. Drawdowns observed in observation wells do not suffer from this limitation. Without correcting for well losses, single well tests and their data analysis underestimate transmissivity and travel time.

(5) Many different types of geochemical data are being collected under a variety of individual projects (i.e. paleoclimate, saturated and unsaturated zone hydrology, discharge estimates for modeling). Although the geochemical data is being assimilated into a single data base, it appears as though it is not being analyzed with an integrated approach. This observation may be a result of the absence of key personnel at data review session. An early developed integrated analysis can be helpful in delineating data deficiency. The apparent future role of geochemistry, related to both data collection and analysis, is unclear.

(6) The protocols for collection of hydrologic data and testing procedures was not well documented. Thus, inconsistency among data collection and analysis for individual test holes were observed. A standardization of collection and analysis

techniques is needed. The development of areal correlations and extrapolations of hydrogeologic conditions is predicated upon consistent collection and analysis techniques at individual test hole locations.

(7) There is a lack of coordination between technical objectives and the implementation of testing and drilling operations which are essential in meeting those objectives. This lack of coordination may result in the collection of information not representative of site conditions.

(8) The site visit was essential to a complete understanding of the data review. Such visits should be made on a regular basis during the drilling and testing program, perhaps with U.S.G.S. staff available.

5.0 REFERENCES

Bredehoeft, J.D. and S.S. Papadopulos, A Method for determining the hydraulic properties of tight formations, Water Resour. Res., pp. 233-238, 1980.

Cooper, H.H., Jr., J.D. Bredehoeft, and I.S. Papadopulos, Response of a finite diameter well to an instantaneous charge of water, Water Resour. Res., pp. 263-269, 1967.

McWhorter, D.B. and D.K. Sunada, Ground-water hydrology and hydraulics, Water Resources Publications, Fort Collins, Co., 290 p., 1977.

Mifflin, M.D., Delineation of Ground-Water Flow Systems in Nevada, Desert Research Institute, Technical Report Series H-W, Publication No. 4, pp. 53, 1968.

Mifflin, M.D. and M.M. Wheat, Pluvial lakes and estimated pluvia climates of Nevada: Nevada Bureau of Mines and Geology, Bulletin 94, 1979.

Moench, A.F., Double-porosity models for a fissured groundwater reservoir with fractur skin: Water Resour. Res., pp. 831-846, 1984.

Papadopulos, S.S., J.D. Bredehoeft, and H.H. Cooper, Jr., On the analysis of "slug test" data, Water Resour. Res., pp. 1087-1089, 1973.

Ramey, H.J., R.G. Agarwal, and I. Martin, Analysis of "slug test" or DST flow period data, J. Can. Petrol. Technol., pp. 37-47, 1975.