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Donald L. Vieth, Director
Waste Management Project Office
U.S. Department of Energy
P.O. Box 14100
Las Vegas, NV 89114

Dear Dr. Vieth:

Attached is a summary of the observations made by the NRC staff during its January 27-28, 1983 visit to the U.S. Geological Survey (USGS) offices in Denver, CO. The observations are based on the staff's review of hydrogeologic data that were gathered by the USGS as part of the NNWSI. The summary was prepared by Tilak R. Verma.

If you have any questions, you may contact Dr. Verma on FTS-427-4683.

Sincerely,

"ORIGINAL SIGNED BY"

Seth M. Coplan, Project Manager
High-Level Waste Technical
Development Branch
Division of Waste Management

Attachment:
Summary

cc: W. Bennett (DOE-HQ)
J. Fiore (DOE-HQ)

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January 27 and 28, 1983 Visit to USGS Offices

Objective:

The objective of the visit was to review the hydrologic data that have been collected by the U. S. Geological Survey as part of the NNWSI for potential siting of a high-level radioactive waste repository in the Yucca Mountain area. This enabled the NRC staff to become more familiar with the status of hydrogeologic investigations at the site than had been possible at the January 18-19, workshop. It gave the Review Team the opportunity to examine the hydrologic data directly and to review the detailed analysis procedures the U.S.G.S. plans to use to interpret it.

General Observations:

The information presented below constitutes the Hydrogeology Review Team's observations with respect to some important issues pertinent to characterization of the groundwater flow system at Yucca Mountain and surrounding areas. The information is keyed to items that were observed by the Team. These items are:

1. Quality assurance manuals (hydrogeologic testing)
2. Sample collection procedure manual
3. Analytical procedures for dissolved inorganics and radioactive constituents manual
4. Borehole geophysical logs for test holes
5. Downhole temperature surveys
6. Single and multiple-hole pump test results
7. Slug test results
8. Borehole flow surveys curves (for all holes)
9. Core description document
10. TAM International drillstem test report for well USW G4
11. Hole design and test plan for geologic information well USW G4

Quality Assurance and Sample Collection Procedure Manuals - The quality assurance manuals were reviewed briefly from the standpoint of adequacy of test procedures. Based on our review, the hydrogeologic testing techniques appear to be sound. In addition to the QA Manuals, the

U.S.G.S. is using several Techniques of Water Resources Investigations (TWRI) for guidance in data collection. The specific TWRIs discussed include: (1) Methods for determination of radioactive substances in water and fluvial sediments, TWRI Book 5, Chapter A5, (2) Methods for analysis of organic substances in water, TWRI Book 5, Chapter A3, and (3) Methods for determination of inorganic substances in water and fluvial sediments, TWRI Book 5, Chapter A1. State-of-the-art techniques are discussed in these manuals.

Borehole Geophysical Logs for Test Holes - The borehole geophysical logs that we observed for the unsaturated zone did not enable us to reach definitive conclusions with respect to the occurrence of water in the unsaturated, zone. Most emphasis was placed on the epithermal neutron log with respect to detection of water in the unsaturated zone. These logs were made before the unsaturated zone was cased off. Hydrogen absorbs the energy from the neutrons. Therefore, a low count on the log means that water is present. In the saturated zone the water content constitutes a measure of porosity. A mojor purpose of using the neutron log in the unsaturated zone is to attempt to identify perched water zones. Moisture contents of the unsaturated zone also can be measured with these logs. Review of these logs did not provide any conclusive evidence of perched water in the unsaturated zone.

The neutron logs are now being re-run with the casing in place.

The new logs will provide an opportunity to compare the logs for moisture distribution before and after casing installation, The comparison should be help eliminate the effect of the open hole and or drilling fluid on the natural mositure content and the logs. However, the NRC staff anticipates that success of this approach will be low because any perched water that existed before the well was drilled had probably run down the hole outside the well casing.

The borehole geophysical logging program is, in our opinion, state-of-the-art.

Downhole temperature surveys (in the saturated zone) were interesting in that in the saturated zone temperature versus depth produced relatively straight lines with an approximate 45° slope, indicating conductive heat flow. Only a few intervals showed vertical convective flow, as indicated by a relatively vertical temperature profile. Throughout most of the hole temperatures seem to indicate little vertical fluid flow.

Single and Multiple-Hole Pump Tests - The single-hole pump tests being conducted at the site seem appropriate for small-diameter single-hole hydraulic property testing. The pumping rates are sufficiently high that even with single hole tests, a significant portion of each aquifer can be stressed and characterizated. However, the data for transmissivity from these single boreholes are inconclusive for establishing a reasonable understanding of the groundwater flow system under the Yucca Mountain area. The NRC staff thinks that large-scale multiwell tests could be useful in enhancing the understanding of the groundwater flow system in the Yucca Mountain area. Some large scale tests have been conducted, as discussed below.

