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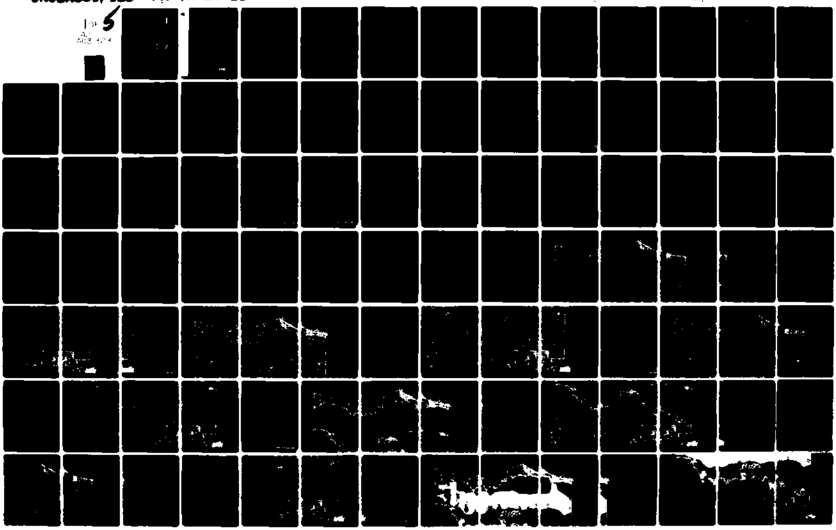

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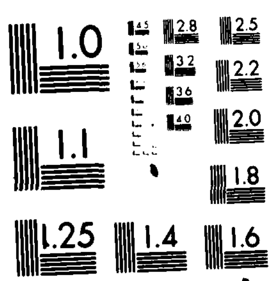

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VOLUME IB
NEVADA-UTAH
VERIFICATION STUDIES, FY 79

PREPARED FOR
SPACE AND MISSILE SYSTEMS ORGANIZATION (SAMSO)
NORTON AIR FORCE BASE, CALIFORNIA

FUGRO NATIONAL, INC.
Consulting Engineers and Geologists

MX SITING INVESTIGATION
GEOTECHNICAL EVALUATION
VOLUME IB, NEVADA-UTAH
VERIFICATION STUDIES, FY 79

Prepared for:

U.S. Department of the Air Force
Space and Missile Systems Organization (SAMSO)
Norton Air Force Base, California 92409

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24 August 1979

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: FN TR 27-1B — 2. GOVT ACCESSION NO.: [illegible]	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): Volume IB Nevada-Utah verification studies FY 79	5. TYPE OF REPORT & PERIOD COVERED: Final
	6. PERFORMING ORG. REPORT NUMBER: FN-TR-27 IB
7. AUTHOR(s): Fugro National, Inc.	8. CONTRACT OR GRANT NUMBER(s): F04704-78-C-0027
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Ertec Western Inc. (formerly Fugro National) P.O. Box 7765 Long Beach Ca 90807	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 64312 F
11. CONTROLLING OFFICE NAME AND ADDRESS: U.S. Department of the Air Force Space and Missile Systems Organization Norton AFB Ca 92409 (SAMSO)	12. REPORT DATE: 24 Aug 79
	13. NUMBER OF PAGES: 120
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report)
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

Distribution Unlimited

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Geographic setting, ~~[illegible]~~, Geology ~~setting~~, ~~[illegible]~~ soils ~~[illegible]~~, Terrain ~~[illegible] White River, Garden-Coal, Reveille-Railroad, Big Smoky, Dry Lake/Ralston~~ Seismic refraction, resistivity survey

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The objectives of this report are to verify sufficient suitable area for deployment of the MX system & to provide preliminary physical & engineering characteristics of the soil. ~~[illegible]~~ Includes summary of depth to water, depth to rock, terrain variability, soil characteristics, seismic and resistivity surveys for White River, Garden-Coal, Reveille-Railroad, Big Smoky and Dry Lake - Ralston CDPs.

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FOREWORD

This report was prepared for the Department of the Air Force, Space and Missile Systems Organization (SAMSO), in compliance with Contract No. F04704-78-C-0027, CDRL Item 005A2. It presents geological, geophysical, and geotechnical data and evaluates the suitability of portions of Nevada and Utah for siting the MX Land Mobile Advanced ICBM System.

This report is the first of several Verification reports which will be prepared. The objectives are to verify sufficient suitable area for deployment of the MX System and to provide preliminary physical and engineering characteristics of the soils. The Verification studies are the final phase of a site-selection process which was begun in 1977. Previous studies have been termed Screening, Characterization, and Ranking. In preparing this report, it has been assumed that the reader is familiar with these previous studies.

In this report, discussions are limited to the hybrid trench and vertical shelter basing modes. In most cases, the discussions and data for hybrid trench also apply to the horizontal shelter since the depth of excavation is about the same. In particular, suitable area for the hybrid trench will also be suitable for the horizontal shelter.

Results of the FY 79 Verification Studies are contained in 11 volumes as follows:

Geotechnical Results

Volume 1A - Sections 1.0, 2.0, and 3.0 contain Introduction, Results and Conclusions, and Recommendations for Future Studies. Sections 4.0 through 6.0 contain summary geotechnical discussions for Whirlwind, Snake East, and Hamlin CDPs.

*Volume 1B - Sections 7.0 through 10.0 contain summary geotechnical discussions for White River North, Garden-Coal, Reveille-Railroad and Big Smoky CDPs. Section 11.0 briefly explains previous work performed in Dry Lake and Ralston sites. A bibliography and appendix follow Section 11.0.

Geotechnical Data Volumes

- Volume II - Whirlwind CDP
- Volume III - Snake East CDP
- Volume IV - Hamlin CDP
- Volume V - White River North CDP
- Volume VI - Garden-Coal CDP
- Volume VII - Reveille-Railroad CDP
- Volume VIII - Big Smoky CDP
- Volume IX - Dry Lake CDP
- Volume X - Ralston CDP

* This volume is presented herein.

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LIST OF DRAWINGS

7.0 WHITE RIVER NORTH CDP

7.1 GEOGRAPHIC SETTING

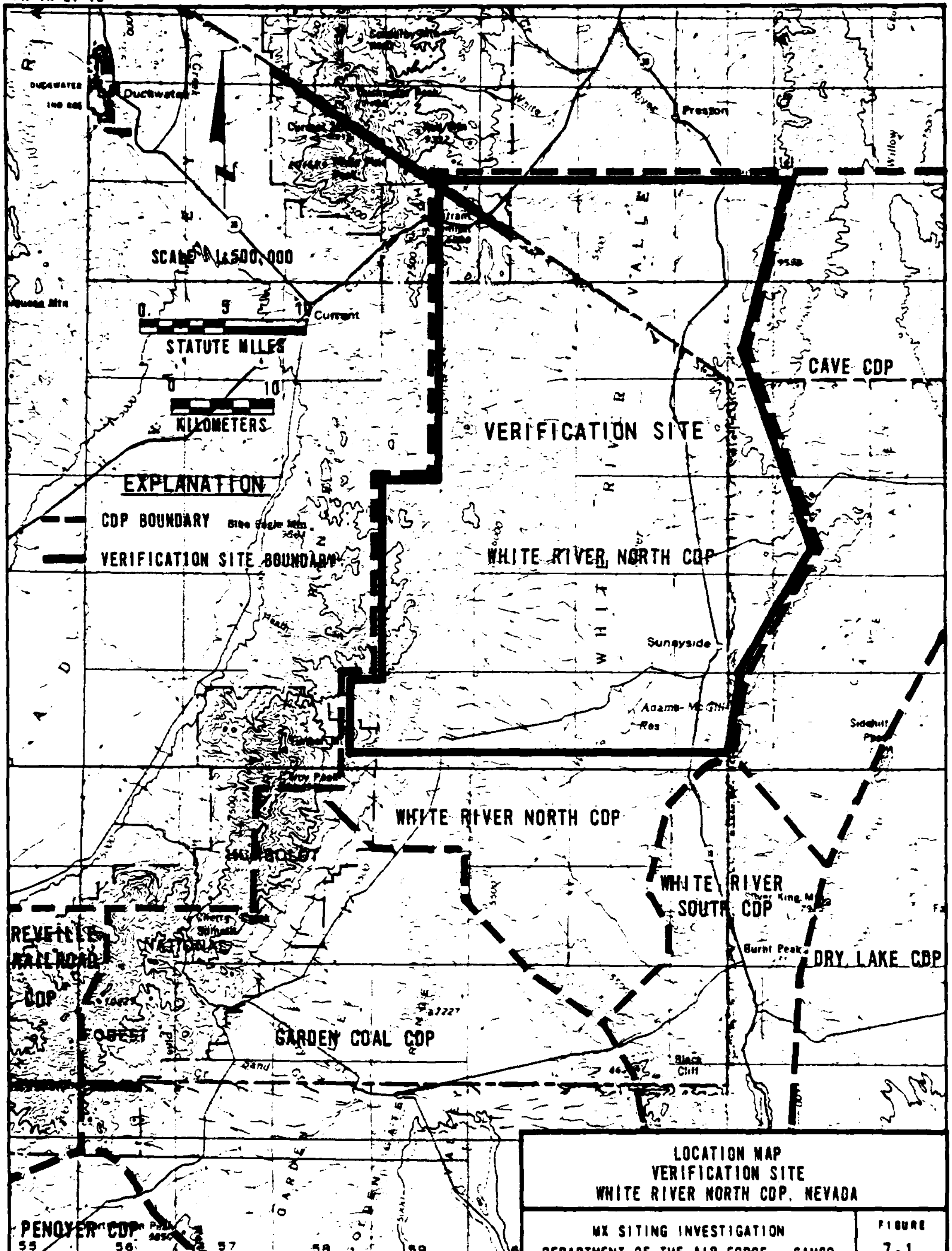
White River North CDP lies primarily in northeast Nye County and portions of Lincoln and White Pine counties in east-central Nevada (Figure 7-1). The CDP is bounded on the east by the Egan Range and on the west by the Grant and Horse ranges. The small farming and ranching community of Lund lies along the northern margin of the CDP and the south is partially bounded by the Golden Gate and Seaman ranges. The White River North Site comprises the more northerly portion of the CDP, extending from the town of Lund in the north to Hot Creek Butte in the south. The northern end of the CDP is approximately 35 miles south of Ely, Nevada. State Highway 38 traverses the east side of the CDP and is the only paved road in the CDP. Access to the site is fair, provided by a moderate system of unmaintained and unsurfaced roads.

7.2 SCOPE

The scope of geologic, geophysical, and soils engineering field activities performed at the site and laboratory tests performed on soil samples from the site are presented in Table 7-1. Locations of the geophysical and engineering activities are shown in Drawing 7-1 (end of Section 7.0).

7.3 GEOLOGIC SETTING

The mountain ranges along the east and west sides of the CDP are predominantly composed of thick, complex sequences of Paleozoic limestones and dolomites with interbedded shales. A local



LOCATION MAP
VERIFICATION SITE
WHITE RIVER NORTH CDP, NEVADA

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAMSO	FIGURE 7-1

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GEOLOGY AND GEOPHYSICS

TYPE OF ACTIVITY	NUMBER OF ACTIVITIES
Geologic mapping stations	63
Shallow refraction	19
Electrical resistivity	23
Gravity profiles	5

ENGINEERING-LABORATORY TESTS

TYPE OF TEST	NUMBER OF TESTS
Moisture/density	106
Specific gravity	3
Sieve analysis	81
Hydrometer	6
Atterberg limits	36
Consolidation	2
Unconfined compression	3
Triaxial compression	3
Direct shear	7
Compaction	6
CBR	6
Chemical analysis	10

ENGINEERING

NUMBER OF BORINGS	NOMINAL DEPTH FEET (METERS)
5	160 (49)
2	50 (15)
NUMBER OF TRENCHES	**NOMINAL DEPTH FEET (METERS)**
5	14 (4)
3	5-10 (2-3)
NUMBER OF TEST PITS	**NOMINAL DEPTH FEET (METERS)**
18	5 (2)
4	3 (1)
NUMBER OF CPTs	**RANGE OF DEPTH FEET (METERS)**
54	1-115 (0.3-45)
TYPE OF ACTIVITY	**NUMBER OF ACTIVITIES**
Surficial soil samples	23
Field CBR tests	0

SCOPE OF ACTIVITIES
VERIFICATION SITE
WHITE RIVER NORTH CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 7-1

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occurrence of Cambrian quartzites is located in the northern portion of the Egan Range near Lund, contributing particularly coarse sediments to that area. Tertiary welded ash-flow tuffs and rhyolitic and andesitic flows primarily occur in the southeastern and southern portions of the CDP in the Grant, Golden Gate, and Seaman ranges, and a few volcanic outliers occur locally in the northeastern and northwestern portions of the CDP.

The mountain ranges exhibit a general north-south structural trend. The Paleozoic rocks bounding the site generally dip eastward from 20 to 40 degrees (Kleinhampl and Ziony, 1967), primarily the result of Laramide deformation. Basin and Range faults cut most of the mid-Tertiary volcanic sequences. Evidence of continued Basin and Range faulting exists along the eastern side of the CDP where the sinuous Egan fault roughly parallels the base of the Egan Range and forms a discontinuous escarpment in Quaternary alluvial deposits.

Thick sequences of basin-fill deposits, composed of lacustrine, alluvial, and fluvial sediments, generally overlie the mid-Tertiary volcanic bedrock (Eakin, 1966). Within the CDP, the County Line oil test penetrated 1475 feet (454 m) of valley fill without encountering rock (McJannett and Clark, 1960). The basin-fill stratigraphy within the construction zone (0 to 160 feet, 49 m) generally consists of a sedimentary sequence, from oldest to youngest.

- Older lacustrine deposits - Lacustrine deposits comprise approximately one-half of the surficial geology, primarily concentrated in a band along the valley axis. The units are possibly mid- to late Tertiary age (Maxey and Eakin, 1949) predominantly composed of sand with some fines which interfinger with coarser-grained alluvial deposits.

- Intermediate alluvial fan deposits - The deposits form a relatively narrow strip along the valley flanks constituting about one-sixth of the site. The fans are composed predominantly of sandy gravel and gravelly sands of Pleistocene age.

- Older fluvial deposits - The ancestral White River and its tributaries left small isolated terrace deposits of sand and gravel along the present drainage.

- Younger alluvial fans - Younger fans cover approximately one-third of the site, actively forming basinward of the intermediate alluvial fans. Deposits are predominantly silty sand in composition with some gravel.

- Stream channel deposits - These deposits are actively forming in White River and its tributaries. Materials are generally limited in extent and composed of fines and sands.

The surficial geology in the White River North Site is presented in Drawing 7-2.

7.4 SURFACE SOILS

The White River North Site is characterized by a general north-south banding of surficial soils. Coarse-grained soils occupy both valley flanks, while fine-grained soils are predominant in the central portion of the site. This soil zoning is illustrated by the distribution of surficial geologic units shown in Drawing 7-2. Soils from the several predominant surficial geologic units can be combined into three categories based on their physical and engineering characteristics.

1. Silty sands and clayey sands (A4os, A5ys, and A5is geologic units);

2. Sandy gravels and gravelly sands (A5ys, A5is, and A5ig geologic units); and
3. Sandy silts and sandy clays (A4of geologic unit).

7.4.1 Characteristics

The characteristics of site surficial soils are summarized in Table 7-2, which contains physical properties and laboratory compaction and CBR test results, and provides preliminary road design evaluations. Gradation ranges for the three categories of surficial soils are shown in Figure 7-2.

Silty sands and clayey sands are the most common surficial soil with an approximate areal distribution ranging from 35 to 55 percent of the site. Sands occur primarily in the alluvial fans of the east and west valley flanks. Sands are present to a lesser degree in the lacustrine and stream channel deposits near the valley center. Sands are usually graded coarse to fine and have appreciable fines that are mostly nonplastic to slightly plastic. Weak to moderate calcium carbonate cementation is often present within 2 feet (0.6 m) of the ground surface.

Sandy gravels and gravelly sands have an approximate areal distribution of 15 to 25 percent in the site. These soils are primarily located in alluvial fans of the east and west valley flanks, and gravel content usually increases with approach to the mountain fronts. Gravelly soils are more widely distributed throughout the steeply sloping fans along the eastern side of the site than in the more gently sloping fans along the western

SOIL DESCRIPTION		Silty Sands and Clayey Sands		Sandy Gravel
USCS SYMBOLS		SM, SC		GM, SM
PREDOMINANT SURFICIAL GEOLOGIC UNITS		A4os, A5ys, A5ls		A5ys,
ESTIMATED AREAL EXTENT	%	35-55		15-25
PHYSICAL PROPERTIES				
COBBLES 3 - 12 inches (8 - 30 cm)	%	0-5		0-10
GRAVEL	%	0-18	[10]	27-38
SAND	%	35-80	[10]	38-53
SILT AND CLAY	%	19-49	[10]	13-35
LIQUID LIMIT		35-67	[2]	NDA
PLASTICITY INDEX		NP-35	[5]	NP
ROAD DESIGN DATA				
MAXIMUM DRY DENSITY	pcf (kg/m³)	104.7-120.0 (1677-1922)	[3]	126.0 (2018)
OPTIMUM MOISTURE CONTENT	%	13.3-20.7	[3]	9.0
CBR AT 90% RELATIVE COMPACTION	%	6-18	[3]	18
SUITABILITY AS ROAD SUBGRADE (1)		fair to good		good
SUITABILITY AS ROAD SUBBASE OR BASE (1)		poor		fair
THICKNESS OF LOW STRENGTH SURFICIAL SOIL (2)	RANGE ft (m)	0.7-14.1 (0.2-4.3)	[26]	0.7-1.0 (0.2-0.
	AVERAGE ft (m)	2.9 (0.9)	[26]	0.8 (0.3)

(1) Suitability is a subjective rating explained in Section A5.0 of the Appendix.

(2) Low strength surficial soil is defined as soil which will perform poorly as a road subgrade at its present consistency; see Table 7-3 for details.

NOTES:

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Sandy Gravels and Gravelly Sands	Sandy Silts and Sandy Clays	
GM, SM	ML, CL, CH	
A5ys, A5is, A5ig	A4of	
15-25	30-50	
0-10	0	
27-38 [6]	0-20 [9]	
30-53 [6]	13-37 [9]	
13-35 [6]	54-85 [9]	
NDA	24-98 [8]	
NP [1]	NP-66 [12]	
126.0 (2018) [1]	110.0-122.8 (1762-1967) [2]	
9.0 [1]	11.3-19.0 [2]	
10 [1]	3-15 [2]	
good	poor	
fair	not suitable	
0.7-1.0 (0.2-0.3) [2]	0.7-10.5 (0.2-3.2) [21]	
0.9 (0.3) [2]	2.9 (0.9) [21]	

NOTES:
- [ ] - Number of tests performed
- NDA - No data available (insufficient data or tests not performed)

CHARACTERISTICS OF SURFICIAL SOILS
VERIFICATION SITE
WHITE RIVER NORTH CDP, NEVADA

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DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 7-2

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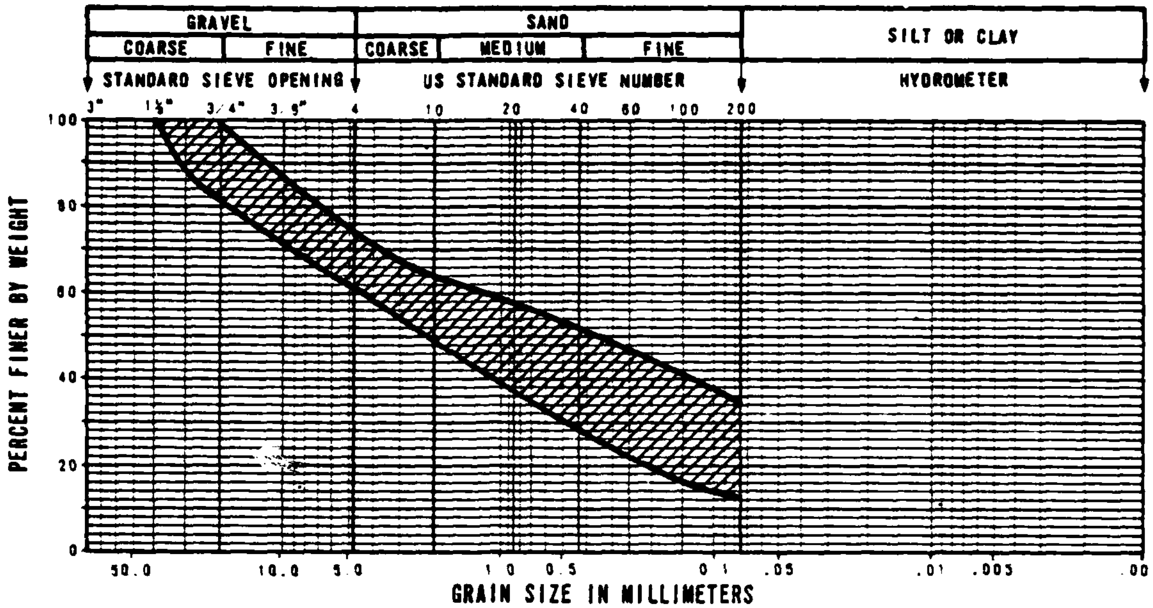
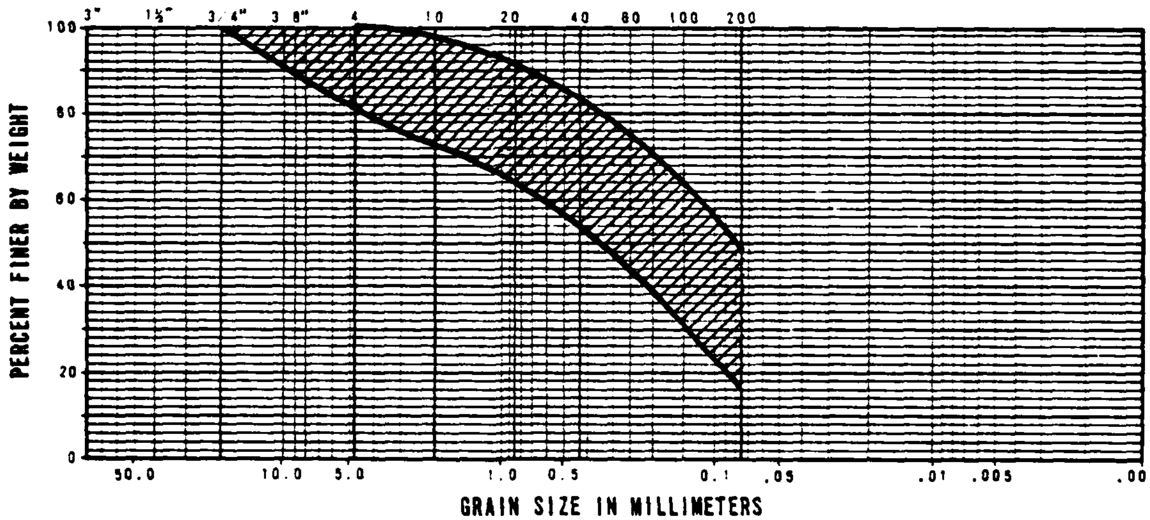


SOIL DESCRIPTION: Sandy Gravels and Gravelly Sands
from 0 to 2 feet (0.0 to 0.6m)



SOIL DESCRIPTION: Silty Sands and Clayey Sands
from 0 to 2 feet (0.0 to 0.6m)

RANGE OF GRADATION OF SURFICIAL SOILS
VERIFICATION SITE
WHITE RIVER NORTH CDP, NEVADA

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAMSO	FIGURE 7-2 1 OF 2

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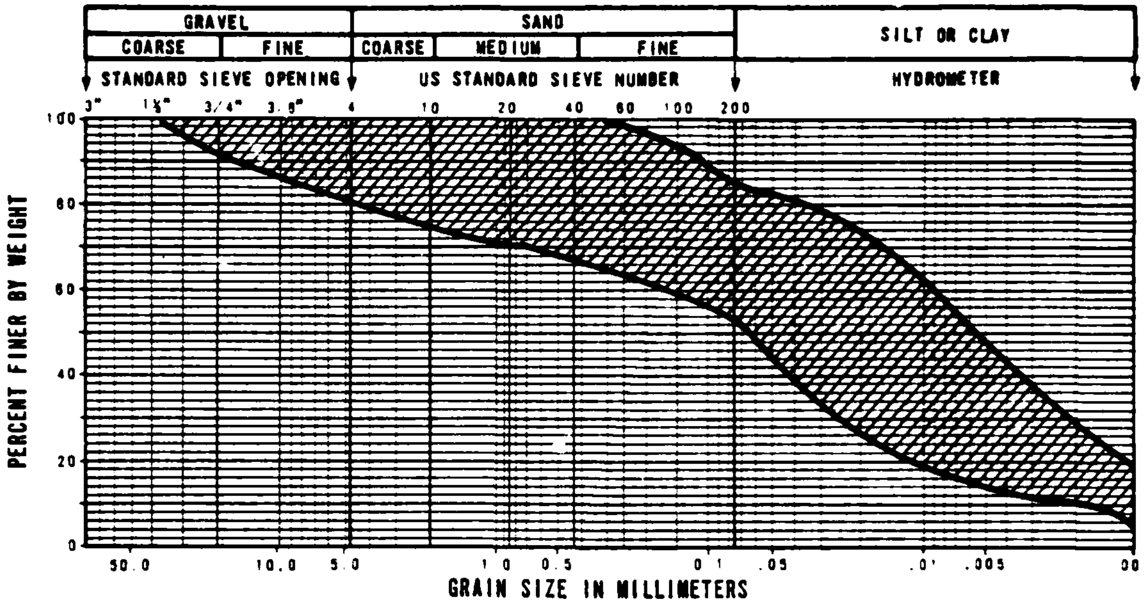
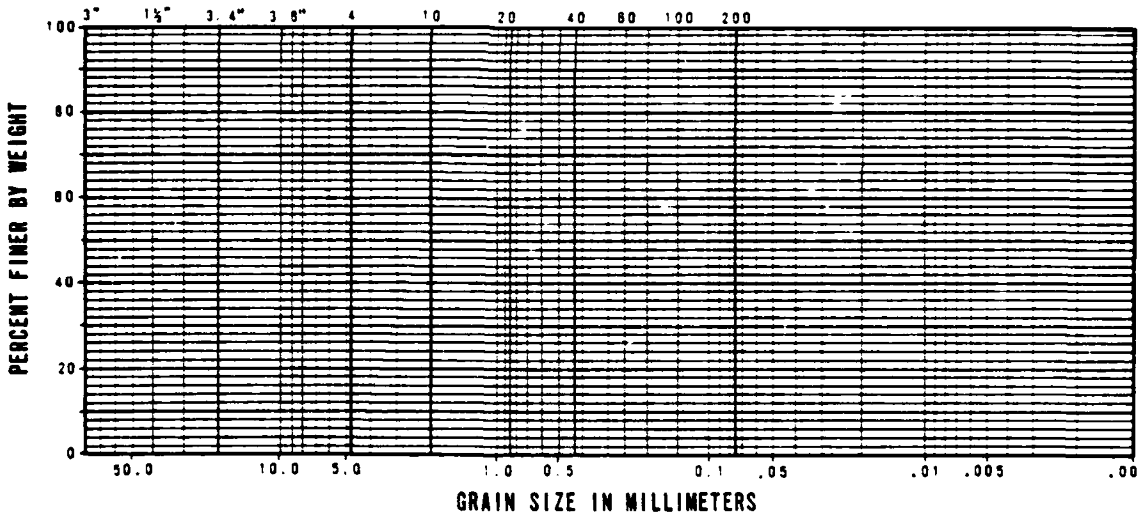


SOIL DESCRIPTION: Sandy Silts and Sandy Clays from 0 to 2 feet (0.0 to 0.6m)



RANGE OF GRADATION OF SURFICIAL SOILS
VERIFICATION SITE
WHITE RIVER NORTH CDP, NEVADA

MX SITING INVESTIGATION
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FIGURE 7-2
2 OF 2

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2 JUL 79

side of the site. Gravelly soils are generally poorly graded and contain appreciable nonplastic fines. Moderate to heavy calcium carbonate cementation often occurs within 2 feet (0.6 m) of the ground surface in gravelly soils of intermediate fans.

Sandy silts and sandy clays have an approximate areal distribution of 30 to 50 percent in the site. A majority of silt or clay soils are lacustrine or channel deposits in the central portion of the site. However, random fine-grained soil deposits also occur in alluvial fans in the east and west valley flanks. These soils contain appreciable amounts of sand and often some gravel. Their plasticity range is from none to high. Moderate or heavy calcium carbonate cementation often occurs at depths between 1 and 2 feet (0.3 and 0.6 m).

7.4.2 Low Strength Surficial Soil

Strengths of in situ surficial soils within the site were evaluated by cone penetrometer tests (CPT). Based on CPT results and soil classification, the thickness of low strength surficial soil at each CPT location was estimated and is presented in Table 7-3. The range and mean thickness values of the low strength interval are summarized in Table 7-2 for each surficial soil category. Coarse-grained soils exhibit low strength to depths ranging from 0.7 to 14.1 feet (0.2 to 4.3 m) with an average of 2.8 feet (0.9 m). Fine-grained soils exhibit low strength to depths ranging from 0.7 to 10.5 feet (0.2 to 3.2 m) with an average of 2.8 feet (0.8 m).

CONE PENETROMETER TEST NUMBER(1)	THICKNESS OF LOW STRENGTH SURFICIAL SOIL (2)		SOIL TYPE (3)
	FEET	METERS	
C-1	0.8	0.2	CL
C-2	1.0	0.3	SM
C-3	1.2	0.4	SM
C-4	1.1	0.3	ML
C-5	0.7	0.2	CL
C-6	4.1	1.2	CH
C-7	1.3	0.4	SM
C-8	0.8	0.2	CH
C-9	1.7	0.5	SM
C-10	NDA	NDA	ML
C-11	NDA	NDA	CL
C-12	NDA	NDA	SM
C-13	1.2	0.4	SM
C-14	0.7	0.2	SM
C-15	2.3	0.7	ML
C-16	1.0	0.3	CL/ML
C-17	1.1	0.3	SM
C-18	0.9	0.3	SC
C-19	5.7	1.7	SM
C-20	4.9	1.5	CL
C-21	1.6	0.5	CH
C-22	1.0	0.3	SC/GP
C-23	1.6	0.5	SM
C-24	8.1	2.4	CH
C-25	1.9	0.6	SM
C-26	1.3	0.4	CL
C-27	10.5	3.2	CH
C-28	1.0	0.3	SM

CONE PENETROMETER TEST NUMBER(1)	THIC… F…
C-29	1
C-30	7.
C-31	1.
C-32	2.
C-33	2.
C-34	1.
C-35	14
C-36	1.
C-37	1.
C-38	0.
C-39	3.
C-40	1.
C-41	1.
C-42	7.
C-43	1.
C-44	1.
C-45	0.
C-46	4.
C-47	1.
C-48	11.
C-49	8.2
C-50	1.7
C-51	1.0
C-52	1.0

(1) For Cone Penetrometer Test locations see Drawing 7-1, Activity Location Map.

(2) Thickness corresponds to depth below ground surface. Low strength surficial soil is defined as soil which will perform poorly as a road subgrade at its present consistency. Low strength is based on Cone Penetrometer Test results using the following criteria:

Coarse-grained soils: $q_c < 120$ tsf (117 kg/cm^2)
Fine-grained soils: $q_c < 80$ tsf (78 kg/cm^2)

where q_c is cone resistance.

(3) Soil type is based on Unified Soil Classification System; see Section A5.0 in the Appendix for explanation

NOTES

...ER (1)	THICKNESS OF LOW STRENGTH SURFICIAL SOIL (2)		SOIL TYPE (3)
	FEET	METERS	
	1.4	0.4	SM
	7.7	2.3	SM/ML
	1.3	0.4	SM
	2.0	0.6	ML SP-SM
	2.2	0.7	SM
	1.0	0.3	SM
	14.1	4.2	SC
	1.2	0.4	CL
	1.3	0.4	SM
	0.7	0.2	SM
	3.6	1.1	SC
	1.6	0.5	SM
	1.3	0.4	CL/GP
	7.1	2.1	ML
	1.2	0.4	CL
	1.3	0.4	CL
	0.6	0.2	CL
	4.0	1.2	SM
	1.0	0.3	CL
	11.6	3.5	SM
	6.2	1.9	ML
	1.7	0.5	SC
	1.6	0.5	SM/CL
	1.6	0.5	SM

CONE PENETROMETER TEST NUMBER (1)	THICKNESS OF LOW STRENGTH SURFICIAL SOIL (2)		SOIL TYPE (3)
	FEET	METERS	

NOTES: • For fine-grained soils (ML, CL, MH and CH), thickness of low strength surficial soil will vary depending on moisture content of the soil at time of testing.

• SM/GM - Indicates SM underlain by GM

• NDA - No data available

THICKNESS OF LOW STRENGTH SURFICIAL SOIL
VERIFICATION SITE
WHITE RIVER NORTH CDP, NEVADA

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TABLE 7-3

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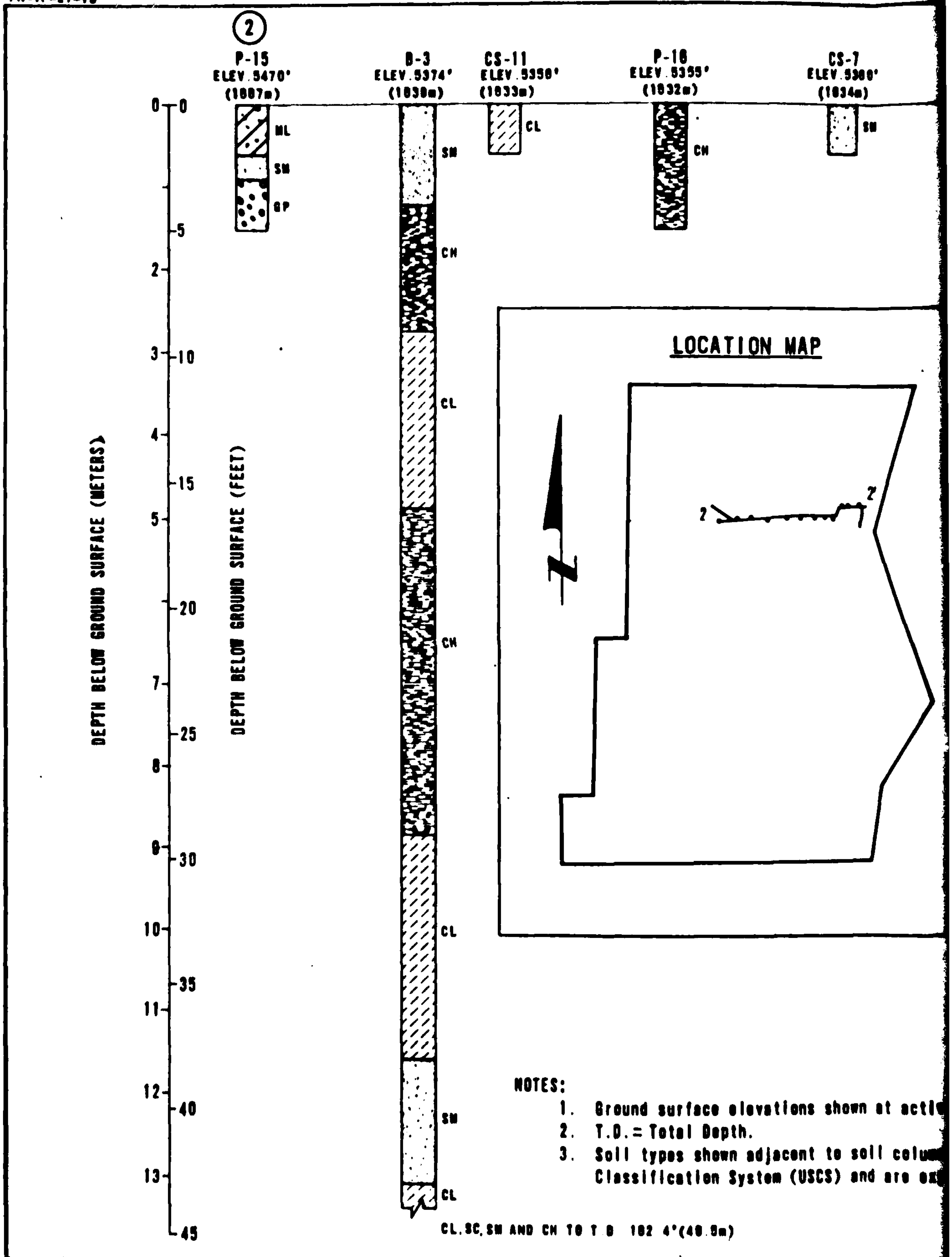
AFV-

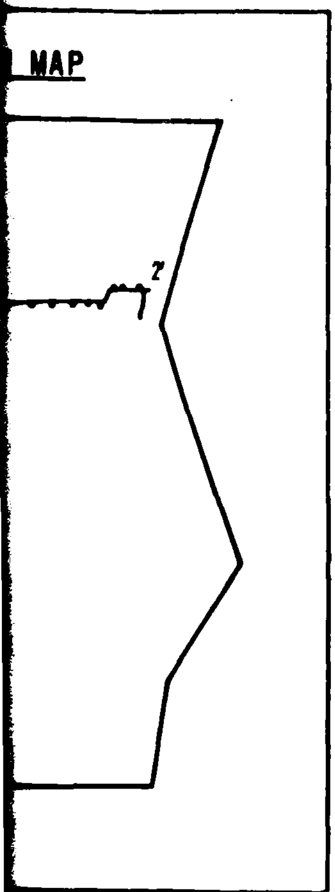
Cone penetrometer tests were performed in the White River North Site after surficial soils were softened by moisture from several early winter storms, thus probably somewhat increasing the estimated thickness of low strength soil in comparison to thicknesses for similar but dry soil. A highly variable degree of calcium carbonate cementation was observed in surficial soils and is confirmed by the variable thickness of low strength surficial soils.

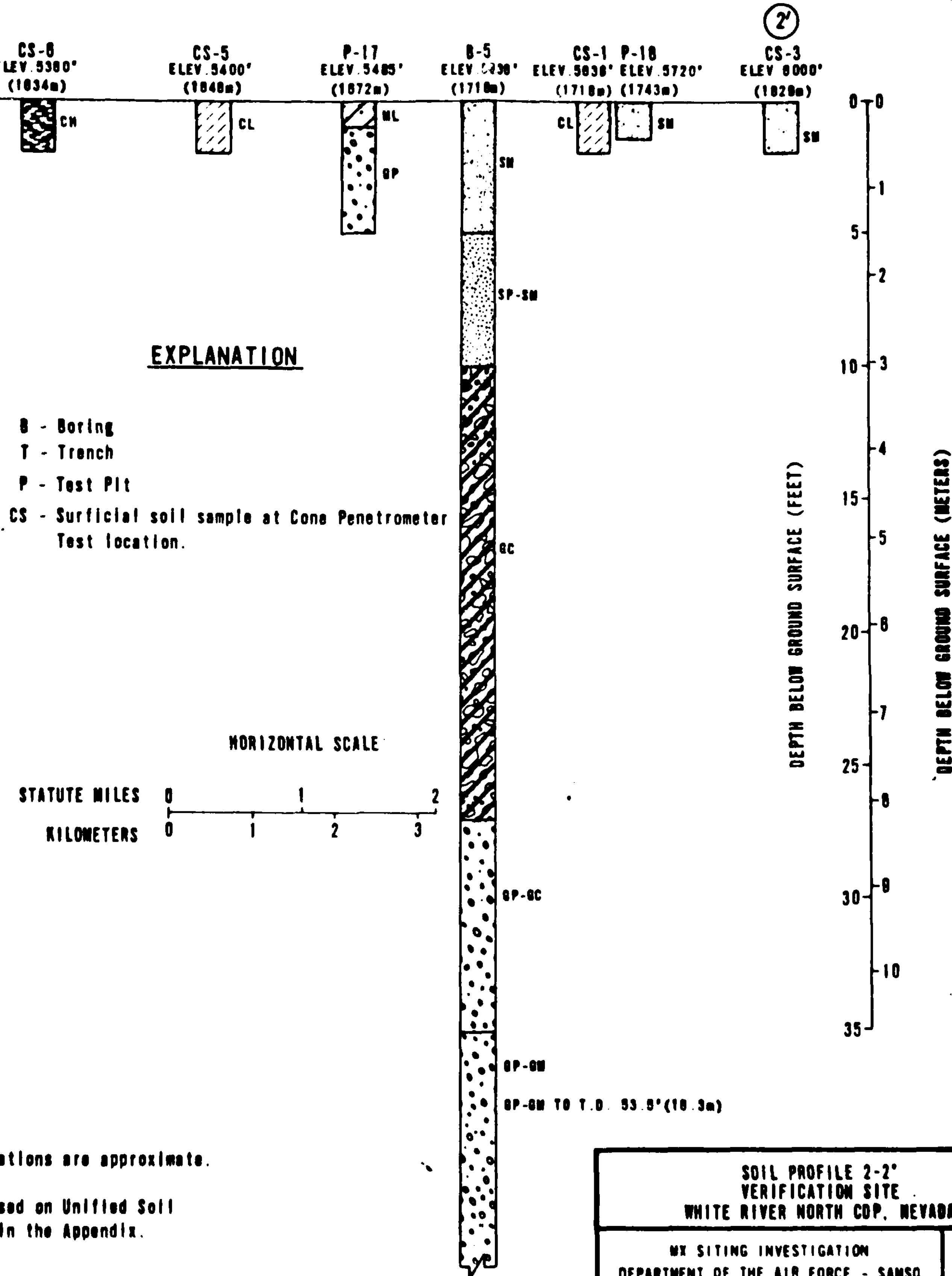
7.5 SUBSURFACE SOILS

Coarse-grained soils, consisting of sandy gravels and gravelly sands with minor silt and clay interbeds, are predominant at the east and west flanks of the site. These coarse-grained deposits apparently correlate with intermediate and young alluvial fans. Subsurface soils within the central portion of the site are predominantly fine-grained and are associated with the lacustrine deposits. These fine-grained soils consist of stratified sandy silts and sandy clays of slight to high plasticity with occasional sand interbeds. The composition of subsurface soils with depth, as determined from borings, trenches, and test pits, is illustrated in the soil profiles presented in Figures 7-3 through 7-6.

Results of seismic refraction and electrical resistivity survyes are summarized in Table 7-4. The characteristics of subsurface soils, determined from field and laboratory tests, are presented in Table 7-5. Ranges of gradation of the subsurface soils are shown in Figure 7-7.


2
P-15
ELEV. 5470'
(1667m)
B-3
ELEV. 5374'
(1638m)
CS-11
ELEV. 5358'
(1633m)
P-16
ELEV. 5355'
(1632m)
CS-7
ELEV. 5360'
(1634m)
ML
SM
GP
CL
CH
DEPTH BELOW GROUND SURFACE (METERS)
DEPTH BELOW GROUND SURFACE (FEET)
LOCATION MAP
2
2'
NOTES:
1. Ground surface elevations shown at acti
2. T.D.= Total Depth.
3. Soil types shown adjacent to soil colu
Classification System (USCS) and are ex
CL,SC,SM AND CH TO T.D. 162.4'(49.5m)





EXPLANATION

B - Boring

T - Trench

P - Test Pit

CS - Surficial soil sample at Cone Penetrometer Test location.

HORIZONTAL SCALE

STATUTE MILES	0	1	2	
KILOMETERS	0	1	2	3

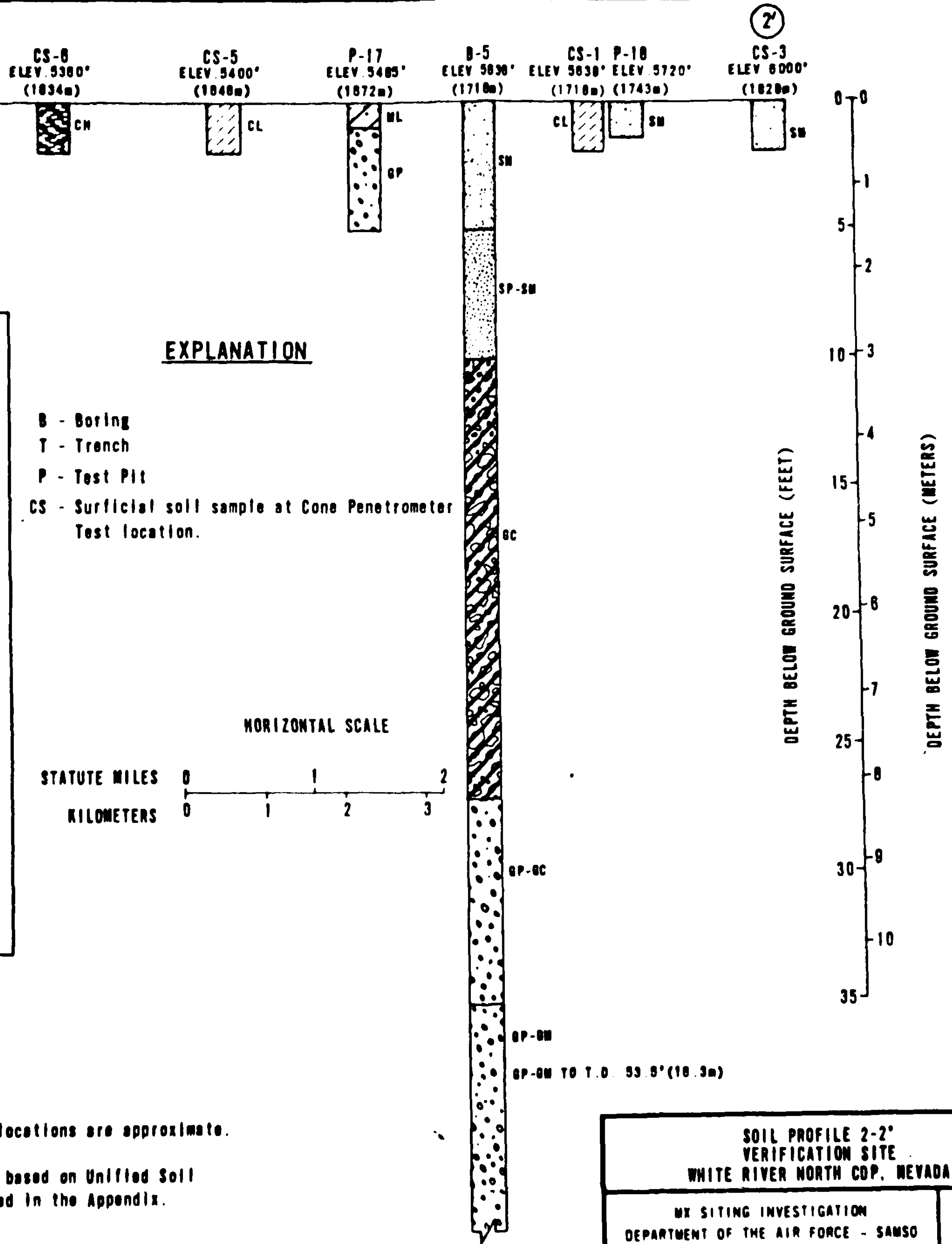
...ons shown at activity locations are approximate.

...ent to soil column are based on Unified Soil (USCS) and are explained in the Appendix.

SOIL PROFILE 2-2'
VERIFICATION SITE
WHITE RIVER NORTH CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FUGRO NATIONAL



EXPLANATION

B - Boring
T - Trench
P - Test Pit
CS - Surficial soil sample at Cone Penetrometer Test location.

HORIZONTAL SCALE

STATUTE MILES 0 1 2
KILOMETERS 0 1 2 3

...ctivity locations are approximate.

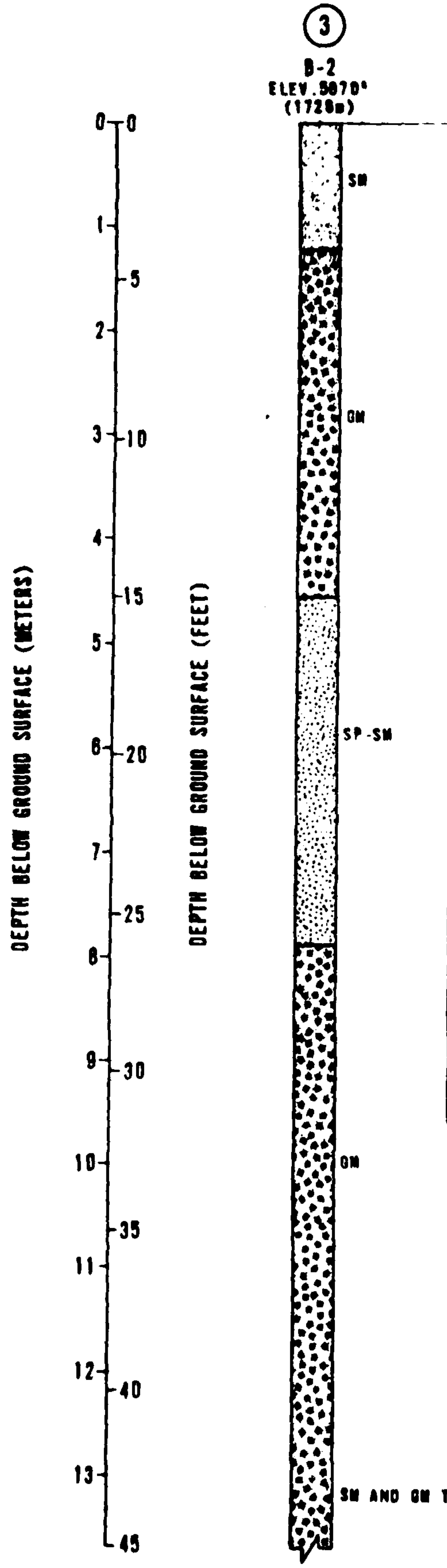
...olumn are based on Unified Soil ... explained in the Appendix.

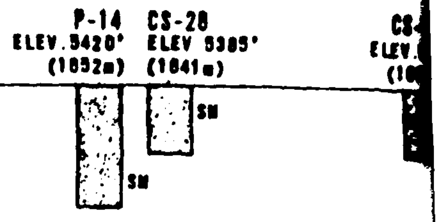
SOIL PROFILE 2-2'
VERIFICATION SITE
WHITE RIVER NORTH CDP, NEVADA

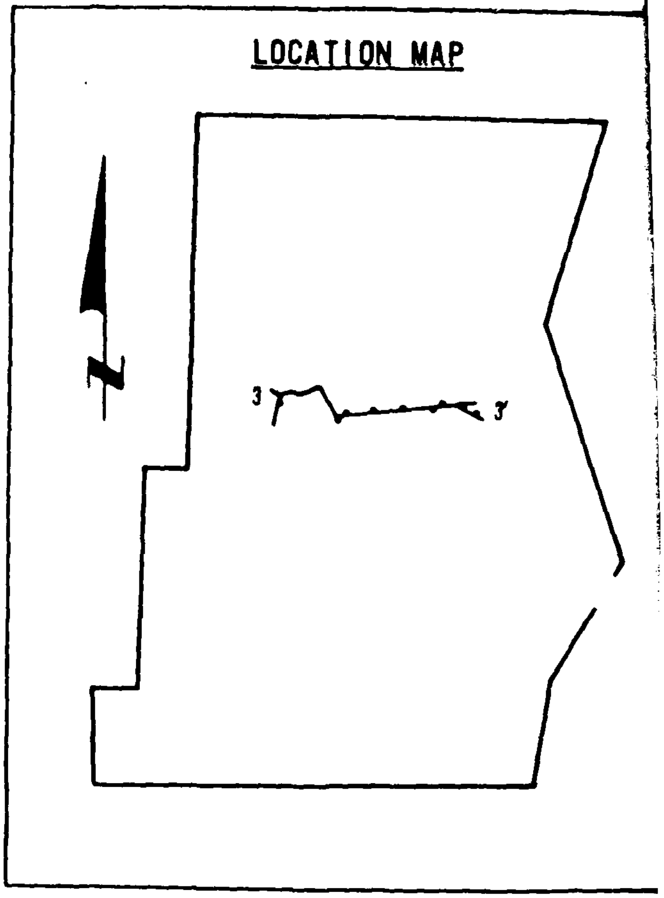
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 7-3

FUGRO NATIONAL, INC.

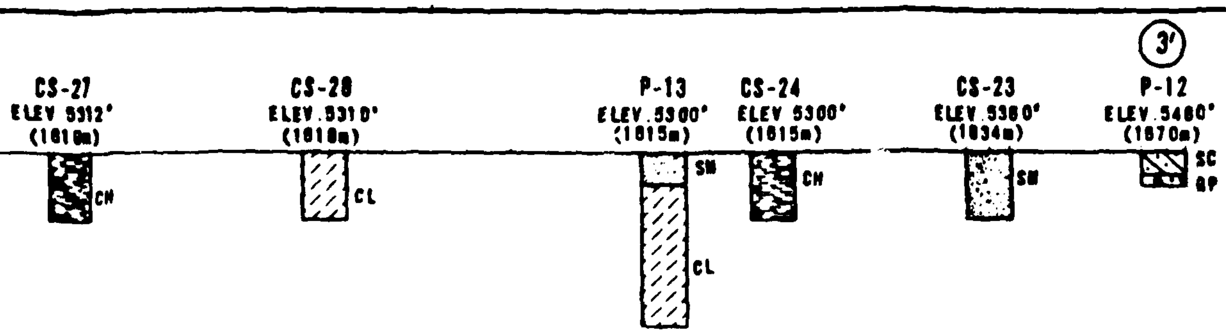


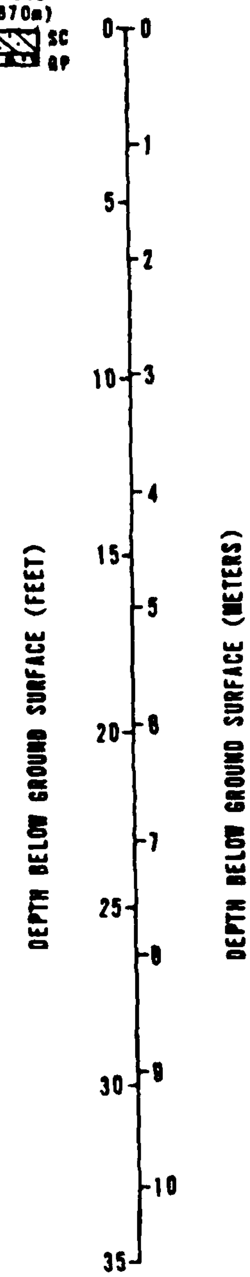


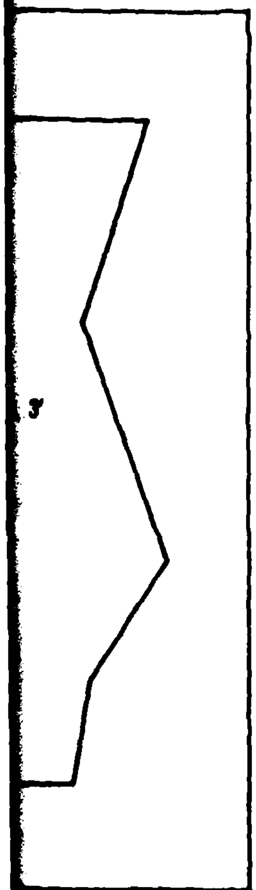


NOTES:

1. Ground surface elevations shown at activit
2. T.D.= Total Depth.
3. Soil types shown adjacent to soil column a
   Classification System (USCS) and are expl







EXPLANATION

B - Boring

T - Trench

P - Test Pit

CS - Surficial soil sample at Cone Penetrometer Test location.

HORIZONTAL SCALE

STATUTE MILES 0 1 2

KILOMETERS 0 1 2 3

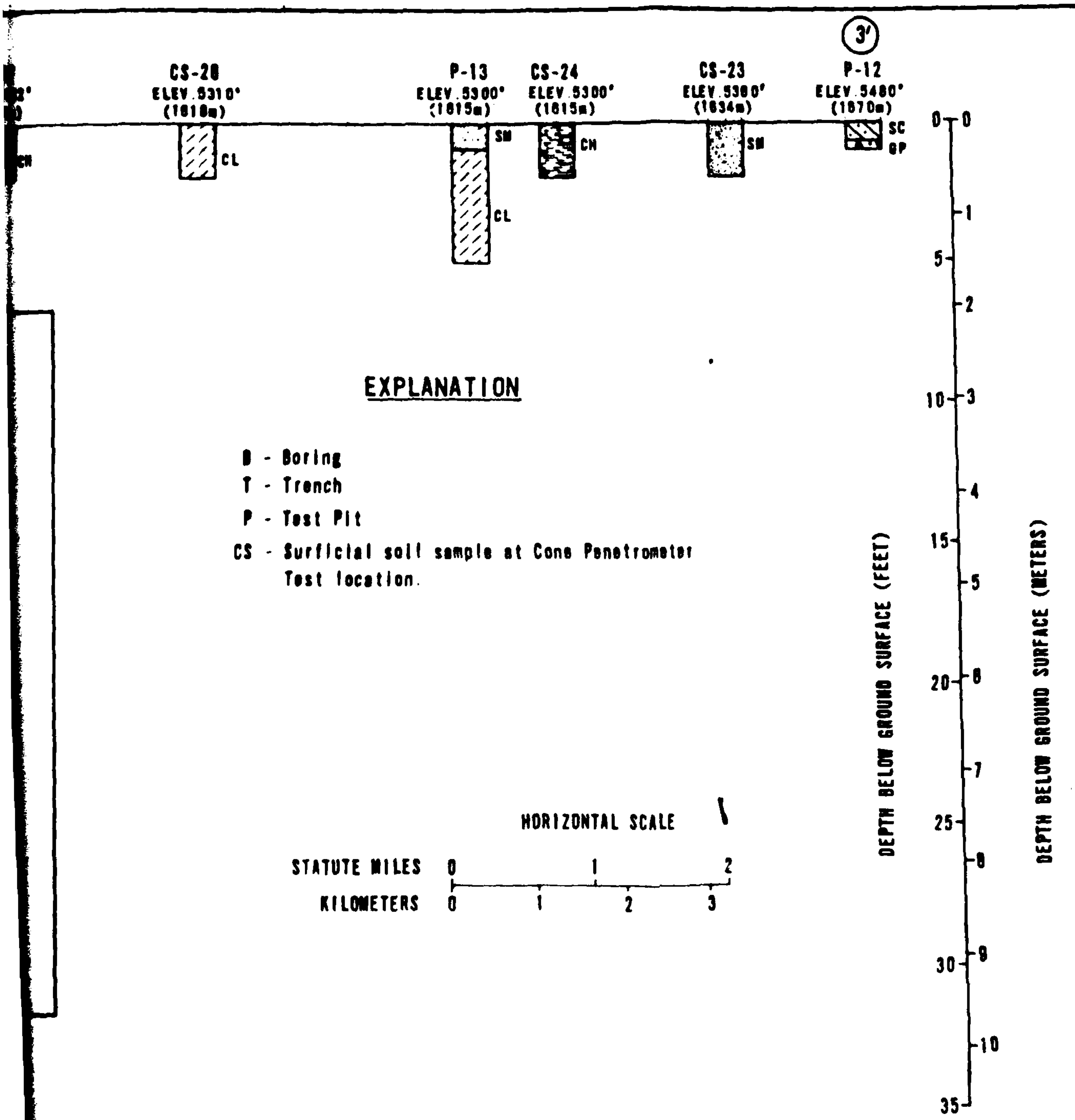
...own at activity locations are approximate.

... soil column are based on Unified Soil ... and are explained in the Appendix.

SOIL PROFILE 3-3'
VERIFICATION SITE
WHITE RIVER NORTH CDP, NEV...

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FUGRO NATIONAL



locations are approximate.

based on Unified Soil

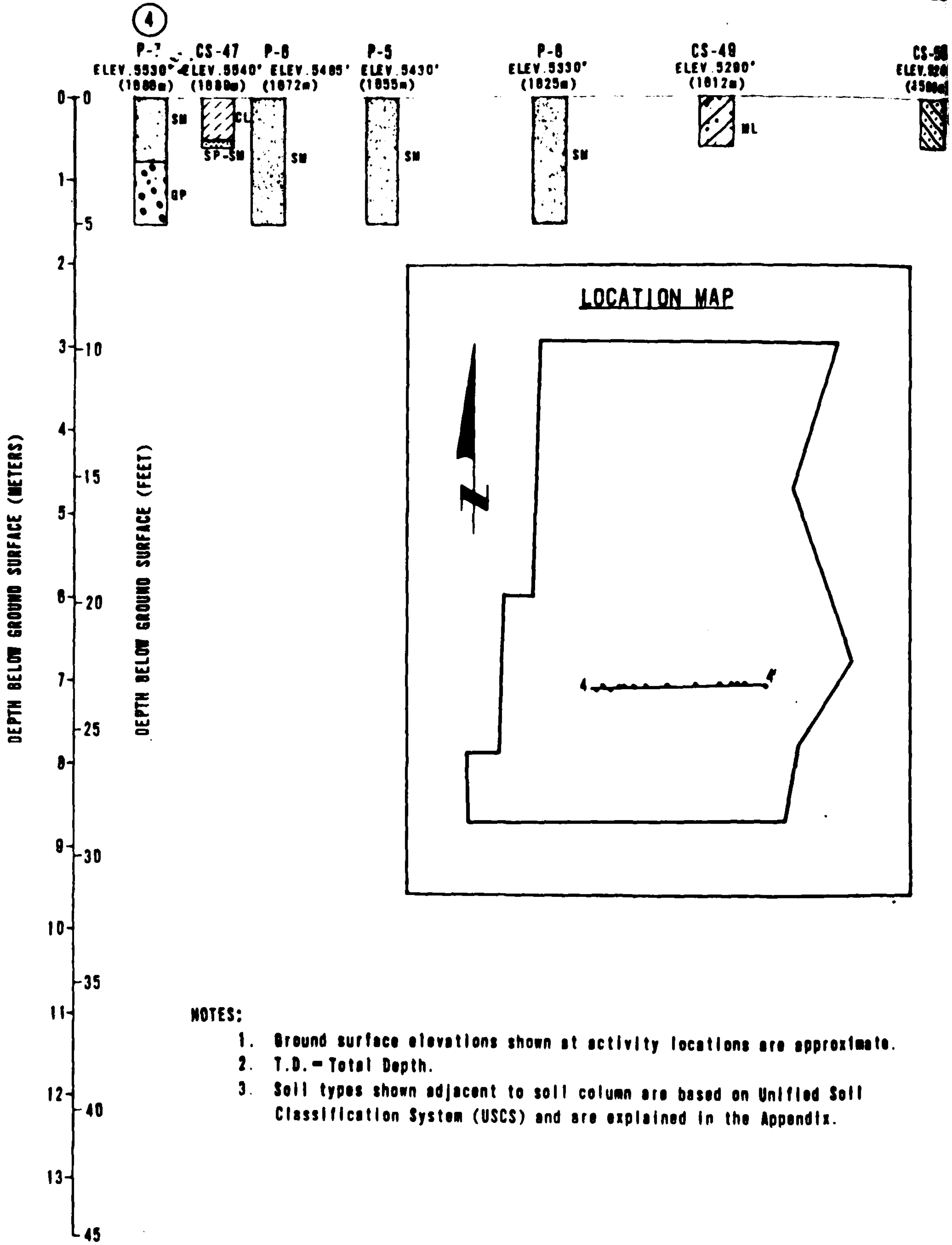
ed in the Appendix.

SOIL PROFILE 3-3'
VERIFICATION SITE
WHITE RIVER NORTH CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

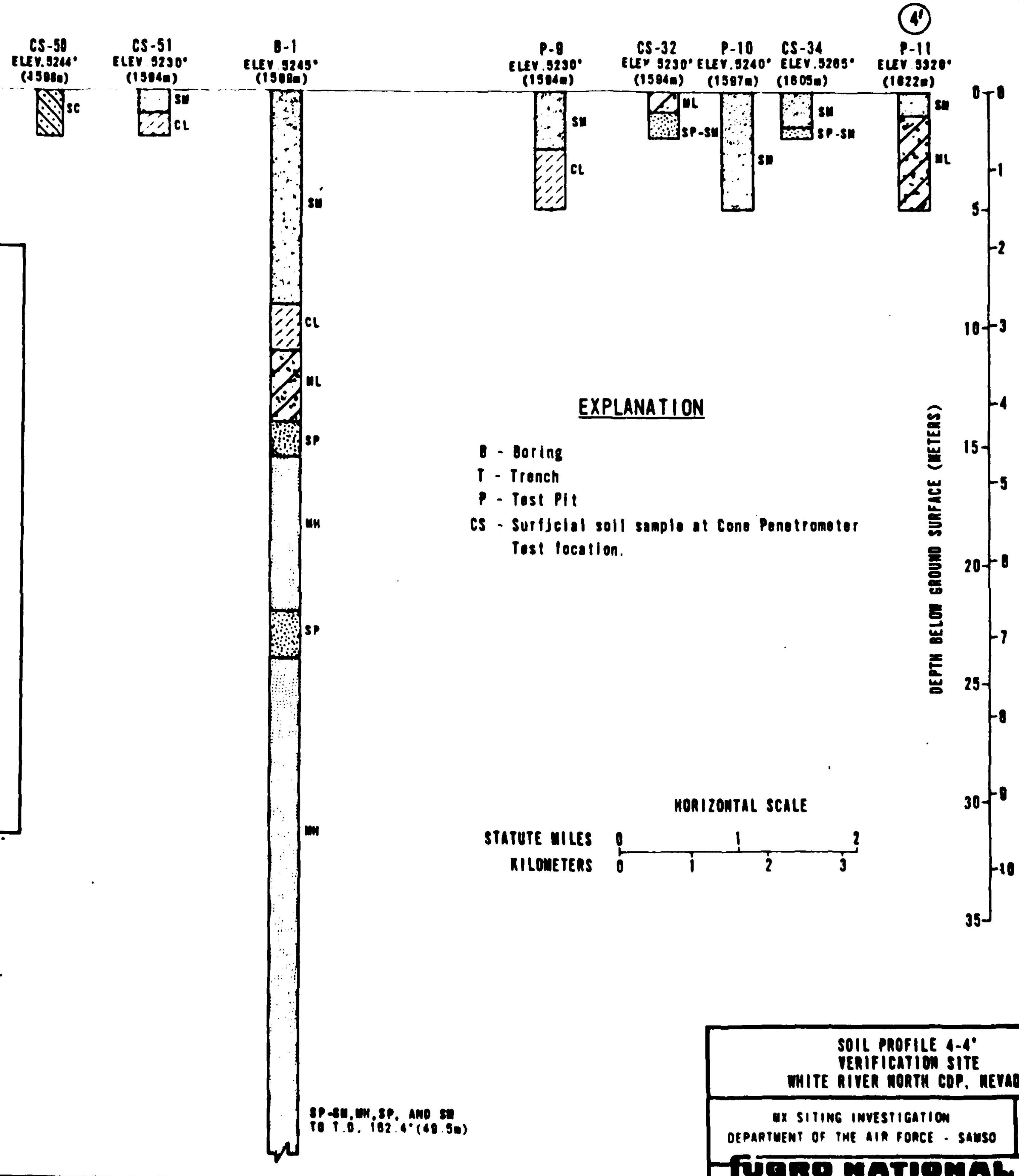
FIGURE 7-4

FUGRO NATIONAL, INC.



NOTES:

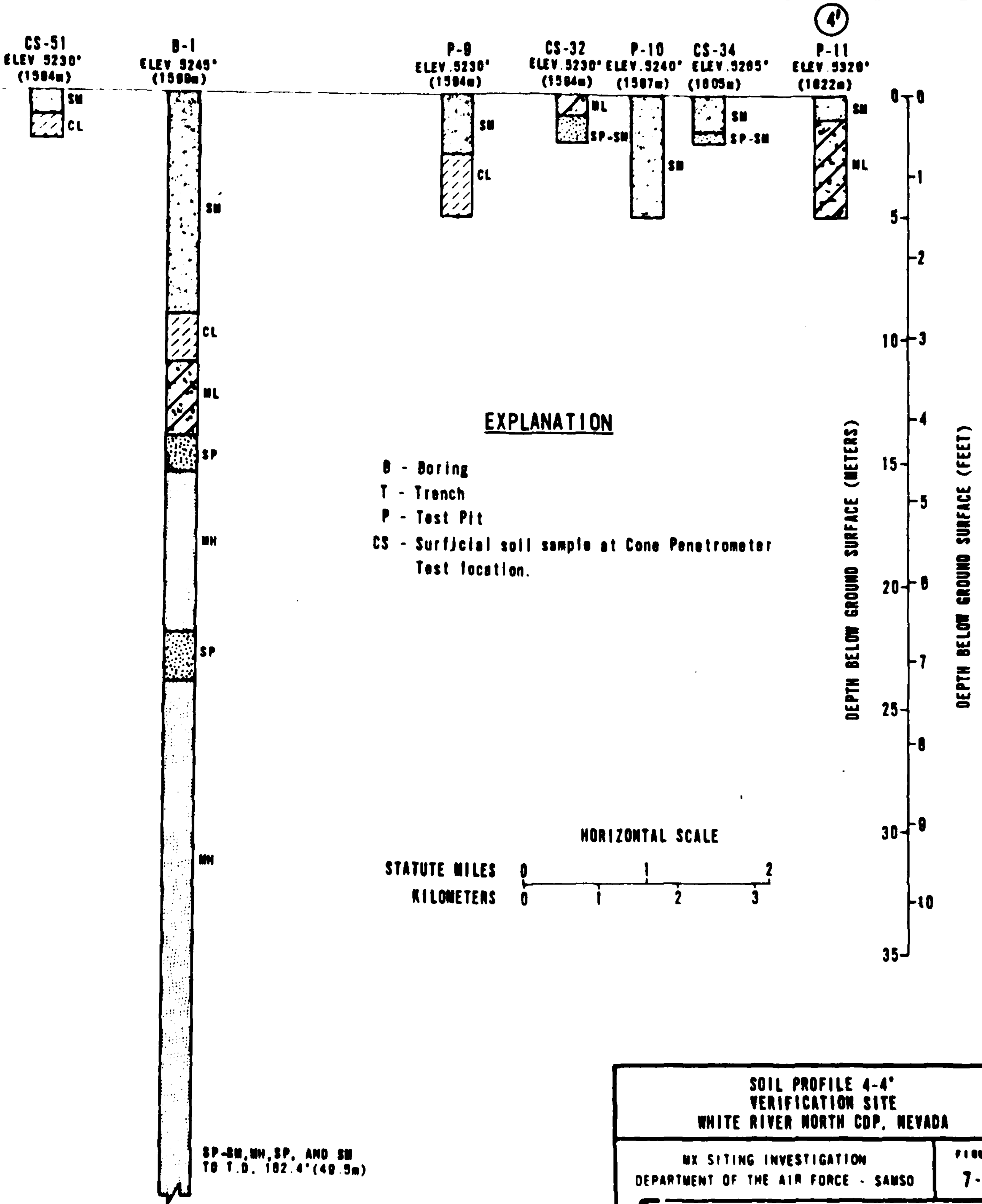
1. Ground surface elevations shown at activity locations are approximate.
2. T.D. = Total Depth.
3. Soil types shown adjacent to soil column are based on Unified Soil Classification System (USCS) and are explained in the Appendix.



SOIL PROFILE 4-4'
VERIFICATION SITE
WHITE RIVER NORTH CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FUGRO NATIONAL



EXPLANATION

B - Boring
T - Trench
P - Test Pit
CS - Surficial soil sample at Cone Penetrometer Test location.

HORIZONTAL SCALE

STATUTE MILES 0 1 2
KILOMETERS 0 1 2 3

SOIL PROFILE 4-4'
VERIFICATION SITE
WHITE RIVER NORTH CDP, NEVADA

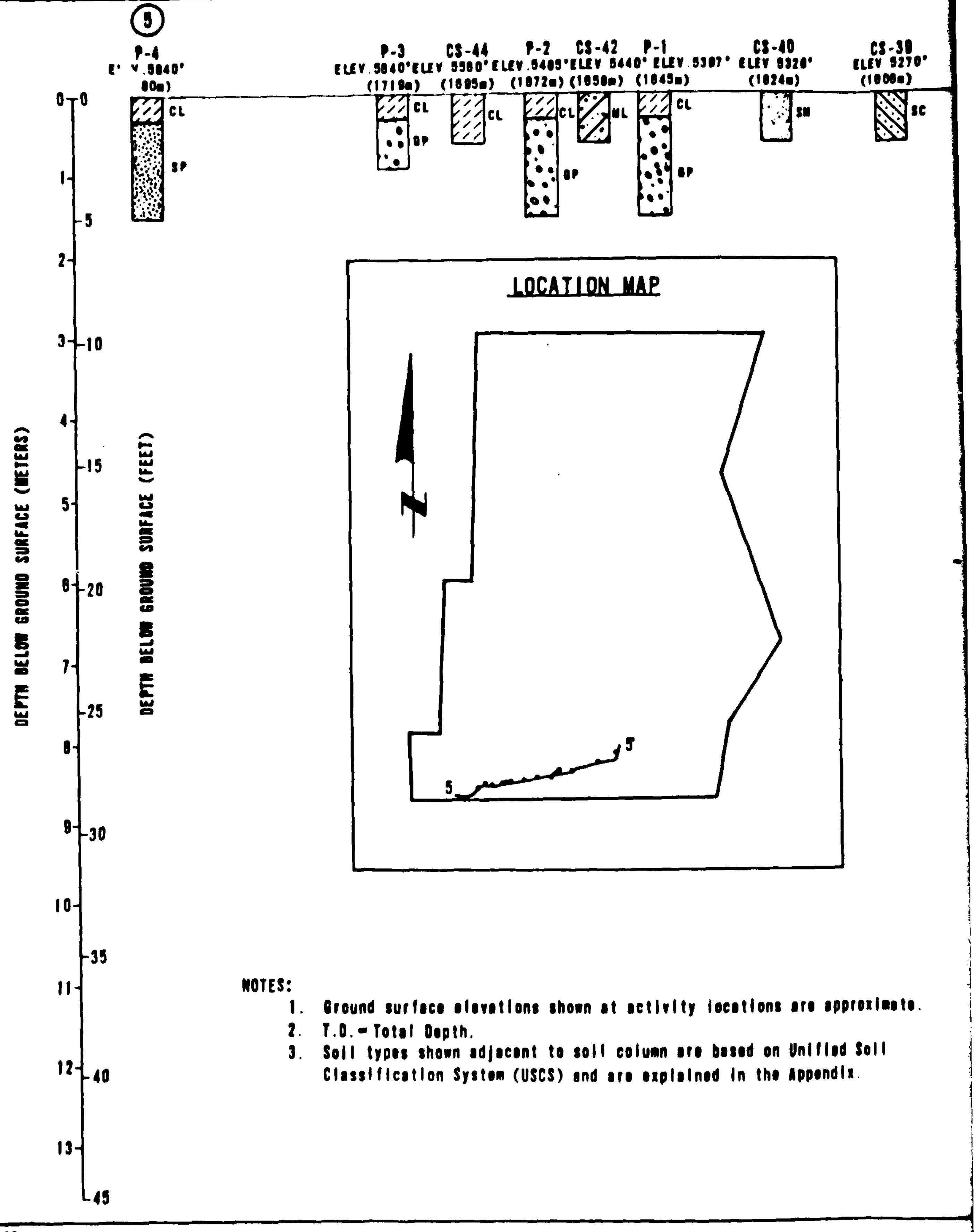
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 7-5

FUGRO NATIONAL, INC.

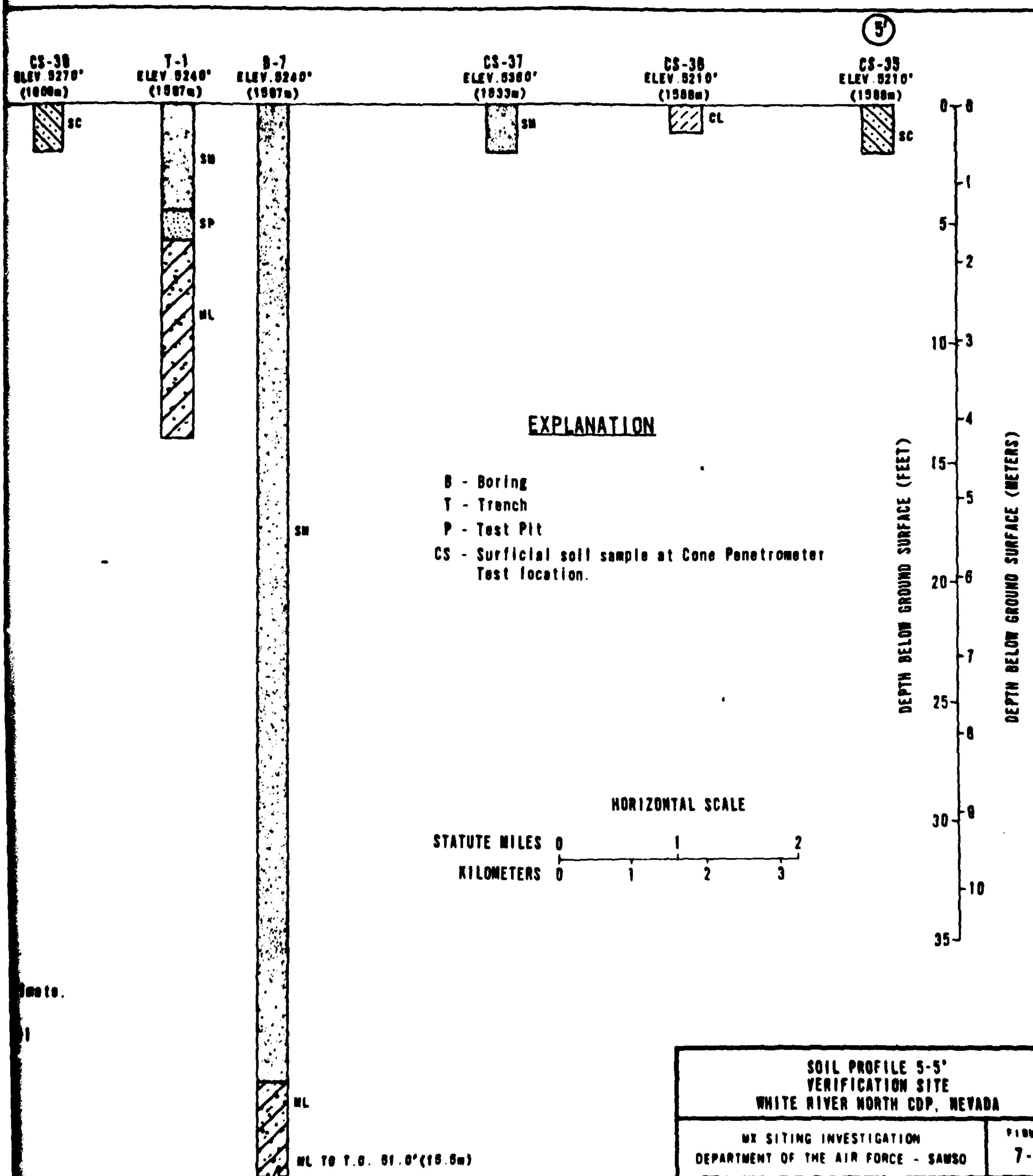
2

1 3



NOTES:

1. Ground surface elevations shown at activity locations are approximate.
2. T.D.= Total Depth.
3. Soil types shown adjacent to soil column are based on Unified Soil Classification System (USCS) and are explained in the Appendix.

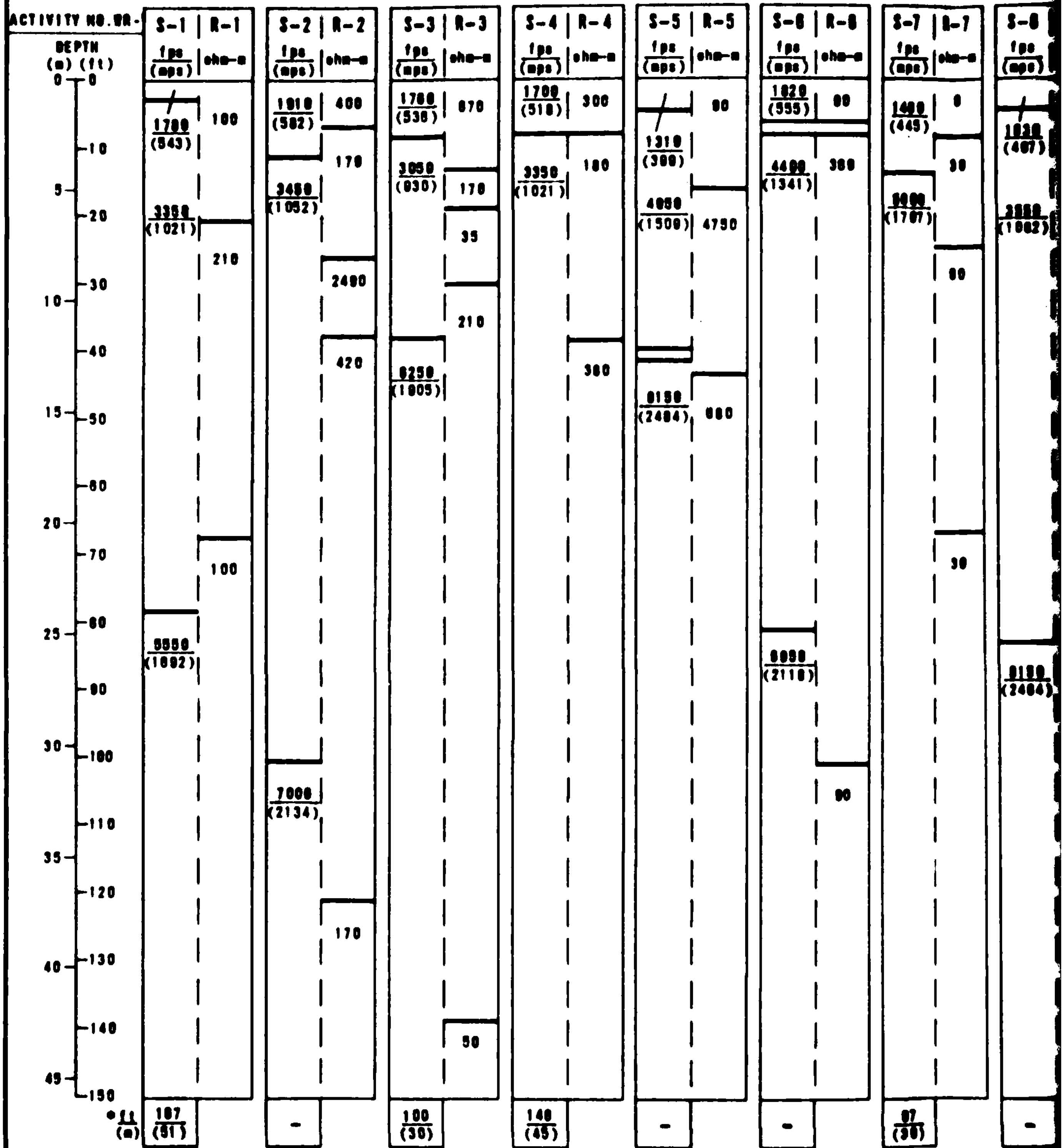


SOIL PROFILE 5-5'
VERIFICATION SITE
WHITE RIVER NORTH CDP, NEVADA

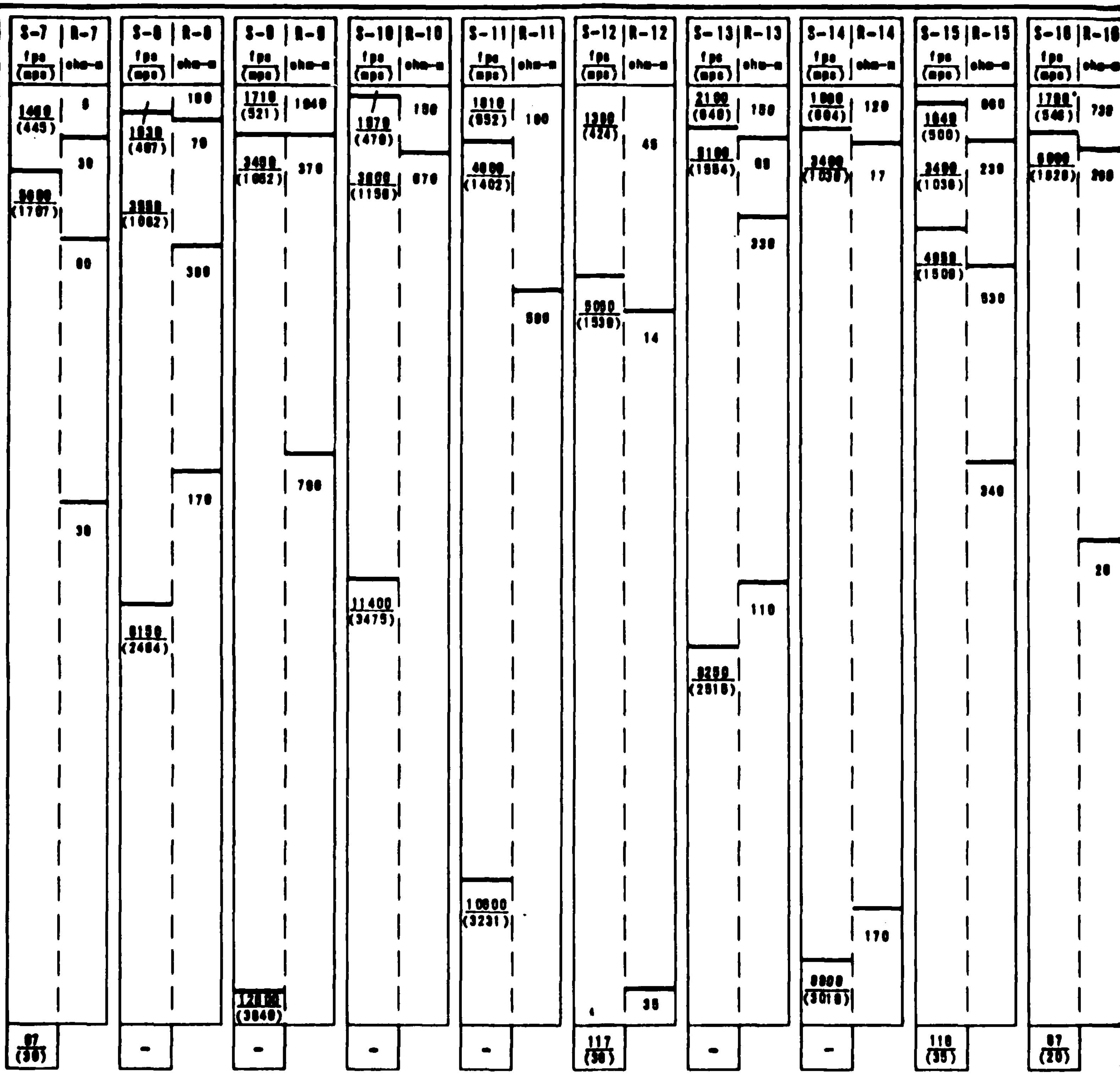
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 7-6

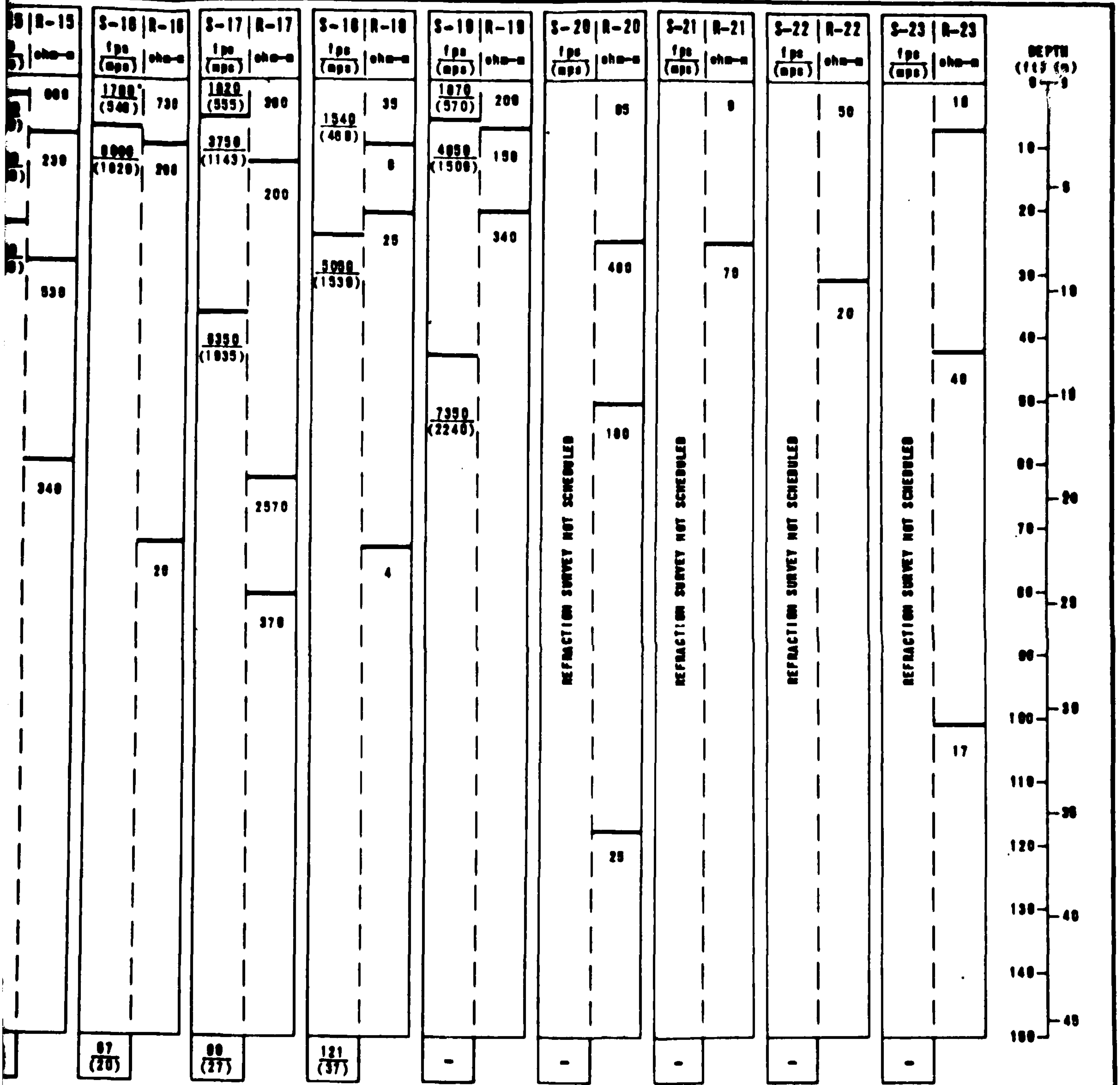
FUGRO NATIONAL, INC.



* Approximate depth above which there is no indication of material with a velocity as great as 7000 fps (2134 mps). See Appendix for an explanation of how this exclusion depth is calculated when the observed velocities are all less than 7000 fps (2134 mps).



S-7 | R-7
fps (mps) | ohm-m
1460 (445)
5800 (1767)
87 (30)
S-8 | R-8
1630 (497)
3550 (1082)
8150 (2484)
S-9 | R-9
1710 (521)
3490 (1062)
12600 (3840)
S-10 | R-10
1570 (479)
3800 (1158)
11400 (3475)
S-11 | R-11
1810 (552)
4600 (1402)
10600 (3231)
S-12 | R-12
1390 (424)
5050 (1539)
117 (36)
S-13 | R-13
2100 (640)
5100 (1554)
8250 (2515)
S-14 | R-14
1980 (604)
3400 (1036)
9900 (3018)
S-15 | R-15
1640 (500)
3400 (1036)
4950 (1509)
116 (35)
S-16 | R-16
1790 (546)
6000 (1829)
87 (26)



SEISMIC REFRACTION AND ELECTRICAL RESISTIVITY VERIFICATION SITE WHITE RIVER NORTH CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 7-4

FUGRO NATIONAL, INC.

DEPTH RANGE	2' - 20' (0.6 - 6.0m)	
SOIL DESCRIPTION	Coarse-grained soils	Fi
	Sandy Gravels, Gravelly Sands, Sands, Silty Sands, and Clayey Sands	Sandy Si… Sandy Cl…
USCS SYMBOLS	GP, GM, GC, SP, SM, SC	ML, CL, …
ESTIMATED EXTENT IN SUBSURFACE %	65-75	25-35
PHYSICAL PROPERTIES		
DRY DENSITY pcf (kg/m^3)	86.5-127.8 (1386-2047) [20]	76.5-94.… (1225-152…
MOISTURE CONTENT %	2.9-30.3 [20]	15.3-48.…
DEGREE OF CEMENTATION	none to high	none to h…
COBBLES 3-12 inches (8-30 cm) %	0-10	0-10
GRAVEL %	0-84 [16]	0-1
SAND %	14-89 [16]	13-40
SILT AND CLAY %	2-40 [16]	60-86
LIQUID LIMIT	NDA	37-54
PLASTICITY INDEX	NDA	17-25
COMPRESSIONAL WAVE VELOCITY fps (mps)	1570-6000 (479-1829) [15]	1390-5600 (424-1707)
SHEAR STRENGTH DATA		
UNCONFINED COMPRESSION S_u - ksf (kN/m^2)	NDA	1.3-4.7 (62-225)
TRIAXIAL COMPRESSION c - ksf (kN/m^2), $\phi°$	NDA	c = 1.7, ϕ=… (81)
DIRECT SHEAR c - ksf (kN/m^2), $\phi°$	c = 0.25, ϕ = 34° (12) [3]	NDA

NOTES:

- Characteristics of soils between 2 and 20 feet (0.6 and 6.0 meters) are based on results of tests on samples from 7 borings, 8 trenches, and 22 test pits, and results of 18 seismic refraction surveys.
- Characteristics of soils below 20 feet (6.0 meters) are based on results of tests on samples from 7 borings and results of 11 seismic refraction surveys.

- [ ]
- NDA –
- Resul…

(0.0 - 6.0m)	20' - 160' (6.0 - 49.0m)	
Fine-grained soils	Coarse-grained soils	Fine-grained soils
Sandy Silts, Clayey Silts, Sandy Clays, and Clays	Sandy Gravels, Gravelly Sands, Sands, Silty Sands, and Clayey Sands	Sandy Silts, Clayey Silts, Sandy Clays, and Silty Clays
ML, CL, CH	GW, GP, GM, GC, SW, SP, SM, SC	ML, MH, CL, CH
25-35	65-75	25-35
76.5-94.9 (1225-1520) [9]	78.4-138.3 (1256-2219) [36]	71.6-110.8 (1147-1775) [28]
15.3-48.0 [9]	7.2-36.2 [36]	15.7-44.7 [28]
none to high	none to moderate	none to high
0-10	0-10	0
0-1 [2]	0-67 [20]	0-1 [4]
13-40 [2]	21-61 [20]	29-47 [4]
60-66 [2]	4-42 [20]	52-71 [5]
37-54 [7]	NDA	35-62 [8]
17-25 [7]	NP [1]	7-47 [8]
1390-5600 (424-1707) [3]	3450-6350 (1052-1935) [8]	1390-5600 (424-1707) [3]
1.3-4.7 (62-225) [3]	NDA	NDA
c = 1.7, ϕ = 36° (81) [3]	NDA	NDA
NDA	c = 4.4, ϕ = 29° • (210) [4]	NDA

- [ ] - Number of tests performed.
- NDA - No data available (insufficient data or tests not performed.)
- • Results for cemented coarse-grained soils

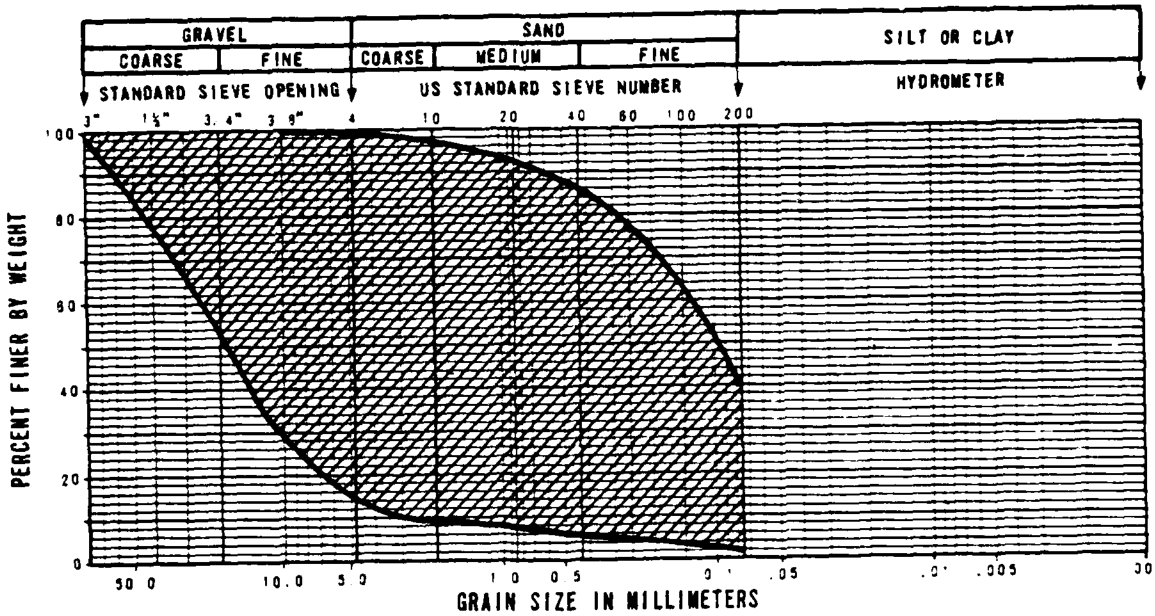
CHARACTERISTICS OF SUBSURFACE SOILS
VERIFICATION SITE
WHITE RIVER NORTH CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

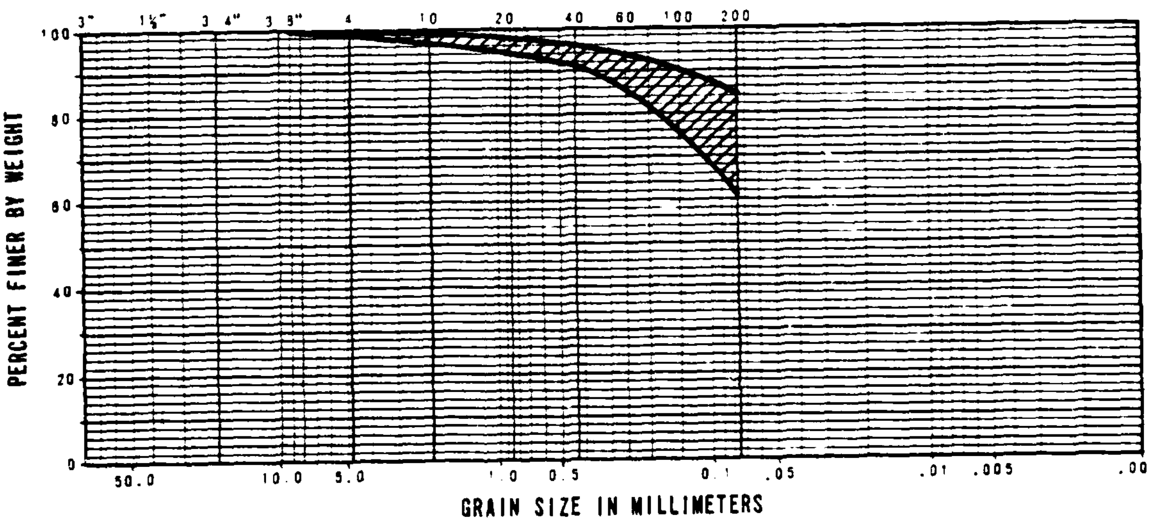
TABLE 7-5

FUGRO NATIONAL, INC.

AFV-20



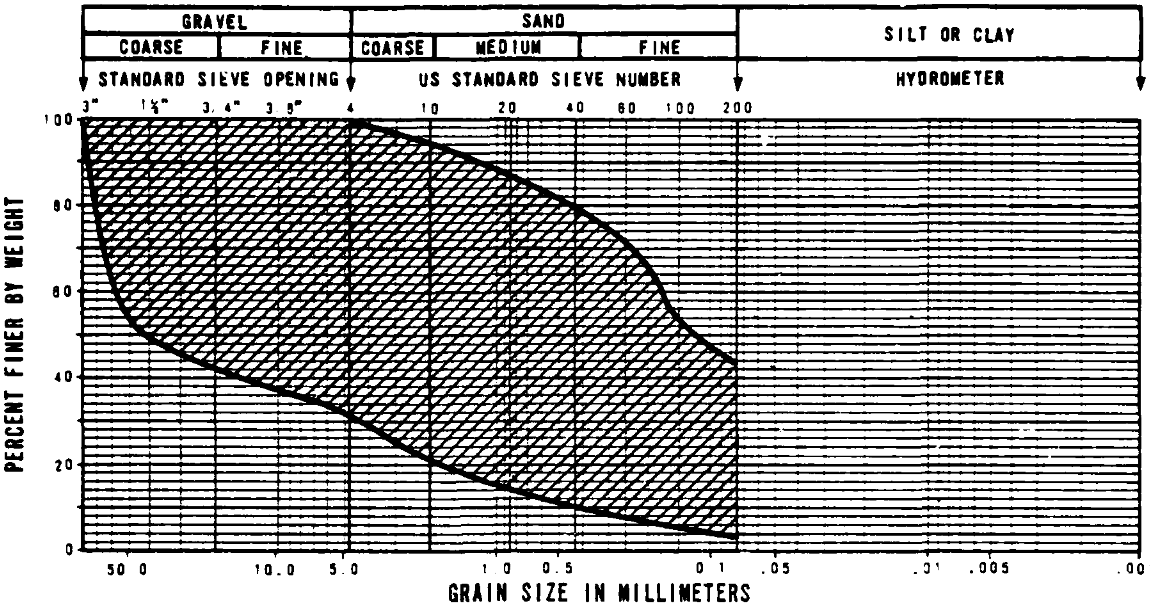
SOIL DESCRIPTION: Coarse-grained soils from 2 to 20 feet (0.6 to 6m)



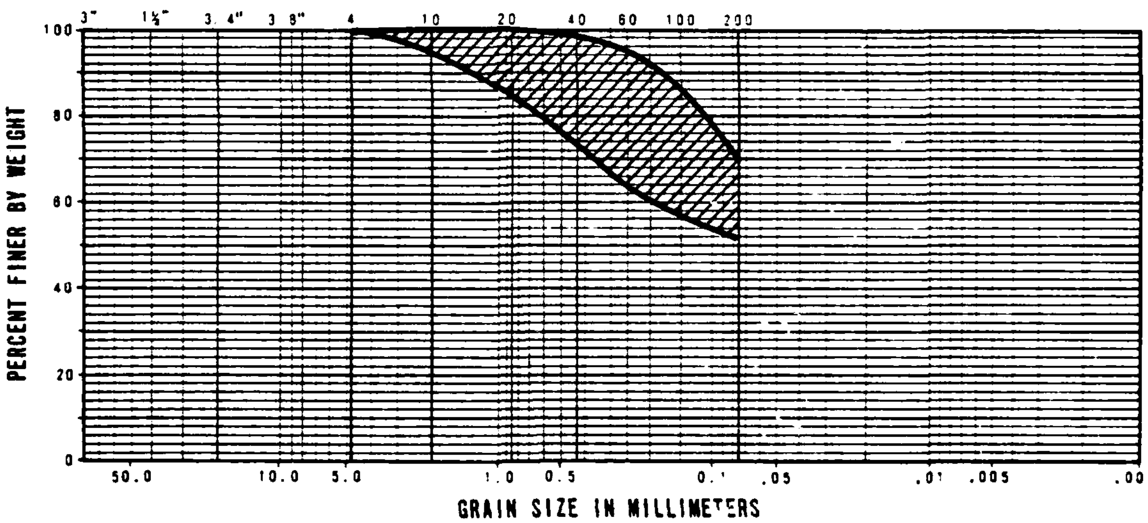
SOIL DESCRIPTION: Fine-grained soils from 2 to 20 feet (0.6 to 6m)

RANGE OF GRADATION OF SUBSURFACE SOILS VERIFICATION SITE WHITE RIVER NORTH CDP, NEVADA	
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAMSO	FIGURE 7-7 1 OF 2

FUGRO NATIONAL, INC.



SOIL DESCRIPTION: Coarse-grained soils from 20 to 160 feet (6 to 49m)



SOIL DESCRIPTION: Fine-grained soils from 20 to 160 feet (6 to 49m)

RANGE OF GRADATION OF SUBSURFACE SOILS
VERIFICATION SITE
WHITE RIVER NORTH CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 7-7
2 OF 2

FUGRO NATIONAL, INC.

Coarse-grained subsurface soils are dense to very dense below 5 feet (1.5 m). Variable cementation occurs intermittently, but well-developed, continuous cementation was not encountered. These soils exhibit very low compressibilities and moderate to high shear strengths. The first layer electrical resistivities measured in the coarse-grained soils are all greater than 100 ohm-meters and average 280 ohm-meters. Fine-grained soils (silts and clays) range in consistency from stiff to hard and display well developed, but not continuous, cementation. These soils possess moderate to high shear strength and very low to moderate compressibilities. The first layer electrical resistivities measured in the fine-gained soils are all less than 50 ohm-meters and average 27 ohm-meters.

Electrical conductivity of the soils in the upper 50 feet (15 m) ranges from 0.0003 to 0.0449 mhos per meter (average 0.0106 mhos per meter). At 11 of the 23 activity locations, the measured conductivities were less than the minimum value of 0.004 mhos per meter specified in the Fine Screening criteria. The fine-grained soils are more conductive than the coarse-grained soils, having an average conductivity of 0.0278. The average value for coarse-grained soils is 0.0047 mhos per meter. Chemical test results indicate a potential for "negligible to severe" sulfate attack on concrete in the upper 20 feet (6 m) and negligible sulfate attack below 20 feet.

7.6 TERRAIN

White River North is a topographically open alluvial basin with a wide central flood plain of low gradient. Surface elevations along the valley axis range from approximately 5100 feet (1569 m) in the south to about 5500 feet (1676 m) in the north. Alluvial fans show the greatest diversity of terrain features but are restricted to a relatively narrow band along the mountain flanks. Categories of these terrain conditions are differentiated in Drawing 7-3.

Intermediate alluvial fans along the eastern and western margins of the site are areas of nondeposition and active erosion. Incision depths range from 1.5 feet (0.5 m) to 30 feet (9 m) with an average depth of 7 feet (2 m; category II). Drainage densities vary from three to nine per mile (1.6 km). Surface slopes generally average about 4 percent with steeper slopes occurring near the mountain fronts. Faulting along the east side of the site has created shorter, steeper alluvial fans in contrast to the unfaulted west side of the site.

Younger alluvial fans which generally lie basinward of the intermediate fans are incised to depths up to 8 feet (2.5 m) but generally average less than 1 foot (0.3 m; category I). Drainage density ranges from 3 to 9 per mile (1.6 km) and surface slopes are generally about 3 percent. Coarser-grained, younger fans are generally more deeply eroded than the finer-grained facies.

The central portion of the site is occupied by older lacustrine deposits which have been dissected by small drainages to form low, north-south trending ridges with intervening broad troughs. Incision averages about 6 feet (1.8 m; category II) in depth with densities ranging from 2 to 5 per mile. In contrast, the northeast portion of the site is relatively featureless and flat.

7.7 DEPTH TO ROCK

Drawing 7-4 shows the 50-foot (15-m) and 150-foot (46-m) depth to rock contours for the White River North Site. The contours were based on limited data from shallow seismic refraction surveys, drillhole logs, geologic mapping, and published water well logs. The interpretation of the data was tempered with considerations for structural trends and rock types. Less than 8 percent of the site is estimated to have rock at less than 50 feet below the ground surface. Approximately 2 percent of the site is estimated to contain rock at depths between 50 and 150 feet.

The limestone mountains surrounding the site commonly form steep mountain fronts, especially the Guilmette Limestone which crops out in the northwestern portion of the site. Depth to rock contours are particularly close to the mountain fronts in the northwestern and northeastern portions of the site reflecting these conditions.

Low-lying welded ash flow tuffs and other volcanic rocks form outliers in the southwestern portion of the site. These are areas of expected shallow rock which are reflected in the broadly spaced contours encompassing the area.

7.8 DEPTH TO WATER

Drawing 7-5 shows the 50-foot (15 m) and 150-foot (46 m) depth to water contours for the White River North Site. This interpretation is based on water level measurements in existing wells, boring logs, seismic refraction and resistivity data, and published water-well information. Approximately 45 percent of the site has water at less than 50 feet and aproximately 25 percent has water between 50 and 150 feet.

The White River North Site is an open ground-water system which flows from north to south with an approximate gradient of 10 feet per mile (2 m per km). Depths to ground water in the site range from 7 feet (2 m) in the northeastern portion to greater than 500 feet (154 m) near the western margin. The ground water is generally shallowest along the White River drainage channel where it commonly occurs at less than 10 feet (3 m) below the ground surface (Maxey and Eakin, 1949). The 50-foot depth to water contour is coincident in several cases with the limits of the older lacustrine deposits and defines an area of shallow ground water that encompasses the entire central portion of the site.

Ground water is primarily used for farming in the Preston and Lund area north of the site and to a lesser extent for livestock within the site. Measurements of water levels made during Verification studies indicate that a water level decline of 3 to 14 feet (0.9 to 4.3 m) has occurred during the period from 1947 to 1978.

7.9 RESULTS AND CONCLUSIONS

7.9.1 Suitable Area

Suitable area, as determined by FY 79 Verification Studies at the White River North Site, is shown in Drawing 7-6. The site contains approximately 255 mi^2 (660 km^2) of usable area for a hybrid trench and 125 mi^2 (325 km^2) for a vertical shelter concept. These figures vary considerably from previous Screening studies for the following reasons:

1. Shallow ground water was found to be much more widespread than indicated from regional published sources;
2. A large area of previously undetected unsuitable terrain was identified in the southwest portion of the site; and
3. A detailed analysis of depth to rock conditions, based on newly gathered data, resulted in a significant suitable area loss along the margins of the site.

7.9.2 Construction Considerations

Geotechnical factors and conditions pertaining to construction of the MX system in the suitable area are discussed in this section. Both the hybrid trench and vertical shelter basing modes are considered.

7.9.2.1 Grading

Mean surficial slopes in the suitable area are approximately 3 to 4 percent (range of 1 to 9), thus generally requiring minimal preconstruction grading for roads and trenches. More extensive grading will be necessary near the mountain fronts where surface slopes range from 5 to 9 percent.

7.9.2.2 Roads

Surficial soils exhibit low strength to an average depth of 2.8 feet (0.8 m) with maximum depth of 14.1 feet (4.3 m). The subgrade supporting properties of low strength coarse-grained soils is inadequate but can be improved by mechanical compaction. Compaction to a depth of 2 to 3 feet (0.6 to 0.9 m) appears necessary in an majority of the suitable area, with compaction to greater depth required in approximately 10 percent of the site. Based on results of laboratory CBR tests, compacted granular soils will provide fair to good subgrade support for roads.

Due to the exclusion of the central portion of the site as suitable area, roads will be sited in very few areas underlain by fine-grained surficial soils. Supporting qualities of these soils are inadequate for direct support of the base or subbase course of the road system. Results of the CBR tests indicate that mechanical compaction will not adequately strengthen these fine-grained soils. Therefore, required support can be attained by using a select granular subbase layer over a compacted fine-grained soil subgrade. The relatively high fines content renders the coarse-grained soils only marginally suitable as subbase material and unsuitable without processing for use as a base course.

Drainage incisions are generally less than 6 feet (1.8 m) deep within 75 percent of the suitable area. In the remainder of the site, the depth of drainage incision ranges from 6 to 15 feet

(1.8 to 4.6 m). Therefore, the cost of drainage structures for roads and trenches will be moderate.

7.9.2.3 Excavatability and Stability

Subsurface soils in the suitable site area are predominantly coarse-grained with fine-grained soils estimated in less than 10 percent of the construction zone. These soils are generally dense to very dense and have variable calcium carbonate cementation.

