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MEMORANDUM FOR: Malcolm R. Knapp
High-Level Waste Licensing
Management Branch
Division of Waste Management

FROM: Peter M. Ornstein
High-Level Waste Licensing
Management Branch
Division of Waste Management

SUBJECT: INFORMAL NEVADA TEST SITE TRIP REPORT

A summary of the information presented during the Nevada Test Site visit is attached. The purpose of this informal trip report is to brief the Performance Assessment Section on the status of, and personal observations on the DOE investigations. A more formal group trip report is being prepared, but may not be available for some time.

ORIGINAL SIGNED BY

Peter M. Ornstein
High-Level Waste Licensing
Management Branch
Division of Waste Management

Enclosure:
As stated

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INTRODUCTION

During the week of May 17-21, 1982, NRC staff and contractors visited NTS and were briefed by DOE personnel and contractors on the progress of NTS Site Characterization. Discussions pertaining to NTS siting were also conducted with State and University personnel. The purpose of the NRC site visit (and related discussions) was to scope out possible areas of NRC/DOE conflict and to prepare NRC staff for receipt and review of the DOE Site Characterization Report (SCR).

Responsibility for geologic and hydrogeologic reconnaissance of the Yucca Mountain region has been given to the U. S. Geologic Survey (USGS). The USGS is collecting and interpreting data and, with the help of numerical models, devising conceptual models of the regional and local hydrology.

Sandia National Laboratory (SNL) is responsible for the overall performance assessment of NTS. They are collecting and coordinating DOE code development for codes which will be applied at NTS.

This trip report will attempt to explain the Yucca Mountain geology and hydrology as it is presently understood, and to outline performance assessment plans. Unless otherwise stated, all information included is derived from conversations with the USGS (particularly R. Waddell) and SNL (particularly L. Tyler).

GEOLOGY

Yucca Mountain, located in Southern Nevada, straddles the southwestern boundary of the Nevada Test Site (Figure 1). The underlying geology consists of thick welded and non-welded tuff units, deposited during periods of intense volcanic and tectonic activity. Evidence of subsequent tectonic activity is manifest by extensive faulting and fracturing of the tuff units. Displacement in some areas of NTS extend as much as several thousand feet. To the south of Yucca Mountain, the volcanics pinch out and alluvium dominates. Underlying both the volcanics and alluvium are carbonates and clastics (highly faulted) of Paleozoic Age.

The repository siting is being limited to the volcanics. The tuff units under consideration (in order of increasing age and depth) are: Topopah Spring, Calico Hills, Bullfrog, Tram, and to a limited extent, Lithic-rich (Figure 2). The Topopah Spring member, unsaturated at Yucca Moutain, is densely welded and devitrified. The Calico Hills unit, also unsaturated at Yucca Moutain, is nonwelded and zeolitized. The Bullfrog member, is saturated, partially welded, and devitrified. The Tram and Lithic-rich units are saturated, partially welded, and zeolitized.

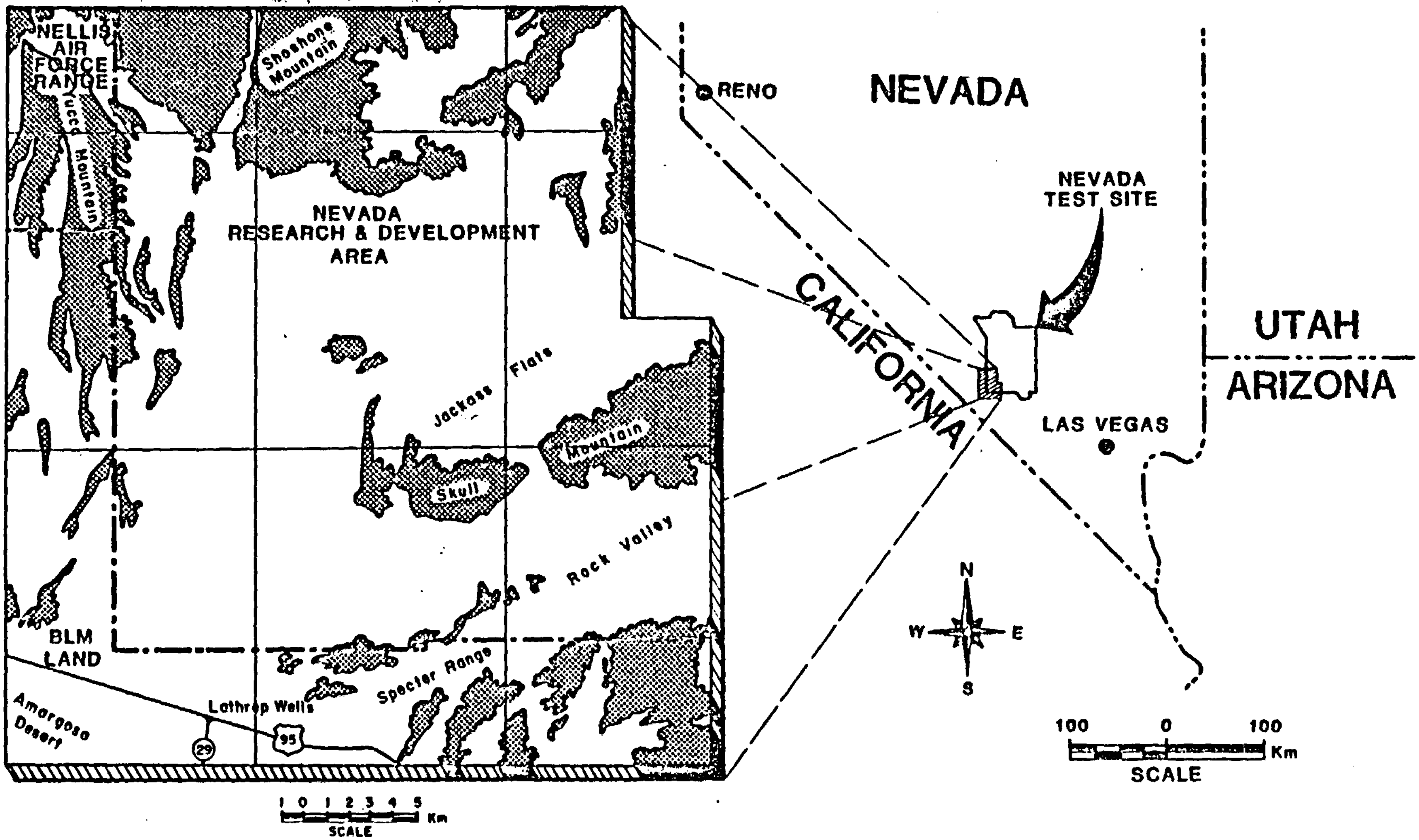


Figure 1. Location map of Yucca Mountain.

Figure 2. General stratigraphy of Yucca Mountain in the vicinity of drill hole UE25a-1.

Era	System	Series	Formation	Member or unit
Cenozoic	Quaternary	Holocene and Pleistocene	Alluvium and colluvium[2]	
	Tertiary	Pliocene	Timber Mountain Tuff	Rainier Mesa Member
		Miocene	Paintbrush Tuff	Tiva Canyon Member[2]
				Yucca Mountain Member
				Bedded tuff[2]
				Pah Canyon Member
				Tonopah Spring Member
			Tuffaceous beds of Calico Hills[1,2]	
			Crater Flat Tuff	Prow Pass Member [1,2]
				Bullfrog Member[1,2]

[1]Not exposed in the immediate vicinity of drill hole

[2]Encountered in drill hole

(From Spengler et al., 1979)

HYDROGEOLOGY

The region around Yucca Mountain consists of several small hydrogeologic basins which feed into the larger Death Valley basin (Figure 3). Yucca Mountain is located in the Alkali Flats-Furnace Creek Ranch (AF-FCR) basin. Discharge from this basin is primarily in the form of phreatophyte evapotranspiration and is estimated at 16,000 acre-feet/year. Just to the east of the AF-FCR basin is the Ash Meadows (AM) basin which has a discharge of 17,000 acre-feet/year expressed as a spring line eminating from upfaulted carbonates. North of AF-FCR is the Oasis Valley (OV) basin which discharges an estimated 3000-5000 acre-feet/year. Underflow is believed to occur from the AM basin into the AF-FCR basin, but it is not known how much. The proposed underflow would be due to a hydrologic connection between the fractured carbonate units on either side of the Ash Meadows fault line (Figure 4). Flow in all basins mentioned is to the south and ultimately terminates in Death Valley.

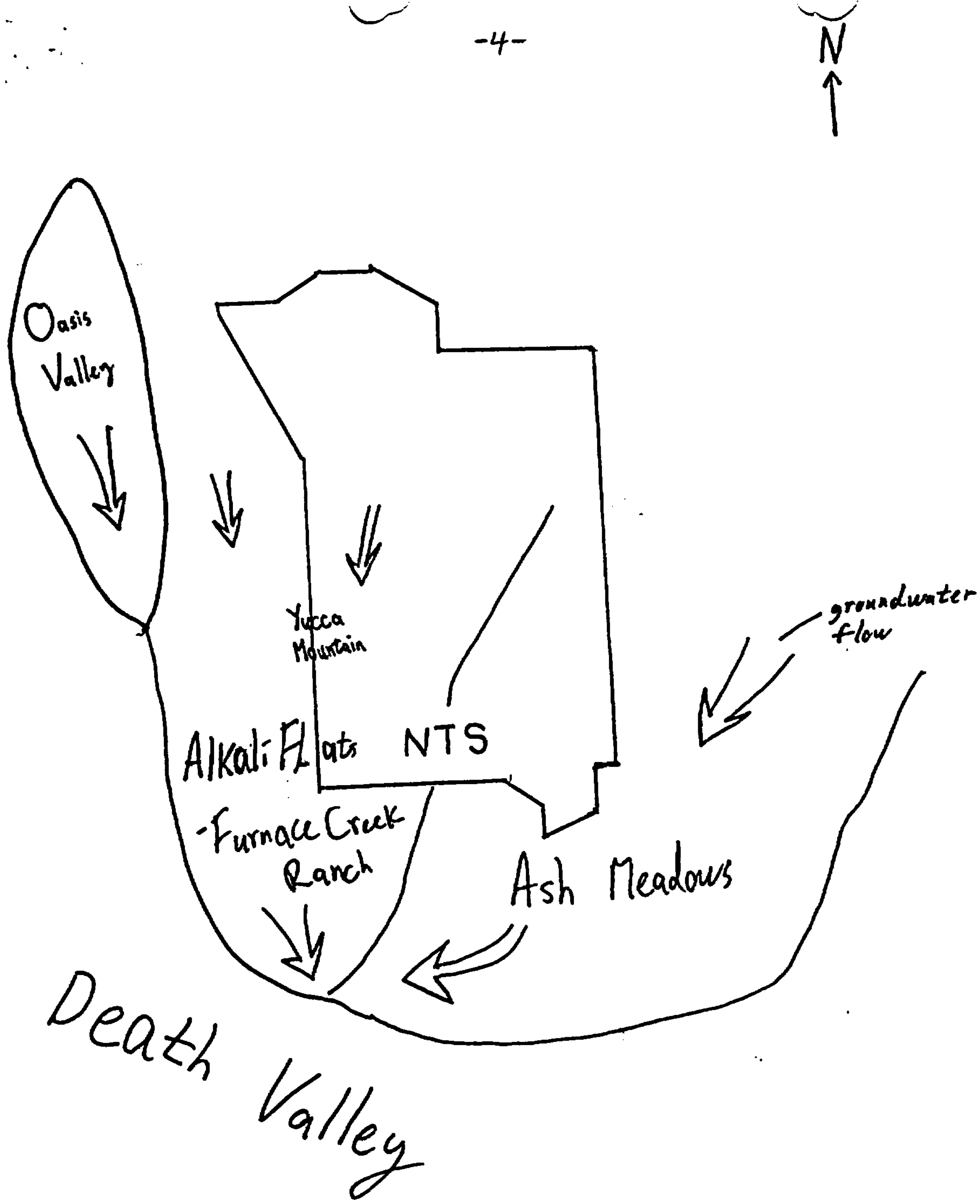


Figure 3. Approximate locations of major groundwater basins near Yucca Mountain.

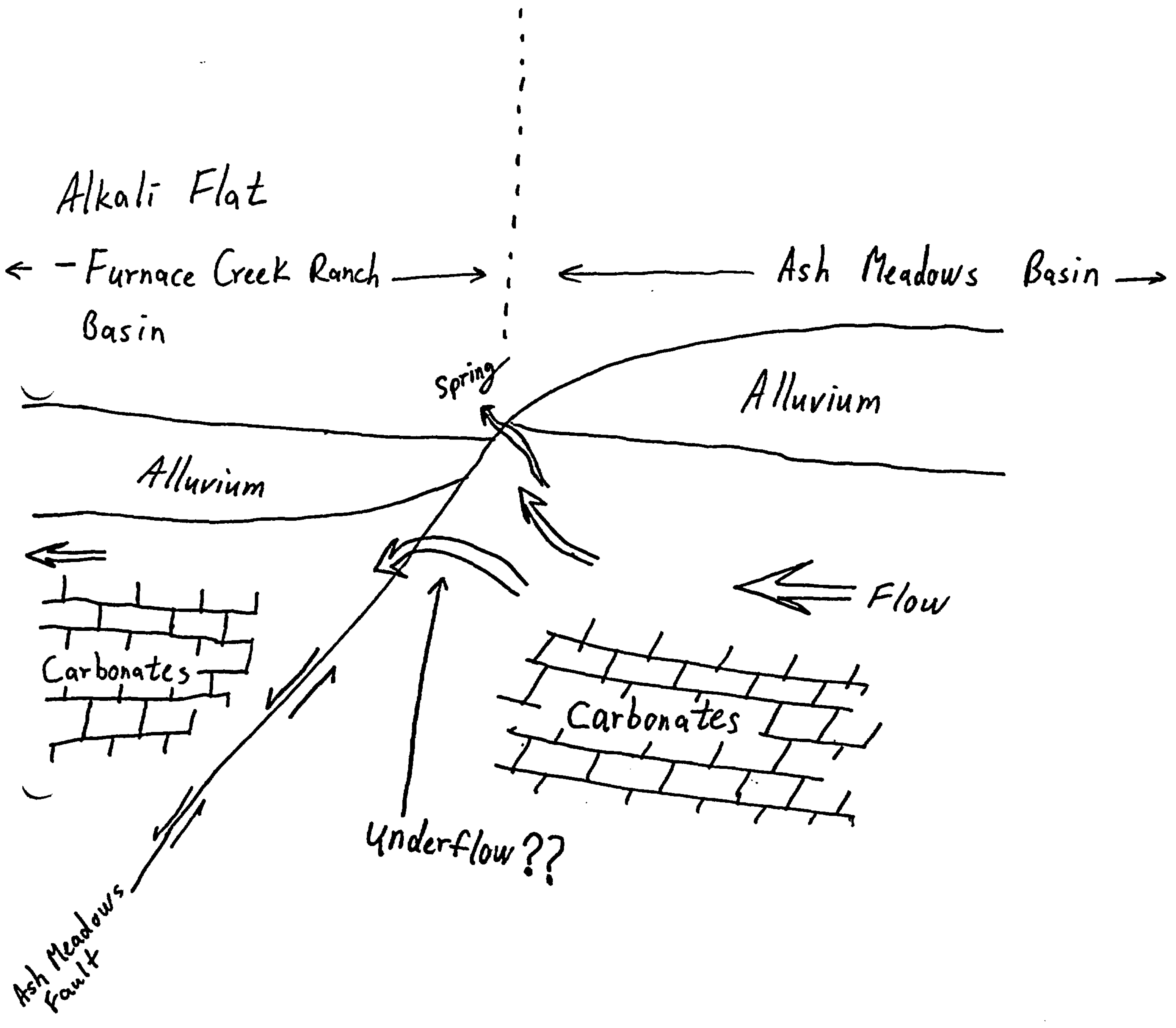


Figure 4. Proposed underflow between AM and AF-FCR basins.

Although groundwater flow within the AF-FCR basin is generally understood, it has not been clearly defined at Yucca Mountain. The USGS has drilled several wells in and around Yucca Mountain (Figure 5, Table 1) and several more are being planned. Geophysical logging and hydrologic testing are being performed at these wells to help understand the controlling flow parameters.

Table 1: Water Levels

Well	Water Level (M)	Notes
25A1	728.8	
25B1	729.4	Prow Pass - $T=600M^2/d$ Bullfrog - $T=600\ M^2/d$
G1	748.6	
G2	1031.0	Age (near Surface) = 2300 YA Age (at depth) = 4000 YA
H1	729.7	Prow Pass $T=150\ M^2/d$ Upper Bullfrog $T=1M^2/d$
H3	729.2	Very low permeability ("Tight")

H4	730.0	Prow Pass, Tram, Upper Bullfrog, and Lithic Ridge are producing units
J12	728.5	
J13	723.3	Topopah Spring Age = 9400 YA Fracture $K=10^{-2}$ cm/sec Matrix $K=10^{-8} - 10^{-10}$ cm/sec

(Well casings extend 200 feet below water table).

Of the wells listed in Table 1, two wells, G2 and J13, deserve special attention. Well G2, located in the northern portion of Yucca Mountain, shows a water level of 300 meters above all the other wells. Two hypothetical explanations have been given (by the USGS) for this anomaly. The first hypothesis is as follows; Paleozoics underlying the entire region are segregated into the Eleana formation to the north (underlying G2) and the carbonates to the south (underlying all other wells). The carbonates act as a high permeability connection between all wells except G2, which is dammed up by the low permeable Eleana fm. Problems (as seen by NRC staff) with this hypothesis are two-fold: 1) none of the paleozoics have yet been found under Yucca Mountain (to a depth of 6000 feet); and 2) a vertical head gradient, which would indicate well interconnection via the underlying carbonates (since the carbonates have a higher conductivity than the tuffs, flow would have a significant vertical component through the tuffs towards the carbonates), does not

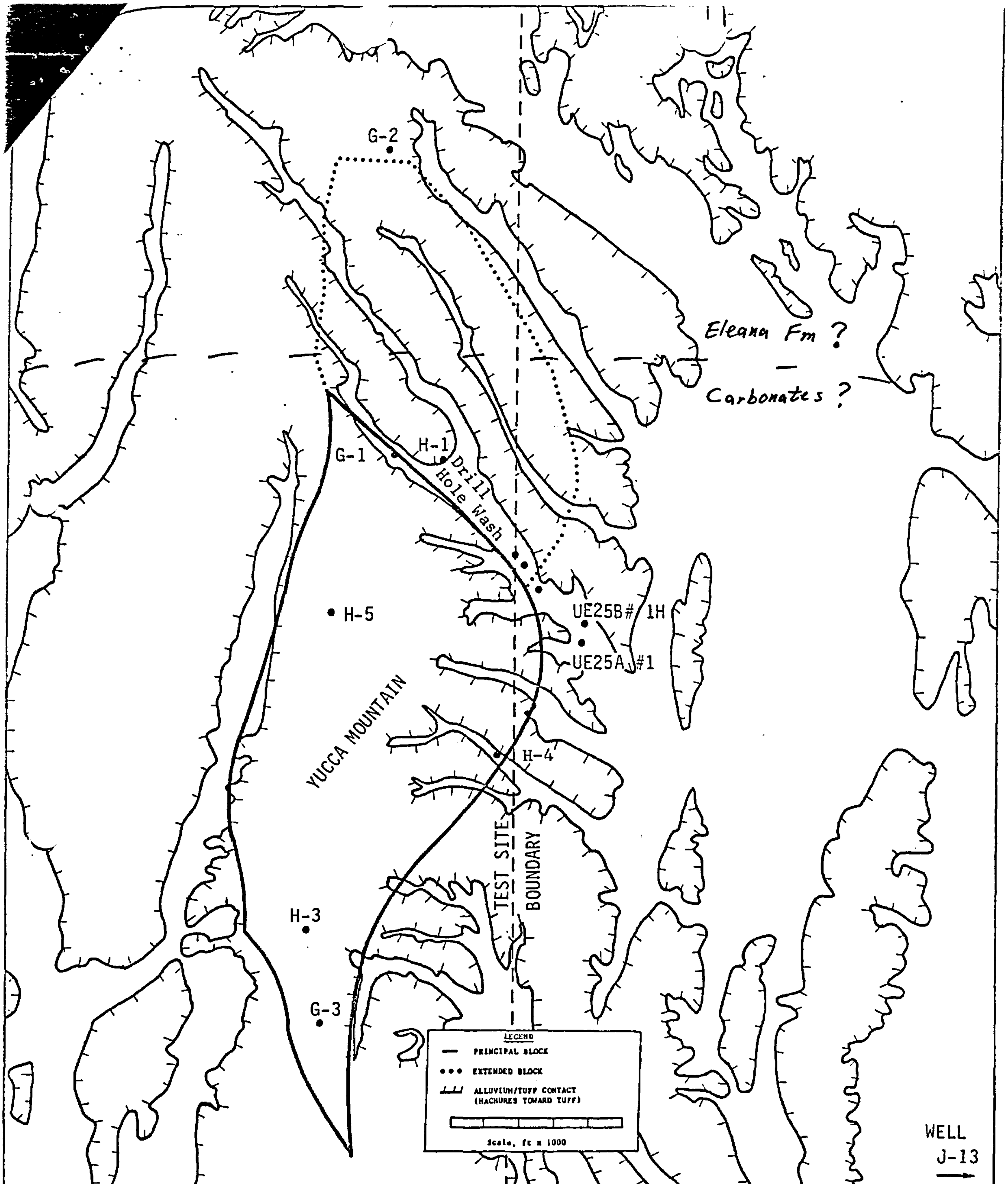


Figure 5. The Candidate Repository Area, Showing Borehole Locations and proposed Paleozoics (from Geotrans Inc.)

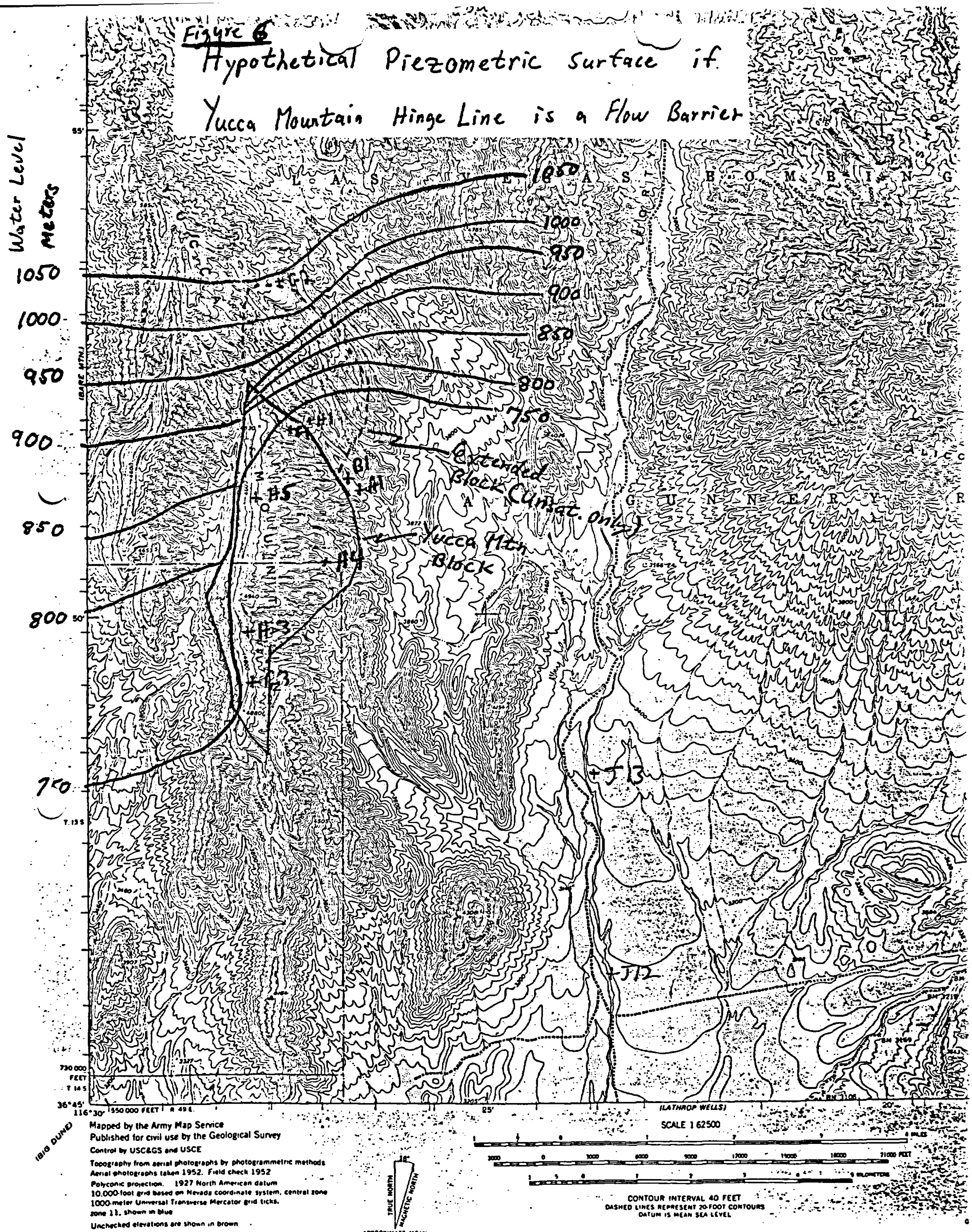
appear to exist. The second hypothesis has the fault of the western scarp of Yucca Mountain acting as a groundwater barrier. Groundwater flow west of the scarp is routed south by a highly permeable area while flow on the east is southeast towards the highly permeable 40 mile wash. The resulting piezometric surface (Figure 6) reflects the high gradient between G2 and the other wells. The problem with this hypothesis is that the groundwater barrier and resulting piezometric surface has not been substantiated with field data. Both of these conceptual models are recognized by the USGS as preliminary and are serving as guides for future USGS reconnaissance. Drill holes PH-1 (on eastern slope of Yucca Mountain) and H6 (west of scarp) are being planned to further scope out the two models. It is apparent that the G-2 water level anomaly must be explained.

Well J13, situated east of Yucca Moutain in 40 mile wash, is currently producing 600 gallons/minute with a drawdown of 20 feet. The aquifer responsible for this high yield is the densely fractured Topopah Spring unit. At Yucca Mountain, Topopah Spring is unsaturated, whereas at 40 Mile Wash it is down faulted below the water table. The implications arising from having a highly productive aquifer in close proximity to Yucca Mountain must be further explored.

Knowledge and understanding of the hydrology at Yucca Mountain are very preliminary (as apparent in the above discussion of G2). There is no apparent spatial correlation of hydraulic conductivity within a given geologic unit (Topopah Spring and the paleozoics withstanding). This results in a lack of hydrostratigraphic units and complexes the hydrogeology. It appears that the most transmissive units are located along fracture zones indicating structural control of flow.

Figure 6

Hypothetical Piezometric Surface if Yucca Mountain Hinge Line is a Flow Barrier



Mapped by the Army Map Service
Published for civil use by the Geological Survey
Control by USC&GS and USCE
Topography from aerial photographs by photogrammetric methods
Aerial photographs taken 1952. Field check 1952
Polyconic projection. 1927 North American datum
10,000-foot grid based on Nevada coordinate system, central zone
1000-meter Universal Transverse Mercator grid ticks, zone 11, shown in blue
Unchecked elevations are shown in brown

Vertical conductivities (Kz) have not been determined at any location. Well tests on the saturated tuffs show low storage coefficients, indicating confined and/or fractured aquifer conditions.

MODELING

The USGS has been using numerical models as a help to gain conceptual understanding of Yucca Moutain hydrogeology. Currently, the modeling effort has been limited to a regional flow study. The study employs the Cooley code (not documented) and publication of results are expected in 2-3 months. Flow simulation was 2-dimensional in the x-y plane with hydraulic conductivities determined empirically through potentiometric and discharge distributions. The study is ongoing and is being revised as new information becomes available. PNL is being supplied with the preliminary results of this study and is in the process of kriging (a geostatistical technique that addresses the spatial bias of data, resulting in a contoured map around data points with standard deviations and uncertainties of the calculated contour values) a regional transmissivity map.

The next phase of the USGS modeling effort includes using the Tracy code (also not documented) to simulate radionuclide transport. The code will be capable of simulating decay chains, linear sorption, matrix diffusion, and kinetic dissolution. The radionuclide inventory used will be similar to that of ORIGEN.

PERFORMANCE ASSESSMENT

The DOE has divided the NTS site suitability question into a number of key issues, subissues, and information needs (Figure 7).

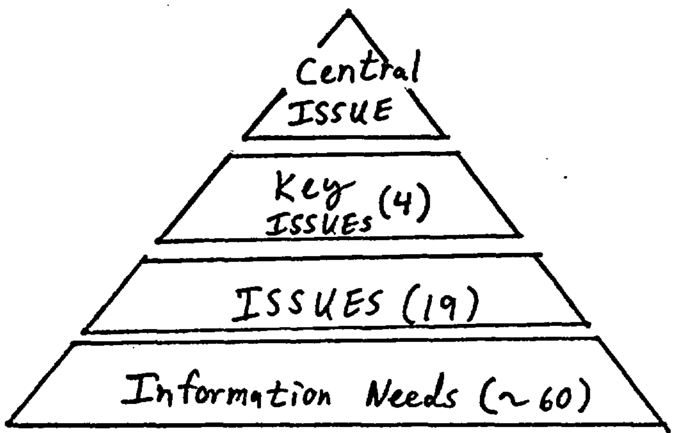


Figure 7. Issue breakdown.

The Central Issues is, "Is the site suitable?" Subdividing the Central Issue are four Key Issues, one of which pertains to performance assessment. "Can the system be modeled?" The subissues under this key issue include modeling capability for both saturated and unsaturated horizons, thermal mechanical modeling, and validation of models with laboratory experiments, field data, and natural analogs.

SNL is responsible for the performance assessment and has compiled a suite of codes, many of which are still under development (Table 2). The two codes receiving most attention are MARIAH (SAT/UNSAT) and TRACR.

Table 2: Preliminary Code List for NTS Performance Assessment

Heat Transport	Groundwater (far-field flow)
COYOTE	MARIAH (SAT/UNSAT)
MARIAH	FRACT
SHAFT 79	TRUST
ARRAYF	PATHS
ADINAT	VTT
Geosphere (far-field transport)	**Species Transport**
SWENT	IONMIG
TRACR	MMT
WAFE	GETOUT
FEMWATER/WASTE	UCB
PABLM	
DACRIN	
Waste Package	**Rock Mechanics**

ORIGIN
WAPPA

SANDIA-ADINA
NIKE
JAC2D
DAMSWEL
VISCOT
STEALTH2D

Geochemistry

EQ3/6
PHR81

MARIAH (SAT/UNSAT) is a 2-D finite element saturated/unsaturated flow code which simulates heat and fluid flow and ignores vapor flow.

TRACR is a 3-D integrated finite difference saturated/unsaturated isothermal flow and transport code. It simulates tracer flow through discrete orthogonal fracture systems where the tracer may be in either liquid or vapor phase. Radionuclide transport is limited to 3-member chains. A heat term is expected to be added. Code documentation should be finished in three months.

A flow chart depicting the SNL performance assessment methodology, as displayed by DOE, is illustrated in Figure 8.

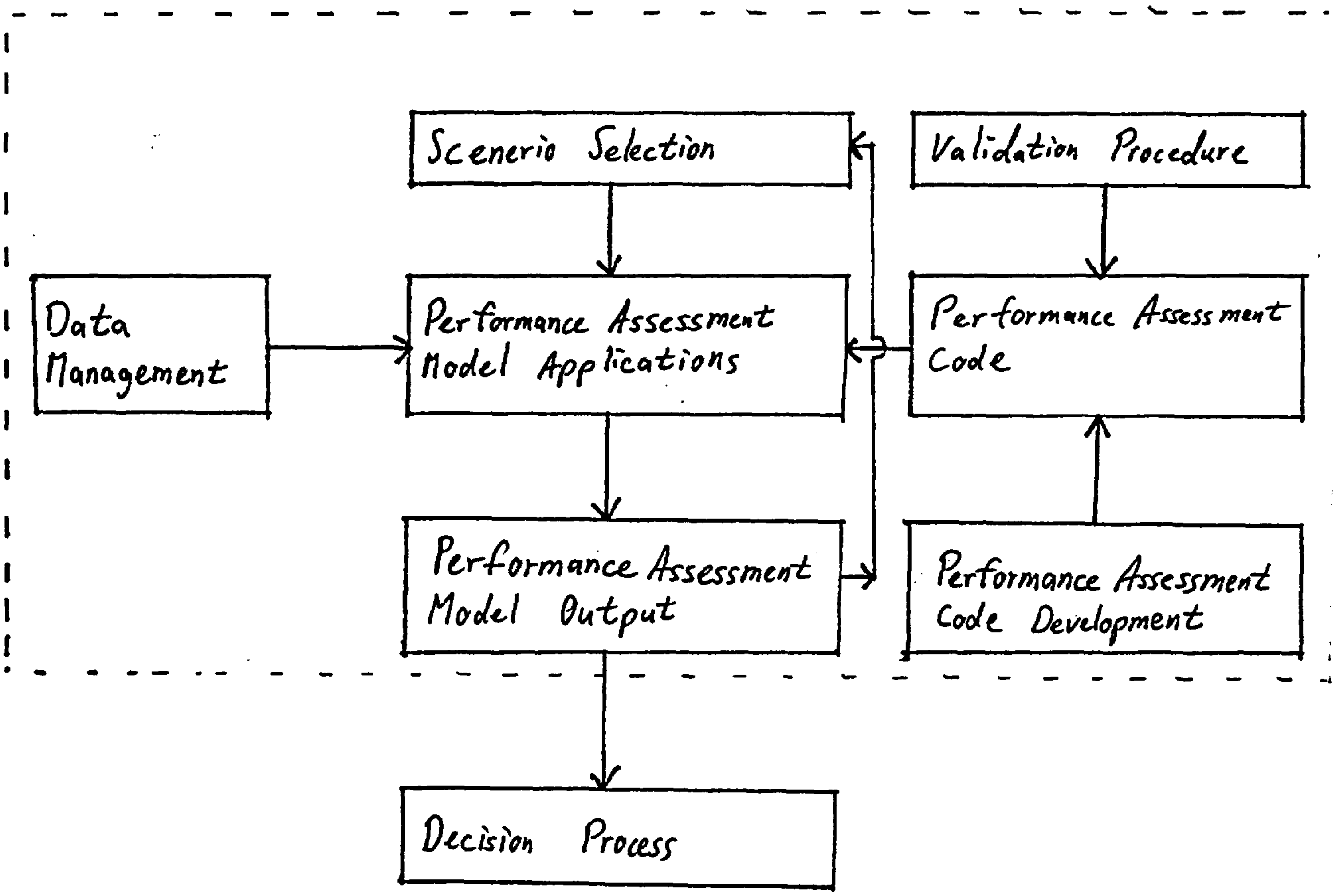


Figure 8. SNL Performance Assessment Methodology

The USGS will supply all geologic and hydrogeologic data for the performance assessment codes, but will not be directly involved in the performance assessment process. Code application will be done onsite (probably by NVOO) and transfer of codes from SNL will take place in FY83.

Scenario selection is far along with over 400 scenarios under consideration. The Geologic Simulation Model (GSM) for NTS is being developed by PNL and may be used to aid in scenario screening. That contract is up for review at the close of FY82 and a decision will be made on continuation of funding. Sensitivity studies of various code input and output will also be included as part of the performance assessment analysis.

DESERT RESEARCH INSTITUTE

Discussions were also held at the Desert Research Institute (DRI) (University of Nevada) in both Reno and Las Vegas. The discussions between DRI and NRC personnel centered on DRI research activities at NTS and possible applications to Yucca Mountain. Funding for DRI projects on NTS comes primarily from the DOE weapons testing programs. These projects include the following:

- Field studies in the unsaturated zone using psychrometers to measure:

  Conductivity as a function of time and depth.
  Suction as a function of time and depth.

- Field studies employing geophysical techniques to study infiltration through the unsaturated zone.

- Theoretical and laboratory analysis of vapor transport due to heat.

- A previous DRI study which may impact unsaturated siting shows recharge seeping through 1000 feet of fractured unsaturated tuff in six months. Further, verification of this study using isotopes is being considered.

- A regional flow model of NTS is also being planned.

OBSERVATIONS AND CONCLUSIONS

Unsaturated Zone:

DOE plans for repository siting in the unsaturated zone are still unknown. Knowledge of hydrologic parameters of the unsaturated tuffs beneath Yucca Mountain is almost nonexistant. The USGS has plans (over the next year) to drill 3 holes (UZ-1, -2, and -3) and to excavate a tunnel into unsaturated portions of the Topopah Spring and Calico Hills formations (the two unsaturated candidate horizons) for experimentation and data collection. It is conceivable that DOE will select an unsaturated horizon irregardless of supporting data availability (due to time constraints).

Paleohydrology:

The most likely adverse climatic change to affect NTS is the recurrence of a pluvial (Pluvials are cyclical, the last one occurring 10,000 YA). Pluvials are characterized by increased precipitation and cooler temperatures resulting in a greater supply of water for surface runoff and groundwater recharge. The affect that the most recent pluvial had on the Yucca Moutain is not known. To date, no paleohydrologic studies site specific to Yucca Moutain have been conducted, nor has a concensus been reached on a regional understanding. A site specific study is warranted in that changes in recharge rates, water levels, discharge locations, and flow gradients will directly impact nuclide flow paths and travel times.

Performance Assessment:

The performance assessment program outlined is extensive and impressive. However, the supporting data base is still preliminary and does not yet justify the expansive modeling program. This is especially true for the unsaturated zone where the data base is weakest. It is not clear as to whether SNL or NVOO will perform the actual modeling, but either way the USGS, who collected the data, developed the conceptual models, and has the best understanding of the hydrogeologic system, will not be involved. If the modeling will be done at NVOO, a further disadvantage will be incurred in that NVOO probably will not have the level understanding of code assumptions and limitations as would SNL.

Hydrogeology:

Much hydrogeologic investigation still needs to be performed at Yucca Moutain. A satisfactory explanation of the water level in Well G2 must be found. The geology underlying the tuffs must be determined as well as the extent and roles structural features have on flow. The questions of vertical flow, components, vertical conductivies, and hydrostratigraphic/structural units must also be resolved. The general flow is believed to be towards the south and east, but a better understanding of the hyrdogeology is prerequisite for more detailed evaluation.

Horizon Selection:

Many portions of the SCR have already been completed and are generic in terms of horizon selection. The entire SCR is scheduled to be complete and ready for DOE review by January 1983. Horizon selection is expected to be made by that time. During the meetings, however, DOE hinted that a specific repository horizon may not be chosen in time for inclusion in the SCR.