Four types of testing are performed: (1) single-hole, constant discharge tests, (2) borehole flow surveys, (3) injection tests between packers and (4) two 2-hole constant discharge tests using holes UE25a-1H and UE25b-1H. These tests are used as follows. The single-hole, constant discharge test is conducted in order to obtain an estimate of transmissivity for the entire uncased interval. During the test, after water levels have stablized, a borehole flow survey (discussed below) is conducted using radioactive tracer injection (iodine-131). This test is used to determine which portions yield water and the percentage of the total discharge that is derived from each water yeilding interval. We attempted to correlate the higher permeability, water yielding units from west to east across Yucca Mountain. We used the borehole flow survey logs in combination with the core logs and geophysical logs for the correlation effort; we also correlated by elevation. We determined that if the high permeability units are correlatible at all the hydraulically continuous zones certainly are not horizontal. Major differences in elevation among permeable zones exist across Yucca mountain. In addition, the Caplier logs suggest the the permeable zones may be fault zones. The boreholes tend to increase in diameter within the water yielding zones. Geologic features other than faults can create this type of caliper log but they are less common than faults. The logs suggest that one water producing zone has been cemented of near the tope of the saturated zone in well H-5.

The injection tests between packers are basically slug tests that are used to measure the permeabilities of the low-to-medium-permeability units that lie between the thin permeable zones identified during the borehole flow survey. The combination of these tests is used to determine the downhole permeability distribution in the single borehole testing program. Tests are state-of-the-art single hole tests that appear to be conducted in a technically sound manner, however the data from the tests in combination are not conclusive with respect to establishing the degree of anistropy and the precise values of permeability on a greater than local scale.

Two 2-well aquifer tests have been performed on wells UE25a-1H and UE25b-1H. The pumping well was UE25b-1H. The first test lasted about 25-30 days; the entire uncased interval was tested. The second test was conducted primarily to obtain a water sample for chemical analysis; however, during the test a zone was packed off and water levels measured; and the test lasted about the same length as the previous test. Only the data from the first test were made available to the NRC team.

The first test (pumping well UE25a-1H and observation well UE25b-1H) actually consisted of two separate parts. During the first part, the pumping rate changed so the test was repeated. Both drawdown and recovery data were collected. The pumping rate for the repeated test was 35.8 l/s. One semi log plot that was presented displayed pronounced boundary (impermeable) effects (our interpretation). No drawdown was observed at well UE25b-1H, which also was monitored during the test. Interpretation for these tests by the USGS is not yet available.

In addition to these tests, well H1 was pumped and a response was measured in well G1 approximately three tenths of a mile feet away. However, we did not see any interpretation of the results. We were told that the borehole interpretation report will include the interpretation of results.

The two hole tracer test also is planned for wells UE25a-1H and UE25b-1H. Plans for this test are being based on the logs and the results of the aforementioned pump test.

Slug Tests - Once the low-to-medium-permeability intervals have been determined from the borehole flow survey, injections tests between packers are run. Inflatable packers seal off the zone. Transducers (called DMR's) are used to monitor the pressures produced by the injections. Once the packers are in place, the top of the packed-off zone is opened to a column of water. The following three things are measured: (1) pressure, (2) temperature, and (3) barometric pressure. The results one analyzed using the method of Cooper, Bredehoeft, and Papadopulos (1968). These tests can last anywhere from 5 minutes to approximately one day. Once the test is complete the tool is moved to the next interval whereupon the test is repeated. These tests are state-of-the-art, single-hole tests and appear to be professionally conducted. Initial results indicate that the rocks between the aforementioned water producing zone are low in saturated hydraulic conductivity.

Borehole Flow Survey - The borehole flow survey tests being conducted at the site as described by Blankennagel (1967) are of great utility when combined with the borehole geophysical logs. The identity of water yielding units in the boreholes tested is revealed by this test. Transmissivity of each unit identified by the borehole flow survey log can be estimated (as described above) when the borehole survey log is viewed in combination with the results of the pump tests performed over the entire length of the hole. In essence this procedure facilitates the identification and semi-quantification of water yielding units on a hole by hole basis. The borehole survey that consists of pumping the well at some known constant rate. An iodine 131 injector is moved along the hole from bottom up during pumping. The tracer is released in route. It is detected above the source by two detectors moving with the source. The velocity and dilution of the tracer facilitates the measurement of the yield of each water bearing zone. The next logical step is to implement standard pumping test techniques for the purpose of evaluating each of the units identified on a between or among hole basis. The NRC staff was told that such tests are planned.

Core Description Document - G wells are geology wells that are cored and usually drilled using mud as the drilling fluid. The cores are used to determine stratigraphy, structure, and lighology. In addition, laboratory tests are conducted on the cores to measure permeability, porosity, water content, and bulk density. H-wells are hydrology wells that are drilled primarily using soap and some water (referred to as an air-foam with mixture) as the drilling fluid. Water from well J-13 is used to mix with either drilling fluid. This water is tagged with 20 ppm LiCl. This practice of tagging the drilling fluid helps the field hydrogeologist in determining whether or not the tracer level in the discharge has dropped down to the background levels. At this point the well is fully developed and free of drilling fluid contamination. When water is encountered during drilling it cuts the soap and more well cuttings are brought to the surface. The drilling technology being implmented at the site should present no problems with respect to interference with hydrologic data collection and analysis for the saturated zone as long as the H wells and the G wells are sufficiently far apart that mud does not migrate from the G wells to the H wells.

Specifically, the use of air-foam drilling techniques for hydrologic boreholes (H wells) should preclude significant skin effects on hydrologic tests.

TAM International drillstem test report and hole design and test plan for well USW G4 were made available to us for data review. Both documents looked in order.