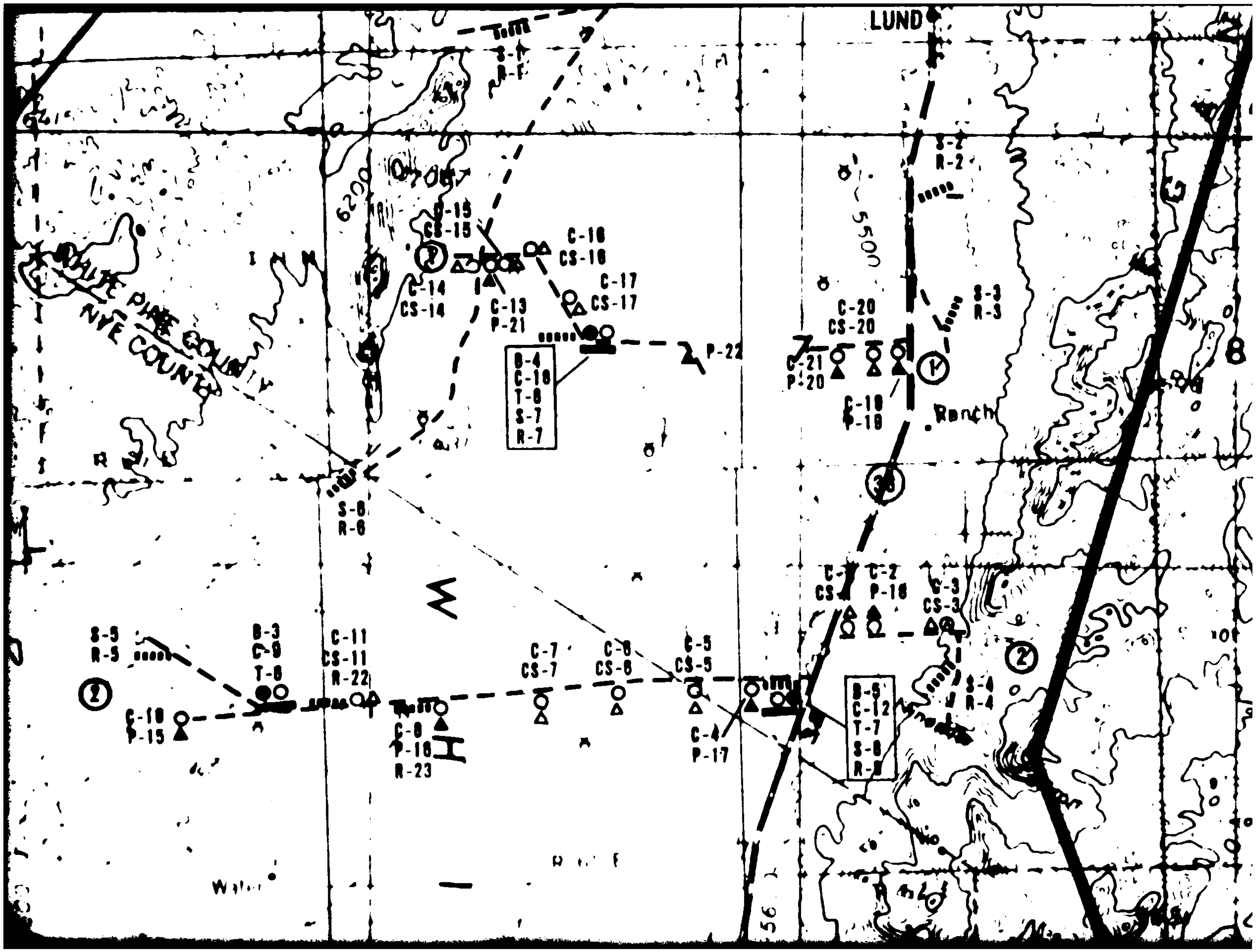
Hybrid Trench: Within the upper 20 feet (6 m), compressional wave velocities indicate that difficult excavation conditions for MX trenchers are expected only in localized areas. These trenchers would be suitable for excavating continuous trenches (for cast-in-place construction) with vertical walls. Due to the fines content and partial cementation of granular site soils, temporary stability is expected for vertical trench walls in most of the site. Because of low strength surficial soil, the top 2 to 5 feet (0.6 to 1.5 m) in all trench excavations will generally have to be sloped back for stability. Requirements for shoring or sloping to full depth of trenches are expected in less than 10 percent of the site.

Vertical Shelter: Compressional wave velocities in the upper 120 feet (36 m) indicate that large diameter auger drills could be used for vertical shelter excavation, with difficult excavation likely in approximately 15 percent of the suitable area. Nearly all excavation will be in granular soils with only intermittent cemented or cohesive soil intervals. Therefore, the vertical walls of these shelters will probably require the use of slurry or other stabilizing techniques.

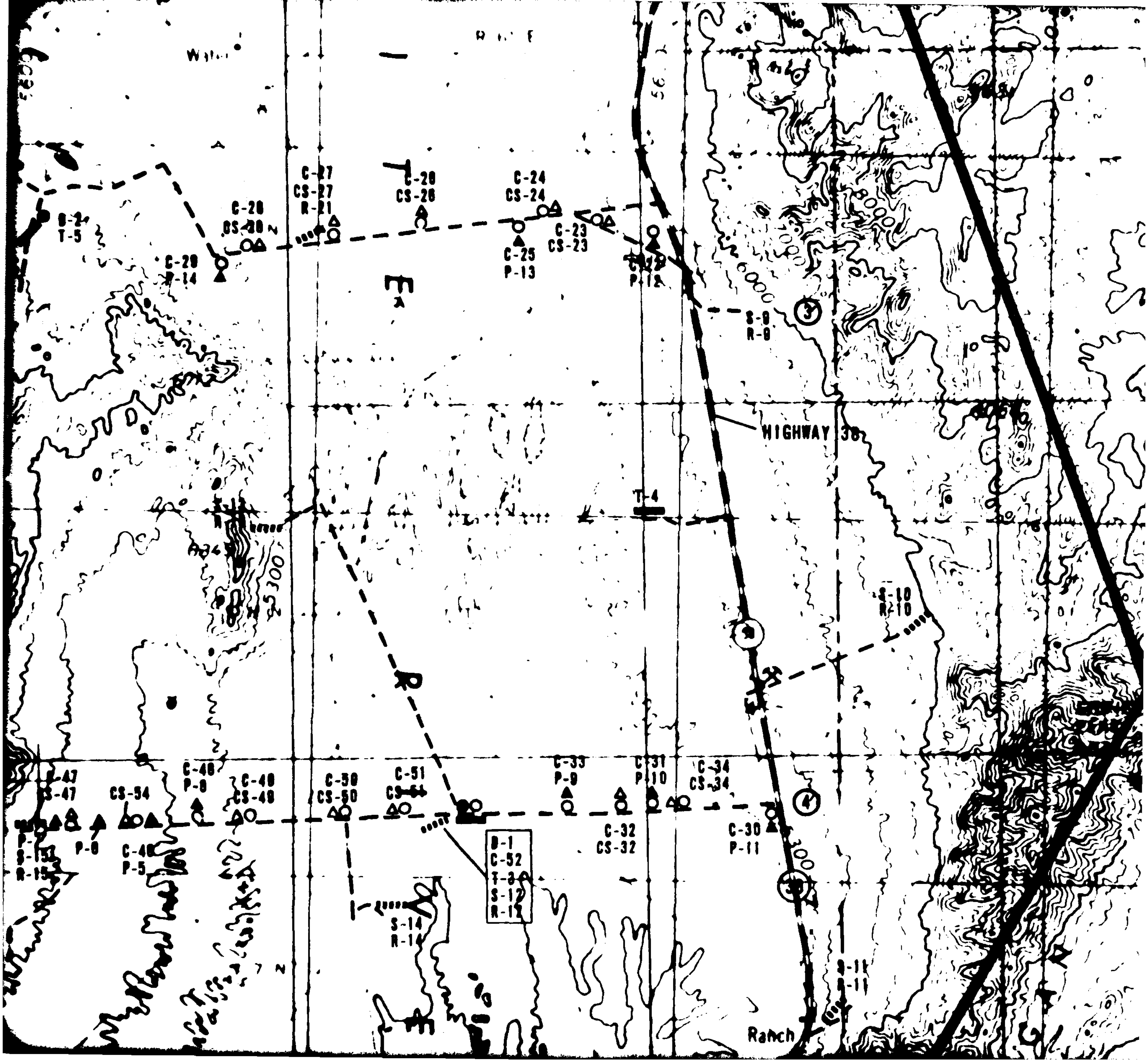
7.10 RECOMMENDATIONS FOR FUTURE STUDIES

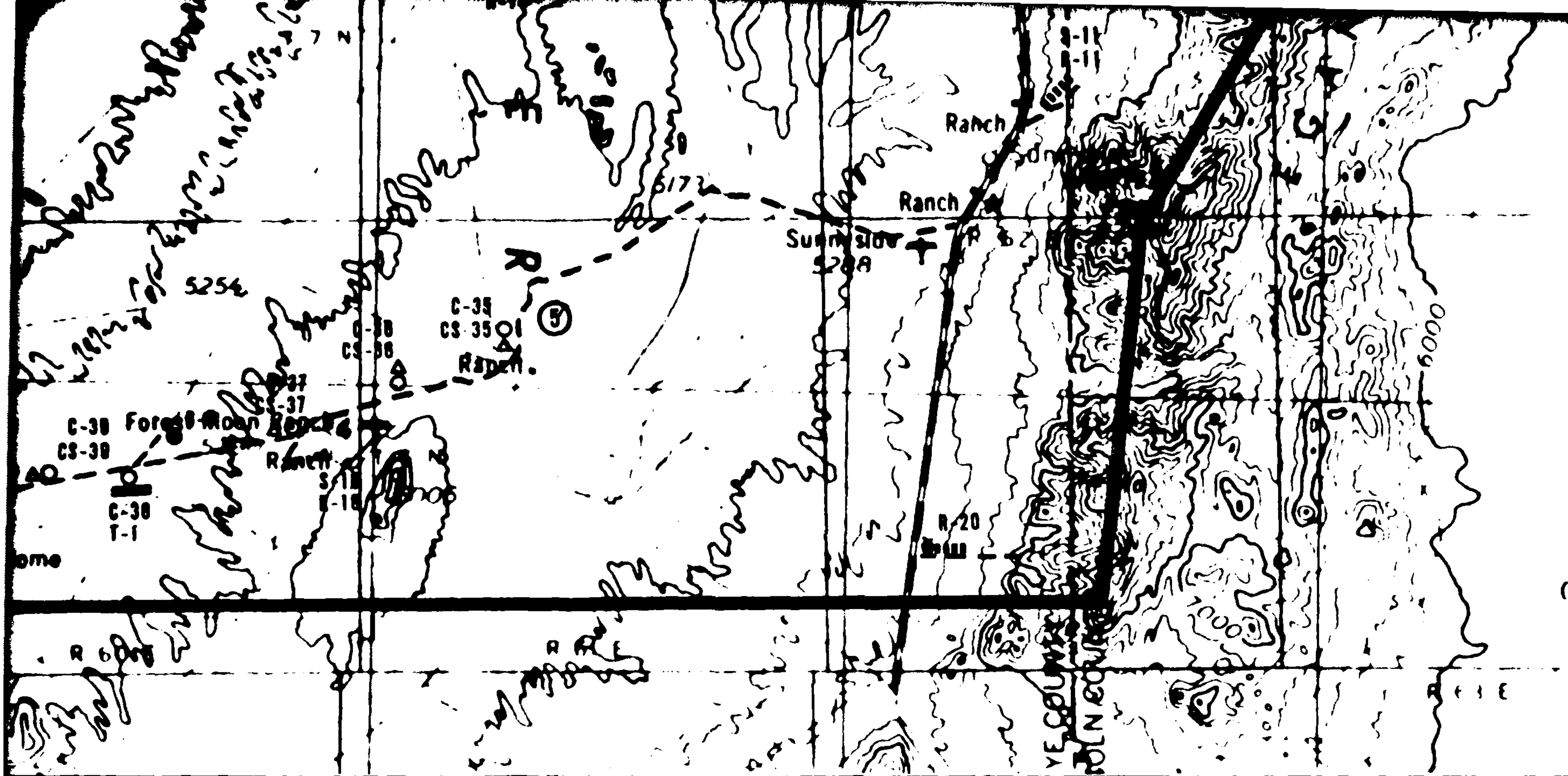
The following geotechnical conditions have been identified as requiring additional investigation.

1. The basinward extent of shallow volcanic rocks in the southwestern part of the site is not accurately known. An array of seismic refraction lines and limited confirmatory borings are recommended to detail the subsurface configuration of these rocks.
2. Ground-water contours are highly approximate in the southern portion of the site. Ground-water observation wells are recommended to provide better contour control.



LUND
Ranch
5500
6200
WHITE PINE COUNTY
NYE COUNTY
S-2
R-2
S-3
R-3
C-20
CS-20
C-21
P-20
C-19
P-19
38
C-15
CS-15
C-16
CS-16
C-17
CS-17
C-14
CS-14
C-13
P-21
B-4
C-10
T-8
S-7
R-7
P-22
S-6
R-6
S-5
R-5
B-3
C-9
T-6
C-11
CS-11
R-22
C-8
P-16
R-23
C-19
P-15
C-7
CS-7
C-6
CS-6
C-5
CS-5
C-4
P-17
B-5
C-12
T-7
S-8
R-8
C-2
P-18
C-3
CS-3
S-4
R-4
W
H
56


HIGHWAY 38
Ranch
C-27
CS-27
R-21
C-28
CS-28
C-24
CS-24
C-23
CS-23
C-25
P-13
S-9
R-9
T-4
S-10
R-10
C-33
P-9
C-34
CS-34
C-32
CS-32
C-30
P-11
C-50
CS-50
C-51
B-1
C-52
S-12
S-14
CS-54
P-5



LANATION

BORING

CONE PENETROMETER TEST (CPT)

SURFACE SAMPLE AT CPT LOCATION

TRENCH

TEST PIT

SEISMIC REFRACTION LINE

ELECTRICAL RESISTIVITY LINE

ACTIVITY LINE

PLANATION

BORING

CONE PENETROMETER TEST (CPT)

SURFACE SAMPLE AT CPT LOCATION

TRENCH

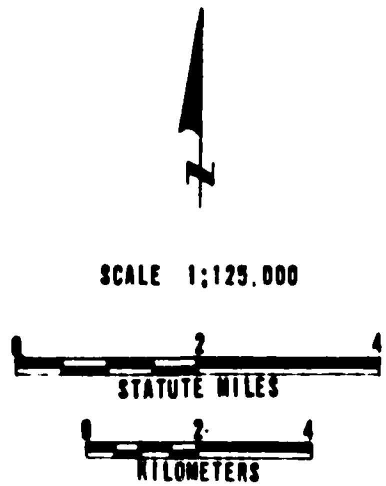
TEST PIT

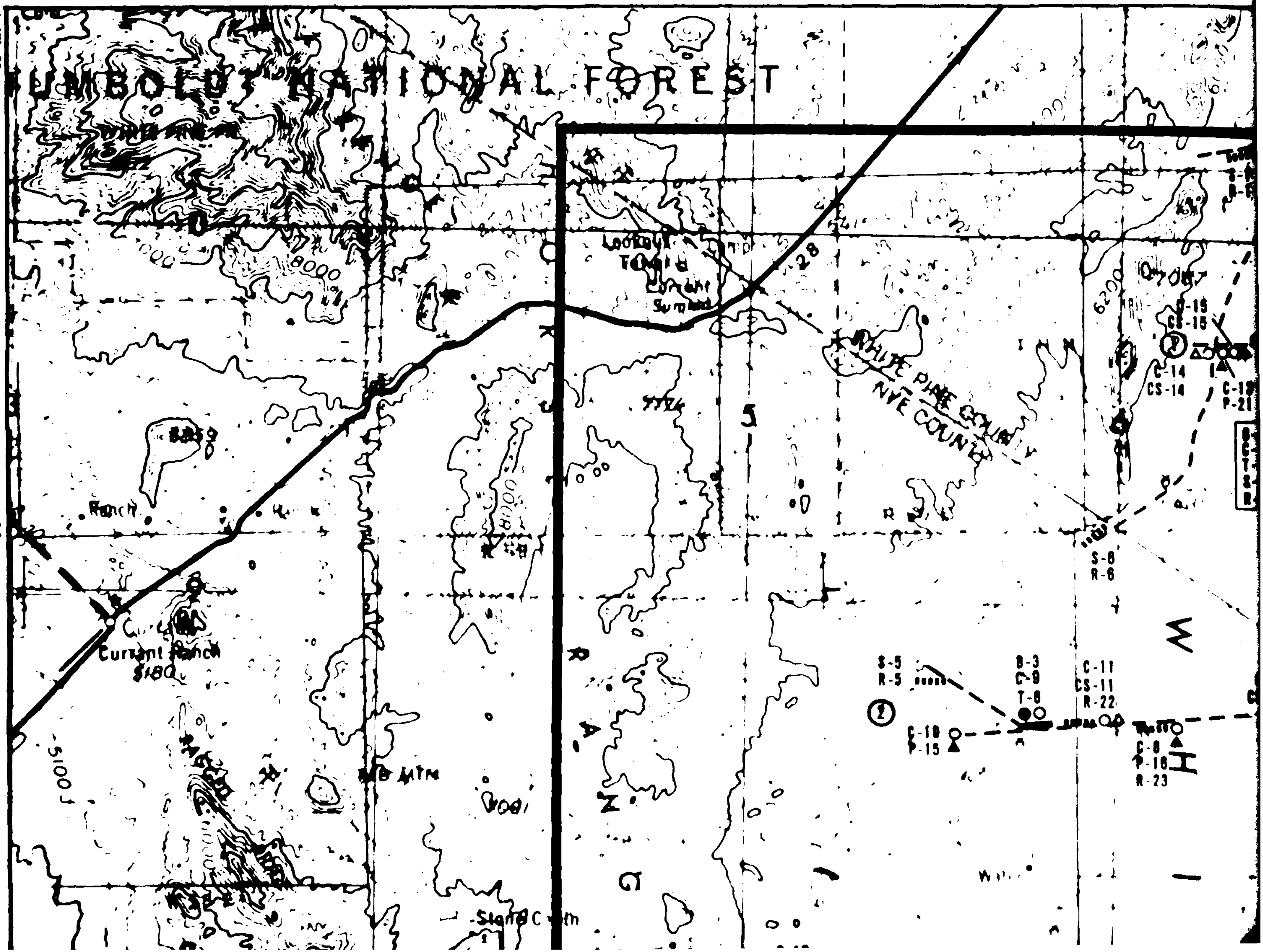
SEISMIC REFRACTION LINE

ELECTRICAL RESISTIVITY LINE

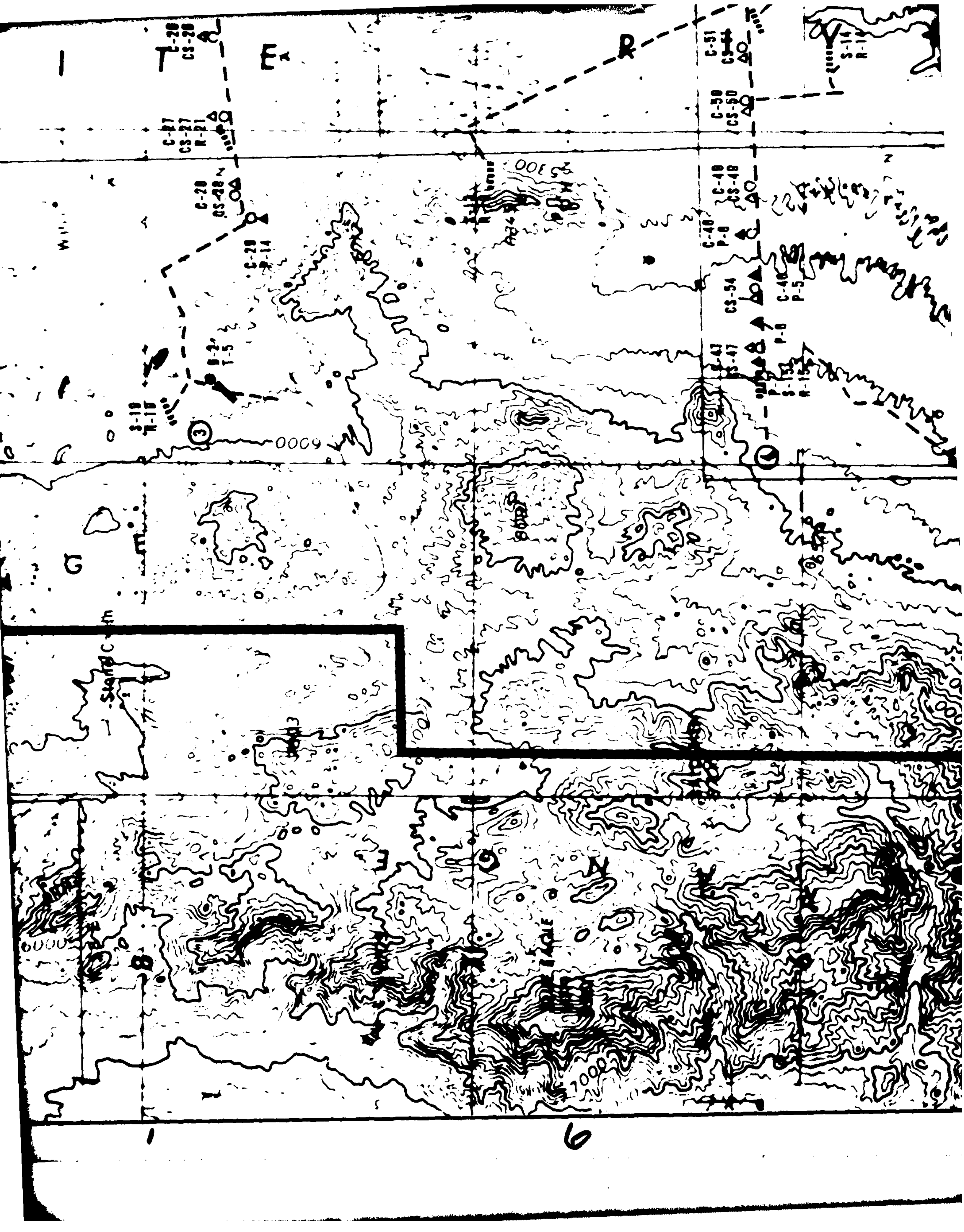
ACTIVITY LINE

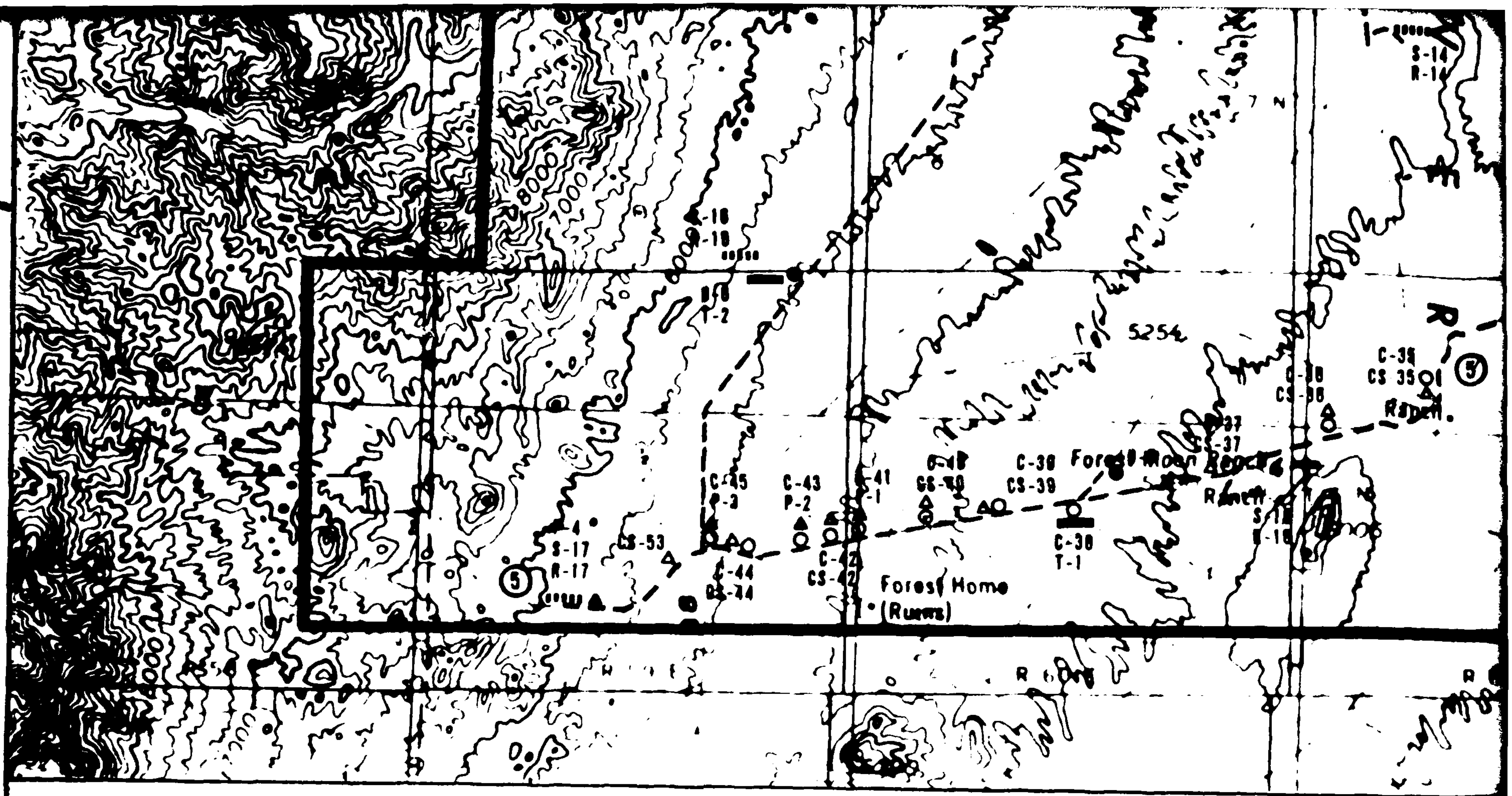
activities were performed at the same location.
cation is designated by either (1) the boring
the CPT symbol, if no boring was drilled




HUMBOLDT NATIONAL FOREST
Lookout
Current Summit
28
5
WHITE PINE COUNTY
NYE COUNTY
6200
Ranch
Current Ranch
5180
5100
8000
S-8
R-6
S-5
R-5
B-3
C-9
T-8
C-11
CS-11
R-22
C-18
P-15
C-8
P-18
R-23
C-14
CS-14
W
H
R
A
N
G

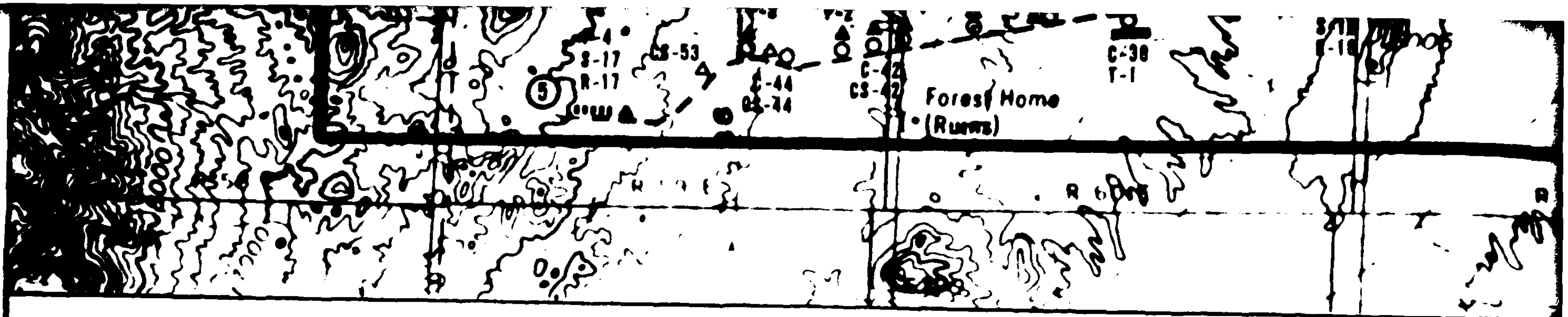
2 JUL 79


I
T
E
R
6000
5300
7000
1
6



EXPLANATION

- ● B-1 BORING
- ○ C-1 CONE PENETROMETER TEST (CPT)
- CS-1 SURFACE SAMPLE AT CPT LOCATION
- ▬ T-1 TRENCH
- P-1 TEST PIT
- S-1 SEISMIC REFRACTION LINE



EXPLANATION

●	B-1	BORING
○	C-1	CONE PENETROMETER TEST (CPT)
	CS-1	SURFACE SAMPLE AT CPT LOCATION
▬	T-1	TRENCH
	P-1	TEST PIT
▪▪▪▪▪	S-1	SEISMIC REFRACTION LINE
	R-1	ELECTRICAL RESISTIVITY LINE
①- - - - -①'		ACTIVITY LINE

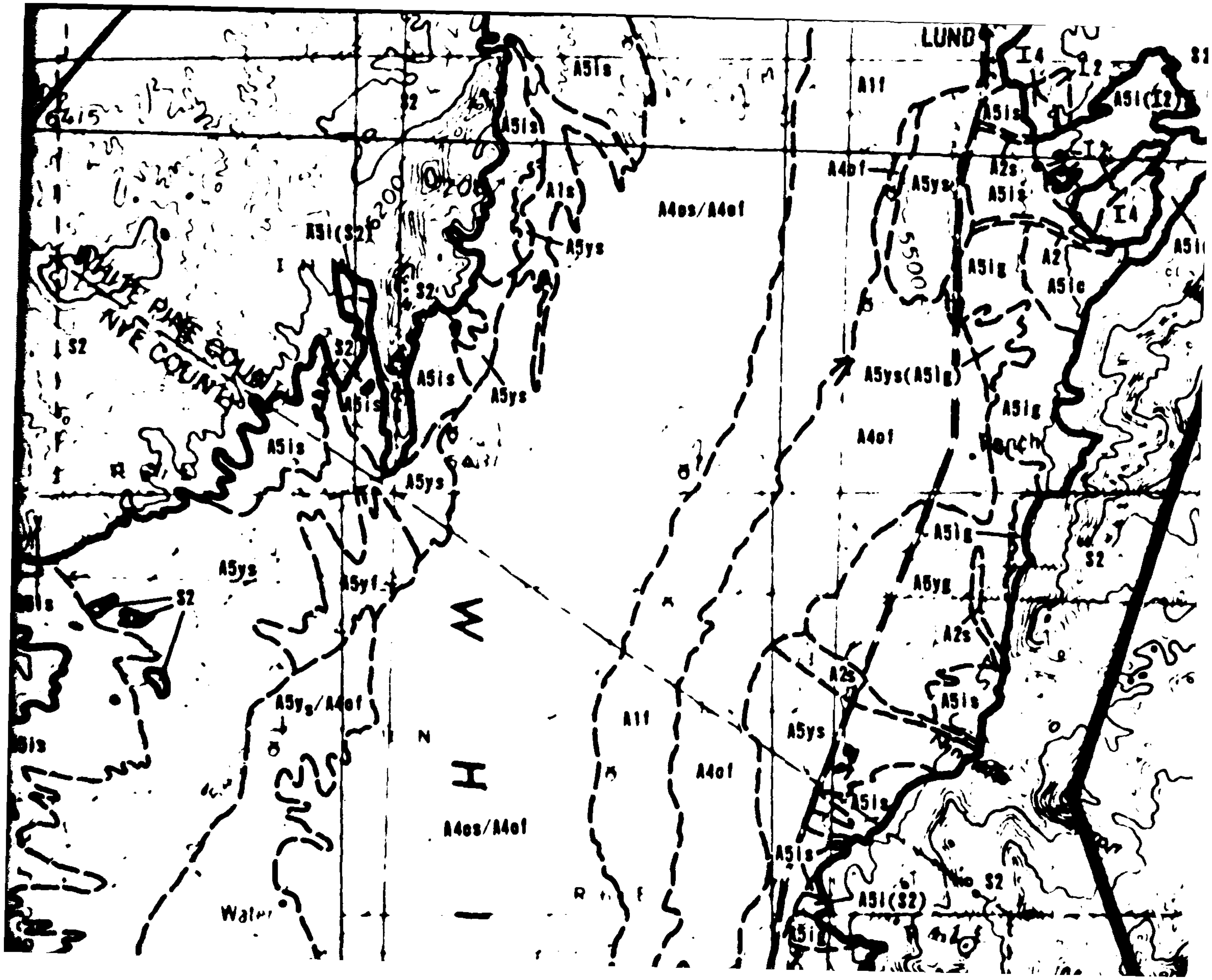
NOTE: Where multiple activities were performed at the same location, the correct location is designated by either (1) the boring symbol or (2) the CPT symbol, if no boring was drilled

ACTIVITY LOCATIONS
VERIFICATION SITE WHITE RIVER CDP, NEVADA

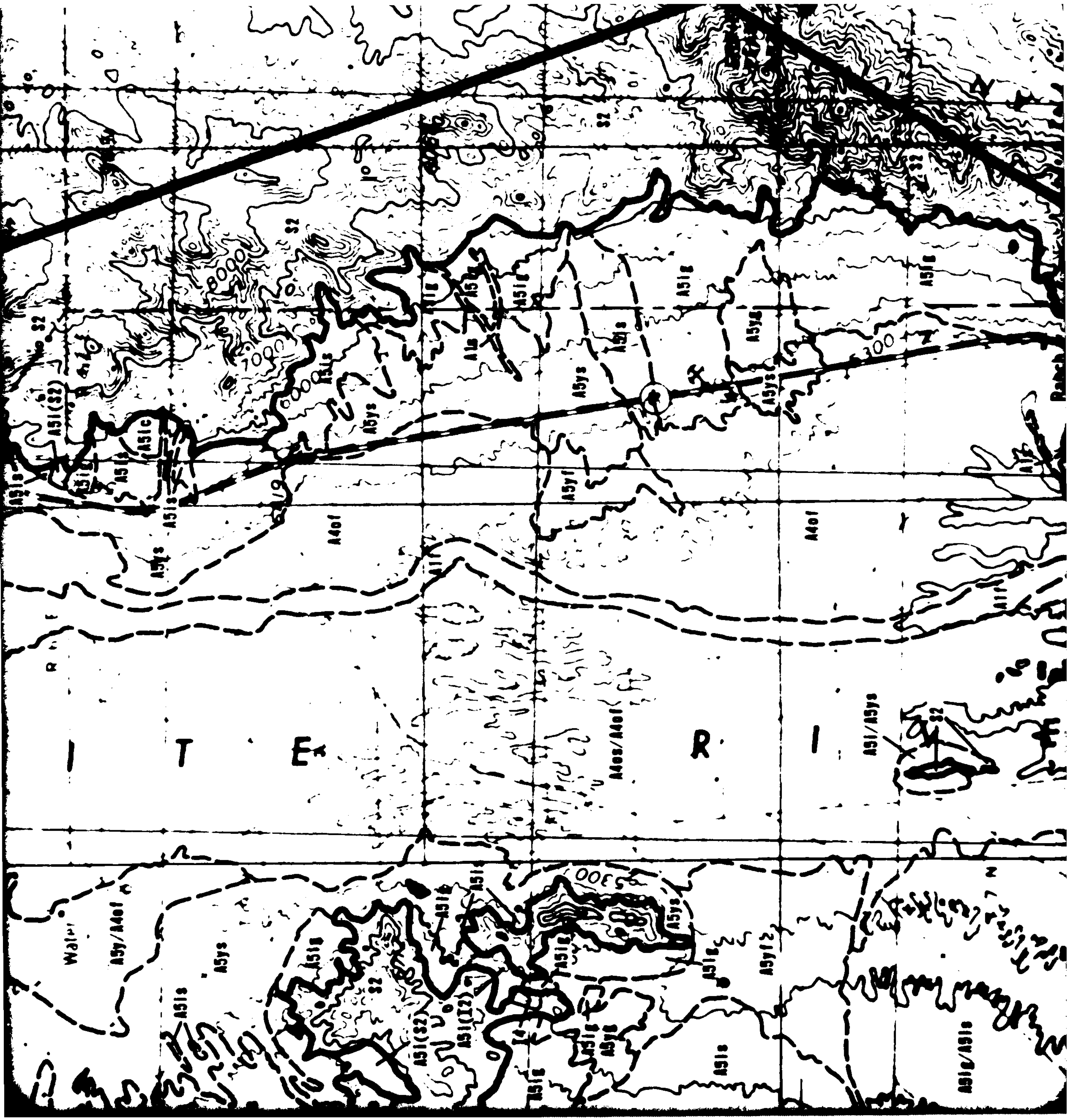
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

DRAWING
7-1

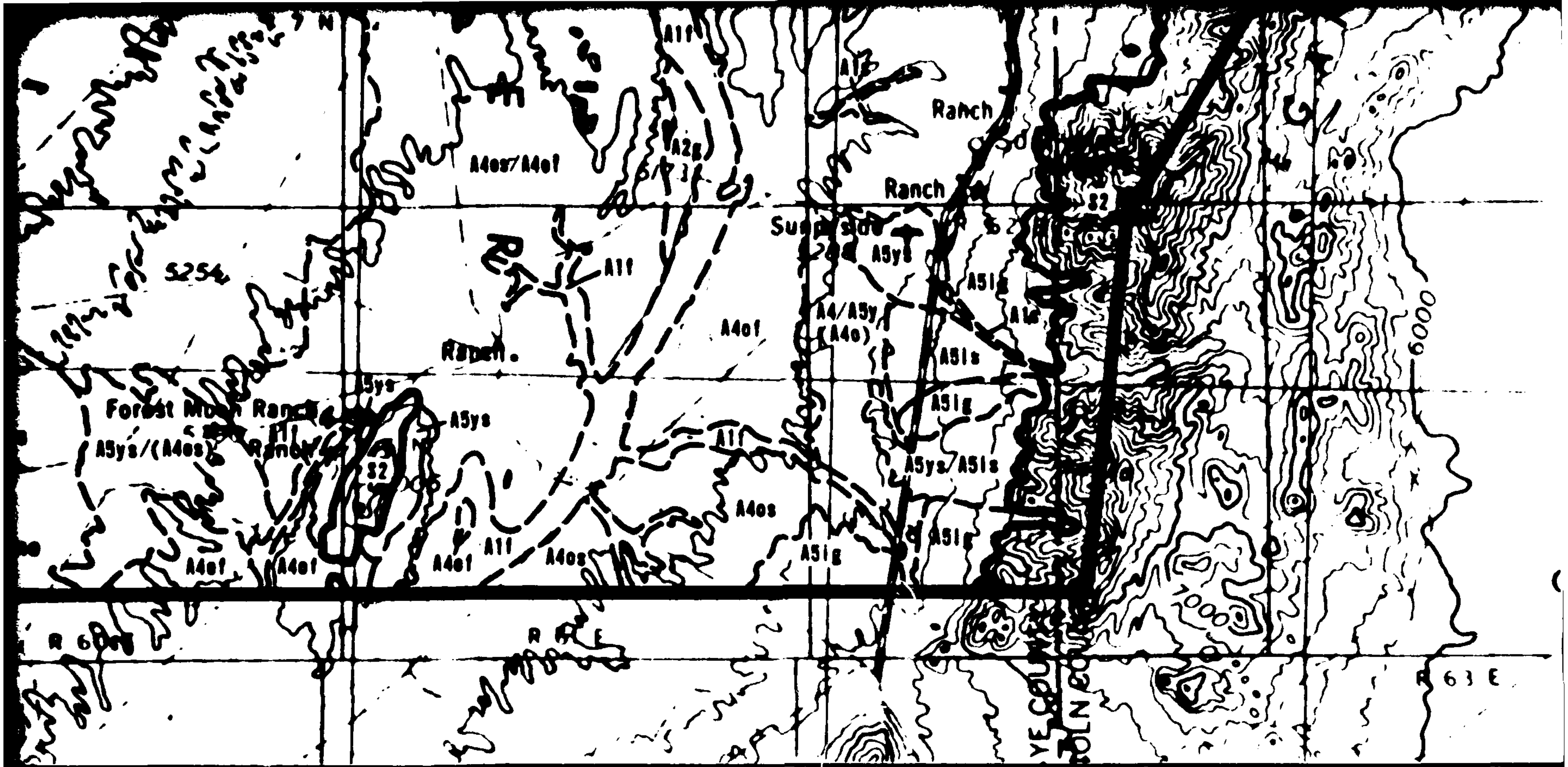
FUGRO NATIONAL, INC.



LUND
A5ls
A1f
A5l(I2)
I4
I2
A2s
A4bf
A5ys
A5ls
A4os/A4of
A5l(S2)
S2
A1s
5500
A5lg
A2
A5lc
WHITE PINE COUNTY
NYE COUNTY
A5ys(A5lg)
A4of
A5yf
A5ys/A4of
W
H
I
N
A5yf
A1f
A2s
Water



S2
8000
7000
6000
A5ys
A5ls
A4of
A4os/A4of
A5l/A5ys
A5y/A4of
A5ls/A5ls
Water
I T E R I



ATION

N-FILL UNITS

nnel and flood-plain deposits of A1f, sandy clay
and gravelly sand (SM,SP).

l and flood-plain deposits in terraces composed
); and A2g, sandy gravel (GP).

nd abandoned shoreline deposits of
A4os, weakly cemented silty sand (SM).

r alluvial fan deposits of: A5yf, sandy silt (ML);
A5yg, sandy gravel (GM,GP).

alluvial fan deposits of: A5yf, sandy silt (ML);
A5yg, sandy gravel (GM,GP).

, intermediate-age alluvial fan deposits of: A5is, weakly
5ig, weakly cemented sandy gravel (GP,GM); A5ic, weakly
percent cobbles

NITS

site flows and plugs

interbedded shale

ates a mixture of either surficial basin-fill

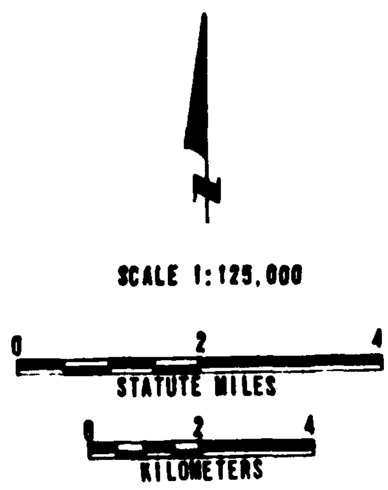
shallow depth.

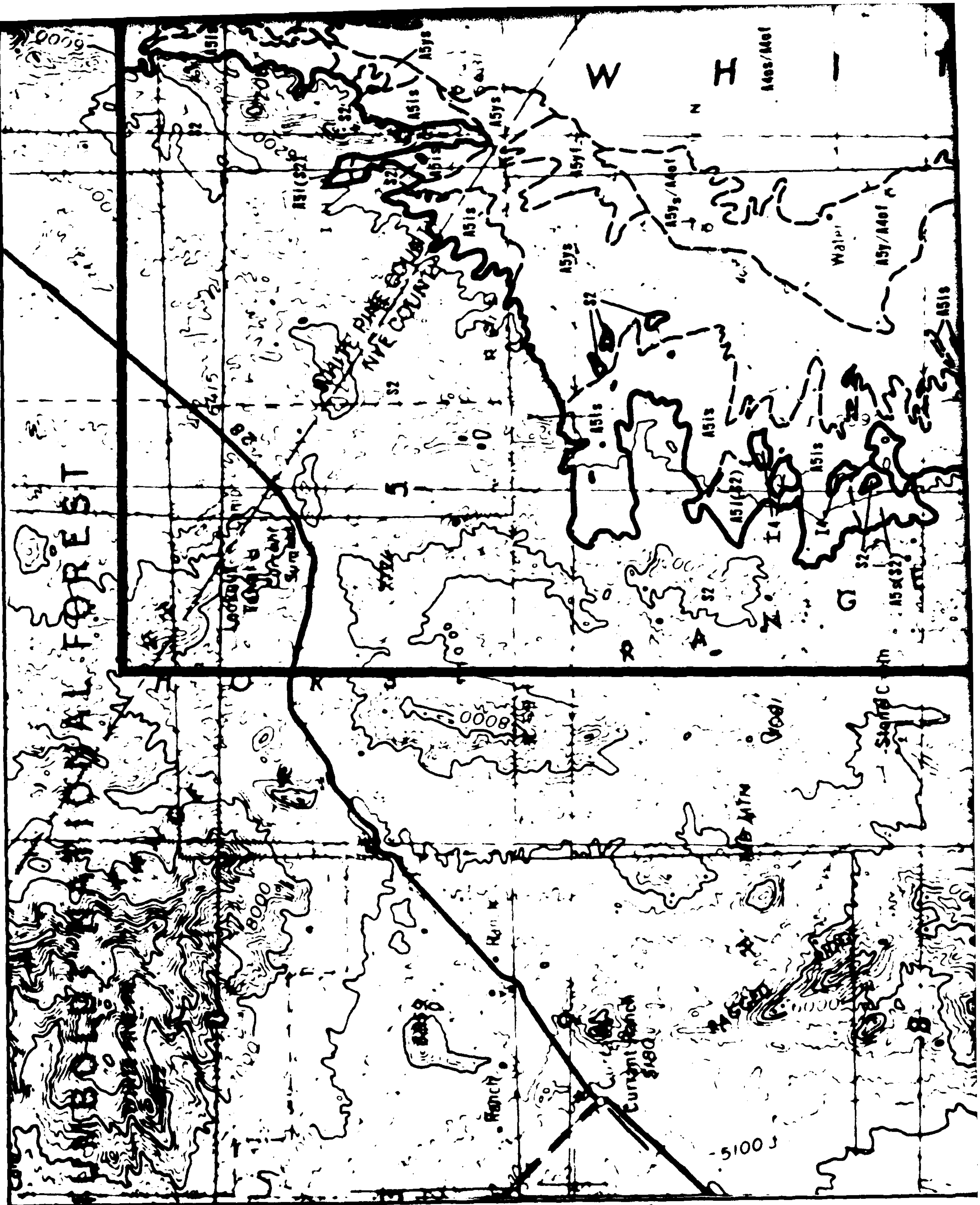
OLS

ock units.
offsetting surficial basin-fill deposits,

e upper several feet of soil. Due to variability of
descriptions refer to the predominant soil types.
pected within each geologic unit.
e presented in Volume X, Drawing 1. A tabulation of
of all geologic units is included in Volume X.

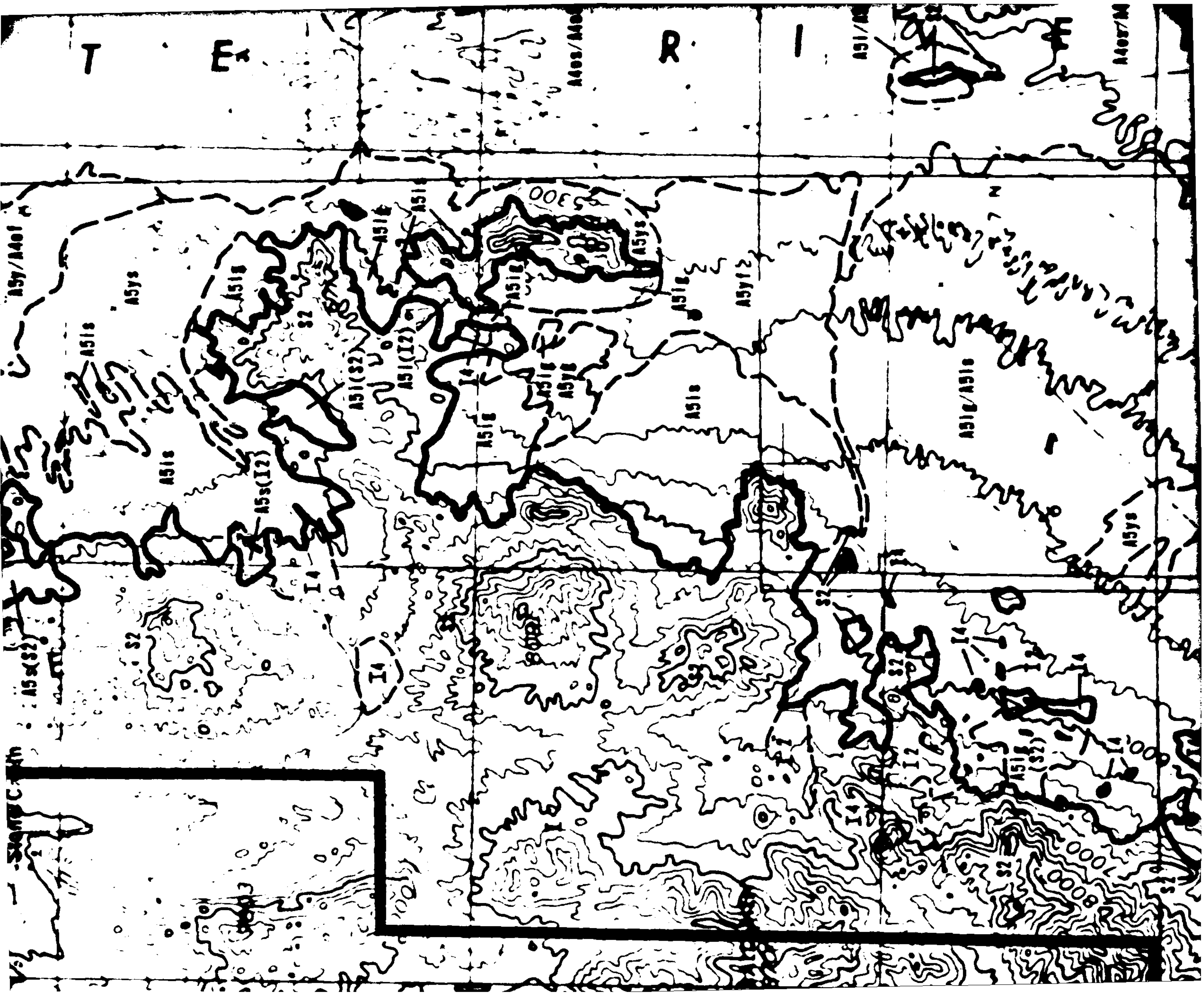
nd Blake (1970), Kleinhampl and Ziony (1967), Techenz

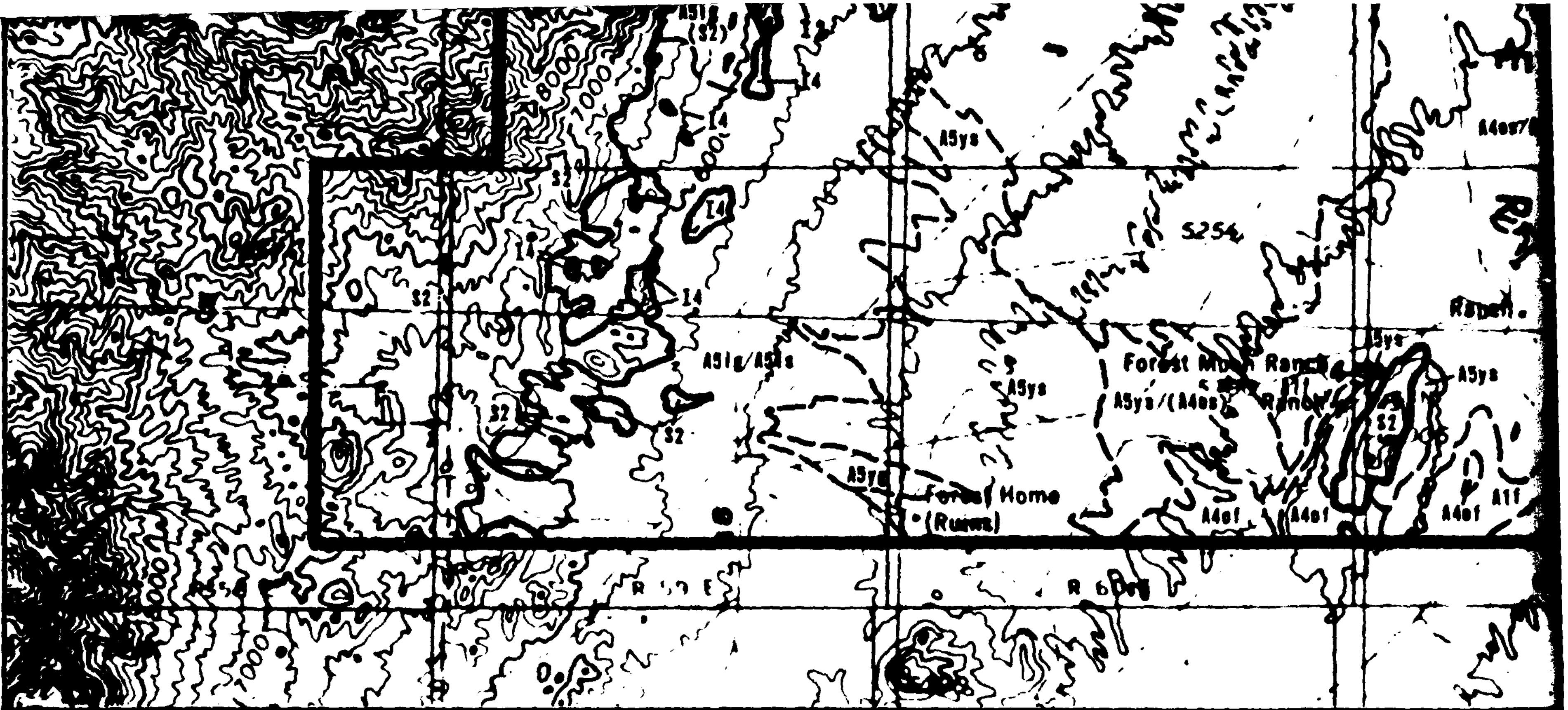




2 JUL 78

4


T
E
R
I
A5ys
A5ls
S2
A5l(S2)
A5l(I2)
A5s(I2)
A5yI2
I4
I2
5300



EXPLANATION

SURFICIAL BASIN-FILL UNITS

A1f **A1s** Younger Fluvial Deposits - Modern stream channel and flood-plain deposits of A1f, sandy clay and sandy silt (CL,ML), and A1s, silty sand and gravelly sand (SM,SP).

A2s **A2g** Older Fluvial Deposits - Older stream channel and flood-plain deposits in terraces composed of; A2s, silty sand and gravelly sand (SM,SP); and A2g, sandy gravel (GP).

A4of **A4os** Older Lacustrine Deposits - Older bed lake and abandoned shoreline deposits of A4of, sandy silt and sandy clay (CL,ML); and A4os, weakly cemented silty sand (SM).

A5yf **A5ys** **A5lg** Younger Alluvial Fan Deposits-Active, younger alluvial fan deposits of: A5yf, sandy silt (ML); A5ys, silty sand and gravelly sand (SM); and A5yg, sandy gravel (SM,SP).

A5yf / A5ys / A5yg — Younger Alluvial Fan Deposits-Active, younger alluvial fan deposits of: A5yf, sandy silt (ML); A5ys, silty sand and gravelly sand (SM); and A5yg, sandy gravel (GM,GP).

A5is / A5ig / A5ic — Intermediate Alluvial Fan Deposits - Inactive, intermediate-age alluvial fan deposits of: A5is, cemented silty sand and gravelly sand (SM); A5ig, weakly cemented sandy gravel (GP,GM); A5ic, cemented gravelly sand with greater than 30 percent cobbles

ROCK UNITS

Igneous (I)

I2 — Rhyolite, quartz latite, rhyodacite, and andesite flows and plugs

I4 — Welded ash-flow tuff

Sedimentary (S)

S1 — Orthoquartzite

S2 — Dolomite and limestone, locally cherty, with interbedded shale

A5ig/A5is Combination of geologic unit symbols indicates a mixture of either surficial basin-fill or rock units inseparable at map scale.

A5i (I2) Parenthetic unit underlies surface unit at shallow depth.

SYMBOLS

Contact between rock and basin-fill.

Contact between surficial basin-fill or rock units.

Fault, trace of surface rupture of faults offsetting surficial basin-fill deposits, ball on downthrown side.

NOTES:
1. Surficial basin-fill units pertain only to the upper several feet of soil. Due to variability of deposits and scale of map presentation, unit descriptions refer to the predominant soil types. Varying amounts of other soil types can be expected within each geologic unit.
2. The distribution of geologic data stations is presented in Volume II, Drawing 1. A tabulation of all station data and generalized description of all geologic units is included in Volume II, Section 1.0.
3. Geology in areas of exposed rock from Hose and Blake (1976), Kleinhampl and Ziony (1967), Tschanz and Pampeyan (1970).

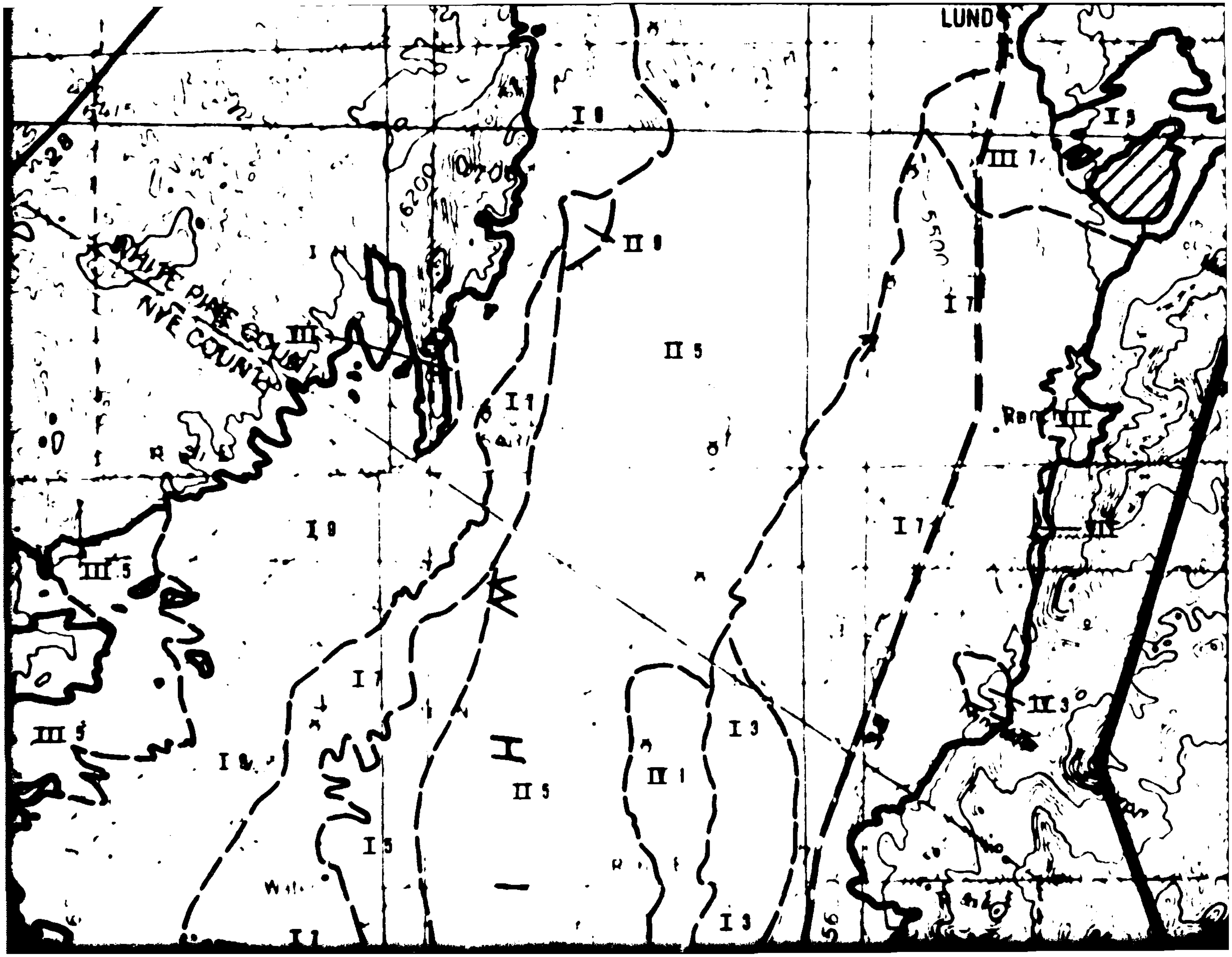
SURFICIAL GEOLOGIC UNITS
VERIFICATION SITE, WHITE RIVER CDP, NEVADA

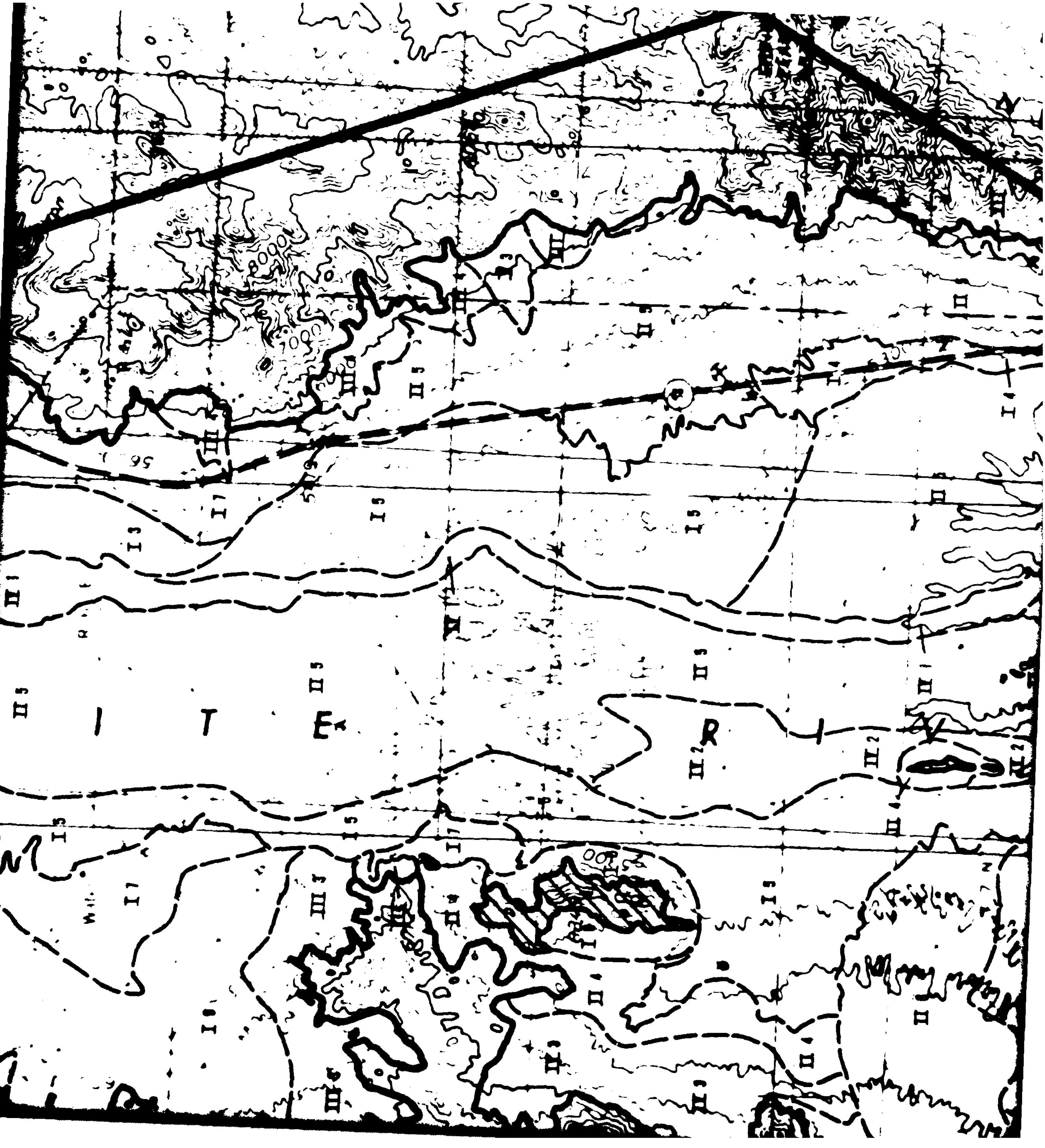
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

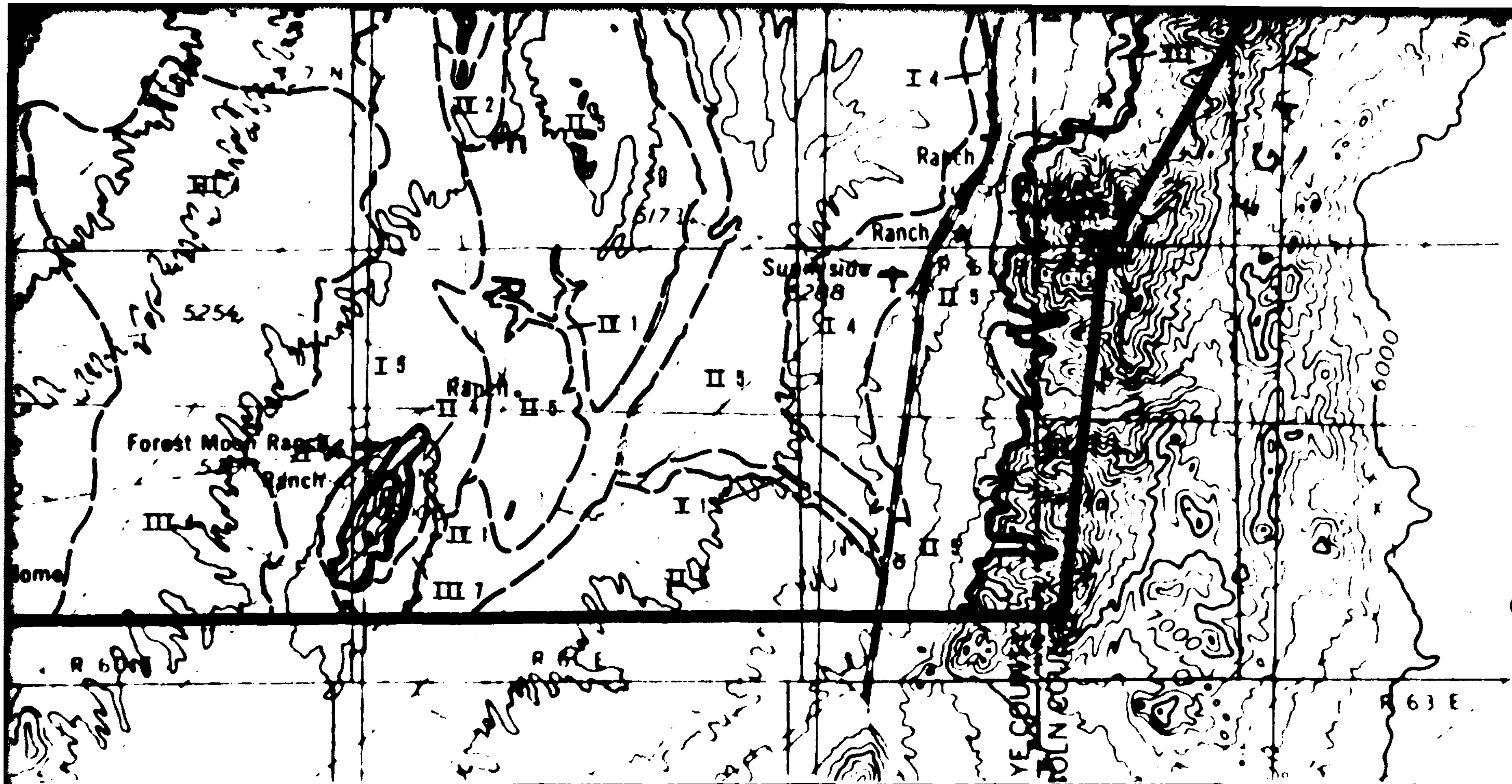
DRAWING 7-2

FUGRO NATIONAL, INC.

7


LUND
WHITE PINE COUNTY
NYE COUNTY
5500
6200
W
H
I





1

3

EXPLANATION

3 ------ Drainage spacing, i.e. the maximum number of drainages of the corresponding category occurring in a random traverse of one statute mile (1.6km)

DRAINAGE DEPTH/DESCRIPTION

Less than 3 feet (1m)

EXPLANATION

I 3------ Drainage spacing, i.e. the maximum number of drainages of the corresponding category occurring in a random traverse of one statute mile (1.6km)

DRAINAGE DEPTH/DESCRIPTION

Less than 3 feet (1m)

3-6 feet (1-2m)

6-10 feet (2-3m)

10-15 feet (3-5m)

Greater than 15 feet (5m)
Complex, highly variable terrain not defined by drainage incision (e.g. dunal or hummocky terrains).

Unsuitable terrain
(see Appendix A2.0. Exclusion Criteria)

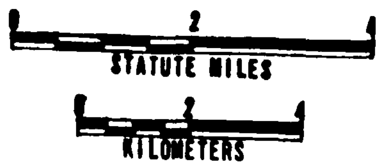
errain categories

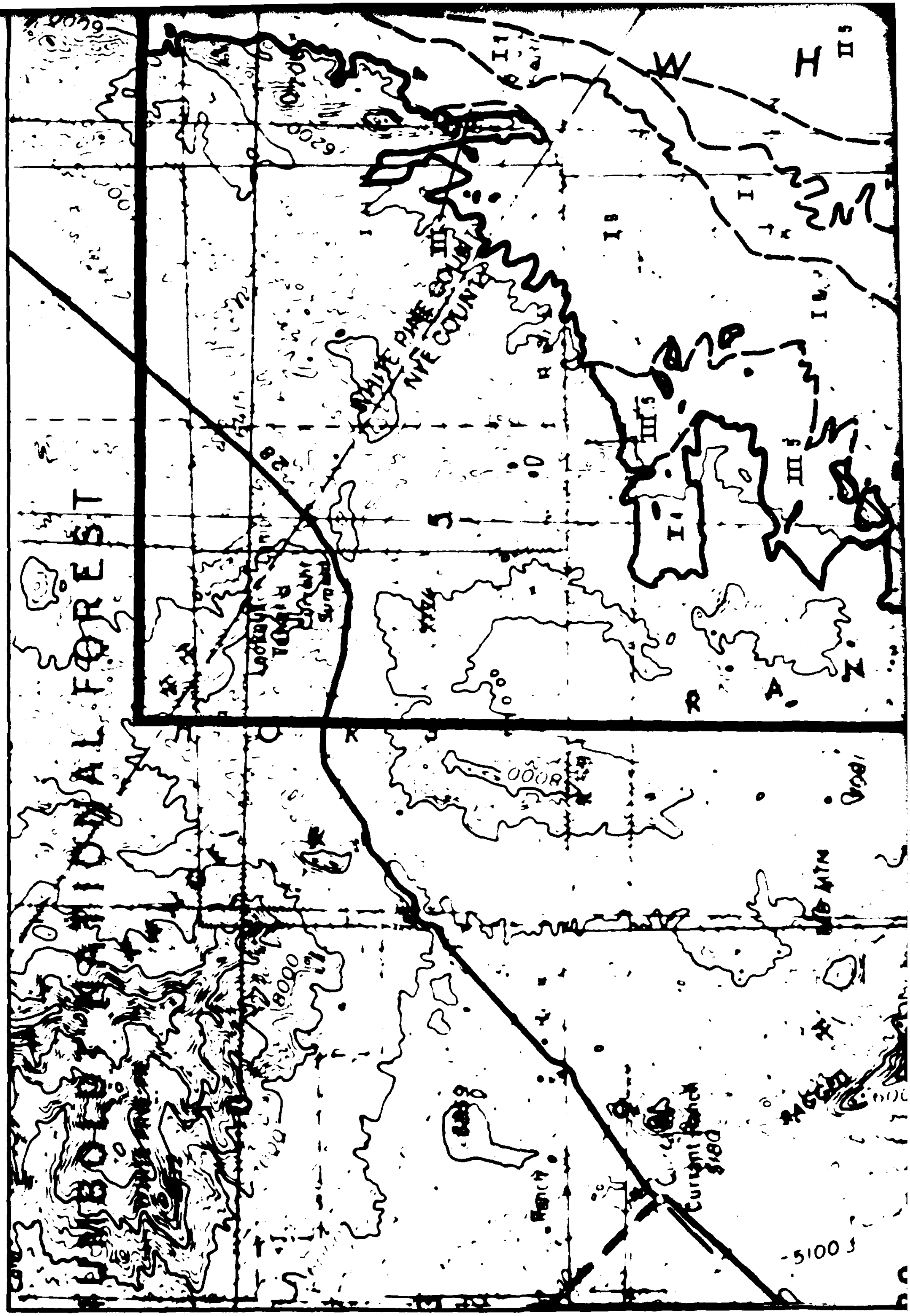
ock and basin-fill

areas of isolated exposed rock.

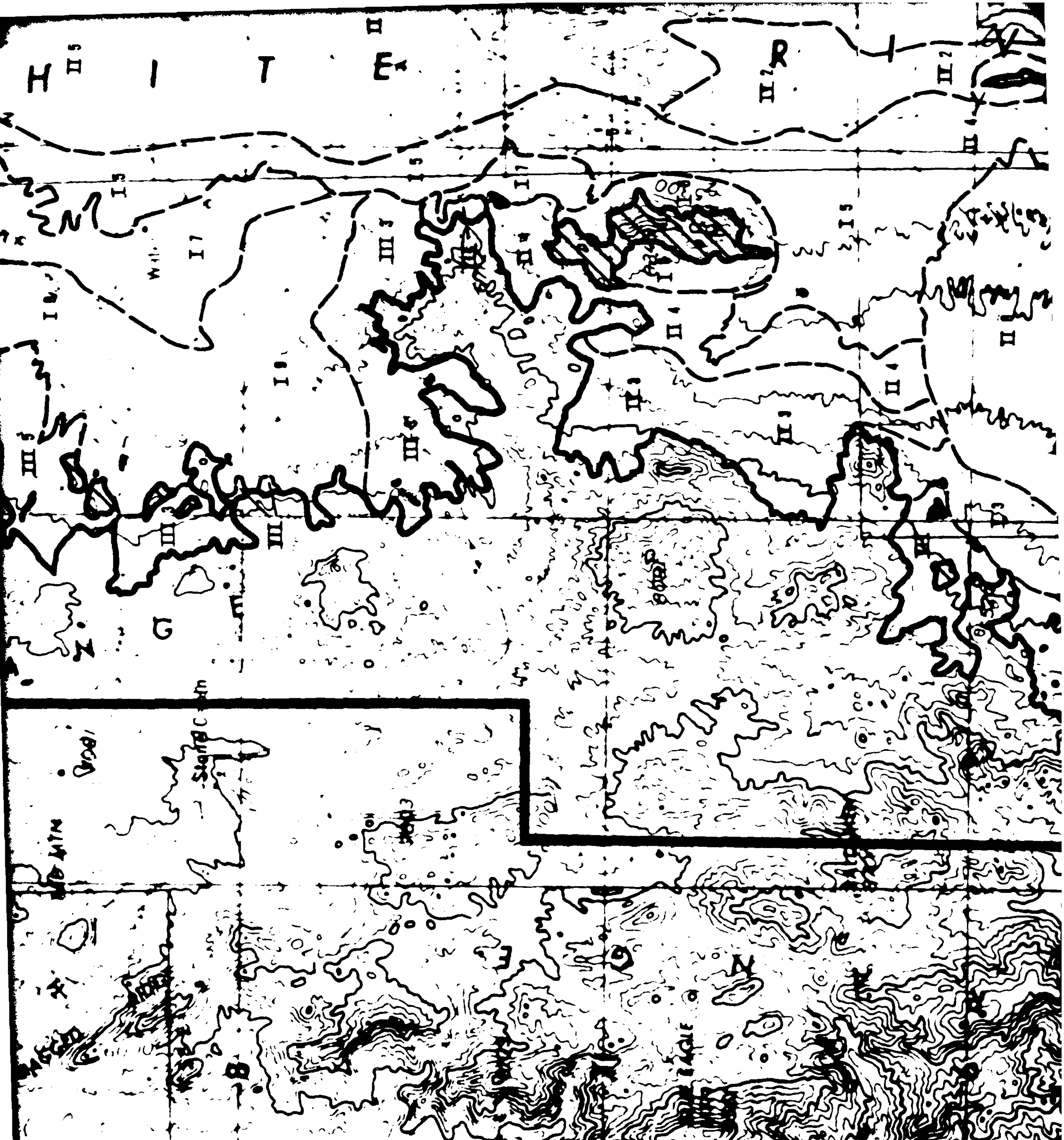
constructing this map are from: (1) field observations, USGS topographic maps, and (3) 1:60,000 and 1:25,000 raphs. Due to scale of presentation and variability of tions, this map is generalized.

SCALE 1:125,000

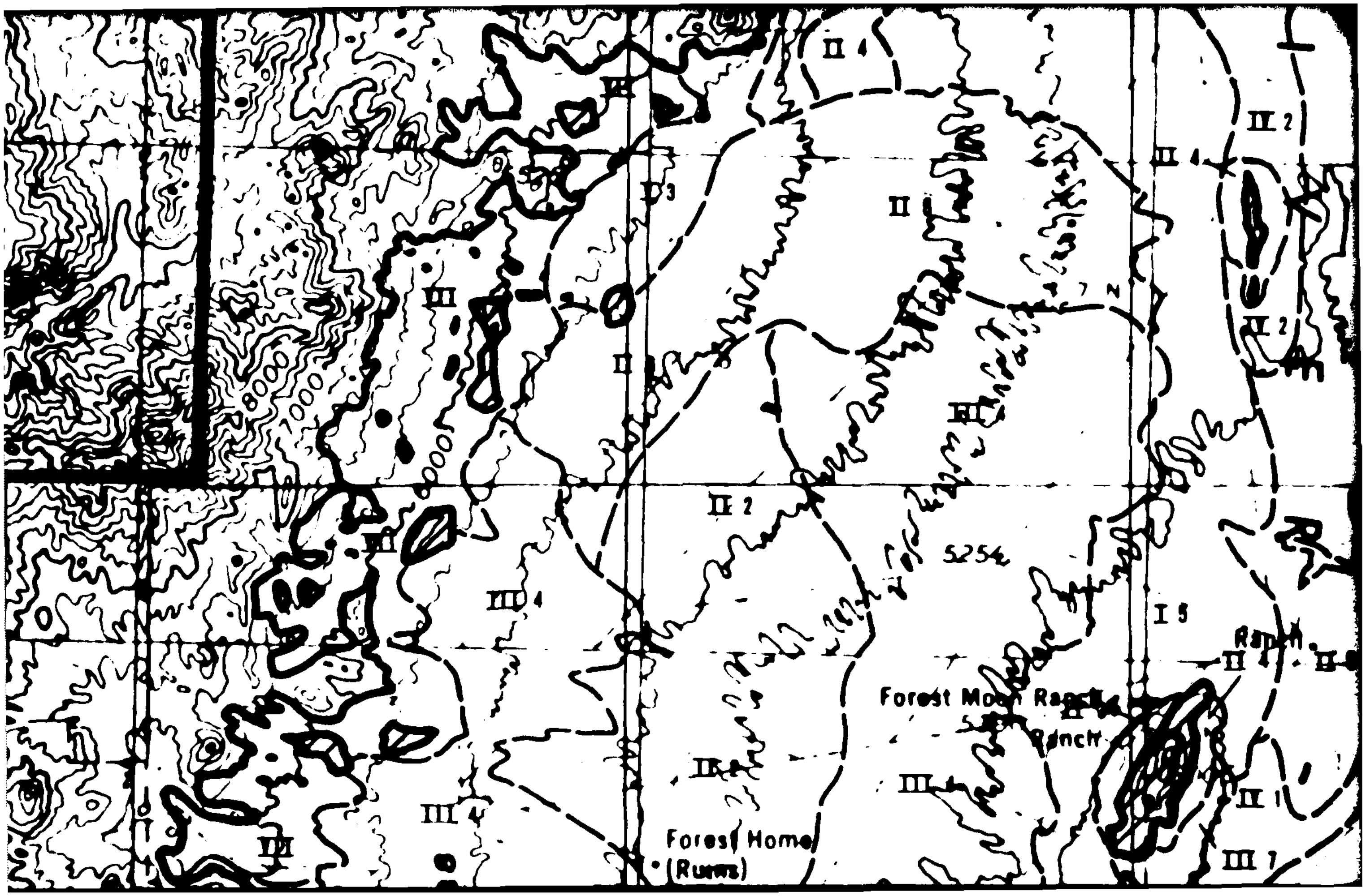



HUMBOLDT NATIONAL FOREST
WHITE PINE COUNTY
NYE COUNTY
Currant Ranch
5180
RAGGED
8000
-5100

2 JUL 79



1 6


Forest Moon Ranch
Ranch
Forest Home
(Ruins)
5254
8000
7000
10000

EXPLANATION

Terrain Category (see table below) ------ III 3 ------ Drainage spacing, i.e. the maximum number of drainages of the corresponding category occurring in a random traverse of one statute mile (1.6km)

TERRAIN CATEGORY	DRAINAGE DEPTH/DESCRIPTION
I	Less than 3 feet (1m)
II	3-6 feet (1-2m)
III	6-10 feet (2-3m)
IV	10-15 feet (3-5m)
V	Greater than 15 feet (5m)
VI	Complex, highly variable terrain not defined by drainage incision (e.g. dunal or hummocky terrains).
VII	Unsuitable terrain (see Appendix A2.0, Exclusion Criteria)

— — Contact between terrain categories

—— Contact between rock and basin-fill

Shading indicates areas of isolated exposed rock.

NOTE: Data used in constructing this map are from: (1) field observations, (2) 1:62,500 USGS topographic maps, and (3) 1:60,000 and 1:25,000 aerial photographs. Due to scale of presentation and variability of terrain conditions, this map is generalized.

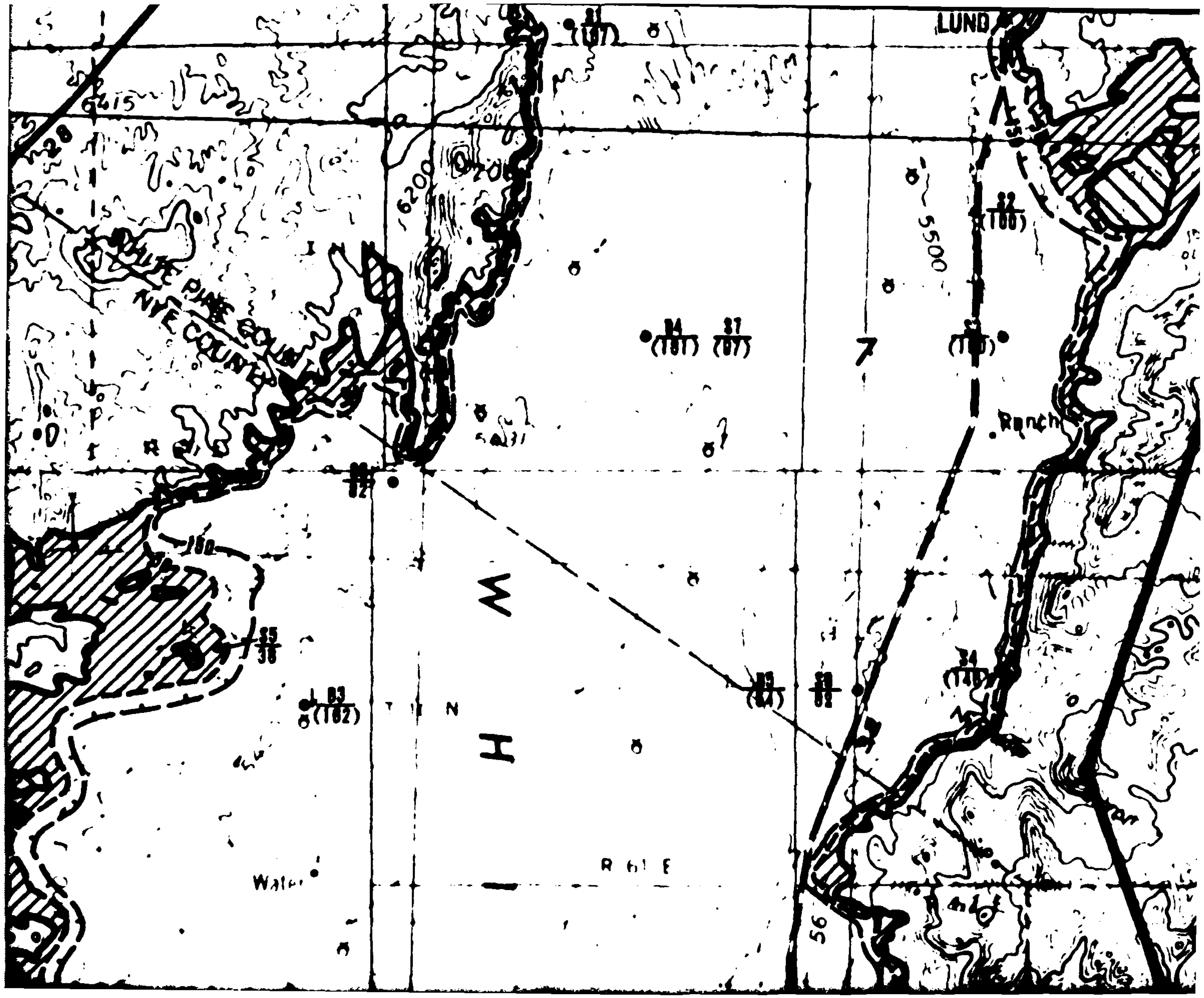
TERRAIN
VERIFICATION SITE, WHITE RIVER CDP, NEVADA

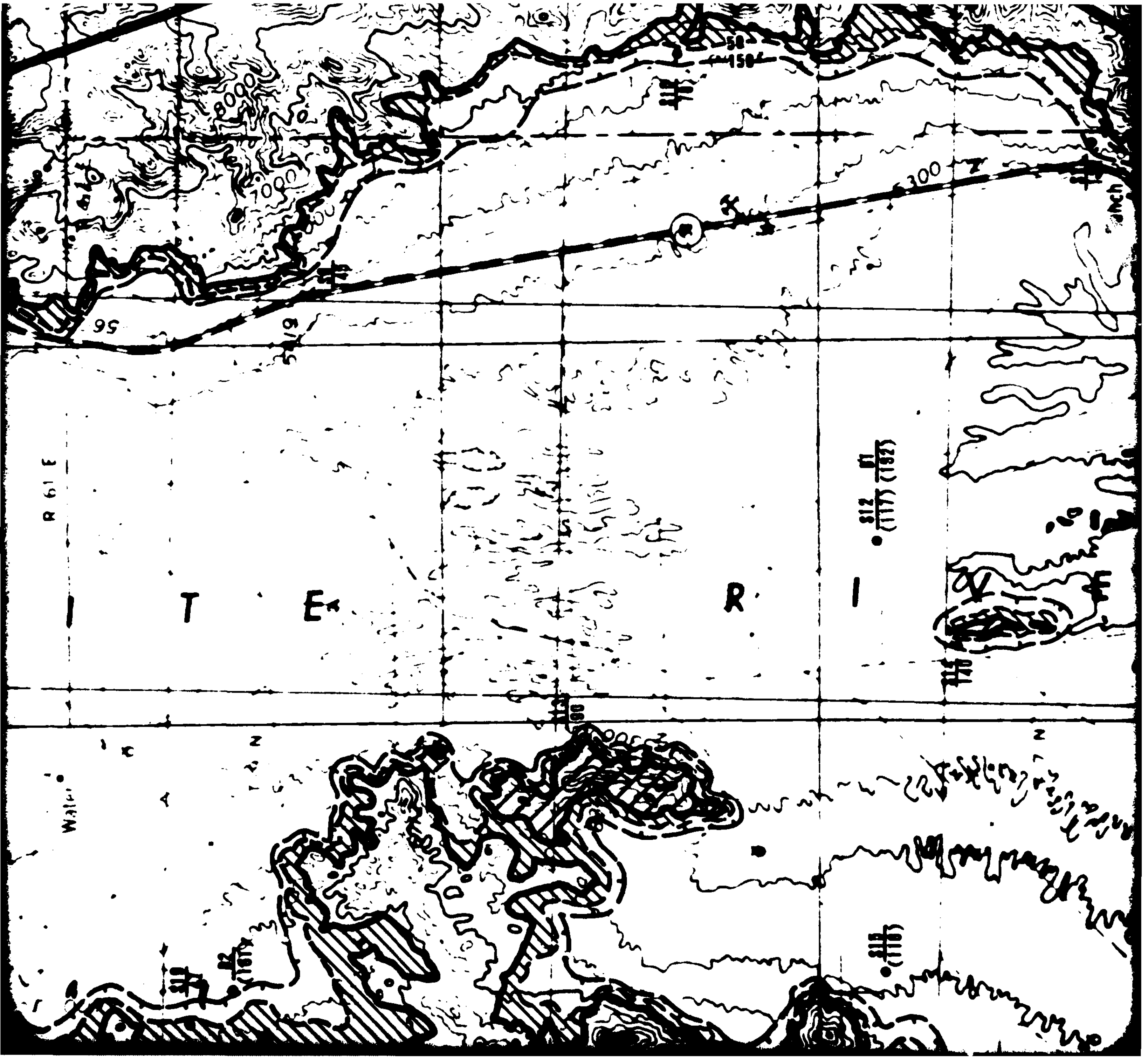
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

DRAWING 7-3

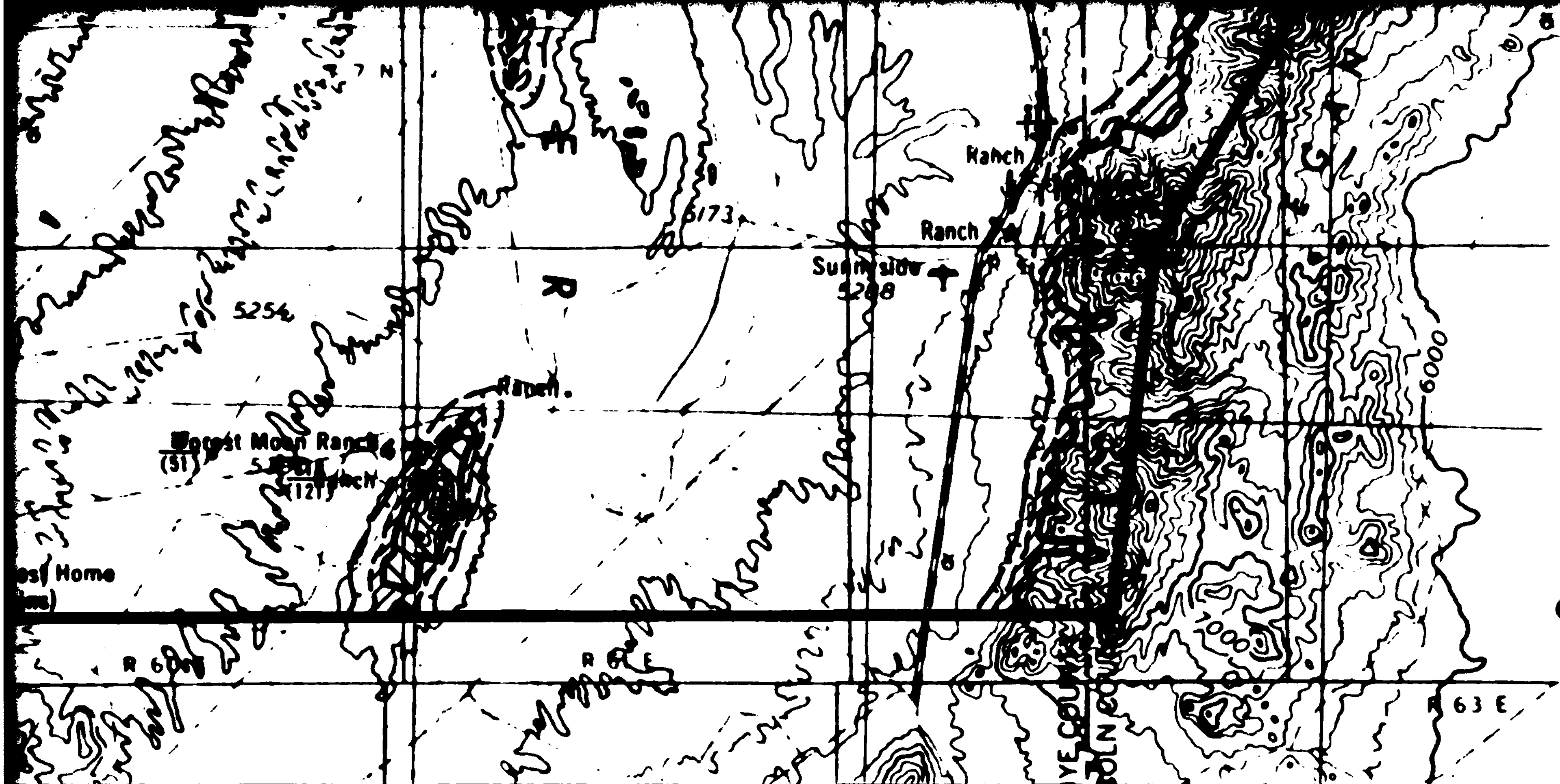
FUGRO NATIONAL, INC.

8


LUND
WHITE PINE COUNTY
NYE COUNTY
5500
6200
6215
Ranch
W
H
Water



8000
7000
300
R 61 E
Water



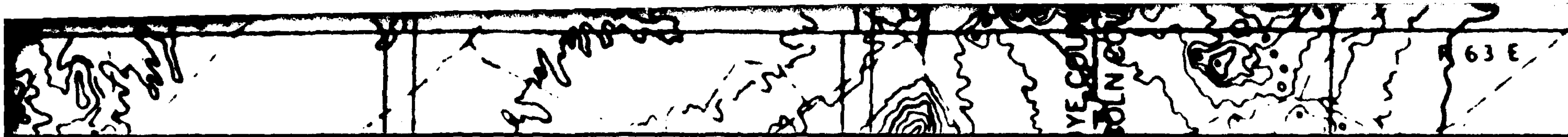
1 3

TION

rock at a depth of approximately
shading indicates rock less
).

rock at a depth of approximately
hachuring indicates rock less
).

and basin-fill.



TION

ock at a depth of approximately
hading indicates rock less
).

ock at a depth of approximately
hachuring indicates rock less
m).

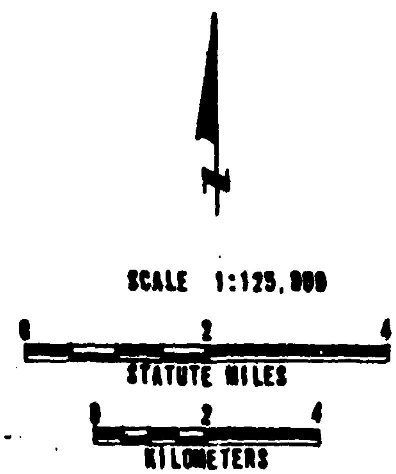
k and basin-fill.

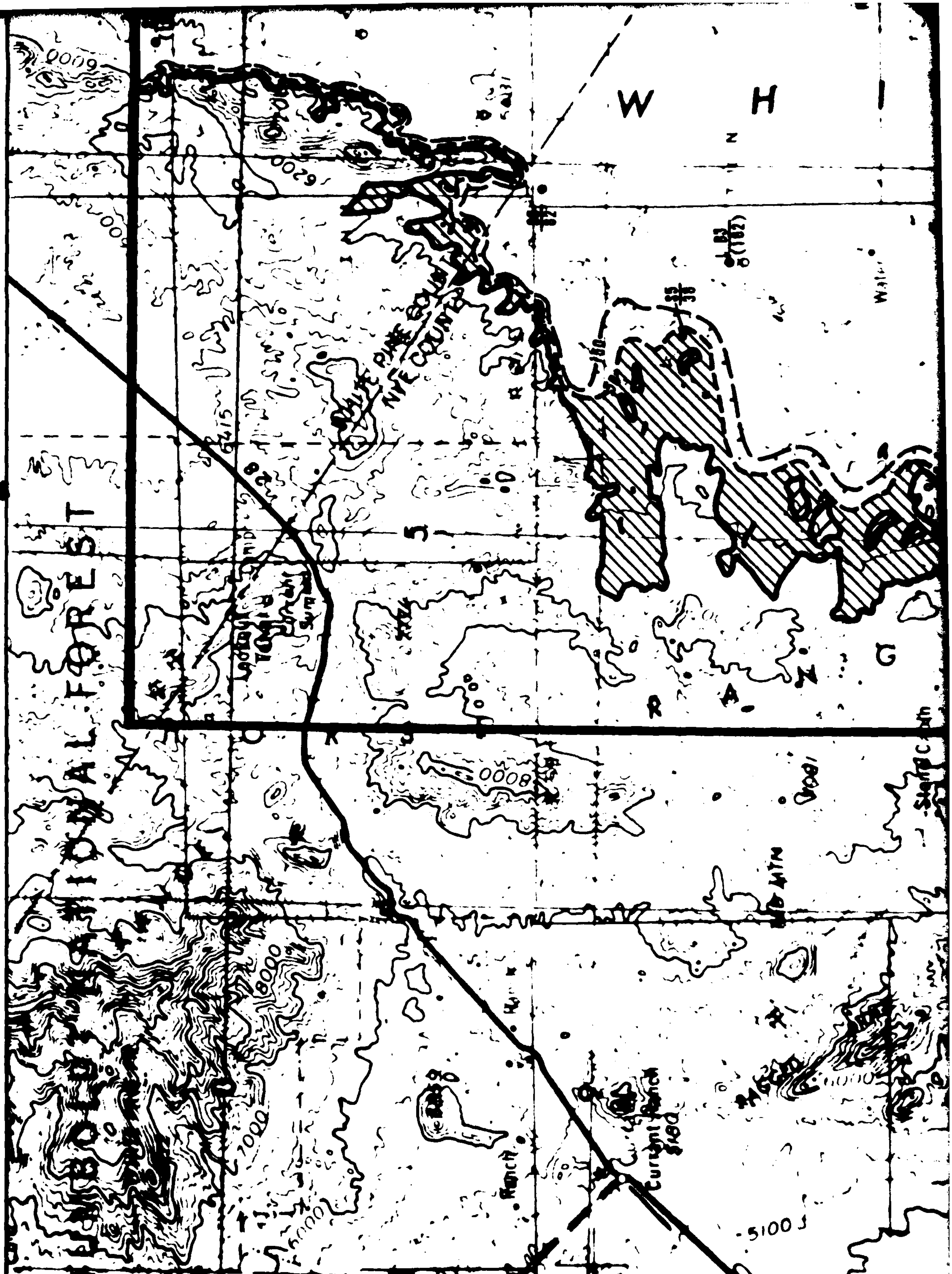
reas of isolated exposed rock.

boring (B), seismic refraction
al resistivity sounding (R).

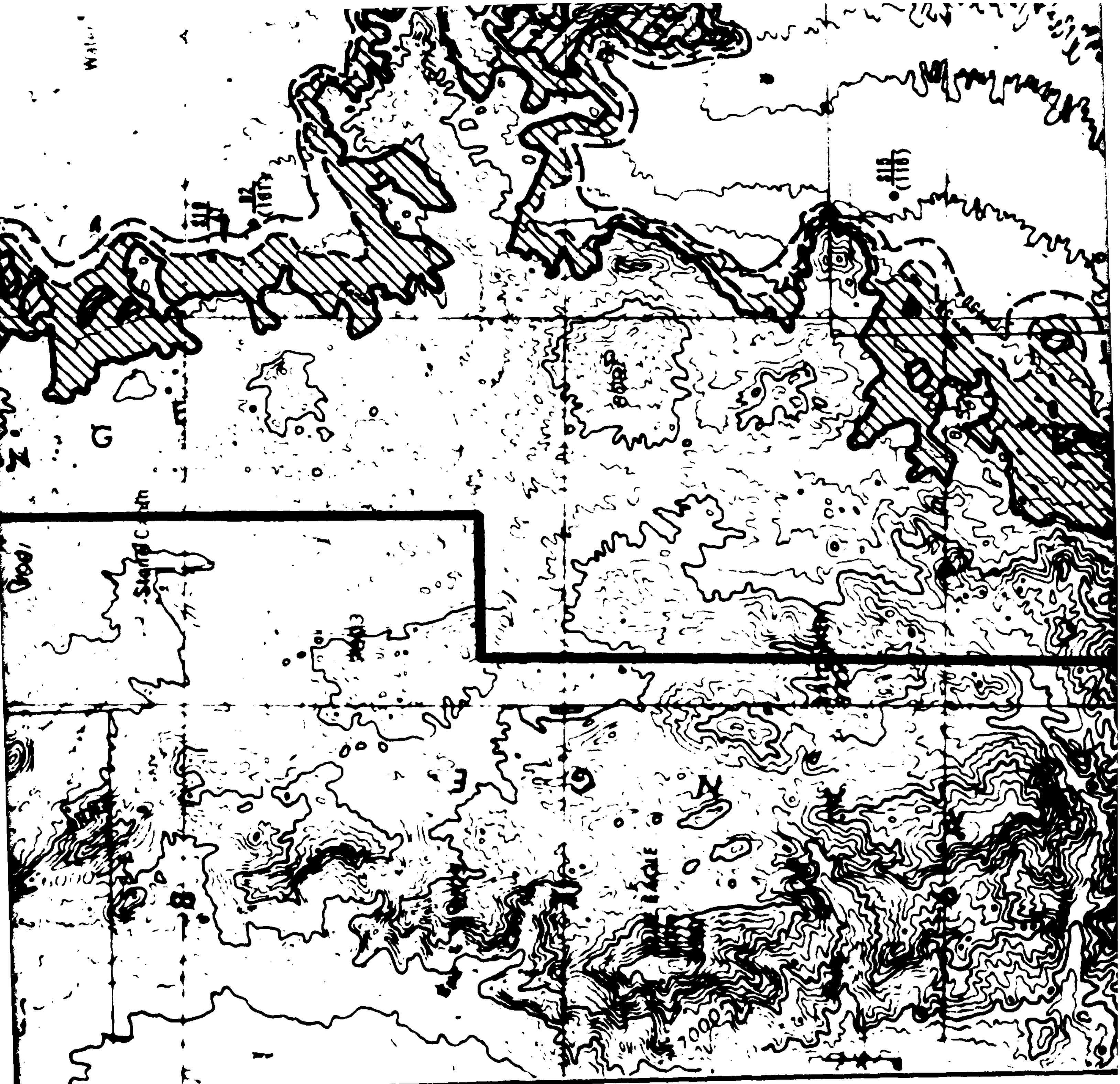
) or, when in parentheses, depth
does not occur (feet)

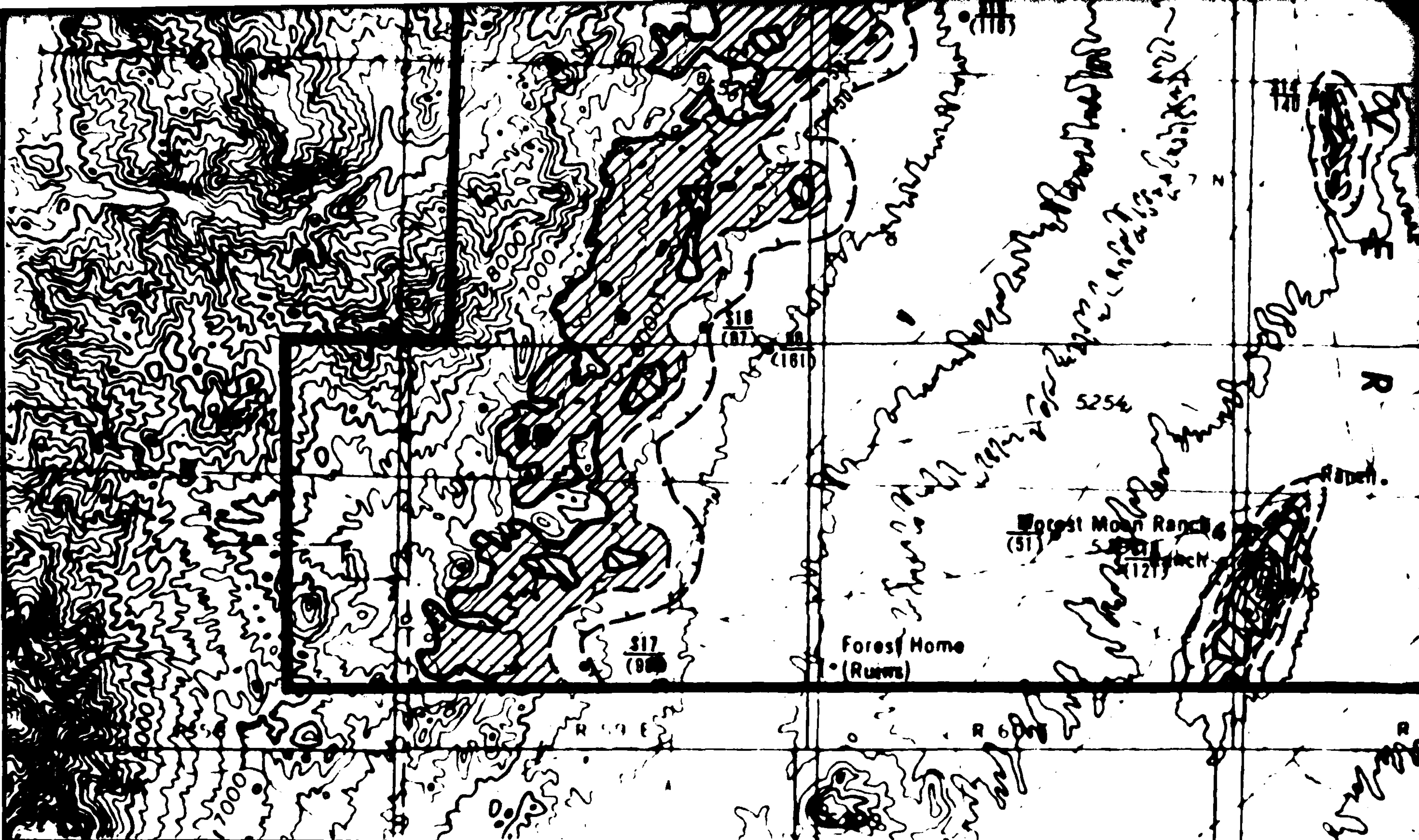
e based on geologic interpretations
data points shown on the map. Some
our locations can be expected as
are obtained.



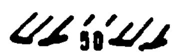

W H I
R A N G
NATIONAL FOREST
WHITE PINE COUNTY
NYE COUNTY
6200
8000
7000
6000
5100
Currant Ranch
Ranch

2 JUL 70

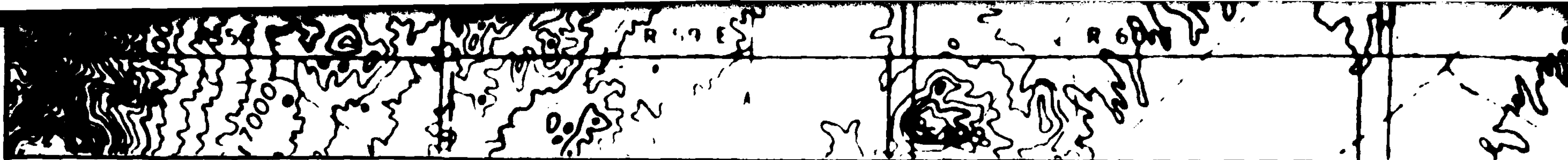




EXPLANATION

 Contour indicates rock at a depth of approximately 50 feet (15m) - shading indicates rock less than 50 feet (15m).

Contour indicates rock at a depth of approximately



EXPLANATION

- 50 — Contour indicates rock at a depth of approximately 50 feet (15m) - shading indicates rock less than 50 feet (15m).
- 150 — Contour indicates rock at a depth of approximately 150 feet (46m) - hachuring indicates rock less than 150 feet (46m).
- Contact between rock and basin-fill.
- Shading indicated areas of isolated exposed rock.
- • S4/75 — Data Source - Fugro boring (B), seismic refraction line (S), electrical resistivity sounding (R), or water well (W). / Depth to rock (feet) or, when in parentheses, depth above which rock does not occur (feet)

NOTE: The contours are based on geologic interpretations and the limited data points shown on the map. Some changes in contour locations can be expected as additional data are obtained.

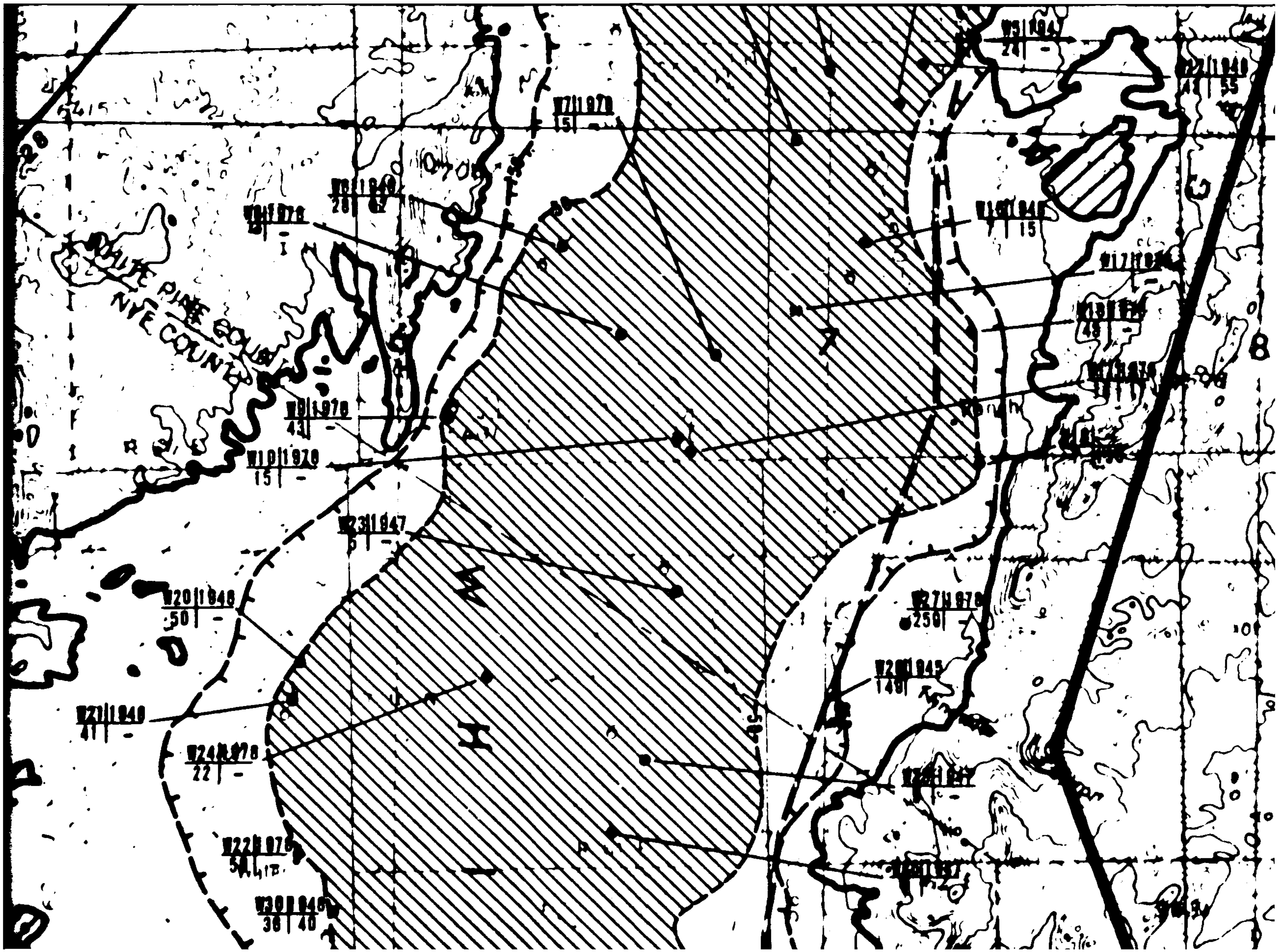
DEPTH TO ROCK
VERIFICATION SITE, WHITE RIVER COP. NEVADA

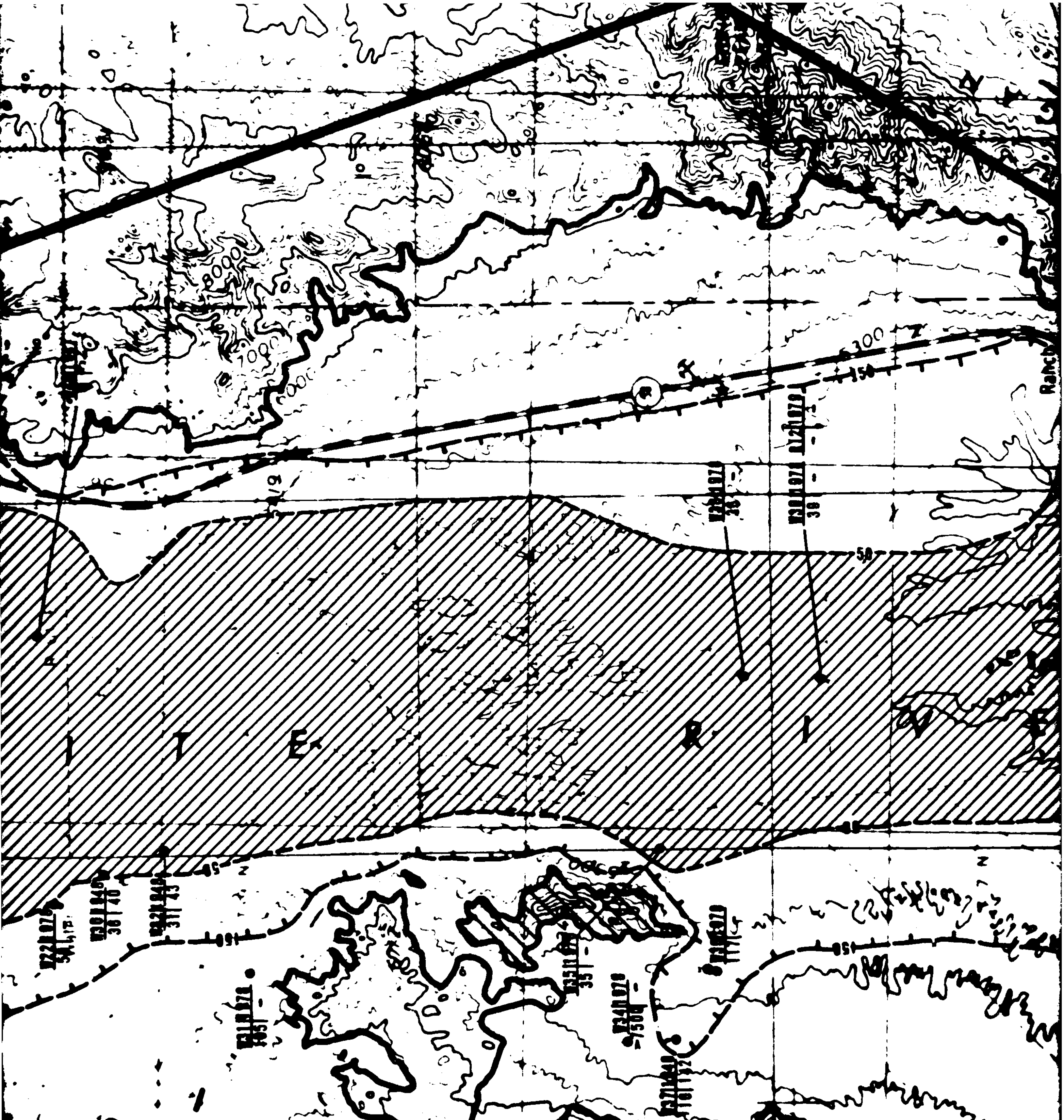
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

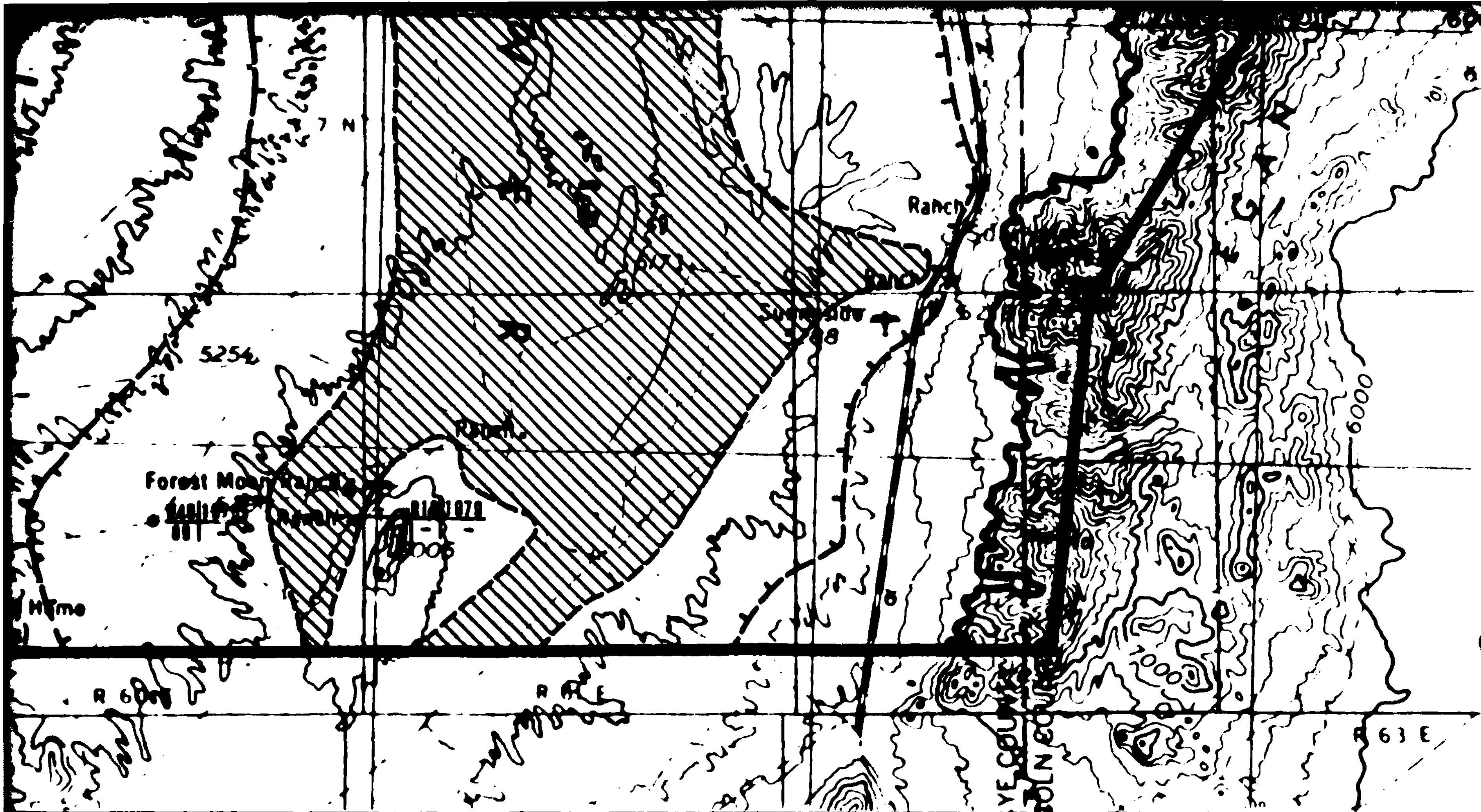
DRAWING
7-4

FUGRO NATIONAL, INC.

8


WHITE PINE COUNTY
NYE COUNTY
W7 | 1970
15 | -
W10 | 1970
15 | -
W8 | 1970
43 | -
W23 | 1947
5 | -
W20 | 1946
50 | -
W21 | 1940
41 | -
W24 | 1978
22 | -
W30 | 1946
38 | 40
W5 | 1947
24 | -
W16 | 1946
7 | 15
W27 | 1978
250 | -
8





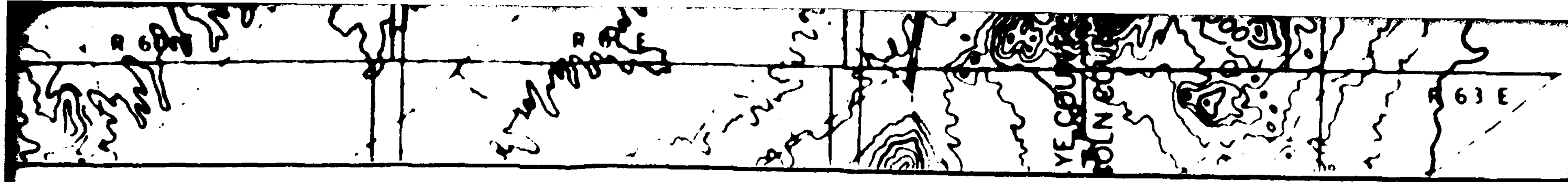
1

3

ATION

...ater at a depth of approximately
...indicates less than 50 feet (15m)

...ater at a depth of approximately
...g indicates less than 150 feet



NATION

water at a depth of approximately
indicates less than 50 feet (15m)

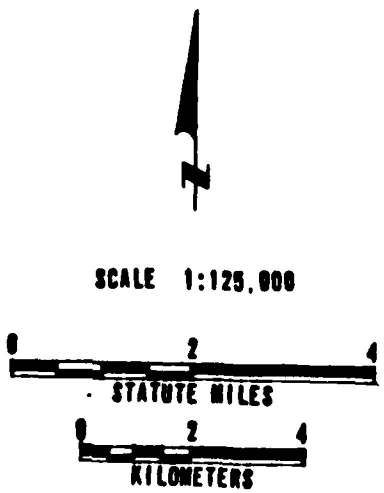
water at a depth of approximately
ing indicates less than 150 feet

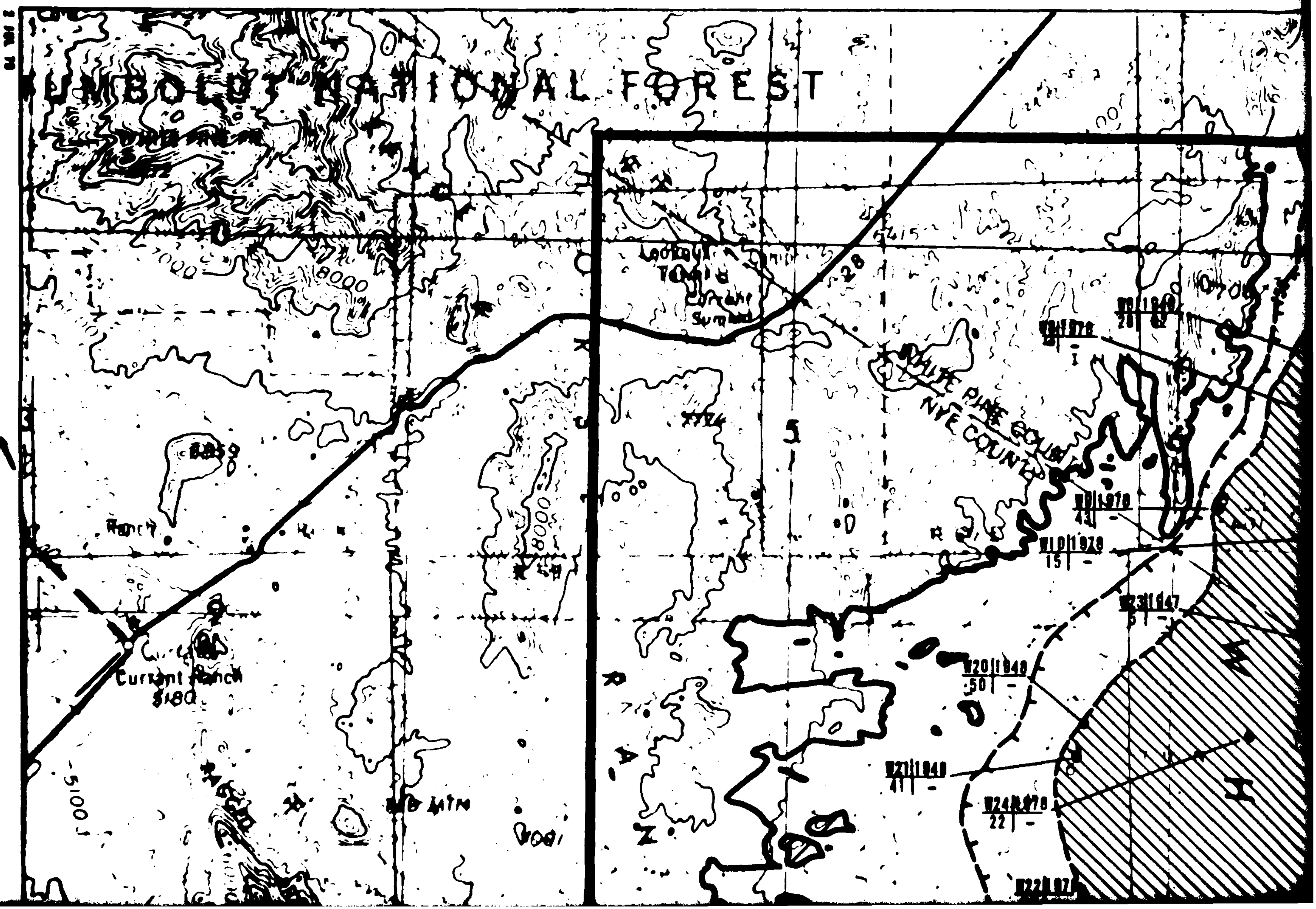
basin-fill.

of isolated exposed rock.

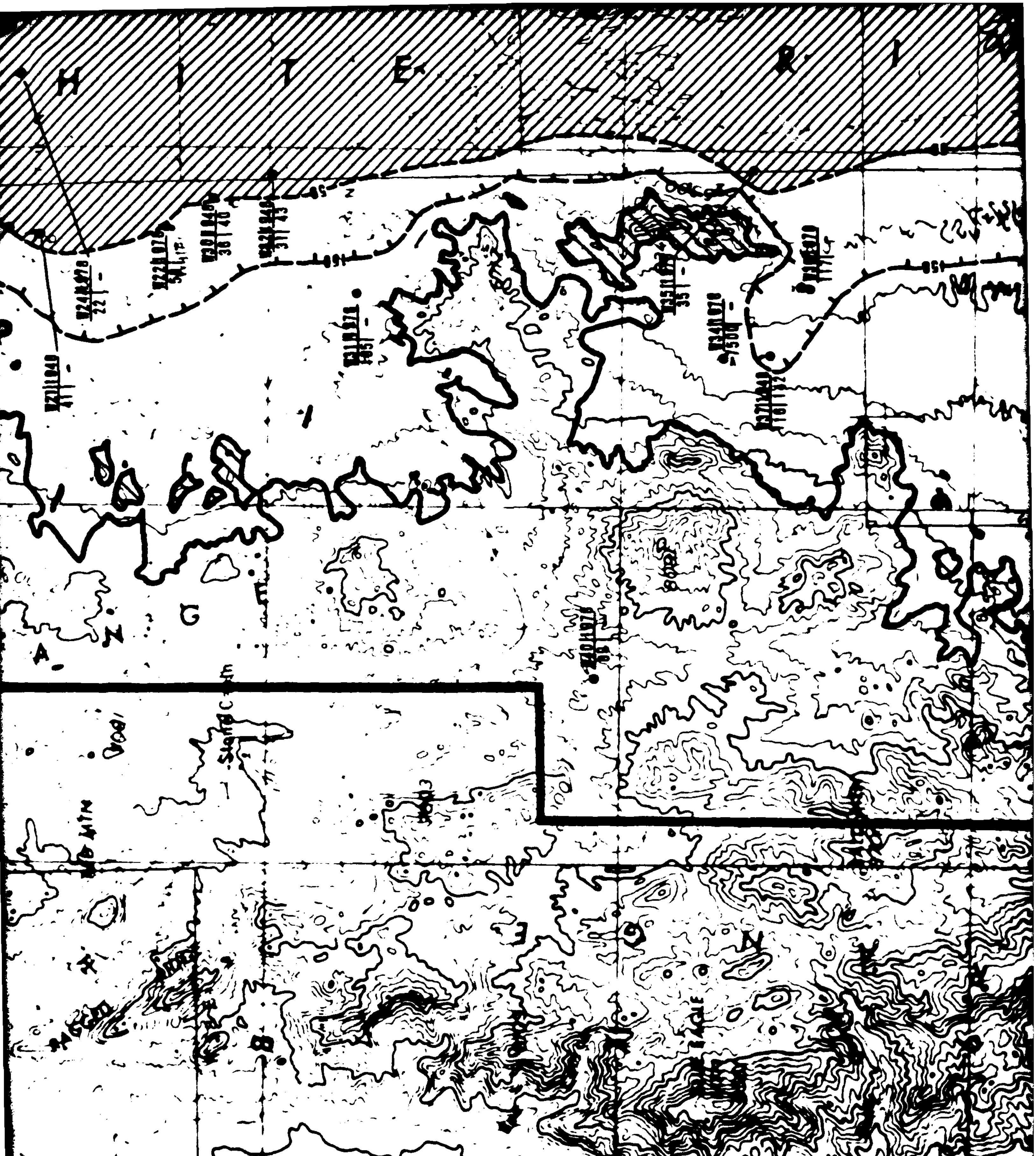
ing (S), seismic lectrical resistivity well (W); see Volume X.	Year of water level measurement
	Depth of well (feet)

sed entirely on the data points shown on the map.
ation has been used and it can be expected that
will change as additional data are obtained.

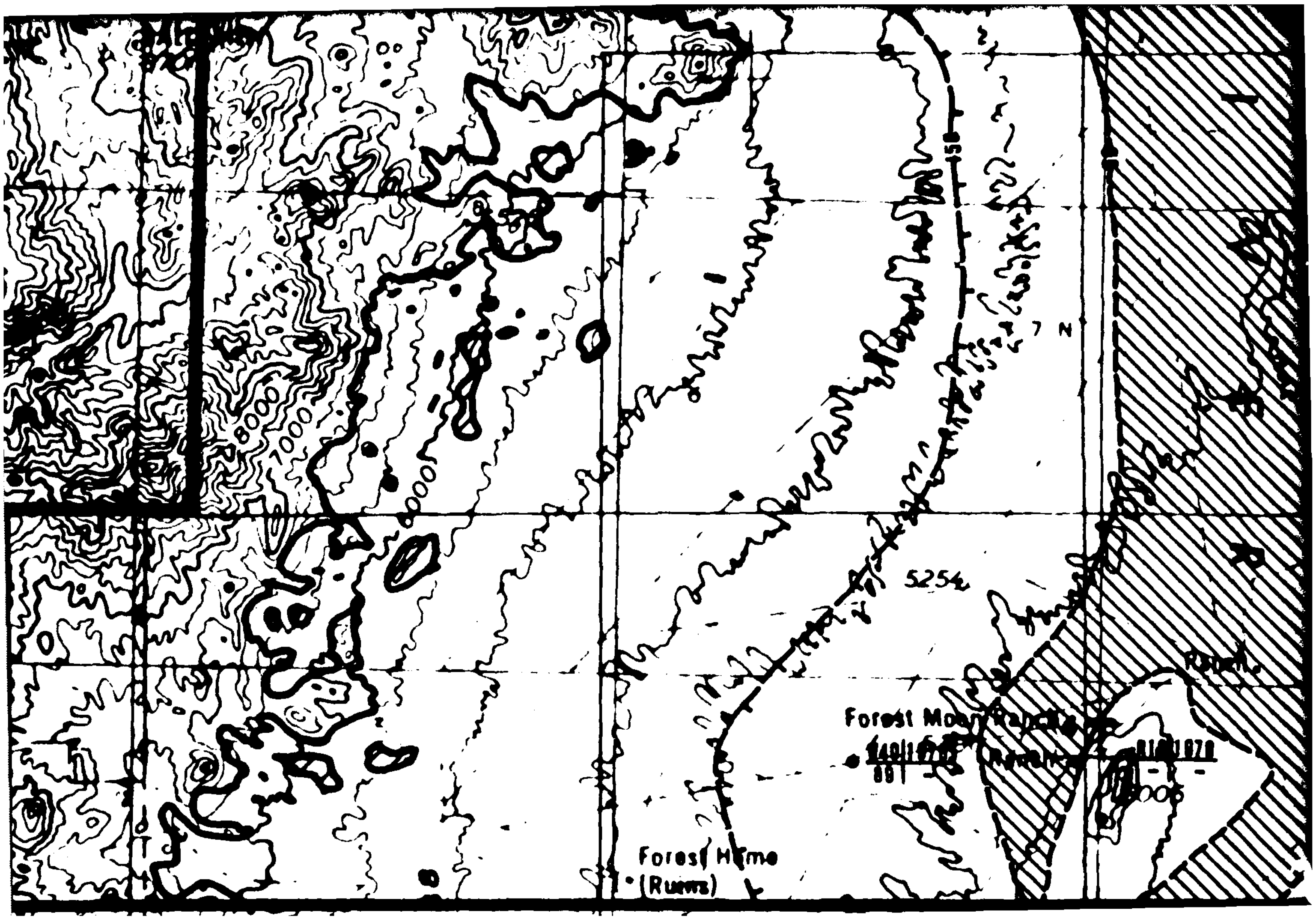



HUMBOLDT NATIONAL FOREST
WHITE PINE COUNTY
NYE COUNTY
Lookout Tower
Current Summit
28
6415
7000
8000
7774
8000
Ranch
Current Ranch
5180
-5100
R A Z
W20|1948
50|
W21|1948
41|
W24|1978
22|
W23|1947
W10|1978
15|
W11|1978
4|
H

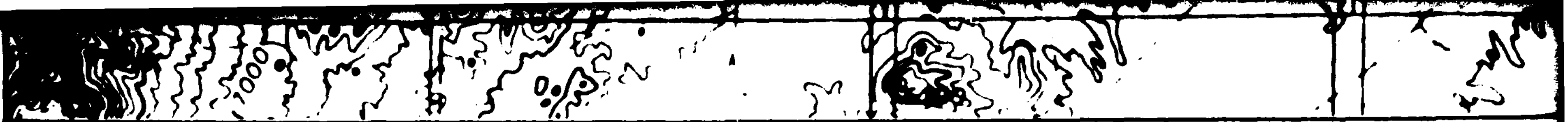
5



1 6



5254
Forest Home
(Ruins)



EXPLANATION

Symbol	Explanation
50 (hachured contour)	Contour indicates ground water at a depth of approximately 50 feet (15m). Shading indicates less than 50 feet (15m) to ground water.
— 150 —	Contour indicates ground water at a depth of approximately 150 feet (46m). Hachuring indicates less than 150 feet (46m) to ground water.
(line)	Contact between rock and basin fill.
(hatched area)	Shading indicates areas of isolated exposed rock.
W2 | 1973 / 75 | 700	Data Source - Fugro boring (B), seismic refraction line (S), electrical resistivity sounding (R), or water well (W); see Volume V, Section 2.0. — Year of water level measurement / Depth to water (feet) — Depth of well (feet)

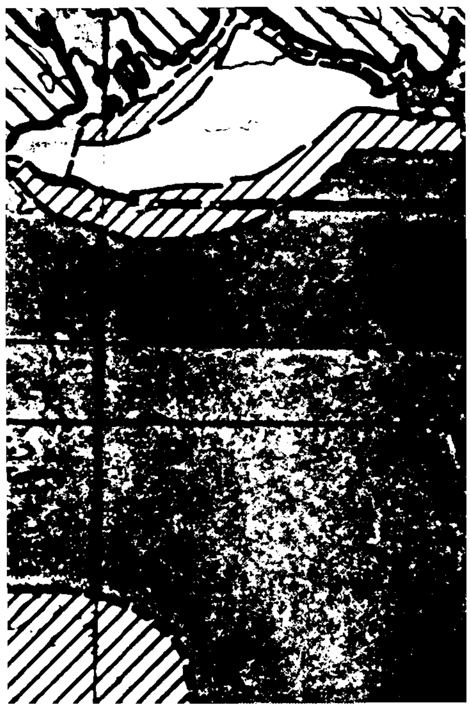
NOTE: The contours are based entirely on the data points shown on the map. Extensive interpolation has been used and it can be expected that contour locations will change as additional data are obtained.

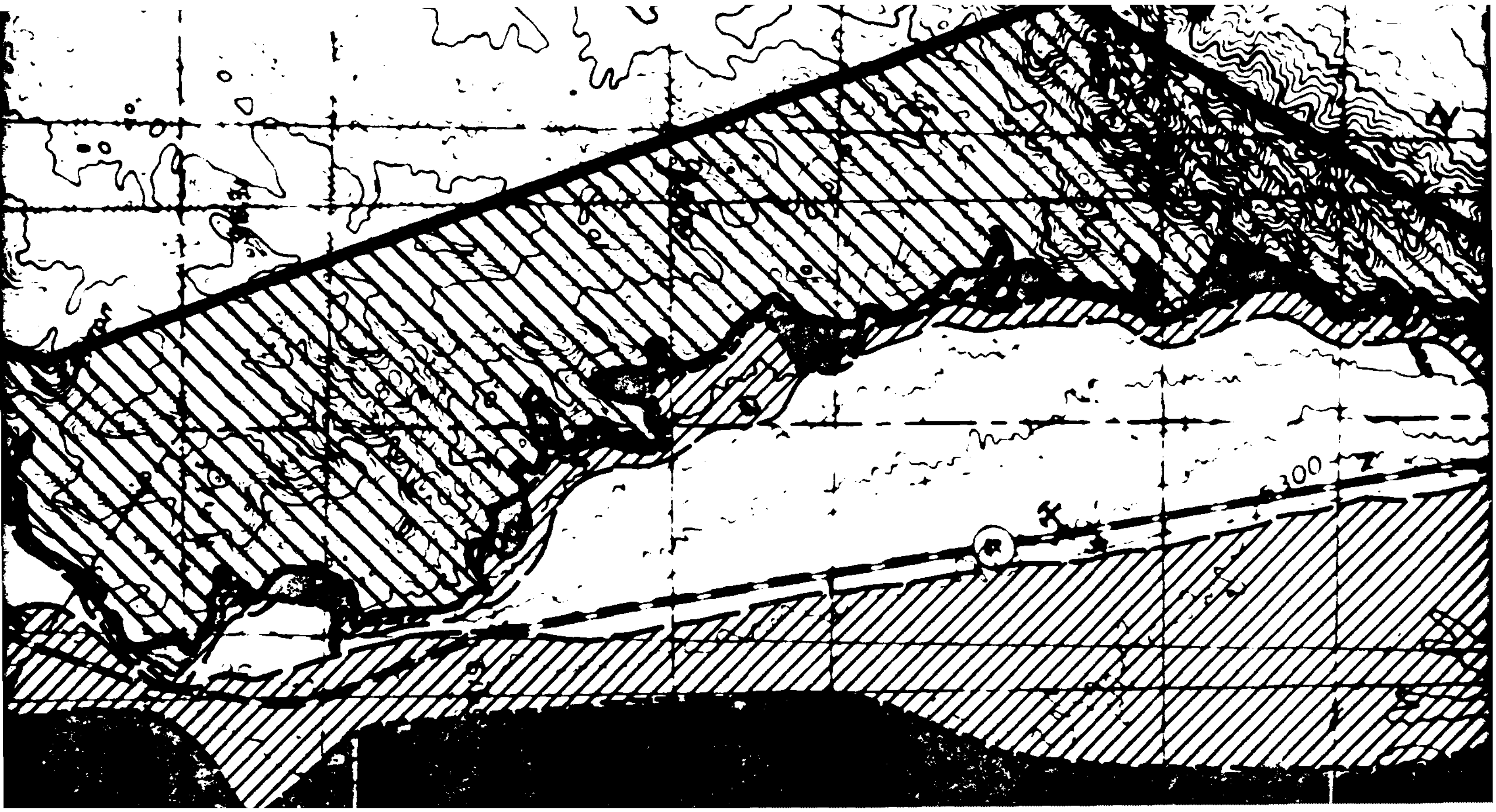
DEPTH TO WATER
VERIFICATION SITE, WHITE RIVER CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

DRAWING 7-5

FUGRO NATIONAL, INC.




300

NATION

ild trench and vertical shelter to rock and water greater than

ild trench and not suitable for th to rock and water greater less than 150 feet (40m)..

ATION

trench and vertical shelter rock and water greater than

trench and not suitable for h to rock and water greater less than 150 feet (46m)..

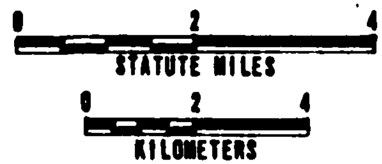
Hybrid trench and vertical determined from application ter, topographic/terrain, and

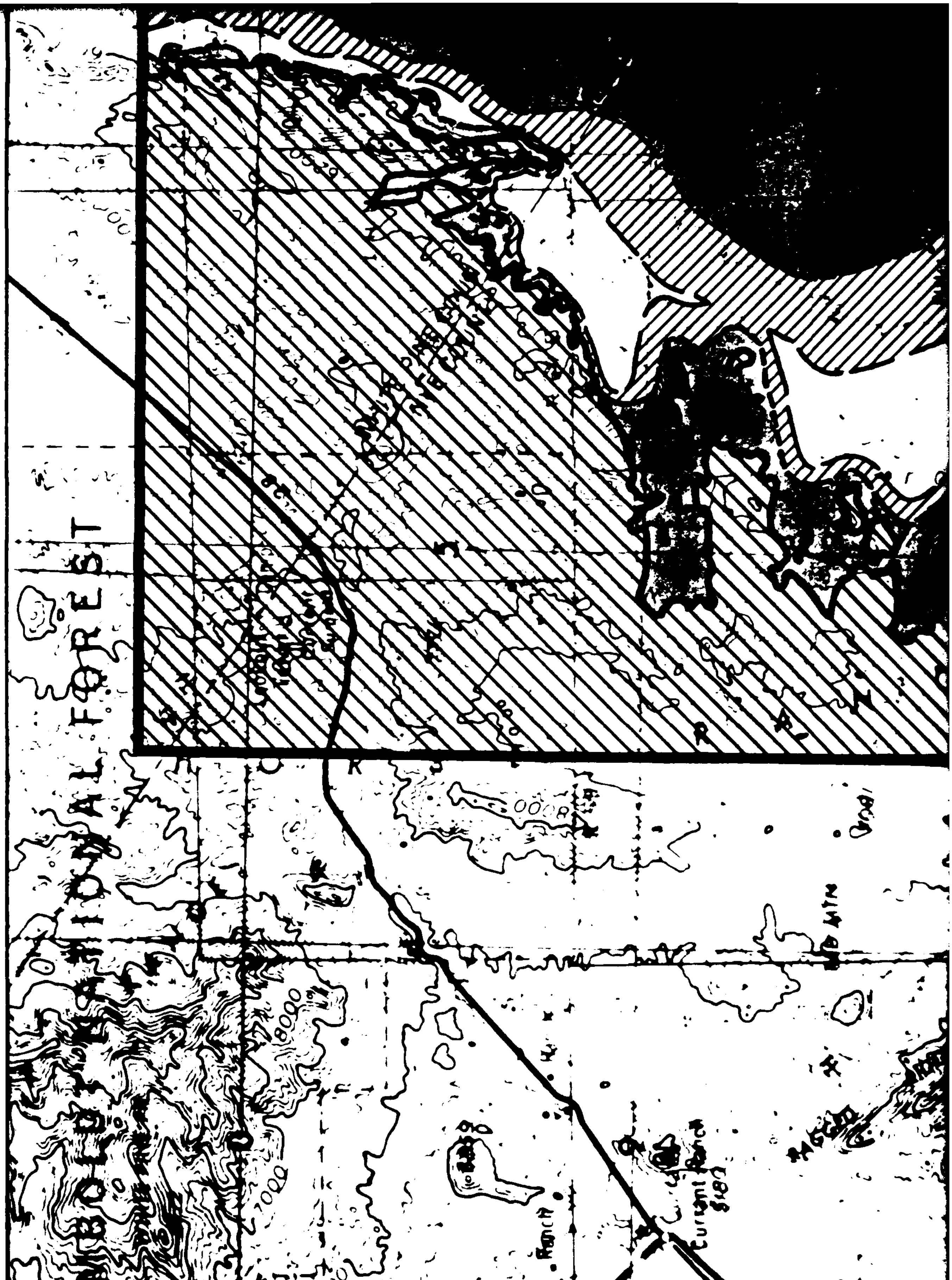
ed rock.

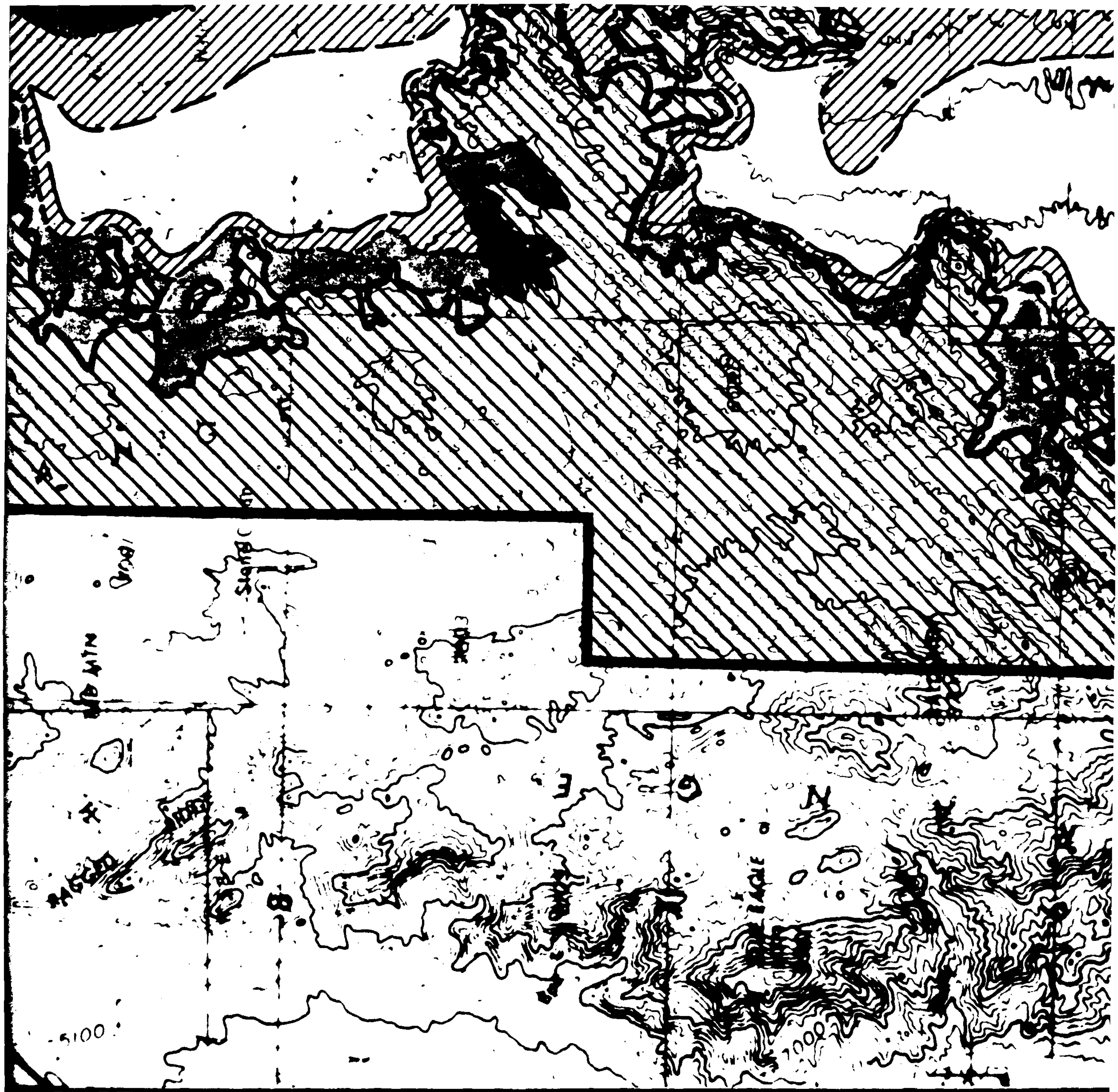
basin-fill.

details regarding suitable criteria.

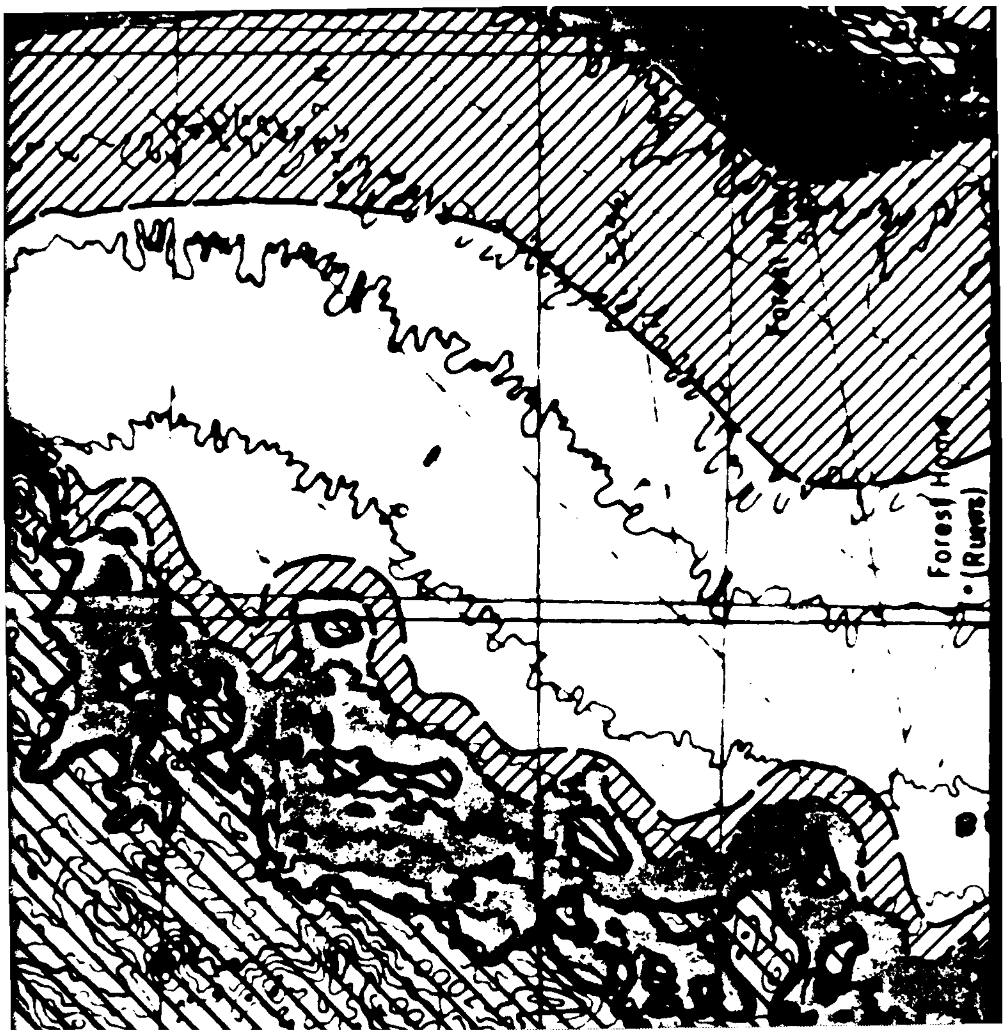
SCALE 1:125,000




NATIONAL FOREST
RAGGED
Current Ranch
Ranch
8000
7000



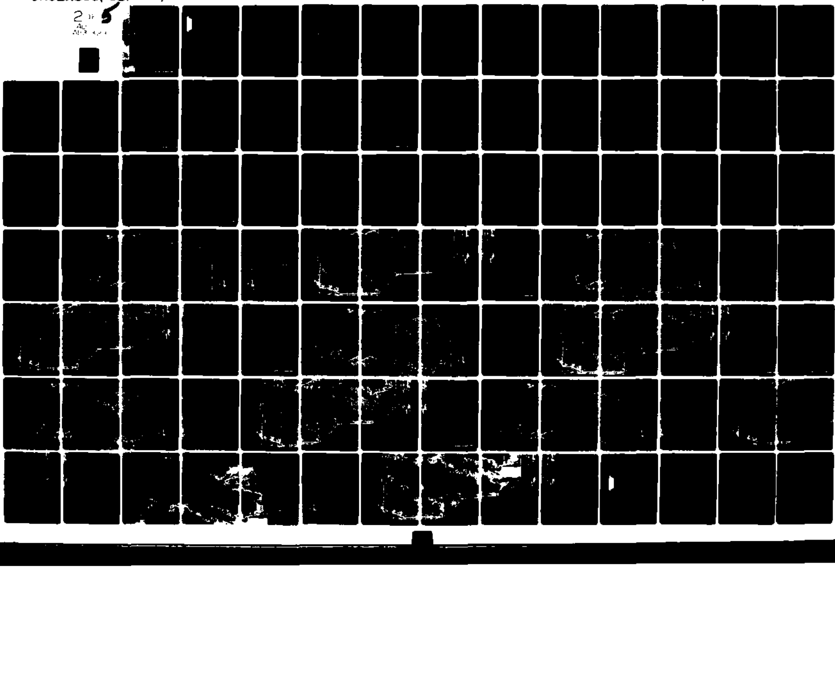
1 6



Forest Hood
(Ruins)

AD-A113 323 FUGRO NATIONAL INC LONG BEACH CA F/G 13/2
MX SITING INVESTIGATION GEOTECHNICAL EVALUATION. VOLUME IB. NEV--ETC(U)
AUG 79 F04704-78-C-0027
UNCLASSIFIED FN-TR-27-1B NL

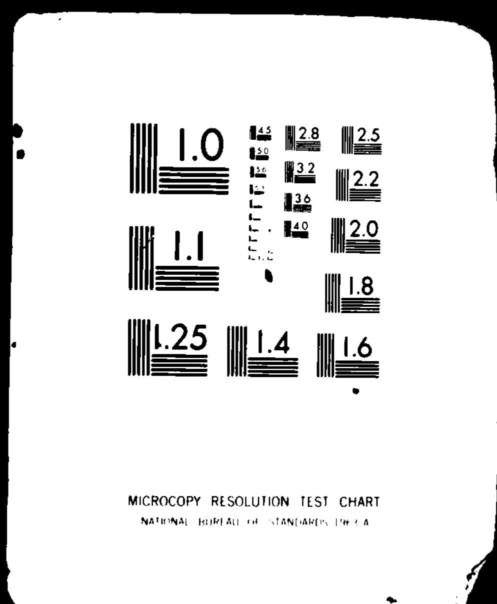
2 of 5

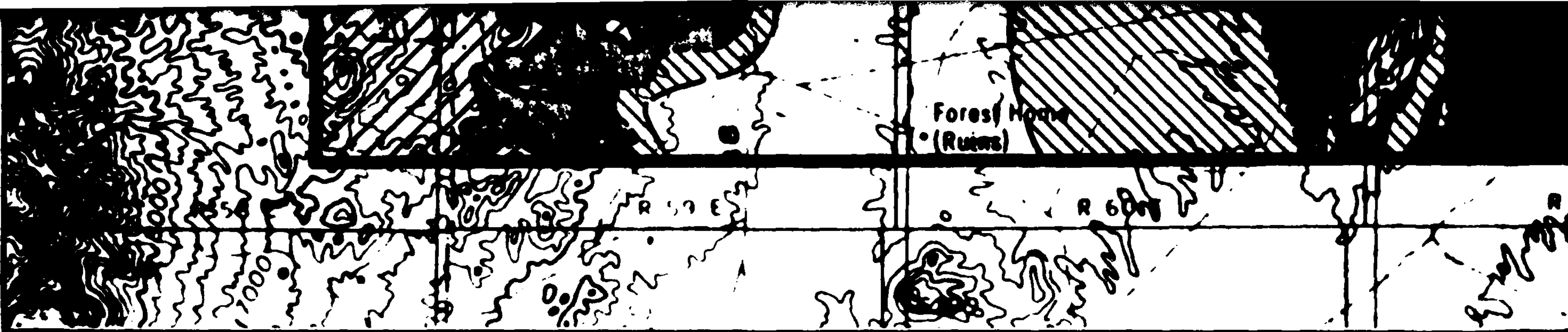


SSIFIE

2 OF 5

AD
A113 323





EXPLANATION

- (blank box) Area suitable for hybrid trench and vertical shelter basing modes. Depth to rock and water greater than 150 feet (40m).
- (hatched box) Area suitable for hybrid trench and not suitable for vertical shelter. Depth to rock and water greater than 50 feet (15m) and less than 150 feet (40m).
- (shaded box) Area unsuitable for both hybrid trench and vertical shelter basing modes as determined from application of depth to rock and water, topographic/terrain, and cultural exclusions.
- (hatched box) Indicates areas of exposed rock.
- (line) Contact between rock and basin-fill.

NOTE: See Appendix A2.0 Table A2-1 for details regarding suitable criteria.

SUITABLE AREA
HYBRID TRENCH AND VERTICAL SHELTER
VERIFICATION SITE, WHITE RIVER COP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

DRAWING 7-6

FUGRO NATIONAL, INC.

8.0 GARDEN-COAL CDP

8.1 GEOGRAPHIC SETTING

The Garden-Coal CDP is located in central Nevada and covers parts of Nye and Lincoln counties (Figure 8-1). It is bounded on the west by the Grant and Quinn Canyon ranges, on the southwest by the Worthington Mountains, and in the east and northeast by the Seaman Range. Garden and Coal valleys, constituting this CDP, are remote and very sparsely populated. The valleys are accessible only by improved and unimproved dirt roads and are principally used as a livestock range.

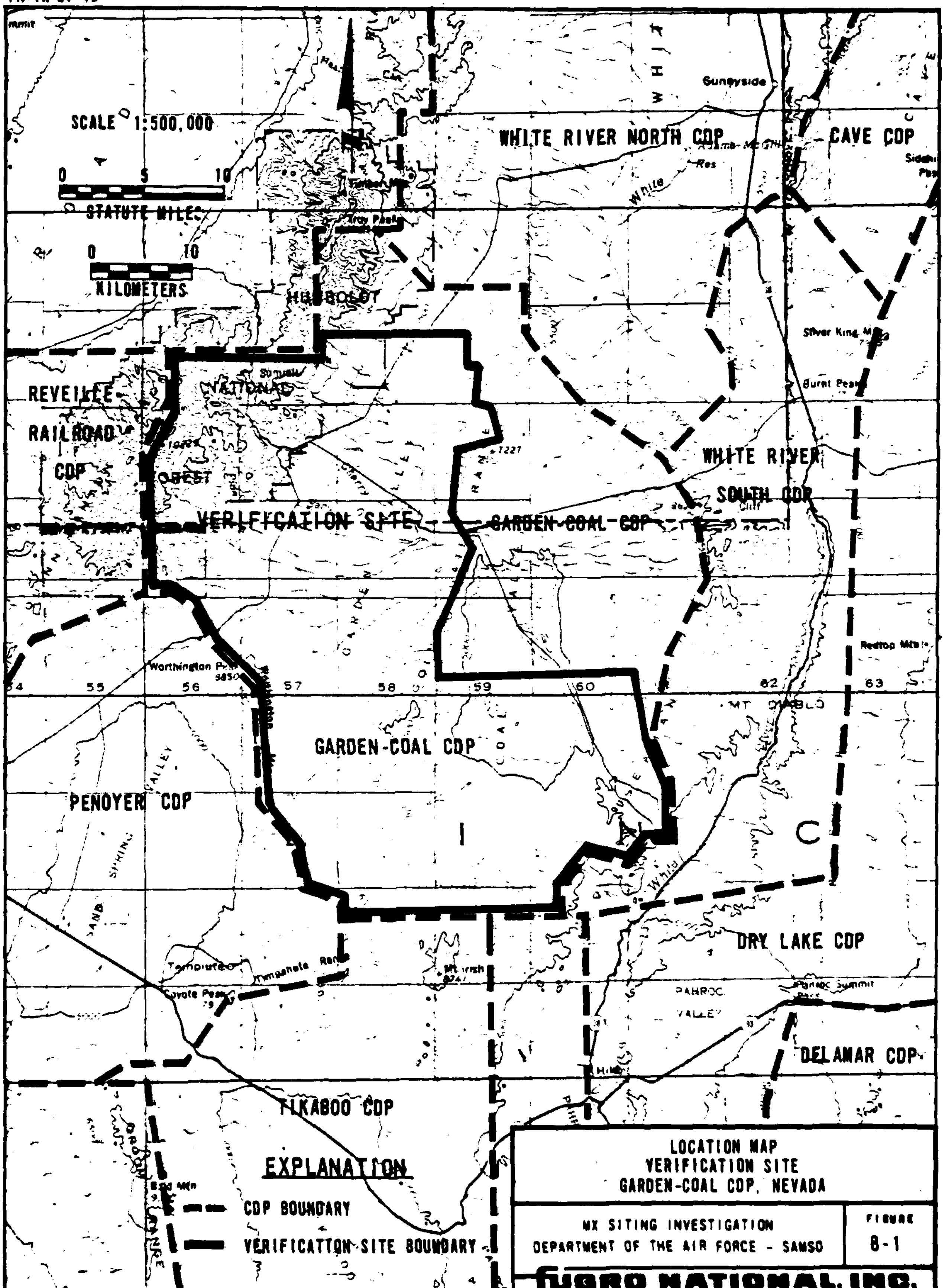
The Verification site encompasses nearly all of the suitable area in Garden Valley and approximately the southern one-third of Coal Valley. The closest town is Ash Springs, located approximately 20 miles (32 km) from the southeast corner of the site. The nearest town large enough to be used for a support facility is Caliente, Nevada, located 55 miles (89 km) east of the site on U.S. Highway 93.

8.2 SCOPE

The scope of geologic, geophysical, and soils engineering field activities performed at the site and laboratory tests performed on soil samples from the site are presented in Table 8-1. Locations of the geophysical and engineering activities are shown in Drawing 8-1 (end of Section 8.0).

8.3 GEOLOGIC SETTING

Two basic lithologies occur in the ranges surrounding the site and are the primary sources of detritus being shed into the


SCALE 1:500,000
0 5 10
STATUTE MILES
0 10
KILOMETERS
WHITE RIVER NORTH CDP
CAVE CDP
Sunnyside
HUMBOLDT
REVEILLE-RAILROAD CDP
NATIONAL
FOREST
WHITE RIVER SOUTH CDP
VERIFICATION SITE
GARDEN-COAL CDP
Silver King Mtn
Burnt Peak
Redtop Mtn
Worthington Peak
54 55 56 57 58 59 60 62 63
GARDEN-COAL CDP
PENOYER CDP
DRY LAKE CDP
PAHROC VALLEY
Pahroc Summit
DELAMAR CDP
TIKABOO CDP
EXPLANATION
CDP BOUNDARY
VERIFICATION SITE BOUNDARY
LOCATION MAP
VERIFICATION SITE
GARDEN-COAL CDP, NEVADA
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO
FIGURE
8-1
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2 JUL 79

GEOLOGY AND GEOPHYSICS

TYPE OF ACTIVITY	NUMBER OF ACTIVITIES
Geologic mapping stations	82
Shallow refraction	19
Electrical resistivity	18
Gravity profiles	5

ENGINEERING-LABORATORY TESTS

TYPE OF TEST	NUMBER OF TESTS
Moisture/density	82
Specific gravity	4
Sieve analysis	61
Hydrometer	1
Atterberg limits	19
Consolidation	2
Unconfined compression	5
Triaxial compression	5
Direct shear	3
Compaction	4
CBR	4
Chemical analysis	13

ENGINEERING

NUMBER OF BORINGS	NOMINAL DEPTH FEET (METERS)
3	160' (49)
2	120' (37)
1	110' (34)
NUMBER OF TRENCHES	NOMINAL DEPTH FEET (METERS)
8	14' (4)
2	10' (3)
NUMBER OF TEST PITS	NOMINAL DEPTH FEET (METERS)
24	5' (2)
5	2' (1)
NUMBER OF CPTs	RANGE OF DEPTH FEET (METERS)
54	0-30' (0-9)
TYPE OF ACTIVITY	NUMBER OF ACTIVITIES
Surficial soil samples	21
Field CBR tests	0

SCOPE OF ACTIVITIES
VERIFICATION SITE, GARDEN-COAL CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 8-1

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basin. The Worthington Mountains and the Golden Gate Range are composed primarily of a Paleozoic carbonate sequence and the Quinn Canyon Range is composed almost entirely of Tertiary volcanic rocks. The Seaman and Grant ranges embody both of these lithologies.

There is evidence to suggest that fault activity has continued or has been renewed along early Cenozoic Basin and Range structures. The Seaman Pass fault (Tschany and Pampeyan, 1970) in Coal Valley and several smaller faults offset Quaternary alluvium in the valleys, but the Seaman Pass fault is probably the only fault with sufficient mapped length to be capable of producing significant surface rupture. Generally, most evidence indicates that tectonically the area is relatively quiescent.

Deposition of sediments in these valleys has been by alluvial processes that have continued throughout the Quaternary. Eakins (1963) has estimated that the total thickness of basin-fill sediments is at least several hundred feet and may exceed 1000 feet (305 m). Surface geologic units mapped in the site (Drawing 8-2) generally consist of several units, from oldest to youngest.

- Older alluvial fan deposits - This unit consists of large, deeply incised, fan-shaped mounds of well-indurated gravels and gravelly sands. Outcrops occur only along the fronts of the Quinn Canyon and Seaman ranges and represent a very small percentage of the site.

- Intermediate alluvial fan deposits - These fans cover approximately one-third of the site, generally occurring as moderately incised high fans along mountain fronts, grading into younger alluvial fan deposits. The deposits are predominantly composed of silty to clayey sands but locally may be gravel.

- o Older lacustrine deposits - These older playa deposits cover the south-central portion of Coal Valley. The central playa is composed of sandy and clayey silts and elevated relic shoreline features to the south of the playa are composed of well-sorted sands.
- o Younger alluvial fan deposits and stream channel deposits - Combined, these units form the most areally extensive deposits in the site, generally occurring in the central portions of Garden Valley and around the periphery of the Coal Valley playa. They are composed of silts, sands, and gravels adn can have a major percentage of any size fraction, but are primarily silty sand.
- o Younger lacustrine deposits - This deposit covers only small areas within the older lake deposits of Coal Valley and receives deposition only during times of peak runoff. It is very similar in compositon to the older lacustrine deposits but is slightly siltier.

8.4 SURFACE SOILS

Although Garden and Coal valleys are adjacent to each other, the surficial soils are quite different. Garden Valley surficial soils are predominantly sandy gravels and gravelly sands with silty sands in the northern portion. Coal Valley has predominantly sandy silt and sandy clay soils with gravelly soils along the valley perimeter. The soils from predominant geologic units (see Drawing 8-2) in both the valleys can be combined into the following categories based on similar physical and engineering properties:

1. Silty sands and clayey sands (from geologic units A5ys and A5is);
2. Gravelly sands and sandy gravels (from geologic units A5ys and A5is); and
3. Sandy silts and sandy clays (from geologic unit A4of).

8.4.1 Characteristics

A summary of the characteristics of surficial soils, based on field and laboratory test results, is presented in Table 8-2. In addition to the physical properties, some road design data are also presented. This includes laboratory compaction and California Bearing Ratio (CBR) test results, ranges and average depths of low-strength surficial soils, and suitability of soils for road use. The range of gradation of surficial soils is presented in Figure 8-2.

Silty sands and clayey sands have an areal extent ranging from 30 to 50 percent of the site. These soils are found in the northern, central, and southern portions of Garden Valley and between the lacustrine deposits and mountain fronts in Coal Valley. They contain appreciable amounts of fine gravels. Soil plasticity ranges from none to slight in Garden Valley and slight to high in Coal Valley.

Sandy gravels and gravelly sands are the dominant surficial soil type with an areal extent ranging from 40 to 60 percent. These soils are found in alluvial fans of both valleys and in shoreline deposits around the dry lake in Coal Valley. They are generally in a loose state near the surface and contain fine to coarse sands and gravels. Soil fines are nonplastic to slightly plastic.

Sandy silts and sandy clays have an areal extent ranging from 10 to 20 percent. These soils are associated with lacustrine deposits and are found predominantly in the dry lakebed of Coal

SOIL DESCRIPTION			Silty Sands and Clayey Sands		Sandy Gr[...] Gravelly [...]
USCS SYMBOLS			SM, SC		SM, SC, [...]
PREDOMINANT SURFICIAL GEOLOGIC UNITS			A5ys, A5ls		A5ys, A5l[...]
ESTIMATED AREAL EXTENT		%	30-50		40-60
PHYSICAL PROPERTIES					
COBBLES 3 - 12 inches (8 - 30 cm)		%	0-5		0-10
GRAVEL		%	0-25	[12]	10-51
SAND		%	38-77	[12]	43-80
SILT AND CLAY		%	12-48	[17]	2-27
LIQUID LIMIT			30-40	[2]	31
PLASTICITY INDEX			NP-21	[4]	13
ROAD DESIGN DATA					
MAXIMUM DRY DENSITY		pcf (kg/m³)	121.9-127.6 (1953-2044)	[3]	120.4 (1929)
OPTIMUM MOISTURE CONTENT		%	9.5-10.5	[3]	12.0
CBR AT 90% RELATIVE COMPACTION		%	15-19	[3]	28
SUITABILITY AS ROAD SUBGRADE (1)			fair to good		good to ver[...]
SUITABILITY AS ROAD SUBBASE OR BASE (1)			fair		good
THICKNESS OF LOW STRENGTH SURFICIAL SOIL (2)	RANGE	ft (m)	0.9-10.4 (0.3-3.2)	[27]	0.7-10.0 (0.2-3.0)
	AVERAGE	ft (m)	3.5 (1.0)	[27]	2.8 (0.9)

(1) Suitability is a subjective rating explained in Section A5.0 of the Appendix.

(2) Low strength surficial soil is defined as soil which will perform poorly as a road subgrade at its present consistency; see Table 8-3 for details.

NOTES:
- [ ]
- NDA -

Sandy Gravels and Gravelly Sands	Sandy Silts and Sandy Clays	
SM, SC, SP, GP, GM	CL, ML	
A5ys, A5is	A4of	
40-80	10-20	
0-10	0	
10-51 [5]	0-1 [3]	
43-80 [5]	22-33 [3]	
2-27 [5]	51-78 [5]	
31 [1]	31-41 [3]	
13 [1]	4-8 [3]	
120.4 (1928) [1]	NDA	
12.0 [1]	NDA	
28 [1]	NDA	
good to very good	poor	
good	not suitable	
0.7-10.0 (0.2-3.0) [10]	0.6-8.0 (0.2-3.0) [7]	
2.8 (0.9) [10]	4.8 (1.5) [7]	

S: • [ ] – Number of tests performed.

• NDA – No data available (Insufficient data or tests not performed)

CHARACTERISTICS OF SURFICIAL SOILS
VERIFICATION SITE, GARDEN-COAL CDP, NEVADA

MX SITING INVESTIGATION
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TABLE B-2

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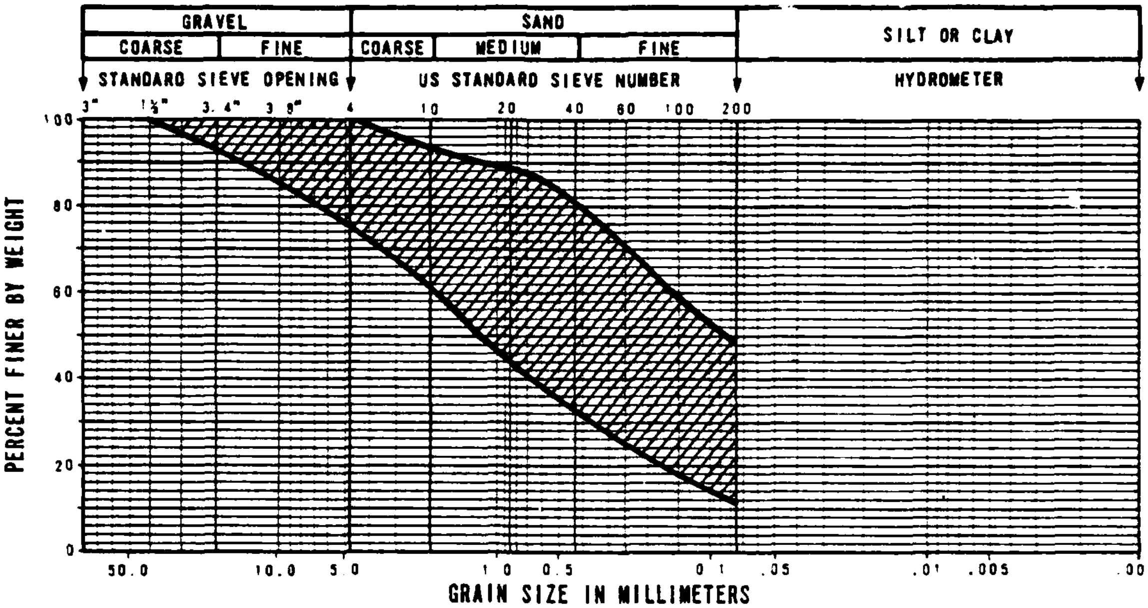
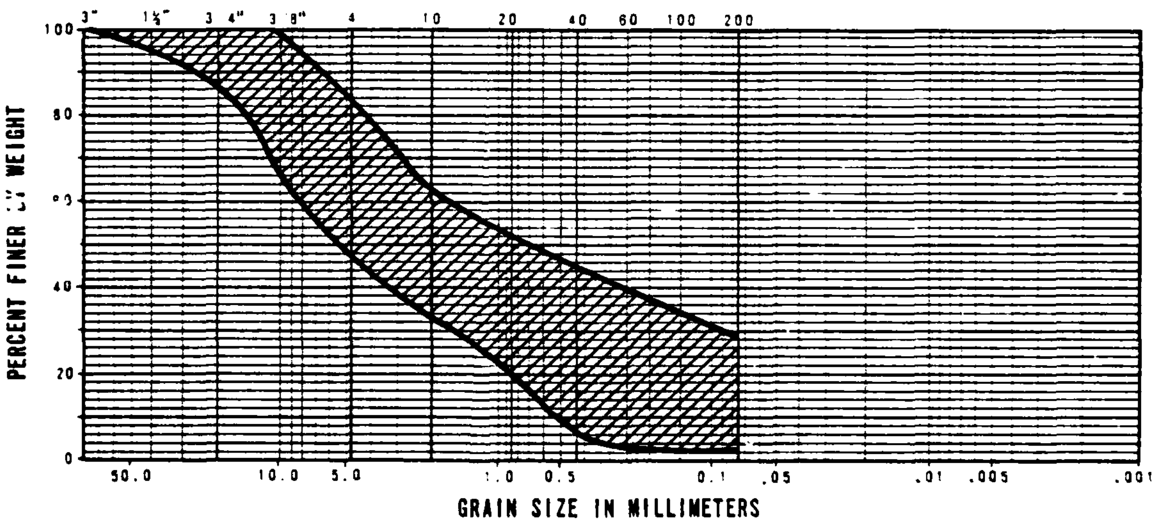
AFV-18



SOIL DESCRIPTION: Silty Sands and Clayey Sands from 0 to 2 feet (0 to 0.6m)



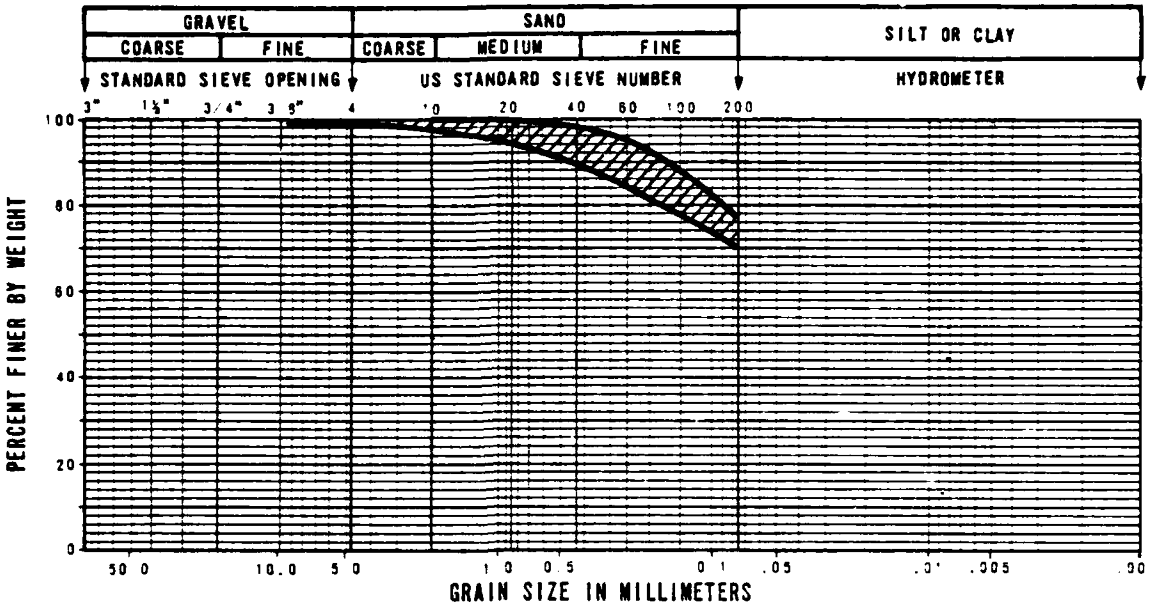
SOIL DESCRIPTION: Sandy Gravels and Gravelly Sands from 0 to 2 feet (0 to 0.6m)

RANGE OF GRADATION OF SURFICIAL SOILS
VERIFICATION SITE, GARDEN-COAL CDP, NEVADA

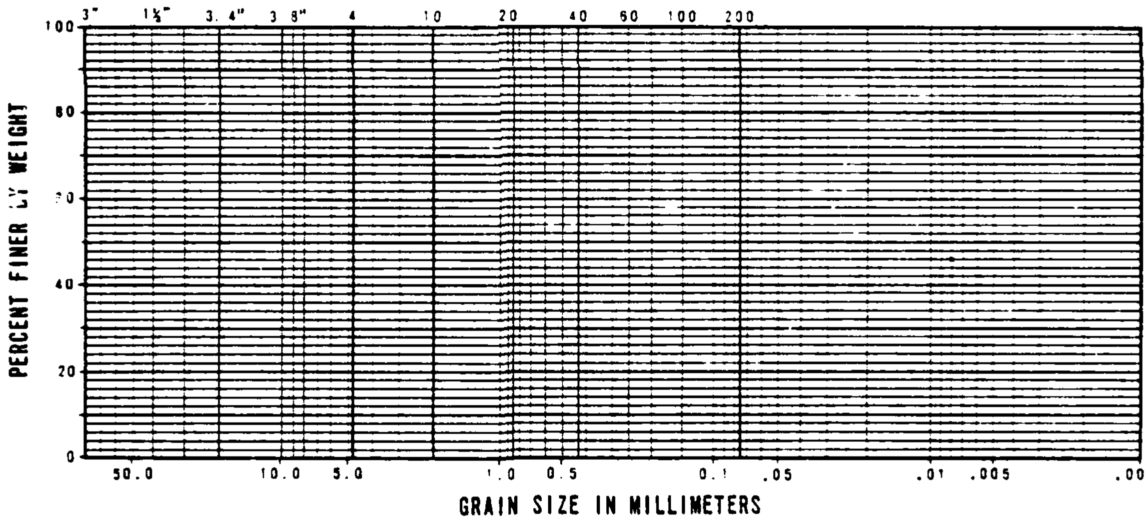
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 8-2
1 OF 2

FUGRO NATIONAL, INC.



SOIL DESCRIPTION: Sandy Silts and Sandy Clays
from 0 to 2 feet (0.0 to 0.6m)



RANGE OF GRADATION OF SURFICIAL SOILS
VERIFICATION SITE, GARDEN-COAL CDP, NEVADA

MX SITING INVESTIGATION
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FIGURE 8-2
2 OF 2

FUGRO NATIONAL, INC.

Valley. They contain an appreciable amount of fine sand, and soil plasticity ranges from slight to high.

8.4.2 Low Strength Surficial Soil

Cone Penetrometer Test (CPT) results were used in conjunction with soil classifications to estimate the thickness of low strength surficial soils. Table 8-3 presents a summary of these results. The low strength soils in Garden Valley show a thickness range of 0.7 to 10.4 feet (0.2 to 3.2 m) with an average of 2.8 feet (0.9 m). These soils are predominantly coarse-grained. The low strength soils in Coal Valley, which are predominantly fine-grained, show a thickness range of 0.6 to 9.8 feet (0.2 to 3.0) with an average of 4.7 feet (1.4 m).

8.5 SUBSURFACE SOILS

The subsurface soils of the Garden-Coal Site are predominantly coarse-grained. Sandy gravels and gravelly sands are found in the central and southern portions of Garden Valley, along the mountain fronts, and in shoreline deposits near the dry lake in Coal Valley. Silty sands are found in the northern portion of Garden Valley. Fine-grained subsurface soils (sandy silts, silts, sandy clays, clays) are found in the dry lakebed of Coal Valley and in the northern portion of Garden Valley. The composition of soils with depth, as determined from borings, trenches, and test pits, is illustrated in soil profiles presented in Figures 8-3 through 8-6.

Results of seismic refraction and electrical resistivity surveys are summarized in Table 8-4. The characteristics of

CONE PENETROMETER TEST NUMBER[1]	THICKNESS OF LOW STRENGTH SURFICIAL SOIL[2]		SOIL TYPE[3]
	FEET	METERS	
C-1	1.1	0.4	SM
C-2	0.9	0.3	SM
C-3	1.0	0.3	GM
C-4	1.6	0.5	SM
C-5	0.9	0.3	SC
C-6	0.9	0.3	SM
C-7	1.2	0.4	SM
C-8	1.9	0.6	SM
C-9	1.1	0.3	SM
C-10	10.4	3.1	SM
C-11	0.9	0.1	GP-GM
C-12	1.3	0.4	GP-GM
C-13	5.6	1.7	SM/GM
C-14	1.1	0.3	SM/ROCK
C-15	0.6	0.2	ROCK
C-16	6.6	2.0	SC
C-17	2.5	0.8	SC
C-18	2.5	0.8	SM
C-19	3.0	0.9	SM/SP-SM
C-20	0.7	0.2	GP
C-21	10.0	3.0	GP/ML
C-22	1.2	0.4	CL
C-23	1.3	0.4	SC
C-24	1.3	0.4	SM
C-25	2.2	0.7	SC
C-26	1.4	0.4	SC
C-27	0.9	0.3	GP-GM
C-28	3.0	0.9	SM/SP-SM

CONE PENETROMETER TEST NUMBER[1]	T
C-29	
C-30	
C-31	
C-32	
C-33	
C-34	
C-35	
C-36	
C-37	
C-38	
C-39	
C-40	
C-41	
C-42	
C-43	
C-44	
C-45	
C-46	
C-47	
C-48	
C-49	
C-50	
C-51	
C-52	
C-53	
C-54	

(1) For Cone Penetrometer Test locations see Drawing B-1, Activity Location Map.

(2) Thickness corresponds to depth below ground surface. Low strength surficial soil is defined as soil which will perform poorly as a road subgrade at its present consistency. Low strength is based on Cone Penetrometer Test results using the following criteria:

Coarse-grained soils: $q_c < 120$ tsf (117 kg/cm^2)
Fine-grained soils: $q_c < 80$ tsf (78 kg/cm^2)

where q_c is cone resistance.

(3) Soil type is based on Unified Soil Classification System; see Section A5.0 in the Appendix for explanation

CONE [P]ENETROMETER [TE]ST NUMBER[1]	THICKNESS OF LOW STRENGTH SURFICIAL SOIL (2)		SOIL TYPE (3)
	FEET	METERS	
C-29	4.9	1.5	SM
C-30	5.6	1.7	ML/SM
C-31	1.6	0.5	GM
C-32	4.5	1.4	SM/GM
C-33	1.3	0.4	SM
C-34	1.2	0.4	GM
C-35	4.6	1.4	SM-SC
C-36	7.0	2.1	SM
C-37	2.7	0.8	SM/SP-SM
C-38	5.9	1.8	SM/SP-SM
C-39	5.3	1.6	SM
C-40	2.1	0.6	SC/SP-SM
C-41	3.0	0.9	SM
C-42	9.3	2.8	SC
C-43	5.3	1.6	SM/GP-GM
C-44	4.9	1.5	CL/SP
C-45	9.5	2.9	SP
C-46	2.1	0.6	SP-SM
C-47	1.6	0.5	SP-SM
C-48	1.7	0.5	CL
C-49	4.6	1.4	SP
C-50	9.8	3.0	CL
C-51	0.6	0.2	CL
C-52	7.7	2.3	ML
C-53	2.5	0.8	ML
C-54	0.6	0.2	GC

CONE PENETROMETER TEST NUMBER[1]	THICKNESS OF LOW STRENGTH SURFICIAL SOIL (2)		SOIL TYPE (3)
	FEET	METERS	

NOTES:
- For fine-grained soils (ML, CL, MH and CH), thickness of low strength surficial soil will vary depending on moisture content of the soil at time of testing.
- SM/GM - Indicates SM underlain by GM
- NDA - No data available

THICKNESS OF LOW STRENGTH SURFIC[...]
VERIFICATION SITE, GARDEN-COAL C[...]

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...ESS OF LOW STRENGTH ...URFICIAL SOIL (2)		SOIL TYPE (3)
...ET	METERS	
[illegible]	1.5	SM
[illegible]	1.7	ML/SM
[illegible]	0.5	GM
[illegible]	1.4	SM/GM
[illegible]	0.4	SM
[illegible]	0.4	GM
[illegible]	1.4	SM-SC
[illegible]	2.1	SM
[illegible]	0.8	SM/SP-SM
[illegible]	1.8	SM/SP-SM
[illegible]	1.6	SM
[illegible]	0.6	SC/SP-SM
[illegible]	0.9	SM
[illegible]	2.8	SC
[illegible]	1.8	SM/GP-GM
[illegible]	1.5	CL/SP
[illegible]	2.9	SP
[illegible]	0.6	SP-SM
[illegible]	0.5	SP-SM
[illegible]	0.5	CL
[illegible]	1.4	SP
[illegible]	3.0	CL
[illegible]	0.2	CL
[illegible]	2.3	ML
[illegible]	0.8	ML
[illegible]	0.2	GC

CONE PENETROMETER TEST NUMBER(1)	THICKNESS OF LOW STRENGTH SURFICIAL SOIL (2)		SOIL TYPE (3)
	FEET	METERS	

...S: • For fine-grained soils (ML, CL, MH and CH), thickness of low strength surficial soil will vary depending on moisture content of the soil at time of testing.

• SM/GM - indicates SM underlain by GM

• NDA - No data available

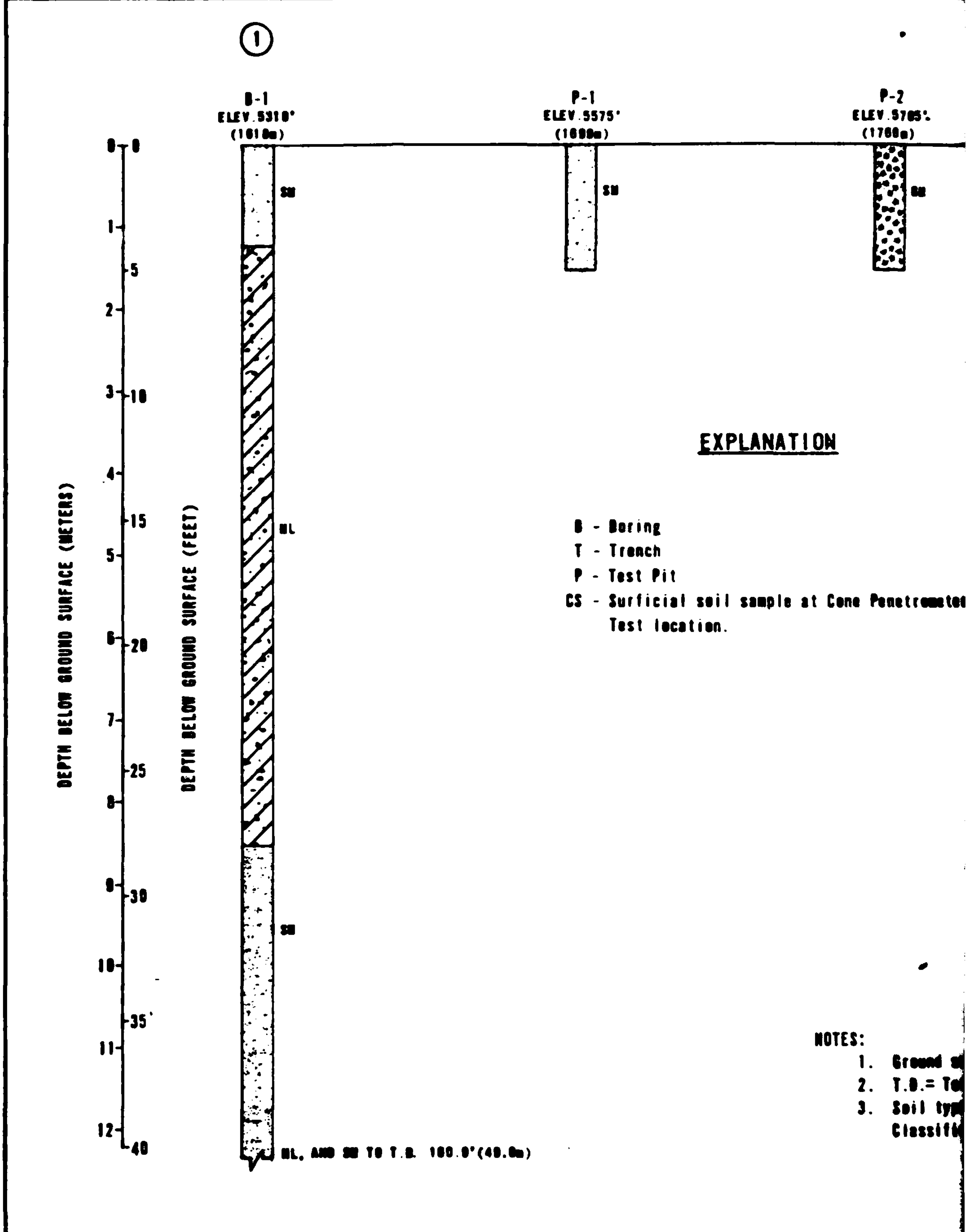
THICKNESS OF LOW STRENGTH SURFICIAL SOIL
VERIFICATION SITE, GARDEN-COAL CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

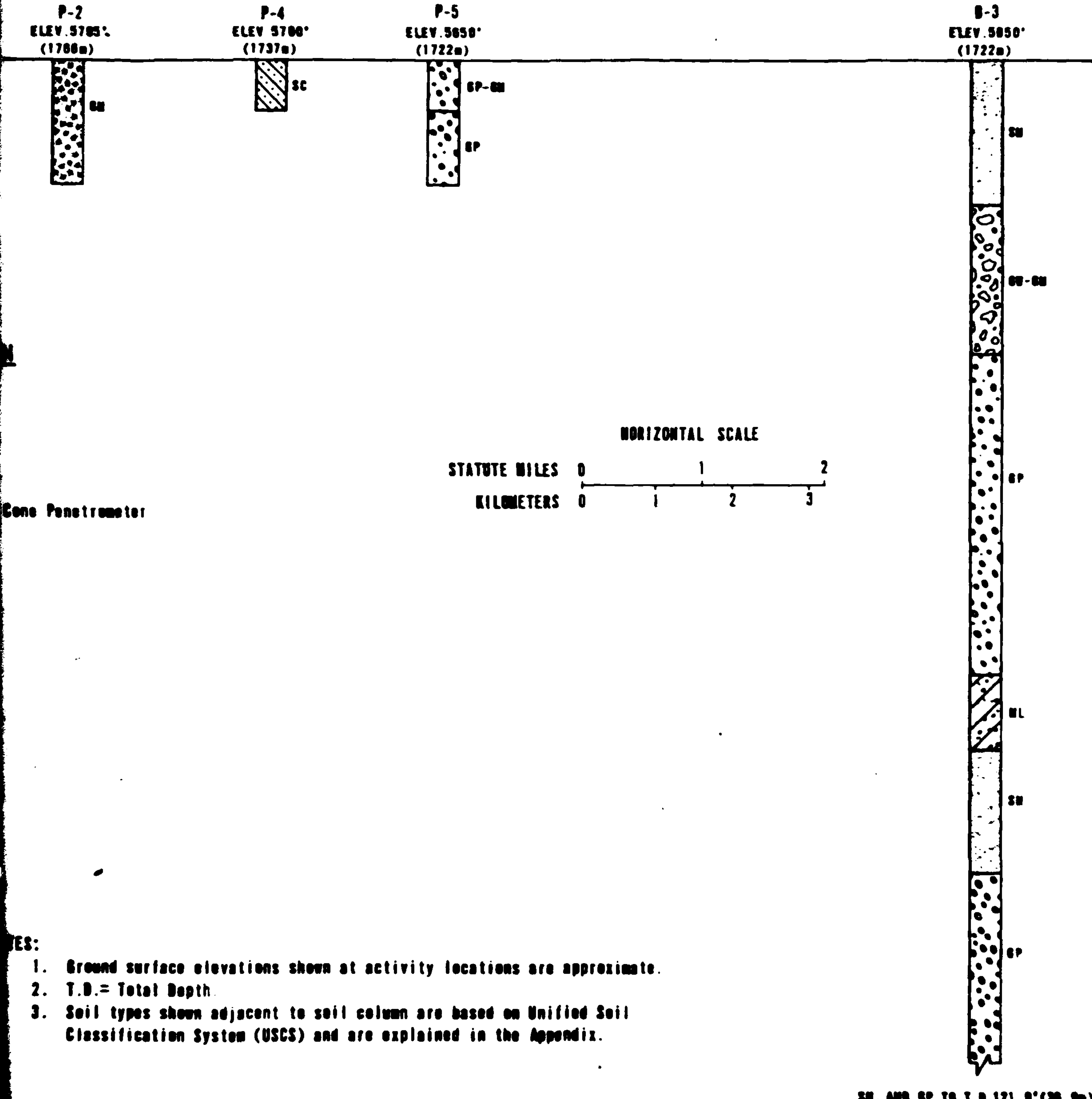
TABLE
8-3

FUGRO NATIONAL, INC.

AFV-21

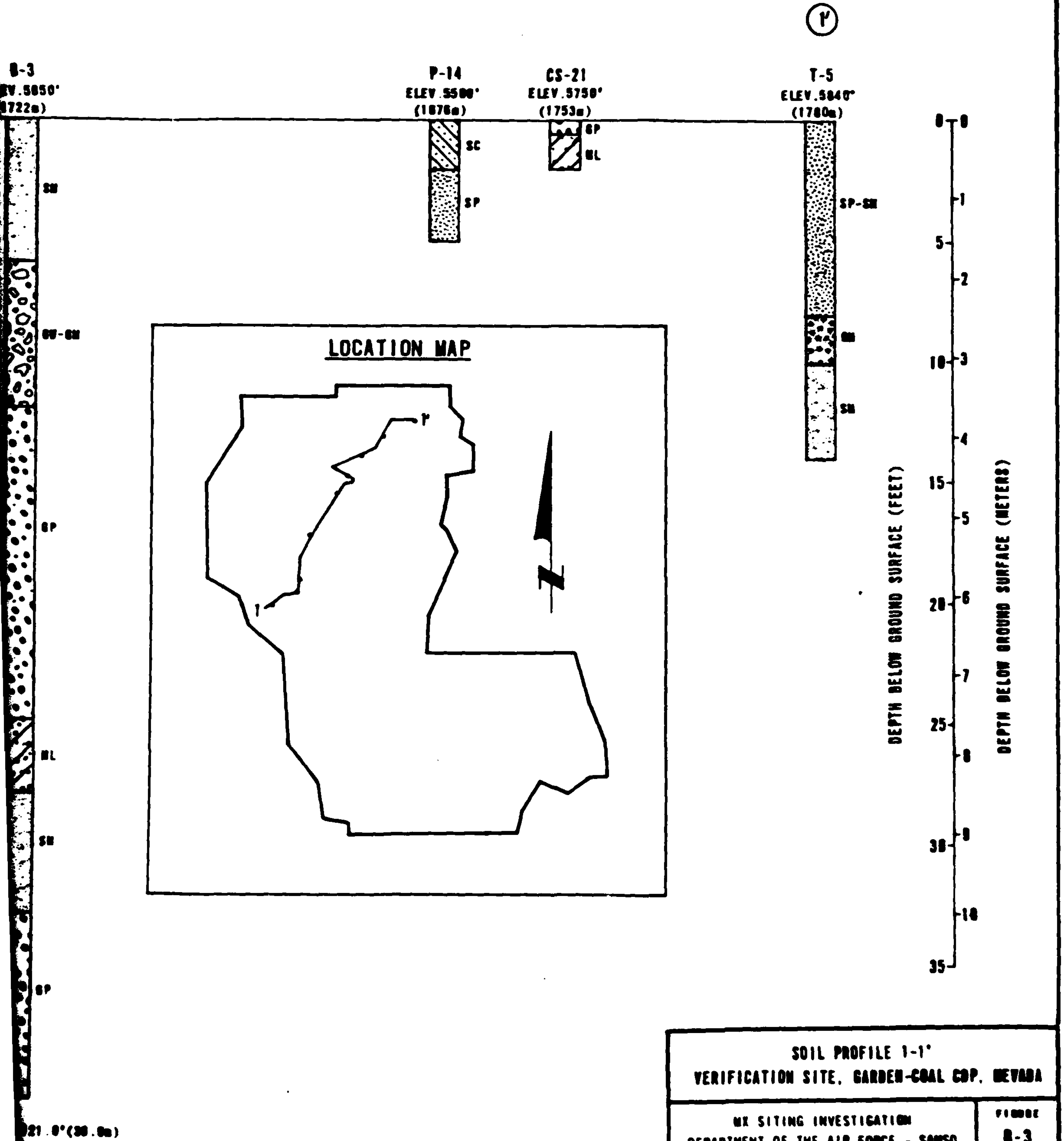


1
B-1
ELEV. 5310'
(1610m)
P-1
ELEV. 5575'
(1690m)
P-2
ELEV. 5785'
(1760m)
DEPTH BELOW GROUND SURFACE (METERS)
DEPTH BELOW GROUND SURFACE (FEET)
0 1 2 3 4 5 6 7 8 9 10 11 12
0 5 10 15 20 25 30 35 40
SM
ML
SM
ML, AND SM TO T.D. 160.0'(49.0m)
SM
GM
EXPLANATION
B - Boring
T - Trench
P - Test Pit
CS - Surficial soil sample at Cone Penetrometer
Test location.
NOTES:
1. Ground s
2. T.D.= To
3. Soil typ
Classific



…ES:

1. Ground surface elevations shown at activity locations are approximate.
2. T.D.= Total Depth
3. Soil types shown adjacent to soil column are based on Unified Soil Classification System (USCS) and are explained in the Appendix.



SOIL PROFILE 1-1'
VERIFICATION SITE, GARDEN-COAL COP, NEVADA

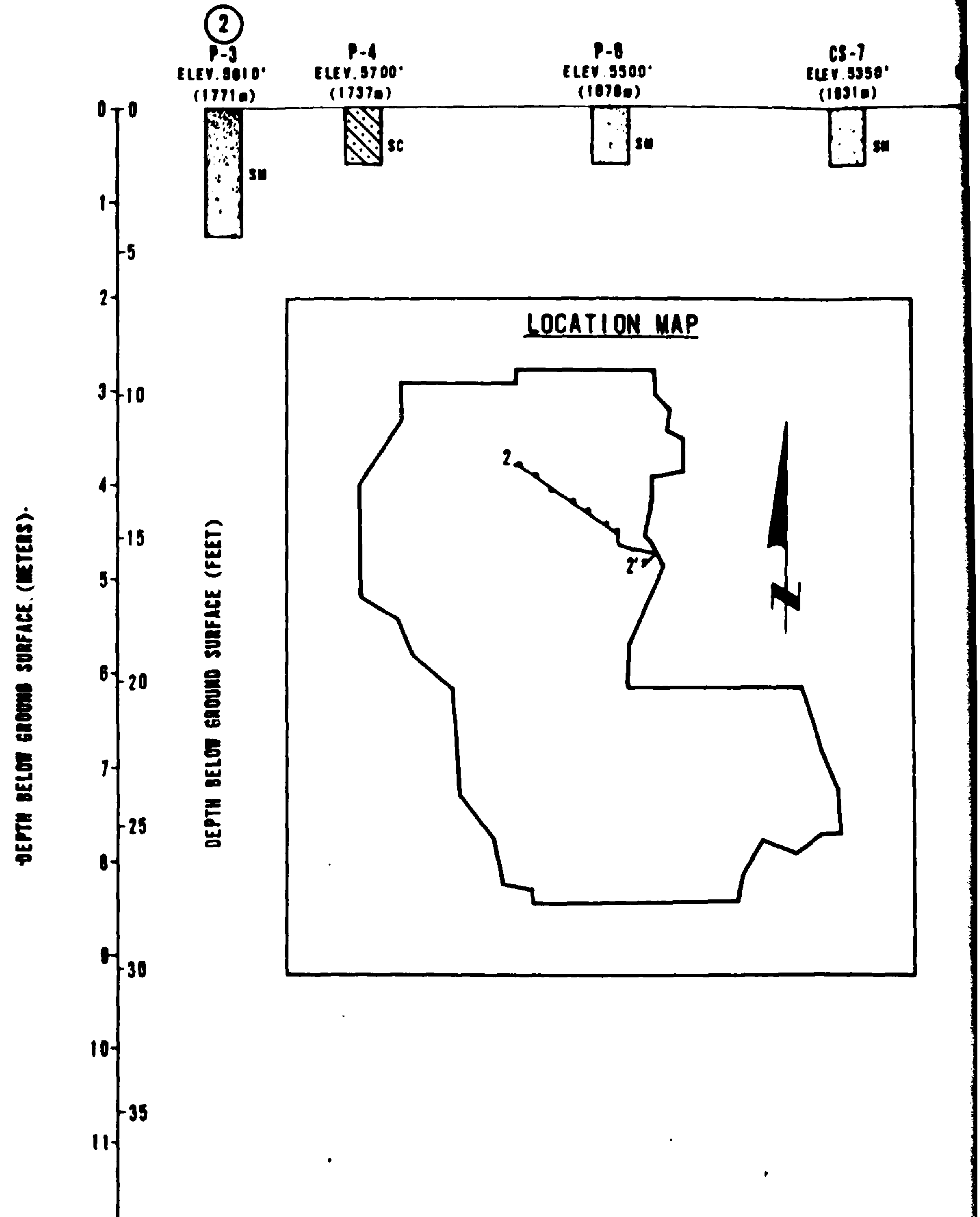
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE
B-3

FUGRO NATIONAL, INC.

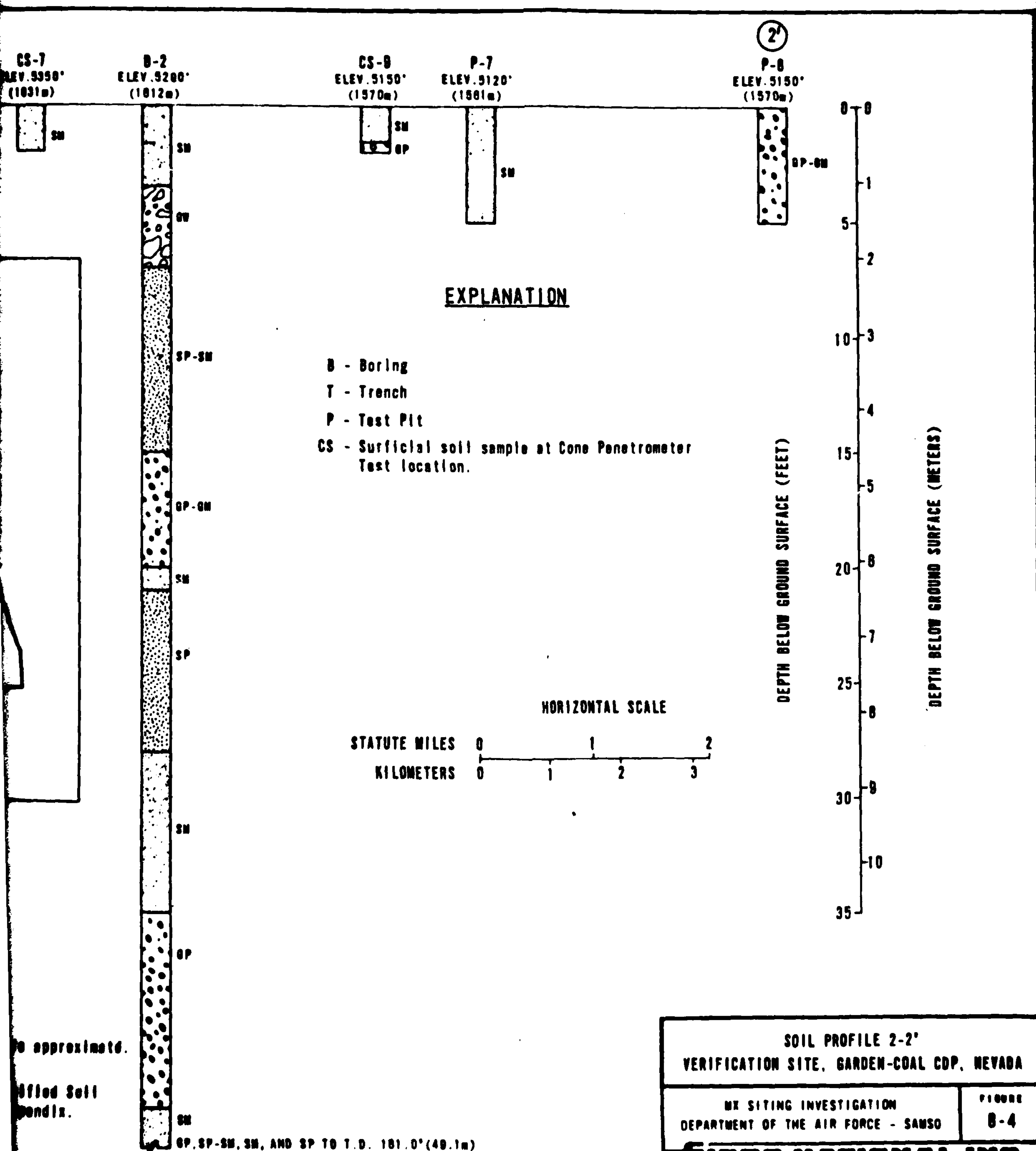
1

3



NOTES:

1. Ground surface elevations shown at activity locations are approximate
2. T.D. = Total Depth.
3. Soil types shown adjacent to soil column are based on Unified Soil Classification System (USCS) and are explained in the Appendix.

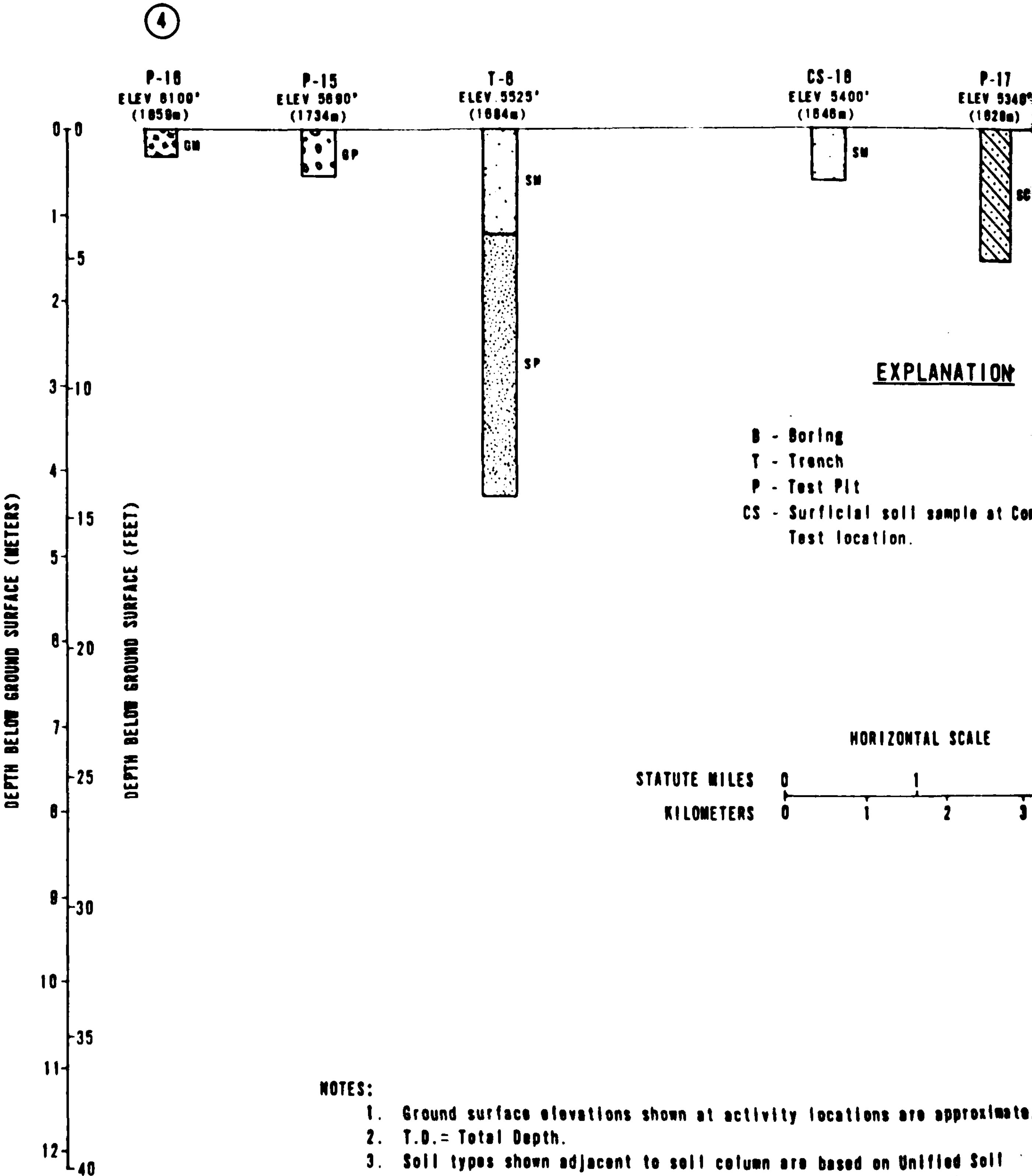


SOIL PROFILE 2-2'
VERIFICATION SITE, GARDEN-COAL CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE B-4

FUGRO NATIONAL, INC.



EXPLANATION

B - Boring
T - Trench
P - Test Pit
CS - Surficial soil sample at Com
Test location.

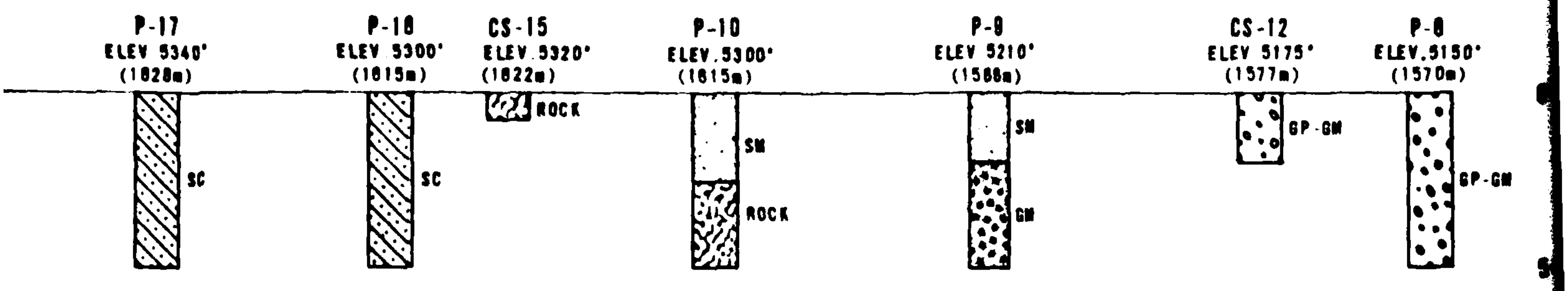
HORIZONTAL SCALE

STATUTE MILES 0 1
KILOMETERS 0 1 2 3

NOTES:

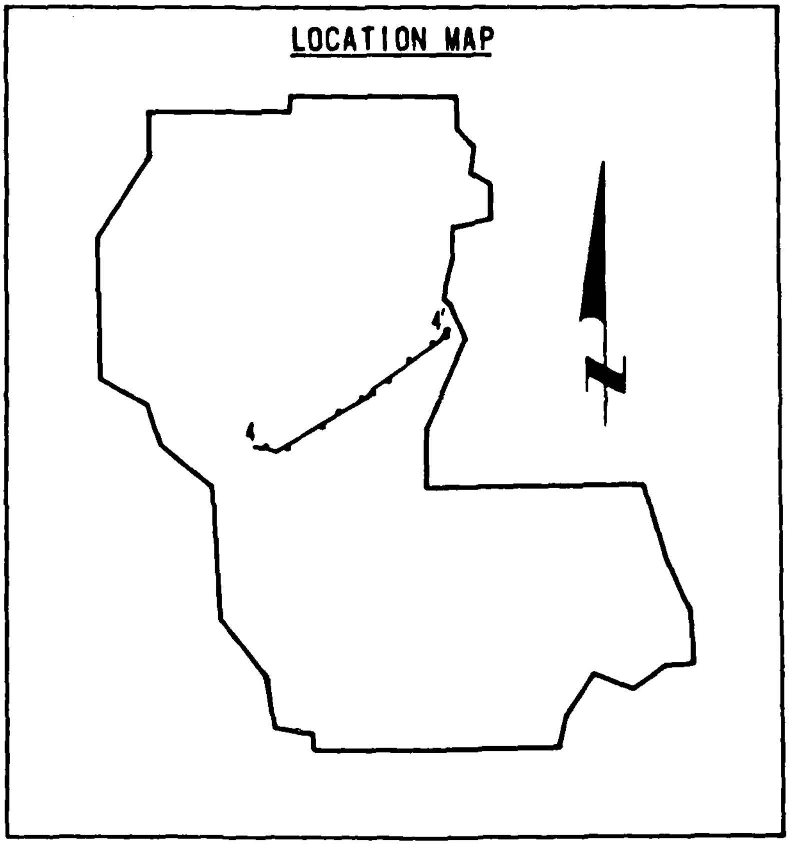
1. Ground surface elevations shown at activity locations are approximate.
2. T.D.= Total Depth.
3. Soil types shown adjacent to soil column are based on Unified Soil Classification System (USCS) and are explained in the Appendix.

(4')

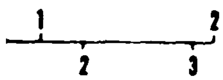


XPLANATION

soil sample at Cone Penetrometer
on.



ZONTAL SCALE



are approximate.

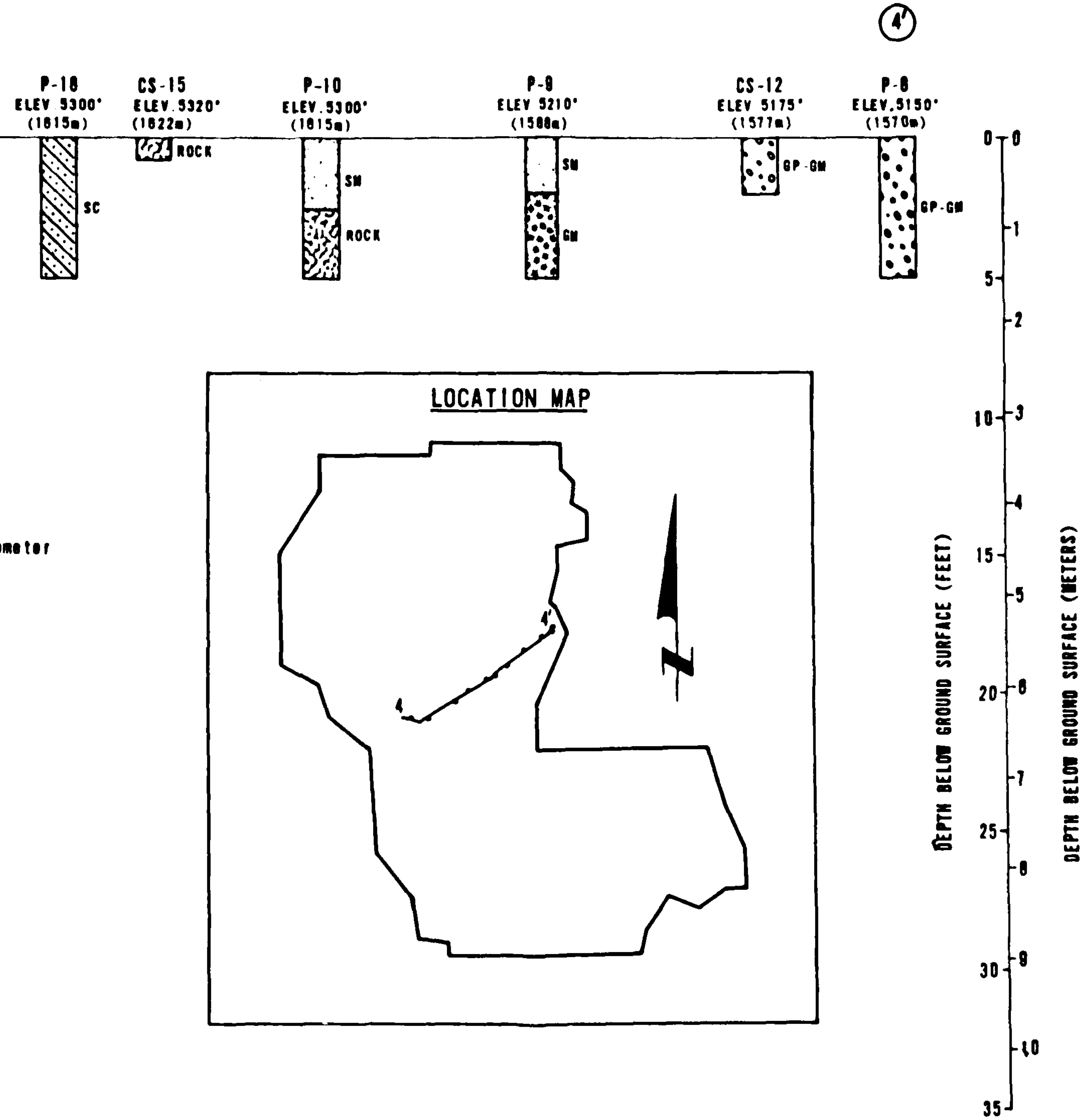
Unified Soil
Appendix.

SOIL PROFILE 4-4' VERIFICATION SITE, GARDEN-COAL
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAM
FUGRO NATIONA

1

2

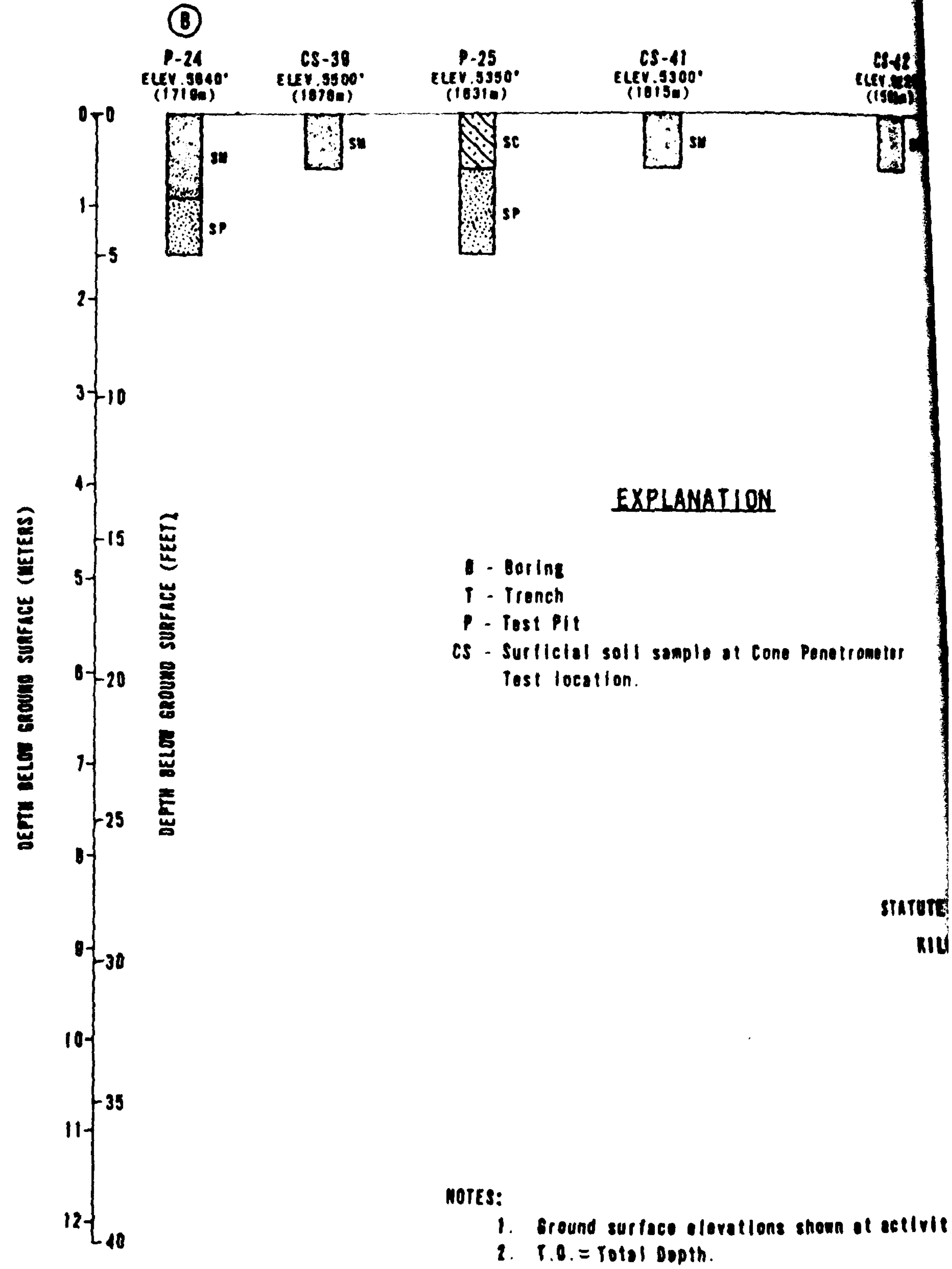
e Penetrometer



SOIL PROFILE 4-4'
VERIFICATION SITE, GARDEN-COAL CDP, NEVADA

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAMSO	FIGURE 8-5

FUGRO NATIONAL, INC.



EXPLANATION

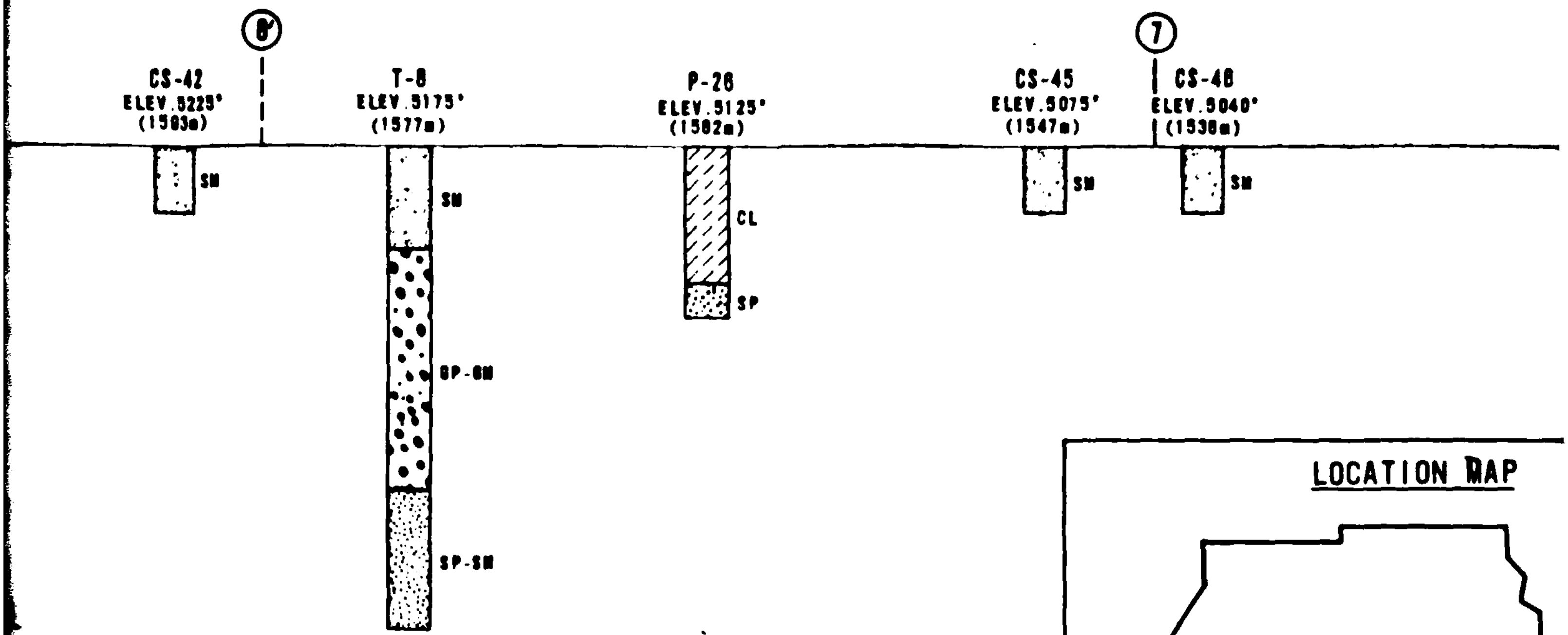
B - Boring
T - Trench
P - Test Pit
CS - Surficial soil sample at Cone Penetrometer Test location.

STATUTE

KIL

NOTES:

1. Ground surface elevations shown at activit
2. T.D. = Total Depth.
3. Soil types shown adjacent to soil column a Classification System (USCS) and are expla

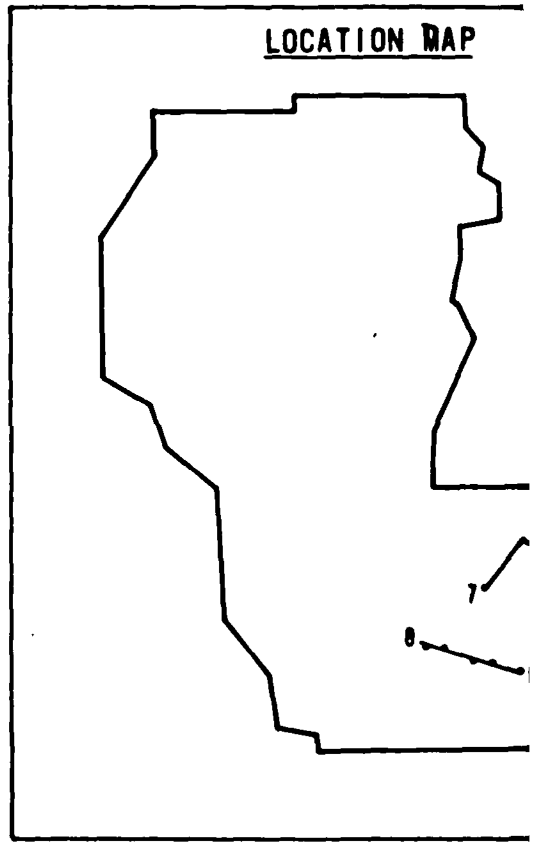


ne Penetrometer

HORIZONTAL SCALE

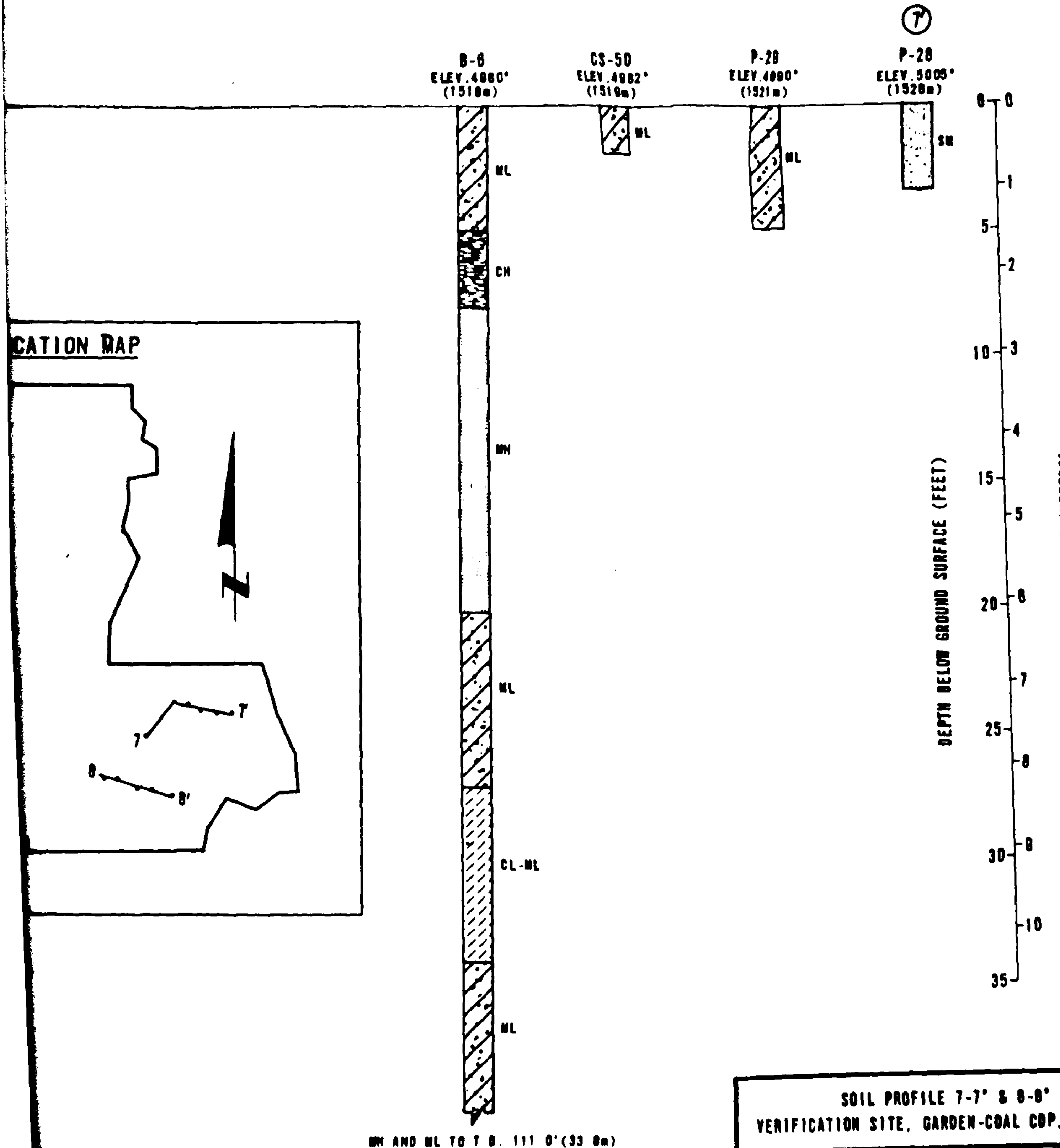
STATUTE MILES 0 1 2

KILOMETERS 0 1 2 3



hown at activity locations are approximate.

soil column are based on Unified Soil
and are explained in the Appendix.



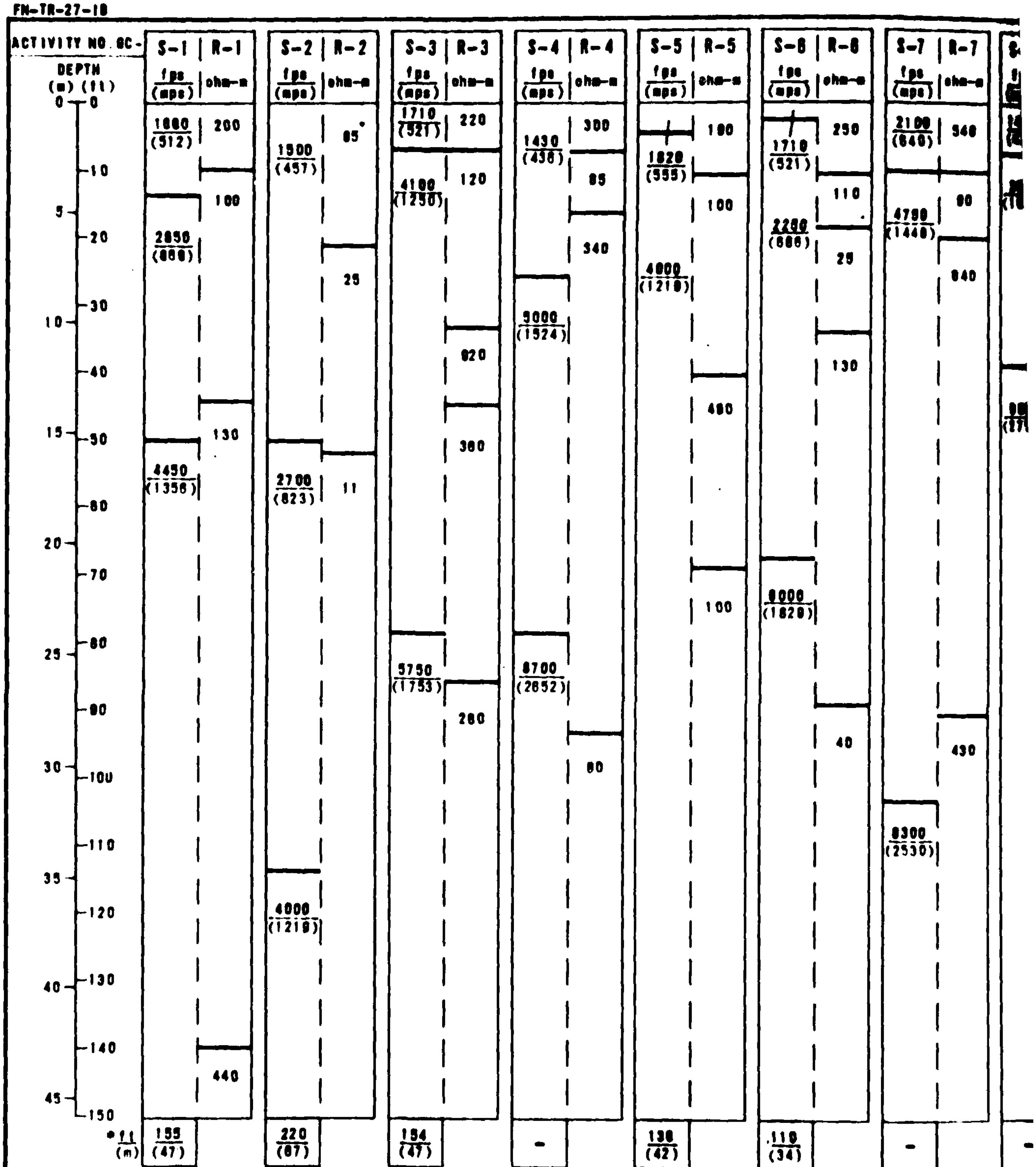
SOIL PROFILE 7-7' & 8-8'
VERIFICATION SITE, GARDEN-COAL COP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

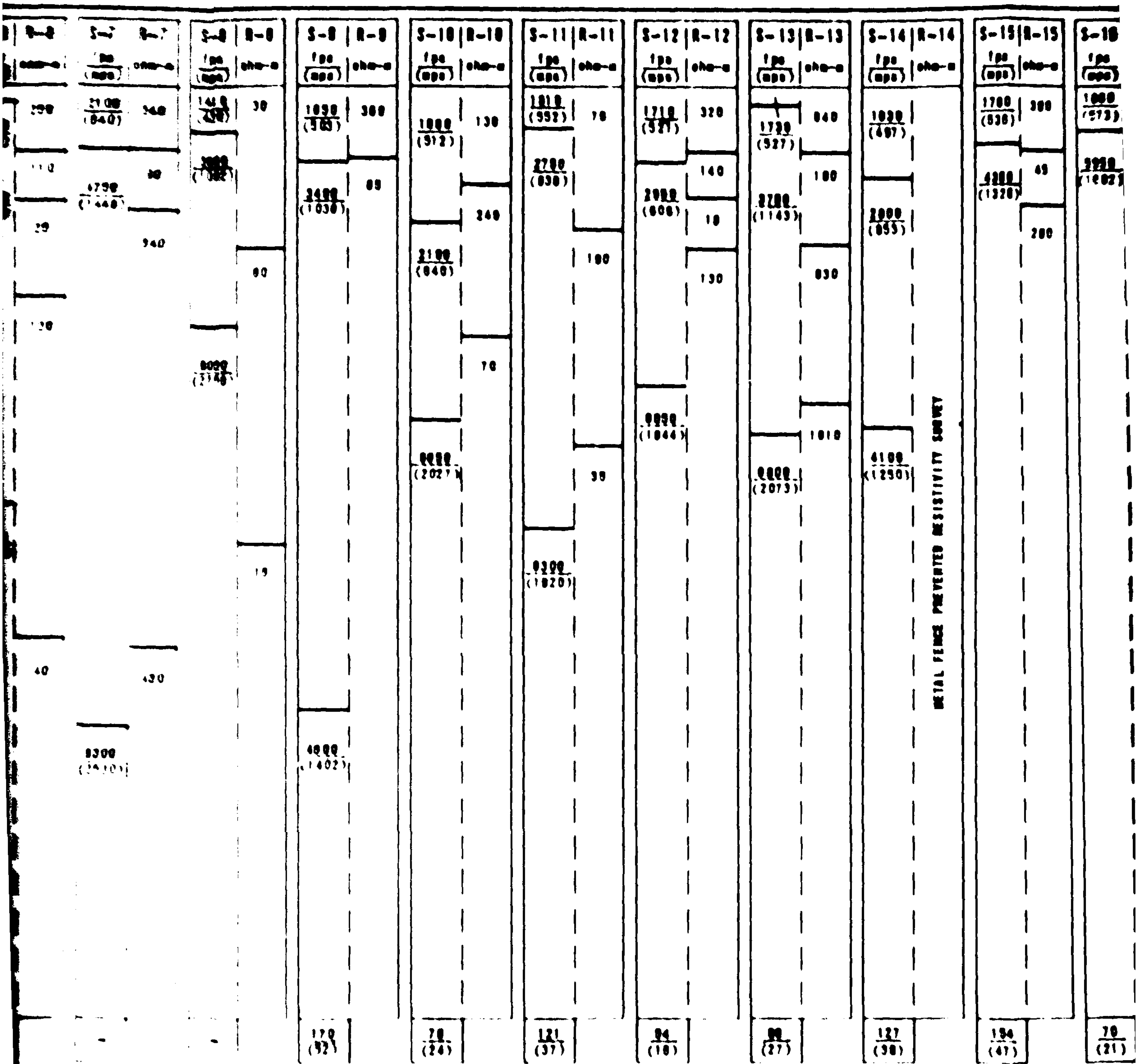
FIGURE
8-8

FUGRO NATIONAL, INC.

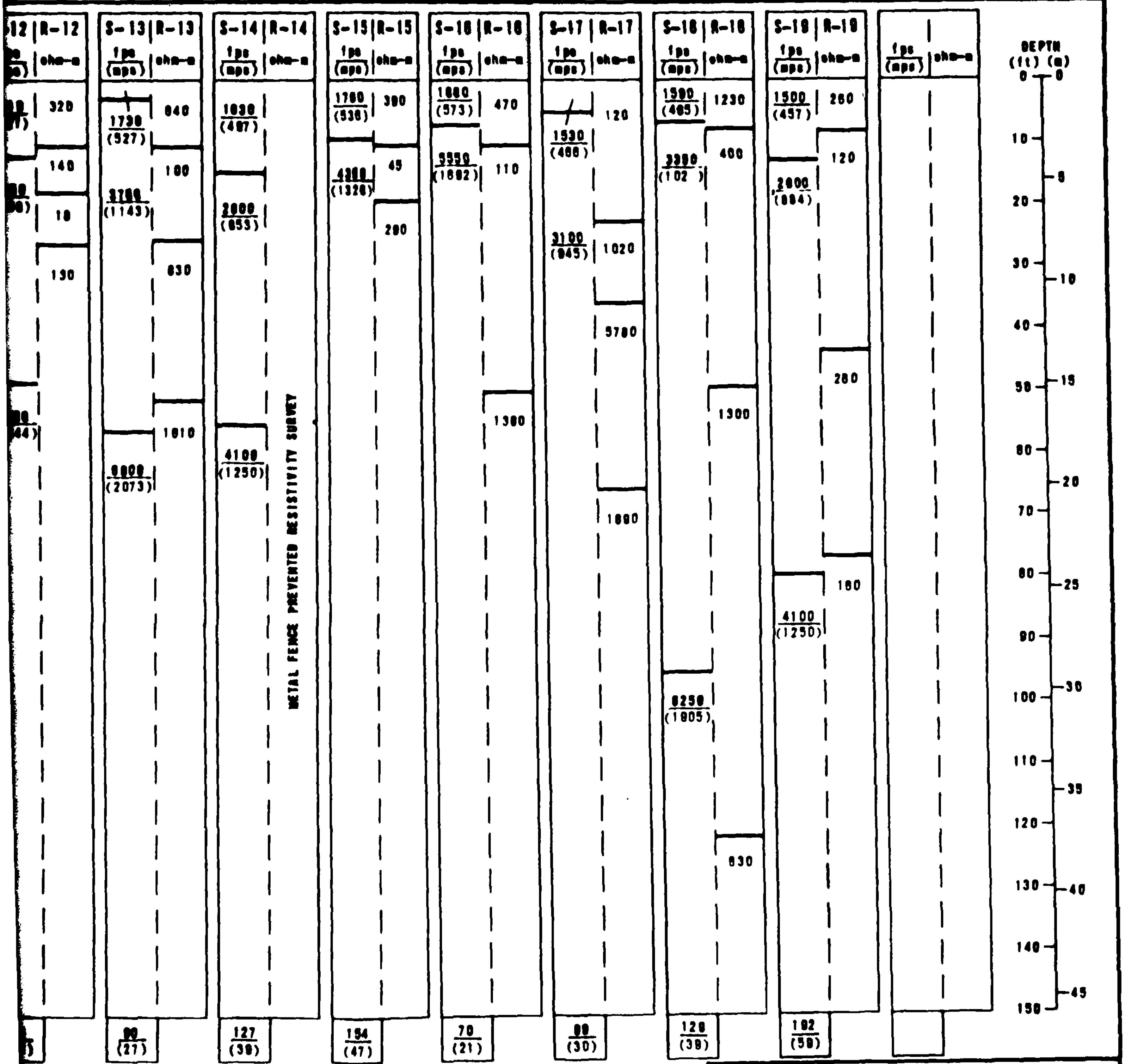
1 3



* Approximate depth above which there is no indication of material with a velocity as great as 7000 fps (2134 mps). See Appendix for an explanation of how this exclusion depth is calculated when the observed velocities are all less than 7000 fps (2134 mps).



S-7
R-7
S-8
R-8
S-9
R-9
S-10
R-10
S-11
R-11
S-12
R-12
S-13
R-13
S-14
R-14
S-15
R-15
S-16
fps (mps)
ohm-m
METAL FENCE PREVENTED RESISTIVITY SURVEY



SEISMIC REFRACTION AND
ELECTRICAL RESISTIVITY
VERIFICATION SITE, GARDEN-COAL CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE
B-4

FUGRO NATIONAL, INC.

AFV-19

3

subsurface soils, as determined from field and laboratory test results, are presented in Table 8-5. Figure 8-7 illustrates the range of gradation of these soils.

The coarse-grained subsurface soils are poorly to well graded and contain coarse to fine sands and gravels. These soils are chiefly associated with alluvial fan deposits of varying age. Granular soils with less than 10 to 15 percent fines are generally loose to dense between depths of 5 and 15 feet (1.5 to 4.6 m). Other granular soils below 5 feet (1.5 m) are generally dense to very dense and have moderate to high shear strengths. Calcium carbonate cementation varies from none to moderate depending on age of the deposit.

The fine-grained subsurface soils are chiefly associated with lacustrine deposits. Soil plasticity varies from slight to high depending in part on the amount of fine sand present. Below 5 feet (1.5 m), these soils are stiff to hard and exhibit low to high shear strengths, depending on the extent of microfracturing in the soil. Calcium carbonate cementation varies from none to weak. Seismic wave velocities of the fine-grained soils are substantially lower than those of the coarse-grained soils (see Table 8-5).

Electrical conductivity of the soils in the upper 50 feet (15 m) ranges from 0.0005 to 0.0226 mhos per meter and averages 0.0065 mhos per meter. At seven of the 18 sites tested, conductivities measured were less than the minimum of 0.004 mhos per meter specified in the Fine Screening criteria. Results of chemical

DEPTH RANGE	2' - 20' (0.6 - 6.0m)	
SOIL DESCRIPTION	Coarse-grained soils	Fi
	Sandy Gravels and Gravelly Sands	Sandy Si Clayey S
USCS SYMBOLS	GP, GW, GM, SM	ML, MH, C
ESTIMATED EXTENT IN SUBSURFACE %	80-90	10-20
PHYSICAL PROPERTIES		
DRY DENSITY pcf (kg/m^3)	108.1-140.9 (1732-2257) [13]	70.7-117. (1133-18
MOISTURE CONTENT %	2.2-13.8 [13]	4.4-28.1
DEGREE OF CEMENTATION	none to moderate	none to m
COBBLES 3-12 inches (8-30 cm) %	0-10	0
GRAVEL %	39-63 [5]	1-3
SAND %	27-50 [5]	12-33
SILT AND CLAY %	4-12 [5]	66-85
LIQUID LIMIT	NDA	53-54
PLASTICITY INDEX	NDA	21-28
COMPRESSIONAL WAVE VELOCITY fps (mps)	1410-5550 (430-1692) [17]	1500-2250 (457-686)
SHEAR STRENGTH DATA		
UNCONFINED COMPRESSION S_u - ksf (kN/m^2)	NDA	2.3 (110)
TRIAXIAL COMPRESSION c - ksf (kN/m^2), $\phi°$	NDA	NDA
DIRECT SHEAR c - ksf (kN/m^2), $\phi°$	NDA	c=0.9, ϕ= (43)

NOTES:

- Characteristics of soils between 2 and 20 feet (0.6 and 6.0 meters) are based on results of tests on samples from 8 borings, 6 trenches, and 20 test pits, and results of 10 seismic refraction surveys.
- Characteristics of soils below 20 feet (6.0 meters) are based on results of tests on samples from 8 borings and results of 10 seismic refraction surveys.

- [ ]
- NDA –

.8 - 6.0m)	20' - 160' (6.0 - 49.0m)	
Fine-grained soils	Coarse-grained soils	Fine-grained soils
Sandy Silts, Silts, Clayey Silts, and Clay	Sandy Gravels, Gravelly Sands, Silty Sands, and Clayey Sands	Sandy Silts, Silts, Sandy Clays, and Clays
ML, MH, CH	GP, GM, GC, SP, SM, SC	ML, MH, CL
10-20	80-90	10-20
70.7-117.7 (1133-1885) [8]	100.9-134.8 (1616-2159) [34]	76.2-116.7 (1221-1869) [17]
4.4-28.1 [8]	7.2-21.5 [34]	6.1-32.7 [17]
none to weak	none to moderate	none to weak
0	0-10	0
1-3 [3]	1-65 [14]	0-2 [4]
12-33 [3]	30-70 [14]	7-43 [4]
66-85 [3]	5-39 [14]	55-93 [4]
53-54 [2]	66 [1]	23-63 [6]
21-28 [2]	NP-39 [2]	5-31 [6]
1500-2250 (457-686) [2]	2100-6800 (640-2073) [17]	2250-6000 (686-1829) [2]
2.3 (110) [1]	1.7 (81) [1]	1.5-8.2 (72-393) [3]
NDA	NDA	c = 0-5.6, ø = 12-36° (0-271) [5]
c = 0.9, ø = 31° (43) [3]	NDA	NDA

- [ ] - Number of tests performed.
- NDA - No data available (insufficient data or tests not performed.)

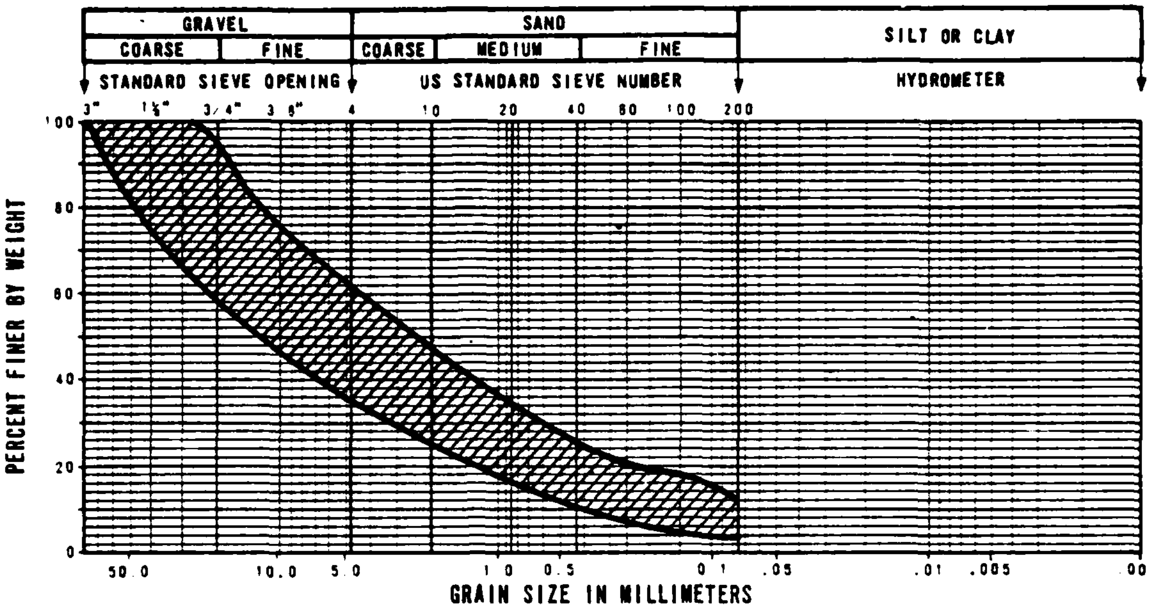
CHARACTERISTICS OF SUBSURFACE SOILS
VERIFICATION SITE, GARDEN-COAL CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

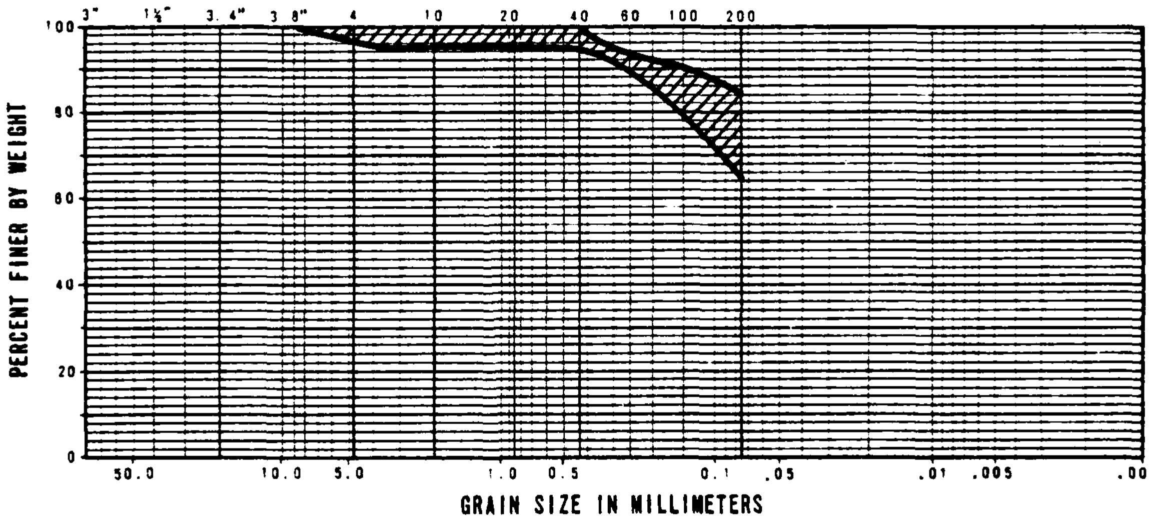
TABLE 6-5

FUGRO NATIONAL, INC.

AFV-20



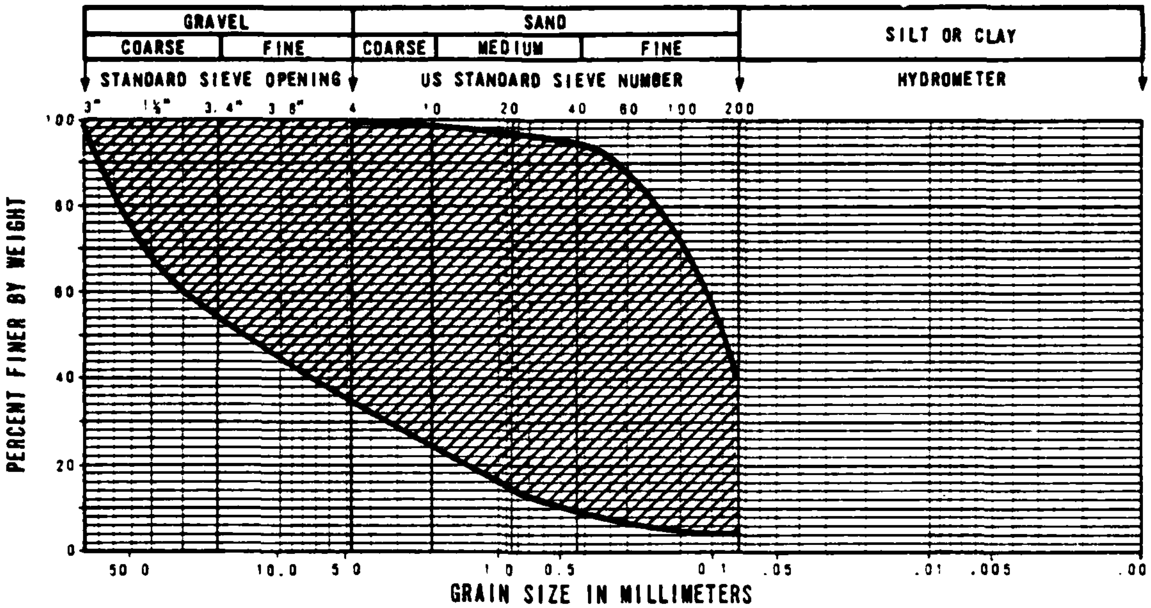
SOIL DESCRIPTION: Coarse-grained soils from 2 to 20 feet (0.6 to 6m)



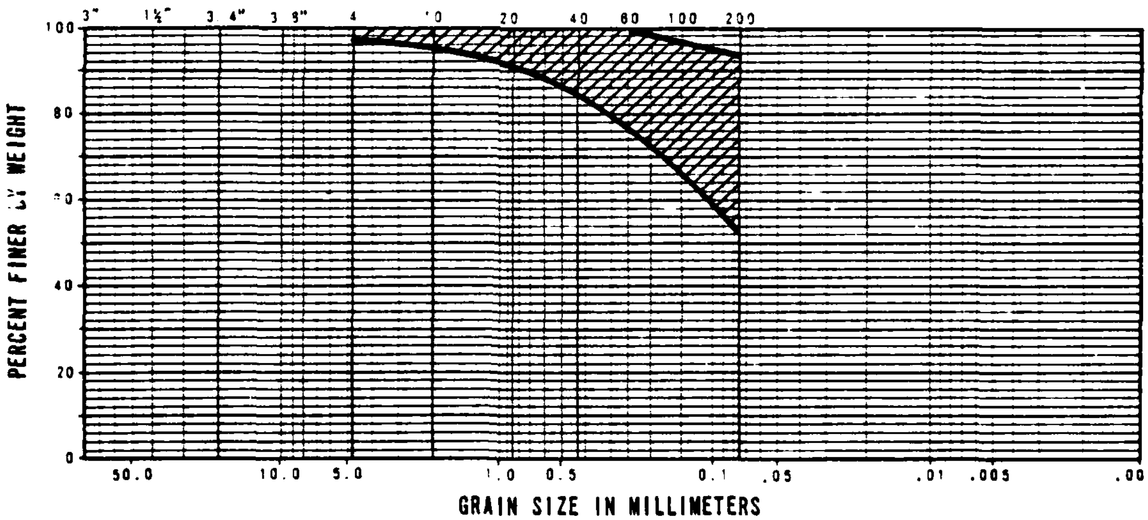
SOIL DESCRIPTION: Fine-grained soils from 2 to 20 feet (0.6 to 6m)

RANGE OF GRADATION OF SUBSURFACE SOILS VERIFICATION SITE, GARDEN-COAL CDP, NEVADA	
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAMSO	FIGURE 8-7 1 OF 2

FUGRO NATIONAL, INC.



SOIL DESCRIPTION: Coarse-grained soils from 20 to 160 feet (6 to 49m)



SOIL DESCRIPTION: Fine-grained soils from 20 to 160 feet (6 to 49m)

RANGE OF GRADATION OF SUBSURFACE SOILS
VERIFICATION SITE, GARDEN-COAL CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 8-7
2 OF 2

FUGRO NATIONAL, INC.

tests indicate that potential for sulfate attack of soils on concrete will be "mild" in Coal Valley but may be "considerable" in Garden Valley.

8.6 TERRAIN

The distribution of terrain categories in the site is shown in Drawing 8-3. These terrain categories bear a very close relationship to geologic units. This is because no suitable scale topographic base maps existed for most of the site and terrain categories were compiled primarily from orthophotoquads.

Depths of incision are greatest in the older and intermediate alluvial fans that flank the mountain fronts. All of the older fans were excluded from suitable area during the field investigation because of adverse terrain (category VII). Drainage depths and surface gradients in the intermediate fans average 6 feet (2 m) and 3 percent, respectively (category II).

The flatter central part of the site is dominated by younger alluvial fans and stream channel or flood-plain deposits. These geologic units generally have drainage depths ranging from 1 foot (0.3 m) to 6 feet (2 m; category II). However, drainage incision depth can exceed 13 feet (4 m) where younger alluvial fans occur on steeper slopes near the mountains (category III). In addition, several long, relatively narrow stream channels are mapped as category VI. This approach was used to distinguish deeply incised major drainages from the surrounding areas of much less incision.

8.7 DEPTH TO ROCK

Drawing 8-4 shows the 50-foot (15-m) and 150-foot (46-m) depth to rock contours for the Garden-Coal Site. The contours were based on limited data from shallow seismic refraction surveys, drillhole logs, geologic mapping, and published water-well logs. The interpretation of the data was tempered with considations for structural trends and rock types. Greater than 20 percent of the site was determined to have rock at less than 50 feet below the ground surface. Approximately 10 percent of the site contained rock at depths between 50 and 150 feet.

The depth to rock interpretation is supported only by limited data from well W-11 in southwest Coal Valley and seismic lines S4 and S8 in east-central Garden Valley. A pedimented reentrant located in the central gap of the Golden Gate Range, was identified by seismic line S-7. Two possibly pedimented areas are the Seaman Wash in southwestern Coal Valley and the gap between the Quinn Canyon Range and the Worthington Mountains in west-central Garden Valley.

8.8 DEPTH TO WATER

Garden and Coal valleys are both hydrologically drained valleys (Eakin, Price, and Harrill, 1976). The depth to the regional ground-water table is generally much greater than 200 feet (61 m) over most of the site (Rush, 1974). Shallow water is known to occur in the southern part of the site where water levels rise to approximately 100 feet (30 m) on both sides of a narrow pedimented gap in the Golden Gate Range. A larger shallow water area is located in northern Garden Valley where water levels in wells W-1 and W-2 were measured at 14 feet and 24 feet (4 m and 7 m), respectively. This anomalous condition is probably caused by a fault barrier in the alluvium at the southern extent.

These data and the approximate configuration of the 50-foot (15-m) and 150-foot (46-m) depth to water contours are presented in Drawing 8-6. The area interpreted to have ground water within 50 feet of the surface comprises approximately 2 percent of the site, and an additional 2 percent is interpreted to have ground water between 50 and 150 feet in depth.

8.9 RESULTS AND CONCLUSIONS

8.9.1 Suitable Area

Resulting suitable area as defined by FY 79 Verification Studies in Garden-Coal Site, is shown in Drawing 8-6. The site contains approximately 295 mi^2 (765 km^2) of usable area for a hybrid trench and 250 mi^2 (650 km^2) for a vertical shelter concept. These results are somewhat different than those reported in previous Intermediate/Fine Screening studies due chiefly to:

1. Identification of pedimented areas in southeastern Coal Valley and between the Quinn Canyon Range and the Worthington Mountains in west-central Garden Valley; and
2. Larger shallow water exclusions in northern Garden Valley.

8.9.2 Construction Considerations

In this section, geotechnical factors and conditions as applicable to the construction of the MX system in the suitable area are discussed. Both the hybrid trench and vertical shelter basing modes are considered in the discussion.

8.9.2.1 Grading

Surficial slopes of the Garden-Coal Site range from 0 to 7 percent with an average of 2 percent. About 5 to 10 percent of the suitable area had measured surface gradients exceeding 5 percent. Therefore, preconstruction grading will be minimal for most of the site.

8.9.2.2 Roads

In general, mechanical compaction of the gravelly and sandy low strength surficial soils in the upper 3 feet (1 m) will be required to improve their subgrade supporting properties. More extensive compaction may be required in about 25 percent of the area having granular surficial soils. Laboratory California Bearing Ratio (CBR) test results indicate that these soils (coarse-grained) will provide good to very good subgrade support for roads when compacted. The fine-grained surficial soils, which have an areal extent of 10 to 20 percent, may not provide suitable subgrade support even when compacted. Therefore, a select granular subbase layer will be required over the compacted fine-grained surficial soils to obtain the required support.

Well-graded gravelly sands and sandy gravels with less than 25 percent fines (passing a No. 200 sieve) can be used for road subbase and base courses. These soils are present at the surface and in the subsurface; however, their extent is not known.

The average drainage incision depth in the suitable site area is 4 feet (1.2 m). Cherry Creek Wash in the northwestern portion of Garden Valley has an incision depth of 66 feet (20 m); however, all other drainages in the site have incision depths ranging from 1 to 46 feet (14 m). Depths exceeding 12 feet (3.6 m) are evident in only 5 to 10 percent of the area. This indicates that the average cost of drainage structures will be moderate.

8.9.2.3 Excavatability and Stability

The soils in the construction zone become dense to very dense below 15 feet (4.6 m). Calcium carbonate cementation is variable but is most developed in the coarse-grained soils.

Hybrid Trench: Compressional wave velocities in the upper 20 feet (6 m) indicate easy to moderately difficult excavation in the suitable area. Continuous trenches could be excavated by an MX trencher for cast-in-place construction. Because of low strength surficial soil, the top 2 to 5 feet (0.6 to 1.5 m) in all trench excavations will generally have to be sloped back for stability. Below this zone, vertical trench walls will be stable in approximately 80 percent of Garden Valley and 60 percent of Coal Valley. Sloping or trench shoring will be required in remaining areas to assure adequate stability.

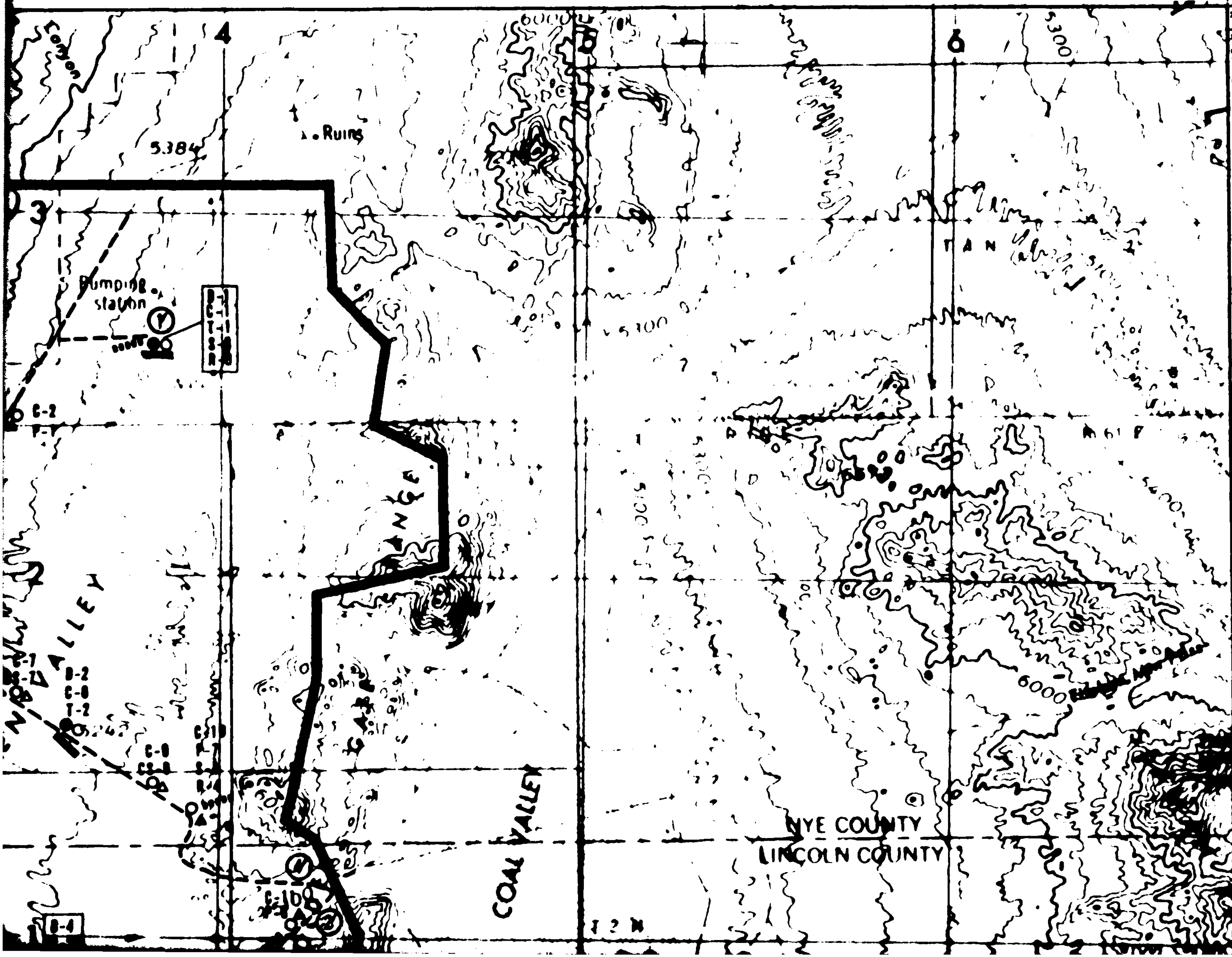
Vertical Shelter: Compressional wave velocities in the upper 120 feet (36 m) indicate that large diameter auger drills could be used for vertical shelter excavations. Slurry or other stabilizing techniques will probably be required to ensure adequate stability of vertical excavation walls.

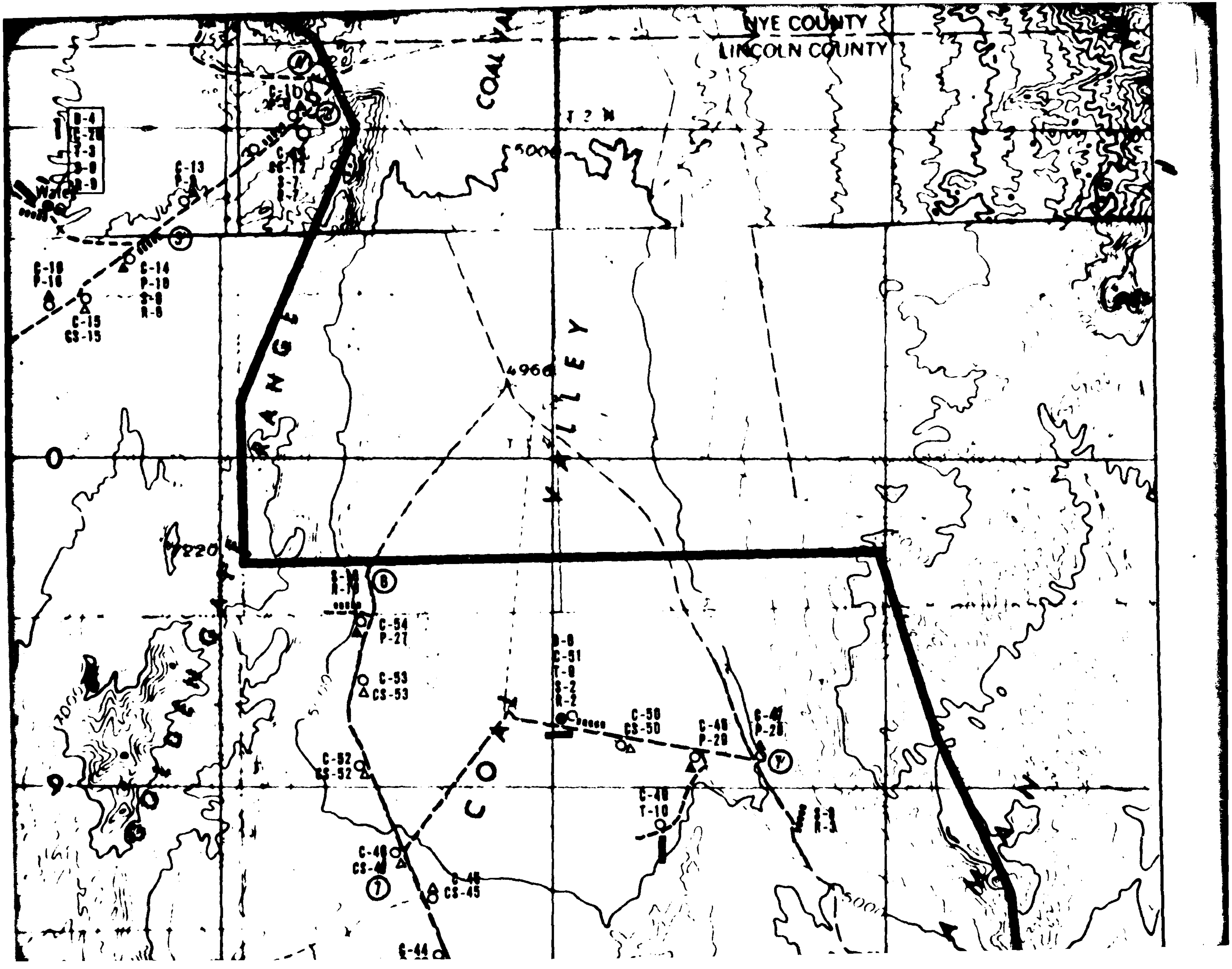
8.10 RECOMMENDATIONS FOR FUTURE STUDIES

The following geotechnical conditions have been identified as requiring additional investigation in order to meet confidence levels attained over most of the Verification site.

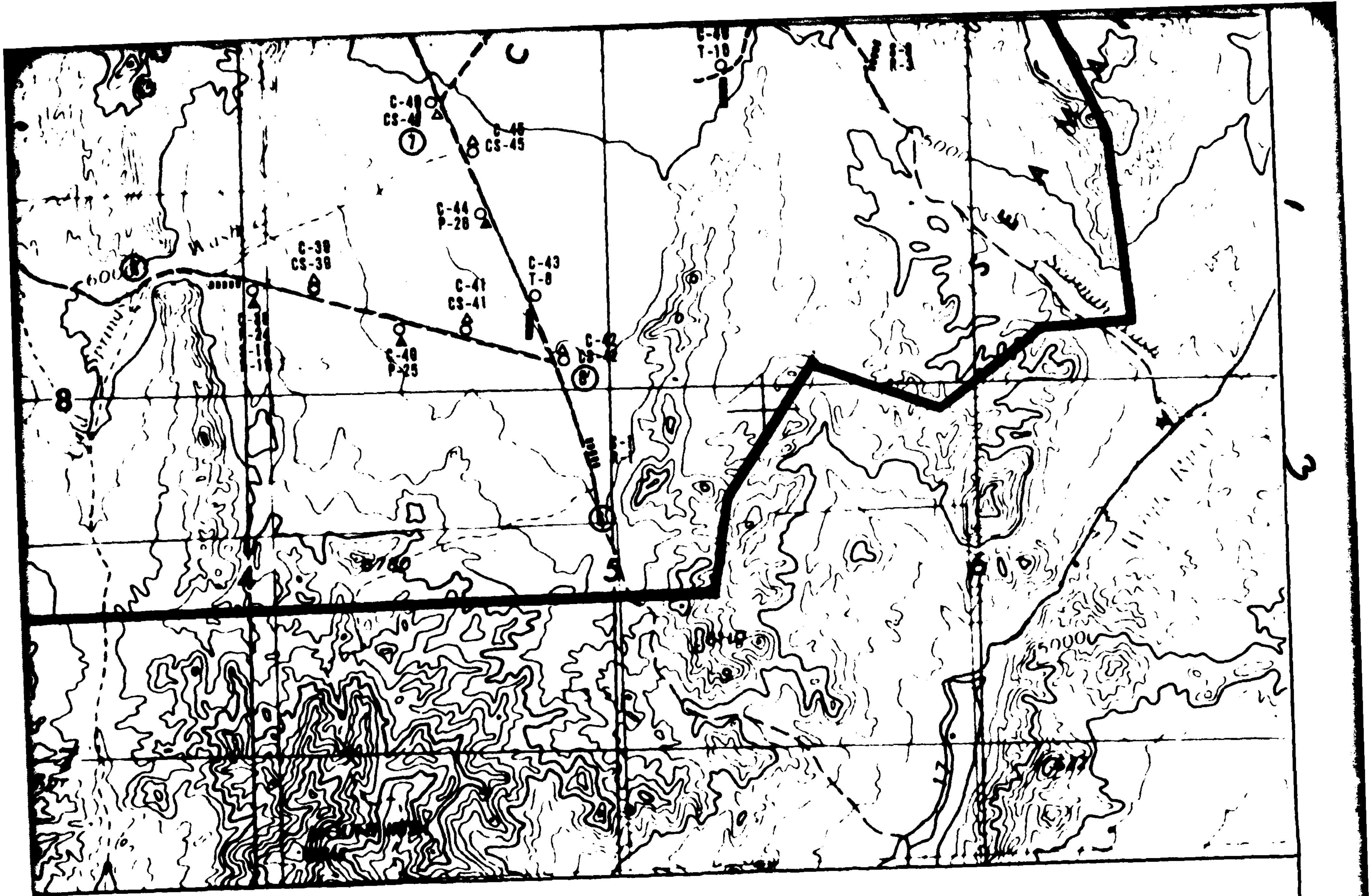
1. The basinward extent and definition of pedimented areas in southeastern Coal Valley and west-central Garden Valley are highly approximate. A limited program of seismic refraction surveys and borings is required to define depth to rock contours.
2. The extent of shallow water and the presence and location of the inferred faults which act as a ground-water barrier in northern Garden Valley are unknown. Detailed geologic mapping, limited geophysical surveys, and ground-water observation wells are recommended to define ground-water conditions and the length and attitude of the fault.
3. A limited Verification program is recommended to define suitable area and basin-fill characteristics for the reconnaissance area north of the present site in Coal Valley.

1

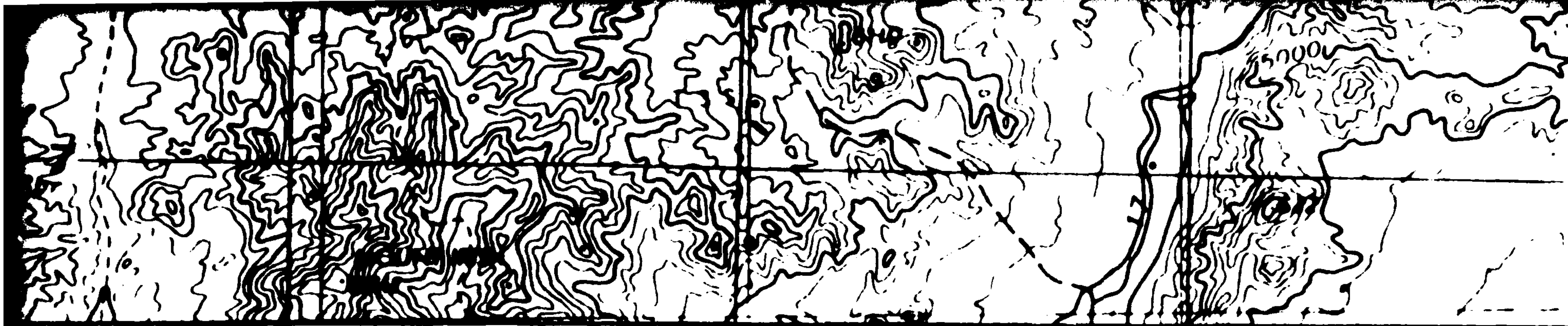

FN-TR-27-13
NYE COUNTY
LINCOLN COUNTY
COAL VALLEY
Pumping station
Ruins
Canyon
5,300
6000
5,384



NYE COUNTY
LINCOLN COUNTY
COAL
RANGE
VALLEY
COAL
4966
5000
C-13
C-14
P-10
C-15
CS-15
C-54
P-27
C-53
CS-53
C-52
CS-52
C-46
C-45
CS-45
C-44
D-6
C-51
T-8
S-2
R-2
C-50
CS-50
C-49
P-29
C-47
P-28
C-48
T-10


C-46
CS-46
C-45
CS-45
C-44
P-28
C-43
T-8
C-39
CS-39
C-41
CS-41
C-40
P-25
C-42
CS-42
C-10
T-10
5000
6000
8

PLANATION



PLANATION

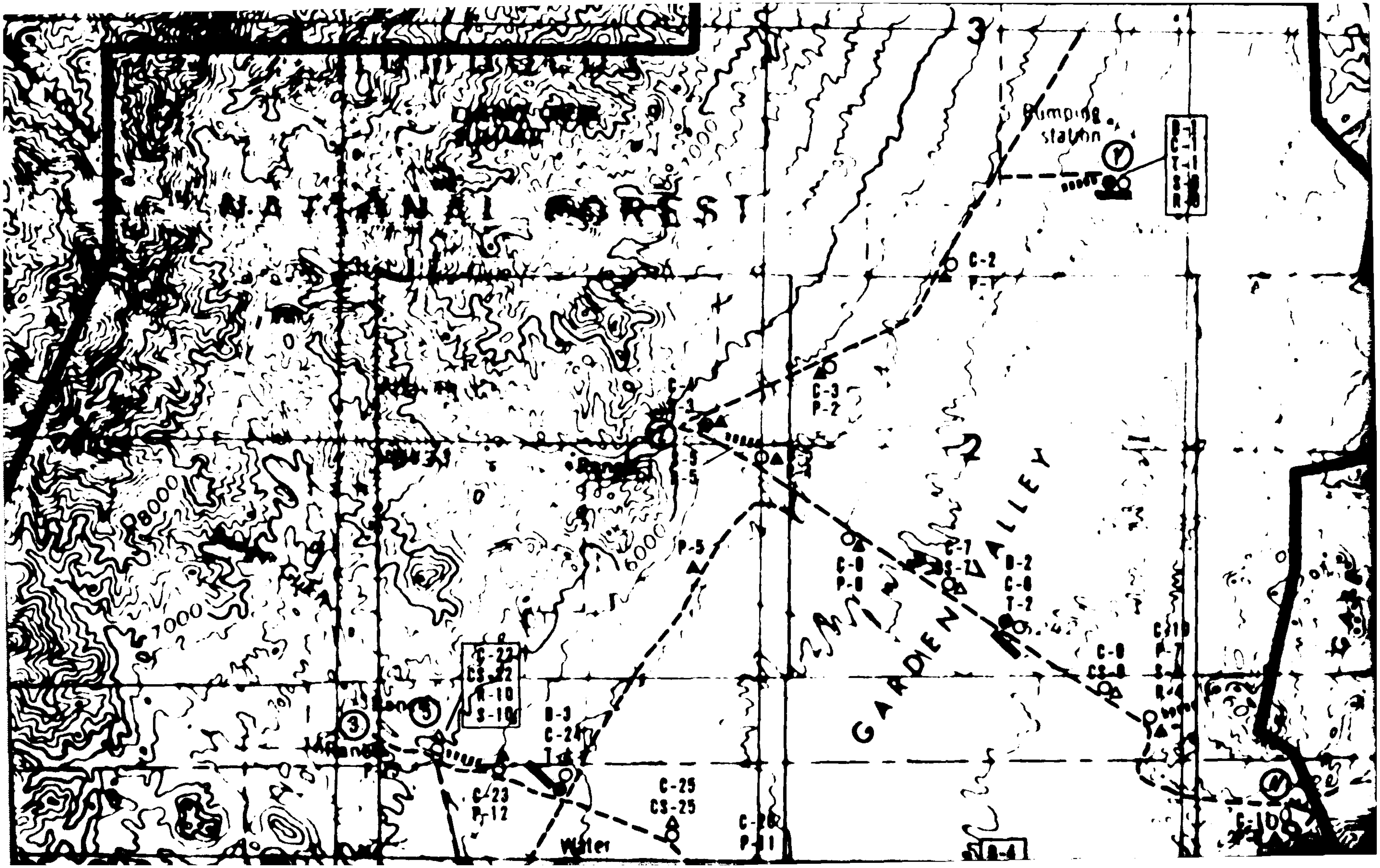
- BORING
- CONE PENETROMETER TEST (CPT)
- SURFACE SAMPLE AT CPT LOCATION
- TRENCH
- TEST PIT
- SEISMIC REFRACTION LINE
- ELECTRICAL RESISTIVITY LINE
- ACTIVITY LINE

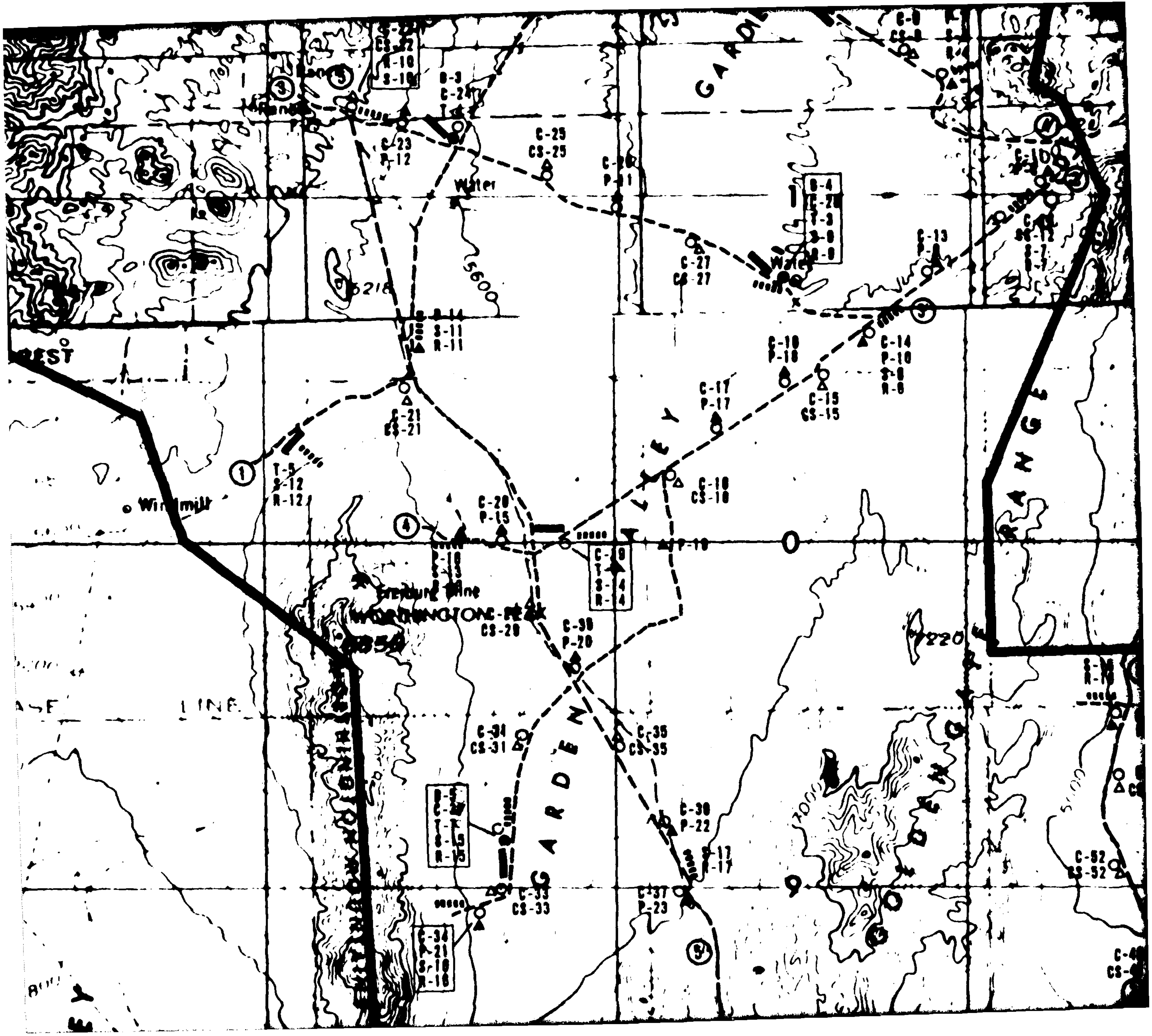
activities were performed at the same location,
ation is designated by either (1) the boring
the CPT symbol, if no boring was drilled.

SCALE 1:125,000

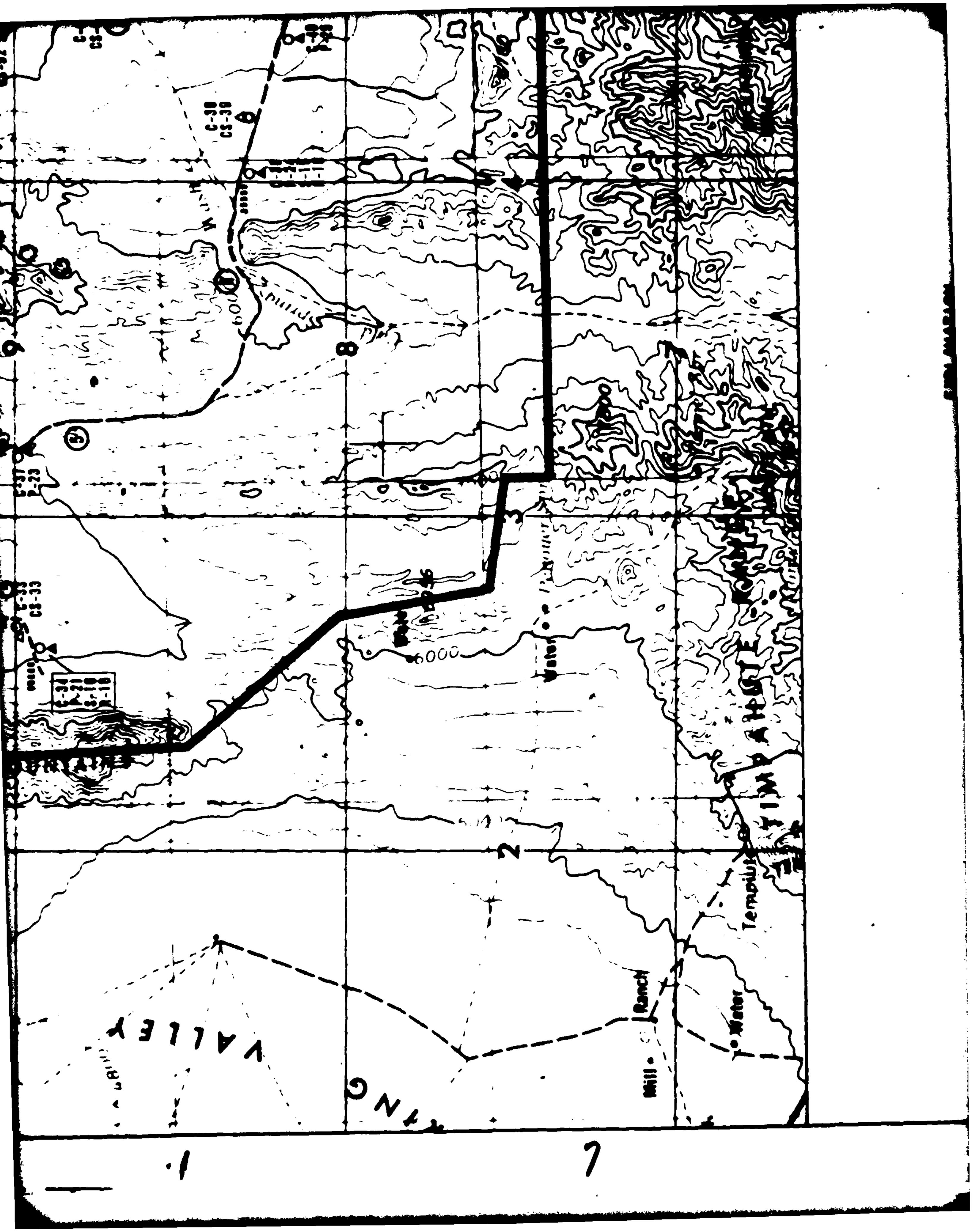
0 2 4
STATUTE MILES

0 2 4
KILOMETERS

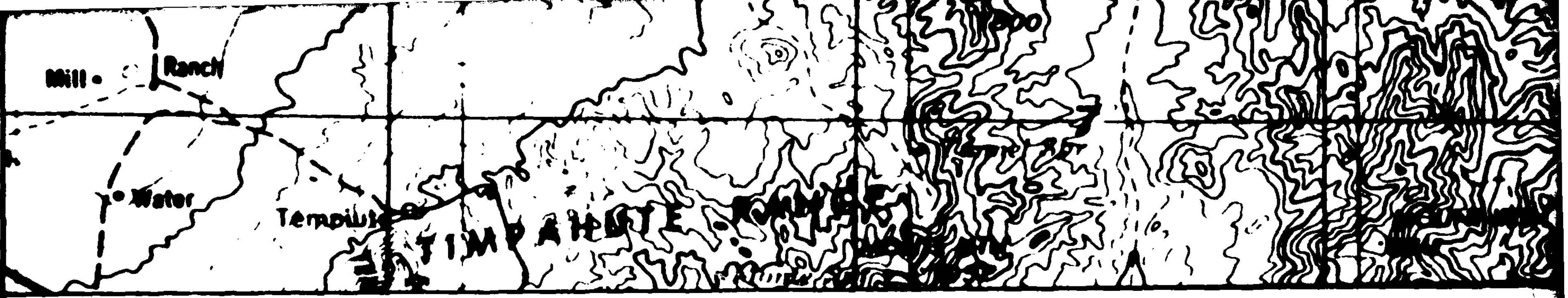

NATIONAL FOREST
GARDEN VALLEY
Pumping station
C-2
P-1
C-3
P-2
P-5
C-25
CS-25
C-23
P-12
C-22
CS-22
R-10
S-10
D-3
C-24
D-2
C-8
T-2
C-100
Water
8000
7000
6000



GARDEN VALLEY
GARDEN VALLEY
RANGE
GOLDEN GATE
WORTHINGTON MOUNTAINS
WORTHINGTON PEAK
Freiburg Mine
Windmill
Water
Water
BASE LINE
5600
5216
7000
5600
C-25
CS-25
C-27
CS-27
C-21
CS-21
C-20
P-15
C-18
CS-18
C-17
P-17
C-15
CS-15
C-14
P-10
C-13
C-23
P-12
T-5
S-12
R-12
S-11
R-11
C-38
P-20
CS-28
C-31
CS-31
C-35
CS-35
C-30
P-22
C-33
CS-33
C-37
P-23
C-52
CS-52
C-34
P-21
S-18
R-18
B-4
T-3
B-3
R-10
S-10
P-18



VALLEY
Ranch
Mill
Water
6000



EXPLANATION

Symbol	Label	Description
●	B-1	BORING
○	C-1	CONE PENETROMETER TEST (CPT)
△	CS-1	SURFACE SAMPLE AT CPT LOCATION
▬	T-1	TRENCH
▲	P-1	TEST PIT
	S-1	SEISMIC REFRACTION LINE
	R-1	ELECTRICAL RESISTIVITY LINE
①-----①		ACTIVITY LINE

NOTE: Where multiple activities were performed at the same location, the correct location is designated by either (1) the boring symbol or (2) the CPT symbol, if no boring was drilled.

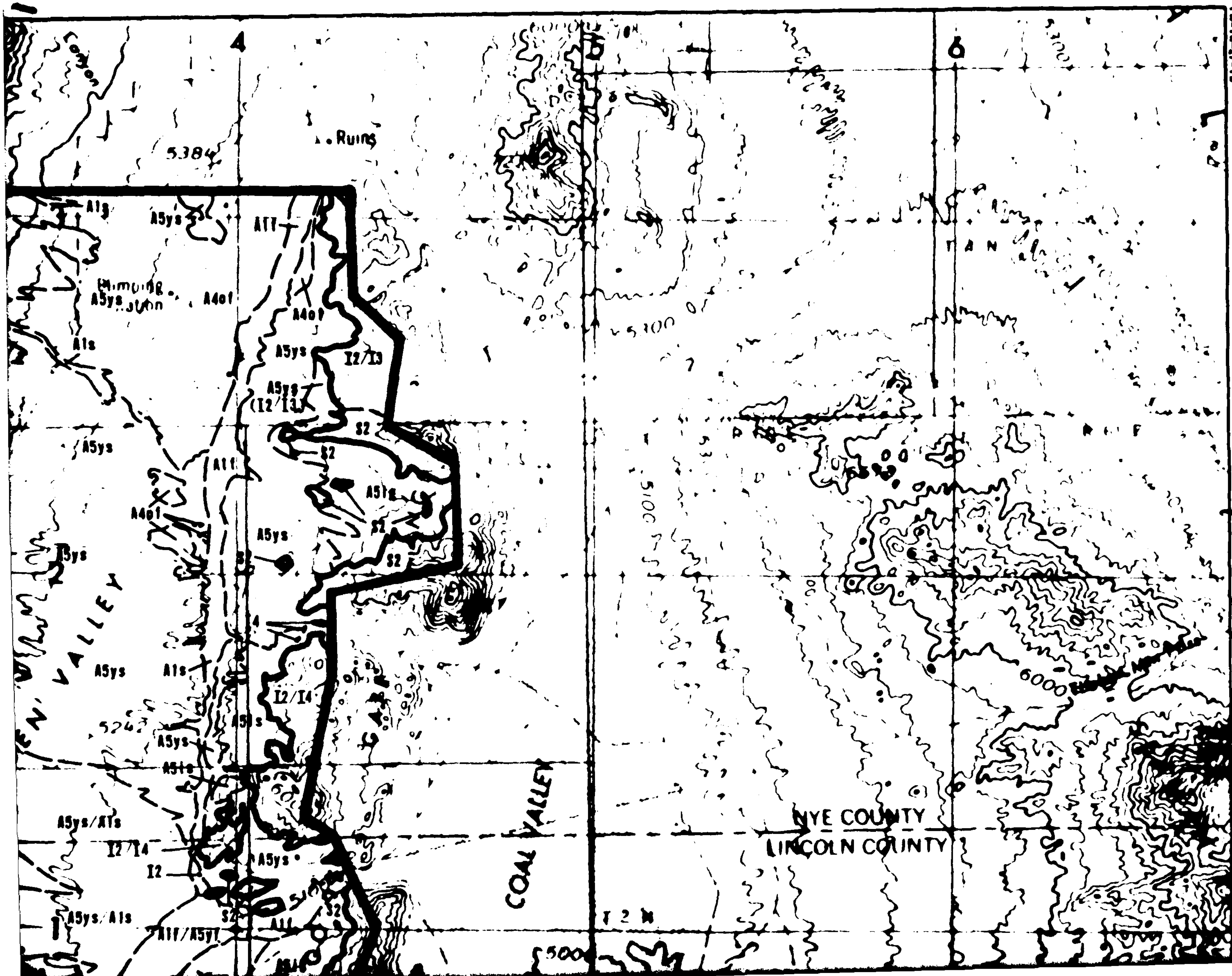
ACTIVITY LOCATIONS
VERIFICATION SITE, GARDEN-COAL CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

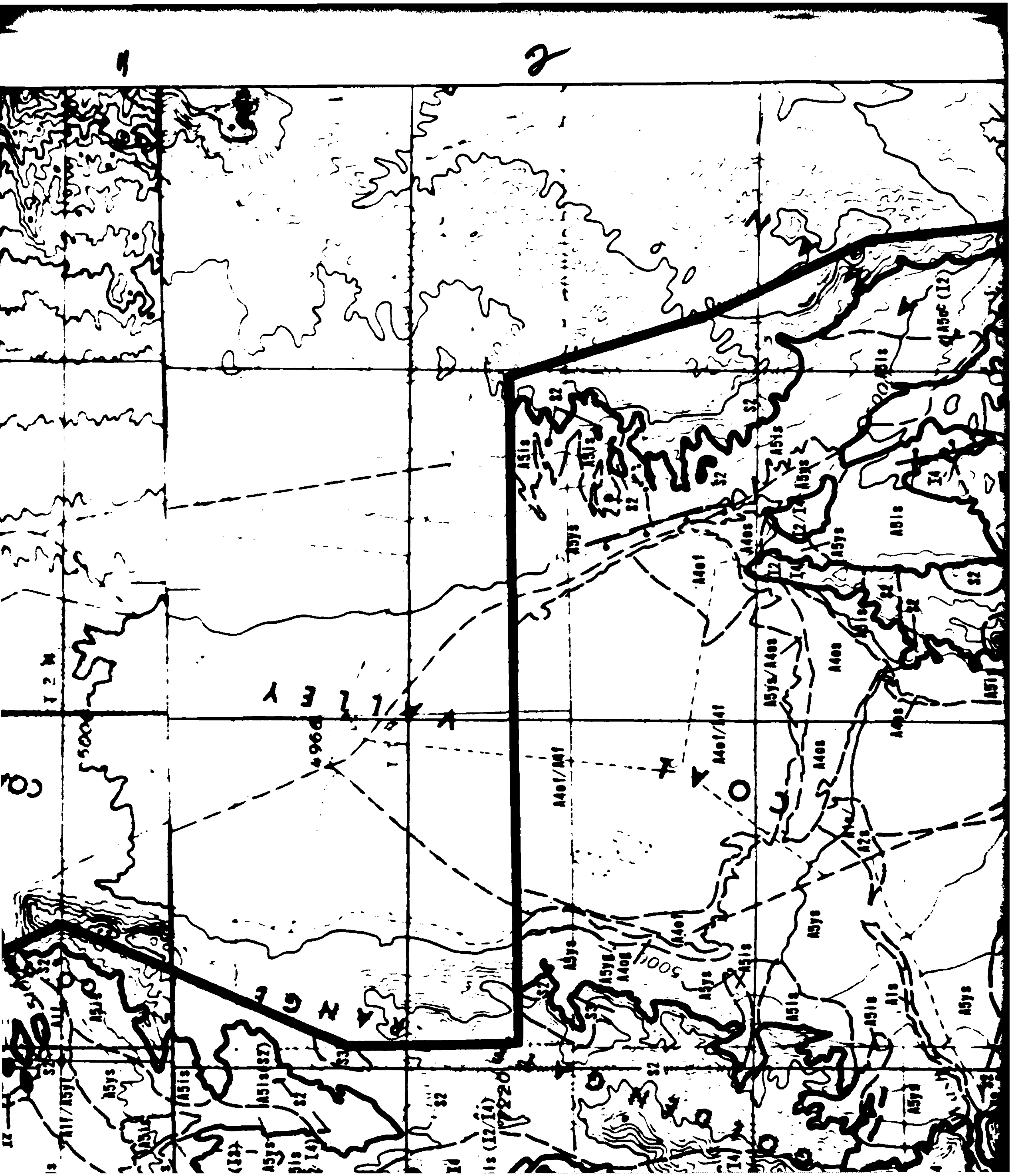
DRAWING 8-1

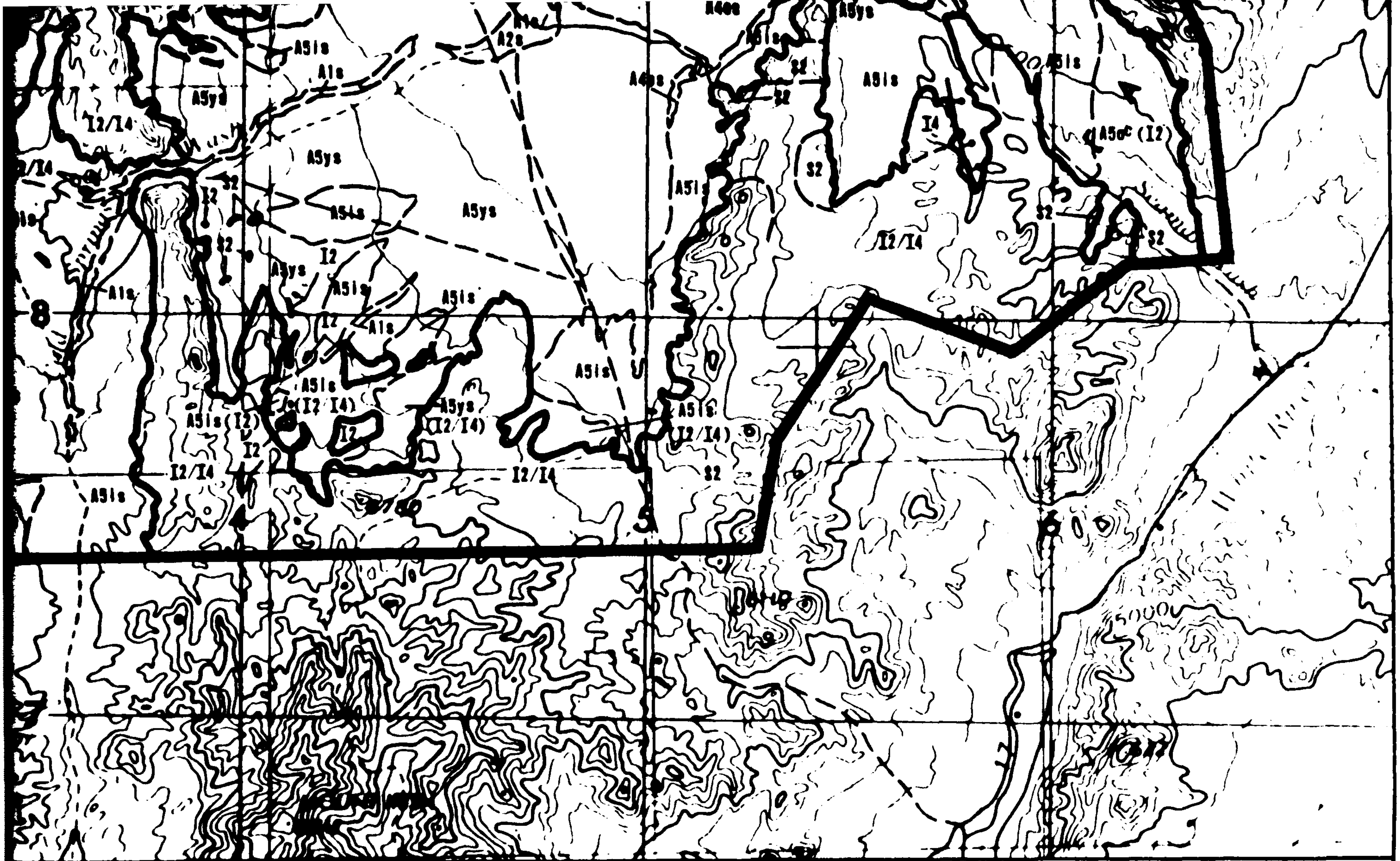
FUGRO NATIONAL, INC.

8



4
5
6
Canyon
5384
Ruins
Nimming John
A5ys
A4of
A1s
I2/I3
S2
A5ts
5100
6000
NYE COUNTY
LINCOLN COUNTY
COAL VALLEY
I2/I4
A5ys/A1s
I2
T 2 N


1
2
A5ls
A5ys
S2
A4es
A4el/A4f
A5ys/A4es
A2s
4964
5000



EXPLANATION

SURFICIAL BASIN-FILL UNITS

...s – Modern stream channel and floodplain deposits of: Alf, clay (CL) and sandy ...y sand (SM).

...Older stream channel and floodplain deposits in terraces composed of silty sand (SM).

SURFICIAL BASIN-FILL UNITS

o - Modern stream channel and floodplain deposits of: A1f, clay (CL) and sandy
y sand (SM).

- Older stream channel and floodplain deposits in terraces composed of silty sand (SM).

- Active playa deposits of sandy silt (ML)

ine Deposits - Inactive playa, older lake bed, and abandoned shoreline deposits of:
A4os, sand and gravelly sand (SP); and A4og, sandy gravel (GP)

posits - Active, younger alluvial fan deposits of: A5yf, sandy silt (ML);
silty sand and gravelly sand (SM); and A5yg, weakly cemented sandy gravel (GM).

an Deposits - Inactive, intermediate-age alluvial fan deposits of:
ted silty sand and gravelly sand (SM); and A5ig, sandy gravel (GM)

sits - Older, highly eroded alluvial fan deposits of moderately cemented
ater than 30 percent boulders and cobbles

ROCK UNITS

, dacite, and andesite

nt, and ignimbrite

locally cherty, with interbedded shale and sandstone

limestone and sandstone

it symbols indicates a mixture of either surficial basin-fill or rock units

lts - Older, highly eroded alluvial fan deposits of moderately cemented
ter than 30 percent boulders and cobbles

ROCK UNITS

dacite, and andesite

t, and ignimbrite

locally cherty, with interbedded shale and sandstone

limestone and sandstone

unit symbols indicates a mixture of either surficial basin-fill or rock units
e

es surface unit at shallow depth.

SYMBOLS

surficial basin-fill units

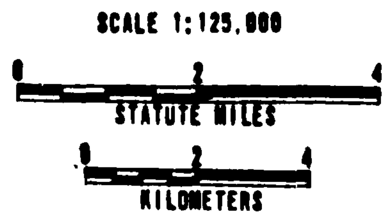
l basin-fill or rock units

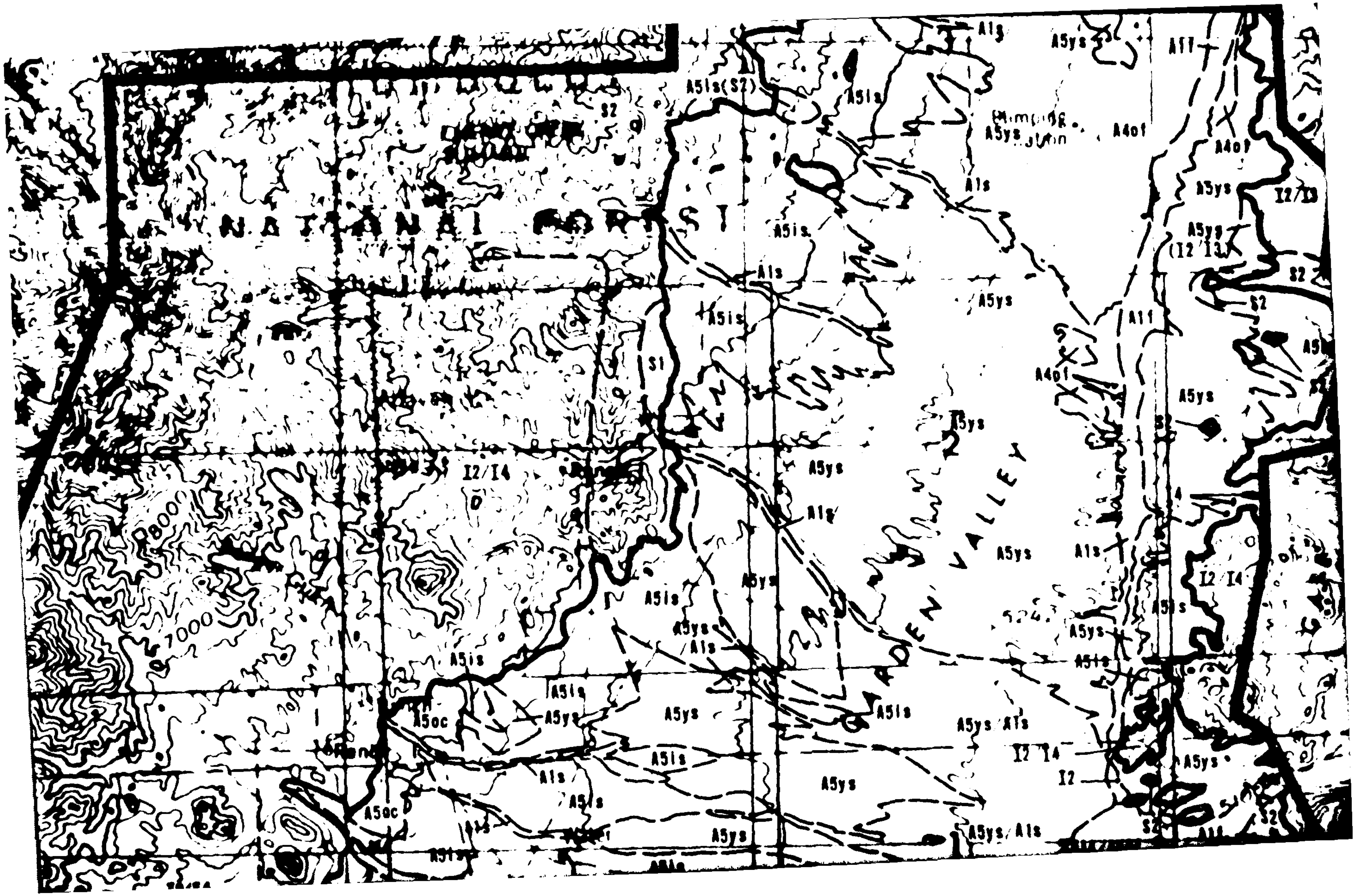
rupture of faults offsetting surficial basin-fill deposits, ball on downthrown side.

pertain only to the upper several feet of soil. Due to variability of surficial deposits
ion, unit descriptions refer to the predominant soil types. Varying amounts of other soil
in each geologic unit

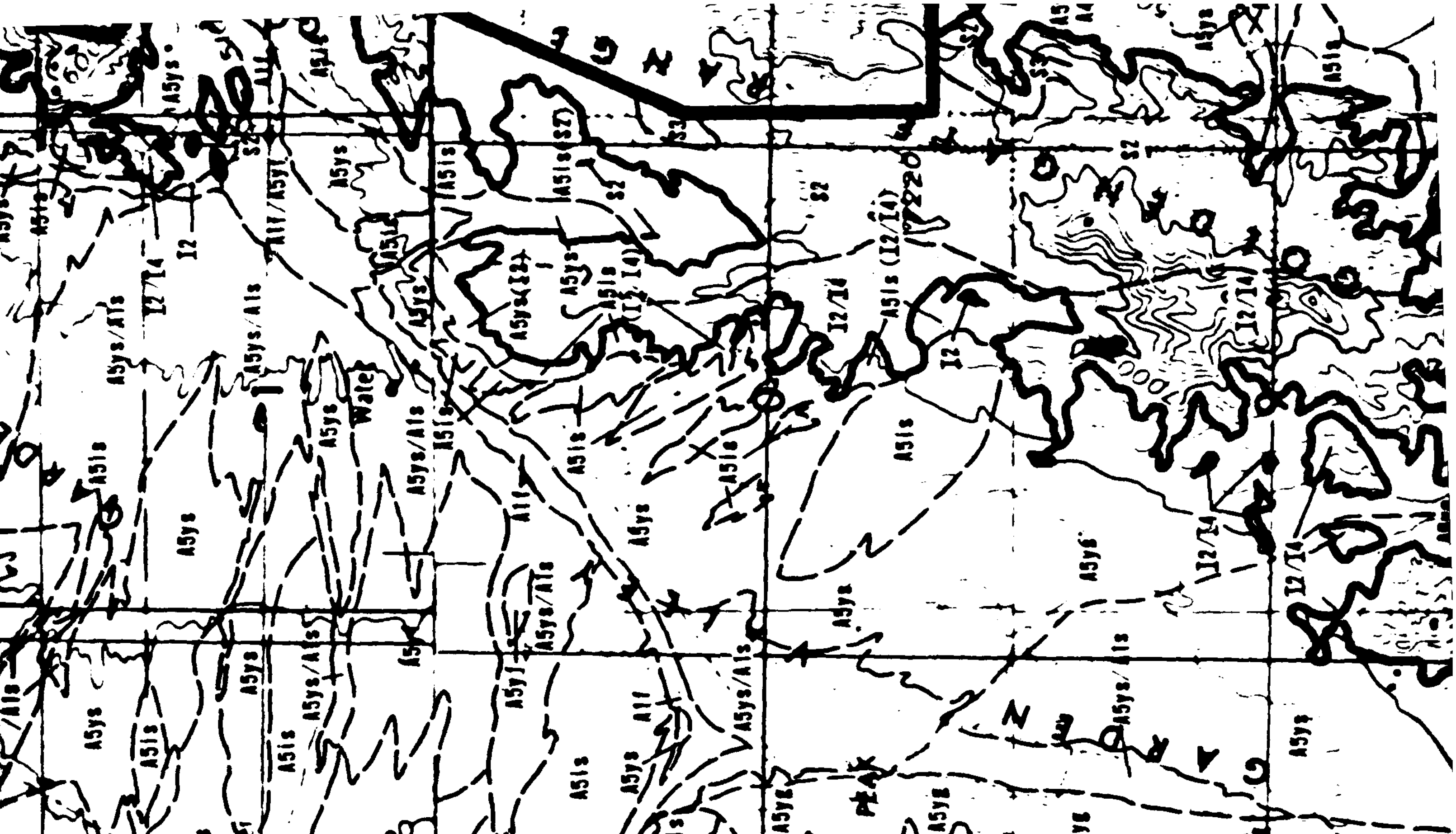
e data stations is presented in Volume II, Drawing 1. A tabulation of all station data
of all geologic units is included in Volume II, Section 1.0.

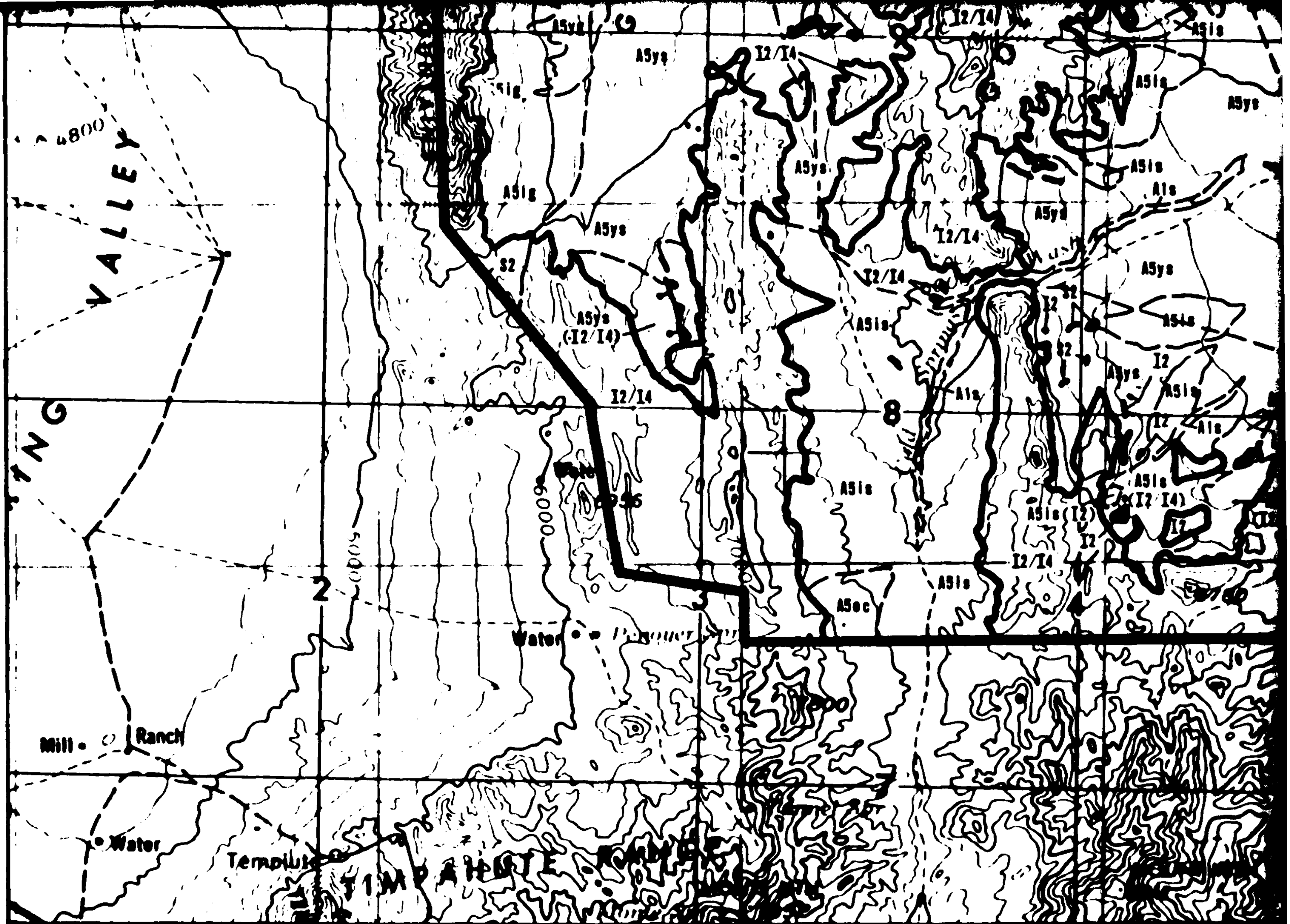
d rock from: Kleinhampl and Ziony (1967), Tschanz and Pampeyan (1970).





VALLEY
A5ys
A1s
A5ls
A5ls(S2)
A4of
A1f
I2/I4
I2/I3
A5oc
S1
S2
7000
8000


WORTHINGTON PEAK
WORTHINGTON MOUNTAINS
GARDEN
RANGE
7220
5600



EXPLANATION

SURFICIAL BASIN-FILL UNITS

EXPLANATION

SURFICIAL BASIN-FILL UNITS

A1f / A1s Younger Alluvial Deposits - Modern stream channel and floodplain deposits silt (ML) and A1s, silty sand (SM).

A2s Older Fluvial Deposits - Older stream channel and floodplain deposits in

A4f Younger Playa Deposits - Active playa deposits of sandy silt (ML)

A4of / A4os / A4og Older Playa and Lacustrine Deposits - Inactive playa, older lake bed, and A4of, sandy silt (ML); A4os, sand and gravelly sand (SP); and A4og, sand

A5yf / A5ys / A5yg Younger Alluvial Fan Deposits - Active, younger alluvial fan deposits of: A5ys, weakly cemented silty sand and gravelly sand (SM); and A5yg, weakly

A5is / A5ig Intermediate Alluvial Fan Deposits - Inactive, intermediate-age alluvial A5is, moderately cemented silty sand and gravelly sand (SM); and A5ig, s

A5oc Older Alluvial Fan Deposits - Older, highly eroded alluvial fan deposits gravelly sand with greater than 30 percent boulders and cobbles

ROCK UNITS

Igneous (I)

I1 Granite

I2 Rhyolite, quartz latite, dacite, and andesite

I3 Basalt

I4 Tuff, tuffaceous sediment, and ignimbrite

Sedimentary (S)

S1 Orthoquartzite

S2 Limestone and dolomite, locally cherty, with interbedded shale and sand

A5lg A5ls, moderately cemented silty sand and gravelly sand (SM); and ...

A5oc Older Alluvial Fan Deposits - Older, highly eroded alluvial fan deposits ... gravelly sand with greater than 30 percent boulders and cobbles

ROCK UNITS

Igneous (I)

I1 Granite

I2 Rhyolite, quartz latite, dacite, and andesite

I3 Basalt

I4 Tuff, tuffaceous sediment, and ignimbrite

Sedimentary (S)

S1 Orthoquartzite

S2 Limestone and dolomite, locally cherty, with interbedded shale and sands...

S3 Shale, with interbedded limestone and sandstone

A5ys/A5ls Combination of geologic unit symbols indicates a mixture of either surf... inseparable at map scale

A5ls(I2) Parenthetic unit underlies surface unit at shallow depth.

SYMBOLS

Contact between rock and surficial basin-fill units

Contact between surficial basin-fill or rock units

Fault, trace of surface rupture of faults offsetting surficial basin-fi...

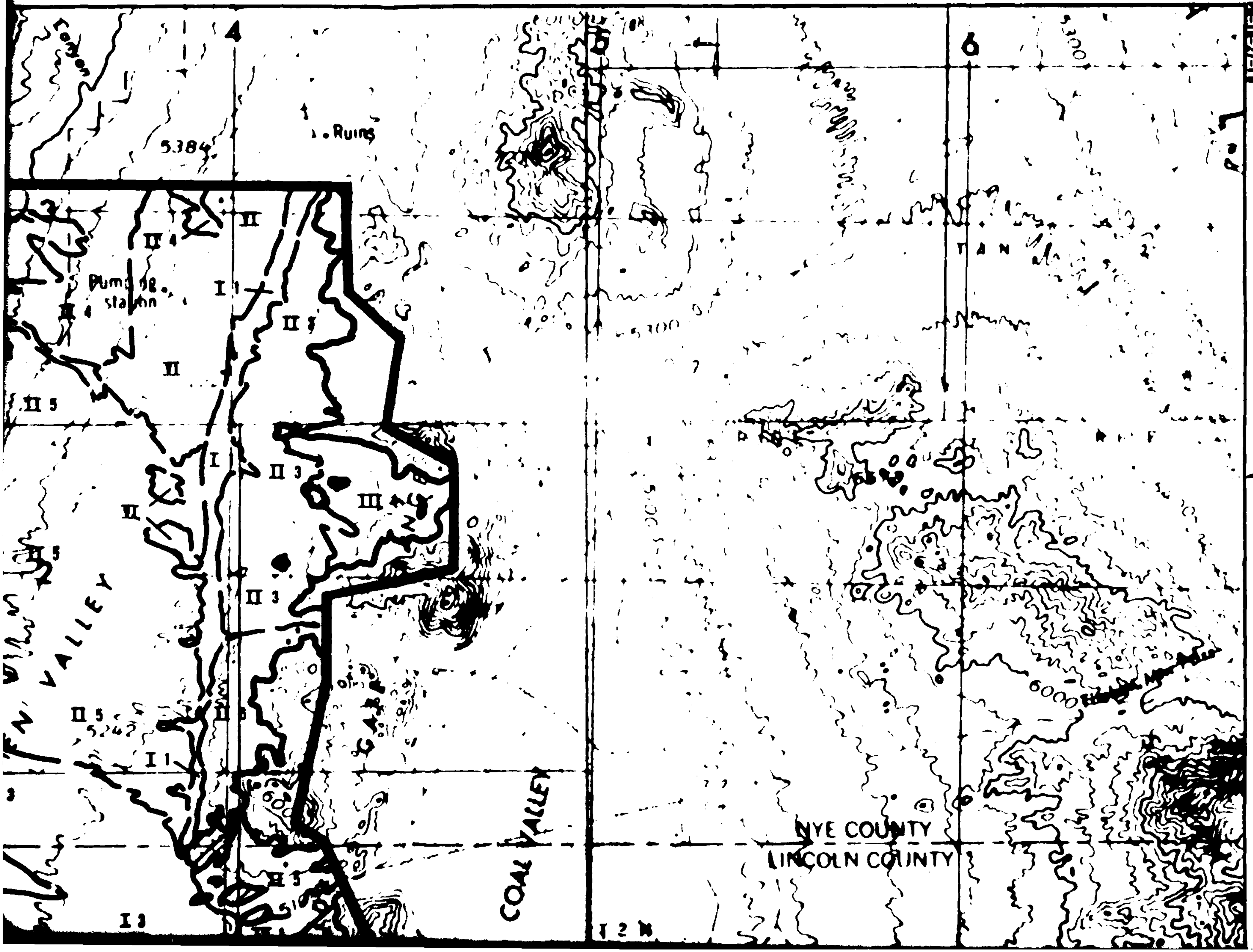
NOTES:
1. Surficial basin-fill units pertain only to the upper several feet of soil. Due ... and scale of map presentation, unit descriptions refer to the predominant soil ... types can be expected within each geologic unit
2. The distribution of geologic data stations is presented in Volume II, Drawing ... and generalized description of all geologic units is included in Volume II, Sect...
3. Geology in areas of exposed rock from: Kleinhampl and Ziony (1967), Tschanz and ...

SURFICIAL GEOLOGIC UNITS VERIFICATION SITE, GARDEN-COAL CDP, NEVADA	
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAMSO	DRAWING 8-2

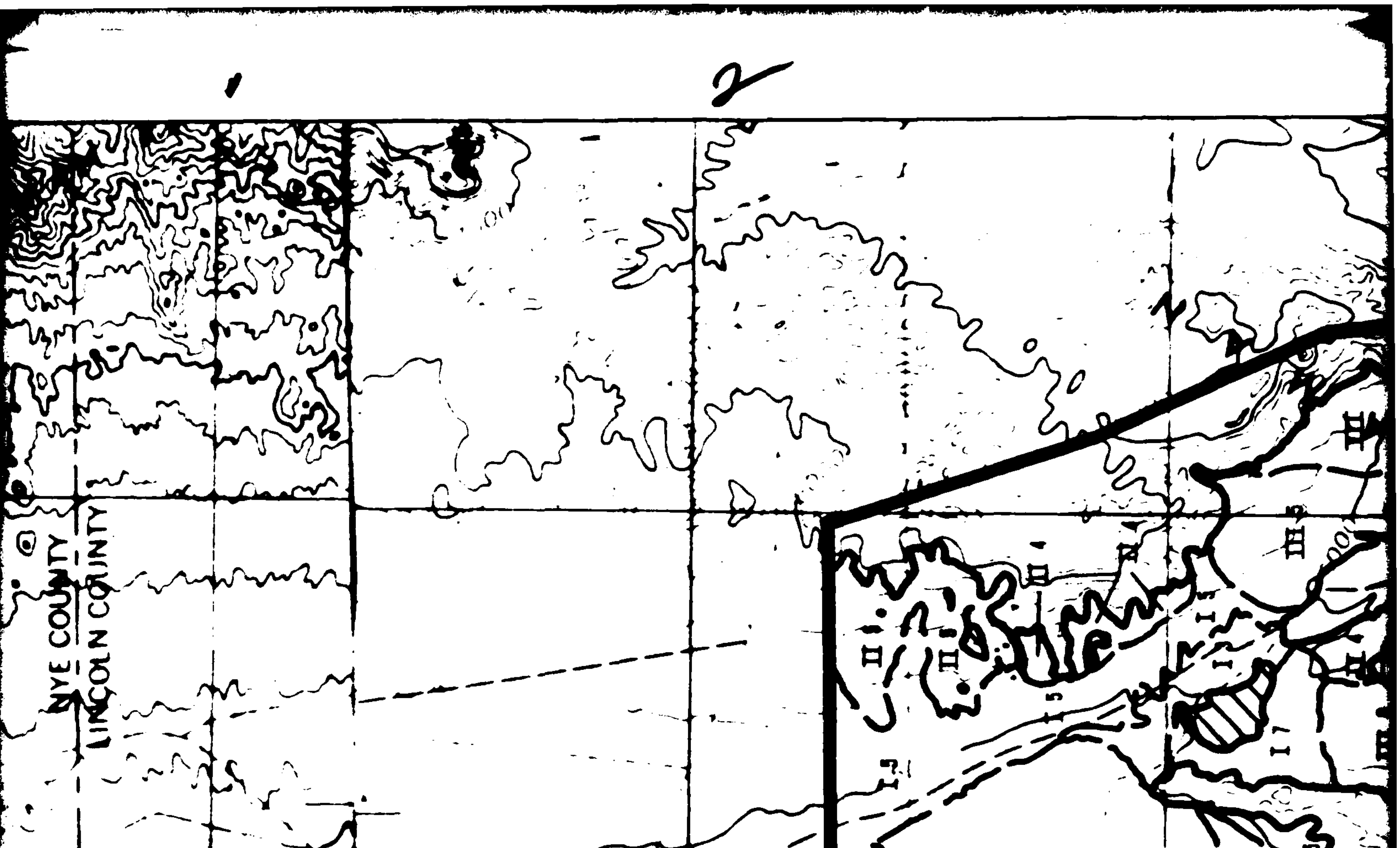
FUGRO NATIONAL, INC.

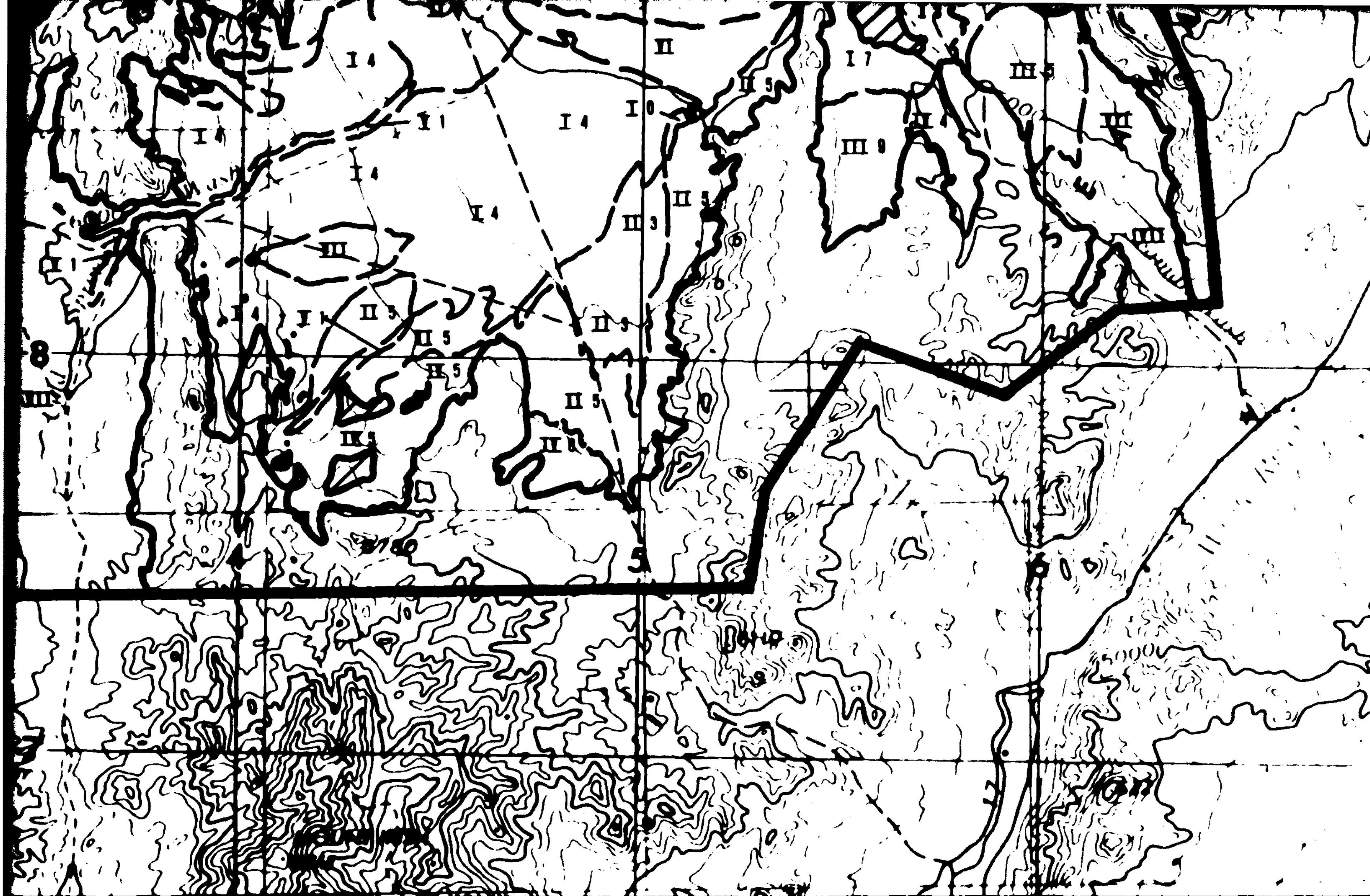
9

10



4
5
6
Ruins
5384
Pumping station
NYE COUNTY
LINCOLN COUNTY
COAL VALLEY
VALLEY
6000
5300


1
2
NYE COUNTY
LINCOLN COUNTY
COAL VALLEY
VALLEY
COAL
RANGE
4966
5000



EXPLANATION

EXPLANATION

------ Drainage spacing, i.e. the maximum number of drainages of the corresponding category occurring in a random traverse of one statute mile (1.6km)

DRAINAGE DEPTH/DESCRIPTION

Less than 3 feet (1m)

3-6 feet (1-2m)

6-10 feet (2-3m)

10-15 feet (3-5m)

Greater than 15 feet (5m)

Complex, highly variable terrain not defined by drainage incision (e.g. dunal or hummocky terrains).

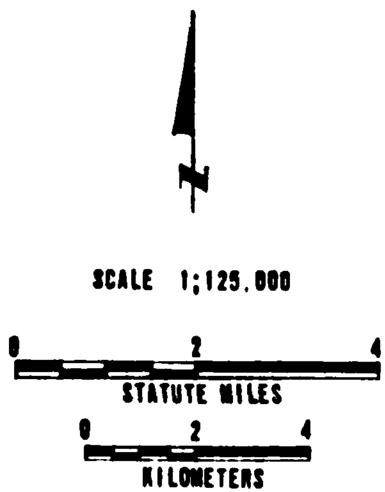
Unsuitable terrain (see Appendix A2.0, Exclusion Criteria)

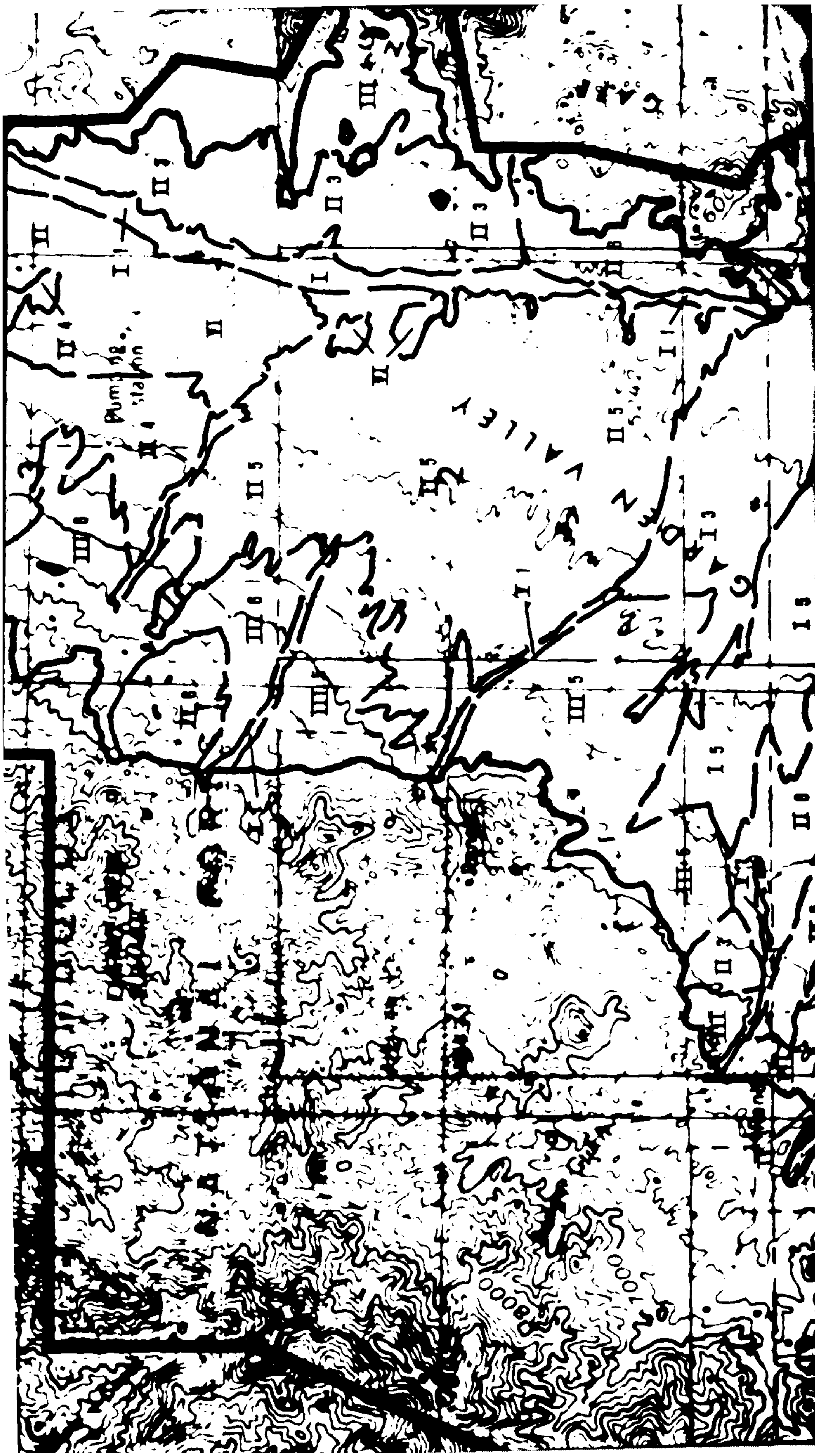
...in categories

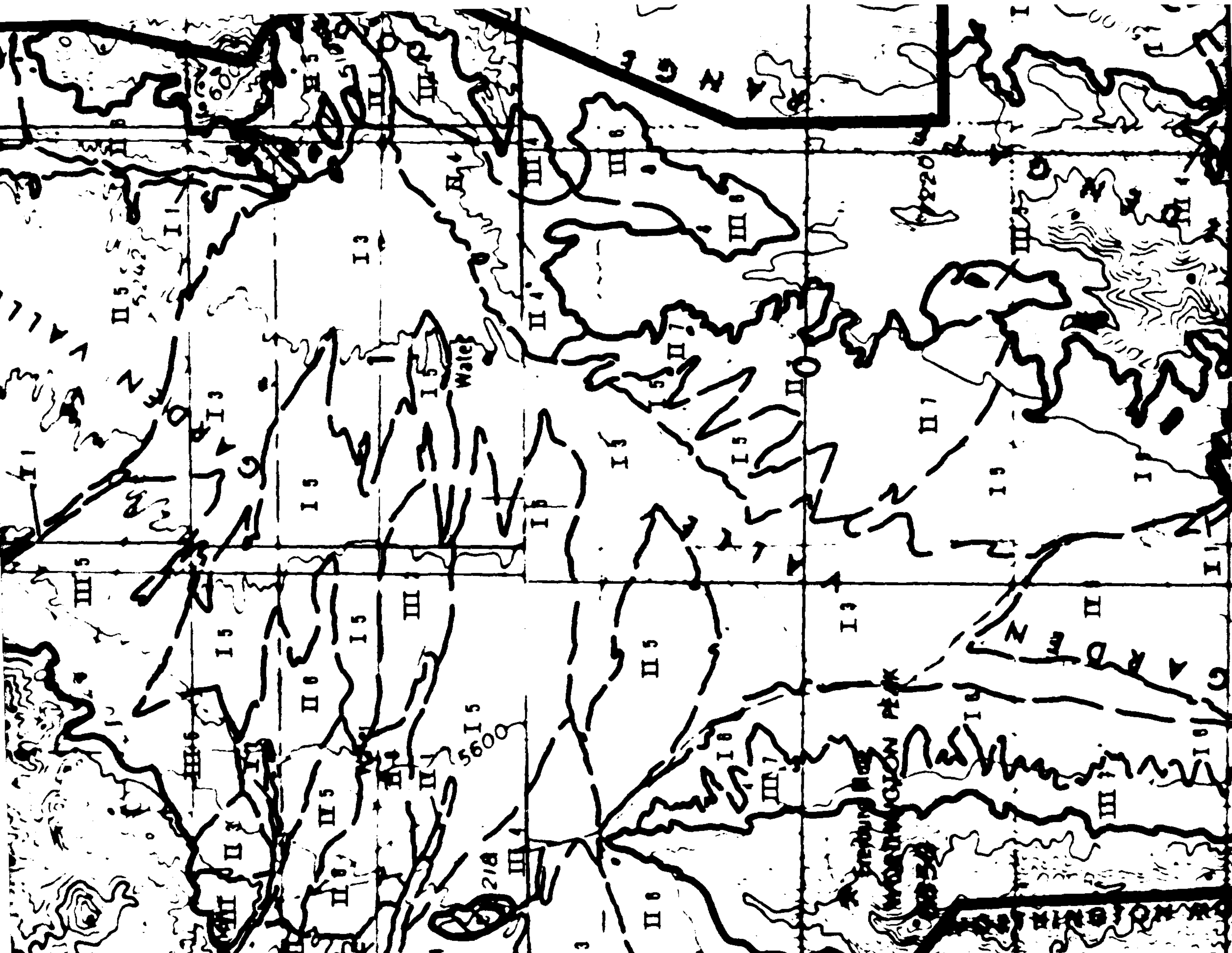
... and basin-fill

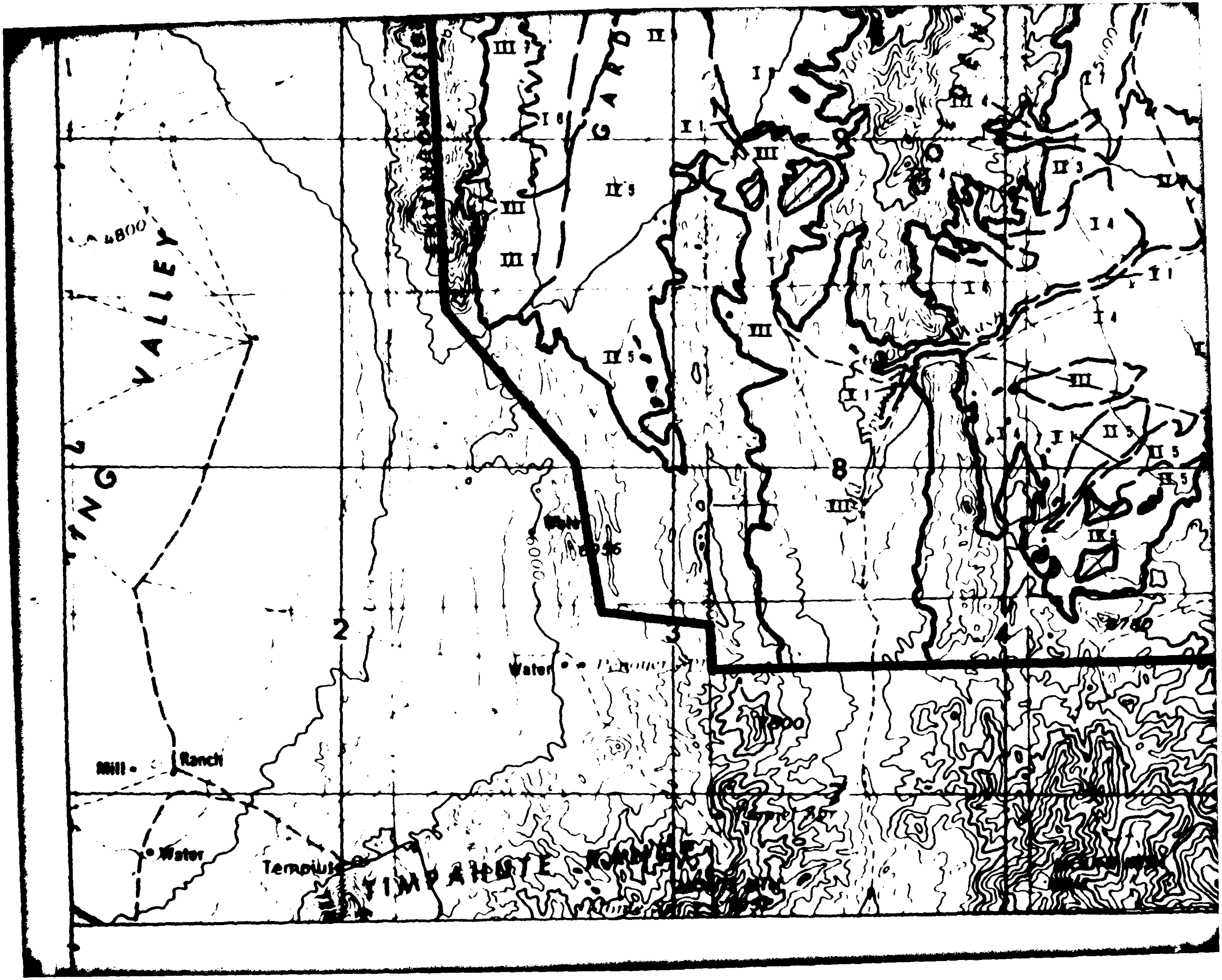
...es of isolated exposed rock.

...ructing this map are from: (1) field observations, ... topographic maps, and (3) 1;60,000 and 1:20,000 ... Due to scale of presentation and variability of ... this map is generalized.




VALLEY





VALLEY
GARD
TIMPAHUTE
Water
Water
Mill
Ranch
Water
Temoluis
8
2
3
4800
6000

EXPLANATION

Terrain Category (see table below) — III 3 — Drainage spacing, i.e. the maximum numbe[r] of drainages of the corresponding cate[gory] occurring in a random traverse of one statute mile (1.6km)

TERRAIN CATEGORY	DRAINAGE DEPTH/DESCRIPTION
I	Less than 3 feet (1m)
II	3-6 feet (1-2m)
III	6-10 feet (2-3m)
IV	10-15 feet (3-5m)
V	Greater than 15 feet (5m)
VI	Complex, highly variable terrain not defined by drainage incision (e.g. dunal or hummocky terrains).
VII	Unsuitable terrain (see Appendix A2.0, Exclusion Criteria)

Contact between terrain categories

Contact between rock and basin-fill

Shading indicates areas of isolated exposed rock.

NOTE: Data used in constructing this map are from: [illegible]

VERIFICATION SITE,

MX SITING INVE

DEPARTMENT OF THE AI

EXPLANATION

Terrain Category (see table below) ------ III 3 ------ Drainage spacing, i.e. the maximum numbe[r] of drainages of the corresponding categ[ory] occurring in a random traverse of one statute mile (1.6km)

TERRAIN CATEGORY	DRAINAGE DEPTH/DESCRIPTION
I	Less than 3 feet (1m)
II	3-6 feet (1-2m)
III	6-10 feet (2-3m)
IV	10-15 feet (3-5m)
V	Greater than 15 feet (5m)
VI	Complex, highly variable terrain not defined by drainage incision (e.g. dunal or hummocky terrains).
VII	Unsuitable terrain (see Appendix A2.6, Exclusion Criteria)

Contact between terrain categories

Contact between rock and basin-fill

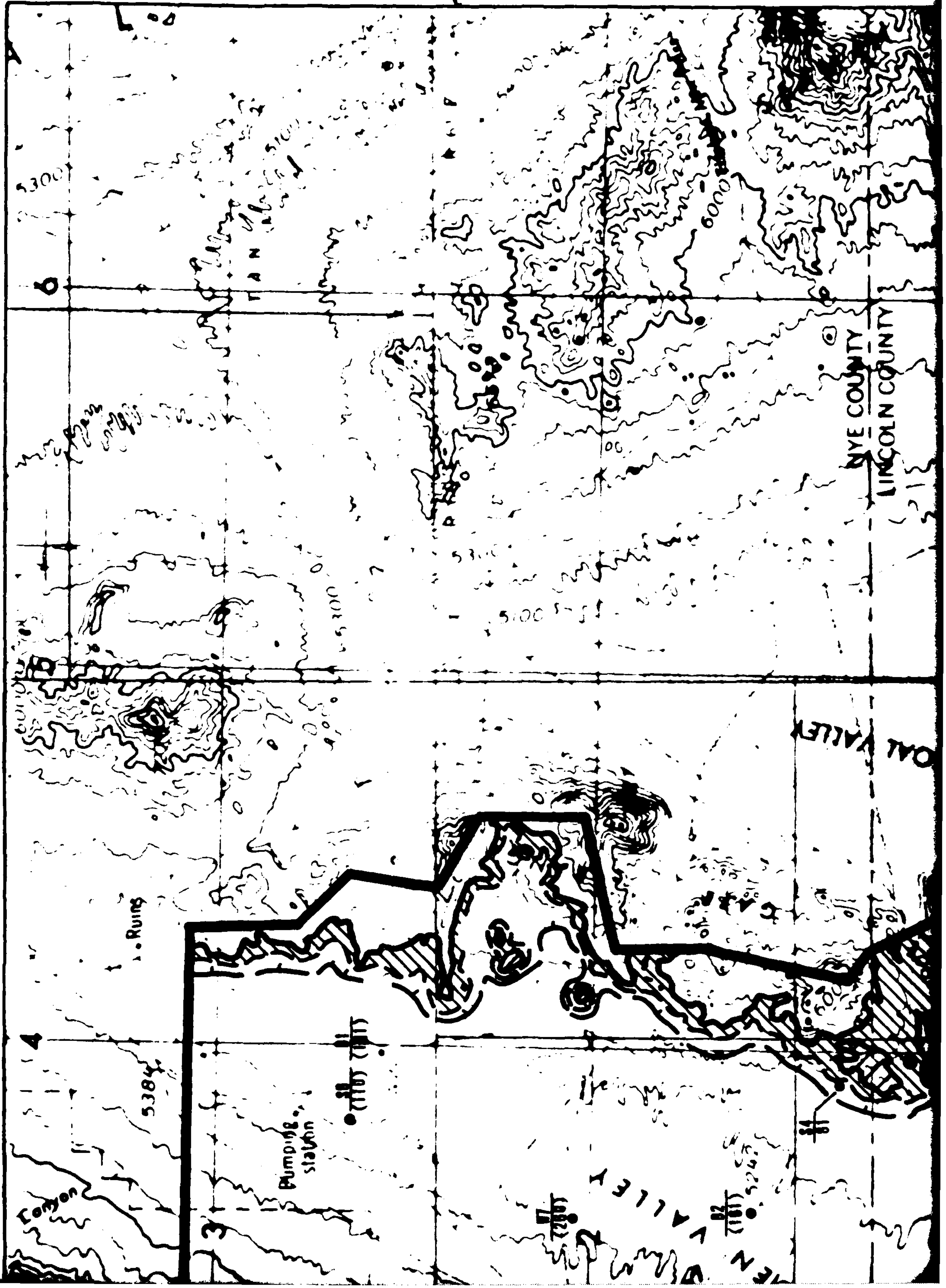
Shading indicates areas of isolated exposed rock.

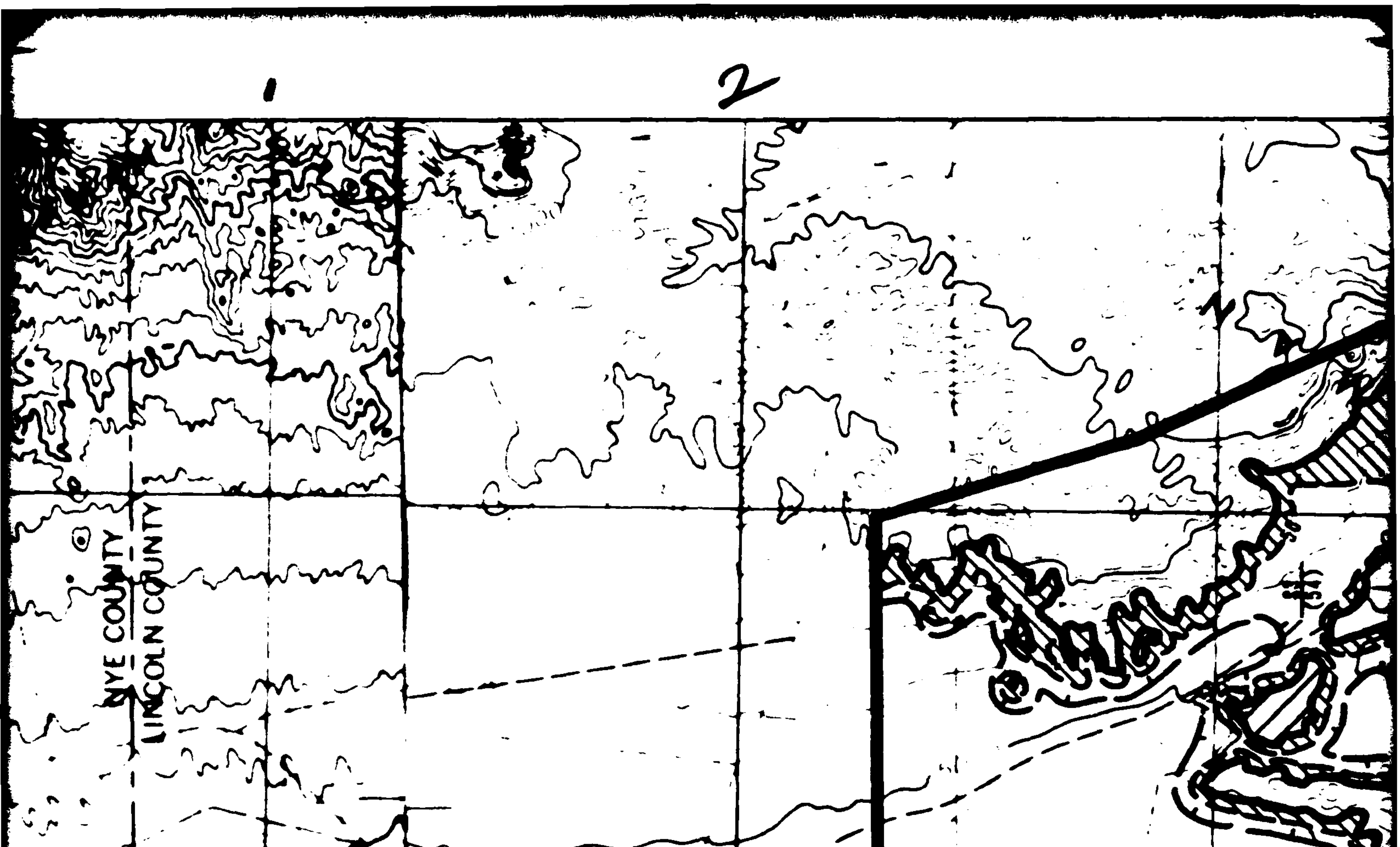
NOTE: Data used in constructing this map are from: (1) field observations, (2) 1:62,500 USGS topographic maps, and (3) 1:60,000 and 1:25,000 aerial photographs. Due to scale of presentation and variability of terrain conditions, this map is generalized.

TERRAIN
VERIFICATION SITE, GARDEN-COAL CDP, NEVADA

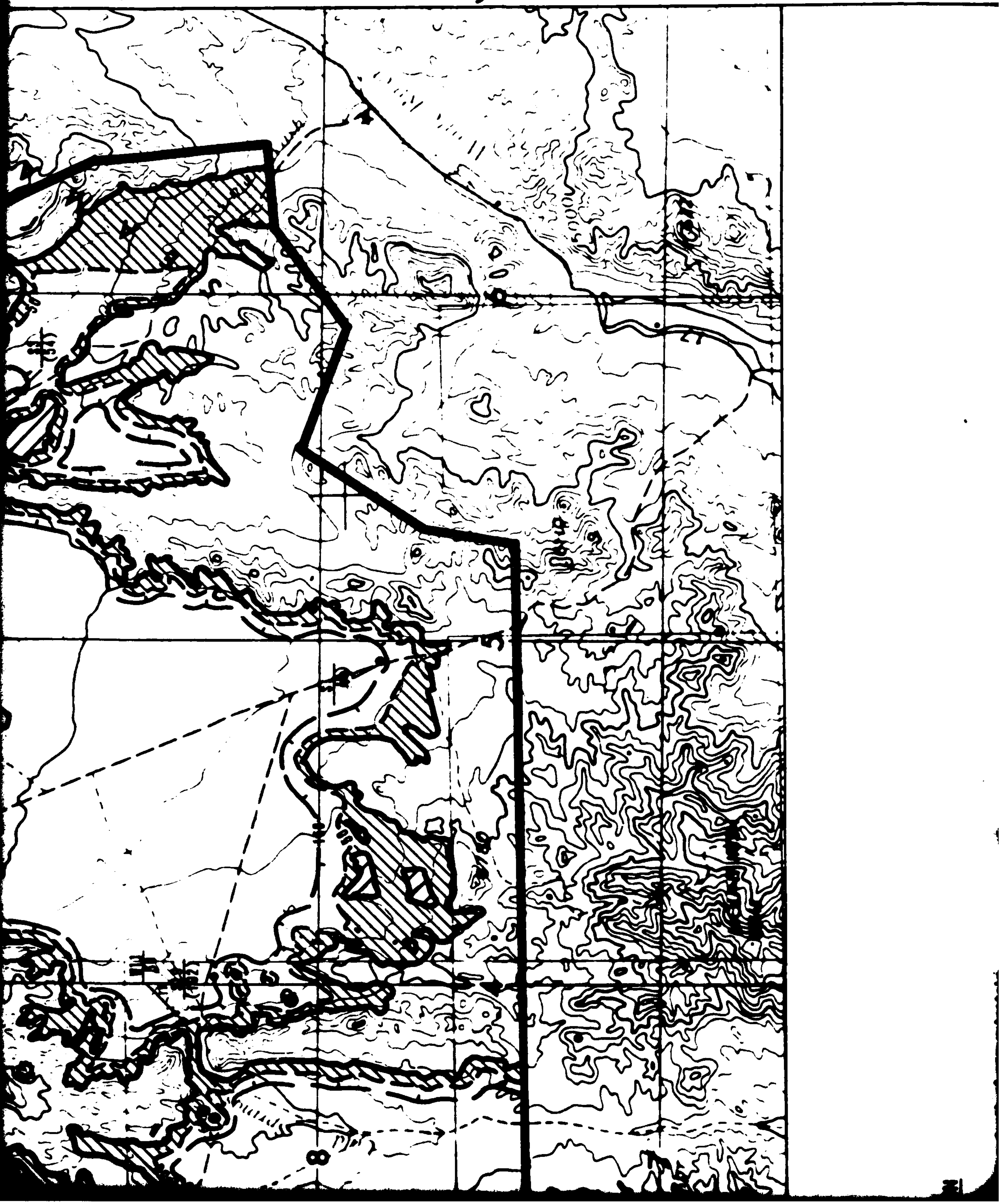
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

DRAWING
B-3


NYE COUNTY
LINCOLN COUNTY
Ruins
Pumping station
Canyon
5384
6000
5300
5100


1
2
NYE COUNTY
LINCOLN COUNTY
COAL VALLEY
5000
4960

1 3



N

at a depth of approximately
ding indicates rock less

at a depth of approximately
athering indicates rock less
.

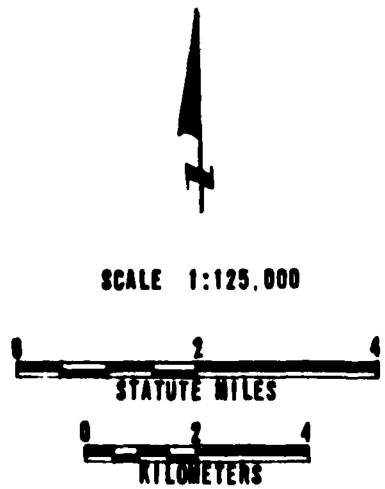
and basin-fill.

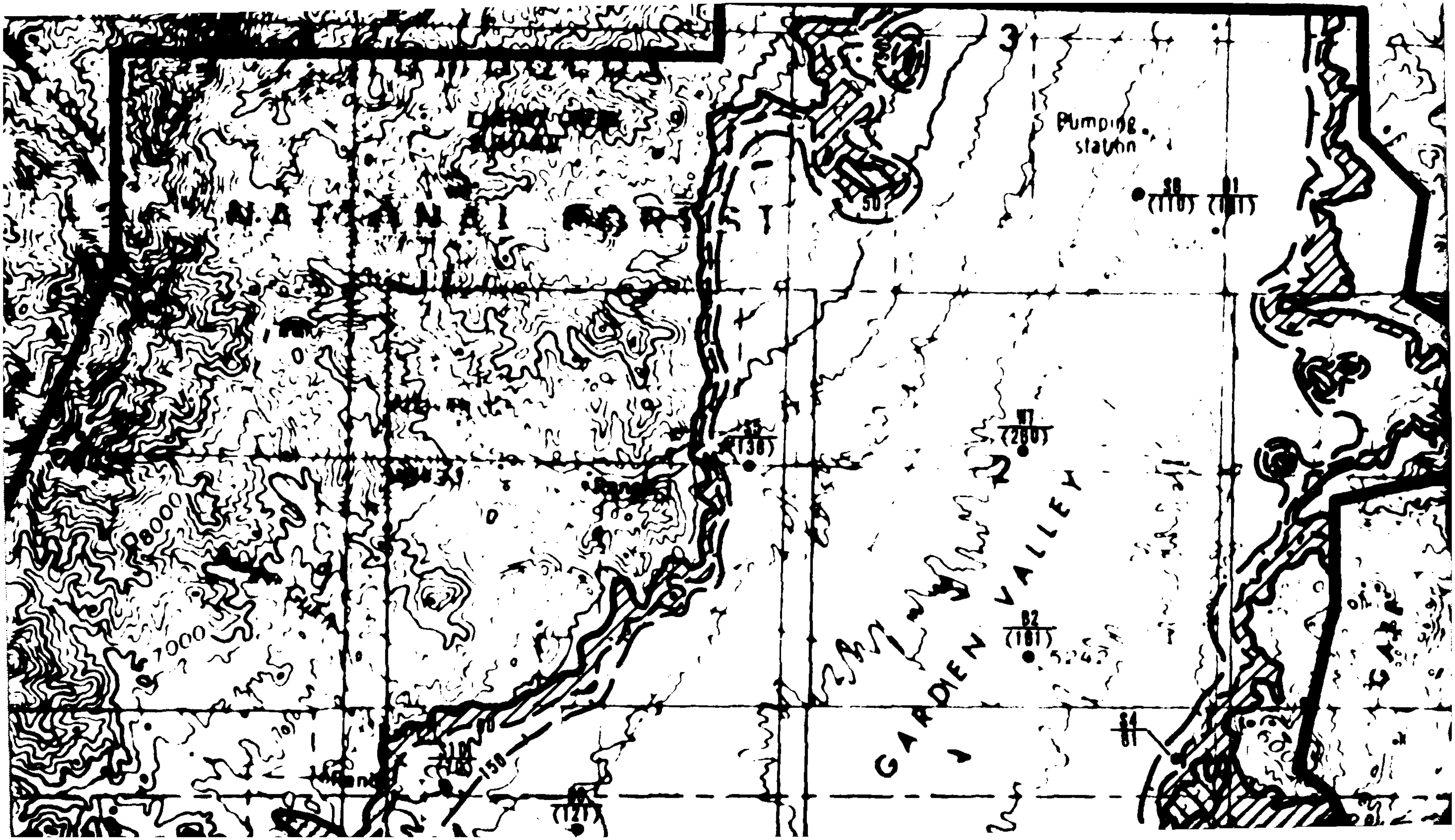
as of isolated exposed rock.

boring (B), seismic refraction
al resistivity sounding (R).

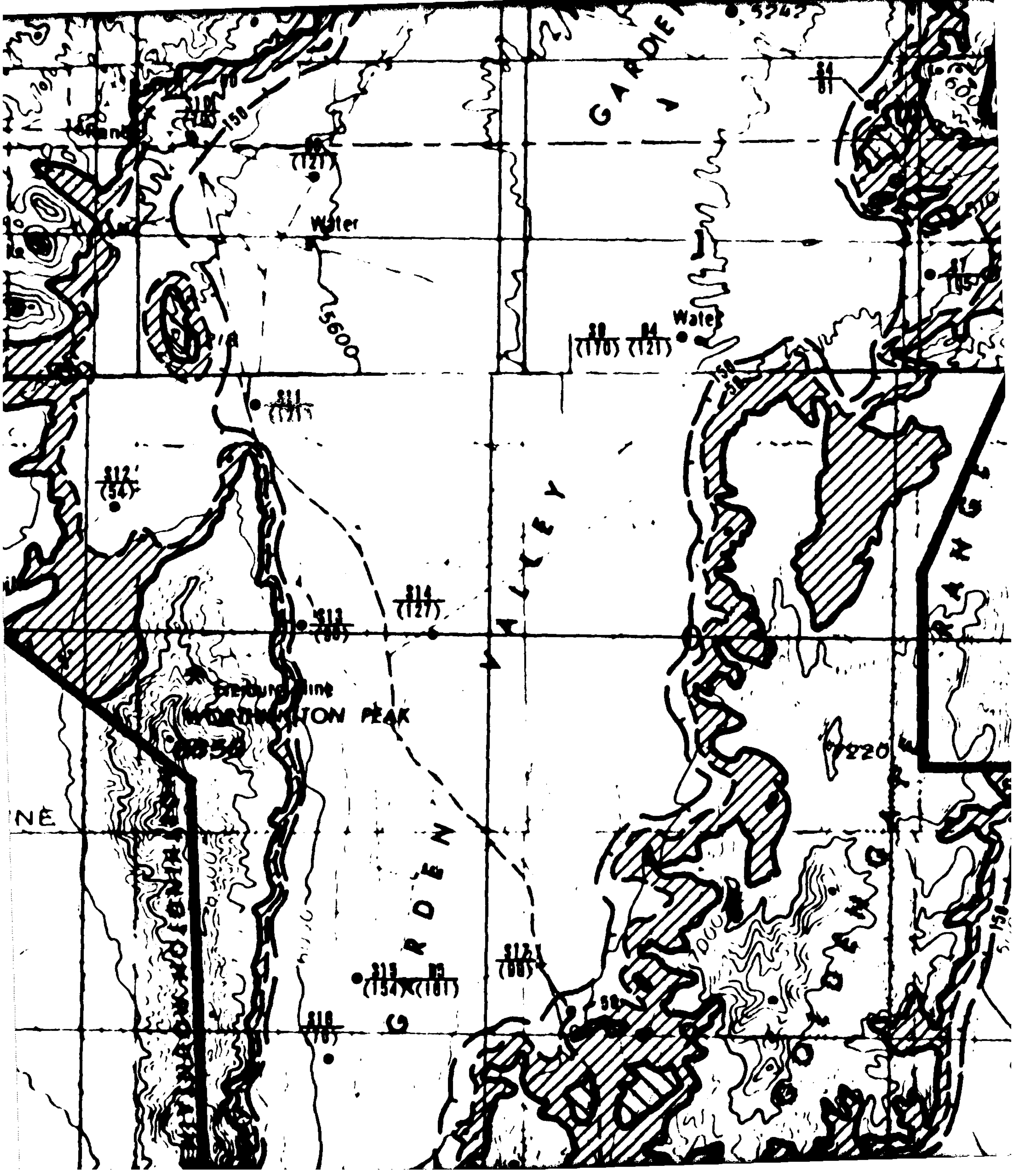
of, when in parentheses, depth
does not occur (feet).

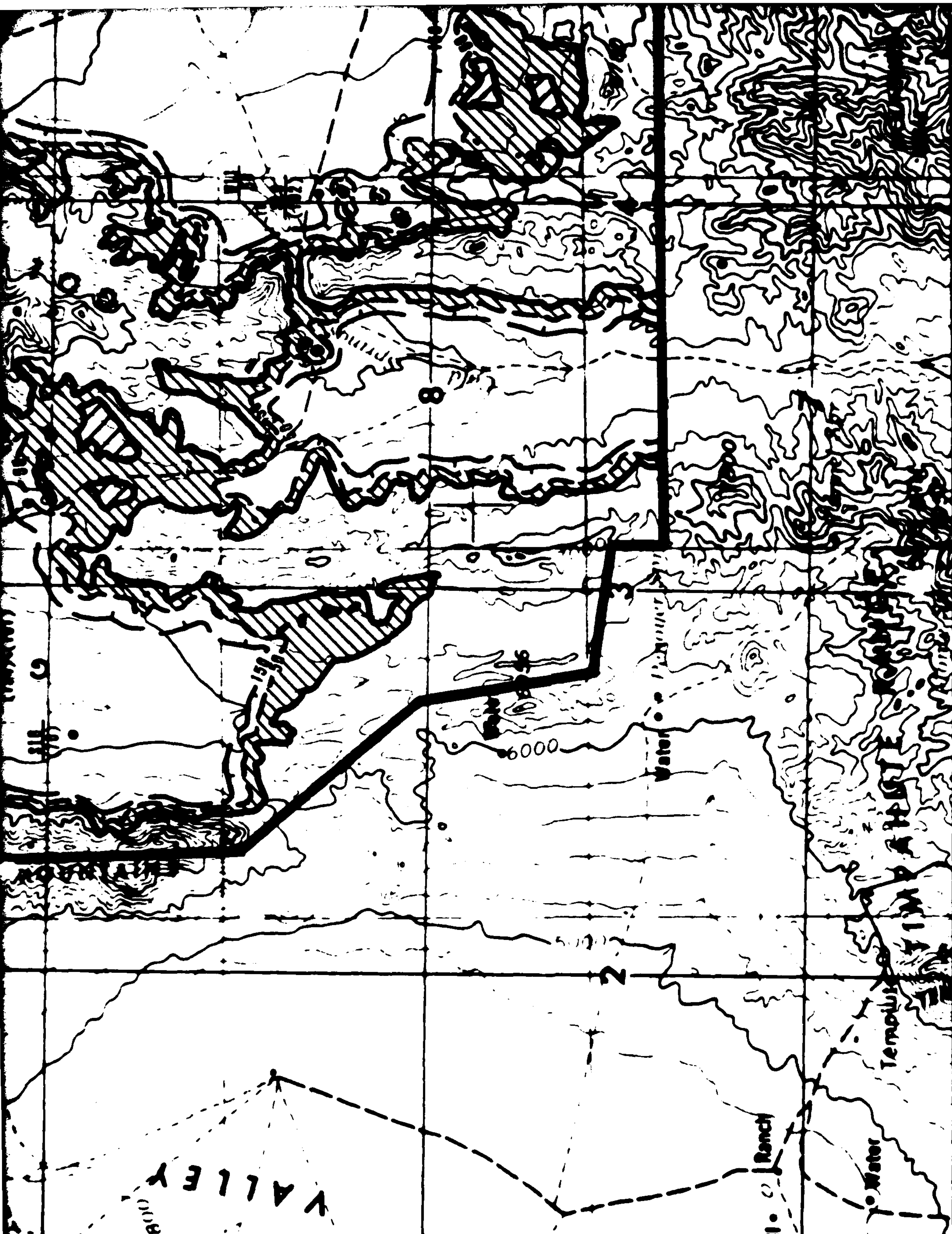
based on geologic interpretations
data points shown on the map. Some
er locations can be expected as
are obtained





GARDEN VALLEY
Pumping station
3
8000
7000
150
(280)
B2
(181)
(110)
(130)


GARDEN VALLEY
WORTHINGTON PEAK
Water
Water
5600
7220
8858



6000
Water
Ranch
Mill
Water
VALLEY

EXPLANATION

Contour indicates rock at a depth of approximately 50 feet (15m) - shading indicates rock less than 50 feet (15m)

Contour indicates rock at a depth of approximately 150 feet (46m) - hachuring indicates rock less than 150 feet (46m).

Contact between rock and basin-fill.

Shading indicates areas of isolated exposed rock.

Data Source - Fugro boring (B), seismic refraction line (S), electrical resistivity sounding (R), or water well (W).

Depth to rock (feet) or, when in parentheses, depth above which rock does not occur (feet).

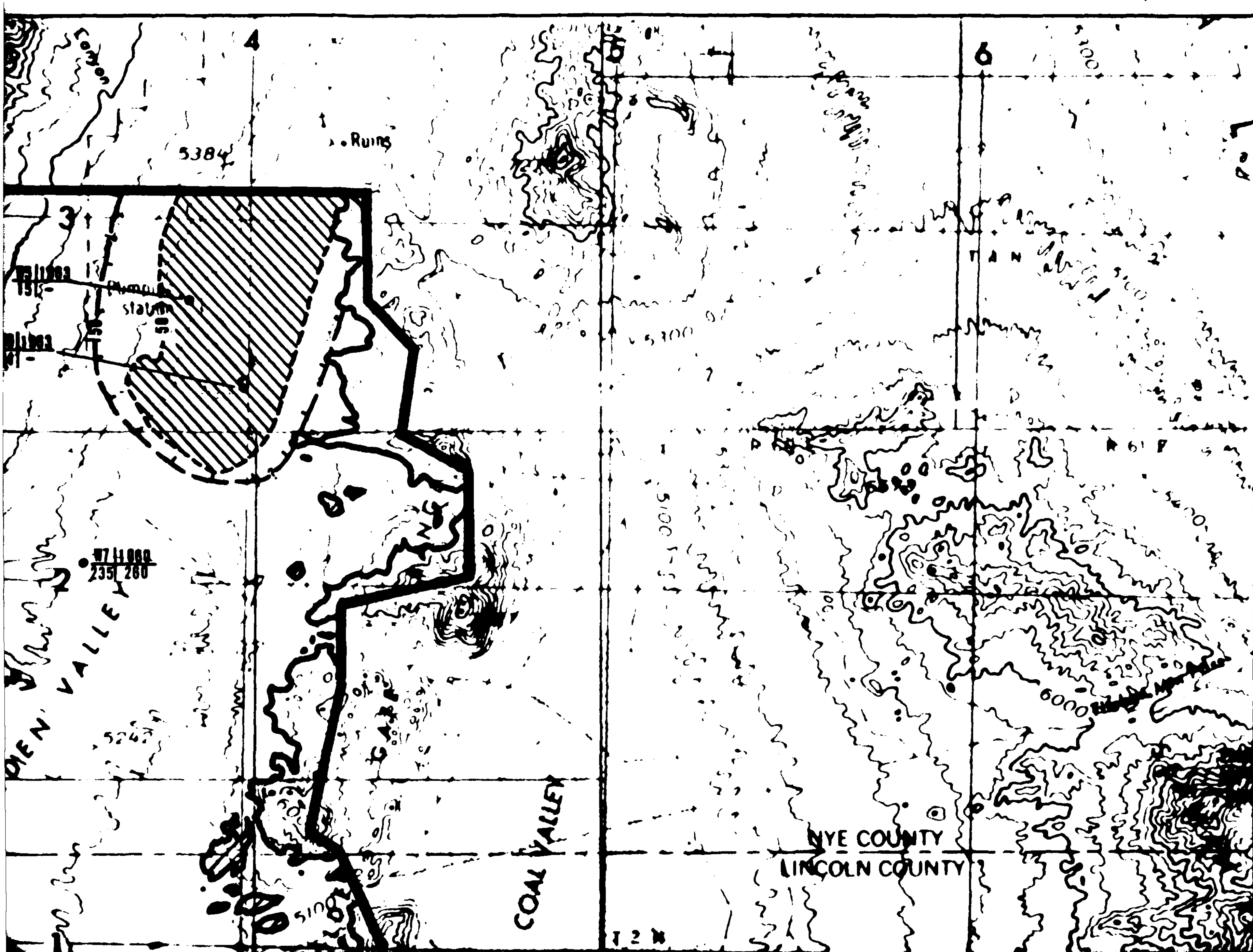
NOTE: The contours are based on geologic interpretations and the limited data points shown on the map. Some changes in contour locations can be expected as additional data are obtained

DEPTH TO ROCK
VERIFICATION SITE, GARDEN-COAL CDP, NEVADA

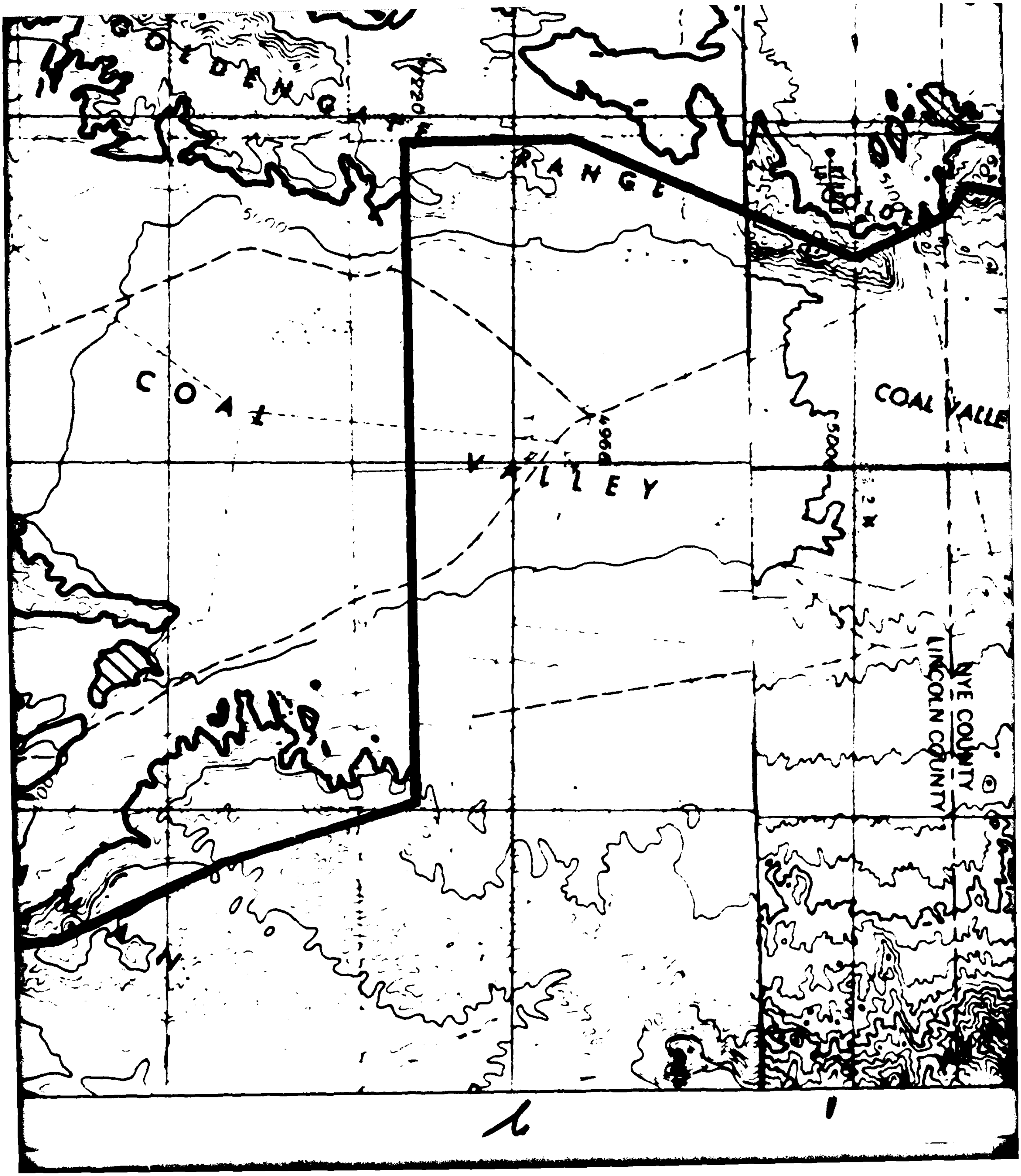
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

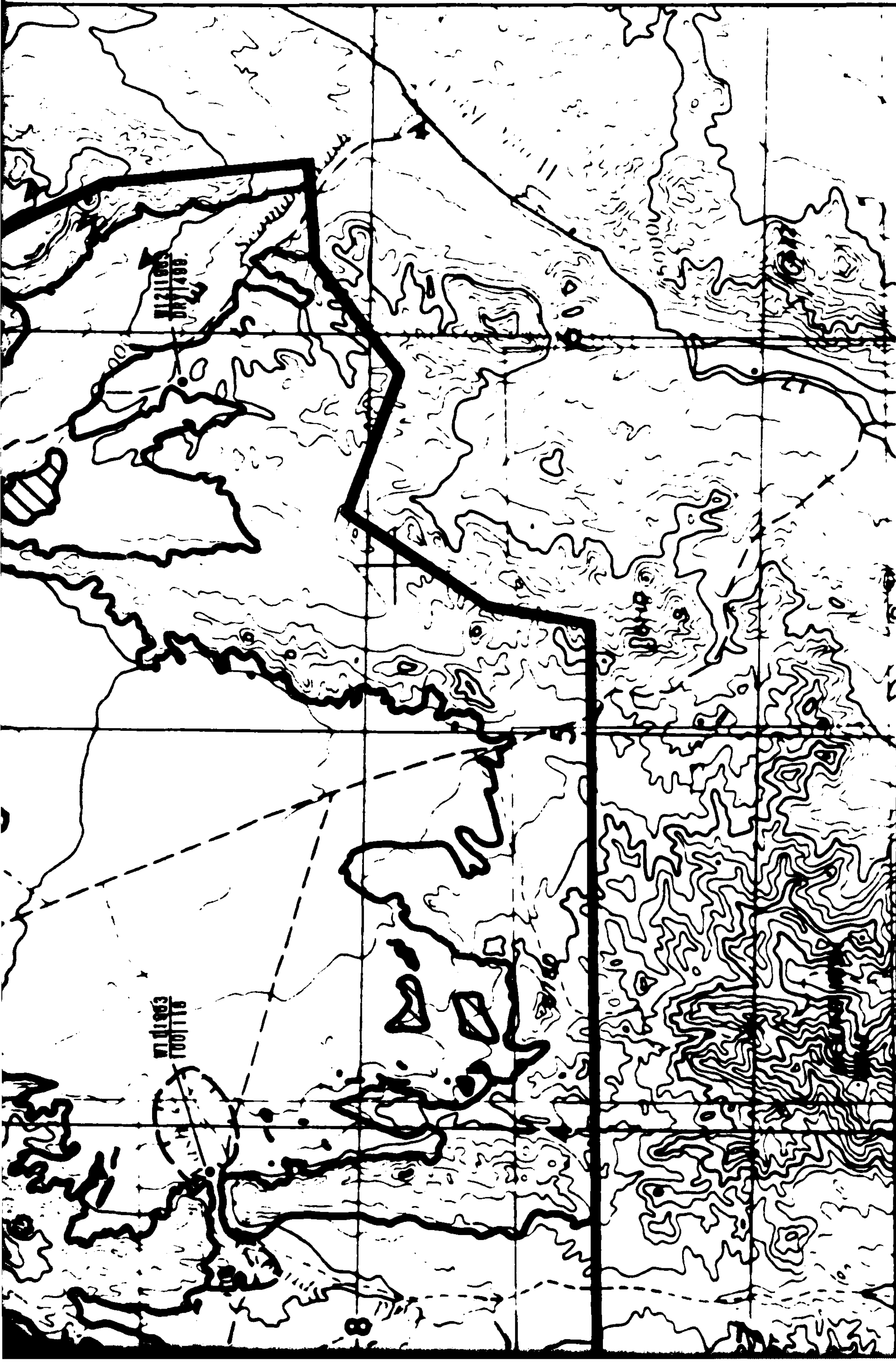
DRAWING
6-4

FUGRO NATIONAL, INC.



NYE COUNTY
LINCOLN COUNTY
COAL VALLEY
Ruins
5384
Canyon
6000
5100
5300
T 2 N


RANGE
5000
COAL
VALLEY
4968
COAL VALLE
NYE COUNTY
LINCOLN COUNTY



TION

ter at a depth of approximately
ere data are extremely sparse.
n 50 feet (15m) to ground water.

ter at a depth of approximately
ere data are extremely sparse.
han 150 feet (46m) to ground water.

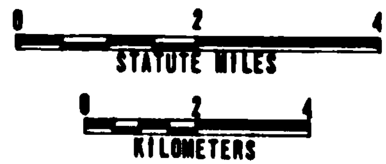
sin-fill

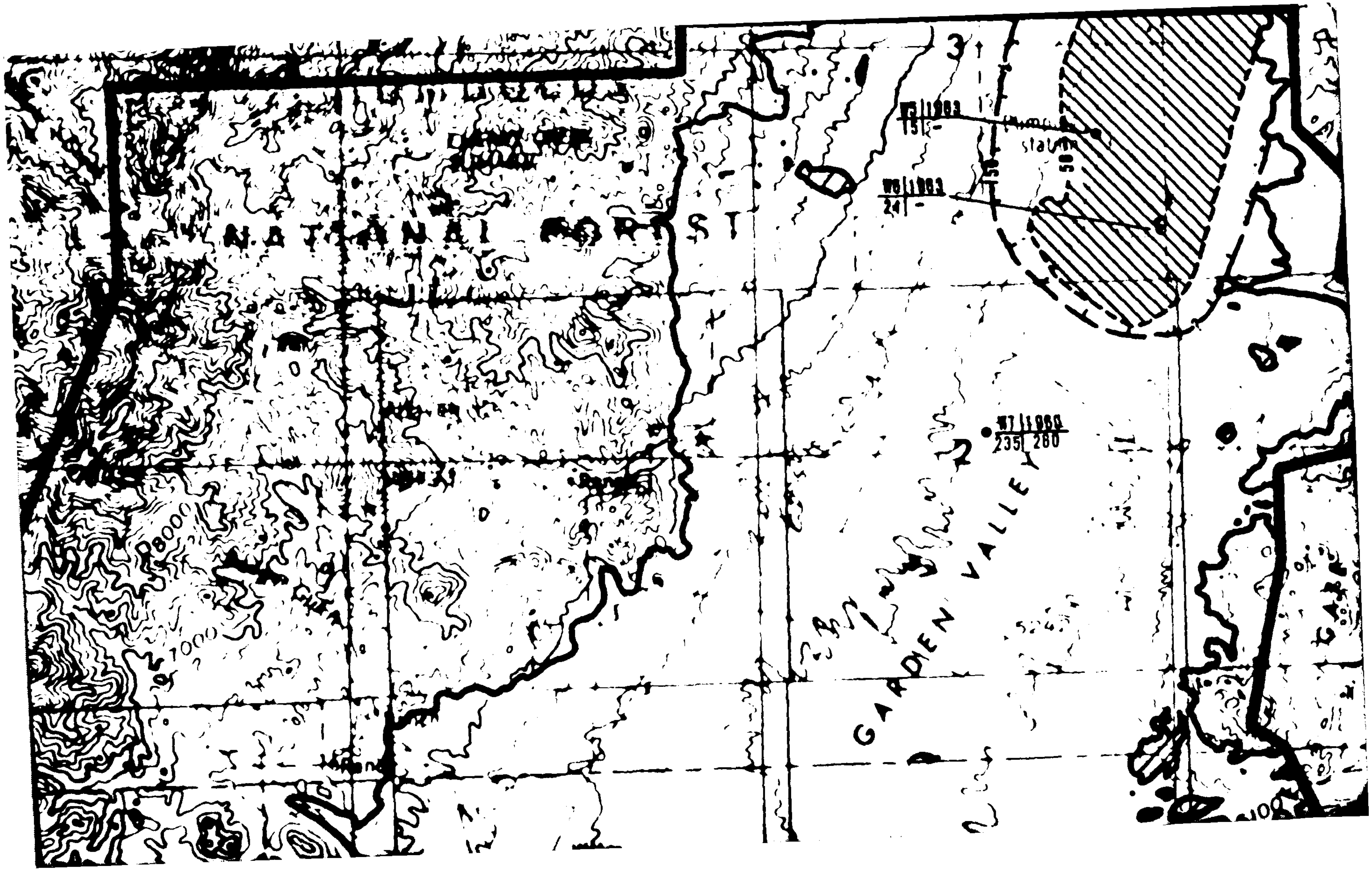
isolated exposed rock.

(S), seismic rical-resistivity l (W); see Volume II	Year of water level measurement
	Depth of well (feet)

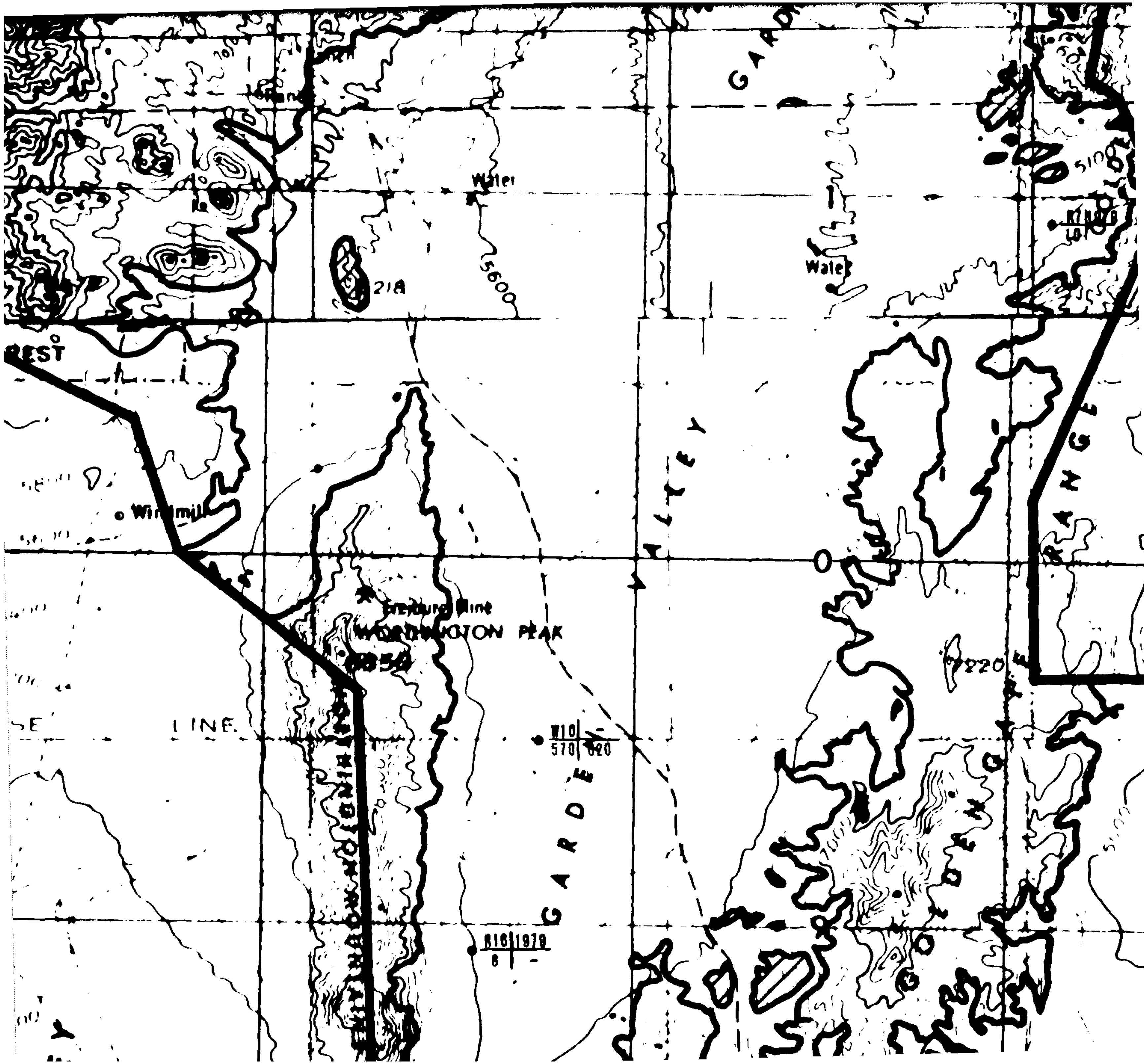
entirely on the data points shown on the map.
ion has been used and it can be expected that
change as additional data are obtained.

SCALE 1:125,000

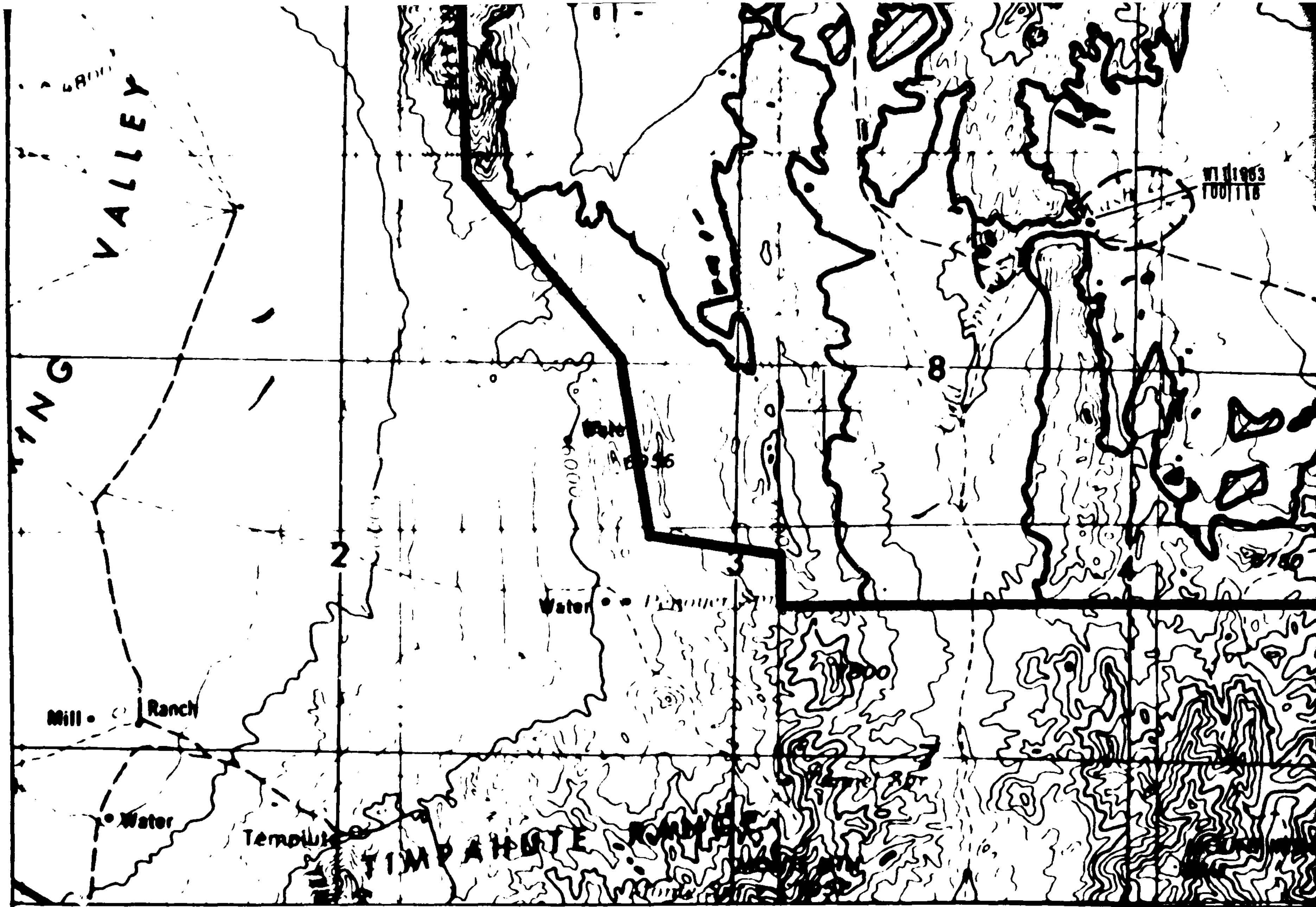




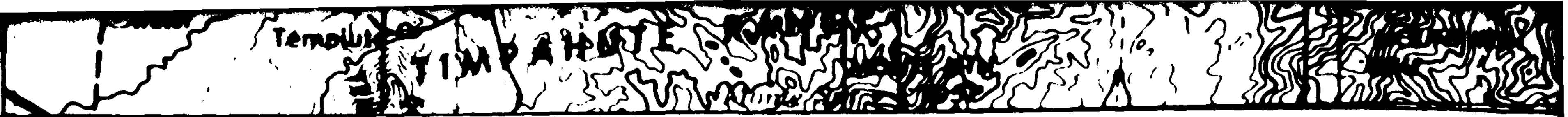
GARDEN VALLEY
NATIONAL FOREST
3
2
8000
7000



WORTHINGTON PEAK
Water
Water
5600
Windmill
LINE
REST



EXPLANATION



EXPLANATION

—50— Contour indicates ground water at a depth of approximately 50 feet (15m) - queried where data are extremely sparse. Shading indicates less than 50 feet (15m) to ground water.

—150— Contour indicates ground water at a depth of approximately 150 feet (46m) - queried where data are extremely sparse. Hachuring indicates less than 150 feet (46m) to ground water.

Contact between rock and basin-fill

Shading indicates areas of isolated exposed rock.

● W2 | 1973 / 75 | 700

Data Source - Fugro boring (B), seismic refraction line (S), electrical-resistivity sounding (R), or water well (W); see Volume II Section 2.0.	Year of water level measurement
Depth to water (feet)	Depth of well (feet)

NOTE: The contours are based entirely on the data points shown on the map. Extensive interpretation has been used and it can be expected that contour locations will change as additional data are obtained.

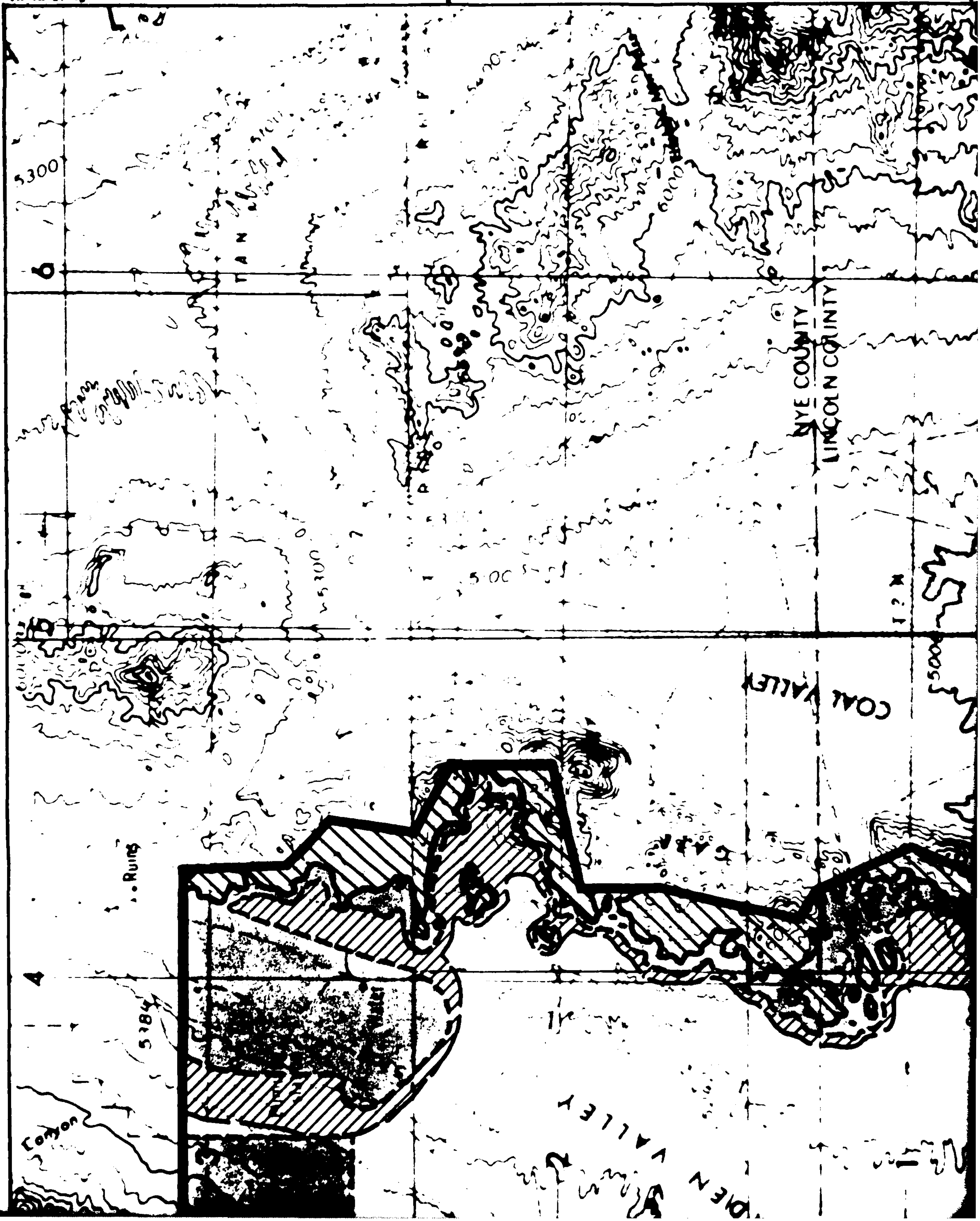
DEPTH TO WATER
VERIFICATION SITE, GARDEN-COAL CDP, NEVADA

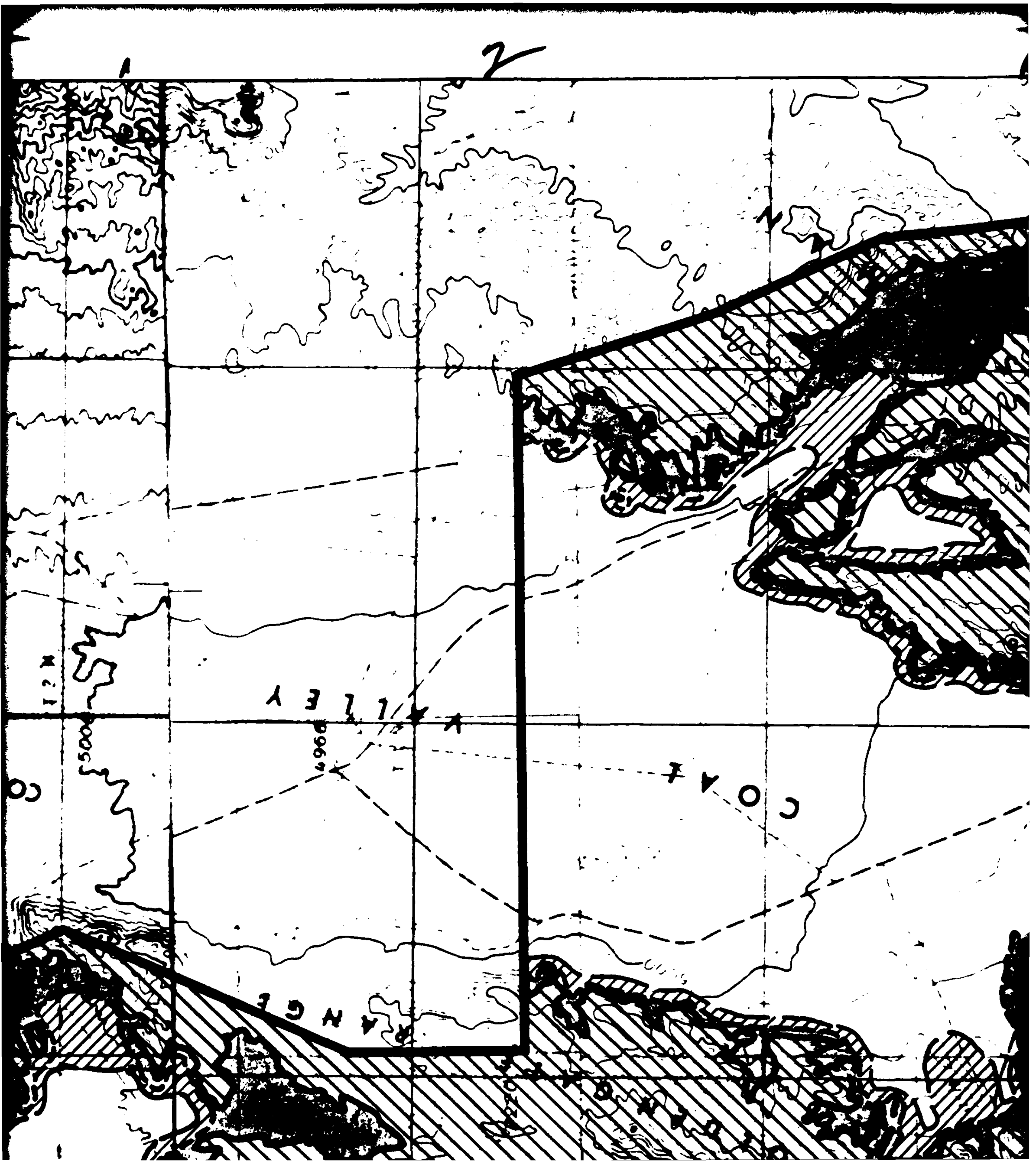
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

DRAWING B-5

FUGRO NATIONAL, INC.

8

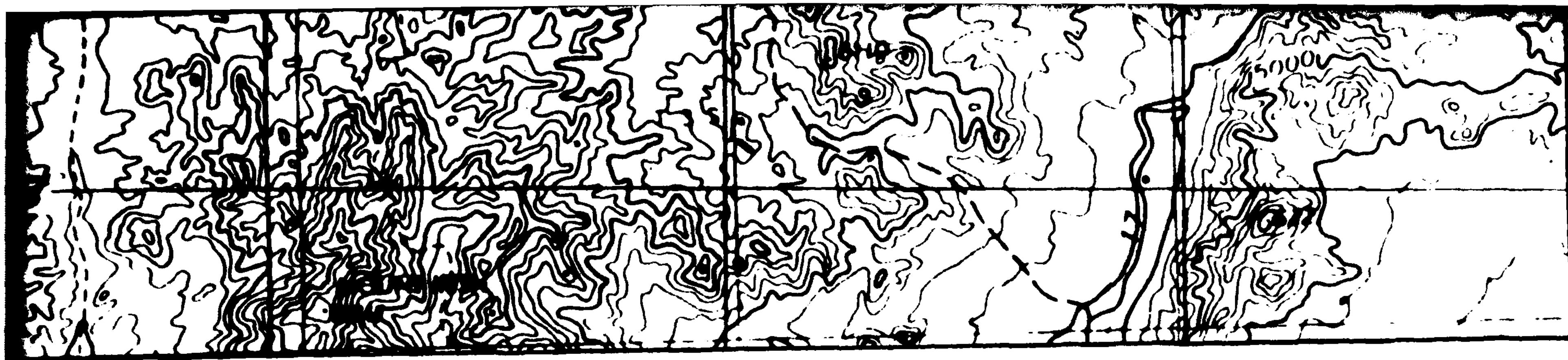

NYE COUNTY
LINCOLN COUNTY
COAL VALLEY
Ruins
Canyon
5300
6000
5384


1
2
VALLEY
4960
5000
COAL
RANGE

3

...h and vertical shelter
...and water greater than

...and not suitable for



...ch and vertical shelter
... and water greater than

...ch and not suitable for
...rock and water greater
...than 150 feet (46m).

...ld trench and vertical
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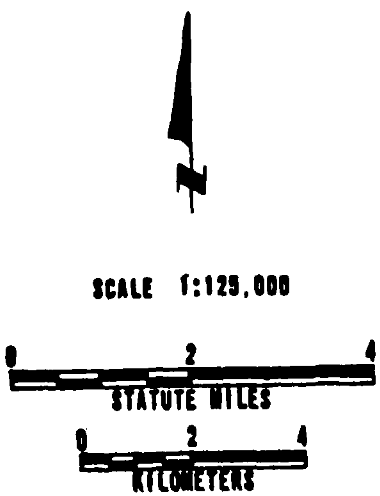
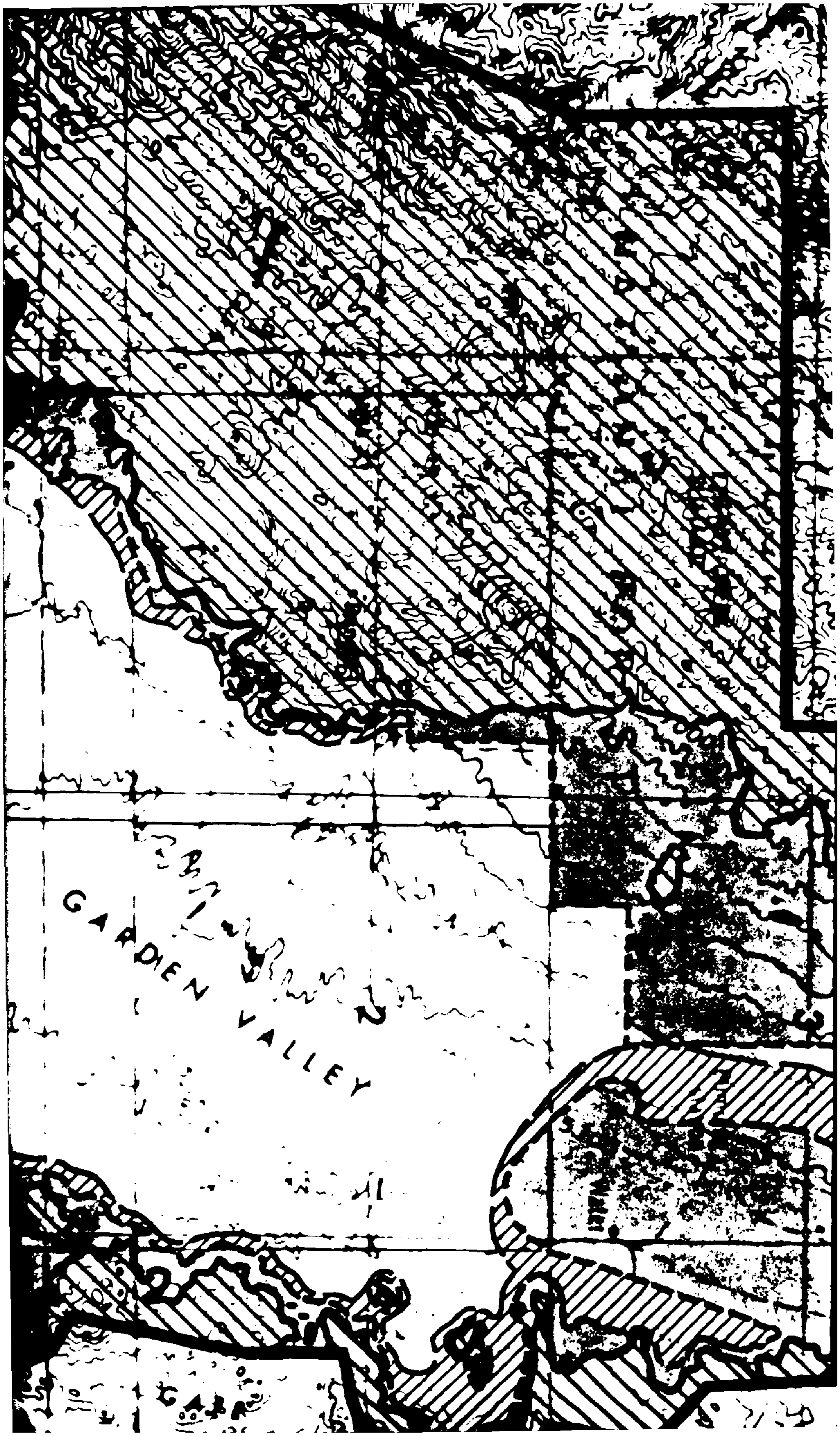
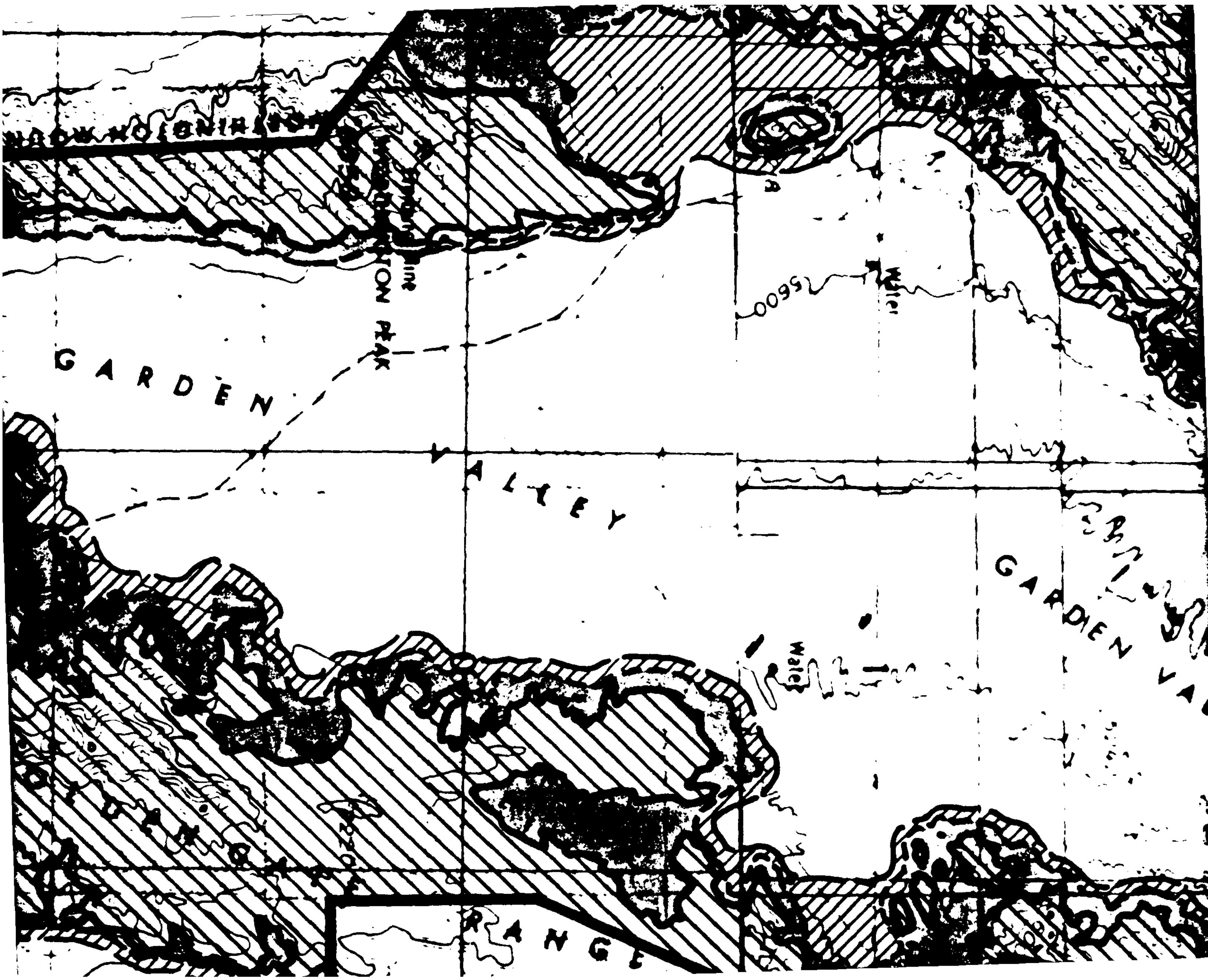
...ck.

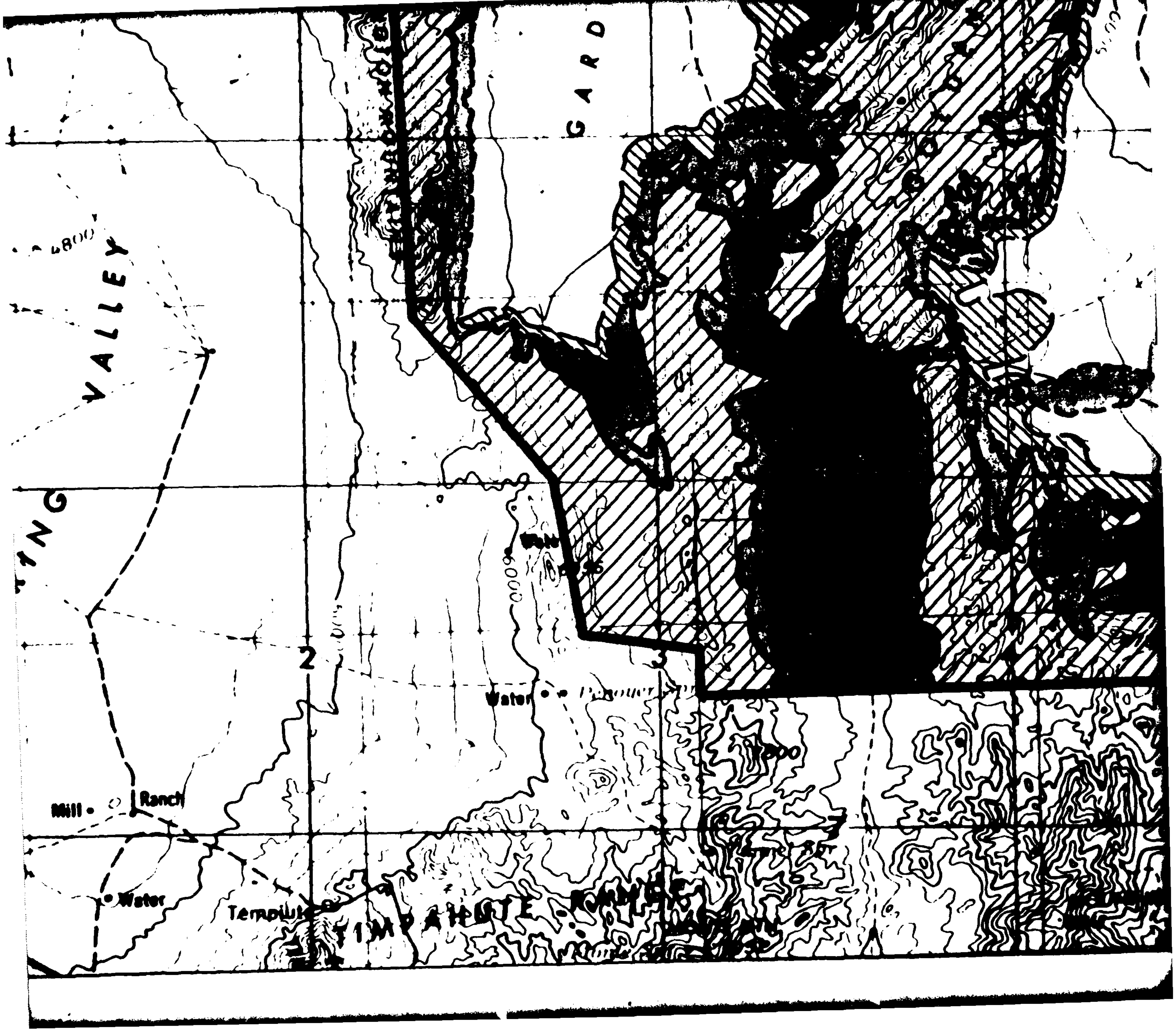
...n fill.

...ile regarding suitable criteria.

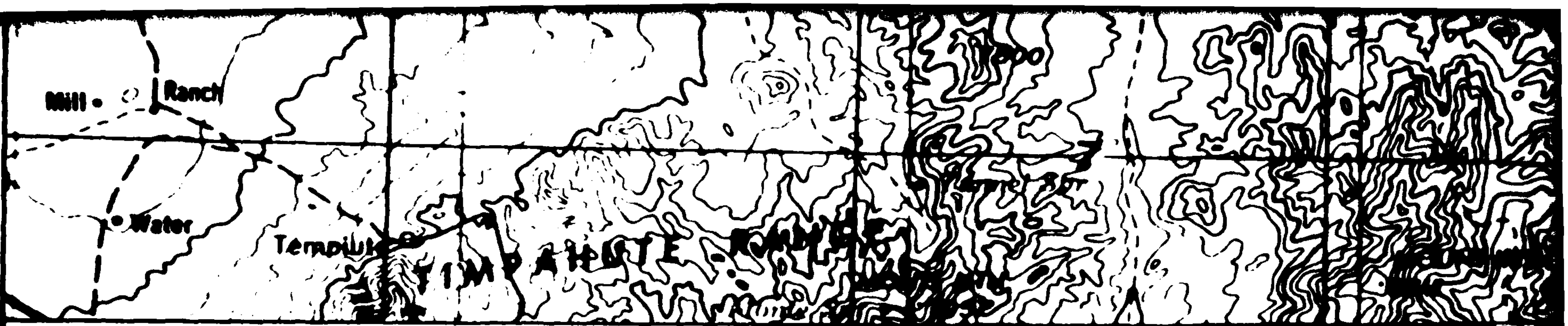



GARDEN VALLEY


GARDEN
VALLEY
GARDEN
5600
Water
Water
RANGE



VALLEY
GARD
Water
Water
Ranch
Mill
Water
Tempiute
TIMPAHUTE RANGE
6000
5000
6800
2
3



EXPLANATION

- Area suitable for hybrid trench and vertical shelter basing modes. Depth to rock and water greater than 150 feet (46m).
- Area suitable for hybrid trench and not suitable for vertical shelter. Depth to rock and water greater than 50 feet (15m) and less than 150 feet (46m).
- Area unsuitable for both hybrid trench and vertical shelter basing modes as determined from application of depth to rock and water, topographic/terrain, and cultural exclusions.
- Indicates areas of exposed rock.
- Contact between rock and basin fill.

NOTE: See Appendix A2.0 Table A2-1 for details regarding suitable criteria.

SUITABLE AREA
HYBRID TRENCH AND VERTICAL SHELTER
VERIFICATION SITE, GARDEN-COAL CDP, NEVADA

MX SITING INVESTIGATION
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DRAWING
0-8

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8

9.0 REVEILLE-RAILROAD CDP

9.1 GEOGRAPHIC SETTING

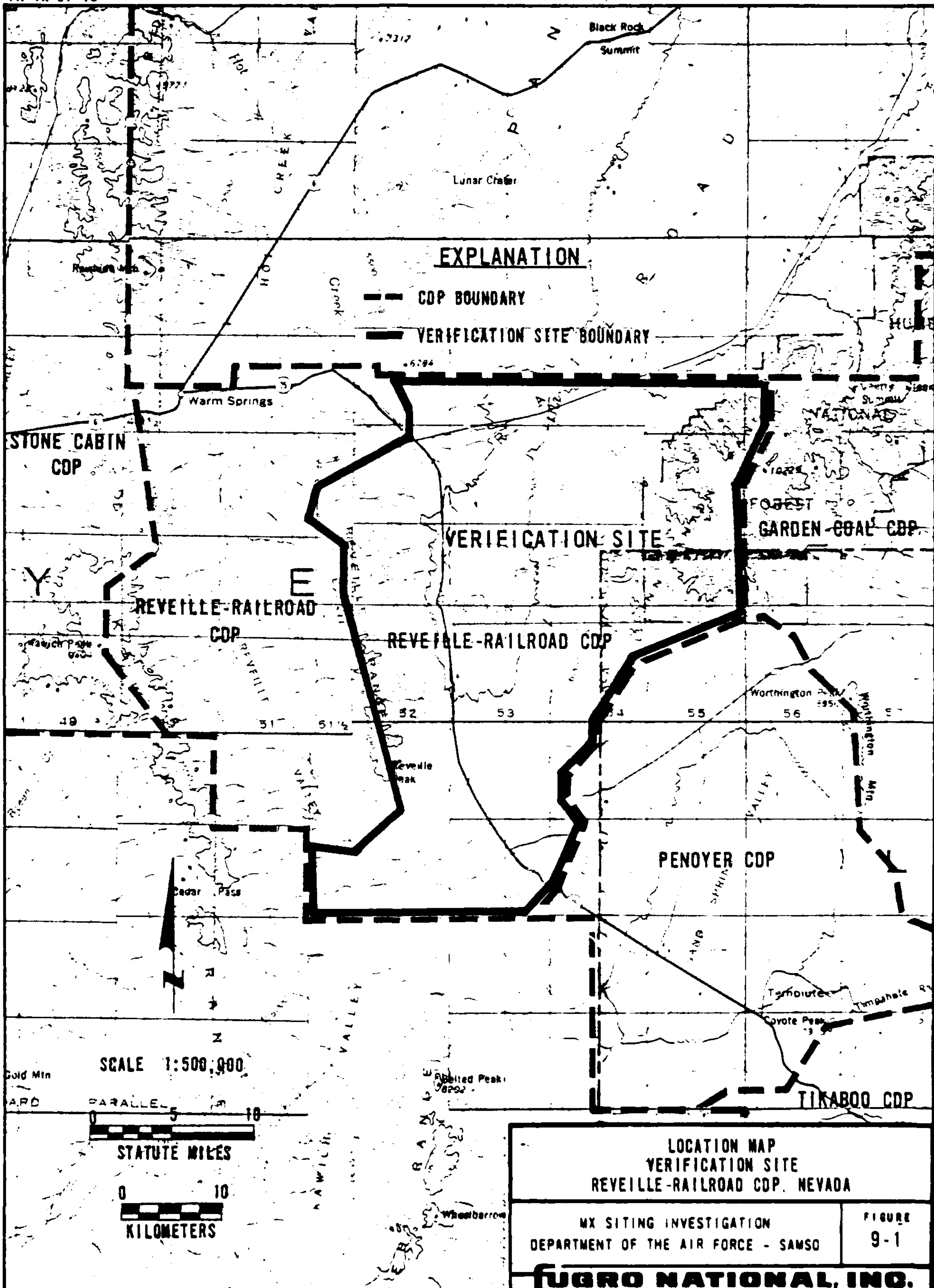
The Reveille-Railroad CDP lies entirely in eastern Nye County, Nevada (Figure 9-1). It is bounded on the west by the Kawich Range, on the east by the Quinn Canyon Range, and on the south and southwest by the Nellis Bombing and Gunnery Range. The northern boundary is arbitrarily located at approximately latitude 30°15'. The site is situated entirely in Railroad Valley, east and south of the Reveille Range. Nevada Highway 25 traverses the site from northwest to southeast and provides the main paved access in the area. The town of Tonopah is located 65 miles to the west. Other roads within the area are unpaved but generally well maintained and pose no problem to travel. The site is utilized principally for grazing and rangeland.

9.2 SCOPE

The scope of geologic, geophysical, and soils engineering field activities performed at the site and laboratory tests performed on soil samples from the site are presented in Table 9-1. Locations of the geophysical and engineering activities are shown in Drawing 9-1 (end of Section 9.0).

9.3 GEOLOGIC SETTING

Rock types in the ranges surrounding the Reveille-Railroad Site consist primarily of Tertiary and Quaternary age volcanic rocks. The Reveille Range, flanking the west side of Railroad Valley, is generally composed of Quaternary basalt in the north and tuff of the White Blotch Spring Formation in the south. Ash fall


EXPLANATION
CDP BOUNDARY
VERIFICATION SITE BOUNDARY
Black Rock Summit
Lunar Crater
Warm Springs
STONE CABIN CDP
VERIFICATION SITE
GARDEN-COAL CDP
REVEILLE-RAILROAD CDP
REVEILLE-RAILROAD CDP
Reveille Peak
Worthington Peak
PENOYER CDP
Cedar Pass
TIKABOO CDP
Coyote Peak
Wheelbarrow
SCALE 1:500,000
0 5 10
STATUTE MILES
0 10
KILOMETERS
LOCATION MAP
VERIFICATION SITE
REVEILLE-RAILROAD CDP, NEVADA
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO
FIGURE
9-1
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2 JUL 79

GEOLOGY AND GEOPHYSICS

TYPE OF ACTIVITY	NUMBER OF ACTIVITIES
Geologic mapping stations	132
Shallow refraction	16
Electrical resistivity	16
Gravity profiles	10

ENGINEERING-LABORATORY TESTS

TYPE OF TEST	NUMBER OF TESTS
Moisture/density	151
Specific gravity	5
Sieve analysis	130
Hydrometer	2
Atterberg limits	44
Consolidation	1
Unconfined compression	5
Triaxial compression	6
Direct shear	6
Compaction	12
CBR	12
Chemical analysis	12

ENGINEERING

NUMBER OF BORINGS	NOMINAL DEPTH FEET (METERS)
6	160 (49)
1	130 (40)
NUMBER OF TRENCHES	**NOMINAL DEPTH FEET (METERS)**
5	14 (4)
3	10 (3)
NUMBER OF TEST PITS	**NOMINAL DEPTH FEET (METERS)**
36	5 (2)
NUMBER OF CPTs	**RANGE OF DEPTH FEET (METERS)**
82	2-26 (1-8)
TYPE OF ACTIVITY	**NUMBER OF ACTIVITIES**
Surficial soil samples	40
Field CBR tests	13

SCOPE OF ACTIVITIES
VERIFICATION SITE
REVEILLE-RAILROAD CDP, NEVADA

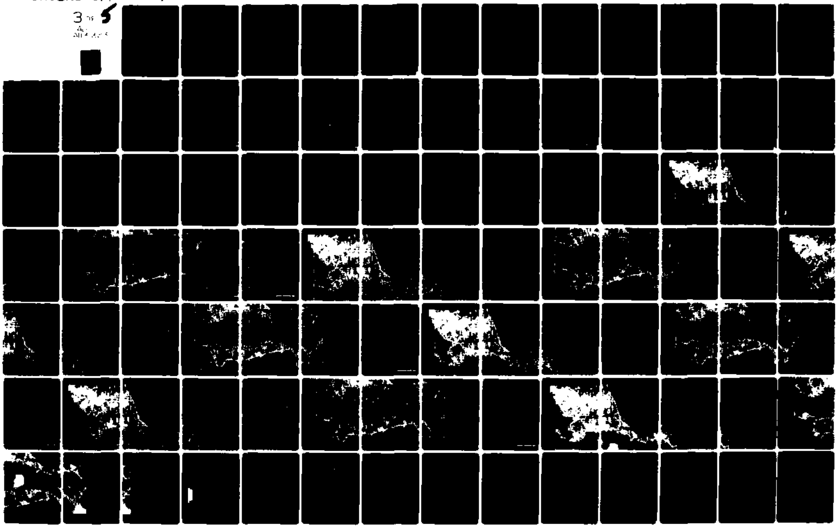
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 9-1

FUGRO NATIONAL, INC.

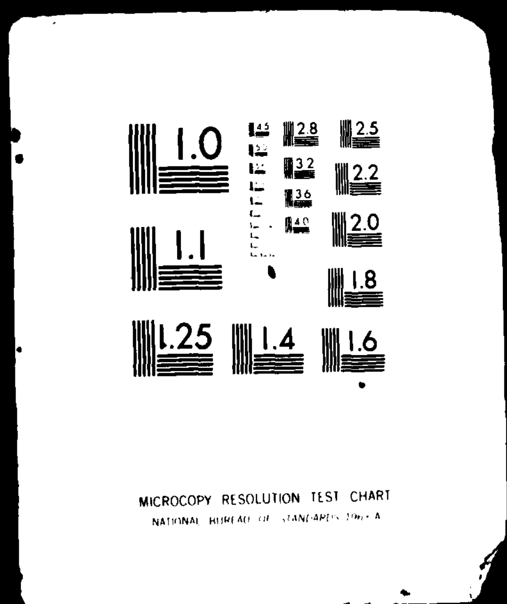
AD-A113 323 FUGRO NATIONAL INC LONG BEACH CA F/G 13/2
MX SITING INVESTIGATION GEOTECHNICAL EVALUATION. VOLUME IB. NEV--ETC(U)
AUG 79 F04704-78-C-0027
UNCLASSIFIED FN-TR-27-1B NL

3 of 5



3 OF 5

AD
A113 323



tuffs, nonwelded ash-flow tuffs, and rhyolitic flows and intrusions also outcrop in the Reveille Range. The southern tip of the range is composed of flows and intrusive masses of intermediate to acidic composition (Cornwall, 1972). The east bounding Quinn Canyon Range is composed chiefly of quartz latite and welded tuffs in the south and younger rhyolitic plugs and dikes in the north.

Faults mapped within the site are restricted to the west and northeast and are primarily range bounding. The most prominent faults trend north-south along the west side of the Railroad Valley and show 1 to 2 meters of normal separation; eastside down. Alluvial faults in the northeast are limited to a single north-northeast trending fault displacing intermediate fan deposits.

Basin-fill deposits within the site are primarily the product of alluvial and lacustrine processes with minor eolian influence. Due to a lack of deep subsurface data, the thickness of the basin-fill deposits within the site is not known. Logs from oil exploration wells in northern Railroad Valley, out of the site area, indicate alluvium at depths as great as 9200 feet (2804 m) (Van Denburgh and Rush, 1974). Alluvial thicknesses may not be as great in southern Railroad.

The distribution of the surficial geologic units at the site is shown in Drawing 9-2. A brief description of the main units is given below.

- Intermediate and younger alluvial fan deposits - Intermediate fans occur adjacent to the mountain fronts and generally grade basinward into broad, low lying young fans. Young fans may be underlain by older lacustrine deposits in areas north of the main playa. Deposits consist predominantly of sand with varying percentages of gravel and fines. Several areas of gravel fans exist along the valley margins; however, they make up only a small percent of the total site area.

- Lacustrine and playa deposits - Older lacustrine deposits are mapped in association with young alluvial fan, sheet sand, and dune deposits. They predominantly border the active playa in the central portion of the site and may also underlie much of the basin north of the main playa. Topographic and photographic evidence suggest that the ancient lake may have been 100 feet (30 m) deep and covered 55 mi^2 (142 km^2) before overflowing into the larger lake in northern Railroad Valley (Van Denburgh and Rush, 1974). Deposits consist predominantly of silts and clays with some localized areas of silty and clayey sands.

- Stream channel and terrace deposits - These units cover a broad area in the southern portion of the site and are flanked on either side by young fans. Deposits consist predominantly of sands and silty sands.

- Sheet sand and dunes - These deposits are mapped in association with lacustrine and young fan materials. These intermixed units are located in the central basin, directly north of the active playa. Deposits consist chiefly of uncemented sands and silty sands.

9.4 SURFACE SOILS

Surficial soils of the Reveille-Railroad Site are predominantly coarse grained. These soils range in gradation from well-graded sandy gravels with little fines to uniform medium to fine sands with appreciable fines. Fine-grained soils, silts and clays, are limited in distribution. The distribution of surficial geologic units is shown in Drawing 9-2. Soils from the predominant surficial geologic units can be combined into three categories based on their physical and engineering characteristics.

1. Silty sands and clayey sands (geologic units A2s, A3s, A5ys, and A5is);
2. Gravelly sands and sandy gravels (geologic units A5ys and A5is); and
3. Silts and clays (geologic unit A4o[f]).

9.4.1 Characteristics

The characteristics of surficial soils are summarized in Table 9-2, which contains physical properties and laboratory compaction and CBR test results and provides preliminary road design evaluations. Gradation ranges for the three categories of surficial soils are shown in Figure 9-2.

Silty sands and clayey sands are the predominant surficial soil. They cover approximately 50 to 70 percent of the site. Sands are widely distributed, being the major component in all areas except near mountain fronts and in the old lacustrine and active playa deposits in the north-central area of the site. Sands have gravel traces and little to appreciable fines which are nonplastic to moderately plastic. Weak calcium carbonate cementation occurs sporadically within 2 feet (0.6 m) of the ground surface.

Sandy gravels and gravelly sands cover approximately 20 to 40 percent of the site. Gravelly soils are most common in the young and intermediate age fans on the valley sides. In general, gravel content of fan deposits increases near mountain fronts, but concentrations of gravelly soils were observed at depths of less than 2 feet (0.6 m) near the valley center in

SOIL DESCRIPTION		Silty Sands and Clayey Sands		Sandy Gravel[s] Gravelly San[ds]
USCS SYMBOLS		SM, SC		GP, GM, GC,
PREDOMINANT SURFICIAL GEOLOGIC UNITS		A2s, A3s, A5ys, A5is		A5ys, A5is
ESTIMATED AREAL EXTENT %		50-70		20-40
PHYSICAL PROPERTIES				
COBBLES 3 – 12 inches (8 – 30 cm) %		0-5		0-10
GRAVEL %		0-10	[25]	11-61
SAND %		51-84	[25]	22-83
SILT AND CLAY %		14-46	[25]	1-22
LIQUID LIMIT		37-38	[3]	NDA
PLASTICITY INDEX		NP-20	[3]	NDA
ROAD DESIGN DATA				
MAXIMUM DRY DENSITY pcf (kg/m³)		112.2-131.1 (1797-2100)	[5]	127.1-129.0 (2036-2066)
OPTIMUM MOISTURE CONTENT %		6.5-15.5	[5]	6.6-9.0
CBR AT 90% RELATIVE COMPACTION %		5-20	[5]	NDA
SUITABILITY AS ROAD SUBGRADE (1)		fair to good		good to very
SUITABILITY AS ROAD SUBBASE OR BASE (1)		poor to fair		fair to good
THICKNESS OF LOW STRENGTH SURFICIAL SOIL (2)	RANGE ft (m)	0.6-9.0 (0.2-2.7)	[61]	0.6-3.0 (0.2-0.9)
	AVERAGE ft (m)	2.8 (0.9)	[61]	1.6 (0.5)

(1) Suitability is a subjective rating explained in Section A5.0 of the Appendix.

(2) Low strength surficial soil is defined as soil which will perform poorly as a road subgrade at its present consistency; see Table 8-3 for details.

NOTES: • [ ]

• NDA –

Sandy Gravels and Gravelly Sands	Sandy Silts, Clayey Silts, and Sandy Clays	
GP, GM, GC, SW, SP, SM	ML, MH, CL	
A1s, A2s	A4of	
20-40	5-15	
0-10	0	
11-81 [13]	0-5 [9]	
22-83 [13]	3-50 [9]	
1-22 [13]	50-97 [11]	
NDA	25-53 [8]	
NDA	5-21 [8]	
127.1-128.0 (2030-2080) [3]	84.0-113.5 (1355-1818) [4]	
0.0-0.0 [3]	15.0-33.0 [4]	
NDA	3 [3]	
good to very good	poor	
fair to good	not suitable	
0.0-3.0 (0.2-0.9) [16]	1.0-7.2 (0.3-2.2) [5]	
1.0 (0.5) [16]	2.0 (0.9) [5]	

S:
- [ ] – Number of tests performed
- NDA – No data available (insufficient data or tests not performed)

CHARACTERISTICS OF SURFICIAL SOILS
VERIFICATION SITE
REVEILLE-RAILROAD CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 9-2

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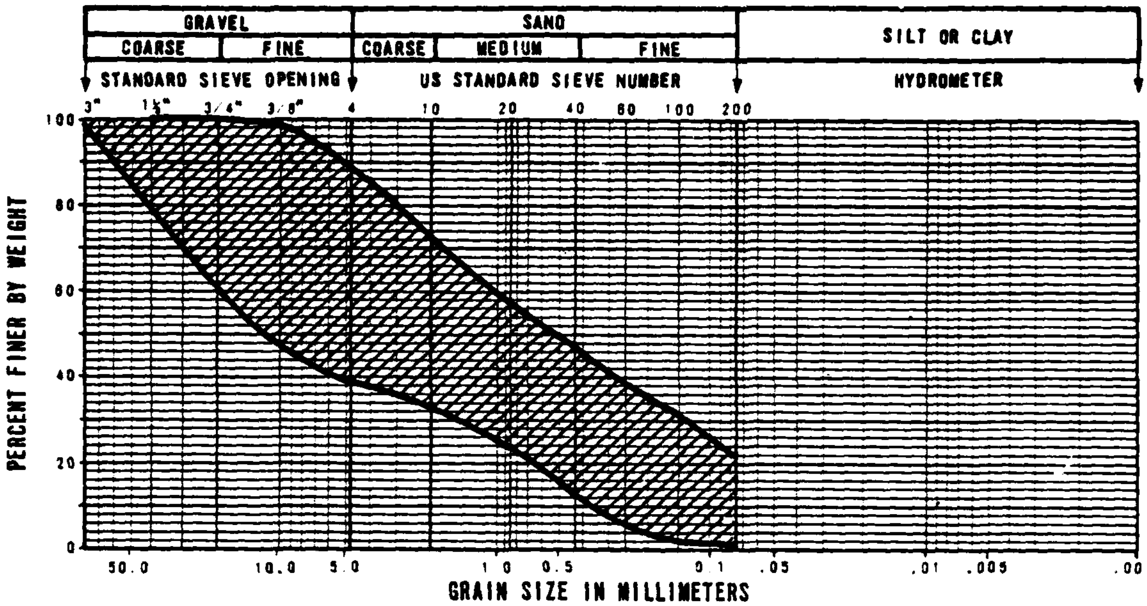
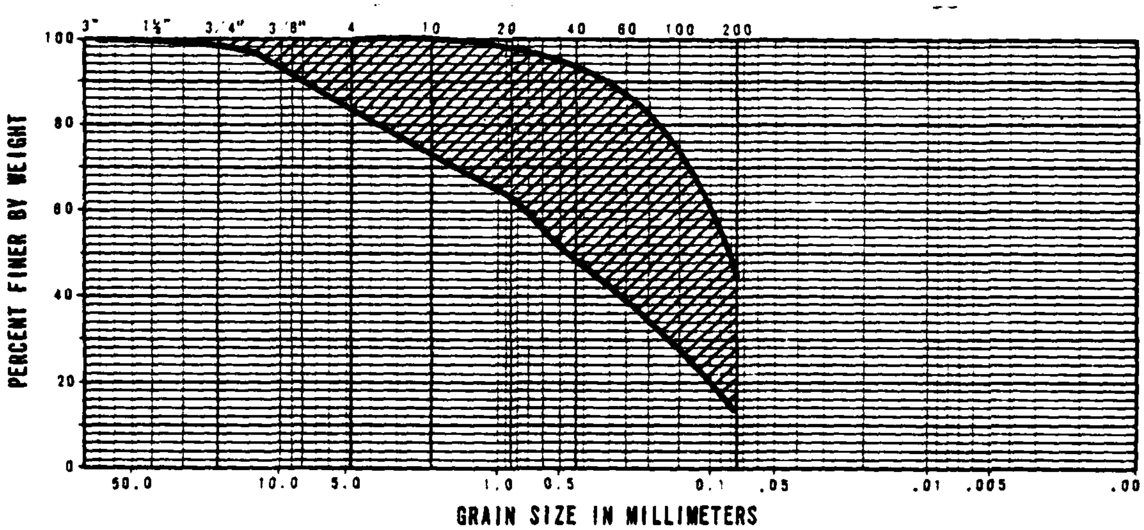
AFV-19



SOIL DESCRIPTION: Sandy Gravels and Gravelly Sands from 0 to 2 feet (0.0 to 0.6m)

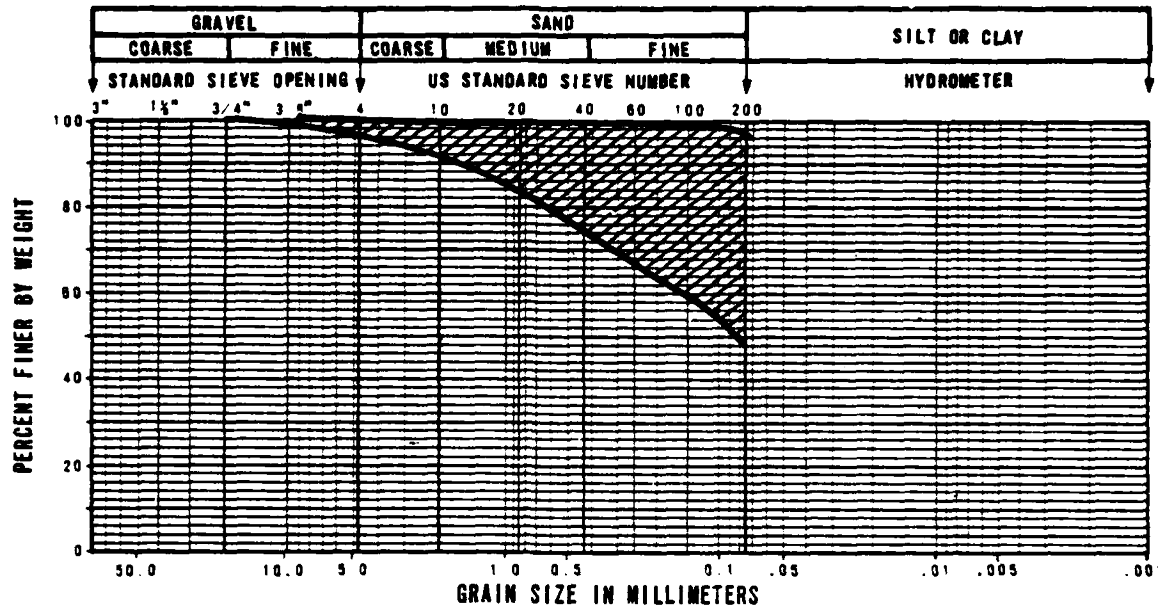


SOIL DESCRIPTION: Silty Sands and Clayey Sands from 0 to 2 feet (0.0 to 0.6m)

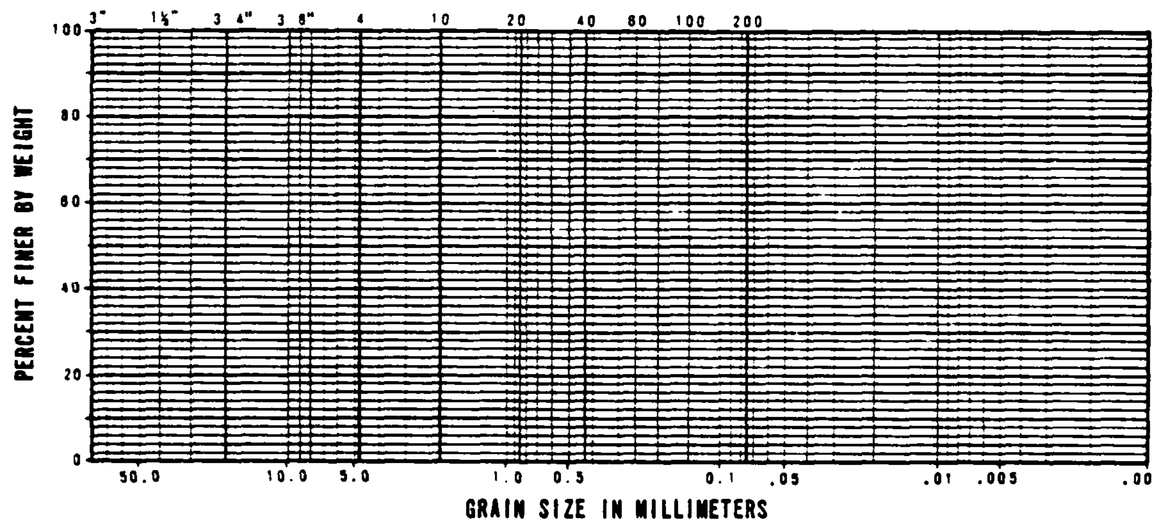
RANGE OF GRADATION OF SURFICIAL SOILS VERIFICATION SITE REVEILLE-RAILROAD CDP, NEVADA	
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAMSO	FIGURE 9-2 1 OF 2

FUGRO NATIONAL, INC.

2 JUL 79



SOIL DESCRIPTION: Sandy Silts, Clayey Silts, and Sandy Clays from 0 to 2 feet (0.0 to 0.6m)



RANGE OF GRADATION OF SURFICIAL SOILS
VERIFICATION SITE
REVEILLE-RAILROAD CDP, NEVADA

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAMSO	FIGURE 9-2 2 OF 2

FUGRO NATIONAL, INC.

the northwest portion of the site. Gravelly sands and sandy gravels have a wide distribution of particle size, are frequently well graded, and contain traces to appreciable amounts of fines which are nonplastic. Weak calcium carbonate cementation also occurs sporadically within 2 feet of the ground surface in gravelly soils.

Silts and clays are least common, covering approximately 5 to 15 percent of the site. They consist of sandy silts and sandy clays and occur predominantly as older lacustrine and active playa deposits in the north-central portion of the site. Fine-grained soil deposits are also sporadically encountered in both young and intermediate alluvial fans. These soils contain traces to appreciable amounts of sand and often traces of gravel. Their plasticity range is from slight to medium.

9.4.2 Low Strength Surficial Soil

Based on CPT results and soil classification, the thickness of low strength surficial soil at each CPT location was estimated and is presented in Table 9-3. The range and mean thickness of the low strength interval are summarized in Table 9-2 for each surficial soil category. Silty and clayey sands exhibit low strengths to depths ranging from 0.6 to 8.8 feet (0.2 to 2.7 m) with an average of 2.9 feet (0.9 m). Sandy gravels and gravelly sands exhibit low strength to depths ranging from 0.6 to 3.0 feet (0.2 to 0.9 m) with an average of 1.8 feet (0.5 m). Silts and clays exhibit low strength to depths ranging from 1.0 to 7.2 feet (0.3 to 2.2 m) with an average of 2.9 feet.

CONE PENETROMETER TEST NUMBER[1]	THICKNESS OF LOW STRENGTH SURFICIAL SOIL[2]		SOIL TYPE[3]
	FEET	METERS	
C-1	0.6	0.2	SM
C-2	1.2	0.4	SM
C-3	3.3	1.0	SM/SP
C-4	2.6	0.8	SM/GP
C-5	2.2	0.7	SM/GP
C-6	2.5	0.8	CL/GP
C-7	4.8	1.8	SM
C-8	2.9	0.9	SM/GP
C-9	2.0	0.6	SW/SC/GP
C-10	1.1	0.3	CL-ML
C-11	1.4	0.4	SM
C-12	3.2	1.0	SM/SW-SM
C-13	2.3	0.7	SM
C-14	2.6	0.8	SM
C-15	2.3	0.7	SC/SM
C-16	1.9	0.6	SC
C-17	1.1	0.3	SW-SM
C-18	1.7	0.5	SM
C-19	1.1	0.3	SC
C-20	1.0	0.3	CL
C-21	1.0	0.3	SC
C-22	0.9	0.3	GC
C-23	4.0	1.2	SM
C-24	2.2	0.7	SP-SM
C-25	1.5	0.4	SM
C-26	3.0	0.9	SM/GP
C-27	2.3	0.7	SM/SP
C-28	5.0	1.5	SP-SM

CONE PENETROMETER TEST NUMBER[1]	THI
C-29	
C-30	
C-31	
C-32	
C-33	
C-34	
C-35	
C-36	
C-37	
C-38	
C-39	
C-40	
C-41	
C-42	
C-43	
C-44	
C-45	
C-46	
C-47	
C-48	
C-49	
C-50	
C-51	
C-52	
C-53	
C-54	
C-55	
C-56	

(1) For Cone Penetrometer Test locations see Drawing 9-1, Activity Location Map.

(2) Thickness corresponds to depth below ground surface. Low strength surficial soil is defined as soil which will perform poorly as a road subgrade at its present consistency. Low strength is based on Cone Penetrometer Test results using the following criteria:

Coarse-grained soils: $q_c < 120$ tsf (117 kg/cm^2)
Fine-grained soils: $q_c < 80$ tsf (78 kg/cm^2)

where q_c is cone resistance.

(3) Soil type is based on Unified Soil Classification System; see Section A5.0 in the Appendix for explanation

	THICKNESS OF LOW STRENGTH SURFICIAL SOIL (2) FEET	METERS	SOIL TYPE (3)
	6.6	2.0	SM
	2.6	0.8	CL/SP-SM
	2.7	0.8	SM
	3.5	1.0	SM
	2.0	0.6	SW-SM
	3.1	0.9	SW-SM
	1.1	0.3	SW-SM
	2.6	0.8	SM
	3.0	0.9	SM/GP
	2.9	0.9	SM/SP-SM
	3.0	0.9	SM
	3.3	1.0	SM/SP-SM
	6.6	2.0	SM
	1.6	0.5	SP-SM
	7.2	2.2	MH/SC
	2.6	0.8	SC/SP-SM
	1.0	0.3	SC-SM
	3.1	0.9	SM
	2.0	0.6	SM/GP
	4.2	1.3	SM/SP
	4.0	1.2	SM/SC
	4.9	1.5	SP-SM
	5.7	1.7	SP-SM
	2.7	0.8	SP-SM
	2.7	0.8	SC
	0.6	0.2	SP
	3.1	0.9	SM
	2.3	0.7	SM/SC/SP

CONE PENETROMETER TEST NUMBER(1)	THICKNESS OF LOW STRENGTH SURFICIAL SOIL (2) FEET	METERS	SOIL TYPE (3)
C-57	3.2	1.0	SC/GP
C-58	5.9	1.8	SM/SP
C-59	1.6	0.5	SM
C-60	2.1	0.6	SM/SP-SM
C-61	3.3	1.0	SM/SC
C-62	0.2	0.1	SP-SM
C-63	3.9	1.2	SC
C-64	1.6	0.5	SP
C-65	2.0	0.6	SM
C-66	4.3	1.3	SP-SM
C-67	1.0	0.3	SM
C-68	1.0	0.3	GM
C-69	1.3	0.4	SP-SM
C-70	5.4	1.6	SM/GP
C-71	2.4	0.7	SP
C-72	5.1	1.5	SM/SC/SM
C-73	4.0	1.2	SC
C-74	1.6	0.5	SM
C-75	4.1	1.2	SC/SP
C-76	1.3	0.4	SM
C-77	2.6	0.8	SC/SP-SC
C-78	3.1	0.9	SM/SP-SM
C-79	2.1	0.6	SC
C-80	1.0	0.3	SM
C-81	1.9	0.6	SC
C-82	0.6	0.2	SM

NOTES:
- For fine-grained soils (ML, CL, MH and CH), thickness of low strength surficial soil will vary depending on moisture content of the soil at time of testing.
- SM/GM - Indicates SM underlain by GM
- NDA - No data available

THICKNESS OF LOW STRENGTH SURFICIAL SOIL
VERIFICATION SITE
REVEILLE-RAILROAD CDP, NEVADA

MX SITING INVESTIGATION
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TABLE B-3

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AFV-21

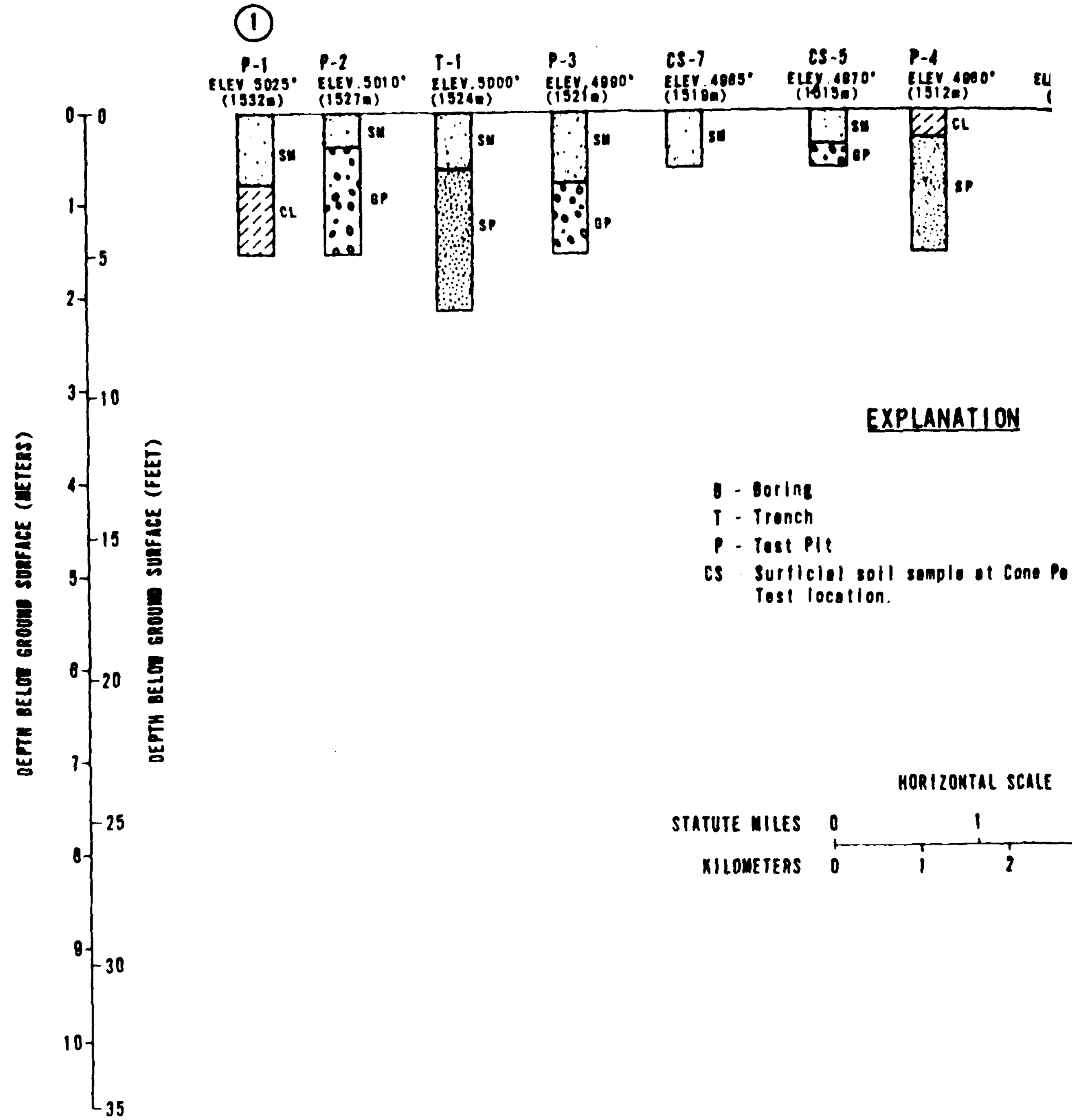
Cone penetrometer tests were performed in the Reveille-Railroad Site when surficial soils were still moist from winter precipitation, thus somewhat increasing the estimated thickness of low strength soil in comparison to thickness for similar but desiccated soils. The variable and often weak degree of calcium carbonate cementation observed in the surficial soils is confirmed by the variable thickness of low strength surficial soils.

9.5 SUBSURFACE SOILS

Subsurface soils are predominantly coarse-grained consisting of sandy gravels, gravelly sands, sands, silty sands, and clayey sands. Fine-grained soils consisting of sandy silts, clayey silts, and sandy clays are significant in the subsurface only in the older lacustrine deposits of the north-central portion of the site. The composition of subsurface soils with depth, as determined from borings, trenches, and test pits, is illustrated in soil profiles presented in Figures 9-3 through 9-6.

Results of seismic refraction and electrical resistivity surveys are summarized in Table 9-4. The physical and engineering characteristics of subsurface soils, determined from field and laboratory tests, are presented in Table 9-5. Ranges of gradation of fine- and coarse-grained subsurface soils are shown in Figure 9-7.

Coarse-grained subsurface soils are dense to very dense below approximate depths of 10 to 15 feet (3.0 to 4.6 m). Calcium carbonate cementation occurs intermittently with the highest degree of caliche development in the gravelly fans near mountain



EXPLANATION

B - Boring
T - Trench
P - Test Pit
CS Surficial soil sample at Cone Pe
Test location.

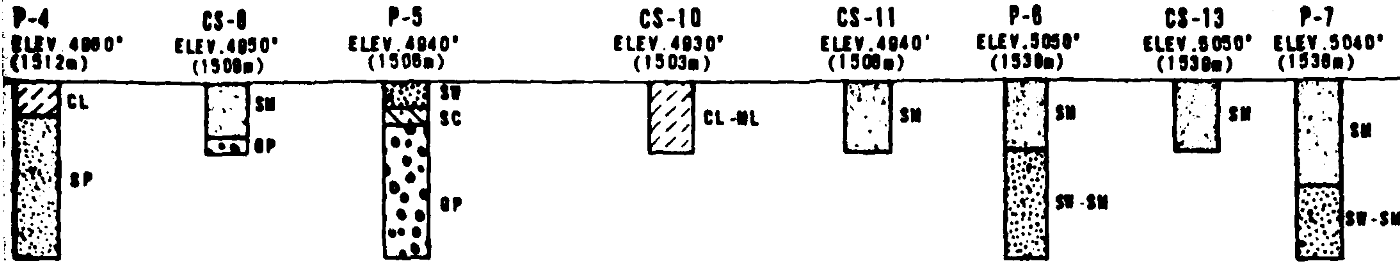
HORIZONTAL SCALE

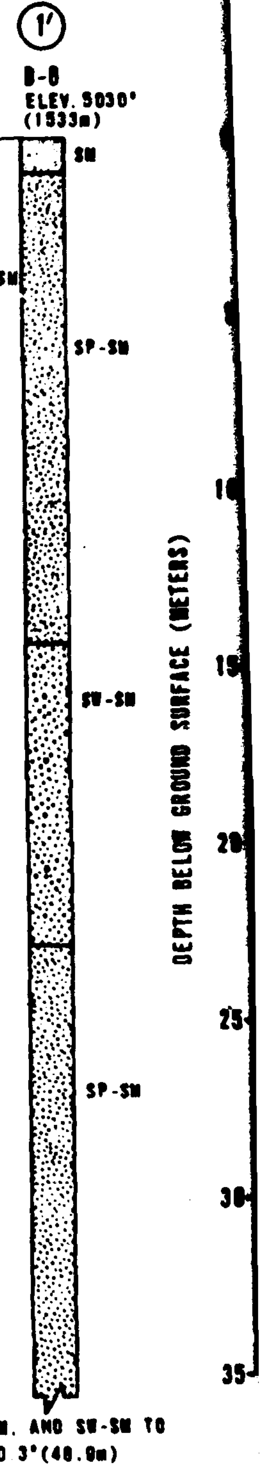
STATUTE MILES 0 1

KILOMETERS 0 1 2

NOTES:

1. Ground surface elevations shown at activity locations are app
2. T.D. = Total Depth.
3. Soil types shown adjacent to soil column are based on Unified Classification System (USCS) and are explained in the Appendi

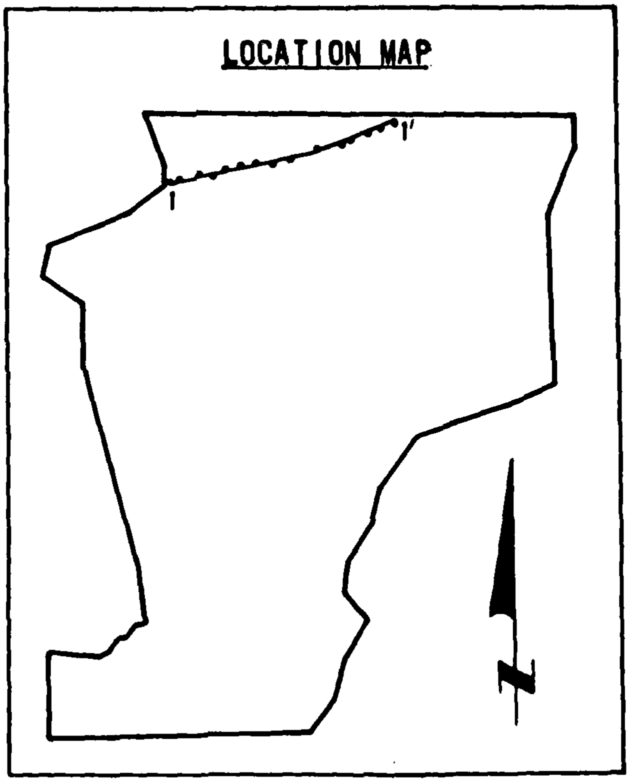




GW, SM, GM, AND SW-SM TO
T.D. 160.3'(48.9m)

LANATION

ample at Cone Penetrometer



IZONTAL SCALE

1 2

2 3

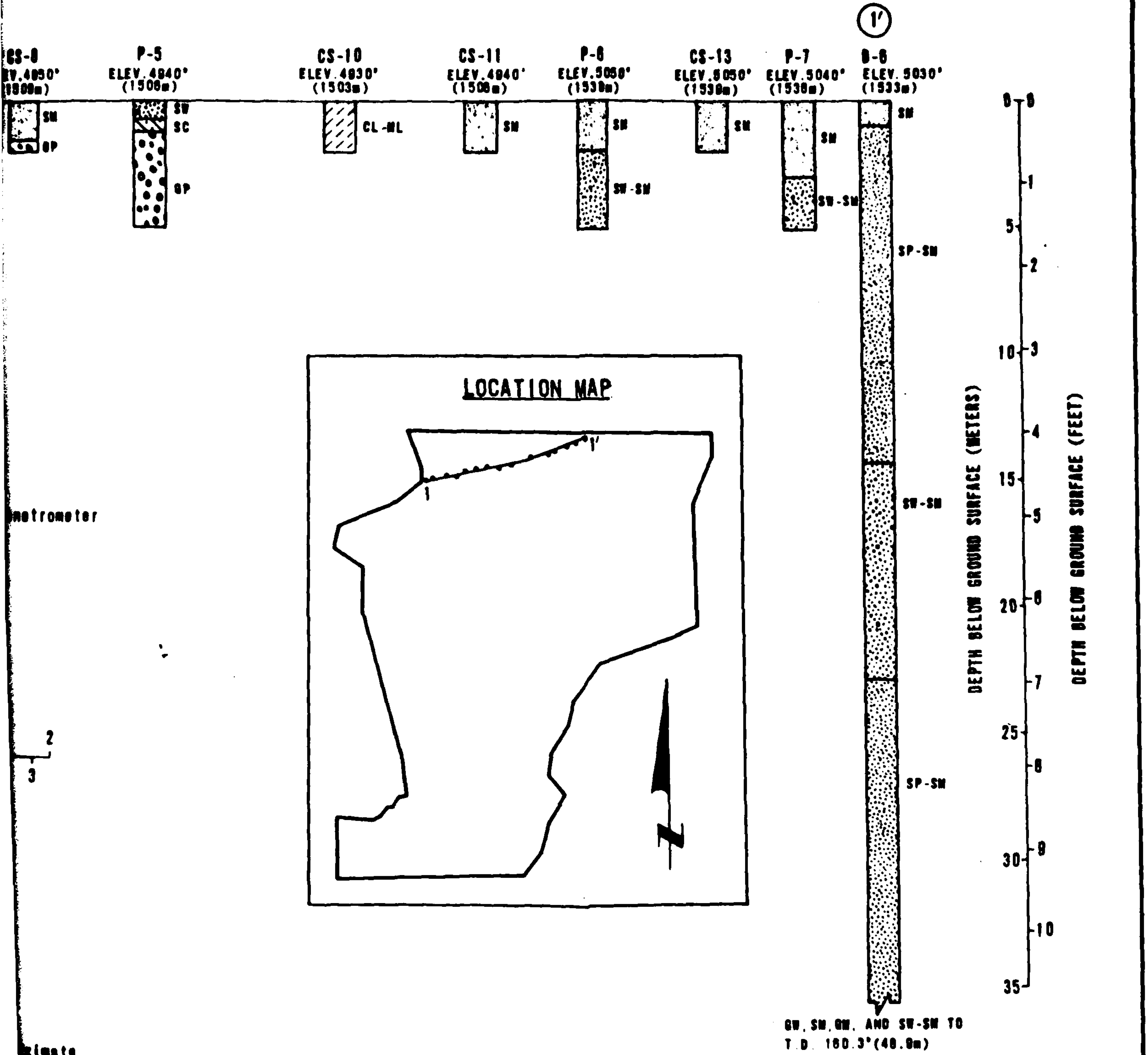
ations are approximate.

ased on Unified Soil
in the Appendix.

SOIL PROFILE 1-1'
VERIFICATION SITE
REVEILLE-RAILROAD COP, NE

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMS

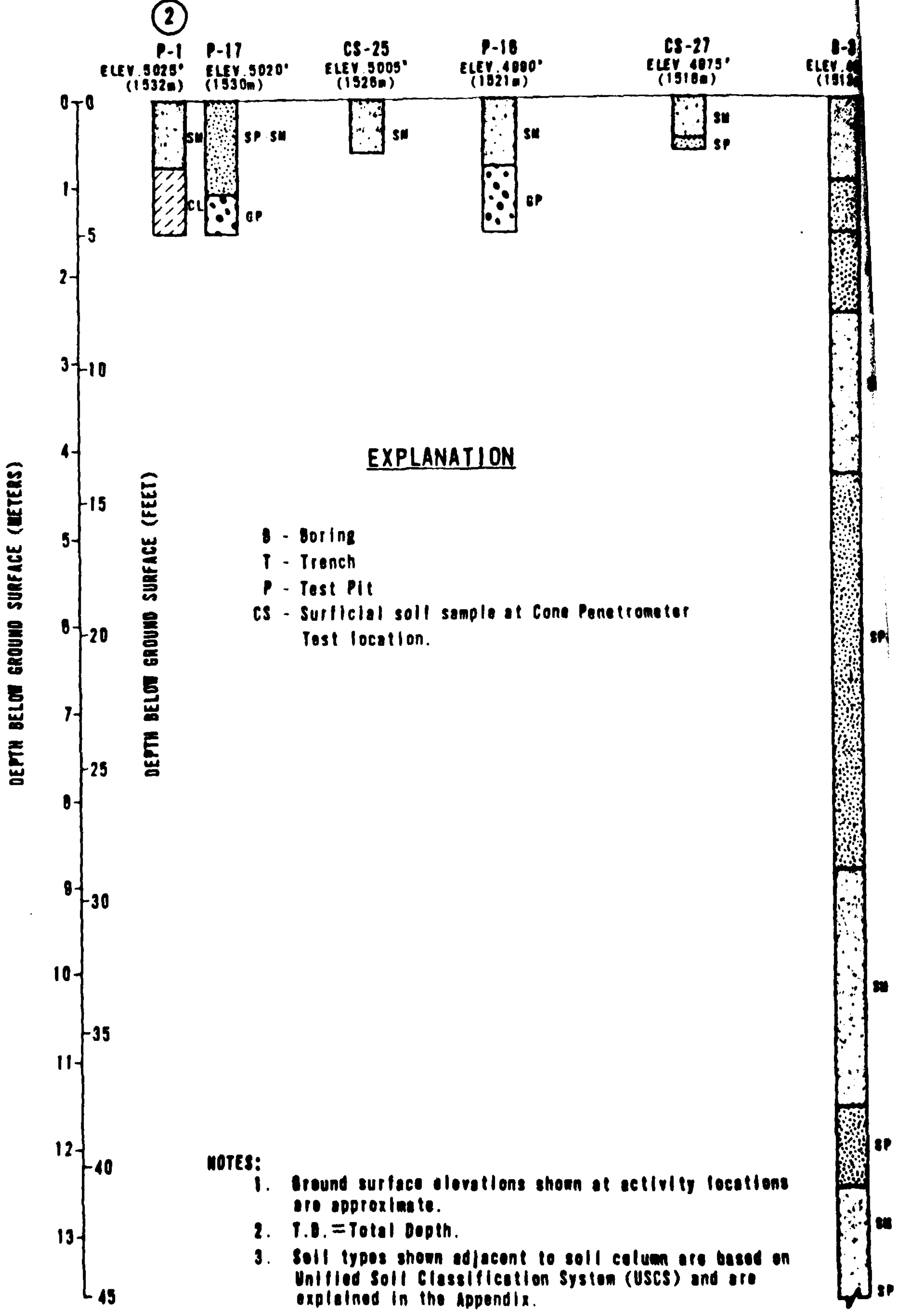
FUGRO NATIONA



SOIL PROFILE 1-1'
VERIFICATION SITE
REVEILLE-RAILROAD CDP, NEVADA

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAMSO	FIGURE 9-3

FUGRO NATIONAL, INC.



EXPLANATION

B - Boring

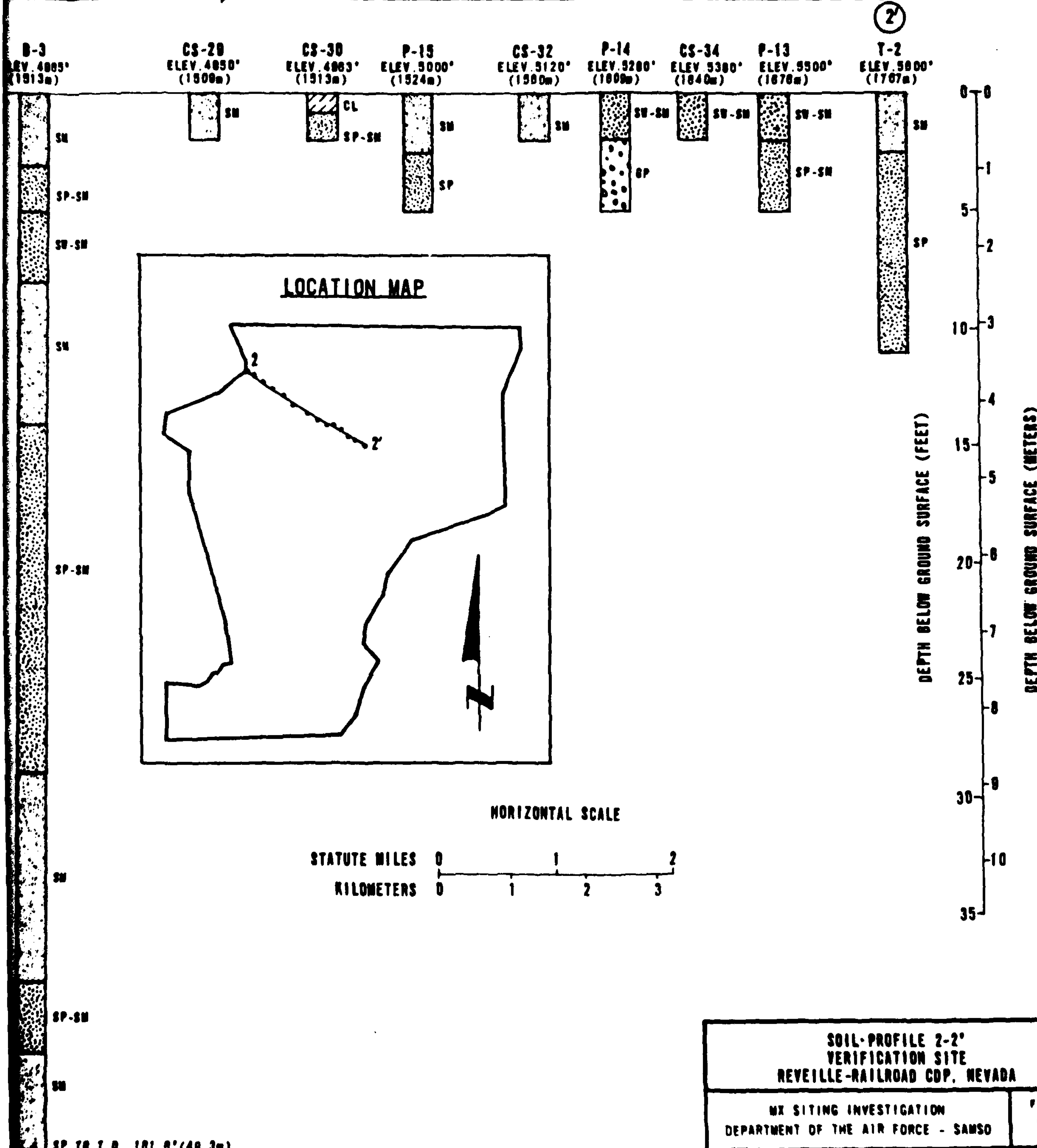
T - Trench

P - Test Pit

CS - Surficial soil sample at Cone Penetrometer Test location.

NOTES:

1. Ground surface elevations shown at activity locations are approximate.
2. T.D.=Total Depth.
3. Soil types shown adjacent to soil column are based on Unified Soil Classification System (USCS) and are explained in the Appendix.

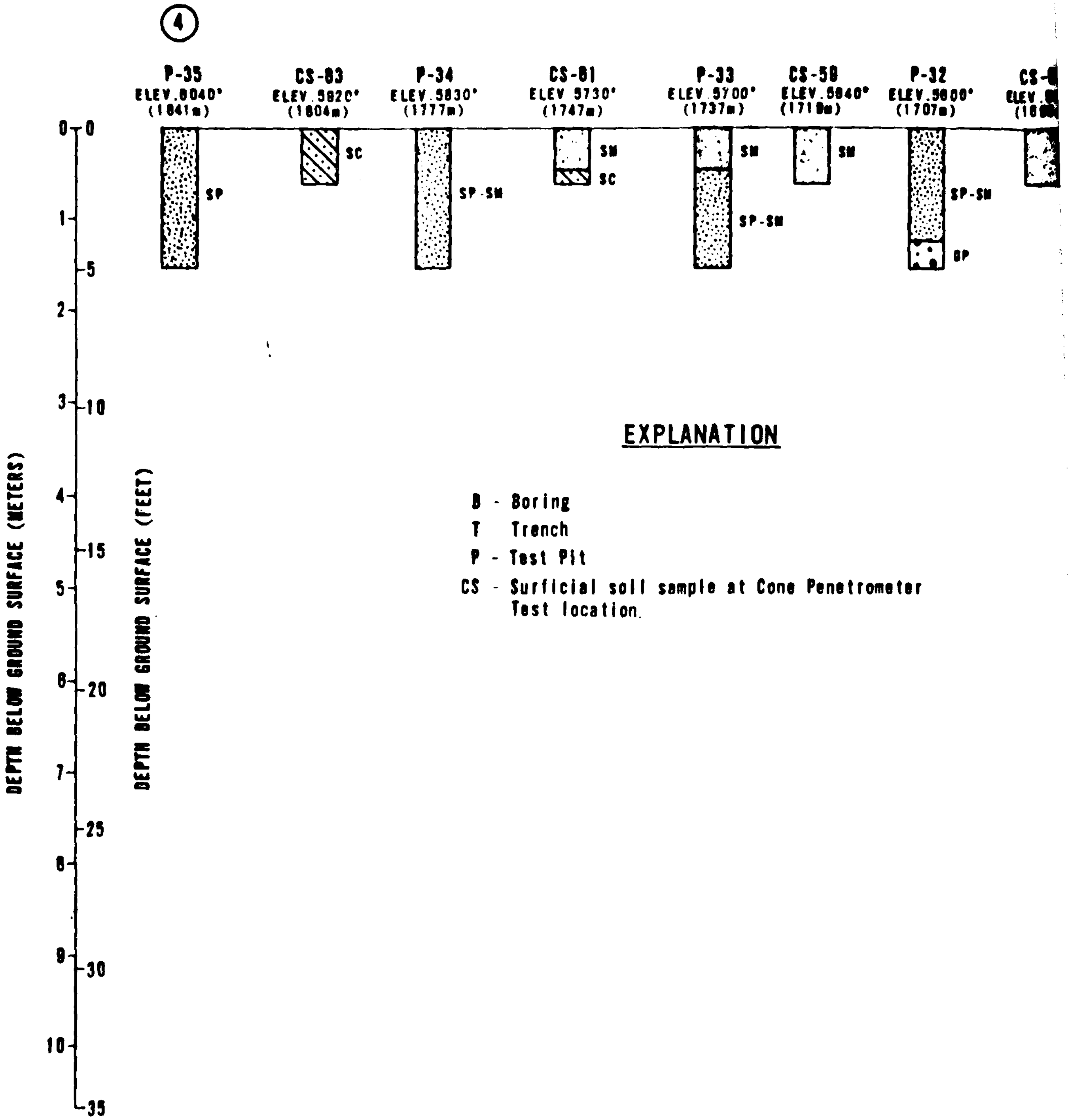


SOIL-PROFILE 2-2'
VERIFICATION SITE
REVEILLE-RAILROAD CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE
9-4

FUGRO NATIONAL, INC

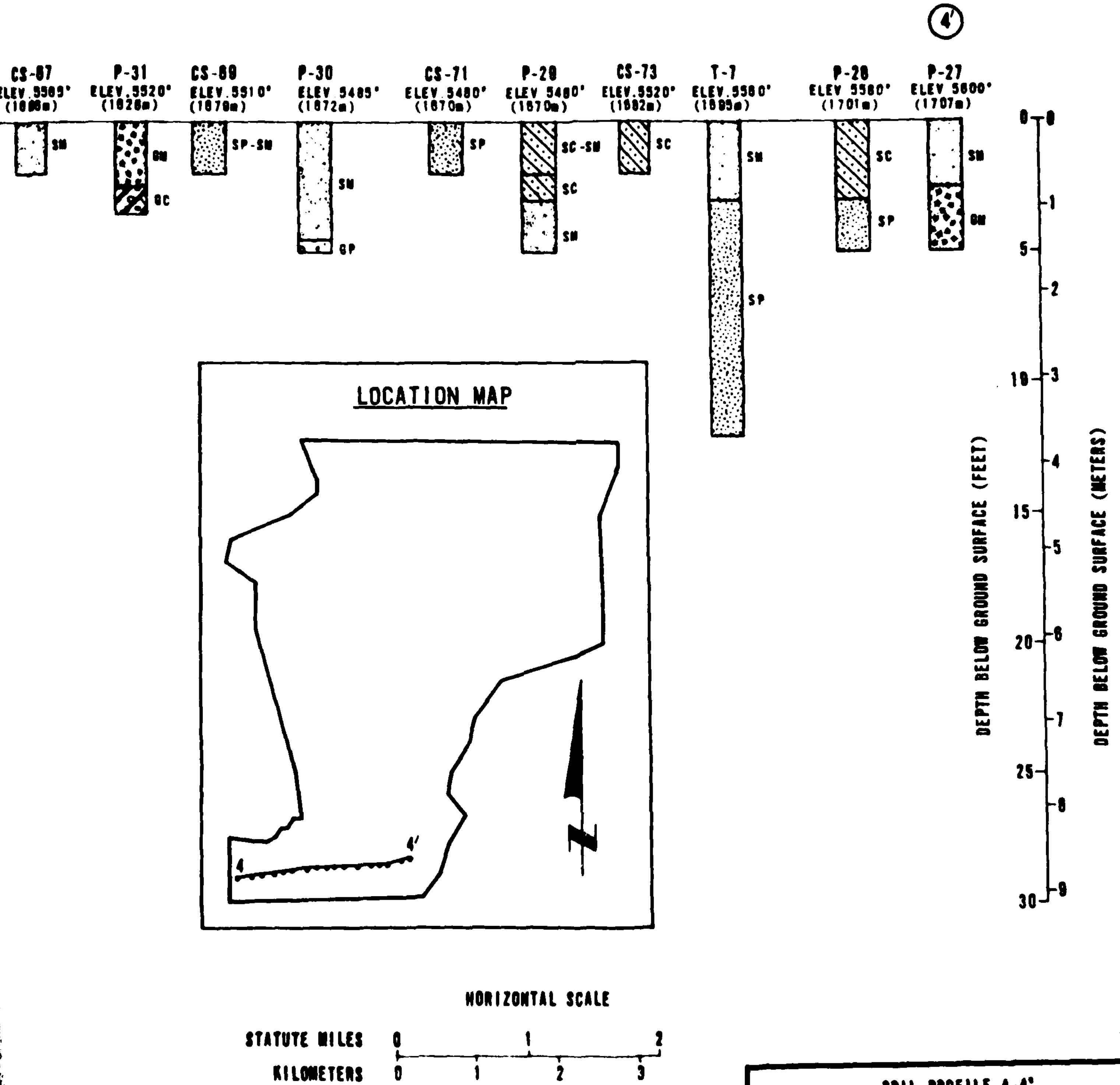


EXPLANATION

B - Boring
T Trench
P - Test Pit
CS - Surficial soil sample at Cone Penetrometer Test location.

NOTES:

1. Ground surface elevations shown at activity locations are approximate.
2. T.D. = Total Depth.
3. Soil types shown adjacent to soil column are based on Unified Soil Classification System (USCS) and are explained in the Appendix.

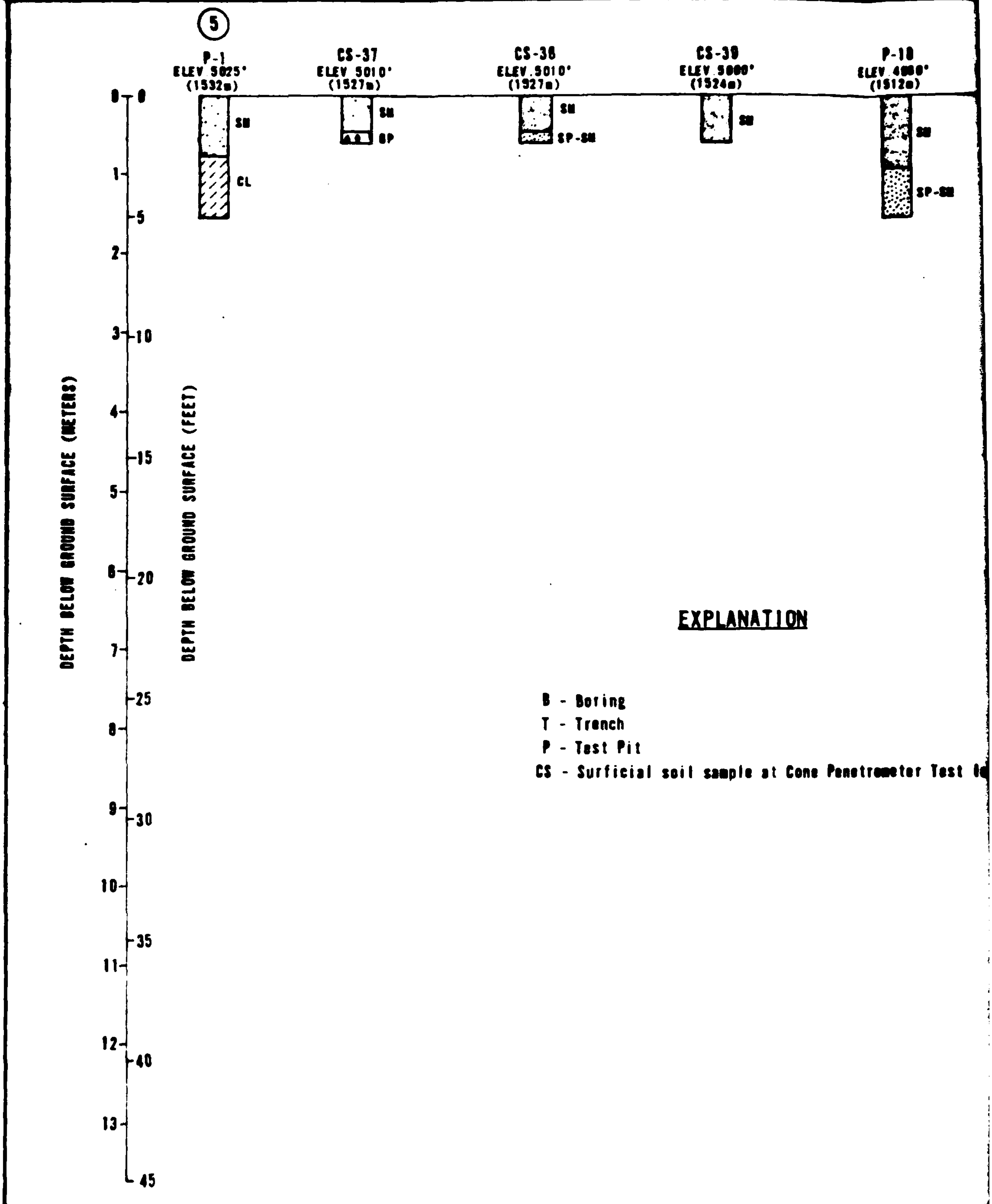


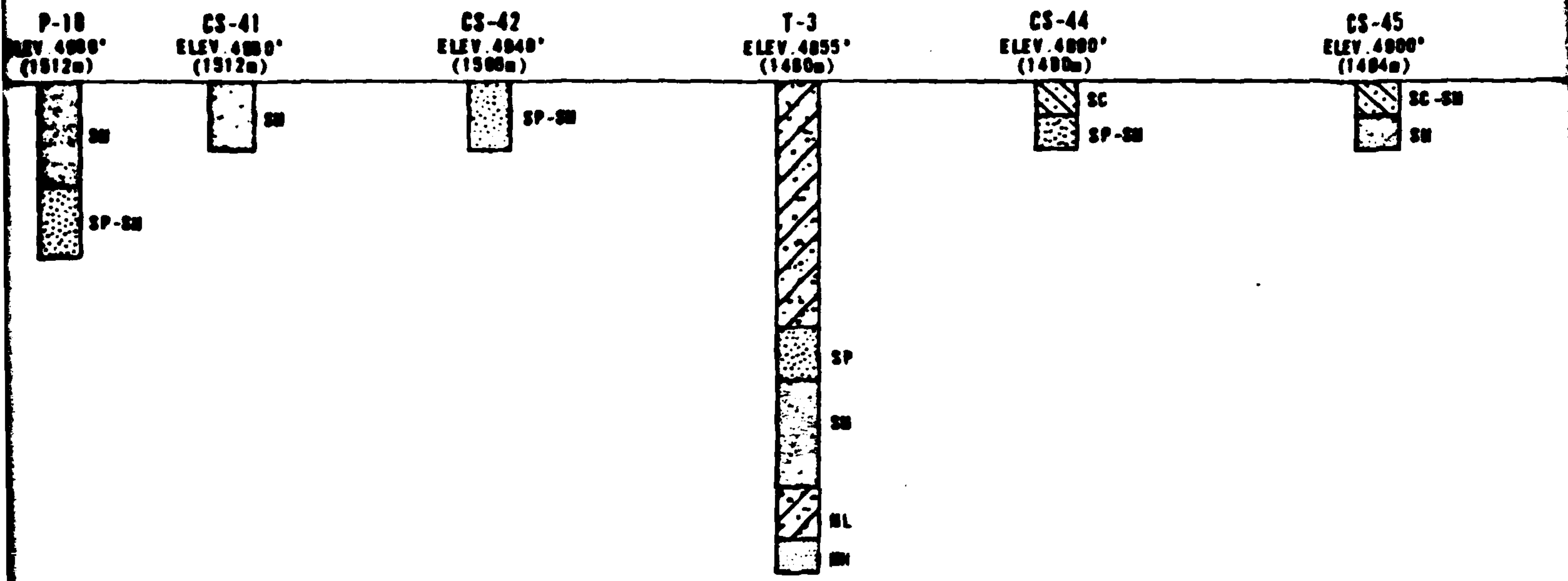
SOIL PROFILE 4-4'
VERIFICATION SITE
REVEILLE-RAILROAD CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE
9-5

FUGRO NATIONAL, INC.

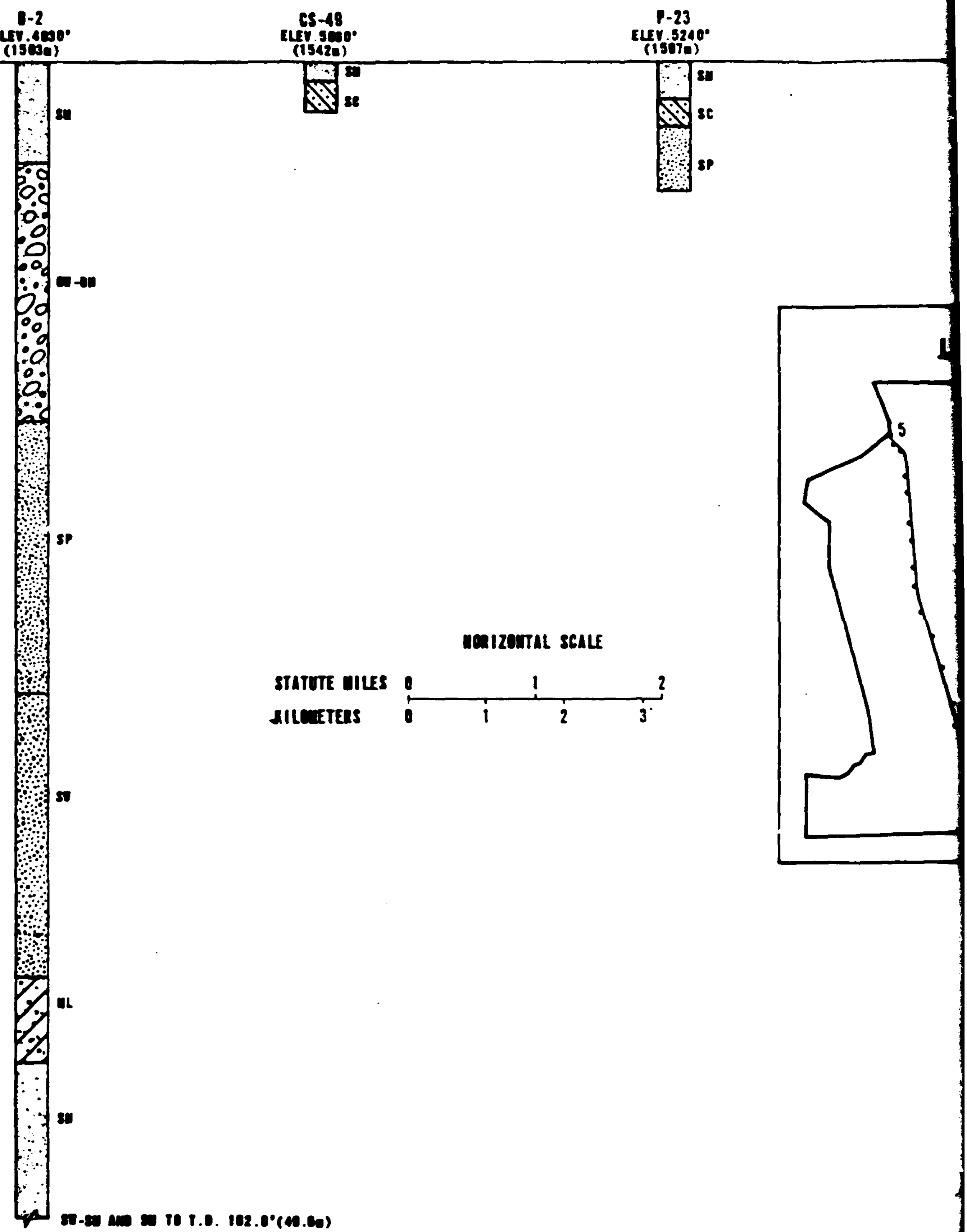

5
P-1
ELEV 5025'
(1532m)
CS-37
ELEV 5010'
(1527m)
CS-38
ELEV 5010'
(1527m)
CS-39
ELEV 5000'
(1524m)
P-18
ELEV 4960'
(1512m)
SM
CL
SM
GP
SM
SP-SM
SM
SM
SP-SM
DEPTH BELOW GROUND SURFACE (METERS)
DEPTH BELOW GROUND SURFACE (FEET)
0 1 2 3 4 5 6 7 8 9 10 11 12 13
0 5 10 15 20 25 30 35 40 45
EXPLANATION
B - Boring
T - Trench
P - Test Pit
CS - Surficial soil sample at Cone Penetrometer Test lo



...meter Test location.

NOTES:

1. Ground surface elevations shown at activity locations are approximate.
2. T.D. = Total Depth.
3. Soil types shown adjacent to soil column are based on Unified Soil Classification System (USCS) and are explained in the Appendix.

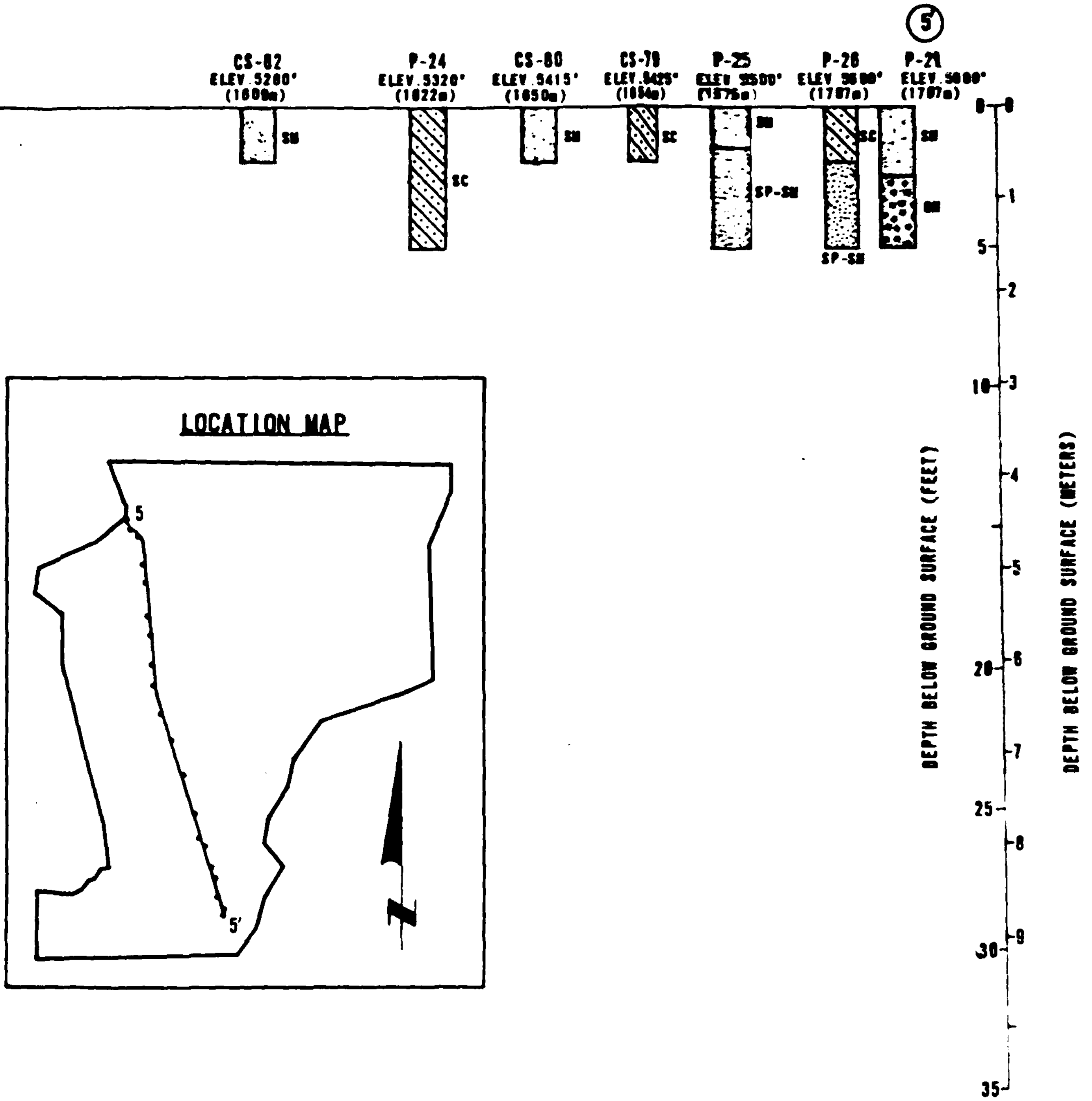


-GM

proximate.

Se.l

z.



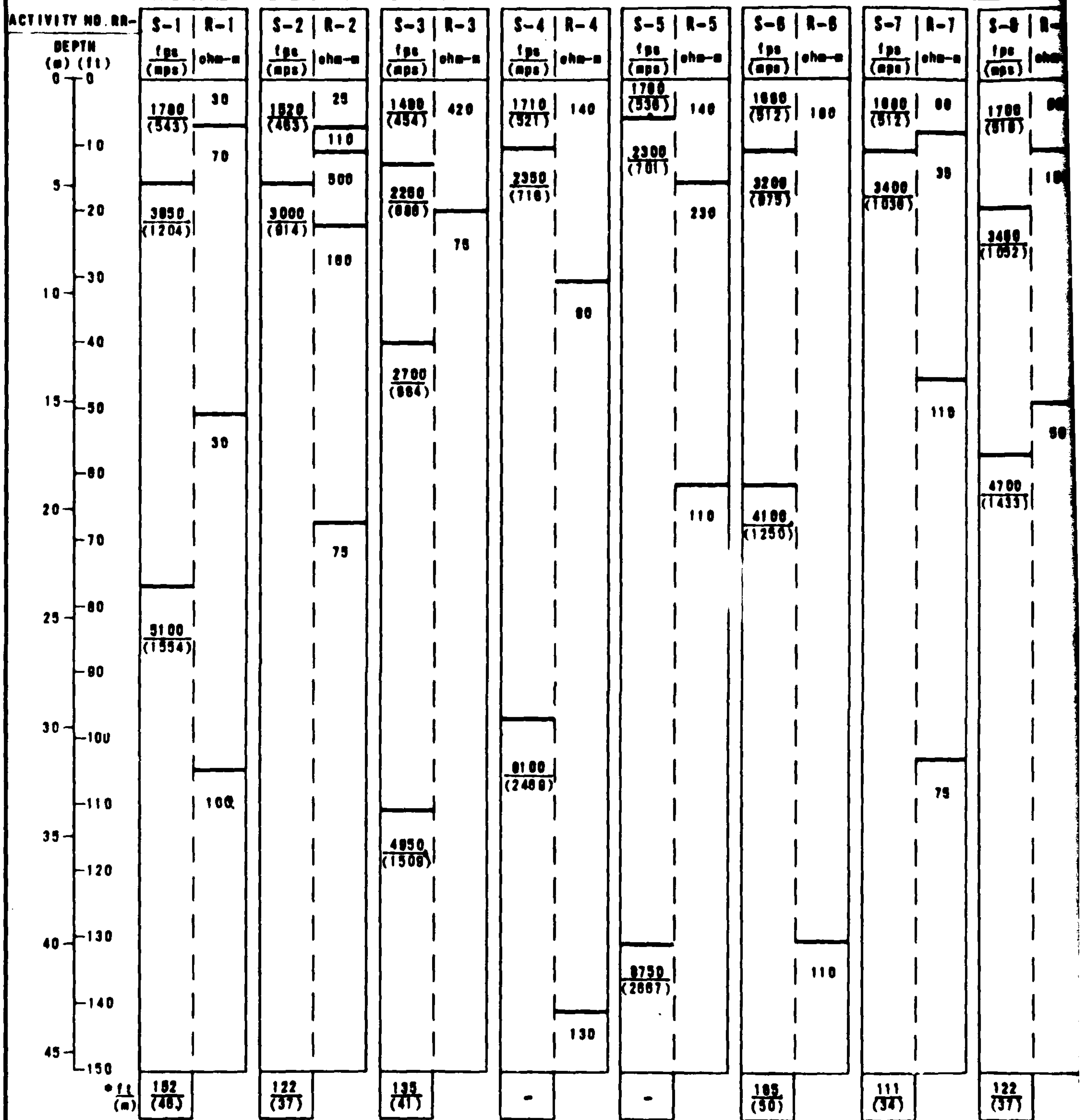
SOIL PROFILE 5-5'
VERIFICATION SITE
REVEILLE-RAILROAD CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

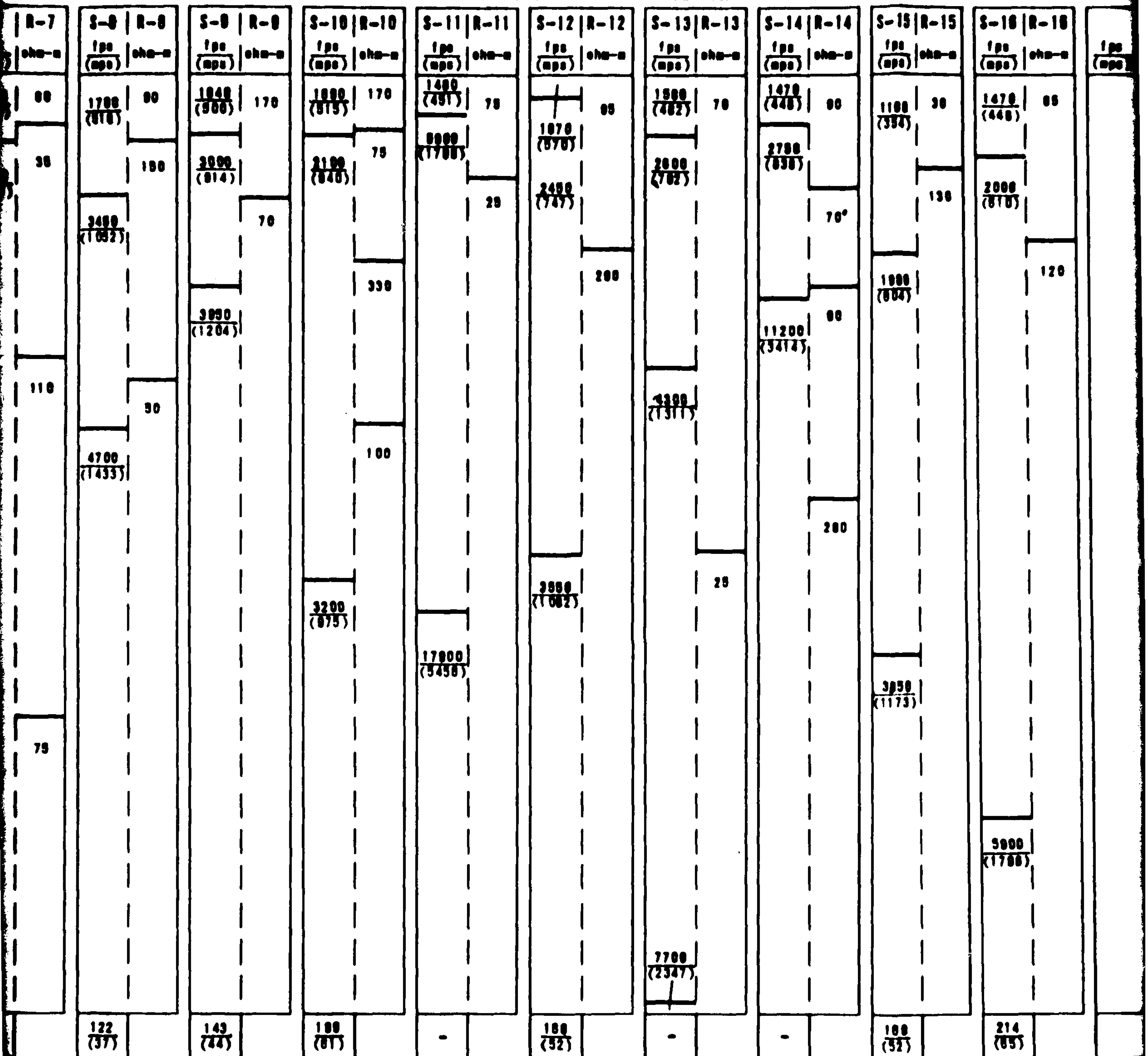
FIGURE 9-6

FUGRO NATIONAL, INC.

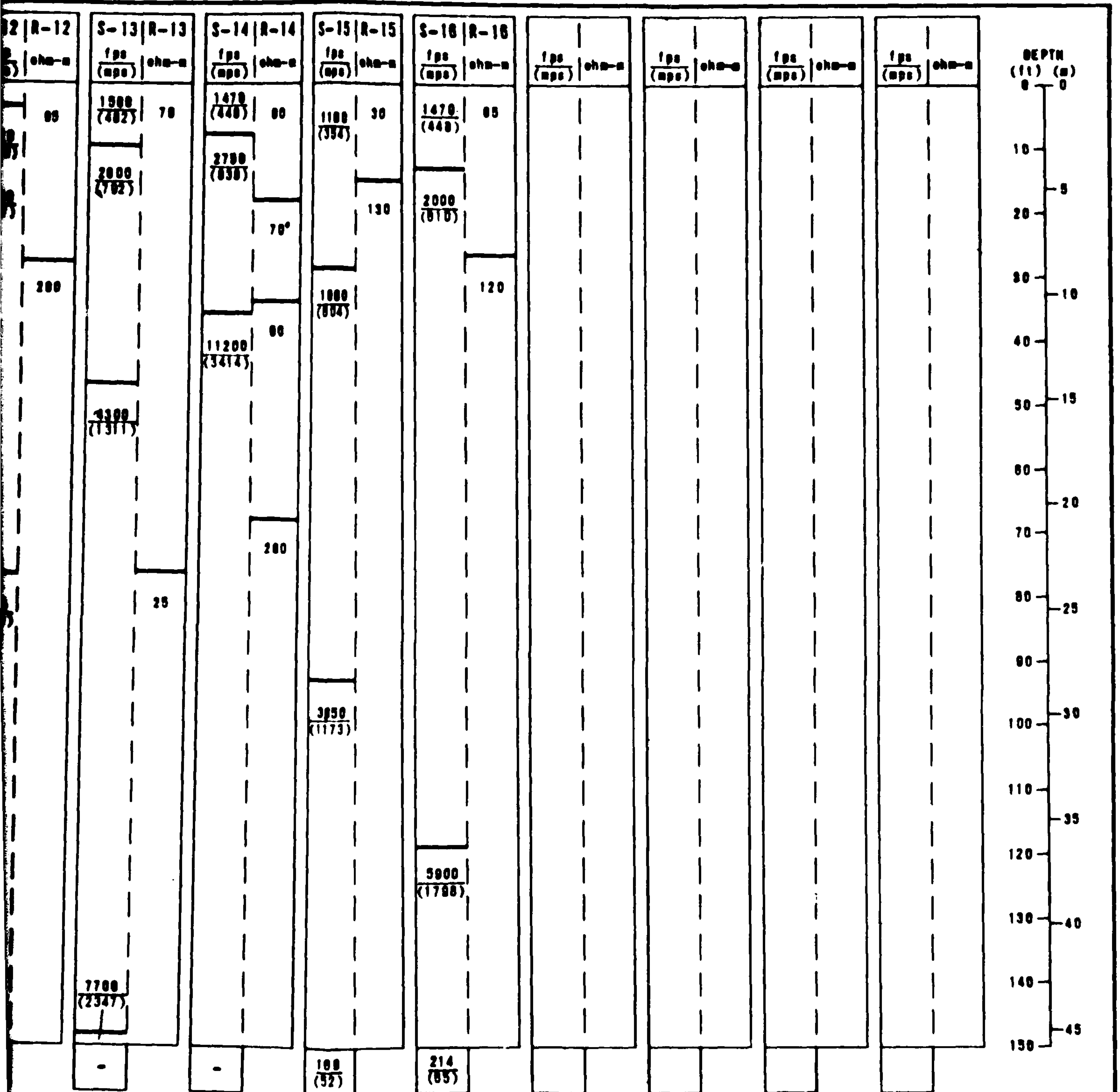
4



* Approximate depth above which there is no indication of material with a velocity as great as 7000 fps (2134 mps). See Appendix for an explanation of how this exclusion depth is calculated when the observed velocities are all less than 7000 fps (2134 mps).



R-7
S-8 | R-8
S-9 | R-9
S-10 | R-10
S-11 | R-11
S-12 | R-12
S-13 | R-13
S-14 | R-14
S-15 | R-15
S-16 | R-16
fps (mps)
ohm-m



SEISMIC REFRACTION AND ELECTRICAL RESISTIVITY VERIFICATION SITE REVEILLE-RAILROAD CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 9-4

FUGRO NATIONAL, INC.

AFV-10

DEPTH RANGE	2' - 20' (0.6 - 6	
SOIL DESCRIPTION	Coarse-grained soils	
	Sandy Gravels, Gravelly Sands, Sands, Silty Sands, and Clayey Sands	Sa Cl Sl
USCS SYMBOLS	GW, GP, GM, SW, SP, SM, SC	ML
ESTIMATED EXTENT IN SUBSURFACE %	85-90	10
PHYSICAL PROPERTIES		
DRY DENSITY pcf (kg/m³)	89.6-122.0 (1435-1954) [23]	88 (1
MOISTURE CONTENT %	2.5-18.8 [23]	20
DEGREE OF CEMENTATION	none to moderate	no
COBBLES 3-12 inches (8-30 cm) %	0-10	0
GRAVEL %	1-60 [25]	0
SAND %	32-98 [25]	1-2
SILT AND CLAY %	1-29 [25]	77
LIQUID LIMIT	22-33 [2]	50
PLASTICITY INDEX	NP-11 [2]	10-
COMPRESSIONAL WAVE VELOCITY fps (mps)	1470-5900 (448-1798) [15]	11 (3
SHEAR STRENGTH DATA		
UNCONFINED COMPRESSION S_u - ksf (kN/m²)	0.9 (43) [1]	1. (5
TRIAXIAL COMPRESSION c - ksf (kN/m²), ø°	NDA	ND
DIRECT SHEAR c - ksf (kN/m²), ø°	NDA	ND

NOTES:

- Characteristics of soils between 2 and 20 feet (0.6 and 6.0 meters) are based on results of tests on samples from 6 borings, 6 trenches, and 36 test pits, and results of 18 seismic refraction surveys.
- Characteristics of soils below 20 feet (6.0 meters) are based on results of tests on samples from 6 borings and results of 18 seismic refraction surveys.

(0.6 - 6.0m)	20' - 160' (6.0 - 49.0m)	
Fine-grained soils	Coarse-grained soils	Fine-grained soils
Sandy Silts, Silts, Clayey Silts, and Silty Clays	Sandy Gravels, Gravelly Sands, Sands, and Silty Sands	Sandy Silts, Silts and Clayey Silts
ML, MH, CL	GW, GP, GM, SW, SP, SM	ML, MH
10-15	90-95	5-10
68.1-80.1 (1091-1283) [2]	90.3-124.4 (1446-1993) [59]	78.2-89.4 (1253-1432) [10]
28.1-30.4 [2]	4.3-28.4 [59]	6.3-37.5 [10]
none to moderate	none to moderate	none to moderate
0	0-10	0
0 [3]	0-63 [30]	2 [1]
1-23 [3]	32-98 [30]	3 [1]
77-98 [3]	2-49 [30]	95 [1]
50-58 [4]	38 [1]	36-79 [illegible]
16-20 [4]	NP-8 [2]	7-43 [5]
1160 (354) [1]	2000-5900 (610-1798) [15]	1980 (604) [1]
1.1 (53) [1]	NDA	0.8-3.5 (38-168) [3]
NDA	c=0, φ=30-45° [6]	NDA
NDA	c=1.1-2.4, φ=28-37° (53-115) [2]	NDA

- [ ] - Number of tests performed.
- NDA - No data available (insufficient data or tests not performed.)

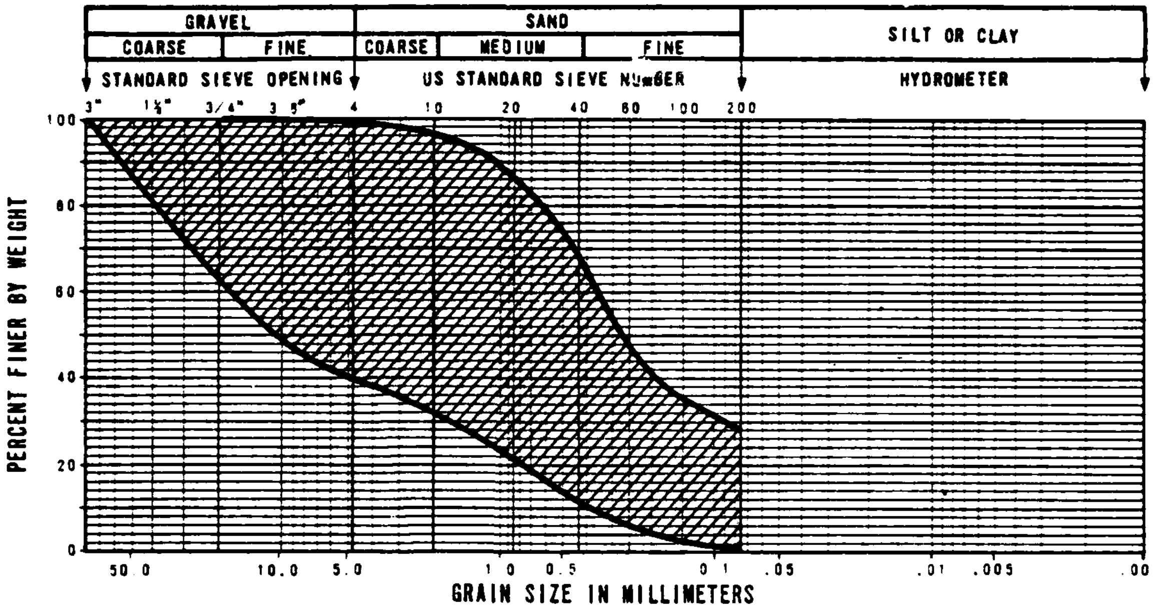
CHARACTERISTICS OF SUBSURFACE SOILS
VERIFICATION SITE
REVEILLE-RAILROAD CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

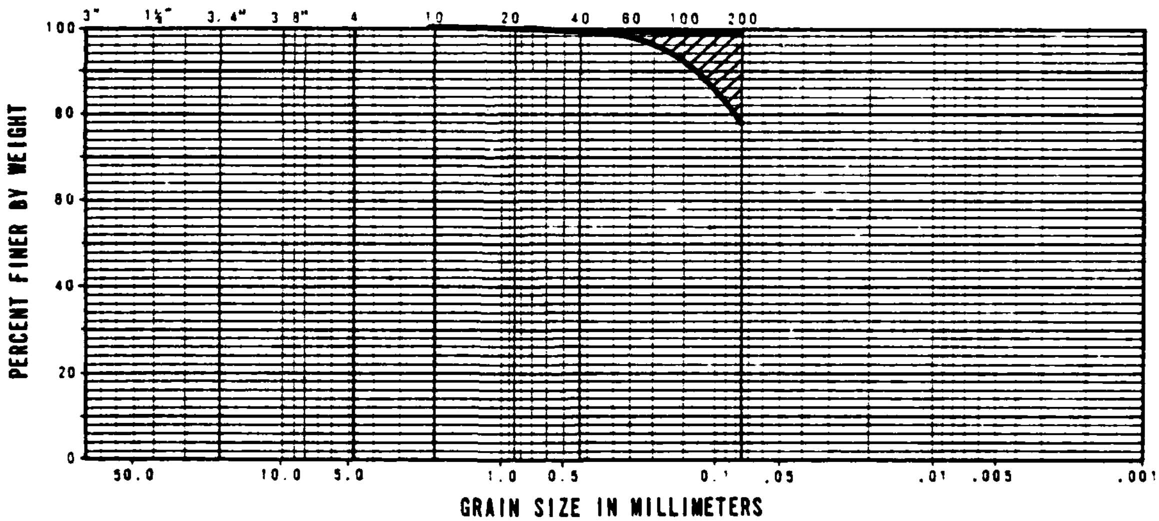
TABLE 9-5

FUGRO NATIONAL, INC.

AFV-2

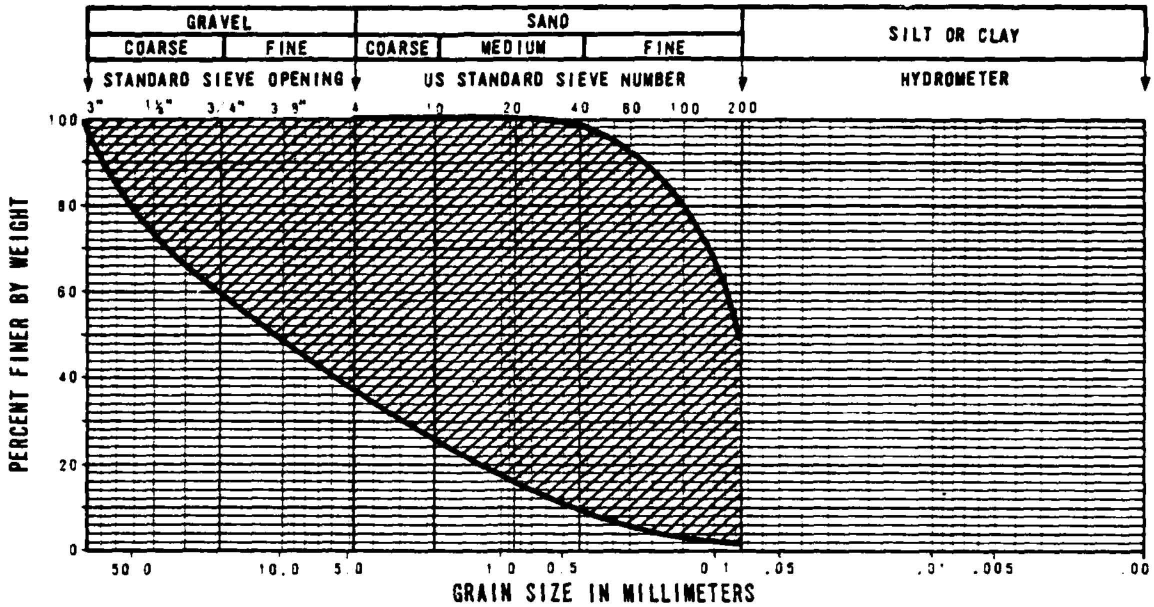


SOIL DESCRIPTION: Coarse-grained soils from 2 to 20 feet (0.6 to 6m)

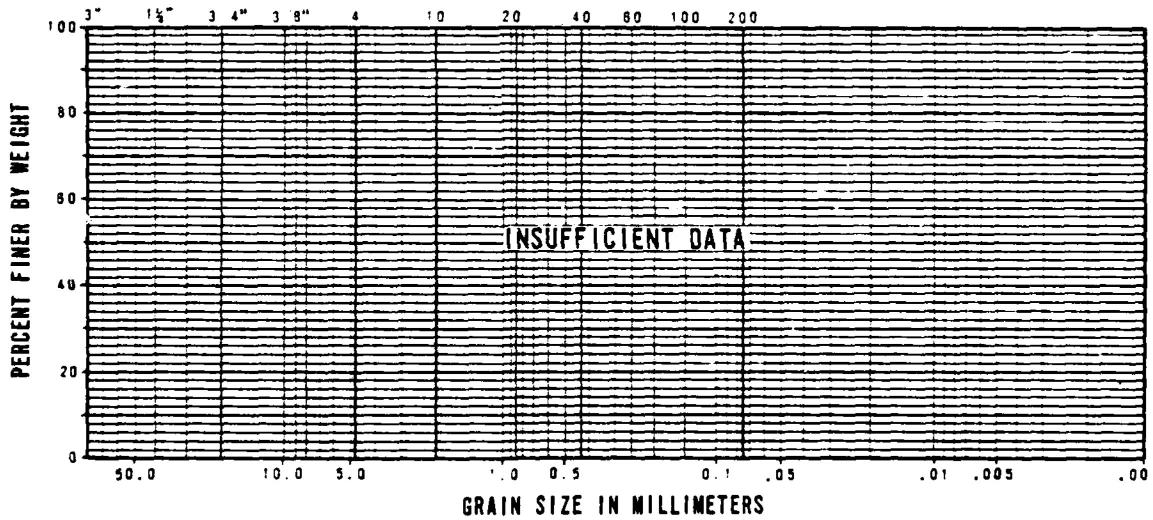


SOIL DESCRIPTION: Fine-grained soils from 2 to 20 feet (0.6 to 6m)

RANGE OF GRADATION OF SUBSURFACE SOILS VERIFICATION SITE REVEILLE-RAILROAD CDP, NEVADA	
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAMSO	FIGURE 9-7 1 OF 2
FUGRO NATIONAL, INC.	



SOIL DESCRIPTION: Coarse-grained soils from 20 to 160 feet (6 to 49m)



SOIL DESCRIPTION: Fine-grained soils from 20 to 160 feet (6 to 49m)

RANGE OF GRADATION OF SUBSURFACE SOILS
VERIFICATION SITE
REVEILLE-RAILROAD CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 9-7
2 OF 2

FUGRO NATIONAL, INC.

fronts. These soils are only slightly compressible and exhibit moderate to high shear strengths. Fine-grained silt and clay soils, near the southern margin of the lacustrine deposits, are desiccated and are stiff to hard. These soils exhibit extensive shrinkage cracking and a resulting blocky texture. Cementation is intermittent but not well enough developed to fill the fractures. These fine-grained soils possess moderate to high shear strength where unfractured, but fracturing will greatly reduce the shear strength. Soil compressibilities range from low to moderate for fine-grained subsurface soils.

Electrical conductivity of the soils in the upper 50 feet (15 m) ranges from 0.0046 to 0.0238 mhos per meter (average 0.0102 mhos per meter). All conductivities exceeded the minimum of 0.004 mhos per meter specified in the Fine Screening criteria. Chemical test results indicate a severe potential for sulfate attack of soils on concrete.

9.6 TERRAIN

Railroad Valley is narrow and elongate in a general north-south direction and is contiguous with Reveille Valley at its southern end. It is one of the longest topographically closed drainage basins in Nevada with washes culminating in two main playas (Van Denburgh and Rush, 1974). The largest playa lies to the north outside of the CDP. The southern playa is higher in elevation and centrally located within the Verification site. Surface gradients within the site are generally low; about 40 feet (12 m) per mile in the south and 16 feet (5 m) per mile north of the playa. The main drainage at the site originates in Reveille Valley, curves eastward around the southern tip of the Reveille Range, and flows northward toward the central playa.

The distribution of terrain features in the Reveille-Railroad Site is shown in Drawing 9-3. The main factors affecting terrain are the topographically closed valley morphology and the presence of a centrally located, active playa which allows sediments eroding from the mountains and adjacent slopes to accumulate in broad young fans, terrace, and other associated deposits along the playa edge. Slopes on these low-lying deposits are gentle (less than 1 percent) and drainages are normally less than 3 feet (1 m) deep (category I). Densities range from 2 to 4 per mile north of the playa and 4 to 6 south of the playa.

Intermediate fans grade upslope from the younger fans and have slopes ranging from 4 to 7 percent. Steeper slopes occur along the Reveille Range where topography is influenced by the range-bounding fault. Drainages in intermediate fans generally range from 7 to 16 feet (2 to 5 m; category IV) deep along the Reveille Range and 3 to 10 feet (1 to 3 m; category III) deep along the Quinn Canyon Range. Steep fans with deeper drainages (7 to 16 ft; 2 to 5 m) also occur in the south-east corner of the site and in the northwest where they are affected by a range-bounding fault. Complex, highly variable terrain (category VI) occurs in the area of dunes directly north of the playa.

9.7 DEPTH TO ROCK

The approximate configuration of the 50-foot (15-m) and 150-foot (46-m) depth to rock contours is shown in Drawing 9-4. This interpretation is based on the extrapolation of topographic rock slope, geologic structure, data from borings and seismic refraction lines, geologic mapping, and pertinent published information. An estimated 15 percent of the site is interpreted to be underlain by rock at depths less than 50 feet. An additional 7 percent is estimated to be underlain by rock at depths between 50 and 150 feet.

Depth to rock contours are interpreted as closely paralleling the rock/alluvium contact in the west and northeast portions of the site, where the rock boundary is controlled by range-bounding faults. This fault is assumed to be normal, and depth to rock on the downthrown fault block is expected to be greater than 150 feet.

Near-surface rock is suspected at several locations along the valley margins. In the southeast, seismic lines S-11 and S-14 supported evidence of a shallow rock zone extending a minimum of 1 mile (1.6 km) from the mountains. Numerous large outcrops of tuff in the northeast indicate probable areas of shallow rock.

9.8 DEPTH TO WATER

The approximate configuration of the 50-foot (15-m) and 150-foot (46-m) depth to water contours for the Reveille-Railroad Site is shown in Drawing 9-5. The interpretation is based on available published well data and other pertinent references summarized in Section 2.0, Volume VII. Less than 5 percent of the total site area is suspected to be affected by shallow water less than 50 feet deep. Approximately 25 percent of suitable area is interpreted to be underlain by water at depths between 50 and 150 feet.

Ground water is interpreted to be less than 150 feet deep over a large portion of the site north of the playa. Recharge flows southward through Twin Spring Slough and northward out of the site area into lower elevations of Railroad Valley. Ground water occurring at less than 50-foot depths is interpreted within the playa near the center of the site and in the area of Twin Springs Slough. Perched water may occur in the northeast; however, the sparseness of data is somewhat inconclusive.

9.9 RESULTS AND CONCLUSIONS

9.9.1 Suitable Area

Suitable area resulting from FY 79 Verification Studies in the Reveille-Railroad Site is shown in Drawing 9-6. The site contains approximately 290 mi^2 (750 km^2) of usable area for a hybrid trench and 155 mi^2 (400 km^2) for a vertical shelter concept. These results are significantly different than those reported in previous Intermediate/Fine Screening studies due chiefly to:

1. New depth to water exclusions interpreted during Verification studies affecting a large area in the central and northern portions of the site;

2. Additional terrain exclusions, primarily in the southwest portion of the site, that had not been discernible at previous screening levels of study; and
3. Reduction in area around the valley margins due to additional shallow rock exclusions.

9.9.2 Construction Considerations

Geotechnical factors and conditions pertaining to construction of the MX system in suitable area are discussed in this section. Both the hybrid trench and vertical shelter basing modes are considered.

9.9.2.1 Grading

Mean surficial slopes in the suitable area are approximately 3 percent (range of 0 to 7 percent). The more steeply sloping areas occur primarily along the west and northeast margins of the valley where fans are influenced by range-bounding faults. Minimal preconstruction grading will be required for roads and trenches, but more extensive grading may be necessary for vertical shelters sited on the steeper, fault-influenced fans.

9.9.2.2 Roads

Surficial soils exhibit low strength to an average depth of 2.6 feet (0.8 m) with maximum depth approaching 9 feet (2.7 m). The subgrade supporting properties of low strength coarse-grained site soils are inadequate but can be sufficiently improved by mechanical compaction. Compaction to a depth of 2 to 3 feet (0.6 to 0.9 m) appears necessary, with compaction to greater depth required in approximately 15 percent of the site.

Based on results of laboratory CBR tests, compacted coarse-grained soils will provide good to very good subgrade support for roads. Supporting qualities of the fine-grained soils are inadequate for direct support of roads. Results of CBR tests indicate that generally mechanical compaction will not adequately strengthen these fine-grained soils. Required support can be attained either by using a select granular subbase layer over the compacted fine-grained soil subgrade or as an alternative, these soils could be partially or totally removed, depending upon their thickness, and replaced by a sufficient thickness of coarse-grained soil to obtain the required subgrade support.

Well-graded gravelly sands and sandy gravels with less than 25 percent fines (passing a No. 200 sieve) could be used for road subbase and base courses. These soils are present at the surface and in the subsurface; however, their extent is unknown.

Drainage incisions are generally less than 6 feet (1.8 m) deep within approximately 90 percent of the suitable area. In the remaining area, depths of drainage incisions range from 6 to 15 feet (1.8 to 4.6 m). Therefore, the cost of drainage structures for roads and trenches will be low.

9.9.2.3 Excavatability and Stability

Subsurface soils in the suitable site area are predominantly coarse-grained with fine-grained soils estimated in less than 15 percent of the construction zone. Subsurface soils are generally dense to very dense below 10 feet (3 m) with infrequent calcium carbonate cementation.

Hybrid Trench: Compressional wave velocities in the upper 20 feet (6 m) indicate easy to difficult excavation in the suitable area. Continuous trenches for cast-in-place construction could be excavated by an MX trencher. Because of low strength surficial soil, the top 2 to 5 feet (0.6 to 1.5 m) in all trench excavations will generally have to be sloped back for stability. Below this depth, vertical trench walls will remain temporarily stable in approximately 75 percent of the suitable area. In the remaining areas, the fines content or degree of cementation in subsurface soils is inadequate to provide temporary stability for vertical cuts without caving or excessive overbreak. Therefore, trench walls in these areas may have to be shored or sloped for stability.

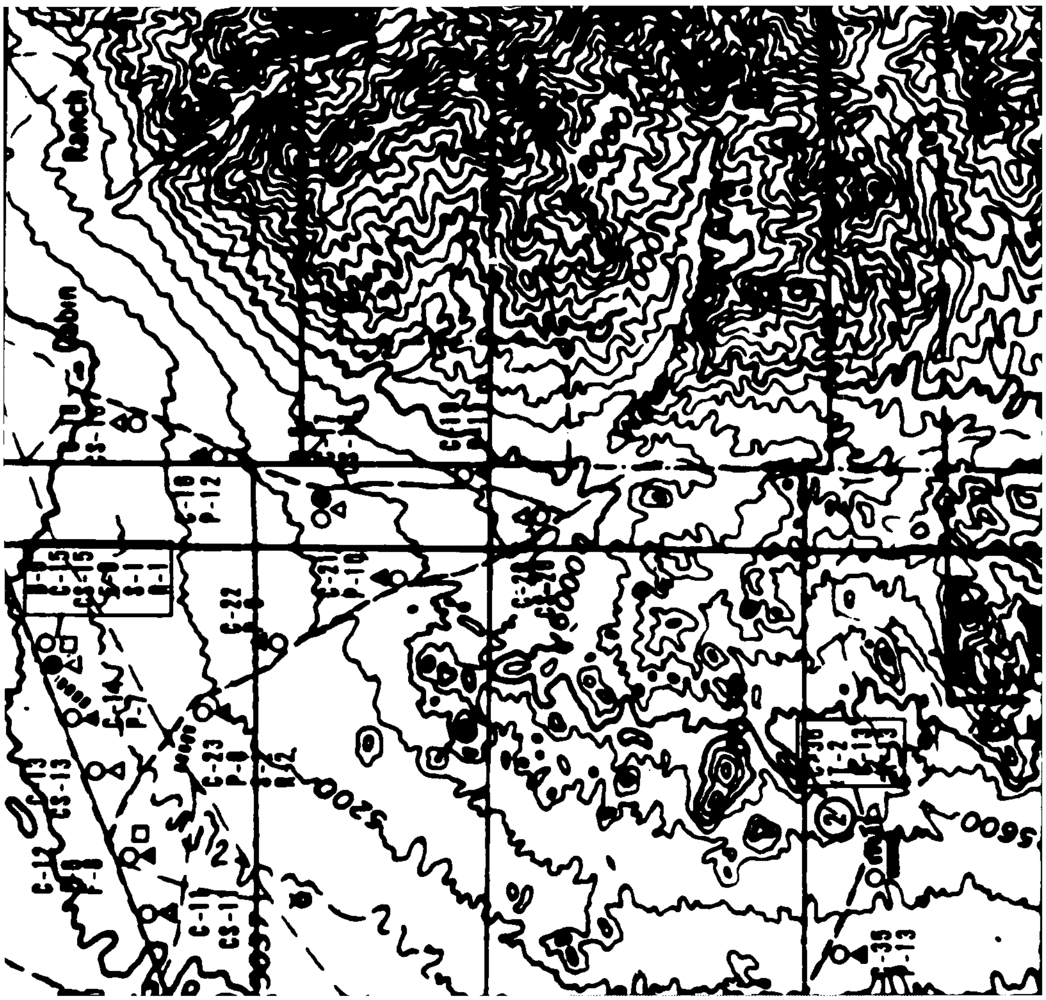
Vertical Shelter: Compressional wave velocities in the upper 120 feet (36 m) indicate that large diameter auger drills could be used for vertical shelter excavation. Nearly all excavation will be in granular soils with only intermittent cemented or cohesive soil intervals. Therefore, the vertical walls of these shelters will probably require the use of slurry or other stabilizing techniques.

9.10 RECOMMENDATONS FOR FUTURE STUDIES

The following geotechnical conditions have been identified as requiring additional information.

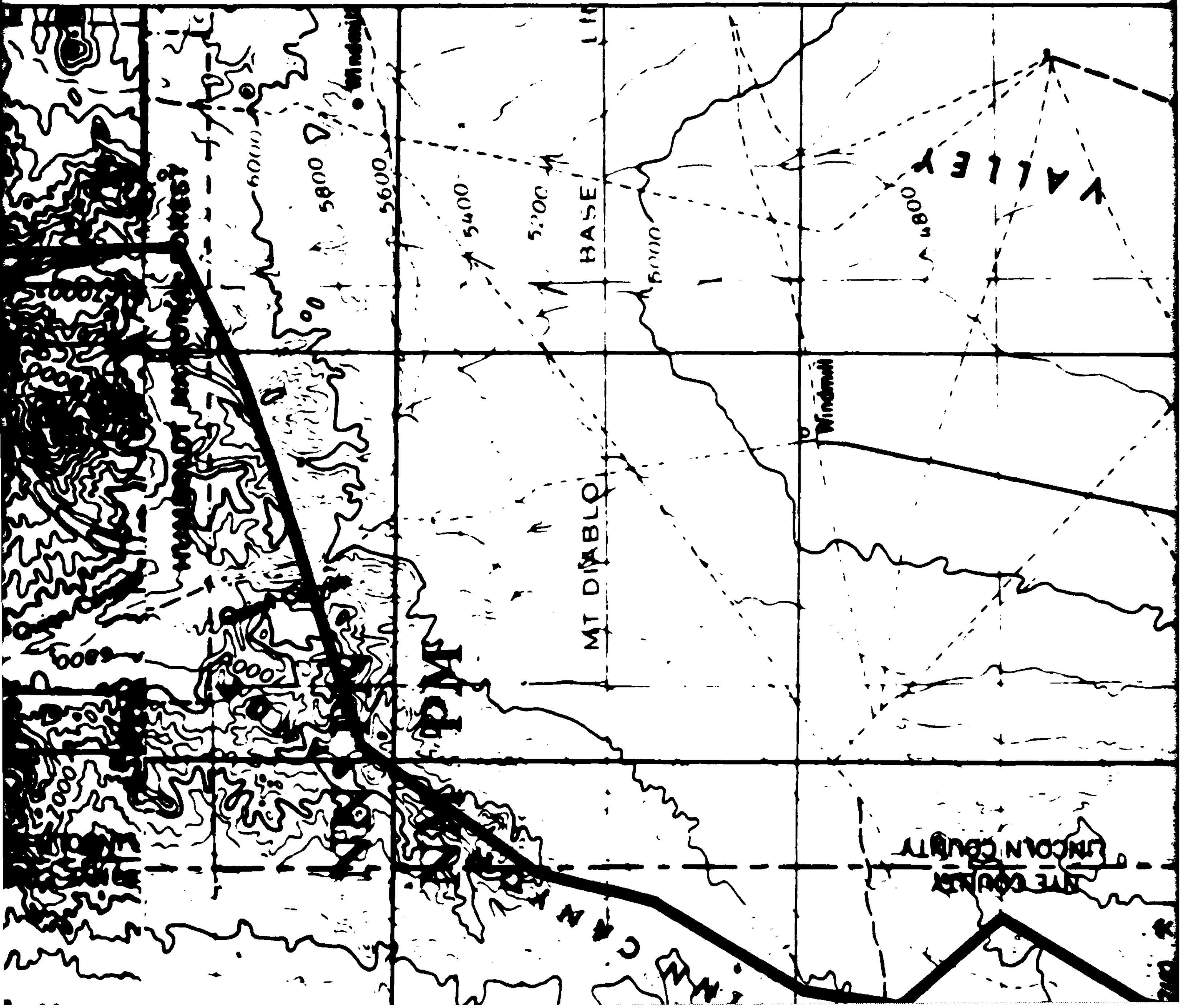
1. The basinward extent of water-lain tuffs is unknown in the northeast corner of the site. Additional borings and seismic refraction surveys are recommended to define the extent within the construction zone.

2. Large areas of shallow water are suspected in the northern and central portions of the site. Ground-water observation wells in selected localities are required to more clearly define depth contours.

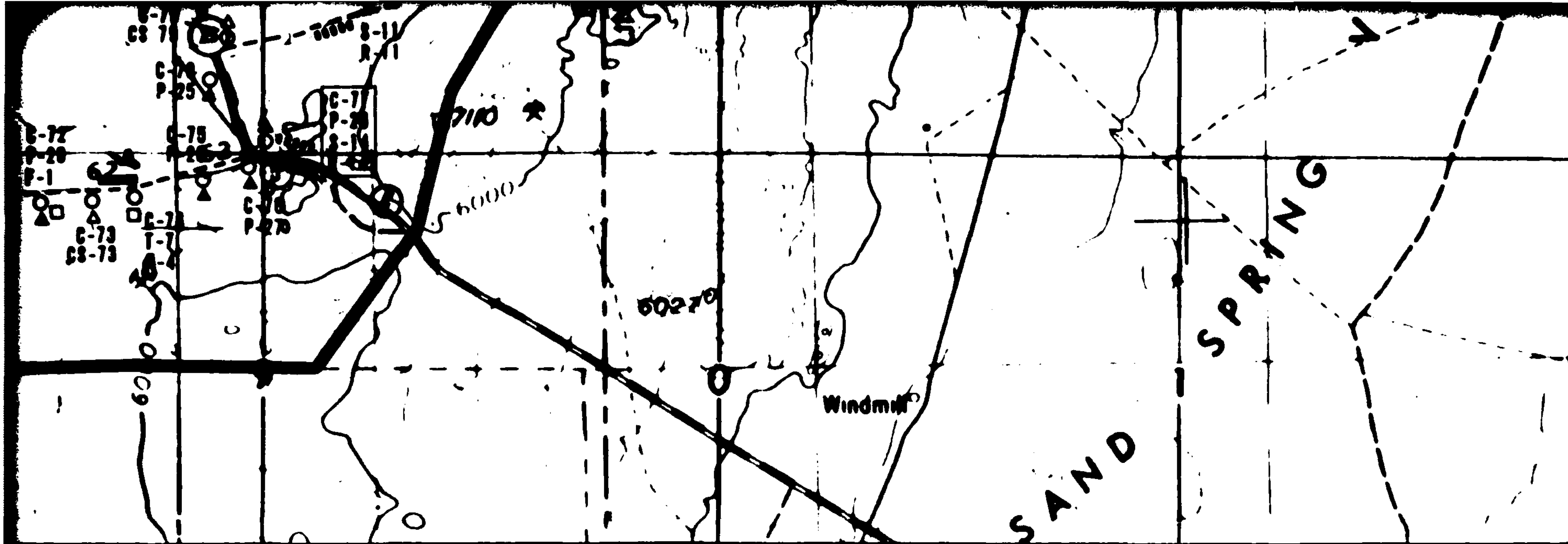

Ranch
5200
5600

1

2



MT DIABLO
BASE
Windmill
5800
5600
5400
5200
VALLEY
LINCOLN COUNTY
NYE COUNTY



EXPLANATION

- B-1 BORING
- C-1 CONE PENETROMETER TEST (CPT)
- CS-1 SURFACE SAMPLE AT CPT LOCATION
- T-1 TRENCH
- P-1 TEST PIT
- S-1 SEISMIC REFRACTION LINE
- R-1 ELECTRICAL RESISTIVITY LINE.
- F-1 FIELD CALIFORNIA BEARING RATIO (CBR) TEST
- ACTIVITY LINE

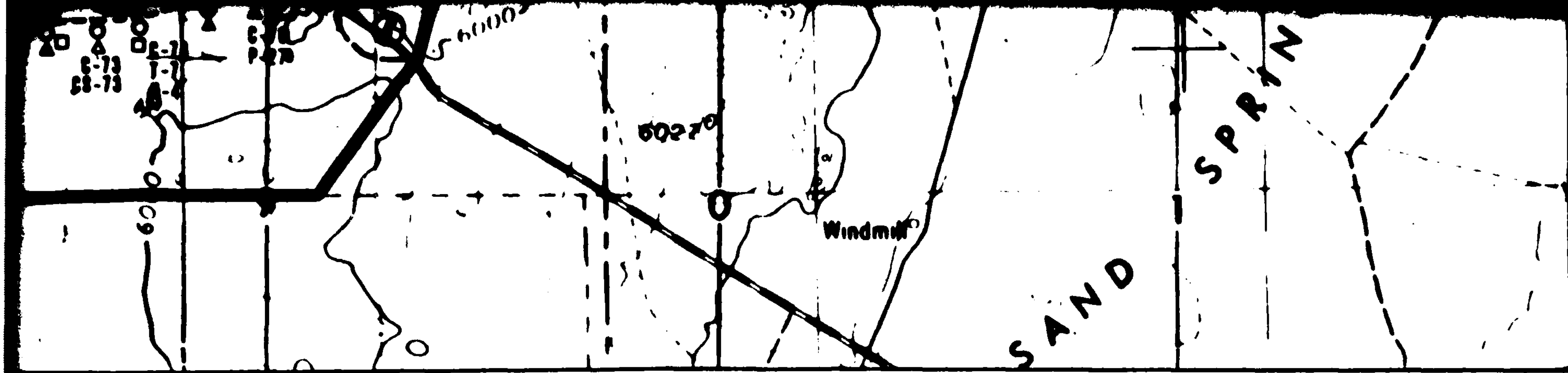
multiple activities were performed at the same location, ...rect location is designated by either (1) the boring ... or (2) the CPT symbol, if no boring was drilled.

SCALE 1:125,000

0 2 4 STATUTE MILES

0 2 4 KILOMETERS

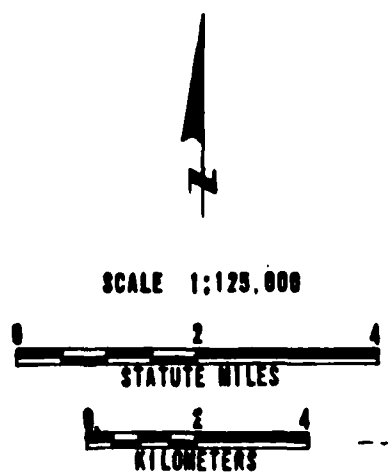
1 3

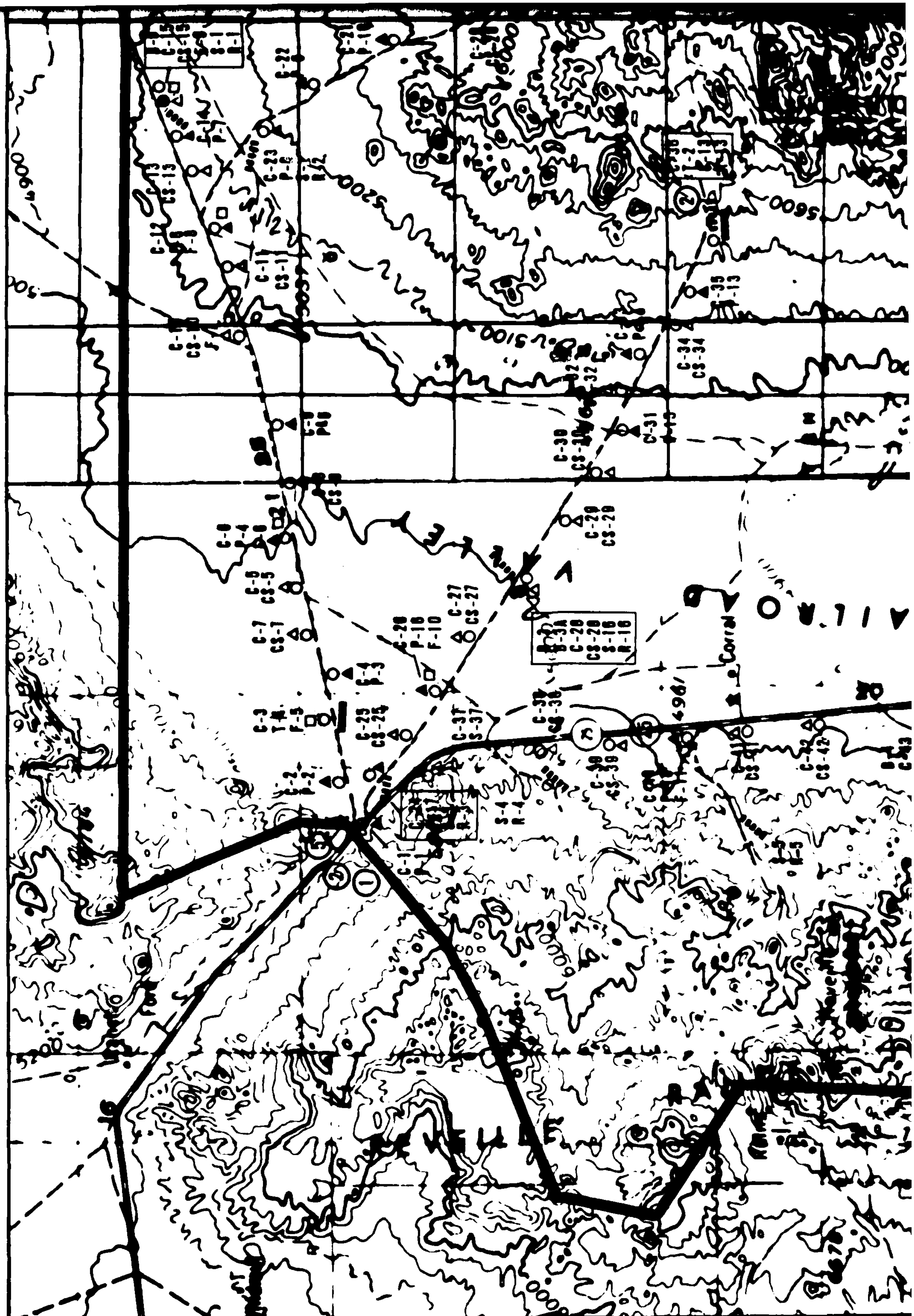


EXPLANATION

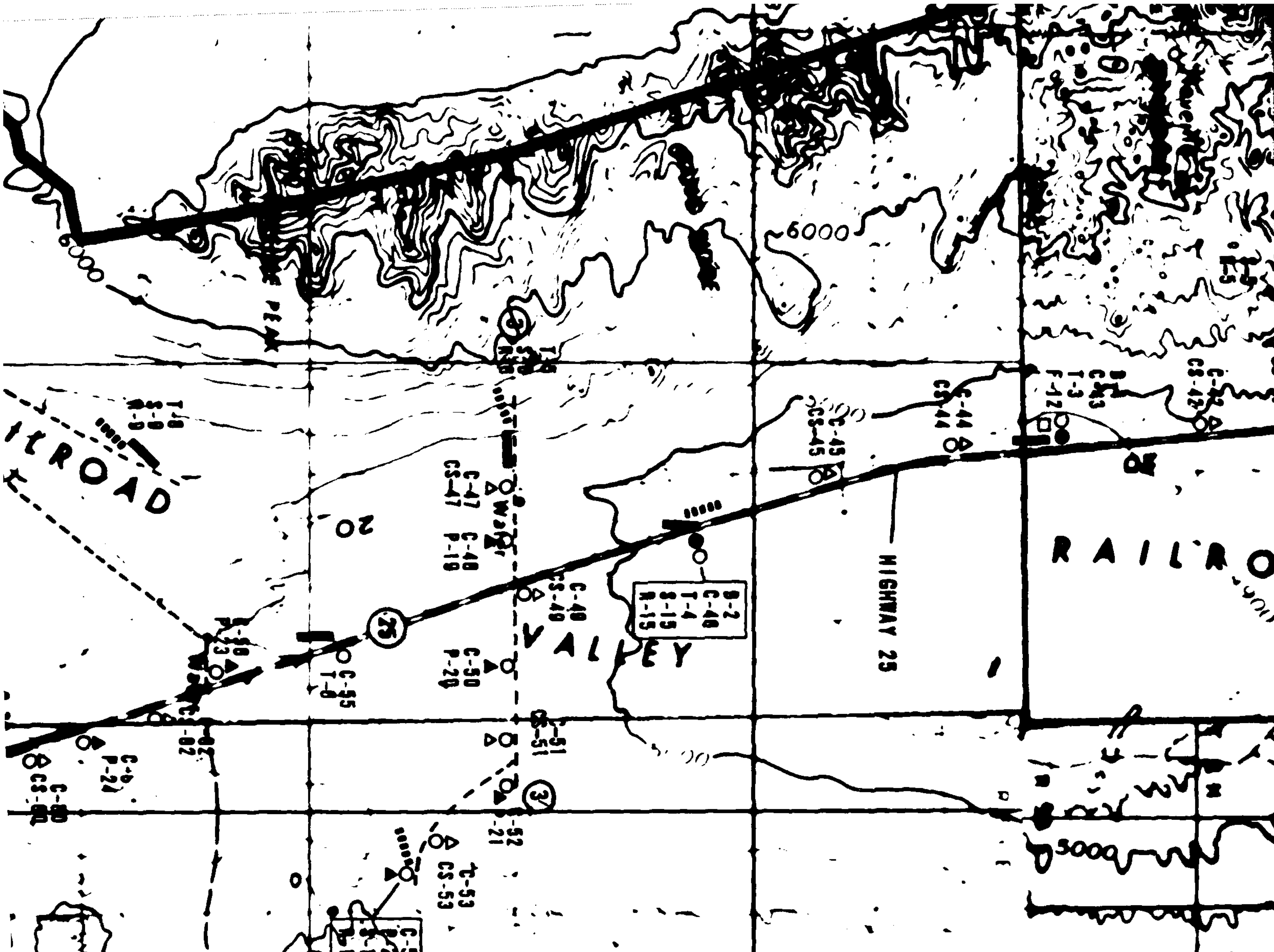
- B-1 BORING
- C-1 CONE PENETROMETER TEST (CPT)
- CS-1 SURFACE SAMPLE AT CPT LOCATION
- T-1 TRENCH
- P-1 TEST PIT
- S-1 SEISMIC REFRACTION LINE
- R-1 ELECTRICAL RESISTIVITY LINE
- F-1 FIELD CALIFORNIA BEARING RATIO (CBR) TEST
- (1) ACTIVITY LINE

multiple activities were performed at the same location, correct location is designated by either (1) the boring or (2) the CPT symbol, if no boring was drilled.

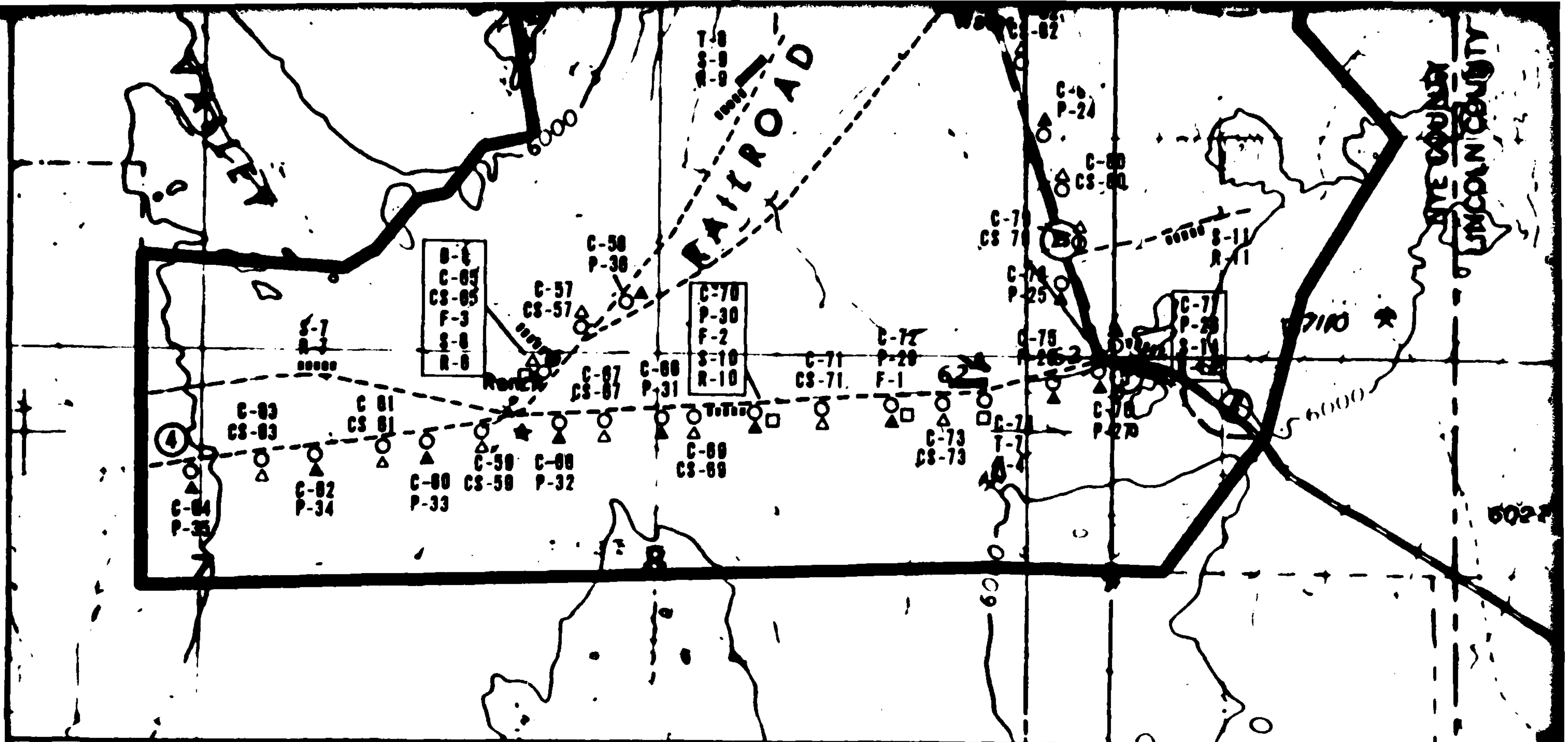




2 JUL 73

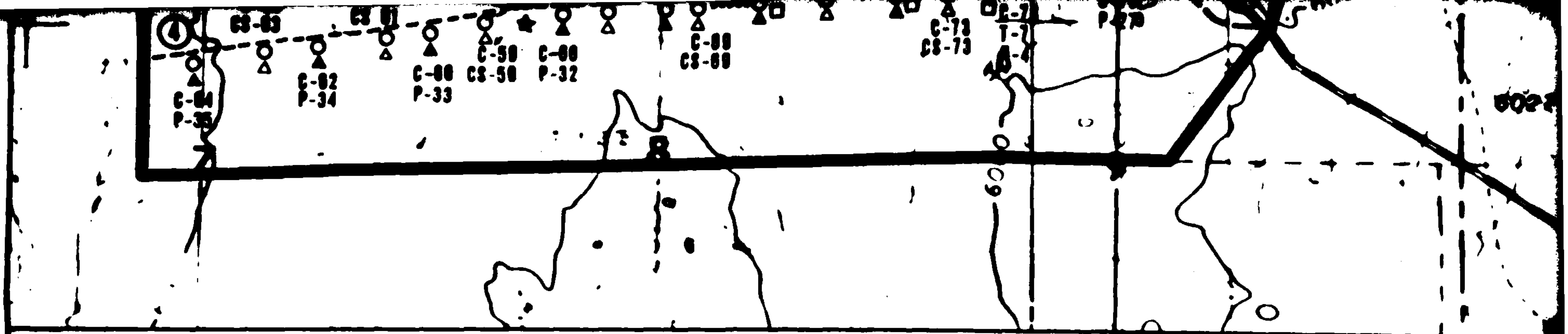


RAILROAD
VALLEY
HIGHWAY 25
25
20
6000
5600
5000
PEAK
C-47
CS-47
C-48
P-19
C-49
CS-49
C-50
P-20
C-51
CS-51
C-52
P-21
C-53
CS-53
C-55
T-6
C-42
CS-42
C-43
T-3
P-12
C-44
CS-44
C-45
CS-45
B-2
C-46
T-4
S-15
R-15
YE COUNTY
COLN COUNTY



EXPLANATION

●	B-1	BORING
○	C-1	CONE PENETROMETER TEST (CPT)
△	CS-1	SURFACE SAMPLE AT CPT LOCATION
▬	T-1	TRENCH
▲	P-1	TEST PIT
ooooo	S-1	SEISMIC REFRACTION LINE
	R-1	ELECTRICAL RESISTIVITY LINE
□	F-1	FIELD CALIFORNIA BEARING RATIO (CBR) TEST



EXPLANATION

- ● B-1 BORING
- ○ C-1 CONE PENETROMETER TEST (CPT)
- △ CS-1 SURFACE SAMPLE AT CPT LOCATION
- ▬ T-1 TRENCH
- ▲ P-1 TEST PIT
- ••••• S-1 SEISMIC REFRACTION LINE; R-1 ELECTRICAL RESISTIVITY LINE
- □ F-1 FIELD CALIFORNIA BEARING RATIO (CBR) TEST
- (1)------(1') ACTIVITY LINE

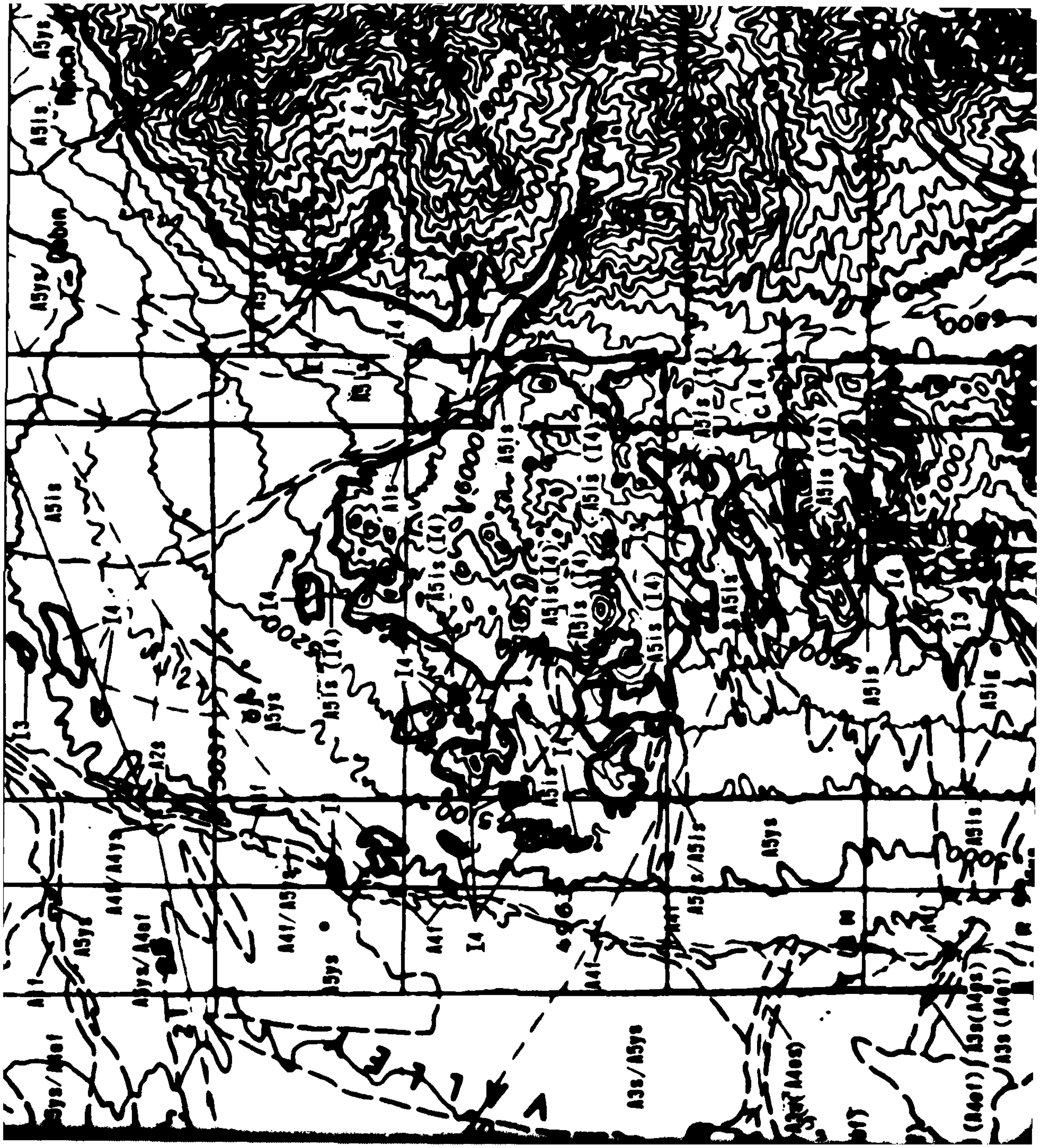
NOTE: Where multiple activities were performed at the same location, the correct location is designated by either (1) the boring symbol or (2) the CPT symbol, if no boring was drilled.

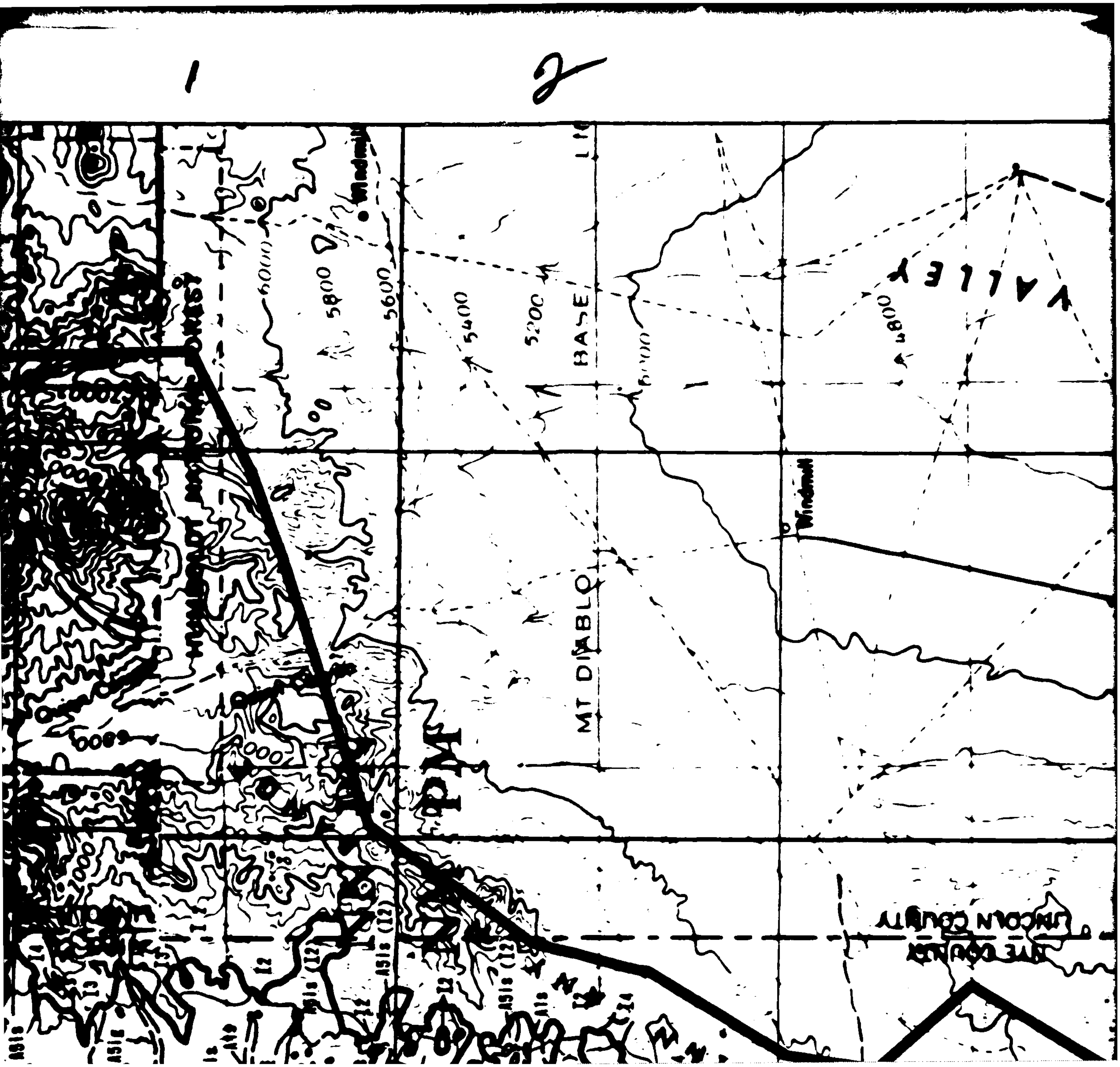
ACTIVITY LOCATIONS
VERIFICATION SITE,
REVEILLE-RAILROAD CDP, NEVADA

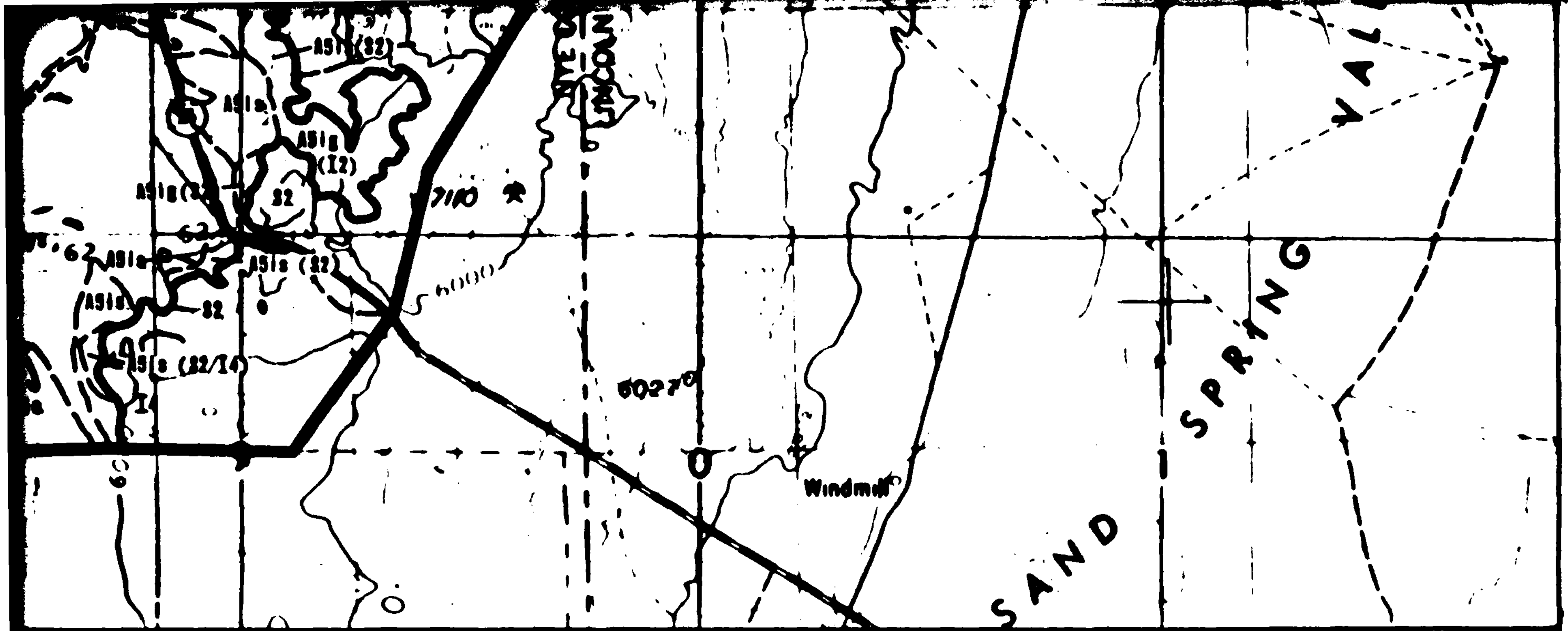
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

DRAWING 8-1

FUGRO NATIONAL, INC.



1
2
6000
5800
5600
5400
5200
BASE
MT DIABLO
VALLEY
4800
Windmill
PM
LINCOLN COUNTY
NYE COUNTY



EXPLANATION

IAL BASIN-FILL UNITS

stream channel and flood-plain deposits of;
ty sand and sand (SM, SP)

eam channel and floodplain deposits in terraces composed
silty sand (SM)

sand (SM) in A3s, thin sheets and silty sand and sand
zed dunes.

laya deposits of clayey silt (ML).

ts - Inactive playa, older lake bed, and abandoned
y clay (CL) and A4es, silty sand (SM).

tive, young alluvial fan deposits of: A5ys, silty sand
andy gravel (GM, GP).

- Active, young alluvial fan deposits of: A5ys, silty sand
, sandy gravel (GM, GP).

its - Inactive, intermediate-age alluvial fan deposits of:
nd and gravelly sand (SM) and A5Ig, weakly cemented

ROCK UNITS

and quartz latite.

predominantly rhyolitic

symbols indicates a mixture of either surficial basin-fill
map scale.
face unit at shallow depth.

SYMBOLS

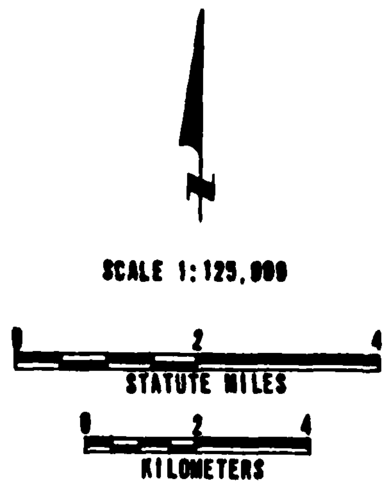
ll

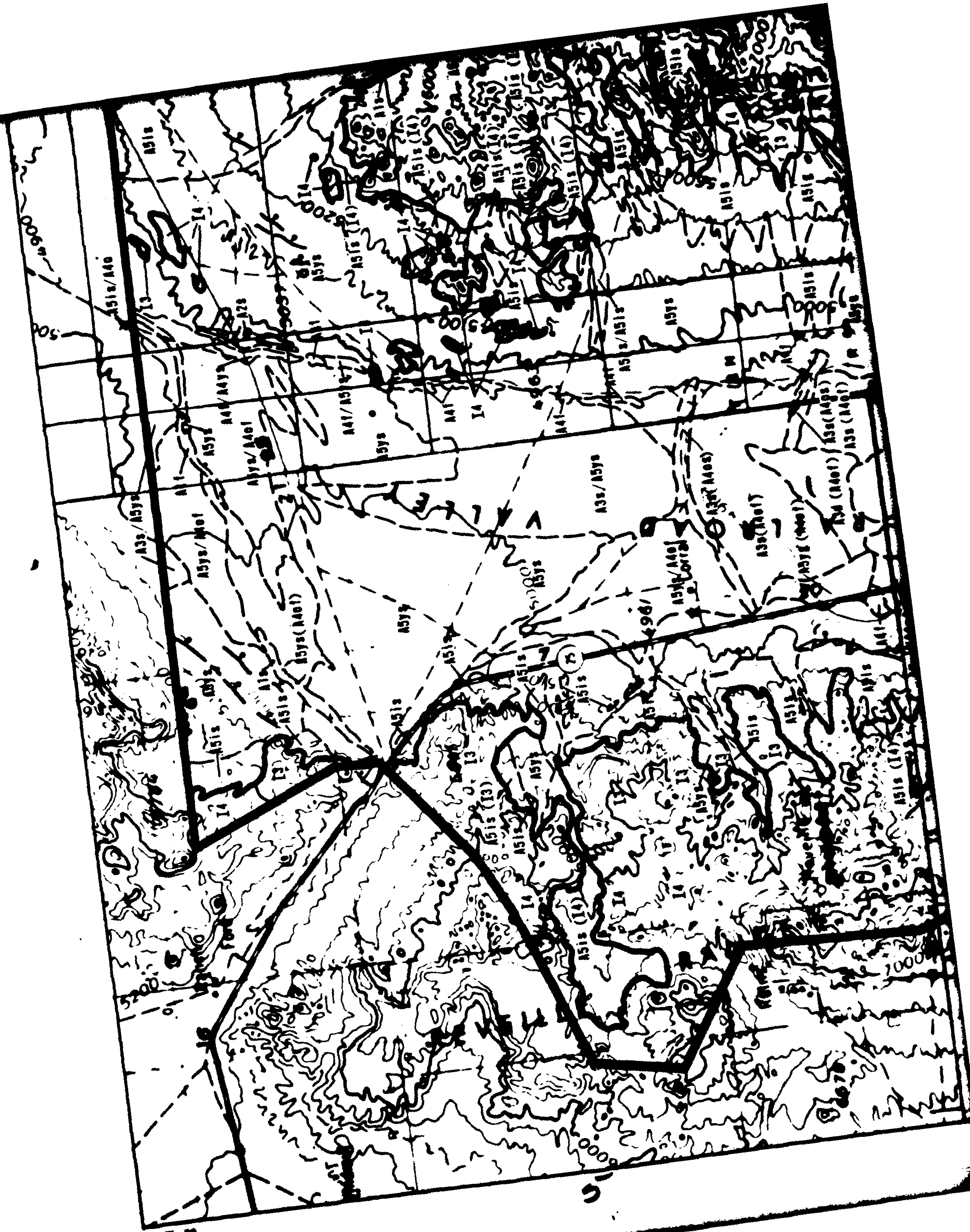
n-fill or rock units. .

e of faults offsetting surficial basin-fill deposits,

ain only to the upper several feet of soil. Due to variability of
map presentation, unit descriptions refer to the predominant soil
r soil types can be expected within each geologic unit.
te stations is presented in Volume III, Drawing 1. A tabulation of
d description of all geologic units is included in Volume III..

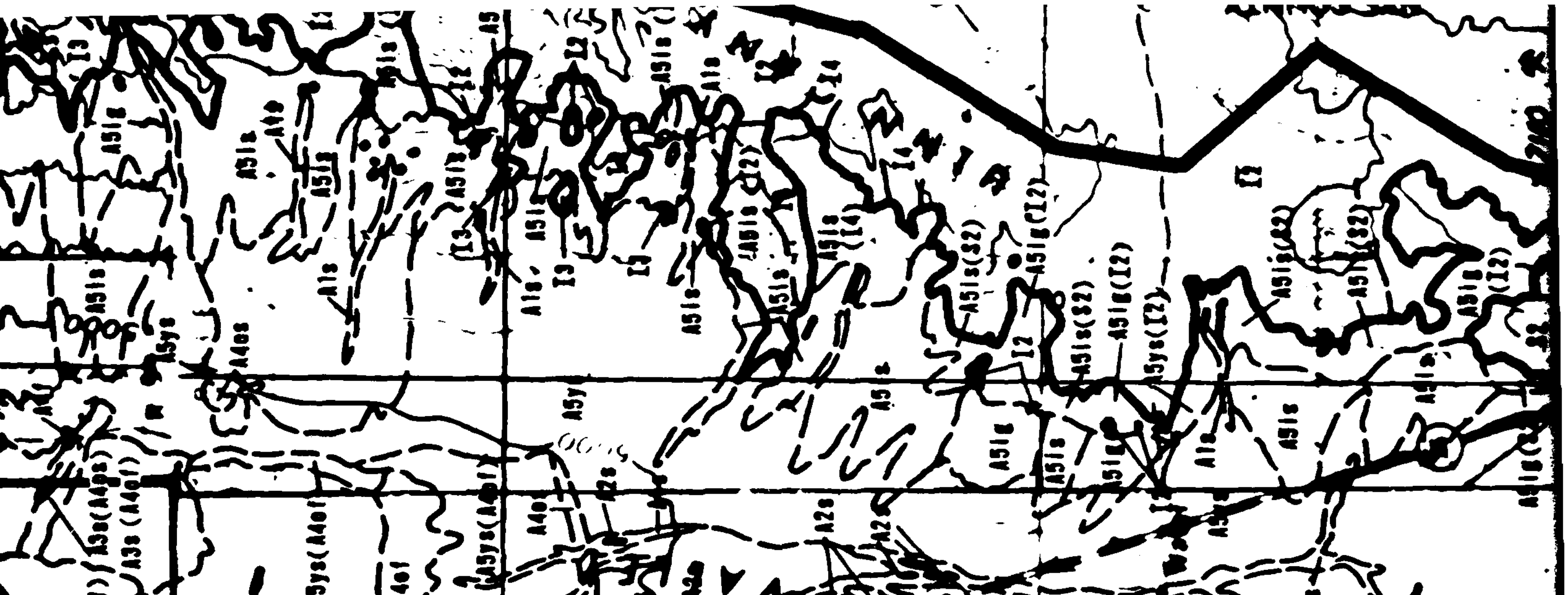
from: Cornwall (1972), Kleinhampl

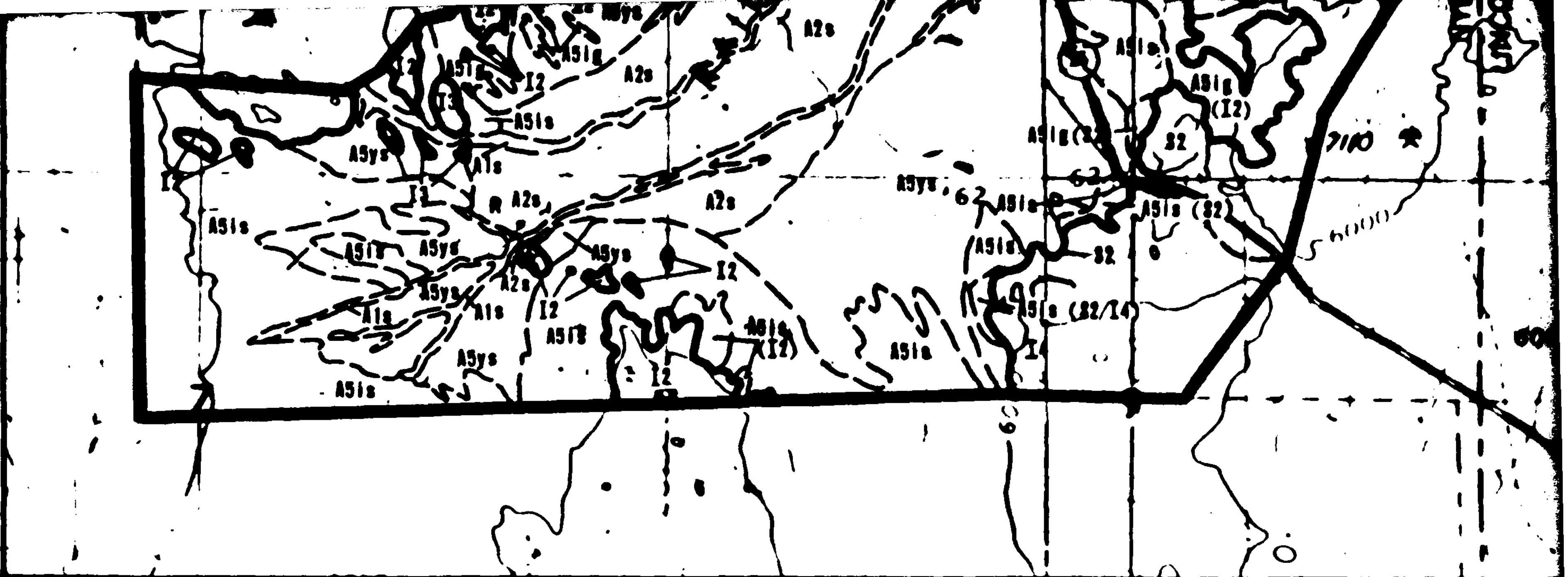




5

2 JUL 79





EXPLANATION

SURFICIAL BASIN-FILL UNITS

A1f / A1s	Younger Fluvial Deposits - Modern stream channel and flood-plain deposits of; A1f, sandy silt (ML) and A1s, silty sand and sand (SM, SP)
A2s	Older Fluvial Deposits - Older stream channel and floodplain deposits in terraces composed of uncemented and weakly cemented silty sand (SM)
A3s / A3d	Eolian Deposits - Windblown silty sand (SM) in A3s, thin sheets and silty sand and sand (SM, SP) in A3d, partially stabilized dunes.
A4f	Younger Playa Deposits - Active playa deposits of clayey silt (ML).
A4of / A4os	Older Playa and Lacustrine Deposits - Inactive playa, older lake bed, and abandoned shoreline deposits of: A4of, sandy clay (CL) and A4os, silty sand (SM).
A5ys / A5yg	Younger Alluvial Fan Deposits - Active, young alluvial fan deposits of: A5ys, silty sand and gravelly sand (SM) and A5yg, sandy gravel (GM, GP).

A5ys / **A5yg** Younger Alluvial Fan Deposits - Active, young alluvial fan deposits of: A5ys, silty sand and gravelly sand (SM) and A5yg, sandy gravel (GM, GP).

A5is / **A5ig** Intermediate Alluvial Fan Deposits - Inactive, intermediate-age alluvial fan deposits of: A5is, weakly cemented silty sand and gravelly sand (SM) and A5ig, weakly cemented sandy gravel (GM).

ROCK UNITS

Igneous (I)

I2 Rhyolite, dacite, rhyodacite, and quartz latite.

I3 Basalt

I4 Tuff and welded ash-fall tuff, predominantly rhyolitic

Sedimentary (S)

S2 Dolomite and limestone

A5ys/A4os Combination of geologic unit symbols indicates a mixture of either surficial basin-fill or rock units inseparable at map scale.

A3s/A4of Parenthetic unit underlies surface unit at shallow depth.

SYMBOLS

Contact between rock basin-fill

Contact between surficial basin-fill or rock units.

Fault, trace of surface rupture of faults offsetting surficial basin-fill deposits, ball on downthrown side.

NOTES:

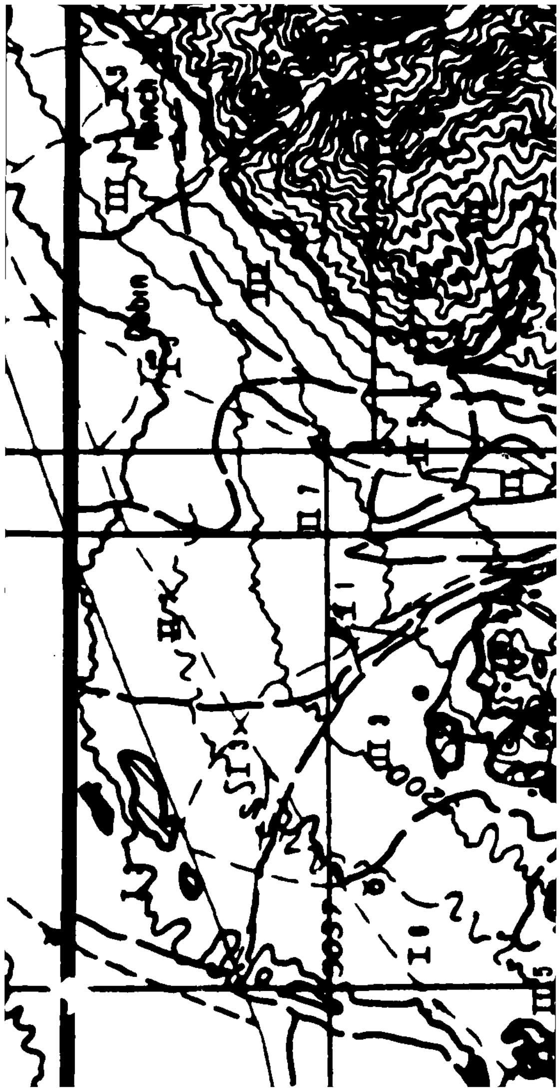
1. Surficial basin-fill units pertain only to the upper several feet of soil. Due to variability of surficial deposits and scale of map presentation, unit descriptions refer to the predominant soil types. Varying amounts of other soil types can be expected within each geologic unit.
2. The distribution of geologic data stations is presented in Volume III, Drawing 1. A tabulation of all station data and generalized description of all geologic units is included in Volume III, Section 1.0.
3. Geology in areas of exposed rock from: Cornwall (1972), Kleinhampl and Ziony (1967)

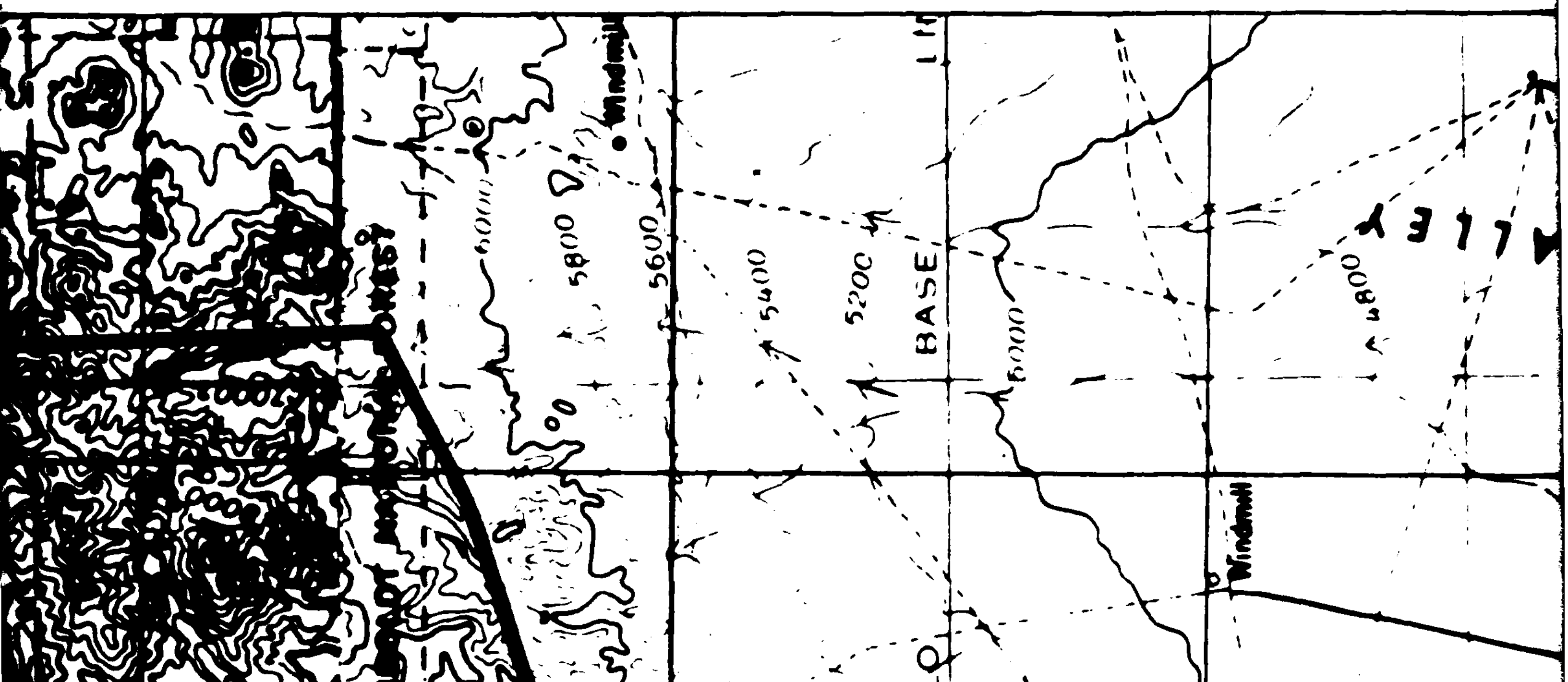
SURFICIAL GEOLOGIC UNITS
VERIFICATION SITE,
REVEILLE-RAILROAD CDP, NEVADA

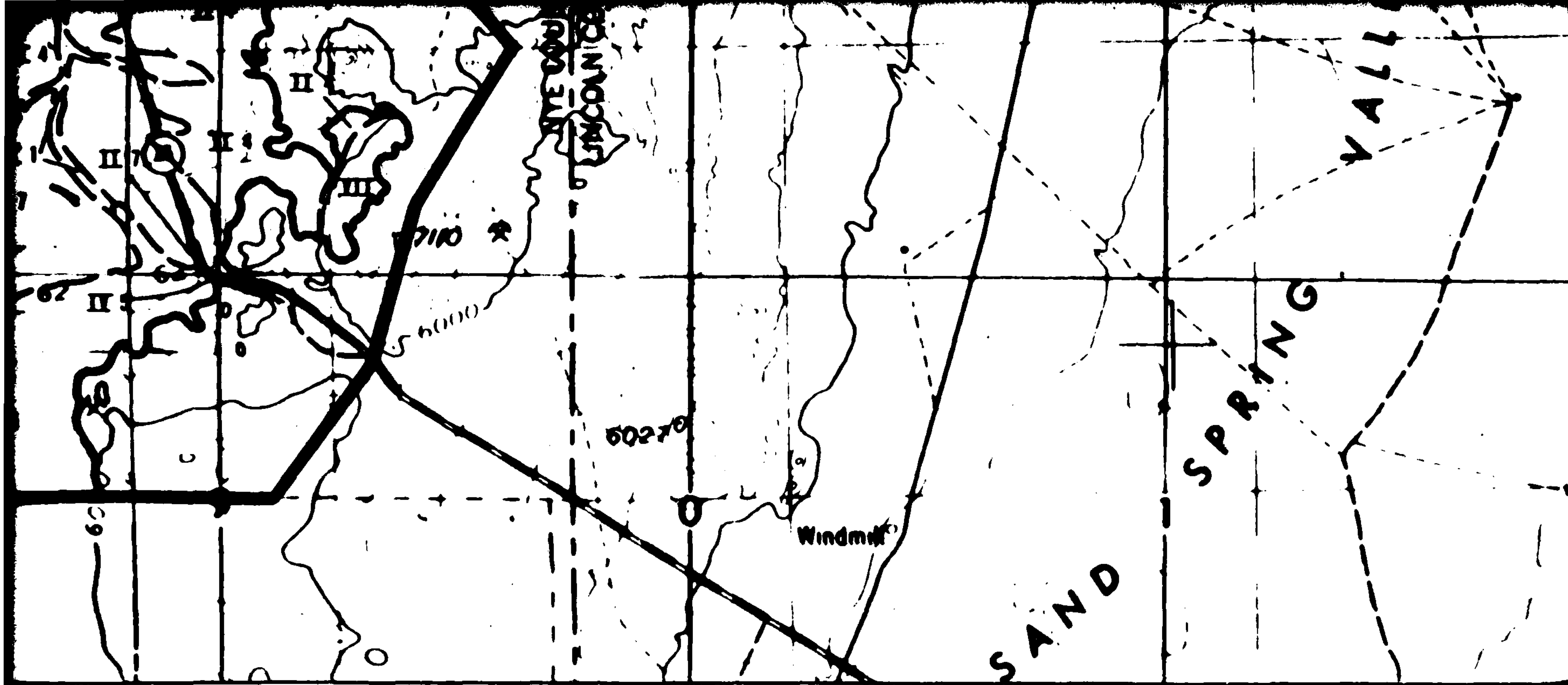
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

DRAWING
9-2

FUGRO NATIONAL, INC.




MT DIABLO
BASE
Windmill
Windmill
5200
5400
5600
5800
PM



EXPLANATION

III 3 - - - - - - Drainage spacing, i.e. the maximum number of drainages of the corresponding category occurring in a random traverse of one statute mile (1.6km)

DRAINAGE DEPTH/DESCRIPTION

Less than 3 feet (1m)

3-6 feet (1-2m)

6-10 feet (2-3m)

10-15 feet (3-5m)

EXPLANATION

III 3 ------ Drainage spacing, i.e. the maximum number of drainages of the corresponding category occurring in a random traverse of one statute mile (1.6km)

DRAINAGE DEPTH/DESCRIPTION

Less than 3 feet (1m)

3-6 feet (1-2m)

6-10 feet (2-3m)

10-15 feet (3-5m)

Greater than 15 feet (5m)

Complex, highly variable terrain not defined by drainage incision (e.g. dunal or hummocky terrains).

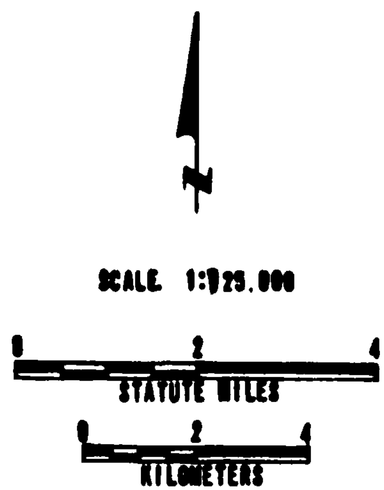
Unsuitable terrain (see Appendix A2.0, Exclusion Criteria)

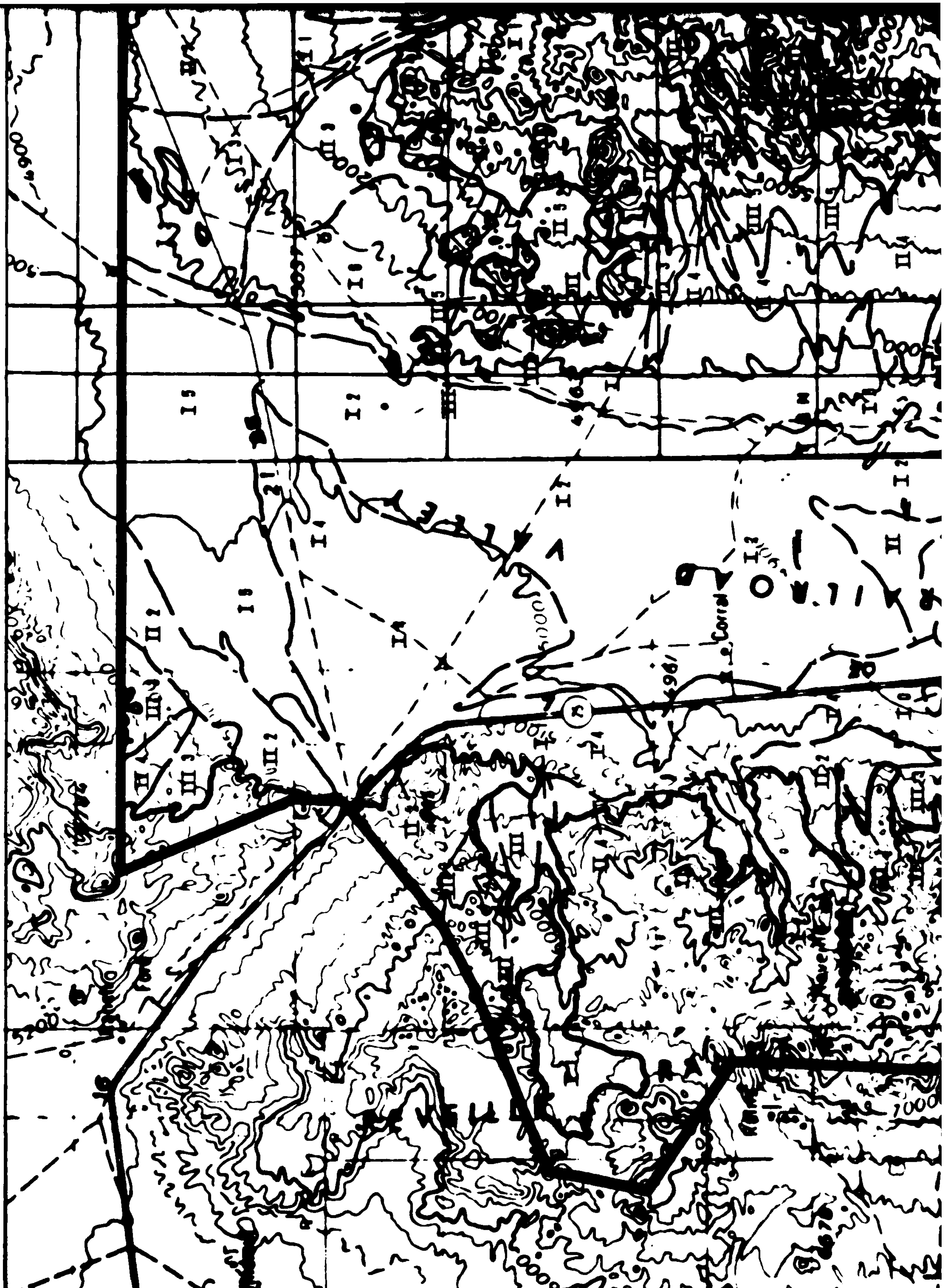
n terrain categories

n rock and basin-fill

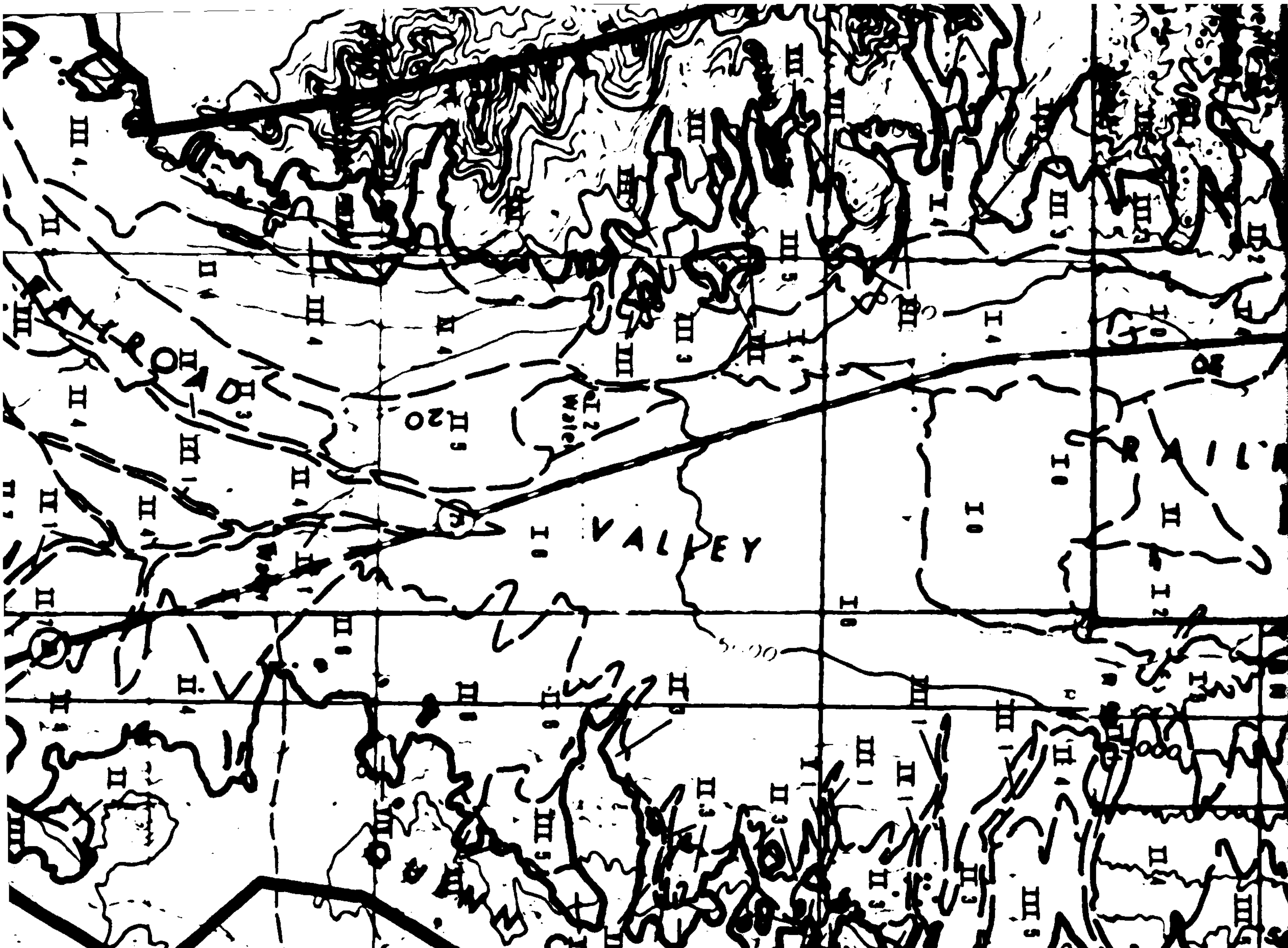
tes areas of isolated exposed rock.

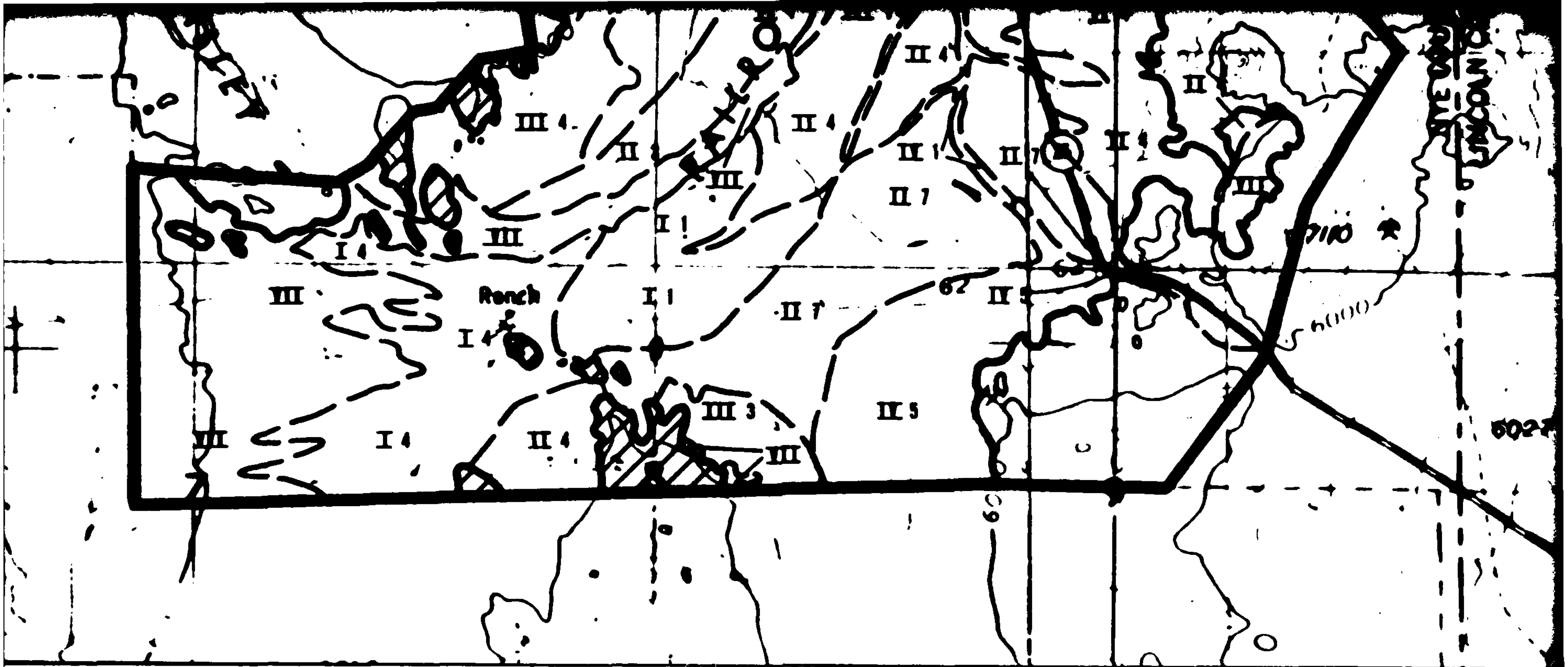
In constructing this map are from: (1) field observations, USGS topographic maps, and (3) 1:60,000 and 1:25,000 otographs. Due to scale of presentation and variability of nditions, this map is generalized.





2 JUL 70


RAILROAD
VALLEY
NYE COUNTY
Wate



EXPLANATION

Terrain Category (see table below) ------ III 3 ------ Drainage spacing, i.e. the maximum number of drainages of the corresponding category occurring in a random traverse of one statute mile (1.6km)

TERRAIN CATEGORY	DRAINAGE DEPTH/DESCRIPTION
I	Less than 3 feet (1m)
II	3-6 feet (1-2m)
III	6-10 feet (2-3m)
IV	10-15 feet (3-5m)

EXPLANATION

Terrain Category (see table below) ------ III 3 ------ Drainage spacing, i.e. the maximum number of drainages of the corresponding category occurring in a random traverse of one statute mile (1.6km)

TERRAIN CATEGORY	DRAINAGE DEPTH/DESCRIPTION
I	Less than 3 feet (1m)
II	3-6 feet (1-2m)
III	6-10 feet (2-3m)
IV	10-15 feet (3-5m)
V	Greater than 15 feet (5m)
VI	Complex, highly variable terrain not defined by drainage incision (e.g. dunal or hummocky terrains).
VII	Unsuitable terrain (see Appendix A2.0, Exclusion Criteria)

— — Contact between terrain categories

～ Contact between rock and basin-fill

Shading indicates areas of isolated exposed rock.

NOTE: Data used in constructing this map are from: (1) field observations, (2) 1:62,500 USGS topographic maps, and (3) 1:60,000 and 1:25,000 aerial photographs. Due to scale of presentation and variability of terrain conditions, this map is generalized.

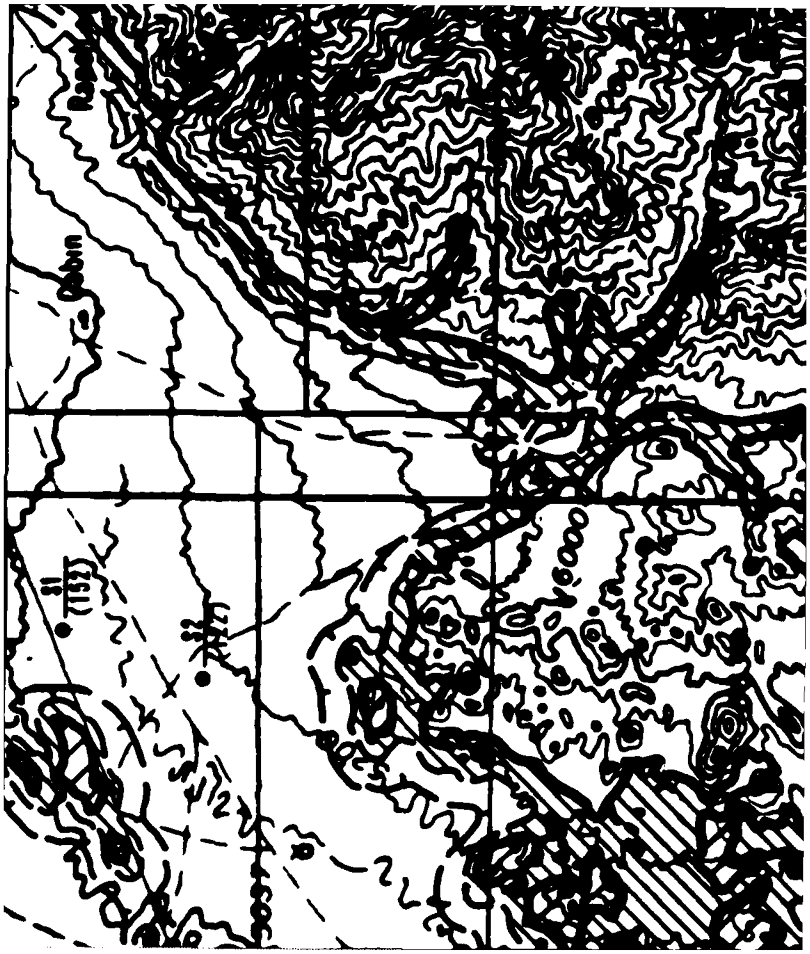
TERRAIN
VERIFICATION SITE,
REVEILLE-RAILROAD CDP, NEVADA

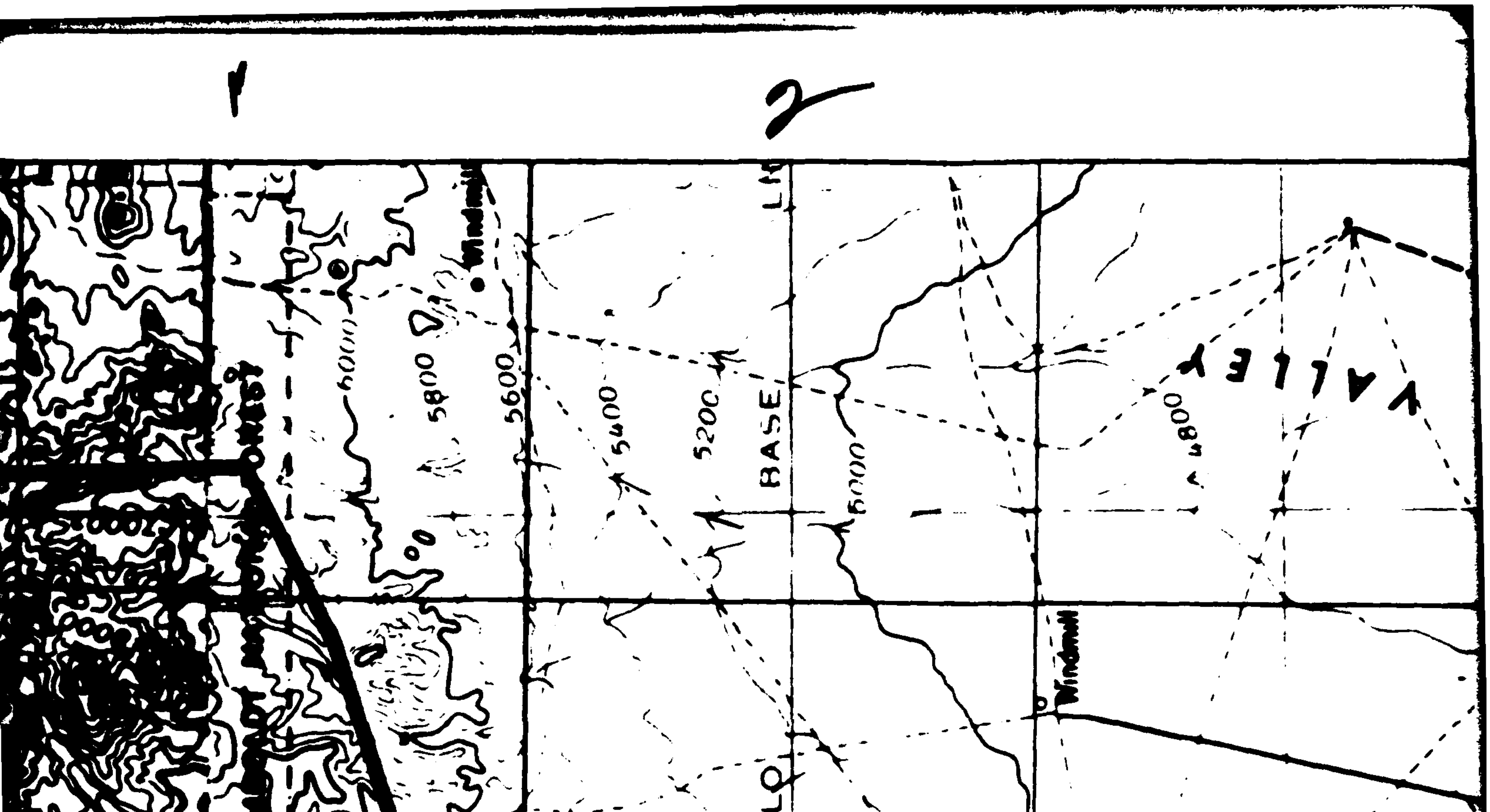
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

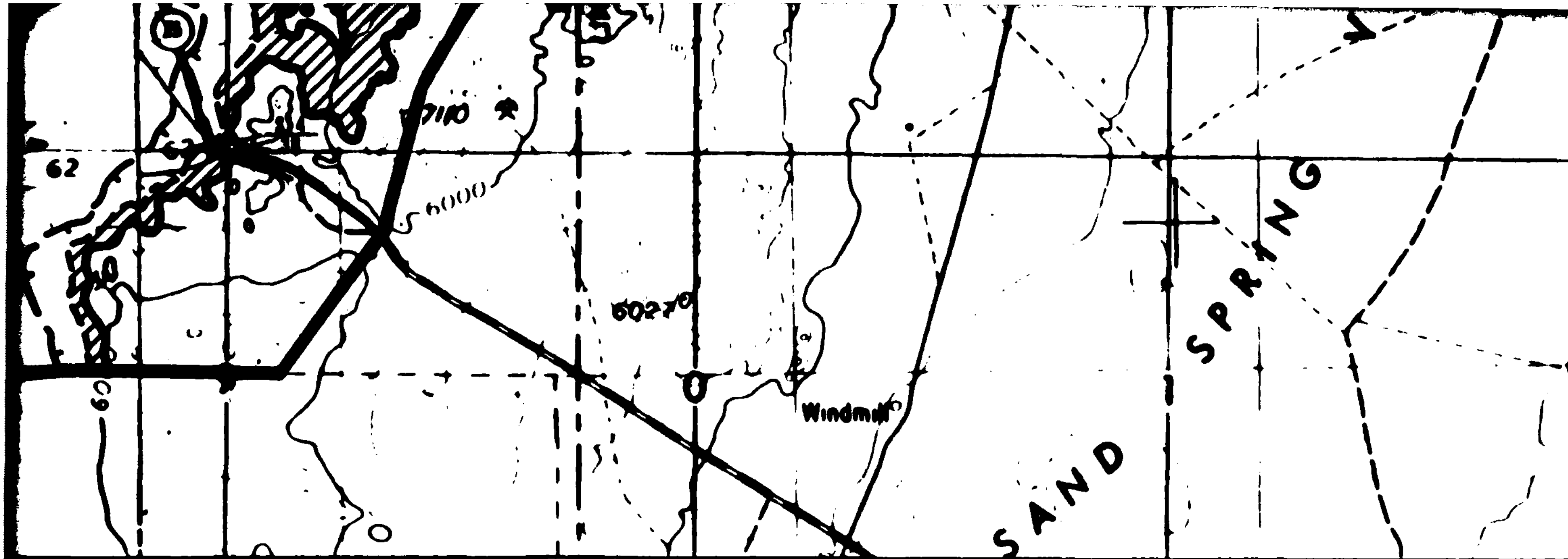
DRAWING 8-3

FUGRO NATIONAL, INC.

8




1
2
MT DIABLO BASE LINE
VALLEY
Windmill
Windmill
LINCOLN COUNTY
NYE COUNTY
6000
5800
5600
5400
5200
4800
7000
6800



3

TION

ock at a depth of approximately
shading indicates rock less
).

rock at a depth of approximately
hachuring indicates rock less.
m).

ck and basin-fill.

areas of isolated exposed rock.

re boring (B), seismic refraction
rical resistivity sounding (R).
D:
t) or, when in parentheses, depth
does not occur (feet).

N

SCALE 1:125,000

TION

rock at a depth of approximately
shading indicates rock less
m).

rock at a depth of approximately
- hachuring indicates rock less.
00m).

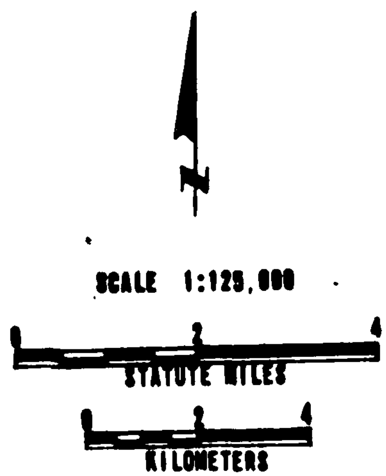
ock and basin-fill.

areas of isolated exposed rock.

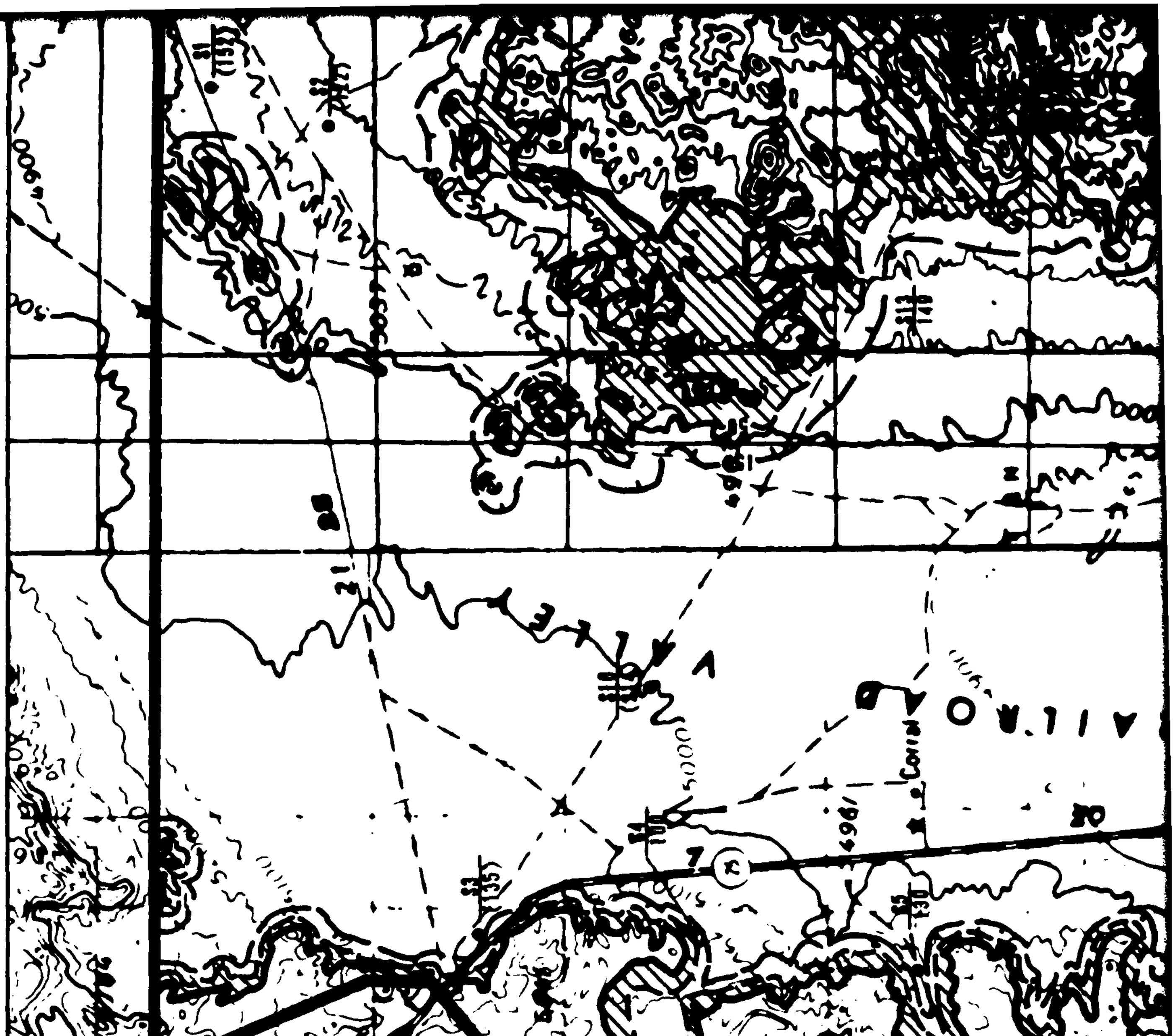
re boring (B), seismic refraction
rical resistivity sounding (R),
W):

nt) or, when in parentheses, depth
k does not occur (feet).

are based on geologic interpretations
ted data points shown on the map. Some
ontour locations can be expected as
ata are obtained.



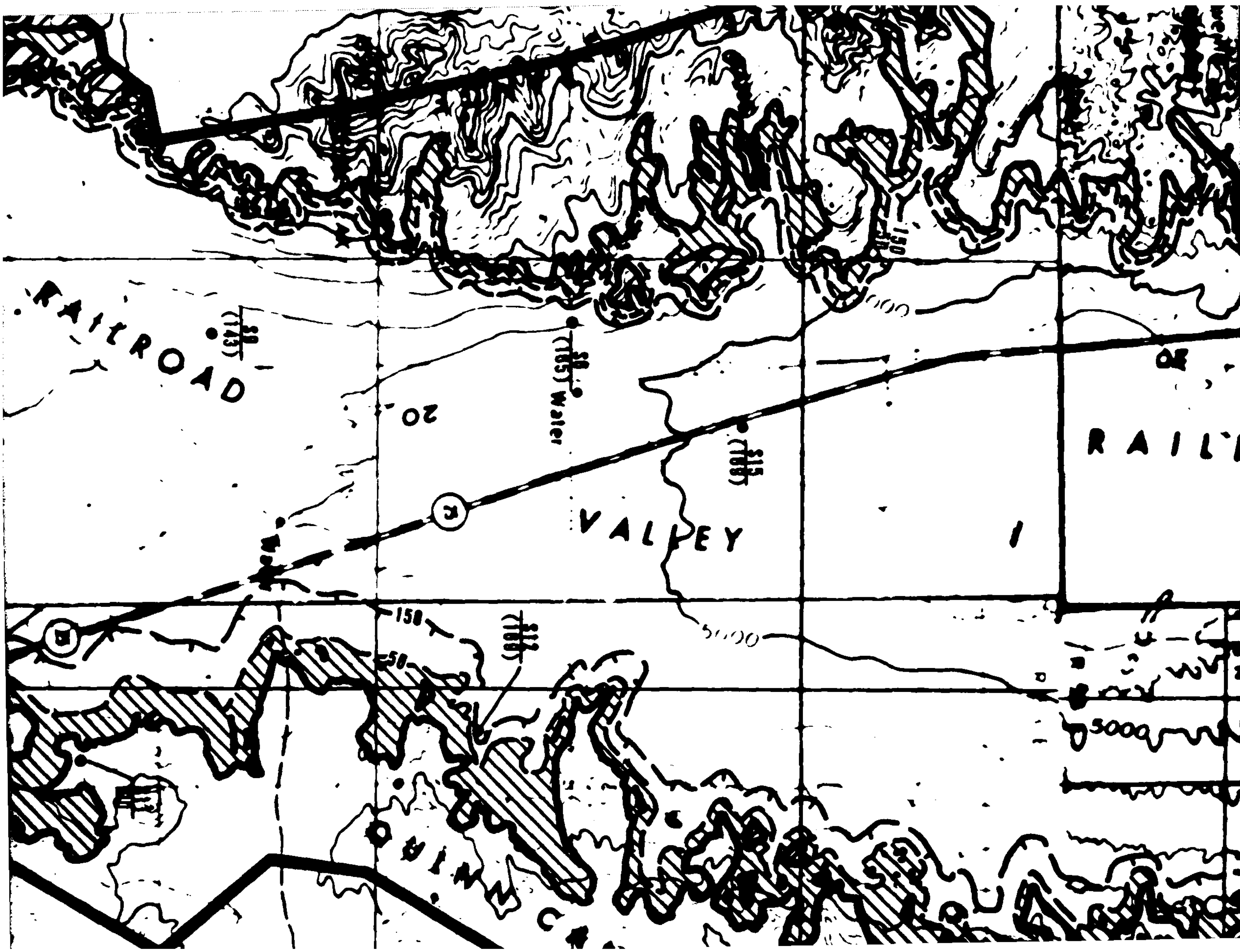
3 1 4



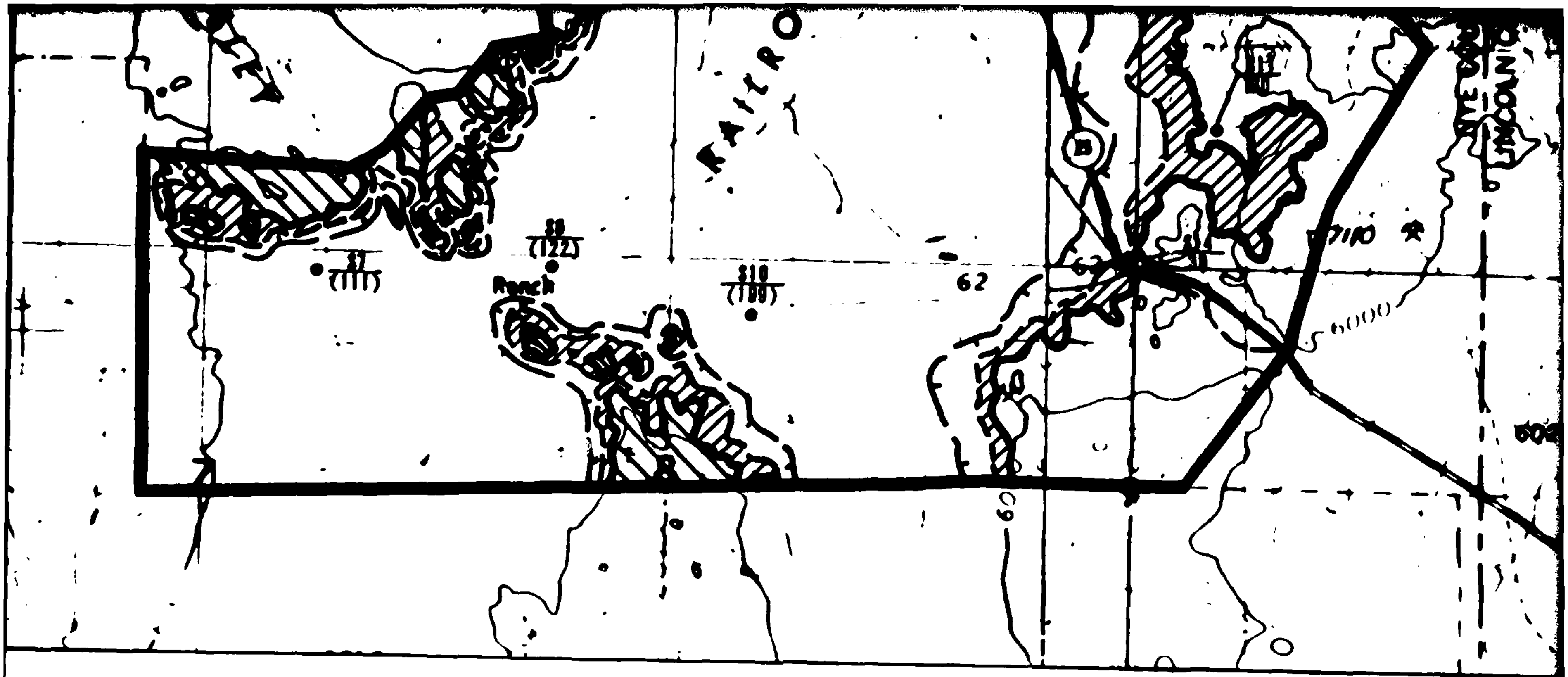
1

2 JUL 79

5



RAILROAD
20
Water
VALLEY
RAIL
5000
150
50



EXPLANATION

Contour indicates rock at a depth of approximately 50 feet (15m) - shading indicates rock less than 50 feet (15m).

Contour indicates rock at a depth of approximately 150 feet (46m) - hachuring indicates rock less than 150 feet (46m).

Contact between rock and basin-fill.

Shading indicates areas of isolated exposed rock.

Data Source - Fugro boring (B), seismic refraction

EXPLANATION

Contour indicates rock at a depth of approximately 50 feet (15m) - shading indicates rock less than 50 feet (15m).

Contour indicates rock at a depth of approximately 150 feet (46m) - hachuring indicates rock less than 150 feet (46m).

Contact between rock and basin-fill.

Shading indicates areas of isolated exposed rock.

84/75 Data Source - Fugro boring (B), seismic refraction line (S), electrical resistivity sounding (R), or water well (W);
Depth to rock (feet) or, when in parentheses, depth above which rock does not occur (feet).

NOTE: The contours are based on geologic interpretations and the limited data points shown on the map. Some changes in contour locations can be expected as additional data are obtained.

DEPTH TO ROCK
VERIFICATION SITE,
REVEILLE-RAILROAD CDP, NEVADA

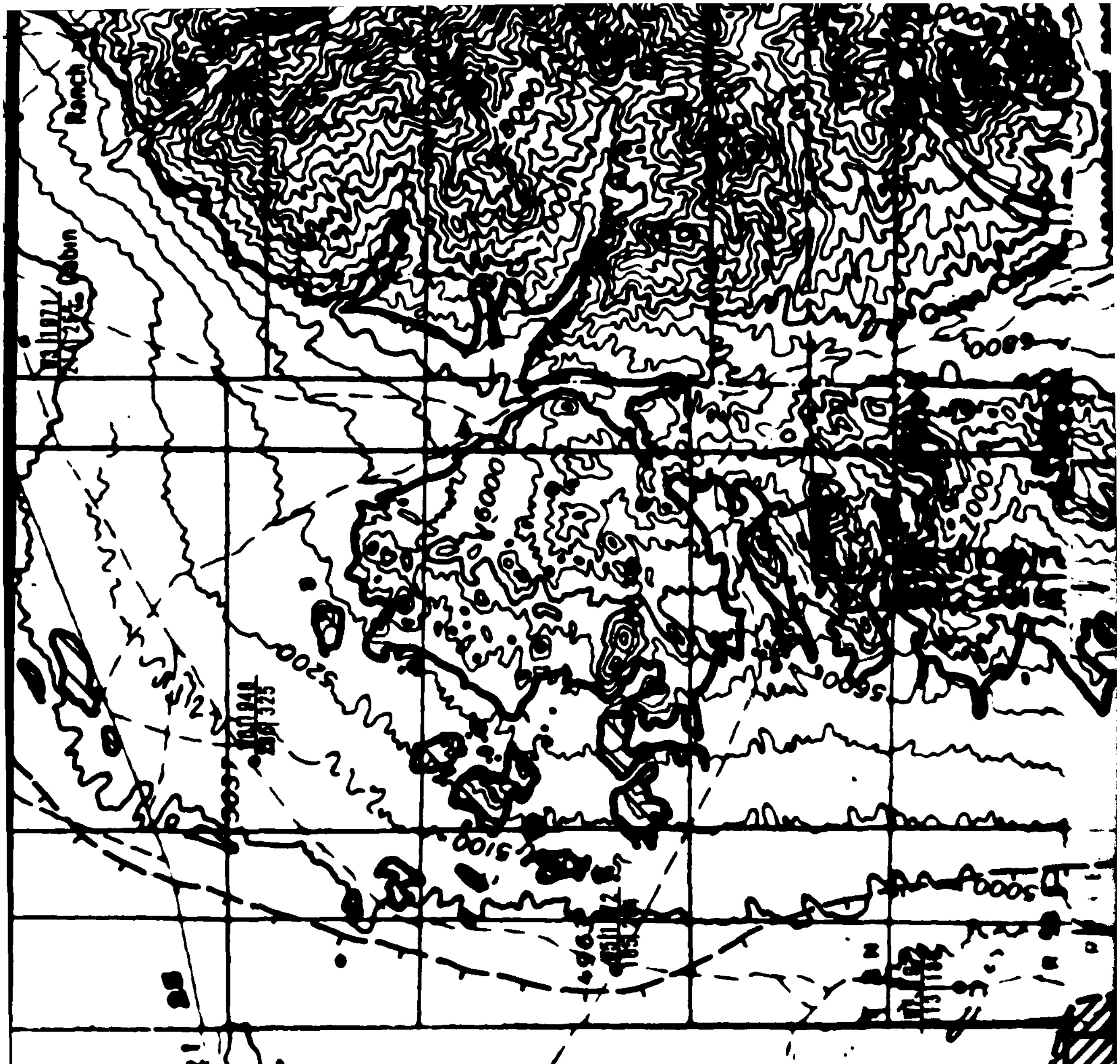
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

DRAWING
9-4

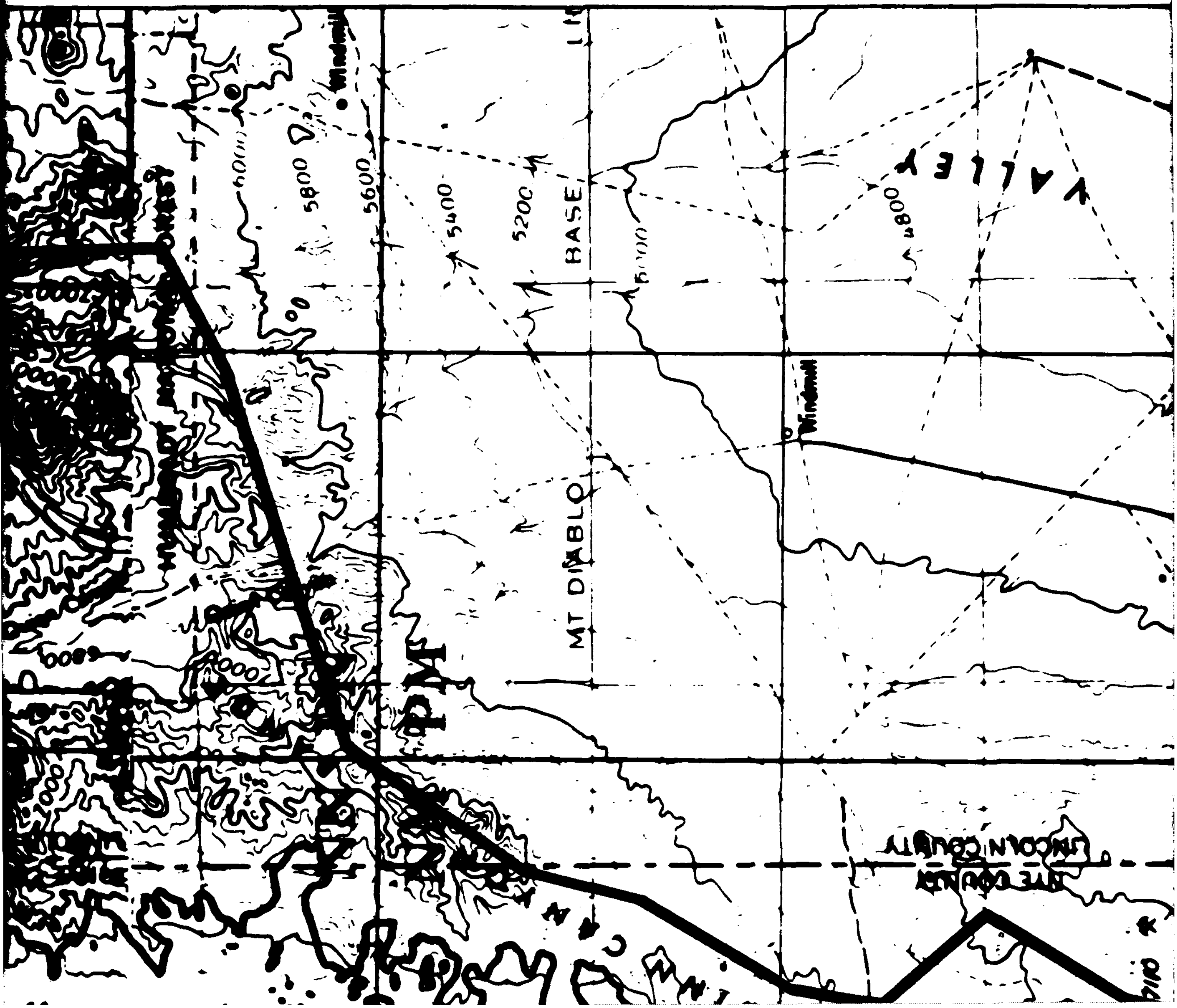
FUGRO NATIONAL, INC.

7

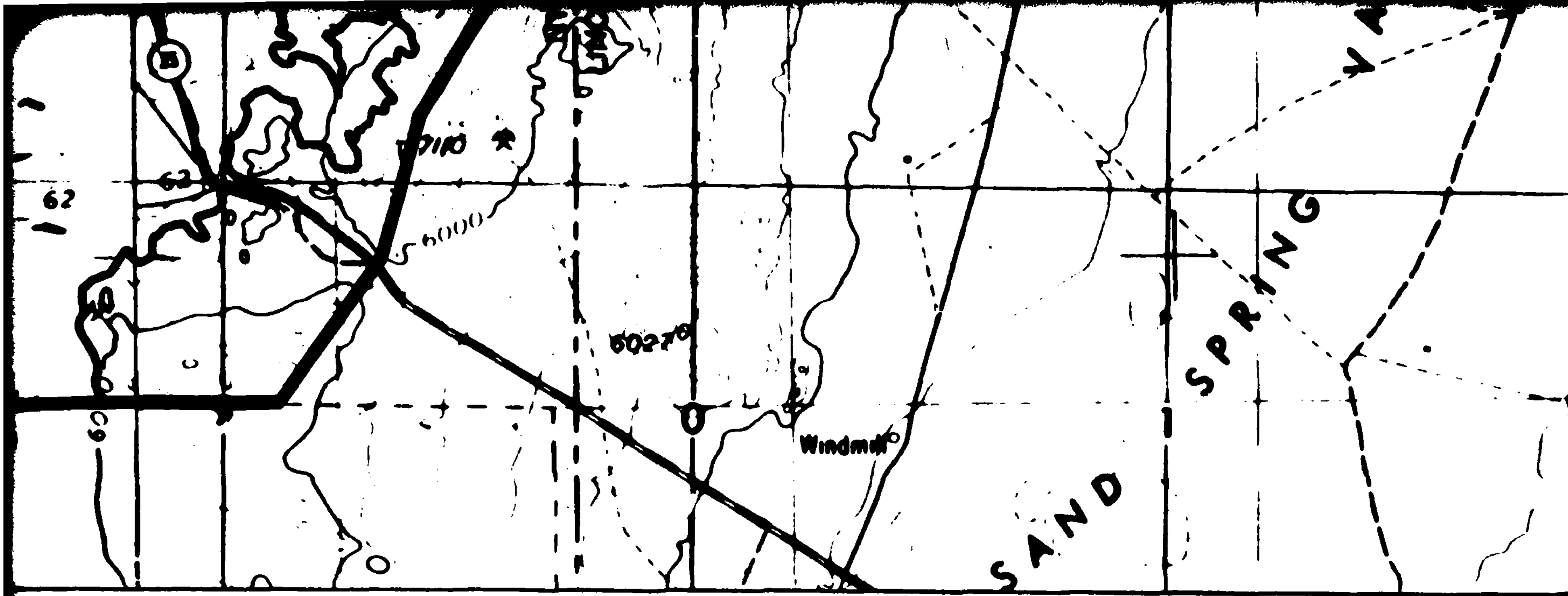
8


Ranch
Cabin

1 2



VALLEY
BASE
MT DIABLO
Windmill
6000
5800
5600
5400
5200
4800
LINCOLN COUNTY
NYE COUNTY



PLANATION

und water at a depth of approximately
lied where data are extremely sparse.
ss than 50 feet (15m) to ground water.

und water at a depth of approximately
ried where data are extremely sparse.
less than 150 feet (40m) to ground water.

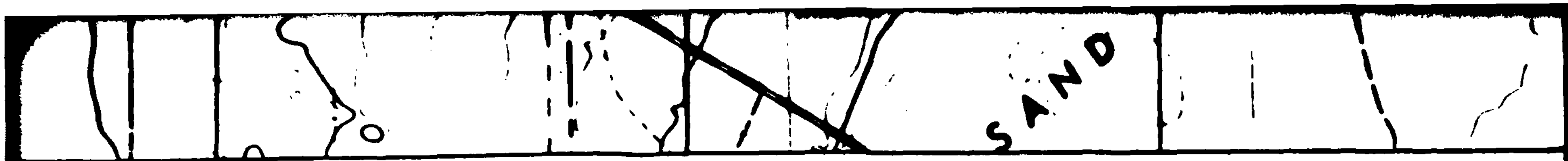
and basin-fill.

es of isolated exposed rock.

oring (B), seismic
electrical resistivity
er well (W); see Volume XII

Year of water-level measurement

Depth of well (feet)



LANATION

nd water at a depth of approximately
ied where data are extremely sparse.
s than 50 feet (15m) to ground water.

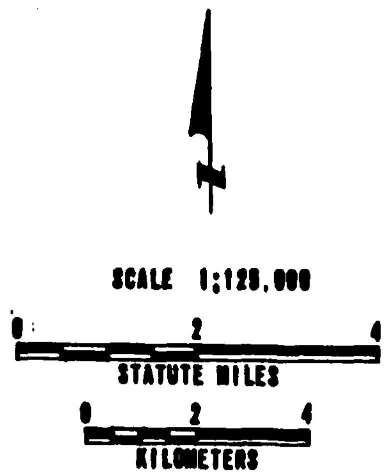
nd water at a depth of approximately
ried where data are extremely sparse.
less than 150 feet (46m) to ground water.

and basin-fill.

es of isolated exposed rock.

oring (B), seismic electrical resistivity er well (W); see Volume III	Year of water-level measurement
	Depth of well (feet)

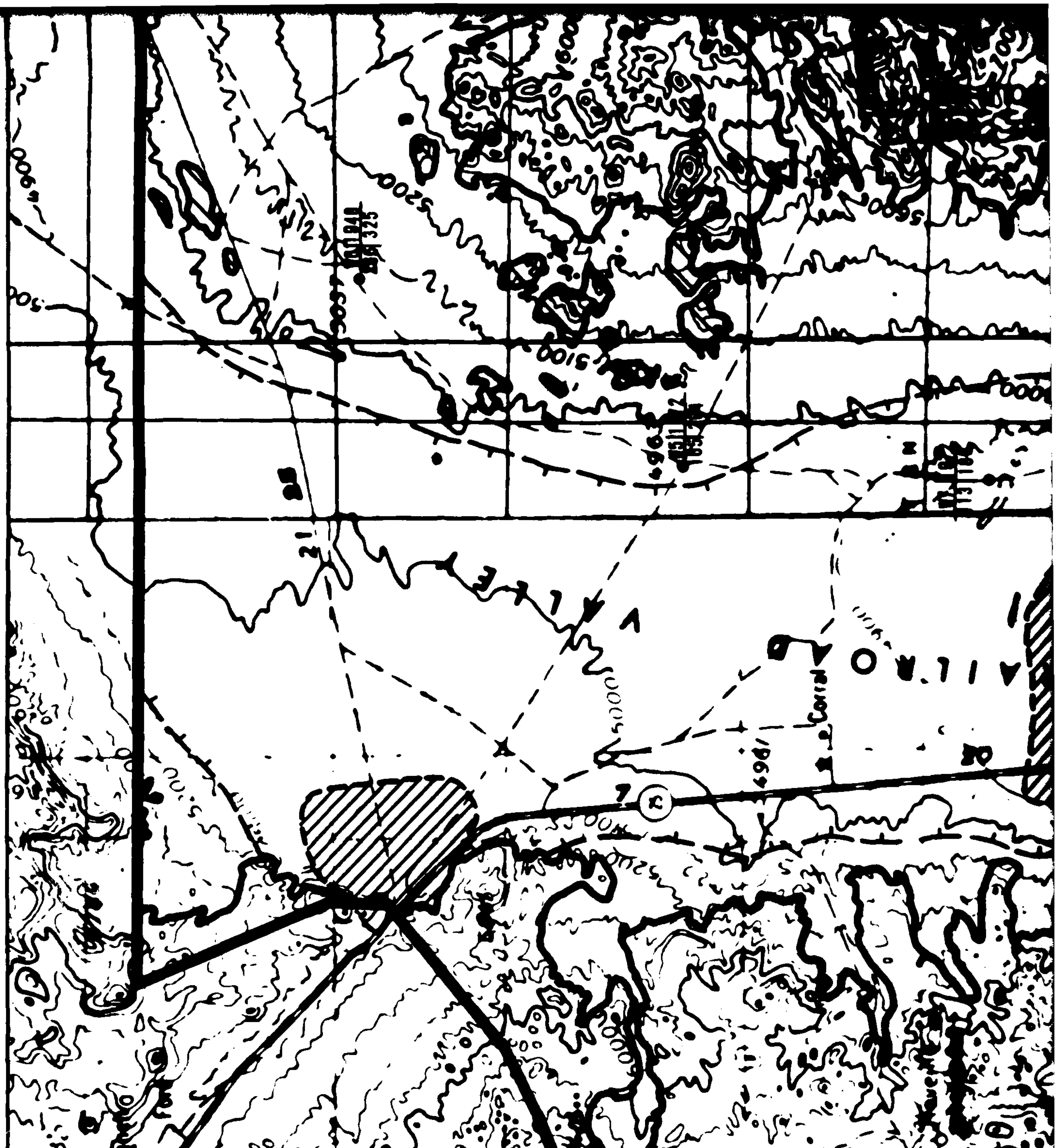
based entirely on the data points shown on the map.
pretation has been used and it can be expected that
es will change as additional data are obtained.



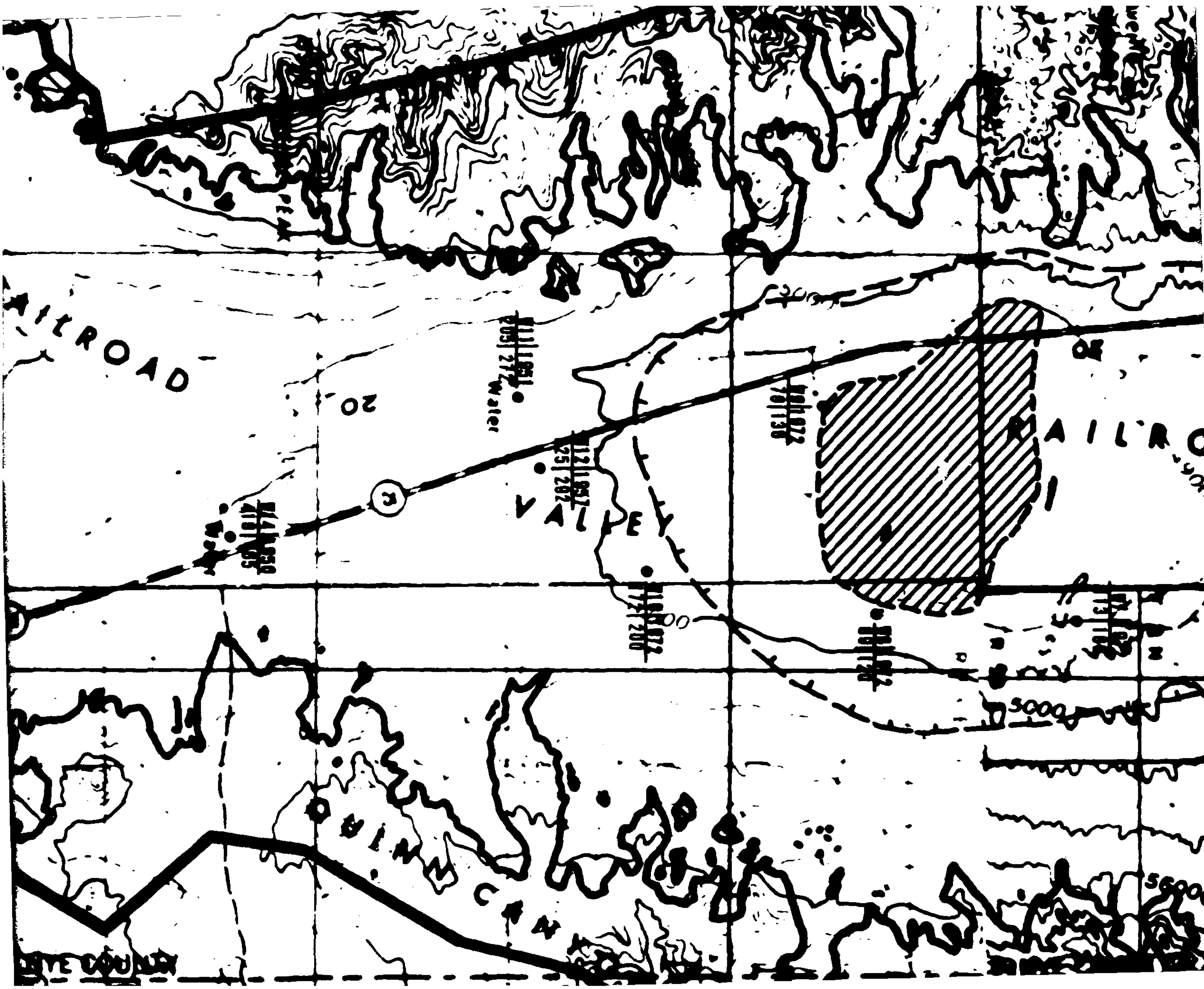
3

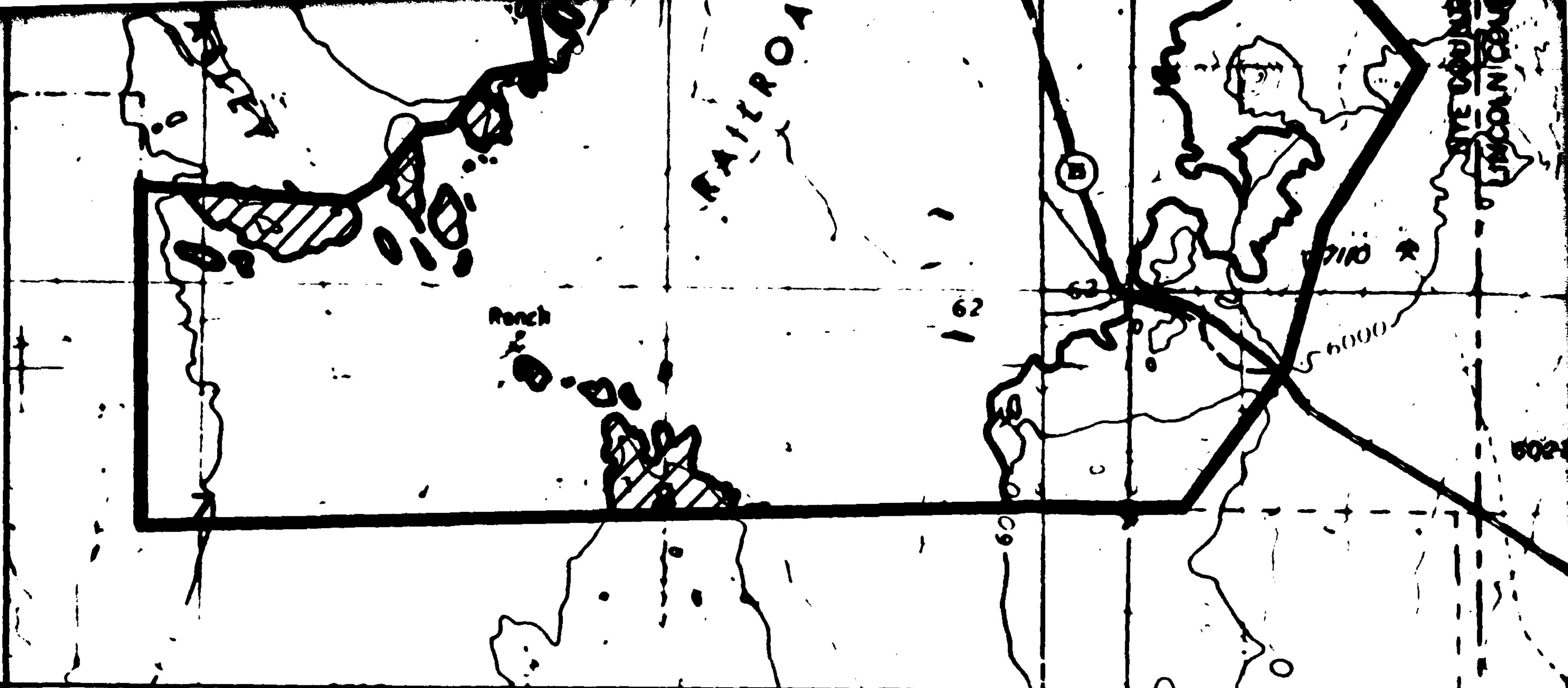
1

4



2 JUL 70


RAILROAD
VALLEY
5000
Water
NYE COUNTY



EXPLANATION

50 — Contour indicates ground water at a depth of approximately 50 feet (15m) - queried where data are extremely sparse. Shading indicates less than 50 feet (15m) to ground water.

150 — Contour indicates ground water at a depth of approximately 150 feet (46m) - queried where data are extremely sparse. Hachuring indicates less than 150 feet (46m) to ground water.

Contact between rock and basin-fill.

Shading indicates areas of isolated exposed rock.

EXPLANATION

50 — Contour indicates ground water at a depth of approximately 50 feet (15m) - queried where data are extremely sparse. Shading indicates less than 50 feet (15m) to ground water.

150 — Contour indicates ground water at a depth of approximately 150 feet (40m) - queried where data are extremely sparse. Hachuring indicates less than 150 feet (40m) to ground water.

Contact between rock and basin-fill.

Shading indicates areas of isolated exposed rock.

• W2 | 1973 / 75 | 700

Data Source - Fugro boring (B), seismic refraction line (S), electrical resistivity sounding (R), or water well (W); see Volume III Section 2.0.	Year of water-level measurement
Depth to water (feet)	Depth of well (feet)

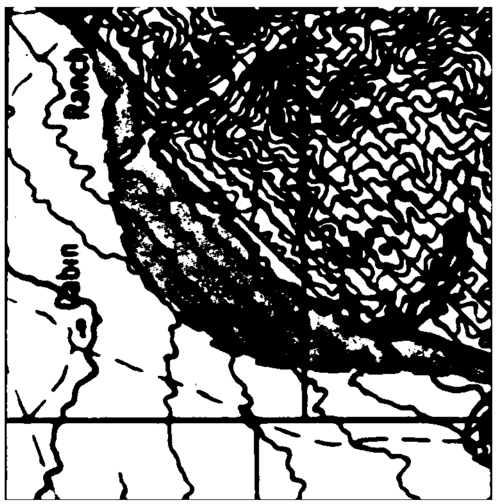
NOTE: The contours are based entirely on the data points shown on the map. Extensive interpretation has been used and it can be expected that contour locations will change as additional data are obtained.

DEPTH TO WATER
VERIFICATION SITE,
REVEILLE-RAILROAD CDP, NEVADA

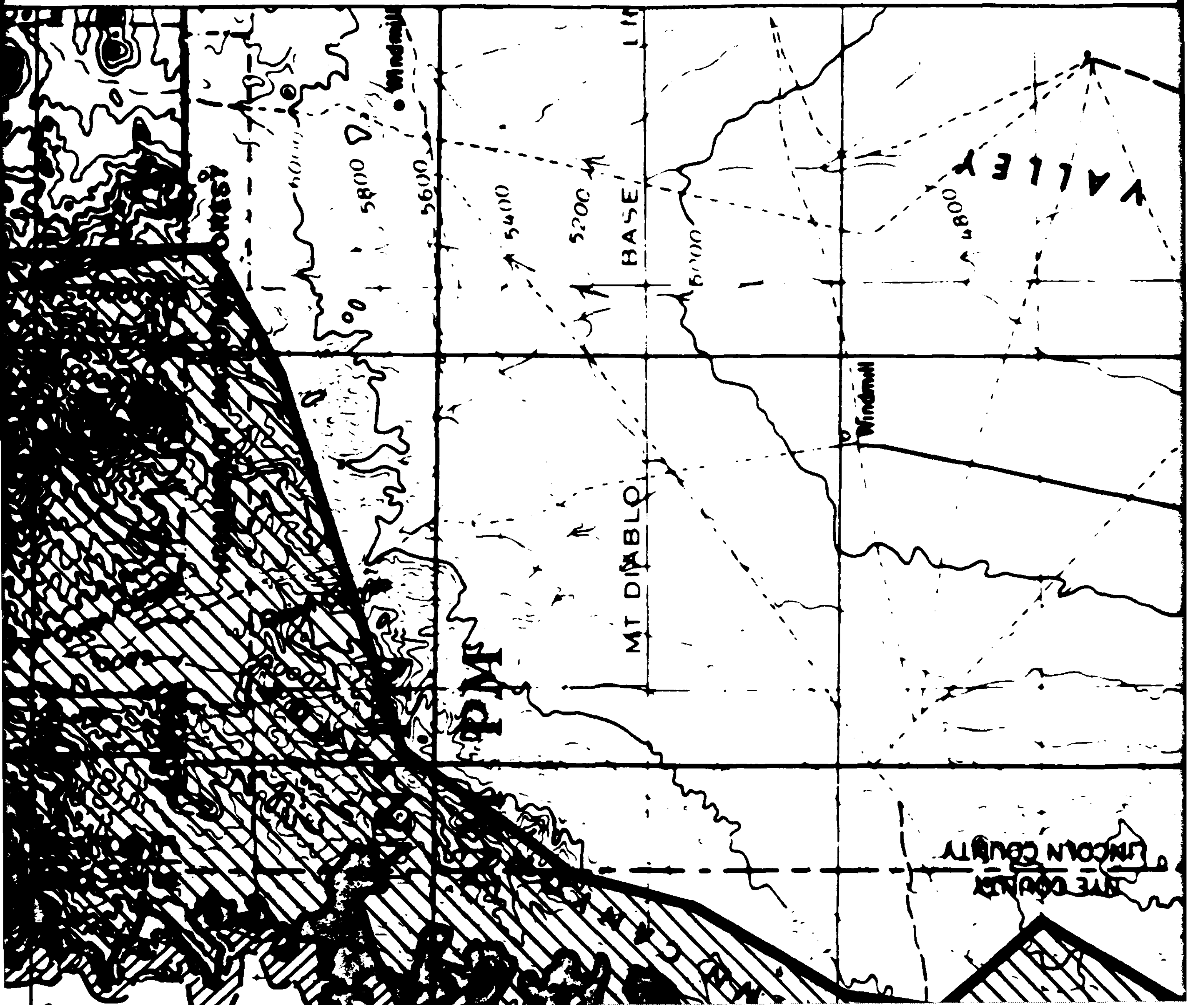
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

DRAWING
0-5

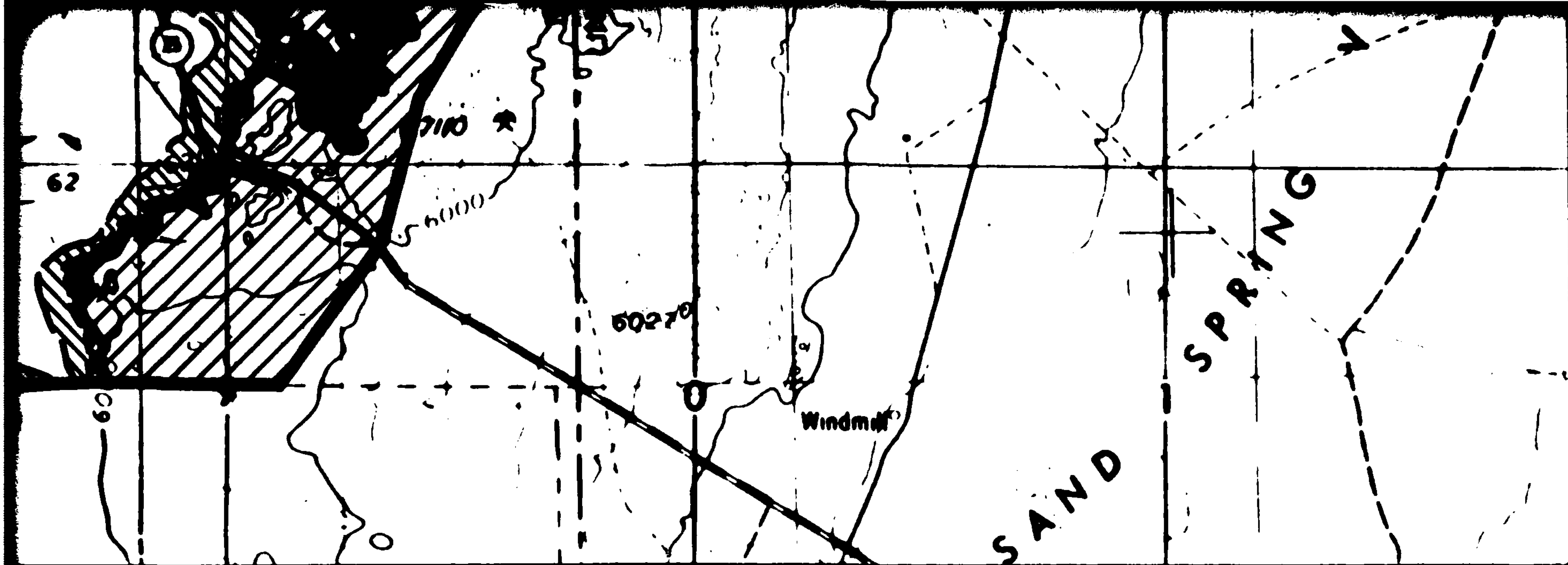
FUGRO NATIONAL, INC.


Ranch

1 2



Windmill
6000
5800
5600
5400
5200
5000
4800
BASE
MT DIABLO
PM
VALLEY
Windmill
LINCOLN COUNTY
NYE COUNTY



NATION

brid trench and vertical shelter
to rock and water greater than

brid trench and not suitable for
depth to rock and water greater
d less than 150 feet (46m).

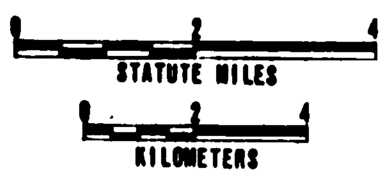
both hybrid trench and vertical
as determined from application
water, topographic/terrain, and

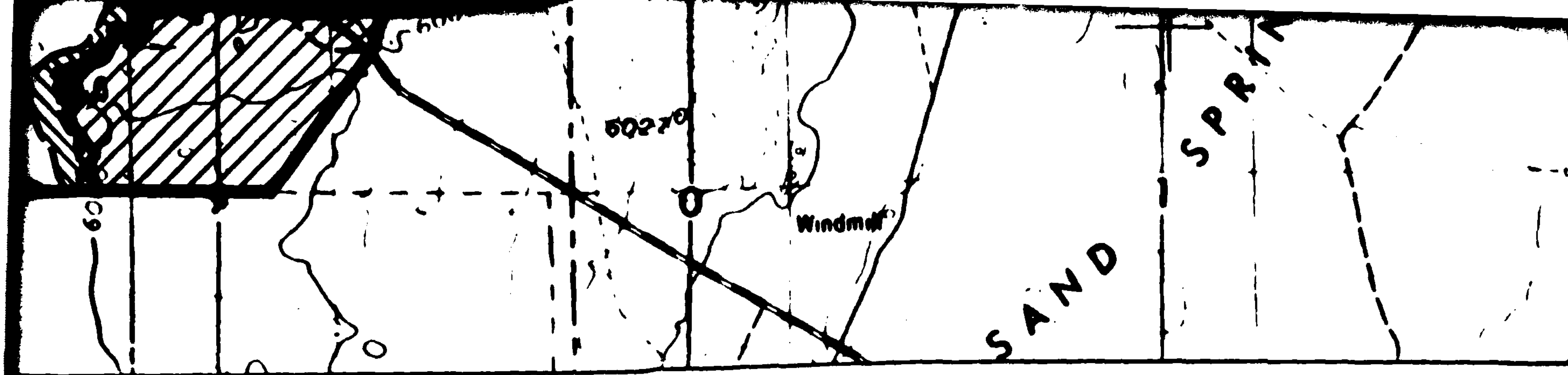
posed rock.

and basin-fill.

for details regarding suitable criteria.

SCALE 1:125,000





NATION

brid trench and vertical shelter
to rock and water greater than

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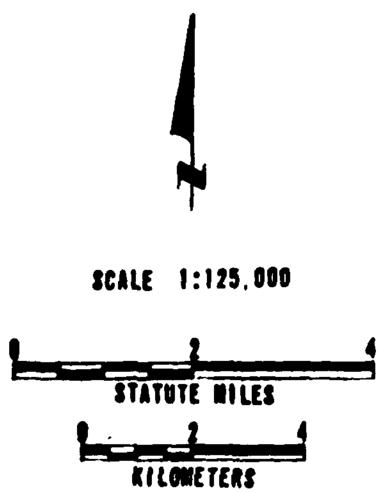
depth to rock and water greater
nd less than 150 feet (46m).

both hybrid trench and vertical
as determined from application
water, topographic/terrain, and

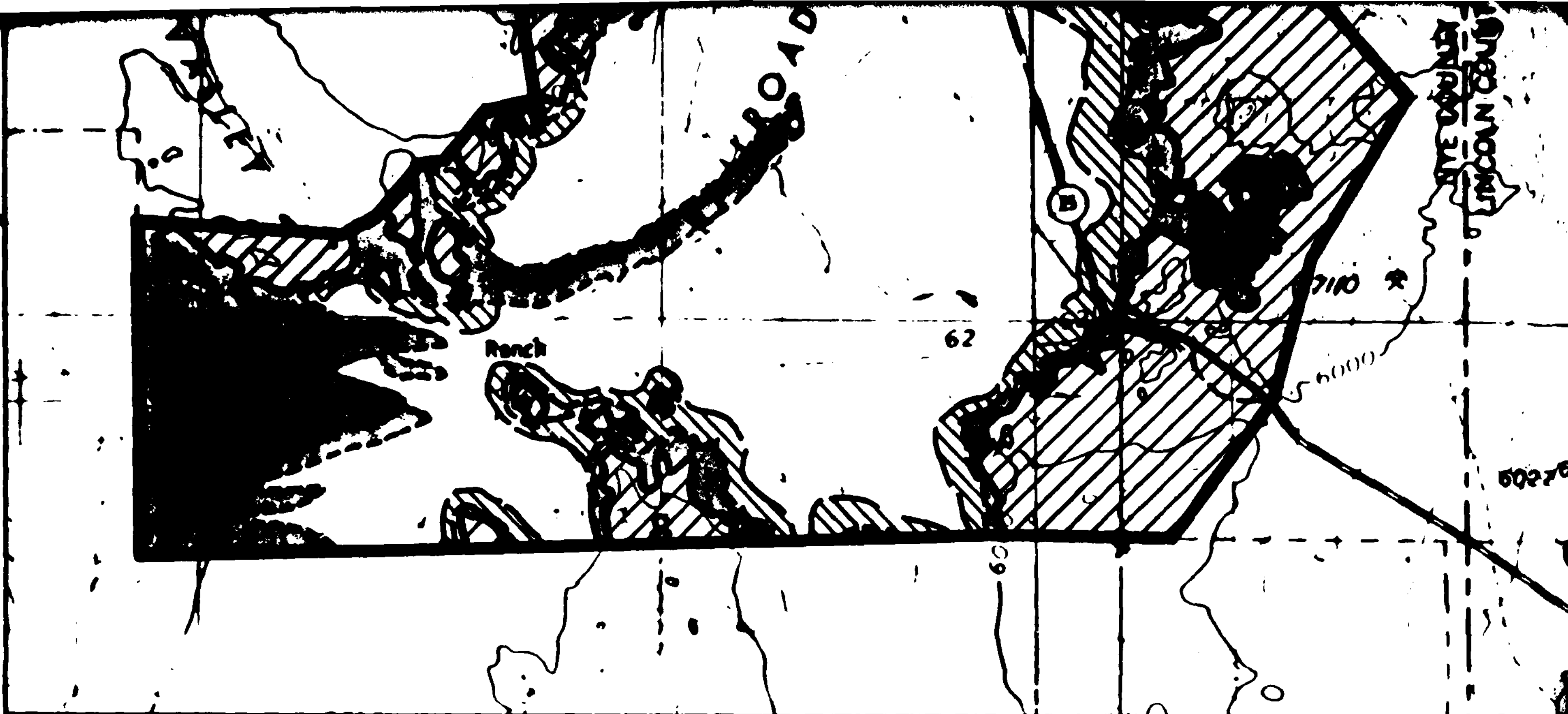
xposed rock.

and basin-fill.

for details regarding suitable criteria.

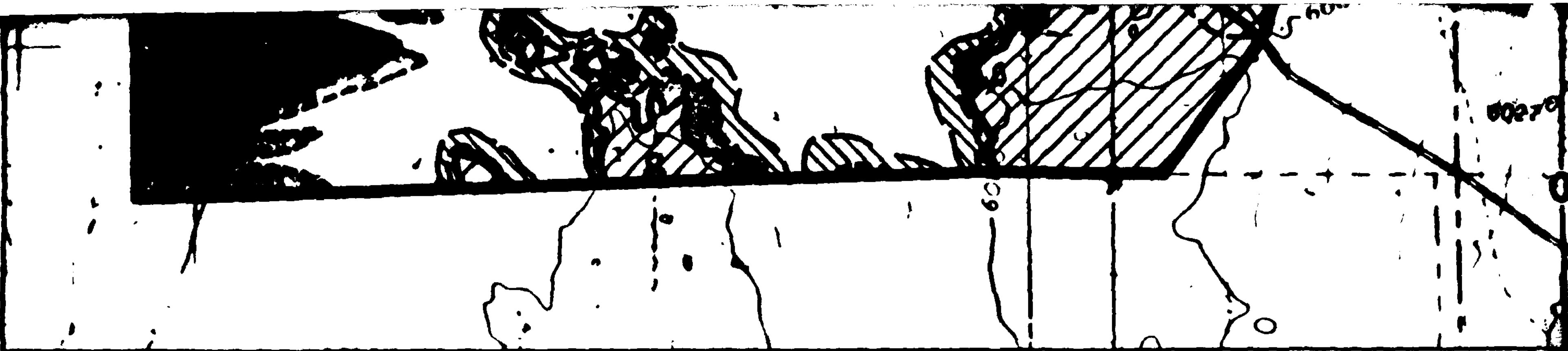



ROAD
Water



EXPLANATION

- Area suitable for hybrid trench and vertical shelter basing modes. Depth to rock and water greater than 150 feet (46m).
- Area suitable for hybrid trench and not suitable for vertical shelter. Depth to rock and water greater than 50 feet (15m) and less than 150 feet (46m).
- Area unsuitable for both hybrid trench and vertical shelter basing modes as determined from application of depth to rock and water, topographic/terrain, and cultural exclusions.
- Indicates areas of exposed rock.
- Contact between rock and basin-fill.



EXPLANATION

- Area suitable for hybrid trench and vertical shelter basing modes. Depth to rock and water greater than 150 feet (46m).
- Area suitable for hybrid trench and not suitable for vertical shelter. Depth to rock and water greater than 50 feet (15m) and less than 150 feet (46m).
- Area unsuitable for both hybrid trench and vertical shelter basing modes as determined from application of depth to rock and water, topographic/terrain, and cultural exclusions.
- Indicates areas of exposed rock.
- Contact between rock and basin-fill.

NOTE: See Appendix A2.0 Table A2-1 for details regarding suitable criteria.

SUITABLE AREA
HYBRID TRENCH AND VERTICAL SHELTER
VERIFICATION SITE,
REVEILLE-RAILROAD CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

DRAWING
8-6

FUGRO NATIONAL, INC.

10.0 BIG SMOKY CDP

10.1 GEOGRAPHIC SETTING

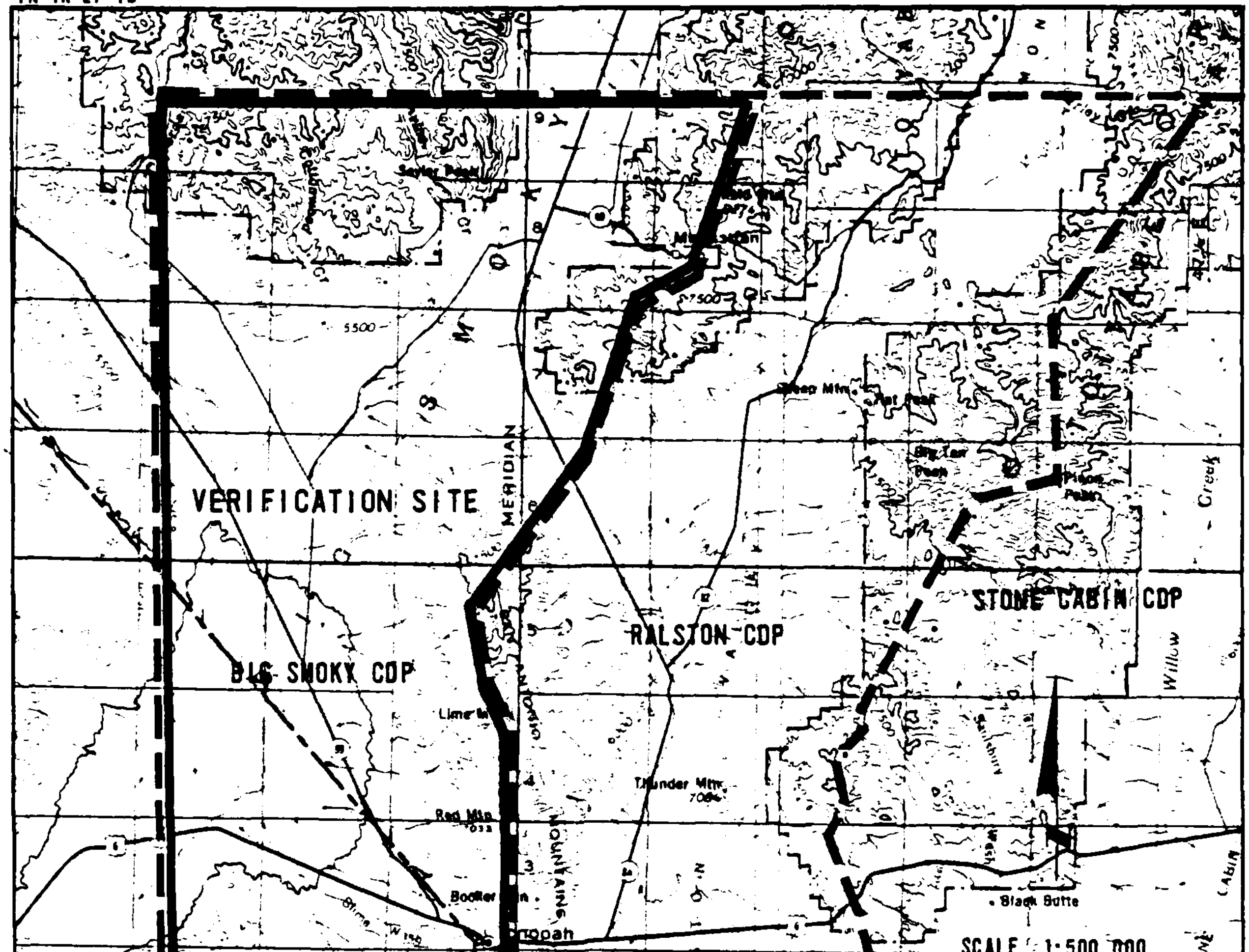
Big Smoky CDP is situated in northeastern Esmeralda and northwestern Nye counties, Nevada (Figure 10-1). The CDP lies east of roughly longitude 117°30' and west of the San Antonio Mountains and Toquima Range. Goldfield, Nevada, forms the southern limits of the CDP and the northernmost boundary is marked at about latitude 38°40'. The verification site includes all area in the CDP north of latitude 38°00'. The town of Tonopah is situated in the southeastern corner of the site off Nevada highways 6 and 95. Access throughout the site is good due to an extensive network of well maintained unpaved roads. The site area is principally used for rangeland, but effects of extensive mining operations are apparent around the valley edge.

10.2 SCOPE

The scope of geologic, geophysical, and soils engineering field activities performed at the site and laboratory tests performed on soil samples from the site are presented in Table 10-1. Locations of the geophysical and engineering activities are shown in Drawing 10-1 (end of Section 10.0).

10.3 GEOLOGIC SETTING

Rock types in the mountains surrounding the Big Smoky Verification Site are extremely diverse. The San Antonio Mountains on the east are composed of Tertiary flows and tuffs with some sediments, predominantly of the Esmeralda Formation along the west flank (Kleinhampl and Ziony, 1967). In northeastern Big Smoky, FN-TR-27-18



LOCATION MAP
VERIFICATION SITE
BIG SMOKY CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 10-1

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2 JUL 79

GEOLOGY AND GEOPHYSICS

TYPE OF ACTIVITY	NUMBER OF ACTIVITIES
Geologic mapping stations	118
Shallow refraction	18
Electrical resistivity	18
Gravity profiles	9

ENGINEERING-LABORATORY TESTS

TYPE OF TEST	NUMBER OF TESTS
Moisture/density	121
Specific gravity	4
Sieve analysis	95
Hydrometer	4
Atterberg limits	27
Consolidation	1
Unconfined compression	3
Triaxial compression	5
Direct shear	14
Compaction	13
CBR	13
Chemical analysis	12

ENGINEERING

NUMBER OF BORINGS	NOMINAL DEPTH FEET (METERS)
6	160 (49)
NUMBER OF TRENCHES	**NOMINAL DEPTH FEET (METERS)**
4	14 (4)
2	10 (3)
NUMBER OF TEST PITS	**NOMINAL DEPTH FEET (METERS)**
32	5 (2)
NUMBER OF CPTs	**RANGE OF DEPTH FEET (METERS)**
80	2-20 (1-6)
TYPE OF ACTIVITY	**NUMBER OF ACTIVITIES**
Surficial soil samples	31
Field CBR tests	19

SCOPE OF ACTIVITIES
VERIFICATION SITE, BIG SMOKY CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 10-1

FUGRO NATIONAL, INC.

southwest dipping Paleozoic shale and limestone and Tertiary air-fall tuffs constitute the Toquima Range (Kleinhampl and Ziony, 1967). The Toiyabe Range at the north end of the site is chiefly Tertiary air-fall and ash-flow tuffs with Permian andesite and Paleozoic shale and limestone along the east flank. Rocks along the west side of Big Smoky (Royston Hills) are chiefly Quaternary-Tertiary basalt and welded tuff.

Prominent north to northeast trending range-bounding faults occur on the steep east side of the Toiyabe Range and on the west side of the San Antonio Mountains. Evidence of active faulting displacing basin-fill deposits is prevalent in Big Smoky. Alluvial fault scarps occur in the southwest near Miller's Pond and along the entire east side of the valley. The faults exhibiting greatest apparent displacement occur east of the Crescent Dunes where scarps are 75 feet (23 m) or more in height. Many faults previously mapped along the east side (Rush and Schroer, 1970) do not show offset in the alluvium and appear principally as tonal lineaments, vegetation changes, or alignment of dunes.

Surficial basin-fill deposits in the site are predominantly sandy younger alluvial fans in association with modern stream, playa, and eolian sheet sand deposits. Basin-fill deposits within the site reach combined thicknesses of about 3000 feet (915 m; Rush and Schroer, 1970). Distribution of these units in the site is shown in Drawing 10-8. A brief description of the principal surficial deposits is given below.

- Younger and intermediate alluvial fan deposits - Intermediate alluvial fans are restricted to mountain front areas and rarely exposed along the valley axis. Younger alluvial fans, commonly in association with fluvial, eolian and playa deposits, occur throughout the central valley, locally extending to the mountain fronts. Deposits consist predominantly of sand with increasing gravel content near steep mountain fronts.

- Stream channel and playa deposits - Stream channel and playa deposits occur in northern and central Big Smoky along major south flowing drainages. Stream gradients are extremely low and isolated playas commonly occur in stream courses and along drainages ponded by dunes. Deposits consist predominantly of silty sand and silt.

- Eolian deposits - Sheet sands are most extensive in eastern Big Smoky surrounding the Crescent Dunes. These dunes are the only active dunes in the site, although dunes stabilized by vegetation occur in the southwest near Miller's Pond and in the northeast near San Antonio Ranch. Deposits consist predominantly of sands occurring as thin sheets or dunes.

10.4 SURFACE SOILS

Surficial soils of the Big Smoky site are predominantly coarse-grained. These range from well-graded sandy gravels to fine to coarse sands with appreciable fines. Soils from the predominant surficial geologic units can be combined into three categories based upon their physical and engineering characteristics.

1. Sands, silty sands, and clayey sands (geologic units A1s, A3s, A5ys, and A5is);
2. Sandy gravels and gravelly sands (geologic units A5ys, and A5is; and
3. Sandy silts and sandy clays (geologic unit A5ys).

10.4.1 Characteristics

The characteristics of surficial soils are summarized in Table 10-2, which contains physical properties and laboratory

SOIL DESCRIPTION			Sands, Silty Sands, and Clayey Sands		Sandy Gravels … Gravelly Sand…
USCS SYMBOLS			SW, SP, SM, SC		GP, GM, SW, SP…
PREDOMINANT SURFICIAL GEOLOGIC UNITS			A3s, A5ys, A5Is		A5ys, A5Is
ESTIMATED AREAL EXTENT		%	70-80		10-30
PHYSICAL PROPERTIES					
COBBLES 3 – 12 inches (8 – 30 cm)		%	0-5		0-10
GRAVEL		%	^0-23	[12]	13-63
SAND		%	45-87	[25]	32-83
SILT AND CLAY		%	3-38	[25]	4-17
LIQUID LIMIT			21-40	[1]	23
PLASTICITY INDEX			NP-18	[7]	NP-2
ROAD DESIGN DATA					
MAXIMUM DRY DENSITY		pcf (kg/m³)	114.0-128.0 (1826-2050)	[6]	118.5-133.4 '1014-2137)
OPTIMUM MOISTURE CONTENT		%	8.5-14.1	[6]	6.0-13.2
CBR AT 90% RELATIVE COMPACTION		%	5-20	[8]	10-33
SUITABILITY AS ROAD SUBGRADE (1)			fair to good		very good
SUITABILITY AS ROAD SUBBASE OR BASE (1)			poor to fair		good
THICKNESS OF LOW STRENGTH SURFICIAL SOIL (2)	RANGE	ft (m)	0.3-5.2 (0.1-1.6)	[61]	0.7-10.0 (0.2-3.0)
	AVERAGE	ft (m)	2.5 (0.8)	[61]	2.2 (0.7)

(1) Suitability is a subjective rating explained in Section A5.0 of the Appendix.

(2) Low strength surficial soil is defined as soil which will perform poorly as a road subgrade at its present consistency; see Table 10-3 for details.

NOTES: • [ ] –
• NDA –

Sandy Gravels and Gravelly Sands	Sandy Silts	
GP, GM, SW, SP, SM	ML	
A5ys, A5is	A5ys	
10-30	0-10	
0-10	0	
13-83 [25]	2 [1]	
32-83 [12]	25 [1]	
4-17 [12]	73 [1]	
23 [5]	22 [1]	
NP-2 [4]	1 [1]	
110.5-133.4 (1914-2137) [6]	114.5 (1834) [1]	
6.0-13.2 [6]	14.7 [1]	
10-33 [6]	3 [1]	
very good	poor	
good	not suitable	
0.7-10.0 (0.2-3.0) [16]	NDA	
2.2 (0.7) [16]	NDA	

NOTES: • [ ] - Number of tests performed

• NDA - No data available (insufficient data or tests not performed)

CHARACTERISTICS OF SURFICIAL SOILS VERIFICATION SITE, BIG SMOKY CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 10-2

FUGRO NATIONAL, INC.

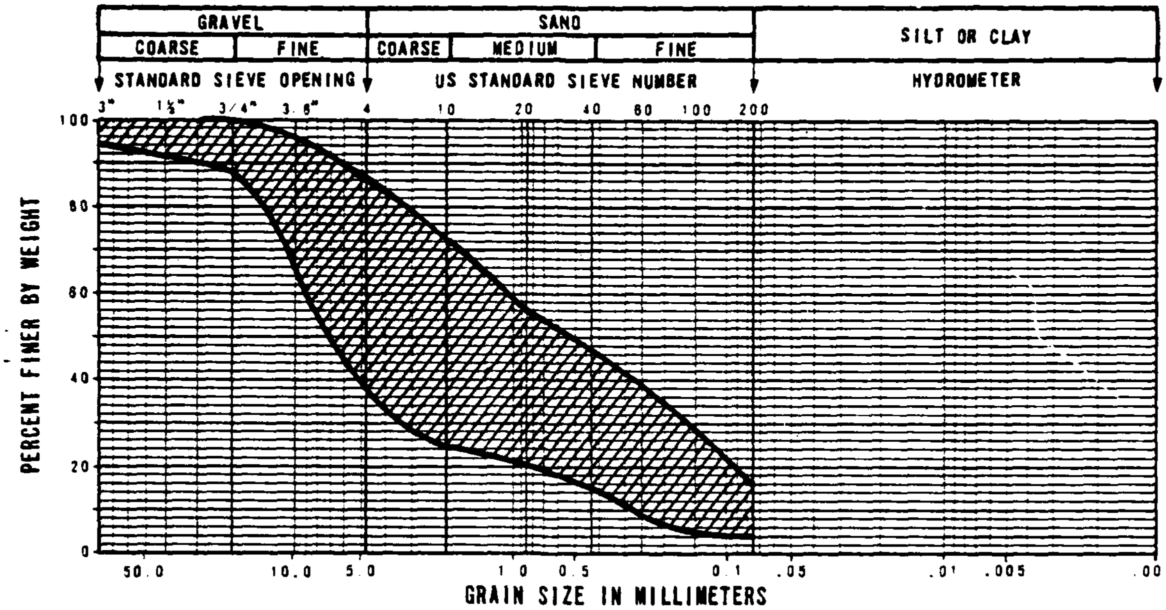
AFV-19

compaction and CBR test results and provides preliminary road design evaluations. Gradation ranges for the three categories of surficial soils are shown in Figure 10-2.

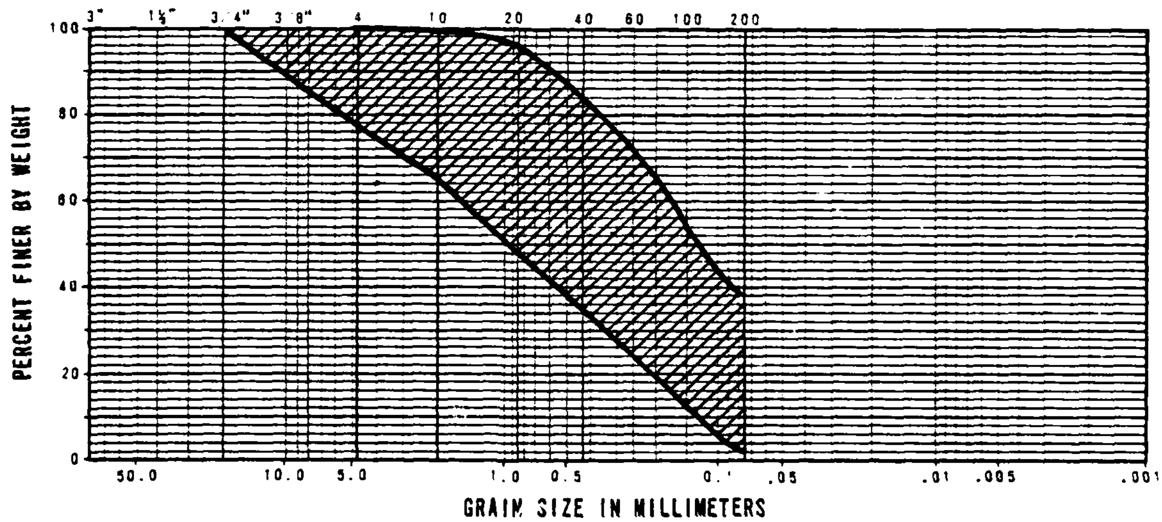
Sands, silty sands, and clayey sands are the predominant surficial soils with an approximate areal distribution ranging from 70 to 90 percent of the site. Sands are widely distributed over all site areas. These sands are graded coarse to fine with traces to little gravel and traces to appreciable fines which are nonplastic to moderately plastic. Uniform fine to medium sands or silty sands have a limited distribution as sheet and dune sands (A3s and A3d) in the east-central and northeast portions of the site. Except for eolian deposits that are uncemented, weak to moderate calcium carbonate cementation often occurs at depths below 1 foot (0.3 m).

Sandy gravel and gravelly sands cover approximately 10 to 30 percent of the site and are distributed throughout young and intermediate fans. The major concentrations of gravelly soils are located in A5yg and A5ig geologic units in steeply sloping areas near mountain fronts. Weak to moderate cementation often occurs in gravelly soils at depths below 1 foot (0.3 m) especially in intermediate fan deposits.

Sandy silts and sandy clays constitute a minor surficial soil component covering less than 10 percent of the site. These fine-grained soils, primarily limited in distribution to modern channel and playa deposits, are also found as isolated pockets in alluvial fans.



SOIL DESCRIPTION: Sandy Gravels and Gravelly Sands
from 0 to 2 feet (0.0 to 0.6m)



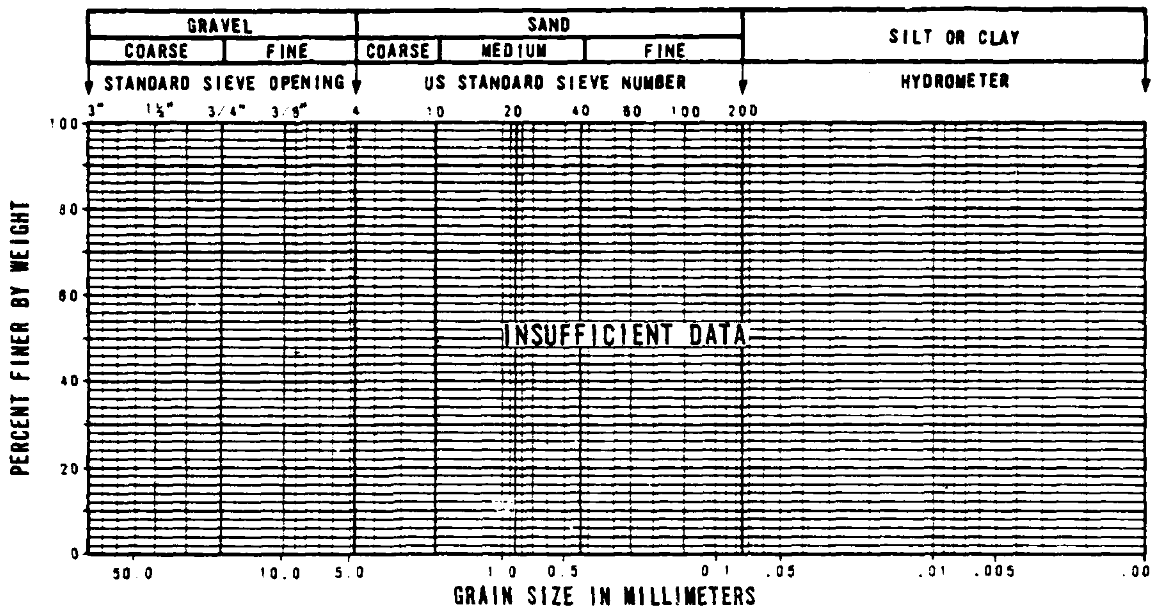
SOIL DESCRIPTION: Sands, Silty Sands, and Clayey Sands
from 0 to 2 feet (0.0 to 0.6m)

RANGE OF GRADATION OF SURFICIAL SOILS
VERIFICATION SITE, BIG SMOKY COP, NEVADA

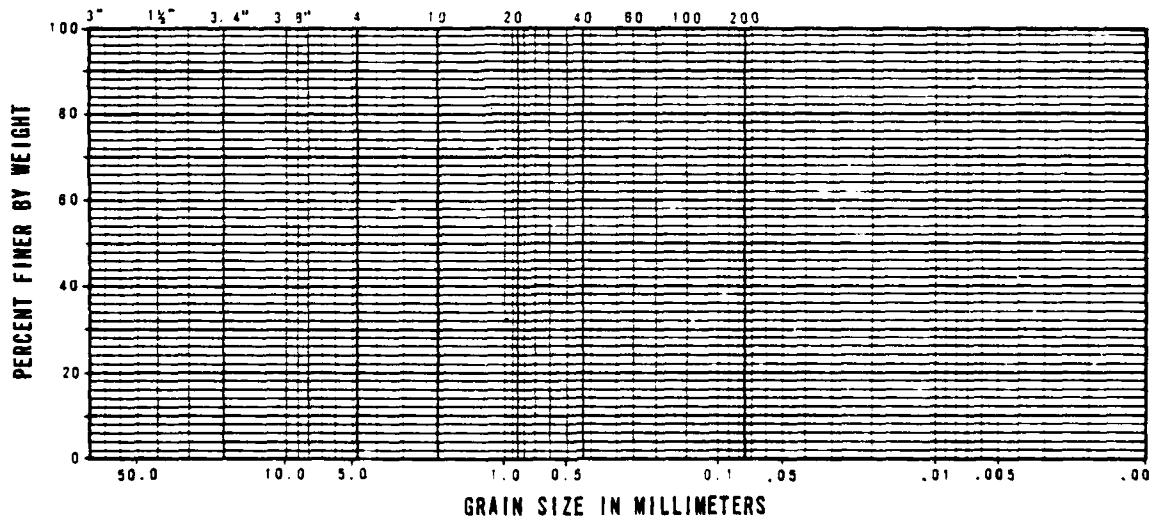
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 10-2
1 OF 2

FUGRO NATIONAL, INC.



SOIL DESCRIPTION: Sandy Silts from 0 to 2 feet (0.0 to 0.6m)



RANGE OF GRADATION OF SURFICIAL SOILS
VERIFICATION SITE, BIG SMOKY CDP, NEVADA

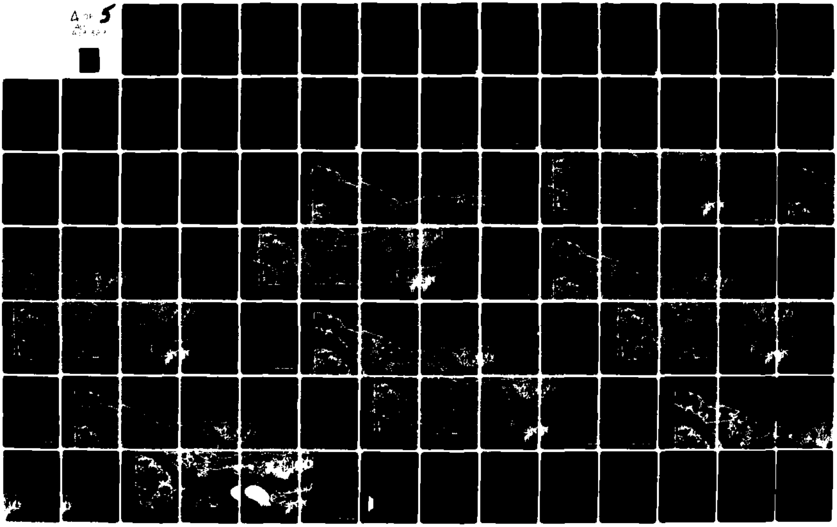
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 10-2
2 OF 2

FUGRO NATIONAL, INC.

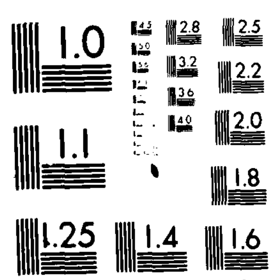
AD-A113 323 FUGRO NATIONAL INC LONG BEACH CA F/G 13/2
MX SITING INVESTIGATION GEOTECHNICAL EVALUATION. VOLUME IB. NEV--ETC(U)
AUG 79 F04704-78-C-0027
UNCLASSIFIED FN-TR-27-1B NL

4 of 5



4 OF 5

AD A113 323



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

10.4.2 Low Strength Surficial Soil

Based on CPT results and soil classification, the thickness of low strength surficial soil at each CPT location was estimated and is presented in Table 10-3. Sands, silty sands, and clayey sands exhibit low strengths to depths ranging from 0.7 to 10.0 feet (0.2 to 3.0 m) with an average of 2.5 feet (0.8 m). Sandy gravels and gravelly sands exhibit low strength to depths ranging from 0.3 to 5.2 feet (0.1 to 1.6 m) with an average of 2.2 feet (0.7 m). Fine-grained soils were not evaluated by CPT. The strength of surficial soils is significantly influenced by the degree of calcium carbonate cementation. A highly variable degree of cementation was observed in surficial soils and is confirmed by the variable thickness of low strength--surficial soils.

10.5 SUBSURFACE SOILS

Subsurface soils within the site are predominantly coarse-grained consisting of sandy gravels, sands, silty sands and clayey sands. Fine-grained soils consisting of silts and clays (buried lacustrine deposits) are found in the southern portion of the site. The composition of subsurface soils with depth, as determined from borings, trenches, and test pits, is illustrated in soil profiles presented in Figures 10-3 through 10.6.

Results of seismic refraction and electrical resistivity surveys are summarized in Table 10-4. The characteristics of subsurface soils, determined from field and laboratory tests, are presented in Table 10-5. Ranges of gradation of fine- and coarse-grained subsurface soils are shown in Figure 10-7.

CONE PENETROMETER TEST NUMBER[1]	THICKNESS OF LOW STRENGTH SURFICIAL SOIL[2]		SOIL TYPE[3]
	FEET	METERS	
C-1	2.2	0.7	SP-SM
C-2	3.0	0.9	SW-SM/SP-SM
C-3	2.2	0.7	SP-SW
C-4	0.9	0.3	SM
C-5	0.6	0.2	SP
C-6	0.7	0.2	SP-SM
C-7	3.6	1.1	SM
C-8	1.9	0.6	SP-SM
C-9	2.0	0.6	SP-SM
C-10	2.0	0.6	SP-SM
C-11	2.9	0.9	GP-GM
C-12	0.7	0.2	SP-SM
C-13	1.0	0.3	SM/GP
C-14	2.7	0.8	SP-SM/GP
C-15	5.9	1.8	SP
C-16	3.9	1.2	SP-SM
C-17	1.3	0.4	SM
C-18	3.7	1.1	SP-SM
C-19	5.9	1.8	SP-SM
C-20	1.5	0.5	SM
C-21	1.2	0.4	SM
C-22	2.9	0.9	SP-SM
C-23	1.5	0.5	SP-SM
C-24	0.8	0.2	SC/SM
C-25	2.6	0.8	SP-SM
C-26	10.0	3.0	SP
C-27	1.0	0.3	SP
C-28	1.9	0.6	SM

CONE PENETROMETER TEST NUMBER[1]	TH
C-29	
C-30	
C-31	
C-32	
C-33	
C-34	
C-35	
C-36	
C-37	
C-38	
C-39	
C-40	
C-41	
C-42	
C-43	
C-44	
C-45	
C-46	
C-47	
C-48	
C-49	
C-50	
C-51	
C-52	
C-53	
C-54	
C-55	
C-56	

(1) For Cone Penetrometer Test locations see Drawing 10-1, Activity Location Map.

(2) Thickness corresponds to depth below ground surface. Low strength surficial soil is defined as soil which will perform poorly as a road subgrade at its present consistency. Low strength is based on Cone Penetrometer Test results using the following criteria:

Coarse-grained soils: $q_c < 120$ tsf (117 kg/cm^2)
Fine-grained soils: $q_c < 80$ tsf (78 kg/cm^2)

where q_c is cone resistance.

(3) Soil type is based on Unified Soil Classification System; see Section A5 D in the Appendix for explanation

ER (1)	THICKNESS OF LOW STRENGTH SURFICIAL SOIL (2)		SOIL TYPE (3)
	FEET	METERS	
	1.1	0.3	SP-SM
	2.2	0.6	SP-SM
	2.1	0.6	SP
	0.7	0.2	SM/GP
	2.1	0.6	SM
	1.7	0.5	SM
	2.3	0.7	SP-SM
	0.7	0.2	SM
	2.5	0.7	SM
	4.9	1.5	SM
	3.6	1.1	SP-SM/GP
	1.1	0.3	SM/SP-SM
	1.9	0.6	SM
	0.6	0.2	GP-GM
	0.3	0.1	GP
	0.9	0.3	SM
	1.2	0.3	SP-SM
	3.3	1.0	SC
	3.7	1.1	SC/ML
	3.1	0.9	SM/GW
	0.7	0.2	SM
	2.4	0.7	SM
	1.6	0.5	SM/SP-SM
	2.2	0.7	SM
	2.6	0.8	SP-SM/GP
	0.7	0.2	SP
	0.5	0.2	GM
	2.9	0.9	SM

CONE PENETROMETER TEST NUMBER (1)	THICKNESS OF LOW STRENGTH SURFICIAL SOIL (2)		SOIL TYPE (3)
	FEET	METERS	
C-57	1.7	0.5	SM
C-58	0.7	0.2	SM
C-59	1.6	0.5	SM
C-60	1.3	0.4	SC
C-61	2.1	0.6	SM
C-62	3.3	1.0	SP-SM
C-63	0.9	0.3	SP
C-64	0.5	0.2	SC/SM
C-65	6.9	2.1	SM
C-66	4.3	1.3	SP-SM/SM
C-67	5.9	1.8	SP-SM
C-68	3.4	1.0	SP-SM
C-69	0.7	0.2	SM
C-70	3.1	0.9	SP
C-71	5.1	1.5	SP-SM
C-72	3.9	1.2	SP
C-73	2.7	0.8	SP-SM
C-74	5.2	1.6	SW-SM
C-75	3.5	1.1	SC/GP
C-76	1.9	0.6	SM
C-77	2.3	0.7	SP-SM
C-78	6.6	2.0	SM
C-79	1.0	0.3	SC/GP
C-80	0.4	0.1	GP

NOTES:

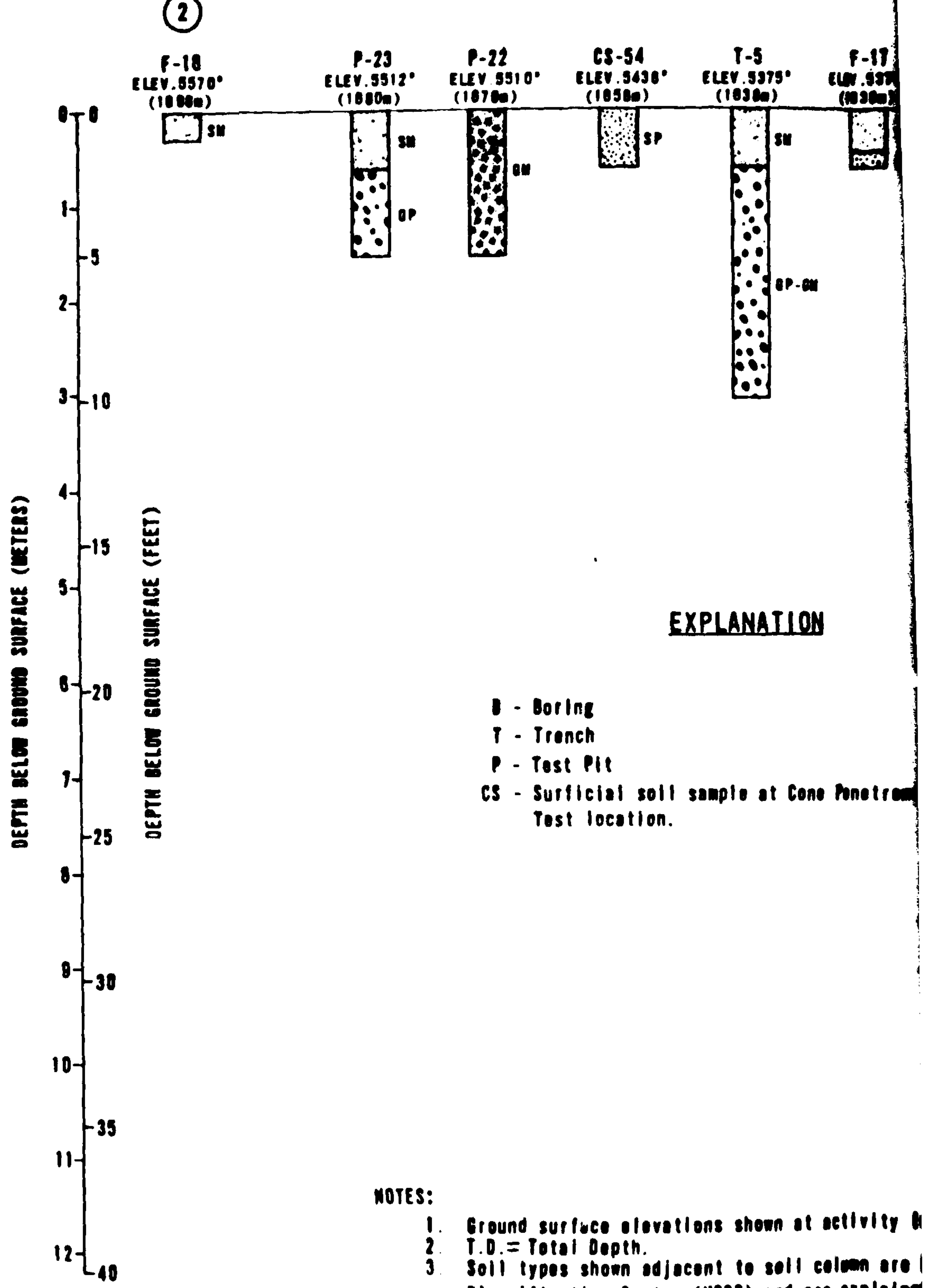
- For fine-grained soils (ML, CL, MH and CH), thickness of low strength surficial soil will vary depending on moisture content of the soil at time of testing.
- SM/GM - Indicates SM underlain by GM
- NDA - No data available

THICKNESS OF LOW STRENGTH SURFICIAL SOIL
VERIFICATION SITE, BIG SMOKY CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 10-3

FUGRO NATIONAL, INC.

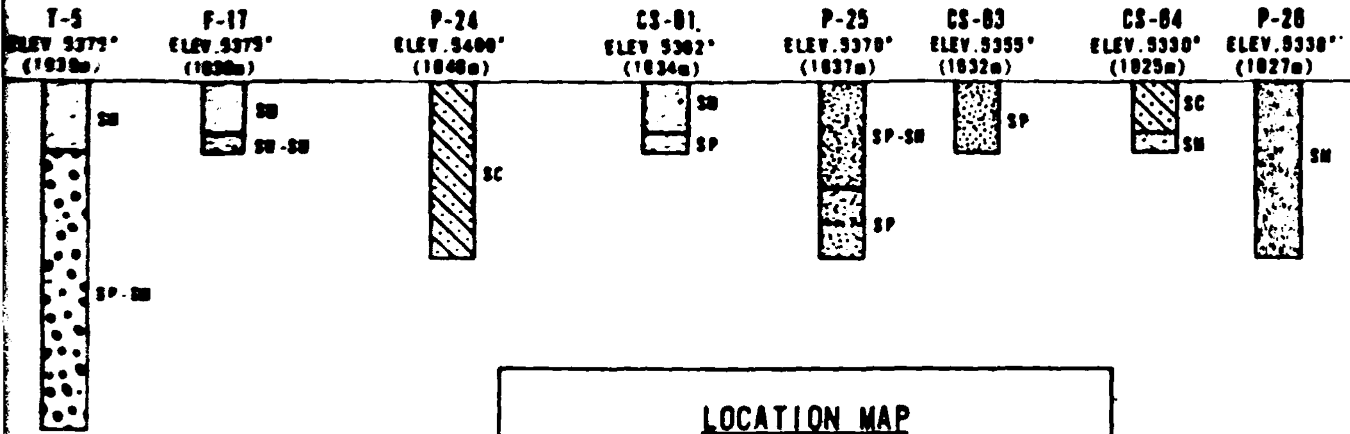


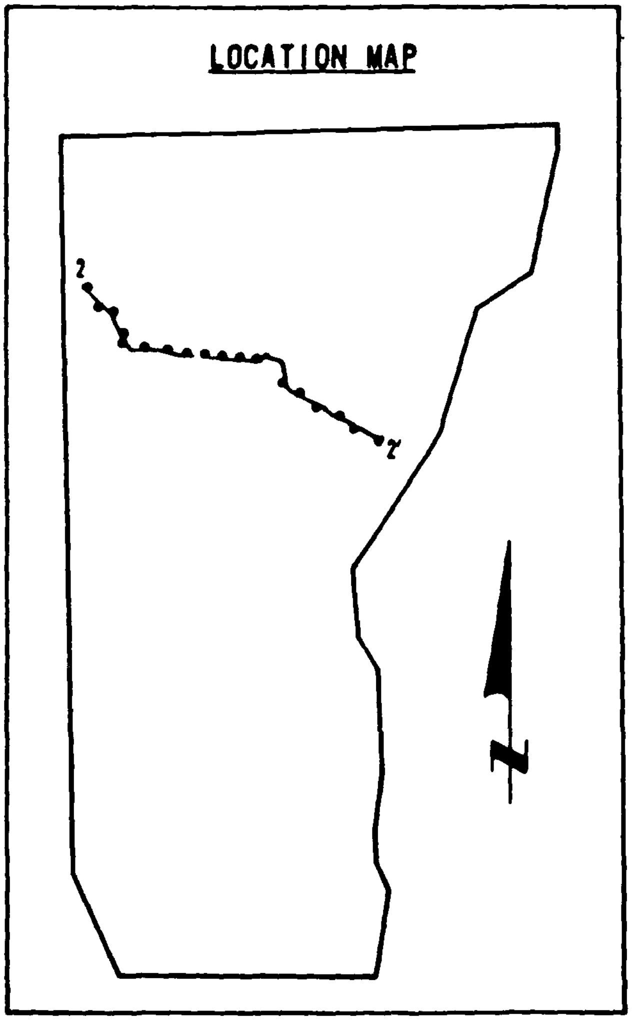
EXPLANATION

B - Boring
T - Trench
P - Test Pit
CS - Surficial soil sample at Cone Penetrom
Test location.

NOTES:

1. Ground surface elevations shown at activity 0
2. T.D.= Total Depth.
3. Soil types shown adjacent to soil column are
Classification System (USCS) and are explained





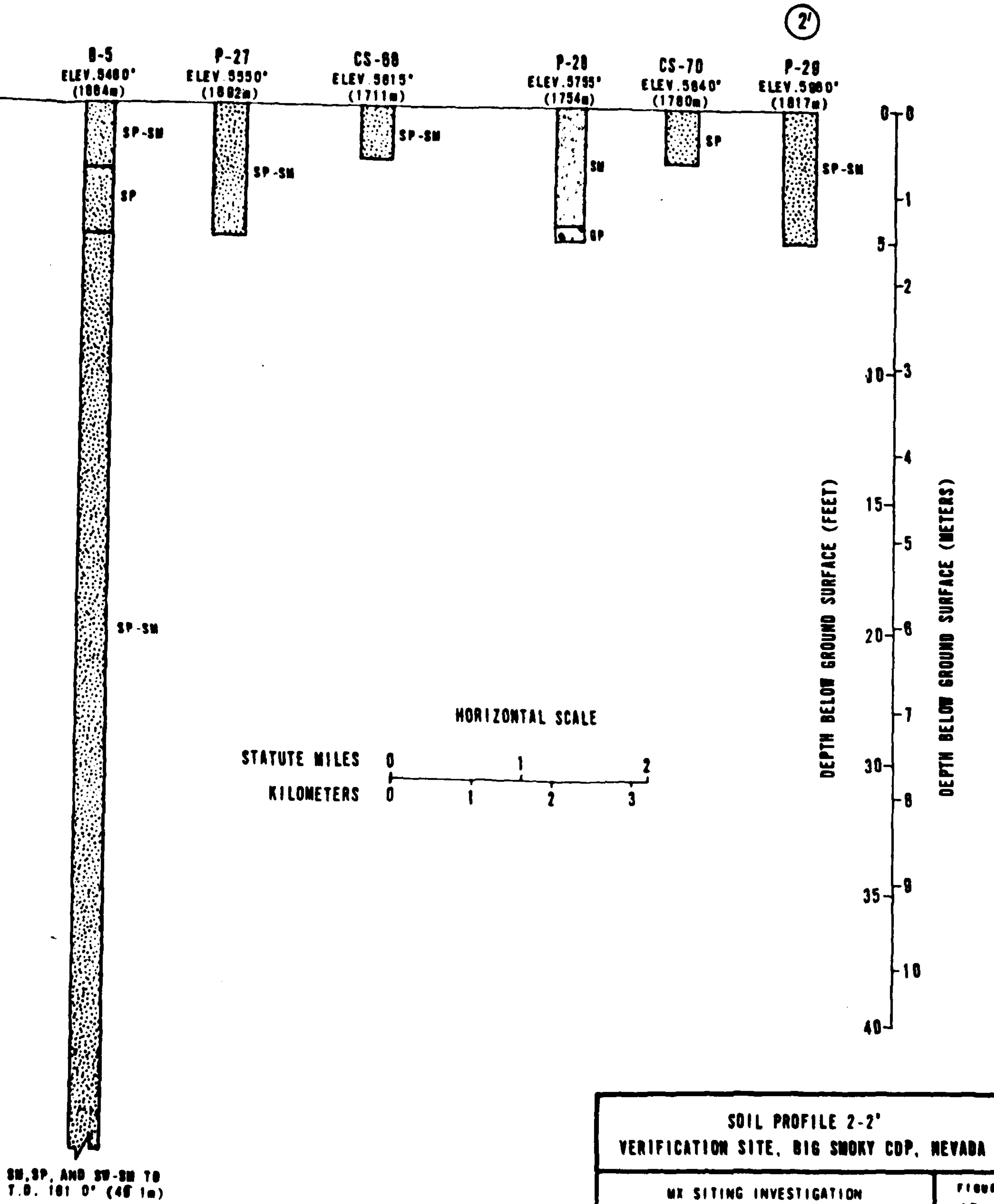
LANATION

le at Cone Penetrometer

hown at activity locations are approximate

e soil column are based on Unified Soil
) and are explained in the Appendix.

2

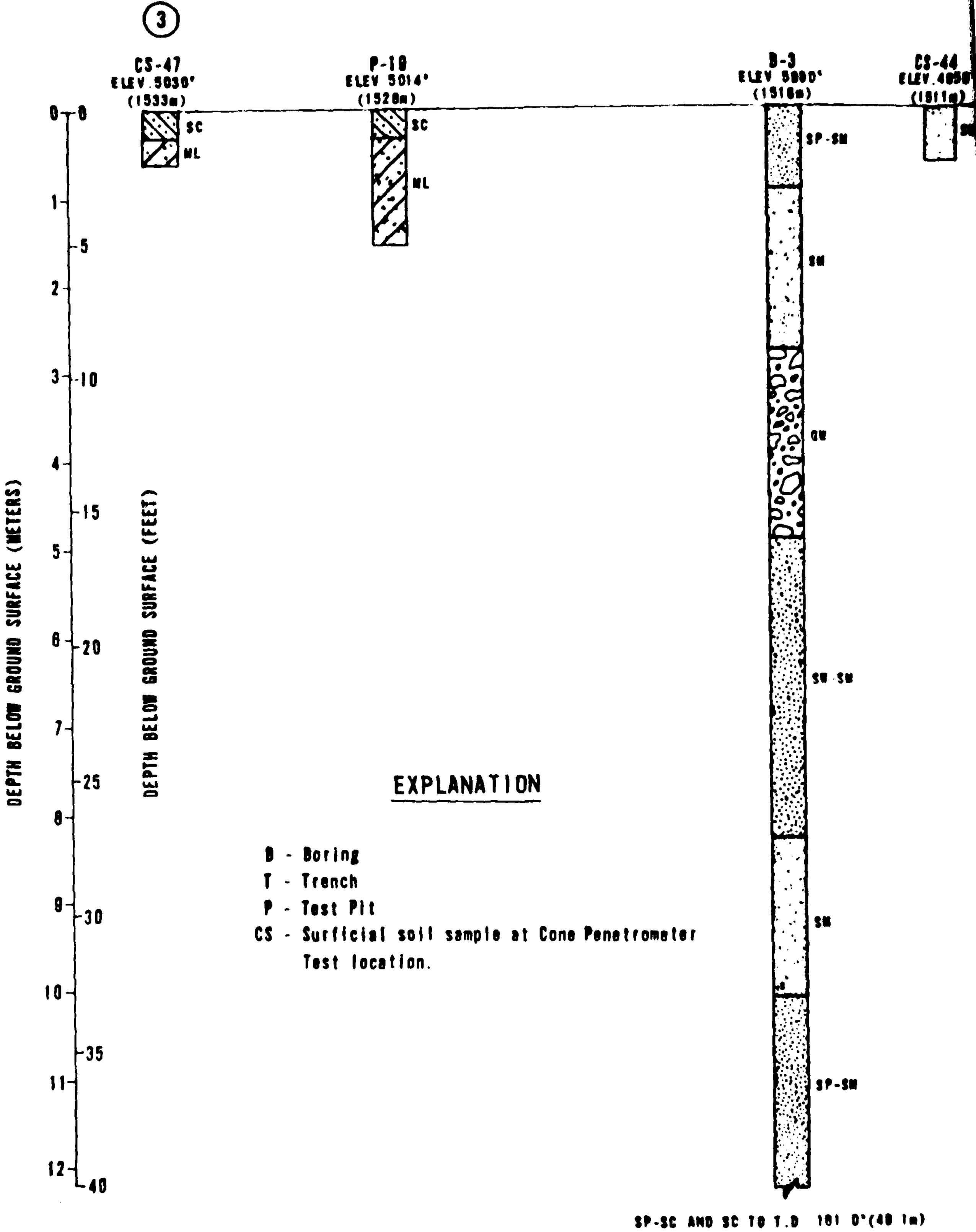


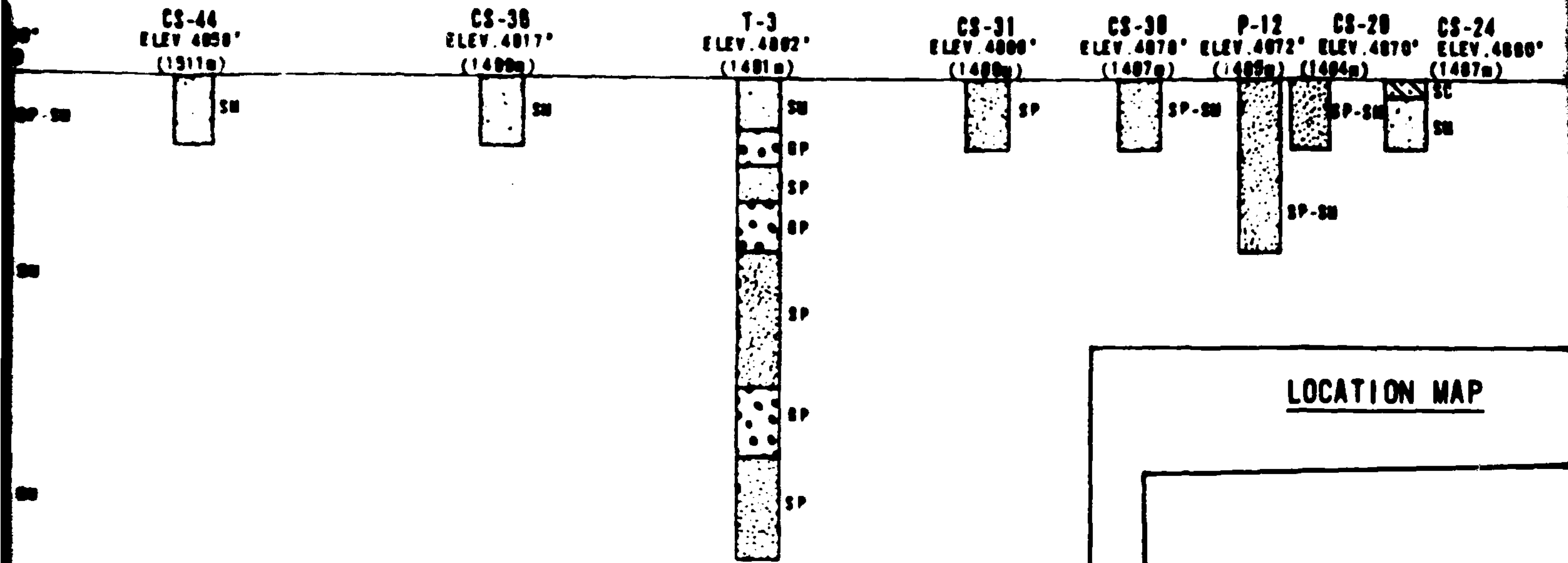
SOIL PROFILE 2-2'
VERIFICATION SITE, BIG SMOKY CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 10-3

FUGRO NATIONAL, INC.

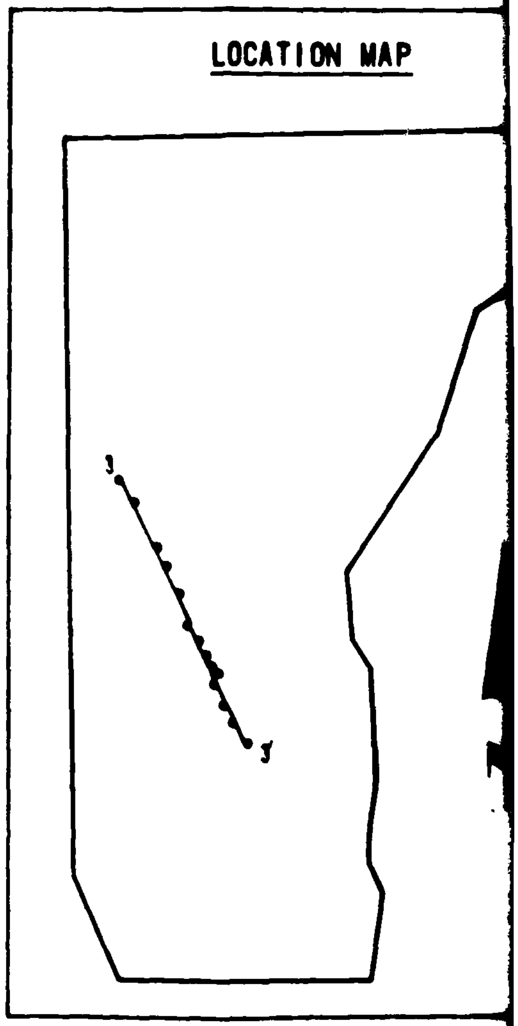

3
CS-47
ELEV. 5030'
(1533m)
SC
ML
P-19
ELEV 5014'
(1528m)
SC
ML
B-3
ELEV 5000'
(1518m)
SP-SM
SM
GW
SW-SM
SM
SP-SM
CS-44
ELEV. 4950'
(1511m)
DEPTH BELOW GROUND SURFACE (METERS)
DEPTH BELOW GROUND SURFACE (FEET)
0
1
2
3
4
5
6
7
8
9
10
11
12
0
5
10
15
20
25
30
35
40
EXPLANATION
B - Boring
T - Trench
P - Test Pit
CS - Surficial soil sample at Cone Penetrometer Test location.
SP-SC AND SC TO T.D 161 0'(48 1m)



HORIZONTAL SCALE

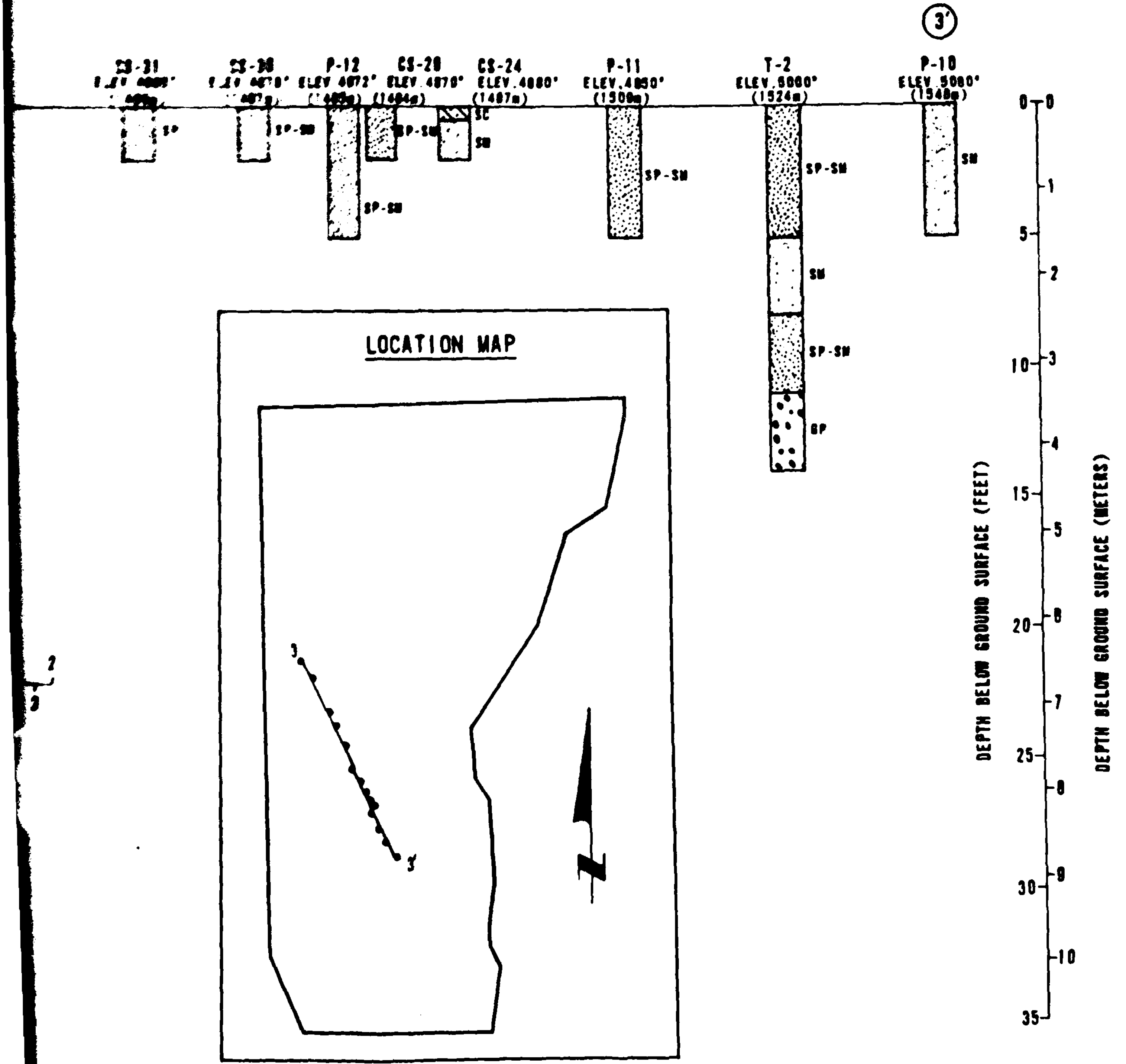
STATUTE MILES 0 1 2

KILOMETERS 0 1 2 3



NOTES:

1. Ground surface elevations shown at activity locations are approximate
2. T.D. = Total Depth.
3. Soil types shown adjacent to soil column are based on Unified Soil Classification System (USCS) and are explained in the Appendix



...f activity locations are approximate.

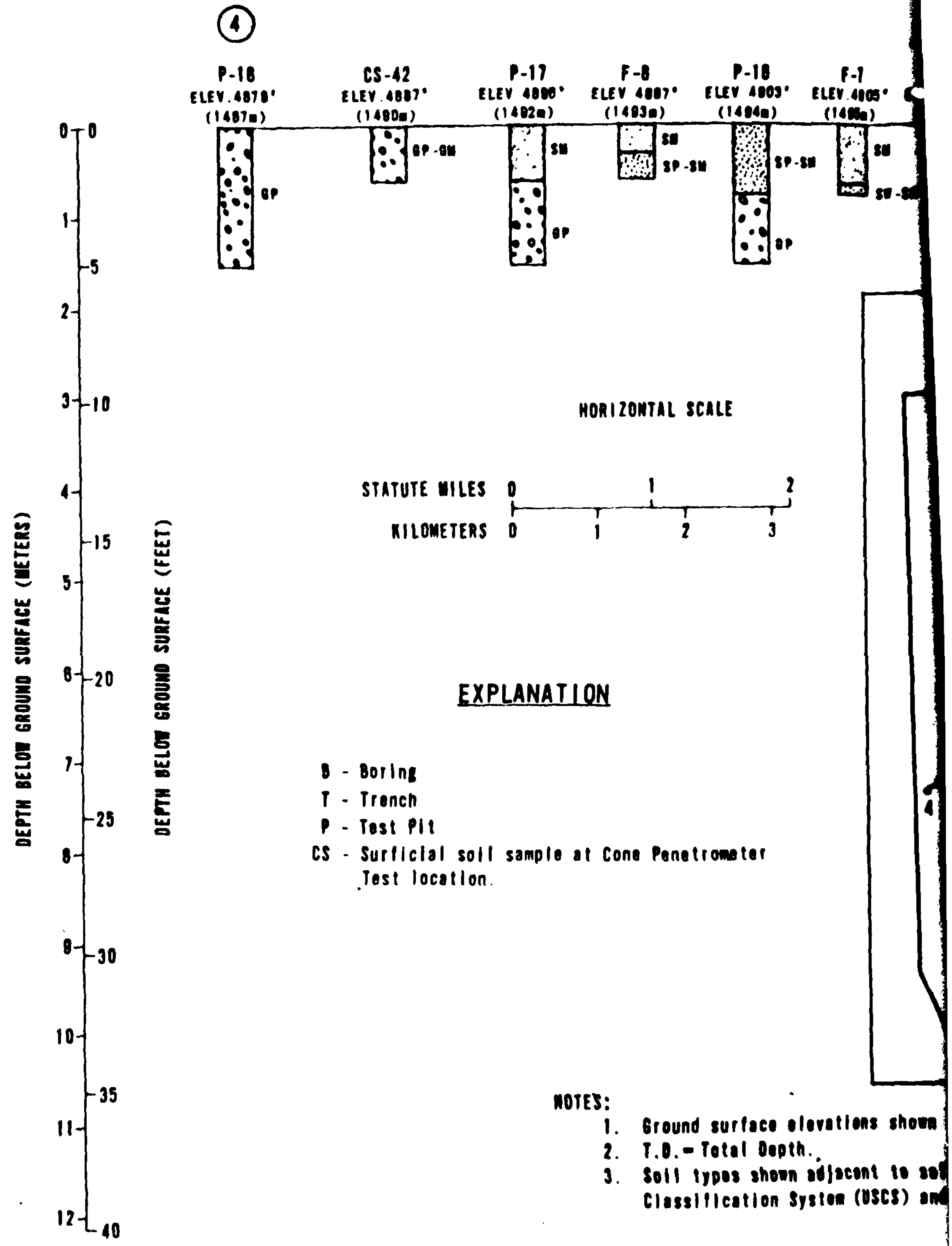
...column are based on Unified Soil ... are explained in the Appendix.

SOIL PROFILE 3-3'
VERIFICATION SITE, BIG SMOKY CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 10-4

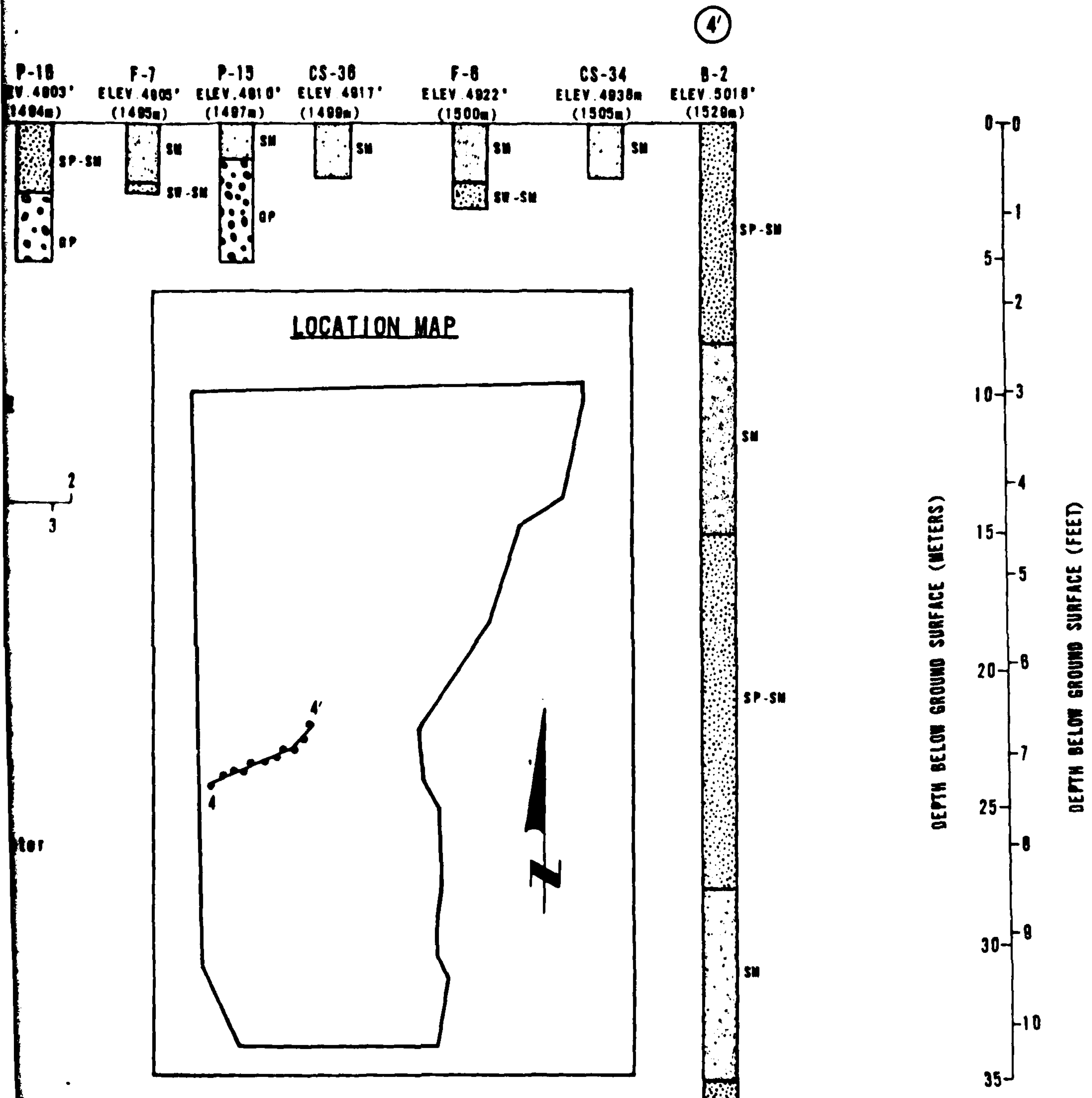
FUGRO NATIONAL, INC.



EXPLANATION

B - Boring
T - Trench
P - Test Pit
CS - Surficial soil sample at Cone Penetrometer Test location.

NOTES:
1. Ground surface elevations shown
2. T.D.- Total Depth.
3. Soil types shown adjacent to so
Classification System (USCS) an



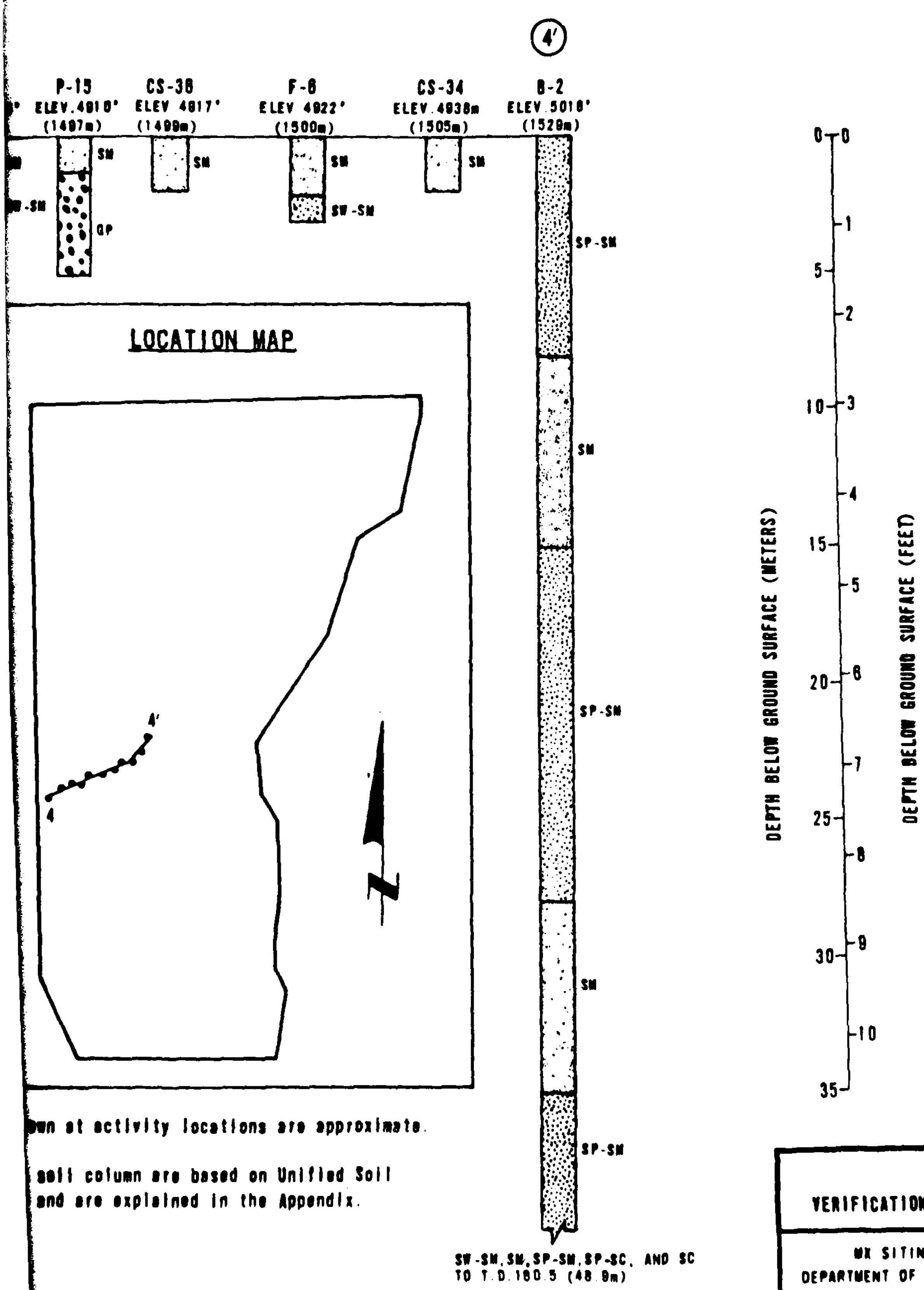
ace elevations shown at activity locations are approximate.
Depth.
shown adjacent to soil column are based on Unified Soil
ion System (USCS) and are explained in the Appendix.

SW-SM, SM, SP-SM, SP-SC, AND SC
TO T.D. 160.5 (48.9m)

SOIL PROFILE 4-4'
VERIFICATION SITE, BIG SMOKY

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAM

FUGRO NATIONA



...wn at activity locations are approximate.

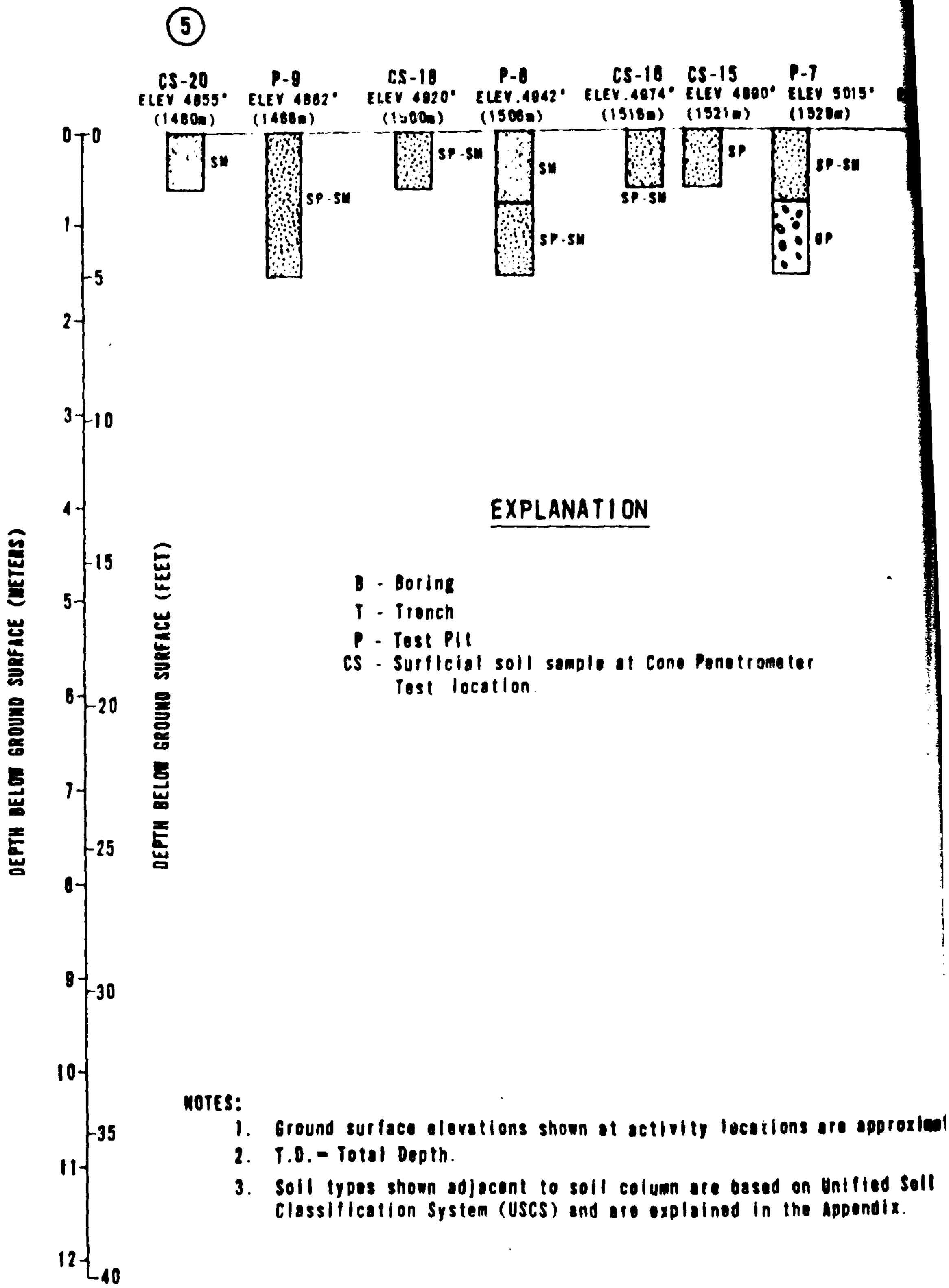
...soil column are based on Unified Soil ...and are explained in the Appendix.

SOIL PROFILE 4-4'

VERIFICATION SITE, BIG SMOKY CDP, NEVADA

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAMSO	FIGURE 10-5

FUGRO NATIONAL, INC.

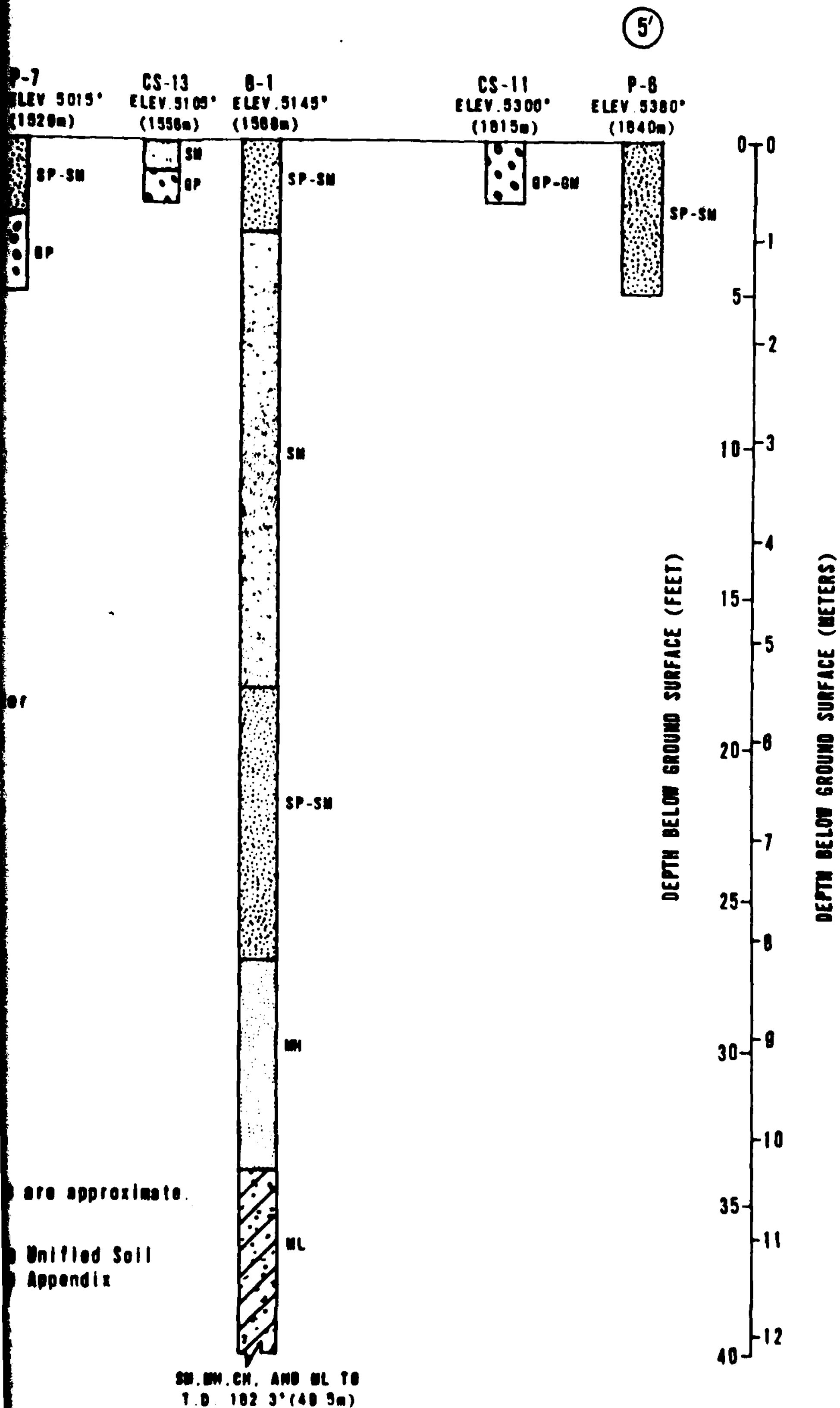


EXPLANATION

B - Boring
T - Trench
P - Test Pit
CS - Surficial soil sample at Cone Penetrometer Test location

NOTES:

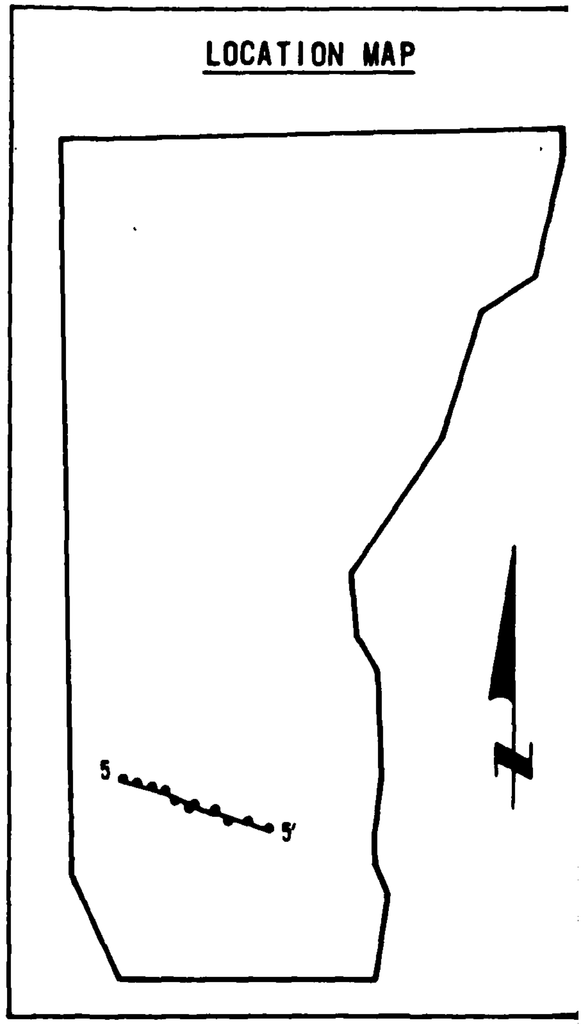
1. Ground surface elevations shown at activity locations are approxima
2. T.D. = Total Depth.
3. Soil types shown adjacent to soil column are based on Unified Soil Classification System (USCS) and are explained in the Appendix.

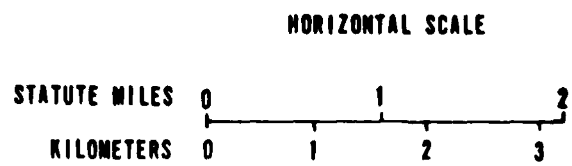


...er

... are approximate.

... Unified Soil
... Appendix

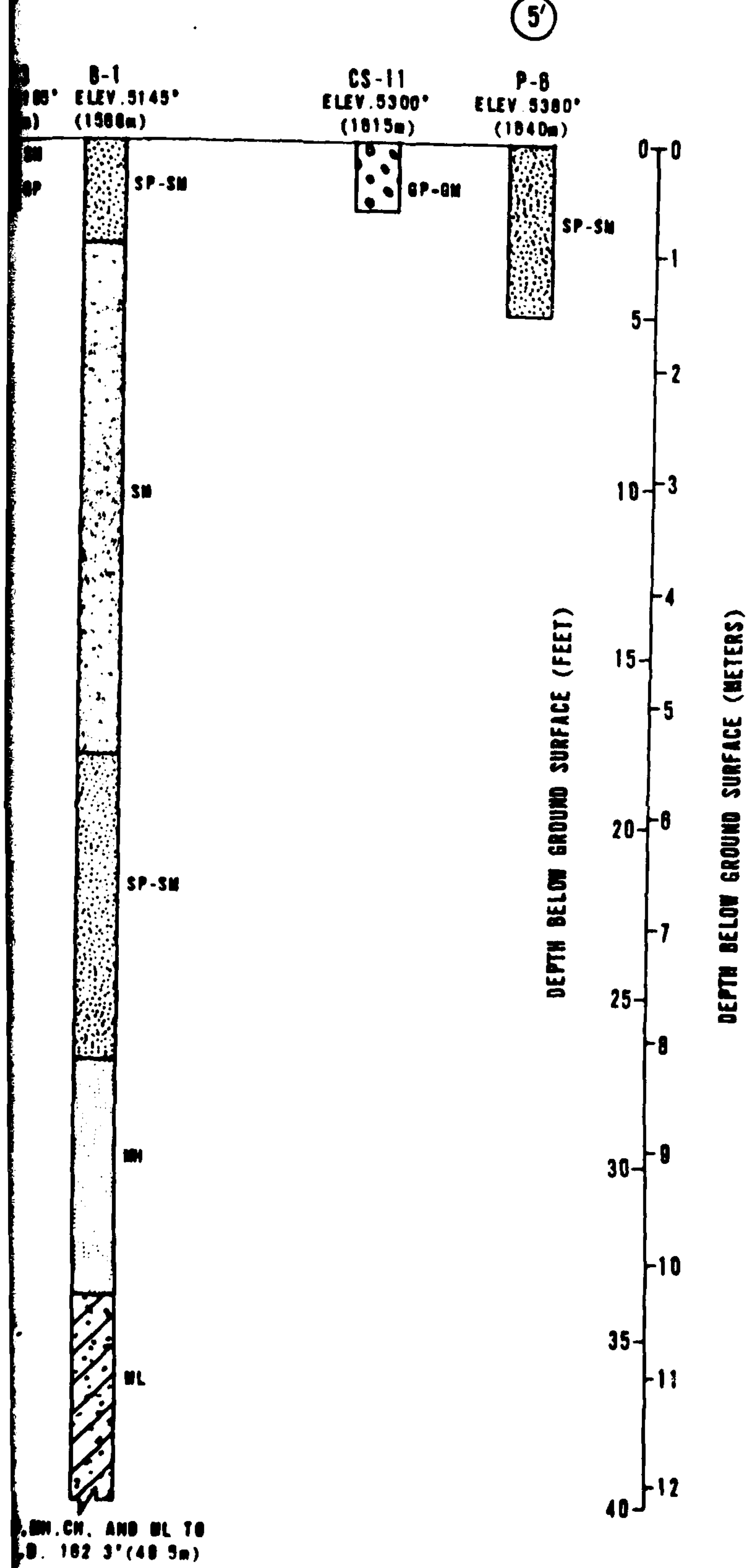


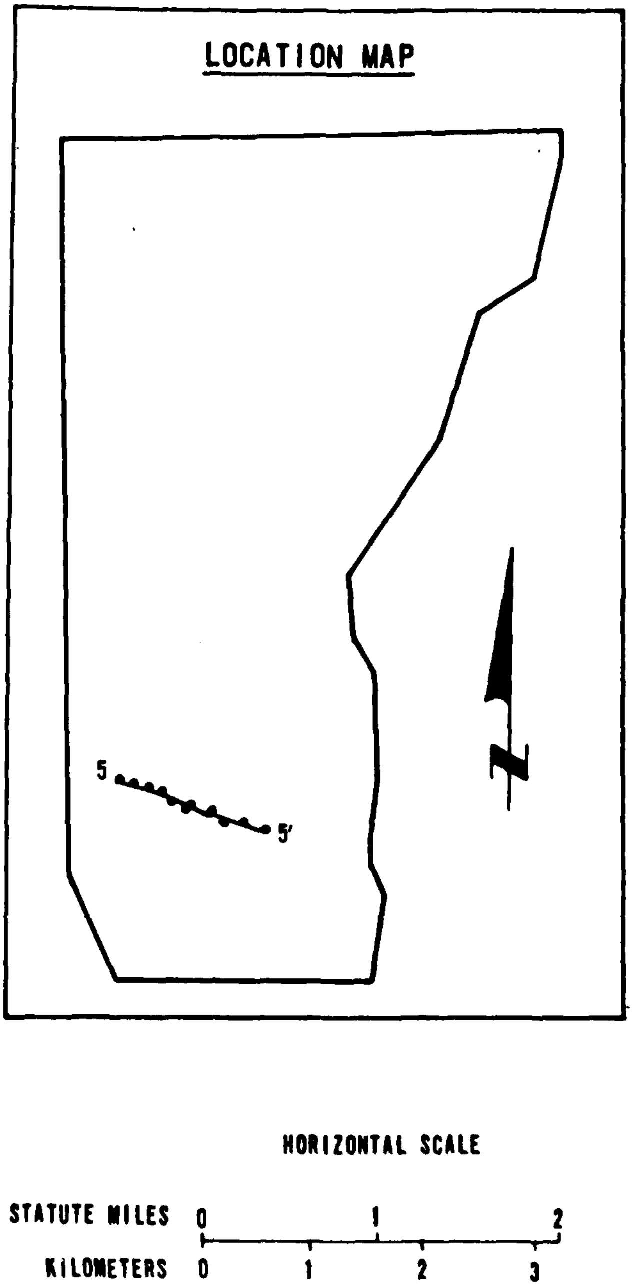


SOIL PROFILE 5-5'
VERIFICATION SITE, BIG SMOKY CDP,

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FUGRO NATIONAL



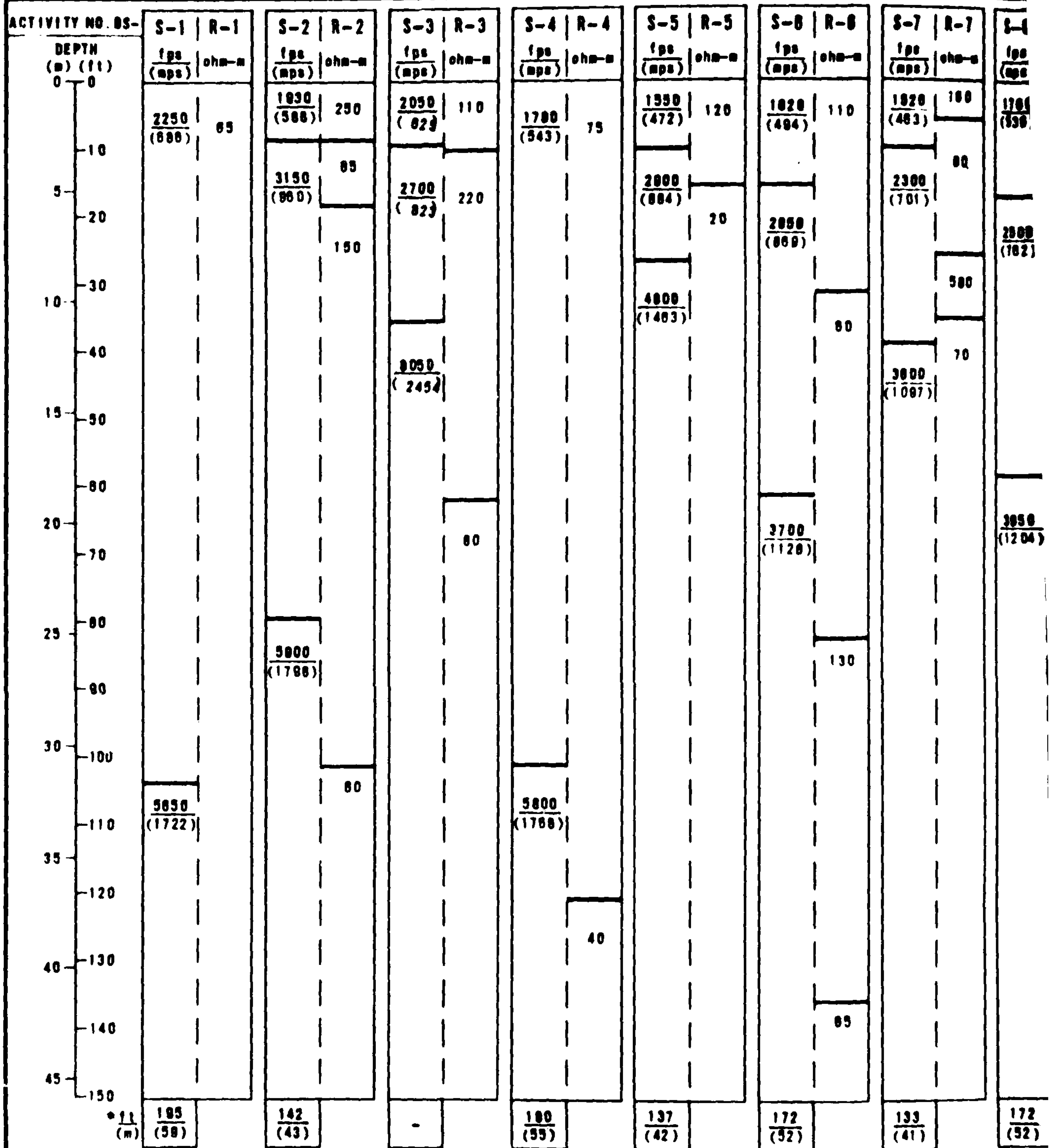


SOIL PROFILE 5-5'
VERIFICATION SITE, BIG SMOKY CDP, NEVADA

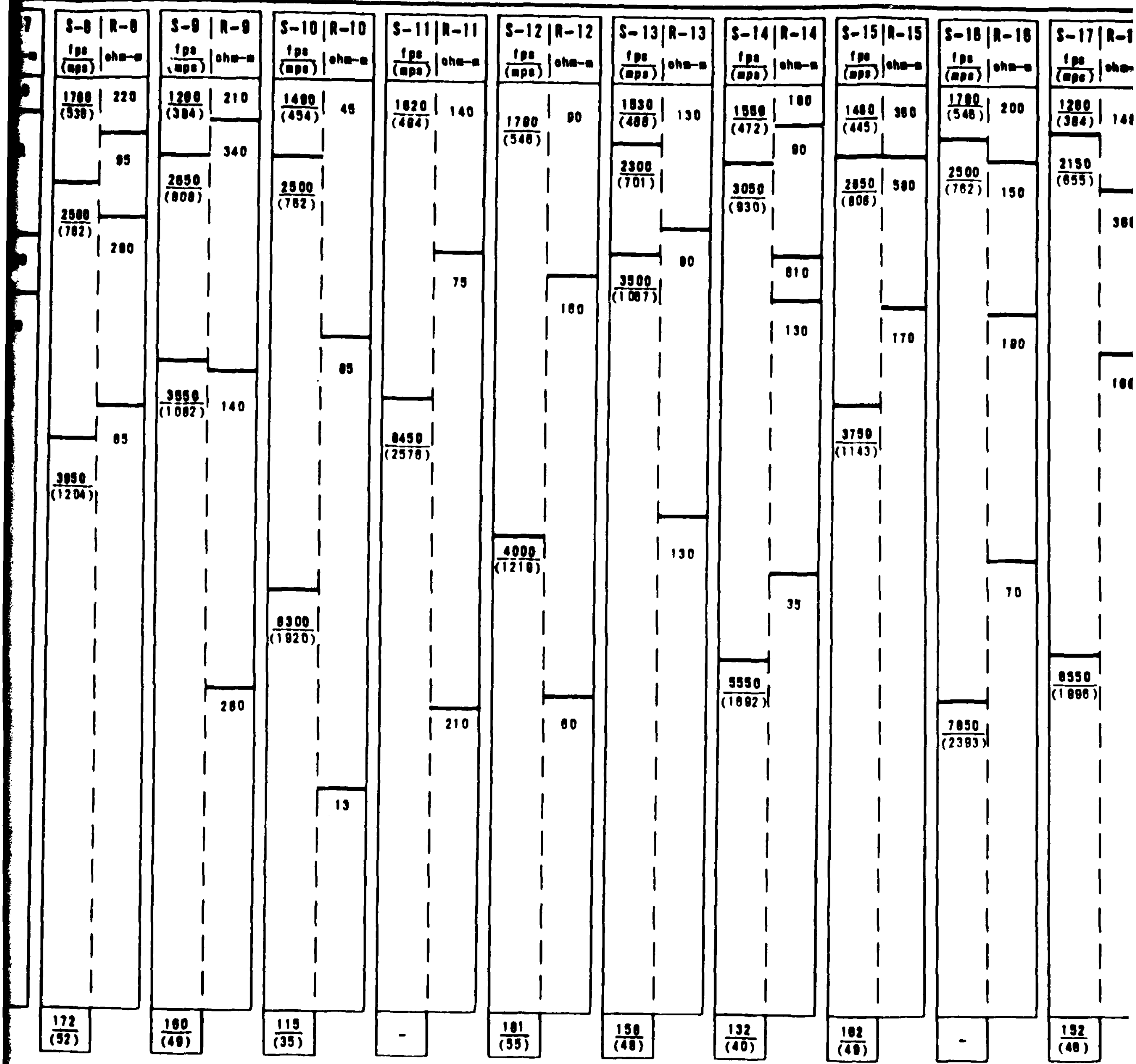
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 10-8

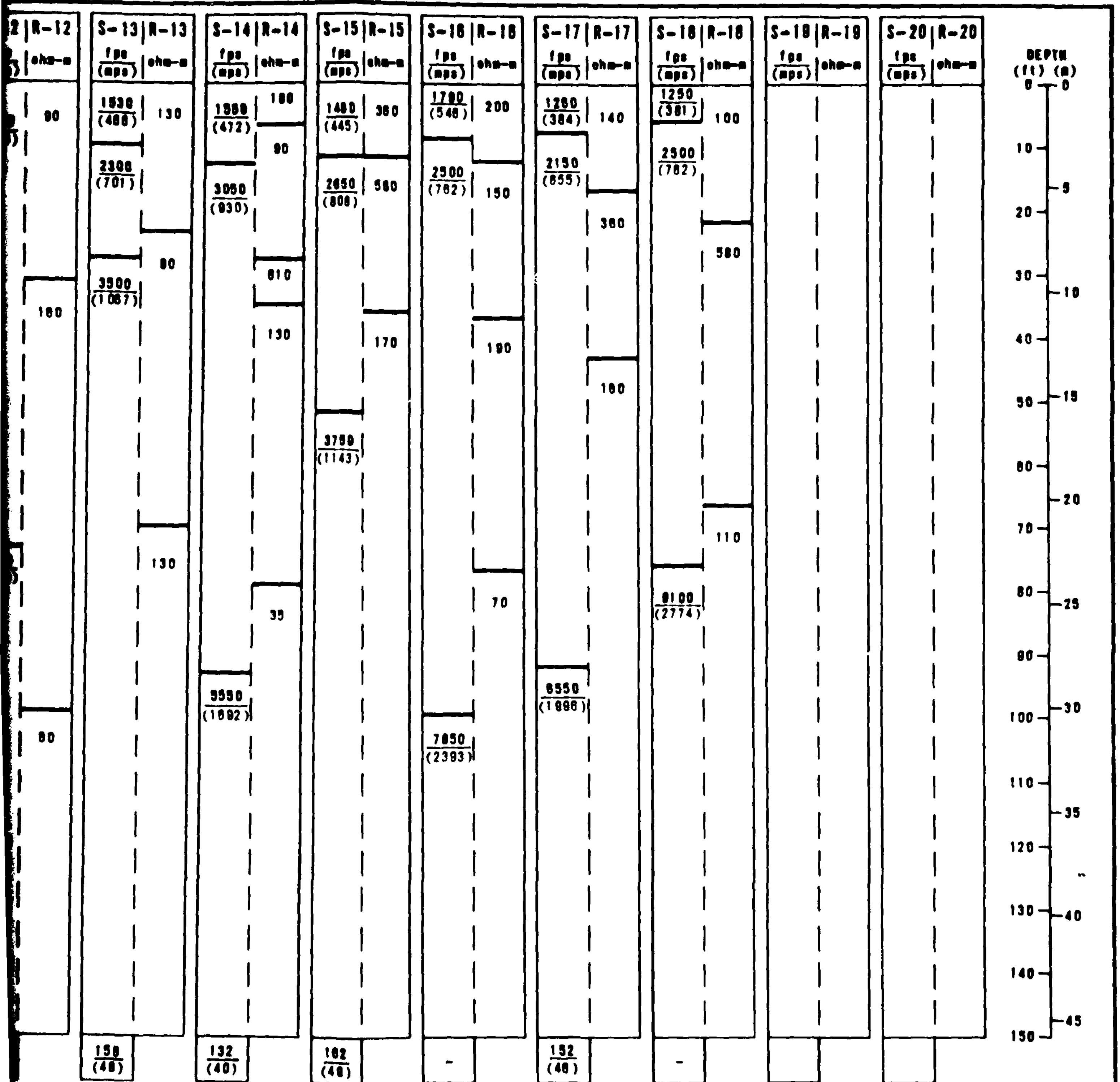
FUGRO NATIONAL, INC.



* Approximate depth above which there is no indication of material with a velocity as great as 7000 fps (2134 mps). See Appendix for an explanation of how this exclusion depth is calculated when the observed velocities are all less than 7000 fps (2134 mps).



S-8 | R-8
fps (mps) | ohm-m
1700 (538) 220 95 2500 (762) 280 3950 (1204) 65 65
172 (52)
S-9 | R-9
1260 (384) 210 340 2650 (808) 3550 (1082) 140 280
160 (49)
S-10 | R-10
1490 (454) 45 2500 (762) 85 6300 (1920) 13
115 (35)
S-11 | R-11
1620 (494) 140 75 8450 (2576) 210
S-12 | R-12
1790 (546) 90 160 4000 (1219) 60
181 (55)
S-13 | R-13
1530 (466) 130 2300 (701) 90 3500 (1067) 130
158 (48)
S-14 | R-14
1550 (472) 180 90 3050 (930) 610 130 35 5550 (1692)
132 (40)
S-15 | R-15
1460 (445) 360 2650 (808) 590 170 3750 (1143)
162 (49)
S-16 | R-16
1790 (546) 200 2500 (762) 150 190 70 7850 (2393)
S-17
1260 (384) 2150 (655) 6550 (1996)
152 (46)



SEISMIC REFRACTION AND ELECTRICAL RESISTIVITY
VERIFICATION SITE, BIG SMOKY CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 10-4

FUGRO NATIONAL, INC.

AFV-10

DEPTH RANGE	2' - 20' (0.6 -	
SOIL DESCRIPTION	Coarse-grained soils	
	Sandy Gravels, Gravelly Sands, Sands, Silty Sands, and Clayey Sands	
USCS SYMBOLS	GW, GP, GM, SW, SP, SM, SC	
ESTIMATED EXTENT IN SUBSURFACE %	85-100	
PHYSICAL PROPERTIES		
DRY DENSITY pcf (kg/m³)	103.4-124.1 (1656-1988) [20]	
MOISTURE CONTENT %	2.8-10.8 [20]	
DEGREE OF CEMENTATION	none to high	
COBBLES 3 - 12 inches (8 - 30 cm) %	0-10	
GRAVEL %	2-59 [17]	
SAND %	38-94 [17]	
SILT AND CLAY %	2-33 [17]	
LIQUID LIMIT	NDA	
PLASTICITY INDEX	NP [1]	
COMPRESSIONAL WAVE VELOCITY fps (mps)	1250-3150 (381-960) [18]	
SHEAR STRENGTH DATA		
UNCONFINED COMPRESSION S_u - ksf (kN/m²)	NDA	
TRIAXIAL COMPRESSION c - ksf (kN/m²), ø°	NDA	
DIRECT SHEAR c - ksf (kN/m²), ø°	NDA	

NOTES:

- Characteristics of soils between 2 and 20 feet (0.6 and 6.0 meters) are based on results of tests on samples from 8 borings, 8 trenches, and 32 test pits, and results of 18 seismic refraction surveys.
- Characteristics of soils below 20 feet (6.0 meters) are based on results of tests on samples from 8 borings and results of 18 seismic refraction surveys.

' - 20' (0.6 - 6.0m)		20' - 160' (6.0 - 49.0m)	
	Fine-grained soils	Coarse-grained soils	Fine-grained soils
Sands,	Sandy Silts	Sandy Gravels, Gravelly Sands, Sands, Silty Sands, and Clayey Sands	Sandy Silts, Silts Clayey Silts, and Clays
SC	ML	GC, SW, SP, SM, SC	ML, MH, CH
	0-5	85-90	10-15
[20]	NDA	84.9-134.0 (1360-2146) [61]	52.4-97.3 (839-1559) [13]
[20]	NDA	4.0-32.6 [61]	6.6-75.4 [13]
	none to moderate	none to low	none to high
	0	0-10	0
[17]	NDA	0-51 [23]	0 [2]
[17]	NDA	36-96 [23]	36-44 [2]
[17]	NDA	1-46 [23]	56-64 [2]
	NDA	29-49 [4]	50-110 [4]
[1]	NDA	7-29 [4]	NP-63 [5]
[16]	NDA	2150-6550 (655-1996) [16]	NDA
	NDA	NDA	5.6-5.8 (268-278) [2]
	NDA	c = 0, ϕ = 37° [2]	c = 1.3, ϕ = 35° (62) [3]
	NDA	c = 1.0-1.6, ϕ = 36-41° (48-77) [12]	NDA

• [ ] - Number of tests performed.

• NDA - No data available (insufficient data or tests not performed.)

CHARACTERISTICS OF SUBSURFACE SOIL
VERIFICATION SITE, BIG SMOKY CDP, NE

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FUGRO NATIONAL, I

2

...8 - 6.0m)	20' - 160' (6.0 - 49.0m)	
Fine-grained soils	Coarse-grained soils	Fine-grained soils
Sandy Silts	Sandy Gravels, Gravelly Sands, Sands, Silty Sands, and Clayey Sands	Sandy Silts, Silts Clayey Silts, and Clays
ML	GC, SW, SP, SM, SC	ML, MH, CH
0-5	85-90	10-15
NDA	84.8-134.0 (1360-2148) [61]	52.4-97.3 (839-1558) [13]
NDA	4.9-32.8 [61]	6.0-75.4 [13]
none to moderate	none to low	none to high
0	0-10	0
NDA	0-51 [23]	0 [2]
NDA	36-96 [23]	38-44 [2]
NDA	1-46 [23]	56-64 [2]
NDA	29-49 [4]	50-110 [4]
NDA	7-29 [4]	NP-63 [5]
NDA	2150-6550 (655-1996) [16]	NDA
NDA	NDA	5.6-5.8 (268-278) [2]
NDA	c=0, ϕ=37° [2]	c=1.3, ϕ=35° (82) [3]
NDA	c=1.0-1.6, ϕ=36-41° (46-77) [12]	NDA

- [ ] - Number of tests performed.
- NDA - No data available (insufficient data or tests not performed.)

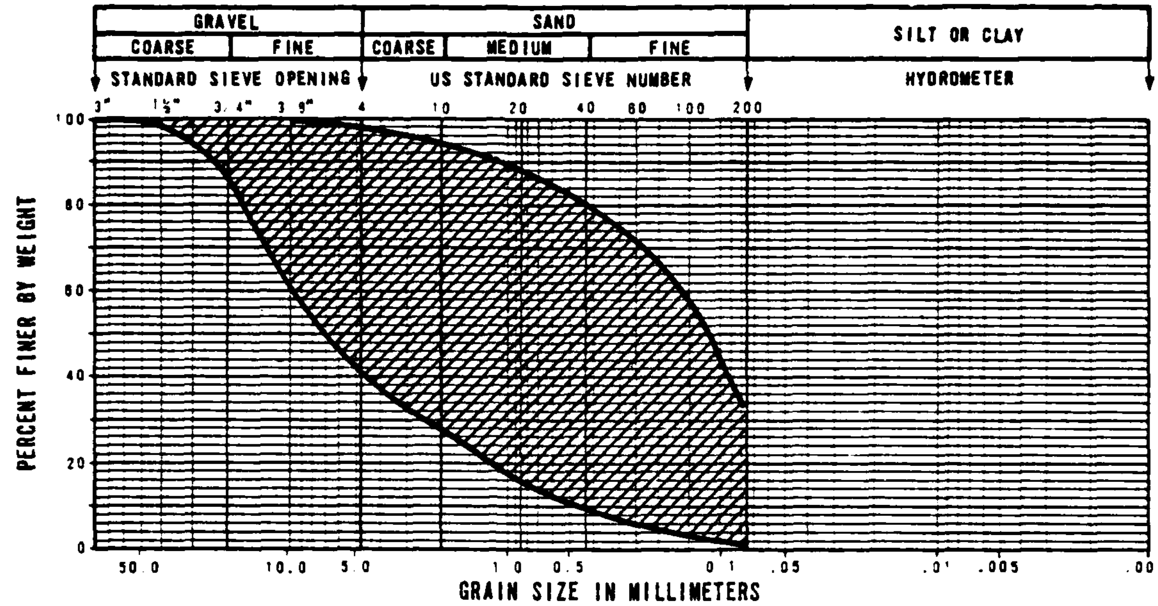
CHARACTERISTICS OF SUBSURFACE SOILS
VERIFICATION SITE, BIG SMOKY CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

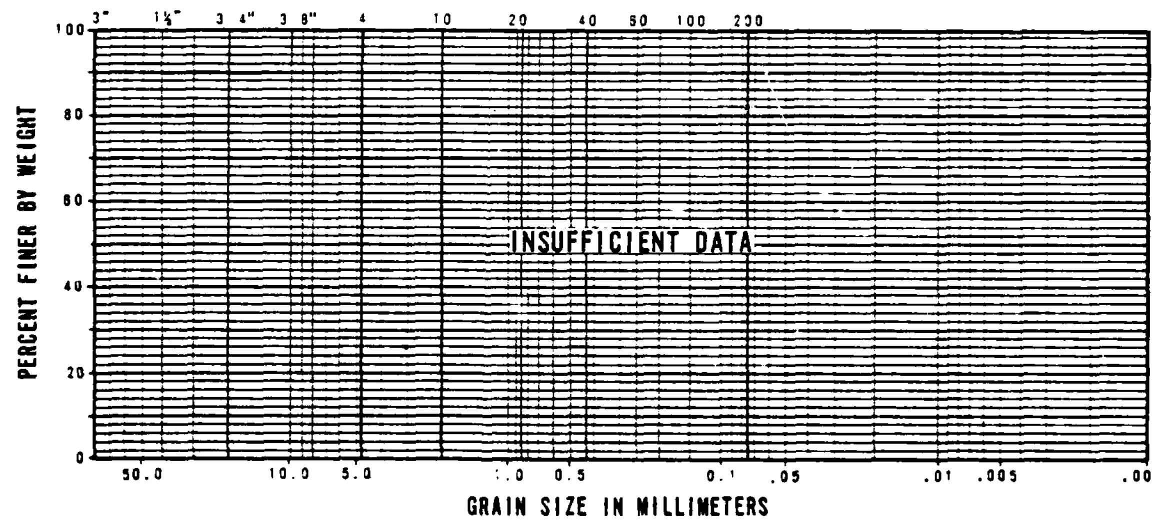
TABLE 10-5

FUGRO NATIONAL, INC.

AFV-20



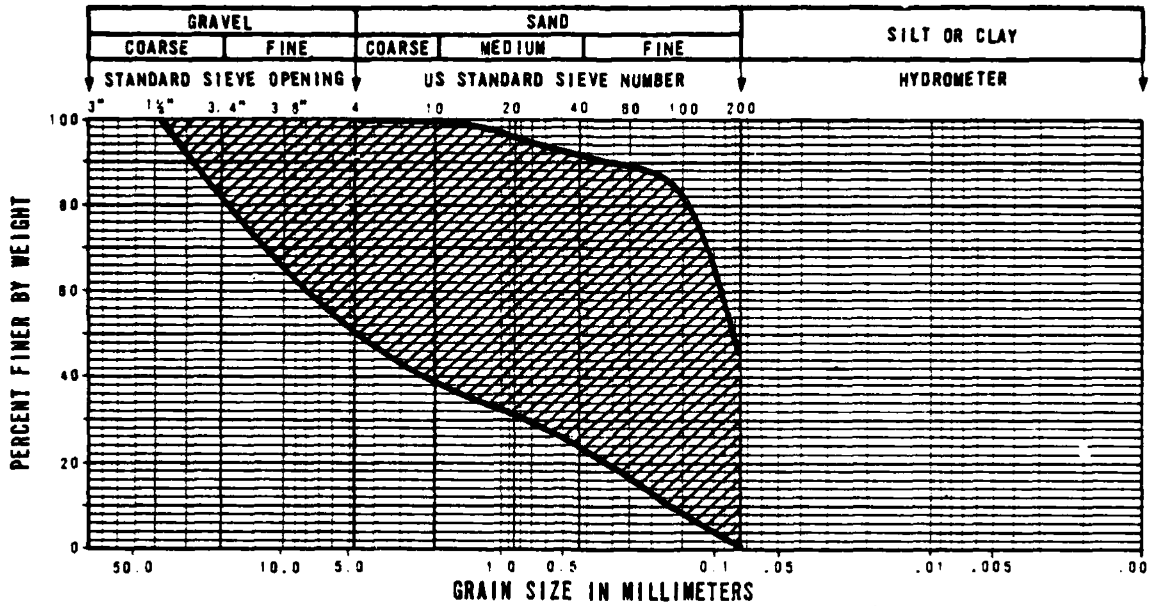
SOIL DESCRIPTION: Coarse-grained soils from 2 to 20 feet (0.6 to 6m)



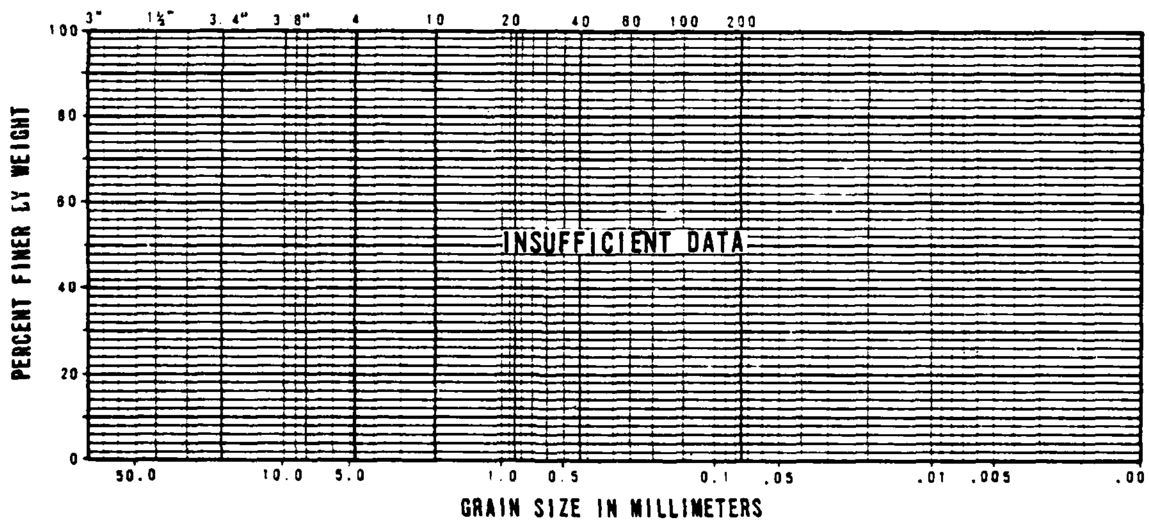
SOIL DESCRIPTION: Fine-grained soils from 2 to 20 feet (0.6 to 6m)

RANGE OF GRADATION OF SUBSURFACE SOILS VERIFICATION SITE, BIG SMOKY CDP, NEVADA	
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAMSO	FIGURE 10-7 1 OF 2

FUGRO NATIONAL, INC.



SOIL DESCRIPTION: Coarse-grained soils from 20 to 160 feet (6 to 49m)



SOIL DESCRIPTION: Fine-grained soils from 20 to 160 feet (6 to 49m)

RANGE OF GRADATION OF SUBSURFACE SOILS
VERIFICATION SITE, BIG SMOKY CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 10-7
2 OF 2

FUGRO NATIONAL, INC.

Granular subsurface soils are dense to very dense below approximate depths of 7 to 15 feet (2.1 to 4.5 m). Calcium carbonate cementation occurs intermittently, but well-developed, continuous cementation was not encountered. The coarse-grained soils exhibit very low compressibilities and moderate to high shear strengths. Fine-grained soils consist of silt and clay deposits below 28 feet (8.5 m) in the southern portion of the site. These apparently buried lacustrine deposits were not encountered in activities in other site areas but may have subsurface distribution throughout the southern and west-central portions of the site. These soils are stiff to hard and display both intermittent calcium carbonate cementation and gypsiferous intervals. These soils possess relatively high shear strength, low compressibilities where cemented or gypsiferous, and moderate compressibilities where uncemented.

Electrical conductivity of the soils in the upper 50 feet (15 m) ranges from 0.0025 to 0.0195 mhos per meter (average 0.0085 mhos per meter). At about 20 percent of the sites tested, the conductivity was less than the minimum of 0.004 mhos per meter specified in the Fine Screening criteria.

Chemical test results indicate negligible potential for sulfate attack of soils on concrete. However, the gypsiferous soils in the buried lacustrine deposits could cause considerable sulfate attack.

10.6 TERRAIN

The distribution of terrain features in the Big Smoky Site is shown in Drawing 10-3. The main factors affecting terrain are the north-south trending drainage, the low surface gradient, and the general valley morphology. Surface gradients in the central basin generally decrease southward at approximately 20 feet (6 m) per mile. Gradients south of Highways 6 and 95 are steeper (50 feet per mile; 15 m) and slope to the northeast.

The broad slope of the valley allows sediments eroding from the mountains and adjacent slopes to be deposited in extensive, low-lying younger fans with gentle slopes (generally between 1 and 3 percent). Drainages in most of the central basin are less than 3 feet (1 m) deep (category I). At the southern end of the site, incision is somewhat greater, averaging about 5 to 7 feet (1.5 to 2 m) in depth (category II). Drainage density averages 5 or more per mile along the main wash to 3 or less in the surrounding young fans and sheet sands.

Intermediate fans along the valley margins are somewhat steeper and more deeply incised. Drainages from 5 to 10 feet (1.5 to 3 m) deep are common in these upper fans (categories II and III). Drainage density generally ranges from 3 to 7 per mile.

The Crescent Dunes in the east-central portion of the site are unstabilized seif dunes up to 200 feet (60 m) high that are excluded due to their excessive relief. Other dunes, located near San Antonio Ranch in the north and Miller's Pond in the south, are 10 to 16 feet (3 to 5 m) high and moderately well vegetated. They are mapped as category VI (complex and highly variable terrain) but are not considered terrain exclusions due to the ease of preconstruction grading.

10.7 DEPTH TO ROCK

Generalized contours depicting depth to rock are shown in Drawing 10-4. All point data used in interpreting the depth to rock are shown on the map. Only three of the 23 data points encountered rock at less than 150 feet (46 m) and only one encountered rock at less than 50 feet (15 m); therefore, much of the interpretation is based primarily on geologic inference from surface data. Less than 15 percent of the site is underlain by rock less than 50 feet deep. An additional 13 percent is estimated to contain shallow rock between depths of 50 and 150 feet.

Depth to rock contours parallel the basin margin closely except along the east side of the valley, particularly in the Tonopah area and in the area north of the San Antonio Mountains, where abundant shallow rock occurs. These areas of suspected rock at less than 50 feet are based on the occurrence of isolated outcrops or on the presence of irregular topography near rock outcrops attributable to shallow rock. Elsewhere, interpretations are generally derived from surface slope projections calibrated with available point data. