

**U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT**

**NUCLEAR WASTE TECHNICAL REVIEW BOARD
FULL BOARD MEETING**

**SUBJECT: SURFACE-BASED TESTING
DRILLING PROGRAM REVIEW**

PRESENTER: DR. J. R. DYER

**PRESENTER'S TITLE
AND ORGANIZATION: DIRECTOR, REGULATORY AND SITE EVALUATION DIVISION
YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
LAS VEGAS, NEVADA**

**PRESENTER'S
TELEPHONE NUMBER: (702) 794-7586**

**DALLAS, TX
APRIL 7-8, 1992**

SURFACE-BASED TESTING OBJECTIVES

The integrated drilling program ensures that data needed to improve site models for use in site characterization and suitability evaluations, performance assessments, and ESF and repository design are obtained in an efficient and cost-effective manner.

Boreholes have been sited for two different strategies:

1. Feature Sampling and Anomaly Characterization
 - Unsaturated Zone
 - Geologic Drillholes
 - Surface Facility Drillholes
 - Water Table Drillholes
 - Calcite Silica Drillholes
 - Drillholes for Water Supply and Tests
 - Forty Mile Wash Drillholes
 - Solitario Canyon Fault Study
 - In Situ Stress Drillhole
 - Tracer Complex Drillholes
 - Volcanic Drillholes

2. Characterization of Statistical Distribution
 - Natural Infiltration
 - Artificial Infiltration
 - Geostatistical Drillholes

SURFACE-BASED TESTING SUMMARY STATUS

	Total	Completed	Planned
Shallow Drillholes (<1,000 ft)	431	164	267
Deep Drillholes (>1,000 ft)	118*	44	64*
Trenches/Test Pits/Pavements	102	70	32
Geophysical Surveys	65	41	24

* Includes 19 possible additional deep drillholes

E550245ft
E545000m

E566660ft
E550000m

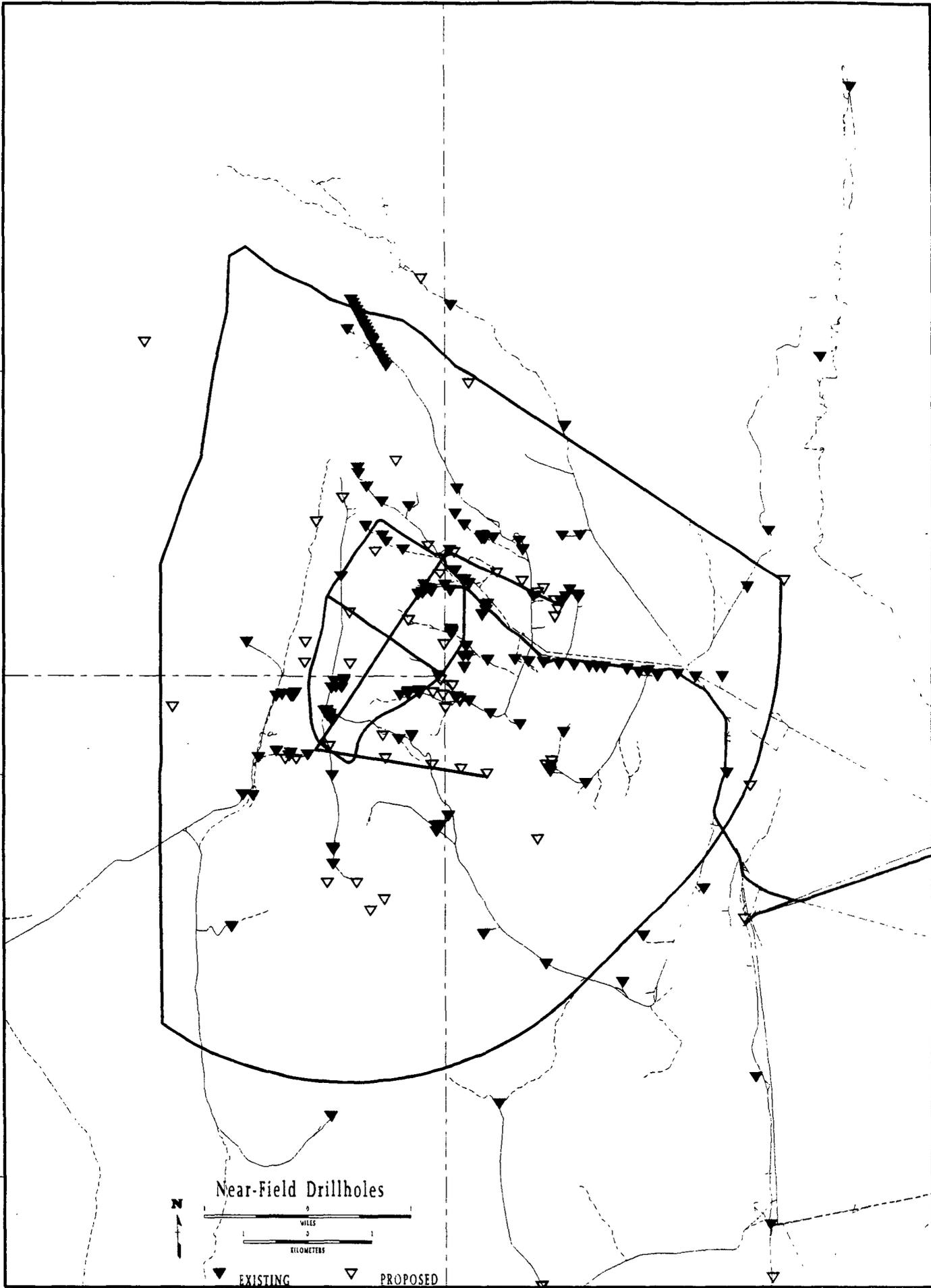
36° 52' 30"

36° 50' 00"

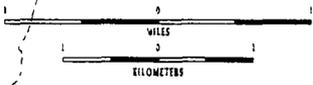
36° 47' 30"

N770210H
N4080900m

N753950H
N4075000m



Near-Field Drillholes



▲ EXISTING △ PROPOSED

116° 30' 00"

116° 27' 30"

116° 25' 00"



YMP-92-070.0

PLANNED DRILLING ACTIVITIES

code	Dry Drilled	Activity	# Planned Holes	Depth Range	Study Plan/SCP Ref	Status	Participant
N	√	Natural Infiltration	30	60-300'	8.3.1.2.2.1.2	NRC	USGS
UZ	√	Unsaturated Zone, Vertical Seismic Profile & Prototype	16	1,700-2,700'	8.3.1.2.2.3.2	NRC	USGS
G	●	Geologic Drill Holes	4	1,100-5,000'	8.3.1.4.2.1	YMP	USGS
SD	√	Geostatistical Drillholes	12	1,800-2,500'	8.3.1.4.3.1	YMP	SNL
NRG/ SRG	√	Surface Facilities Drillholes	11	50'-2,000'	8.3.1.14.2.1	NRC	USGS
W	√	Water Table Drillholes	8	1,700-2,100'	8.3.1.2.3.1	NRC	USGS-LANL
CAL C S	√	Calcite Silica Drillholes	6	80-315'	8.3.1.5.2.1	NRC	USGS
LPRS/ SPRS	√	Rainfall Simulation/Artificial Infiltration	232	5-50'	8.3.1.2.2.1.3	NRC	USGS
DR		Drillholes for water supply & tests	0	NA	8.3.1.16.2.1	IP	SAIC
FM		Forty Mile Wash Drillholes includes SH Shallow Neutron	13	600-800' SH = 33'	8.3.1.2.1.3.3	NRC	USGS
H		Solitario Canyon Fault	3	3000'	8.3.1.2.3.1.1	NRC	USGS
ISS		In Situ Stress Drillhole	1	1,000'	8.3.1.17.4.8	IP	USGS
STC	√	Southern Tracer Complex	4	3,000'	8.3.1.2.3.1	NRC	USGS-LANL
V		Volcanic Drillholes	5	1,000'	8.3.1.8.5.1.1	NRC	LANL

E5444401t
E550000m

E5830651t
E553000m

36° 55' 00"

36° 36' 00"

36° 30' 00"

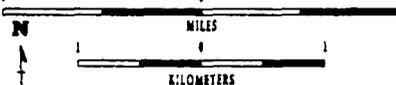
N743351t
N443500m

N772101t
N443500m

N733951t
N443500m

N11
N16
N15
N17
N36
N27
N37
N38
N64
N33
N34
N35

Natural Infiltration



116° 27' 30"

116° 25' 00"



YMP-92-034.0

DRILLING PROGRAM REVIEW

Program: Unsaturated Zone (UZ)

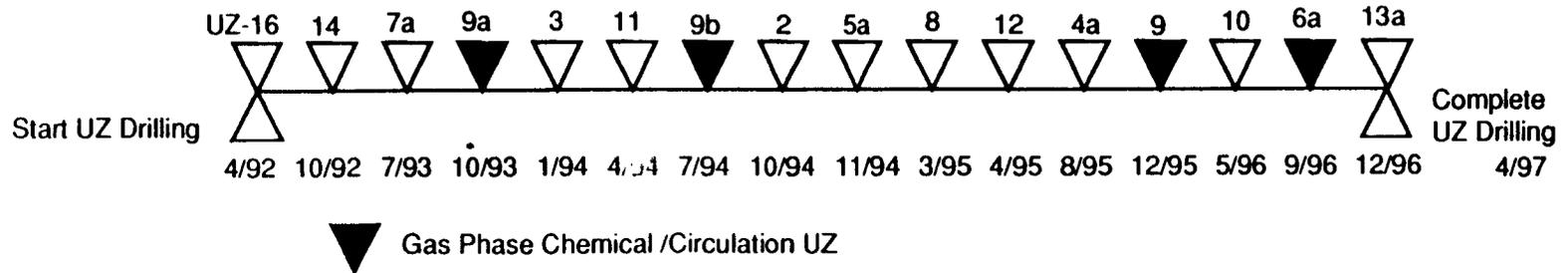
Objectives: To provide detailed information on hydrologic properties, moisture content, and moisture potential in the UZ. Average depths of 550m (1800') will be reached using air as only circulation medium to minimize contamination and disturbance to the in-situ hydrologic conditions.

Information Needs: In-situ moisture condition within the immediate vicinity of the Conceptual Perimeter Drift Boundary. Hydrologic properties and moisture conditions of the UZ. Instrument holes for long-term monitoring of hydrologic properties of UZ. Detection of possible perched water

Related Analyses/Tests: Vertical boreholes (multipurpose) to detect any perched water and obtain samples for analysis. Supporting studies identified in SCPB. VSP investigation hole near UZ-9 complex. Pressure-testing of boreholes, logging (supports 8.3.1.4.3 of SCP)

Number of Boreholes: 16 Planned

Sequencing Schedule:



E550245ft
E545000m

E566660ft
E550000m

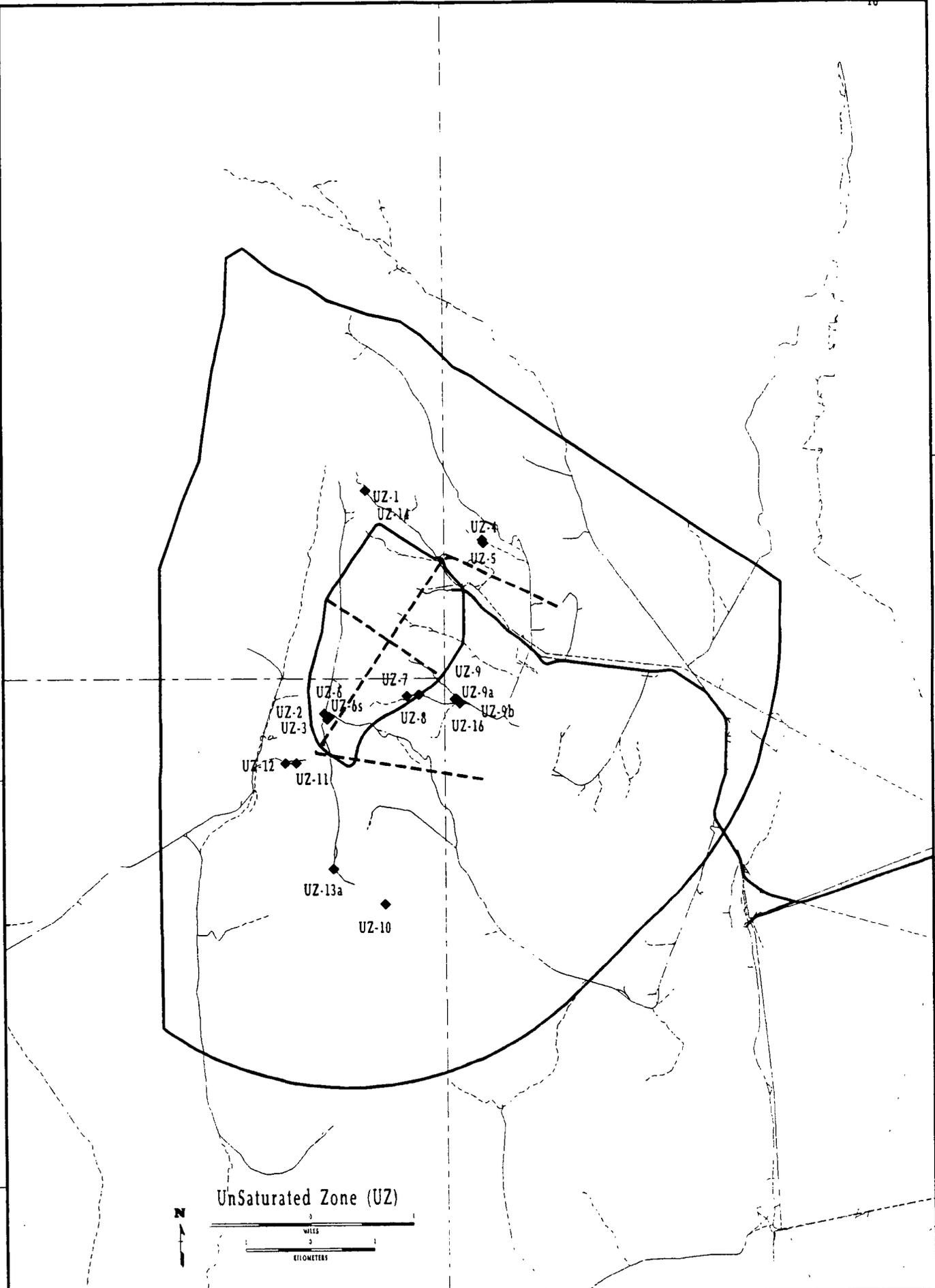
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36° 50' 00"

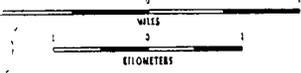
36° 47' 30"

N770210ft
N4080000m

N737950ft
N4075000m



UnSaturated Zone (UZ)



116° 30' 00"

116° 27' 30"

116° 25' 00"



YMP-92-066.0

DRILLING PROGRAM REVIEW

Program: Geologic Holes

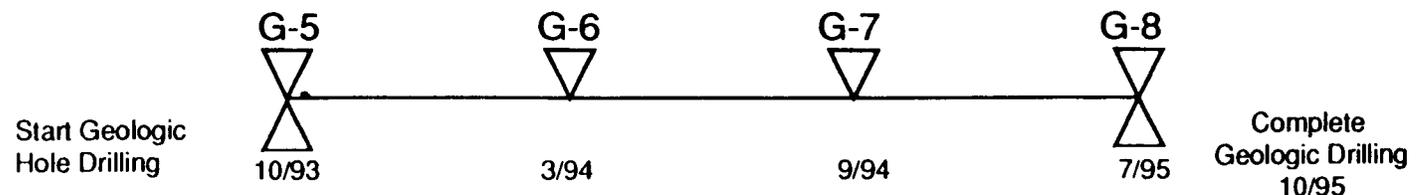
Objectives: This study is to determine the vertical and lateral variability and emplacement history of stratigraphic units and lithostratigraphic subunits within the Yucca Mountain site area.

Information Needs: Will be used to gather pertinent geologic data, develop lithologic correlations, and describe the stratigraphy of the site area. Surface based mapping and borehole activities will be complemented by geologic mapping and testing in the ESF.

Related Analyses/Tests: Supports studies to provide information on mineralogy, petrology, and rock chemistry within the potential emplacement horizon and along potential flow paths (SCP 8.3.1.3.2). Part of the integrated drilling program and geophysical activities (SCP 8.3.1.4.1). Studies to provide information for spatial distribution of thermal and mechanical properties (SCP 8.3.1.15.1), and information for spatial distribution of ambient stress and thermal conditions (SCP 8.3.1.15.2).

Number of Boreholes:
15 existing
4 new
19 total

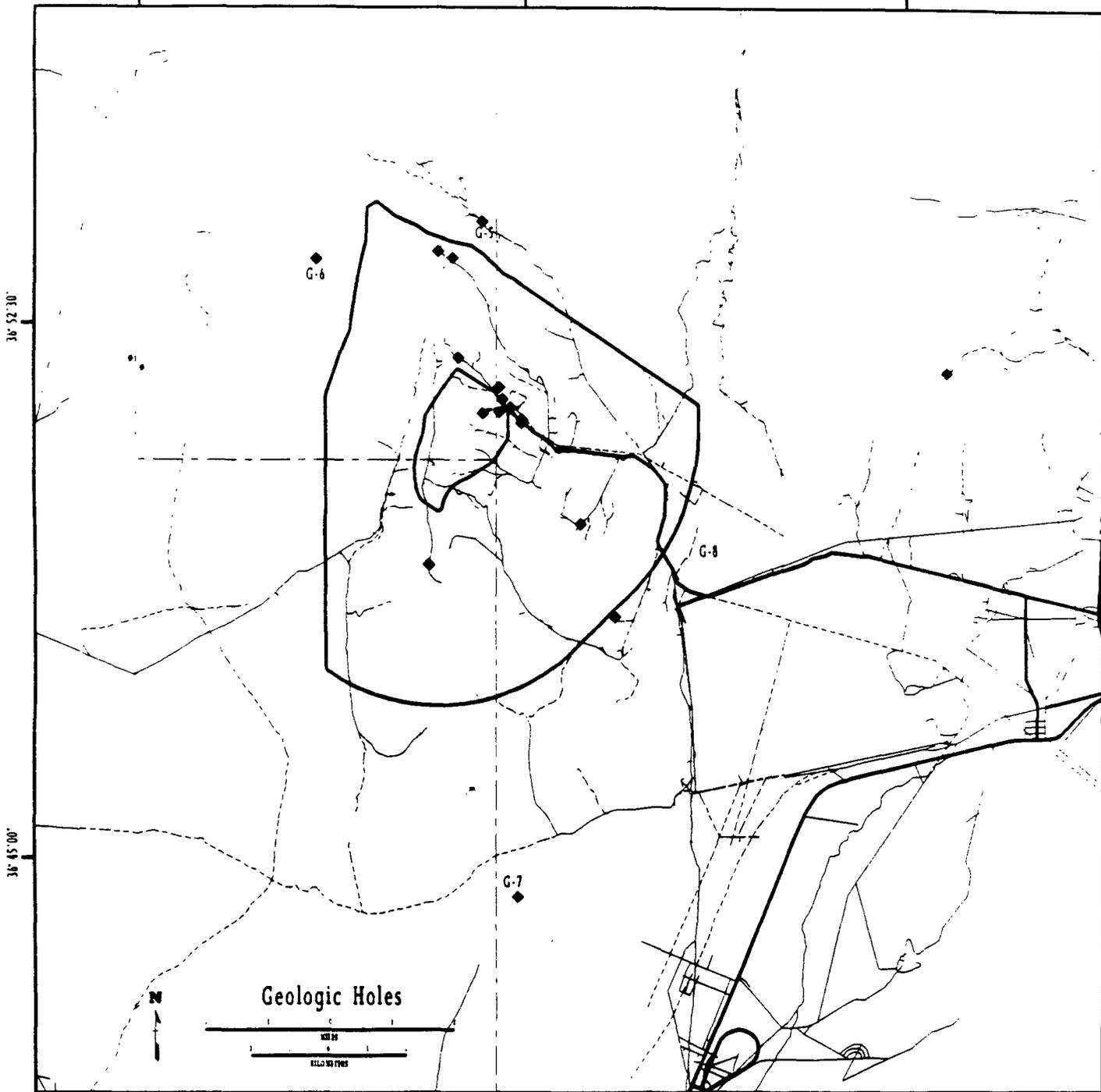
Sequencing Schedule:



255:00m
254:00m

255:00m
255:00m

254:51m
255:00m



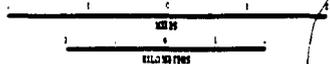
36° 52' 30"

36° 45' 00"

N7701011
N470000m

N7701011
N470000m

Geologic Holes



116° 30' 00"

116° 22' 30"

DRILLING PROGRAM REVIEW

Program: Geostatistical Drillholes (Systematic Drilling Program)

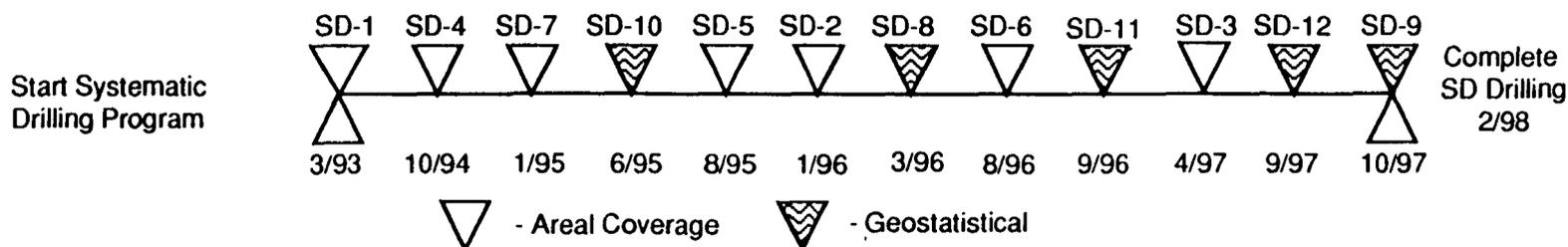
Objectives: This activity will acquire physical rock samples, analytical data, and basic descriptions of the subsurface geology of the proposed repository site on a systematic basis. The Systematic Drilling program consists of twelve boreholes, located in conjunction with the feature sampling program, including (1) seven boreholes to provide areal coverage and (2) five boreholes to provide information for evaluation of the geostatistical approach.

Information Needs: The samples and information are important for characterizing the three-dimensional distribution of rock characteristics and hydrologic and geochemical variables in the unsaturated zone.

Related Analyses/Tests: The strategy for locating boreholes is based on the requirements of the 3-D rock characteristics model (SCP 8.3.1.4.3.2) and other studies involving analysis of spatial variability (8.3.1.2.2.3.1). Borehole locations and drilling methods are technically and programmatically integrated with other activities including site vertical borehole study (8.3.1.2.2.3.2), Solitario Canyon fault study in the SZ (8.3.1.2.3.1.1), and site potentiometric-level evaluation (8.3.1.2.3.1.2).

Number of Boreholes: 12 new

Sequencing Schedule:



E550245ft
E545000m

E566660ft
E550000m

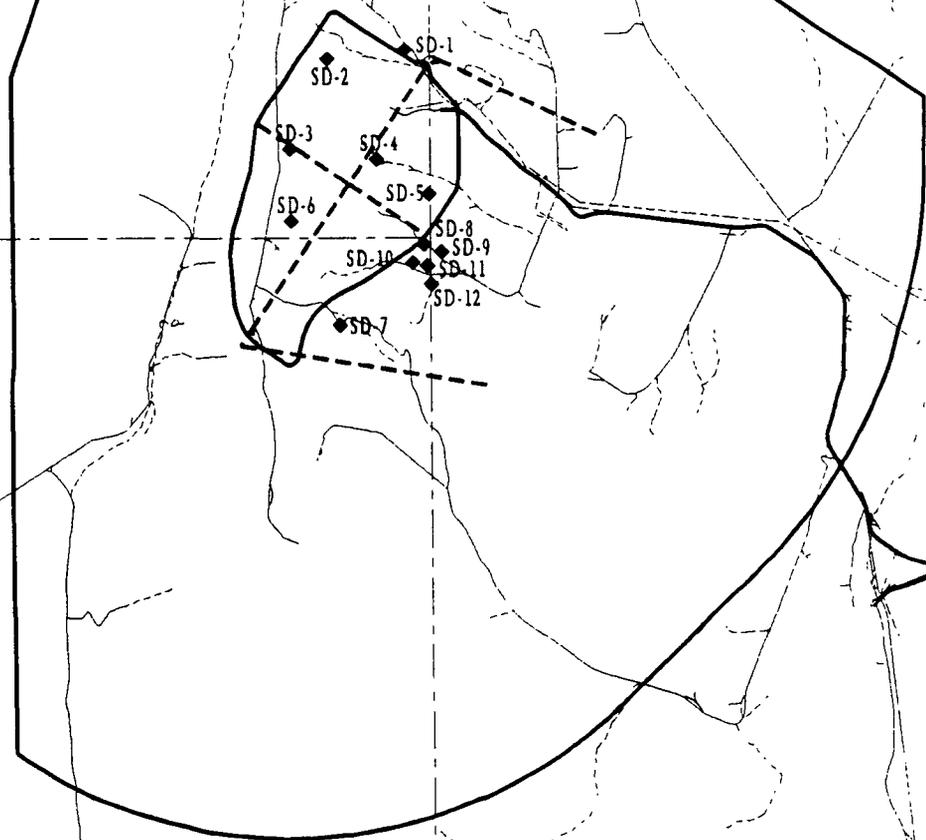
36° 52' 30"

36° 50' 00"

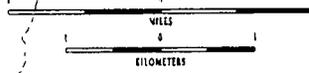
36° 47' 30"

N7702101H
N4080000m

N7519501J
N4075000m



Systematic Drilling Holes



116° 30' 00"

116° 27' 30"

116° 25' 00"



YMP-92-065.0

DRILLING PROGRAM REVIEW

Program: Surface Facilities Drillholes

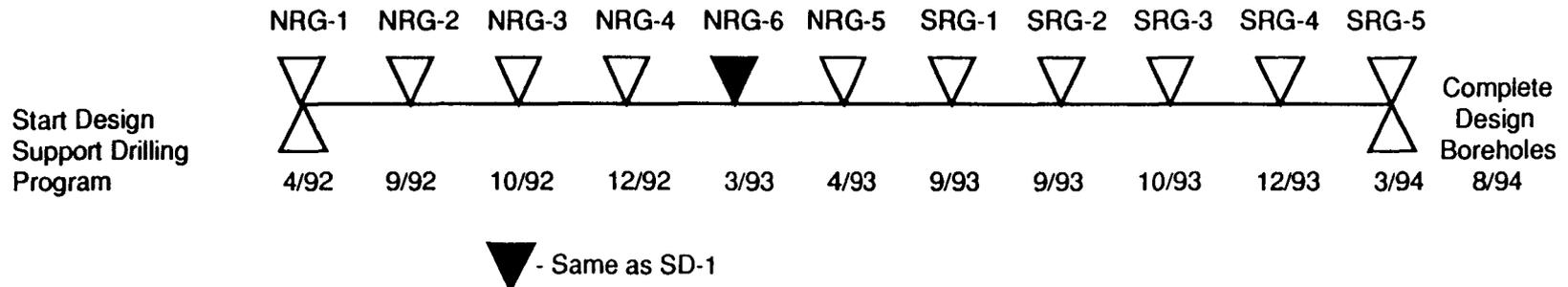
Objectives: The purpose of the drillholes is to provide soil and rock properties information for potential locations of surface facilities and subsurface access facilities

Information Needs: Alluvial and rock stratigraphy and structure, soil and rock classification vs. depth, physical properties vs. depth, mechanical and dynamic properties vs. depth, infiltration-runoff characteristics, etc. will influence the siting of access to underground facilities.

Related Analyses/Tests: Boreholes will be drilled along north and south ramp alignments

Number of Boreholes: 11 new

Sequencing Schedule:



E530245ft
E545000m

E566660ft
E550000m

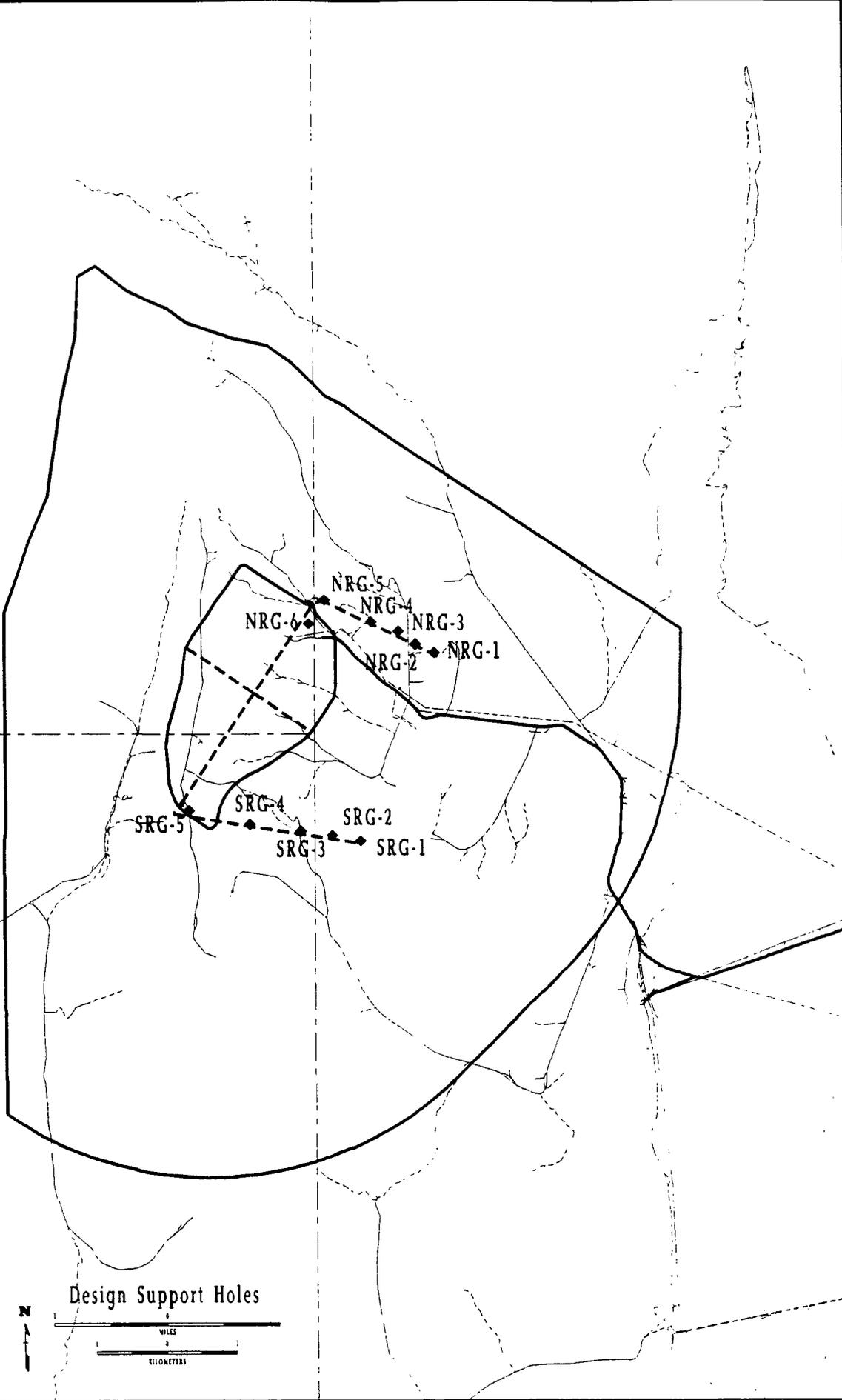
36° 52' 30"

36° 50' 00"

36° 47' 30"

N770210ft
N460000m

N739350ft
N407500m



Design Support Holes



116° 30' 00"

116° 27' 30"

116° 25' 00"



YMP-92-059.0

DRILLING PROGRAM REVIEW

Program: Water Table Holes

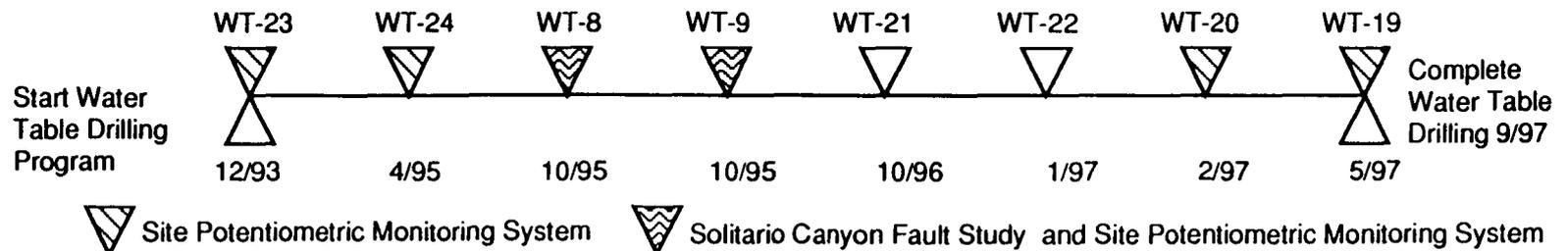
Objectives: Eight additional water table boreholes are planned to be drilled to depths of 1700'-2100' for the exploration and sampling of the water table. Six of the eight will be added to the site potentiometric monitoring network. Two are part of the Solitario Canyon Fault Study.

Information Needs: Water level data, Water samples for chemical and isotropic analyses

Related Analyses/Tests: Supports studies to provide description of the regional hydrologic system (SCP 8.3.1.2.1), studies to provide a description of the UZ hydrologic system (SCP 8.3.1.2.2) and the SZ hydrologic system (SCP 8.3.1.2.3).

Number of Boreholes: 16 existing water table boreholes
8 new boreholes (2 drilled as part of Solitario Canyon Fault Study)
 24

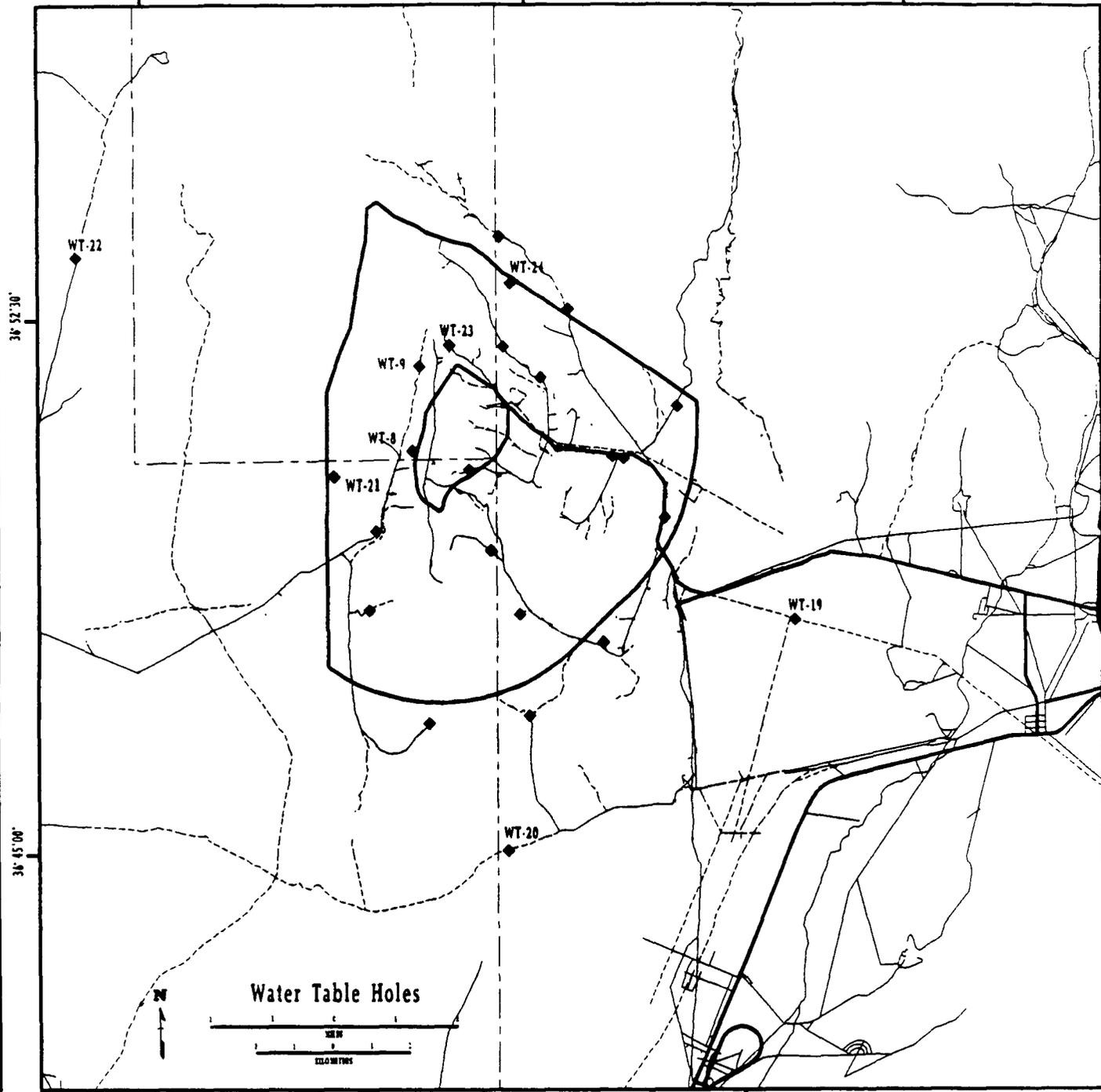
Sequencing Schedule:



E533840ft
E540000m

E566640ft
E550000m

E599475ft
E560000m



Water Table Holes



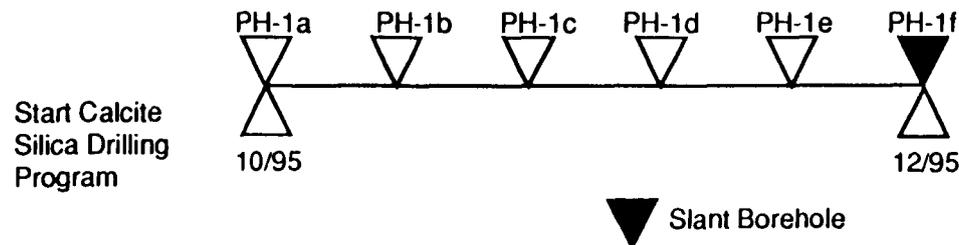
116° 30' 00"

116° 22' 30"

DRILLING PROGRAM REVIEW

- Program:** Calcite Silica
- Objectives:** To determine the ages, distribution, origin, and paleohydrologic significance of calcite and opaline-silica deposits along faults and fractures in the vicinity of Yucca Mountain.
- Information Needs:** If trenching does not expose the base of the deposit, a series of shallow vertical holes will be drilled to intersect the dipping fracture zone at sequentially greater depths. A maximum of five holes such that the deepest would be about 20 meters (79') is planned. If the shallow holes do not reveal the base of the deposit then a low angle hole will be drilled to intersect the fracture zone at a depth of approximately 80 meters (315').
- Related Analyses/Tests:** Standard mapping techniques will be used (SCP 8.3.1.5.1.4.2) to determine location and areal distribution. Fracture-filling materials will be subjected to mineralogic study supported by geochemical investigations.
- Number of Boreholes:** 5 shallow new
1 low angle new (possible)
6 total

Sequencing Schedule:



E550245ft
E545000m

E566660ft
E550000m

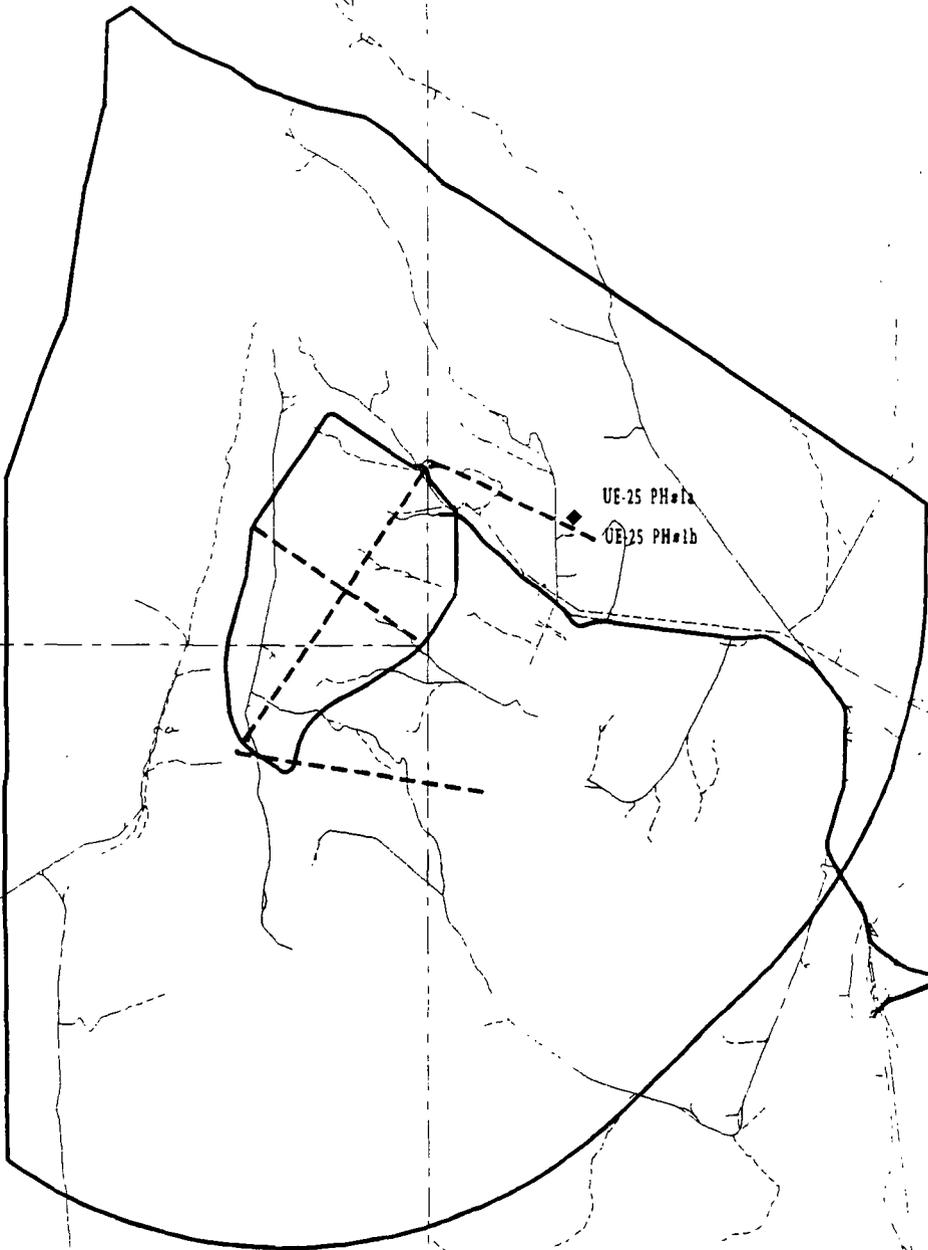
36° 52' 30"

36° 50' 00"

36° 47' 30"

N77021011
N4080000m

N75395011
N4075000m



Calcite Silica Drillholes



116° 30' 00"

116° 27' 30"

116° 25' 00"

EG&G

YMP-92-057.0

DRILLING PROGRAM REVIEW

Program: Artificial Infiltration

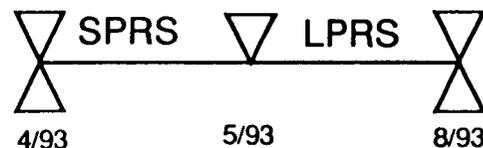
Objectives: Infiltration will be monitored under artificial precipitation rates. Fourteen large-plot rainfall simulation tests and 23 small-plot simulation tests are planned. At each small-plot site, four monitoring holes will be drilled to a depth of about 1.5 m (5'). At each large-plot site, 10 monitoring holes will be drilled to a depth of 9-15 m (30-50').

Information Needs: Water fluxes, flow velocities, and flow pathways will be characterized in major hydrogeologic surficial units under present day and simulated wetter climatic conditions.

Related Analyses/Tests: Parameters will be measured at each site for water budget calculations of infiltration. Meteorological data will be collected for evapotranspiration calculations (SCP 8.3.1.2.1.1). Run-off and sediment yield as a function of rainfall will be determined by monitoring flumes (8.3.1.2.1.2).

Number of Boreholes: 92 at Small Plot Rainfall Simulation (SPRS) sites
140 at Large Plot Rainfall Simulation (LPRS) sites
232 Total

Sequencing Schedule:



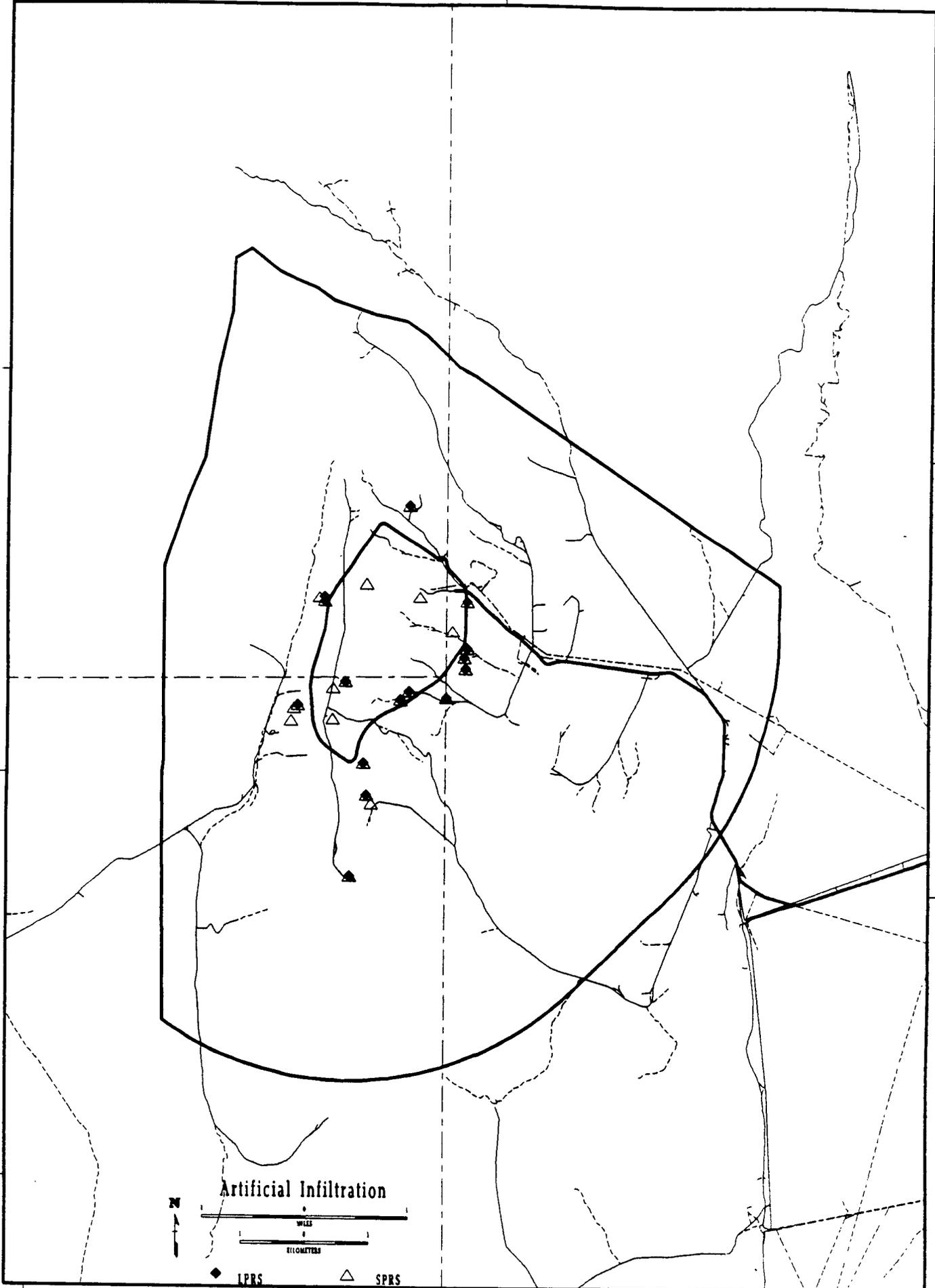
E550245ft
E545000m

E566660ft
E550000m

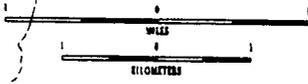
36° 52' 30"

36° 50' 00"

36° 47' 30"



Artificial Infiltration



◆ LPRS

▲ SPRS

116° 30' 00"

116° 27' 30"

116° 25' 00"



YMP-92-044.0

N408000m

N407500m

DRILLING PROGRAM REVIEW

Program: Drillholes for Water Supply and Tests

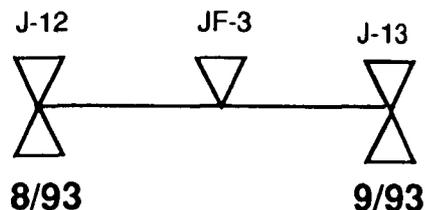
Objectives: This activity is to determine (1) the adequacy of wells J-12 and J-13 in terms of available resource potential and (2) the total cost and technical feasibility of supplying the water needed to support a repository at Yucca Mountain.

Information Needs: Total time-phased water demand through decommissioning, estimated peak water demand, maximum water resources available from wells J-12 and J-13.

Related Analyses/Tests: The data will be collected and other studies performed in support of investigations to provide a description of regional hydrologic system (SCP 8.3.1.2.1), the saturated zone (8.3.1.2.3) and studies to provide information required on present and future value of energy, mineral, land, and ground-water resources (8.3.1.9.2).

Number of Boreholes: Analysis of three existing sites

Sequencing Schedule:



E550245ft
E545000m

E566660ft
E550000m

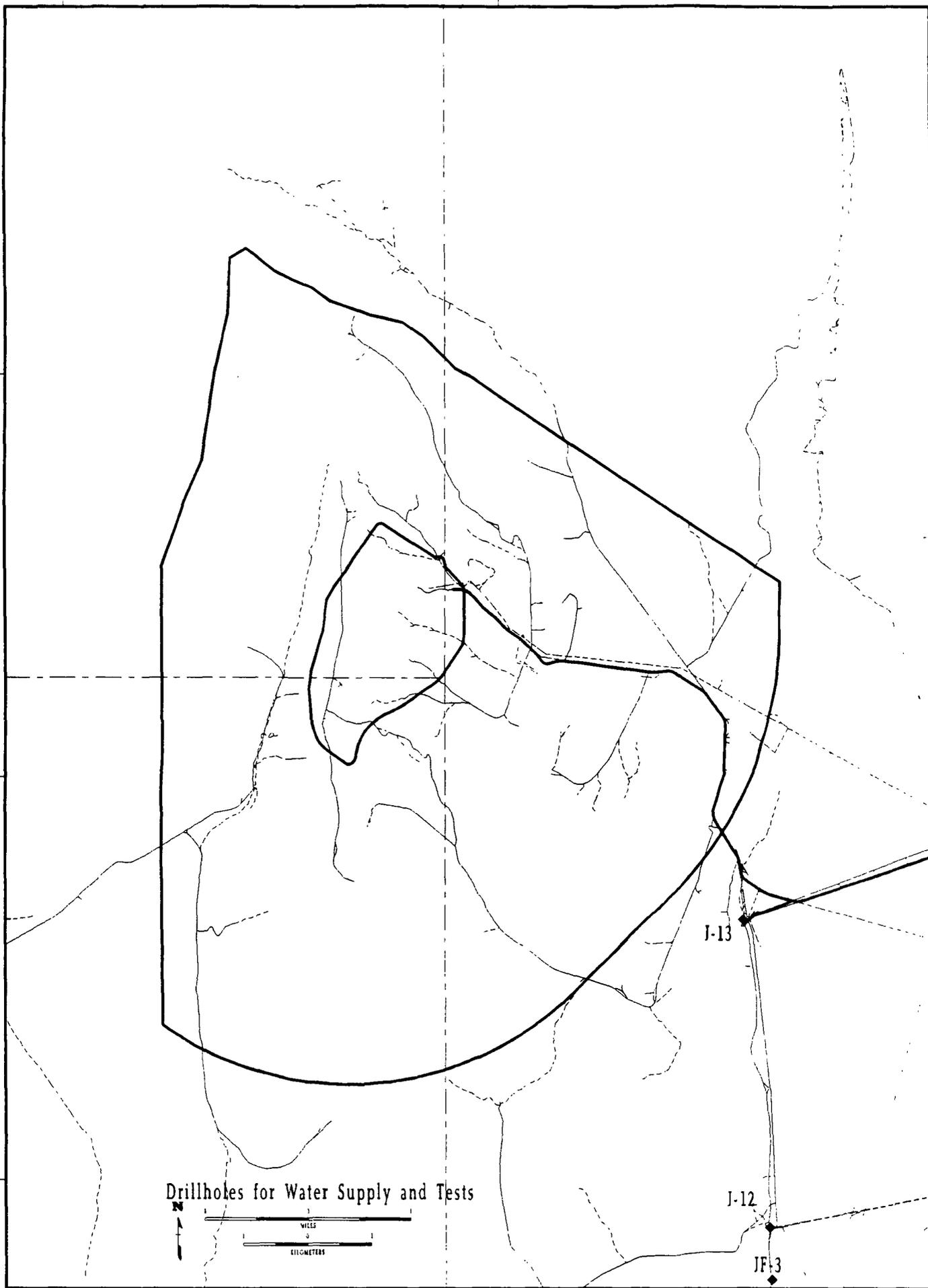
36° 52' 30"

36° 50' 00"

36° 47' 30"

N770210ft
N488000m

N753950ft
N4075000m



116° 30' 00"

116° 27' 30"

116° 25' 00"

EG&G

YMP-92-069.0

DRILLING PROGRAM REVIEW

Program: Fortymile Wash Recharge Study

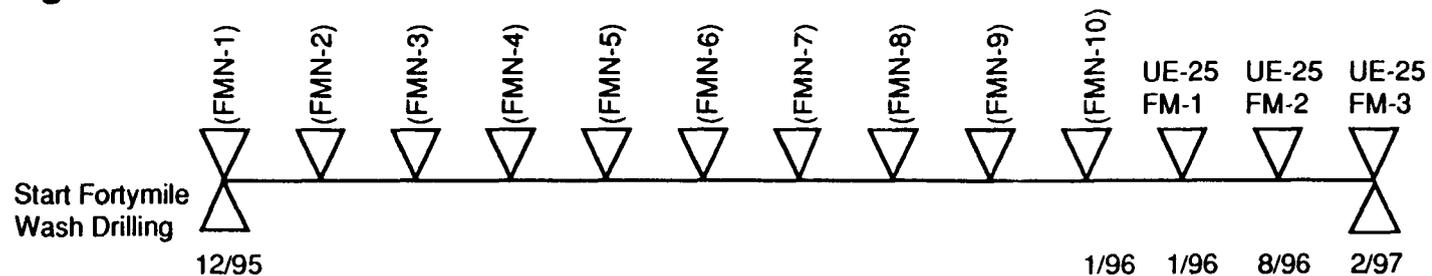
Objectives: As part of the regional groundwater recharge investigations, three holes, each 180-240m (600-800 ft) deep will be drilled in Fortymile Wash to monitor aquifer recharge during precipitation events. Ten shallow holes 10m (33 ft) will be drilled and cased for neutron moisture logging at key locations across Fortymile Wash to monitor infiltration.

Information Needs: Moisture measurements in unsaturated zone, water samples near the top of the saturated zone, perched water samples if encountered. Infiltration rates will be estimated by measuring of streamflow losses and monitoring moisture pulses. Neutron moisture tubes will be installed in the shallow holes.

Related Analyses/Tests: Rainfall/Runoff modelling, hydrologic characteristics of Fortymile Wash drainage basin

Number of Boreholes: 3 deep
10 shallow

Sequencing Schedule:



(FMN = Informal Number)

E533840ft
E540000m

E566660ft
E550000m

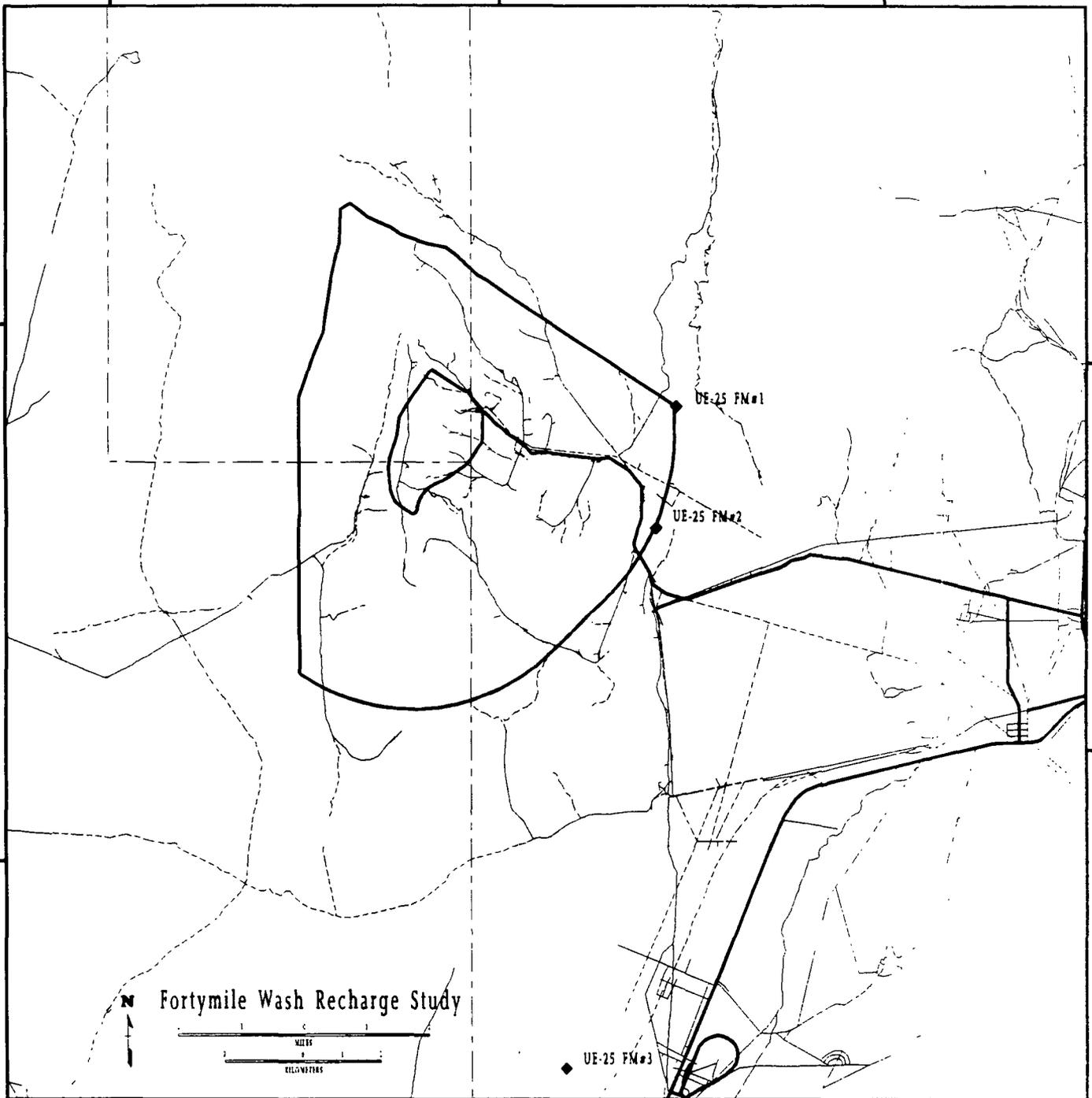
E599475ft
E560000m

36° 52' 30"

36° 45' 00"

N721011
N468000m

N7218511
N4970000m



Fortymile Wash Recharge Study

116° 30' 00"

116° 22' 30"

DRILLING PROGRAM REVIEW

Program: Solitario Canyon Fault Study in Saturated Zone

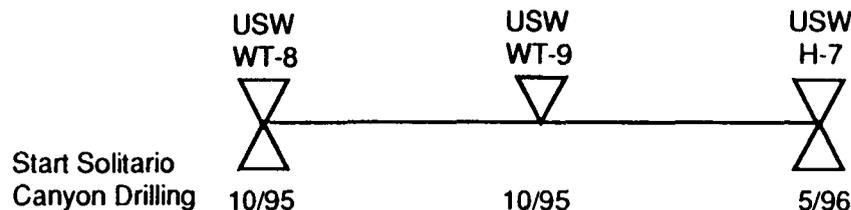
Objectives: To determine the hydrogeologic nature of the Solitario Canyon Fault and if it is a barrier to eastward movement of groundwater through the repository block, one hydrologic test hole will be drilled to 3,000' into the saturated zone in the Solitario Canyon Fault Zone using dry-drilling. To better define the water table west of the Solitario Canyon Fault, two water table drillholes will be drilled to depths of 2,100' to 2,200' using dry-drilling. Pump tests will be conducted at up to 500 gpm.

Information Needs: Aquifer recharge during precipitation, water table level, dissolved solids, pump tests, water sampling. Geophysical and television surveys will be run in the drillholes.

Related Analyses/Tests: Supports studies to provide a description of the regional hydrologic system (SCP 8.3.1.2.1) and the saturated zone hydrologic system (SCP 8.3.1.2.3). Drilling is included in the integrated drilling program and geophysical activities (SCP 8.3.1.4.1)

Number of Boreholes: 3 planned
1 existing (USW H-6)

Sequencing Schedule:



E550245ft
E545000m

E566660ft
E550000m

36°52'30"

36°50'00"

36°47'30"

116°30'00"

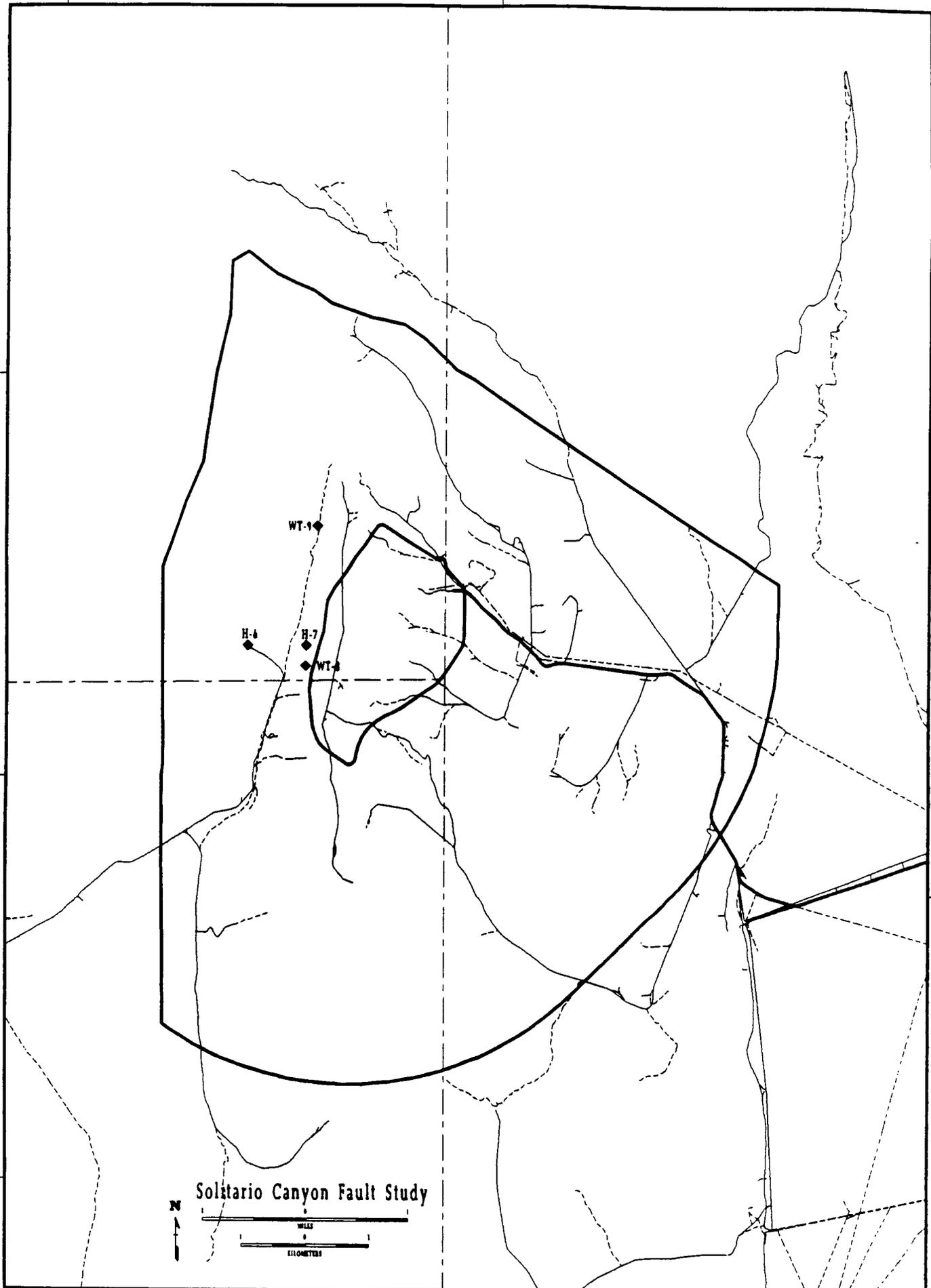
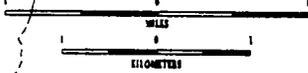
116°27'30"

116°25'00"

N4080000m
U1111111111

N3395011
N4075000m

Solitario Canyon Fault Study



YMP-92-033.0

DRILLING PROGRAM REVIEW

Program: In Situ Stress Drilling

Objectives: Hydrofracture two locations: one near Yucca Mountain at existing borehole location, second (new borehole) east of site on NTS. Depending on outcome, select as many as 20 existing boreholes for in-situ stress testing, after all other tests have been done.

Information Needs: Stress required to cause rock to fracture. Orientation of minimum principal stress. Confirm/deny previous stress measurements at Yucca Mountain.

Related Analyses/Tests: Supports studies to provide information for spatial distribution of ambient stress and thermal conditions (SCP 8.3.1.15).

Number of Boreholes: 1 existing
1 new
2 total

Sequencing Schedule:

Start In-Situ
Stress Drilling
Program

ISS-1

9/94

E533840ft
E540000m

E566660ft
E550000m

E599475ft
E560000m

36° 52' 30"

N720210ft
N4080000m

36° 45' 00"

N737365ft
N4070000m

36° 37' 30"

N704590ft
N4060000m

N671765ft
N4050000m

Location to be
determined

Little Skull
Mtn

Striped Hills

116° 30' 00"

116° 22' 30"

116° 15' 00"



In Situ Stress Drilling



YMP-92-068.0

DRILLING PROGRAM REVIEW

Program: Tracer Complex

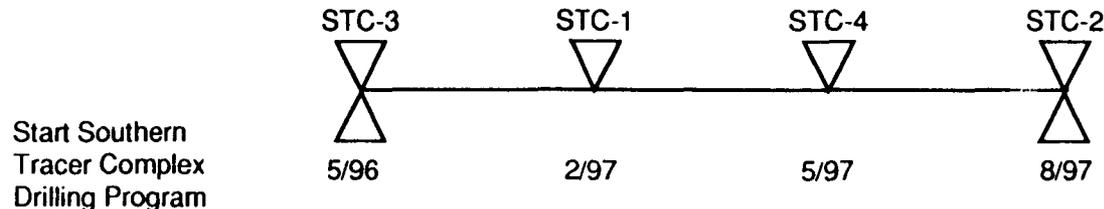
Objectives: About 20 convergent tracer pump tests are planned using various pumping wells, pumping intervals, observation intervals, and tracer schemes. Depending on the results of the tracer tests, either additional tests will be conducted in existing boreholes or a second complex of pump test boreholes will be drilled. The purpose of the additional boreholes is to validate and refine the conceptual model formed during tests at the existing C-well complex.

Information Needs: Characteristics of geohydrologic units and groundwater flow.

Related Analyses/Tests: Supports studies to provide a description of the saturated zone hydrologic system at the site (SCP 8.3.1.2.3) and studies to provide information required on changes in the UZ and SZ hydrology due to tectonic events (SCP 8.3.1.8.3).

Number of Boreholes: 3 C-hole complex (existing) (plus other additional boreholes)
4 Southern Tracer Complex
7 Total

Sequencing Schedule:



E550245ft
E545000m

E566660ft
E550000m

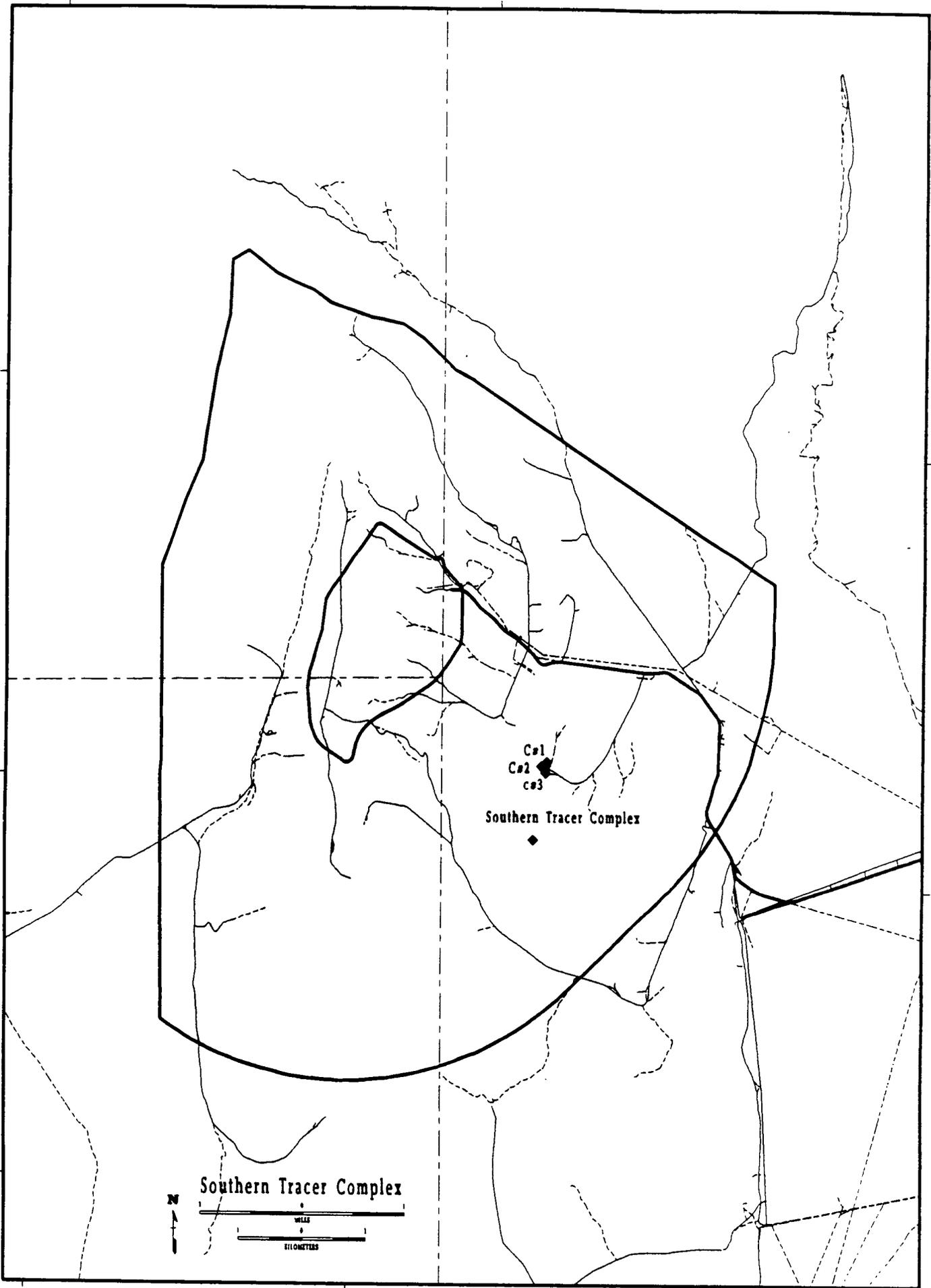
36° 52' 30"

36° 50' 00"

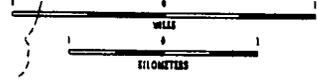
36° 47' 30"

N 4080000m
116° 27' 30"

N 4075000m
116° 25' 00"



Southern Tracer Complex



116° 30' 00"

116° 27' 30"

116° 25' 00"



YMP-92-042.0

DRILLING PROGRAM REVIEW

Program: Volcanic Drilling

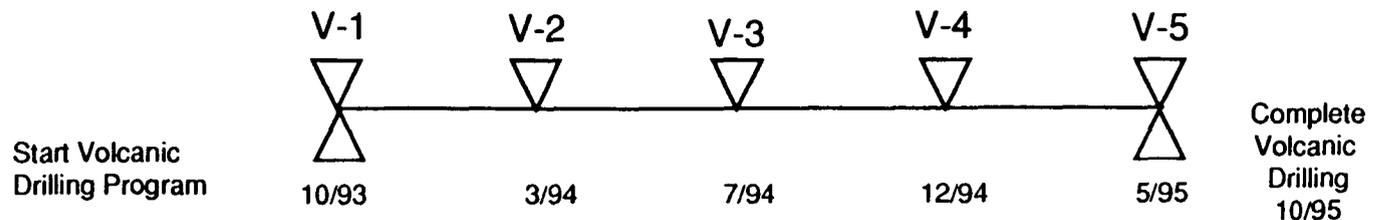
Objectives: This activity is to investigate the origin of four aeromagnetic anomalies found in Crater Flat and Amargosa Valley. The anomaly sites will be drilled and continuous core recovered. A fifth hole may be drilled, dependent on geophysics studies and the results of the other four holes.

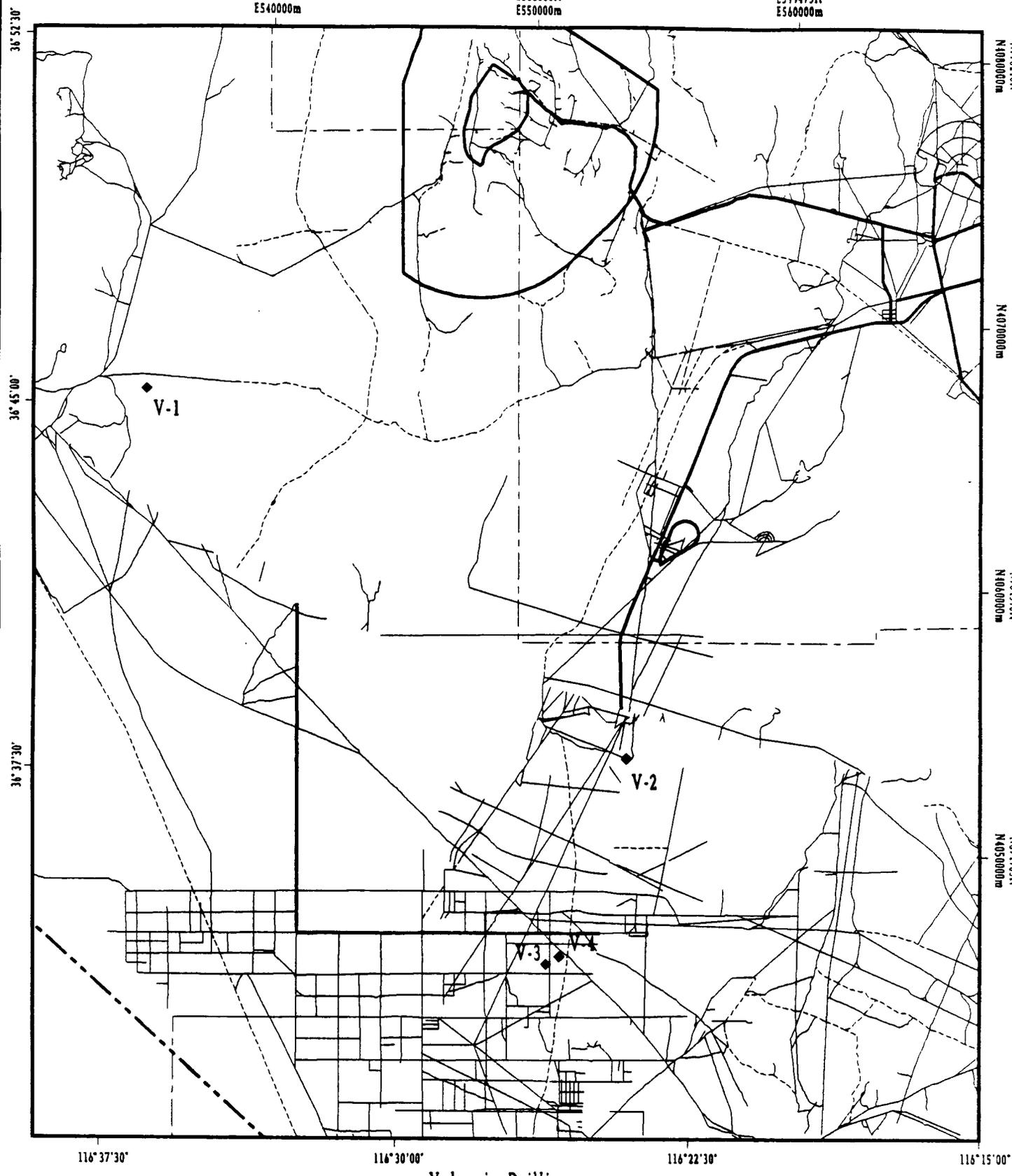
Information Needs: Stratigraphy and location of core, magnetic polarity measurements, major element and trace-element geochemical data, Sr and Nd isotopic data, and petrography of recovered volcanic materials.

Related Analyses/Tests: The data will be combined with potassium argon ages to refine probability calculations and establish a tectonic model of basaltic volcanic activity (SCP 8.3.1.8.1.1.4). K-Ar ages of the core will be combined with major- and trace-element data and isotopic data to test geochemical patterns of basaltic volcanism in the NTS area (SCP 8.3.1.8.5.1.4 and 8.3.1.8.5.1.5).

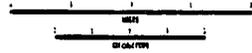
Number of Boreholes: 4 new, 1 possible

Sequencing Schedule:





Volcanic Drilling



SURFACE-BASED TESTING CONCLUSIONS

The integrated drilling program ensures that data needed to improve site models for use in site characterization, performance assessment and repository design are obtained in an efficient and cost-effective manner. Data obtained will contribute to

- A three-dimensional picture of physical characteristics of Yucca Mountain from sampling of a larger volume of rock than the ESF
(spatial heterogeneity)
- Timely information to support suitability determinations
 - Drilling scheduled to be complete 3/98, ESF testing to start 9/97
 - Provide greater understanding of water and gas flow processes
 - Water table evaluations in conjunction with geologic studies
- Iterative input to performance assessment models
 - improve scientific confidence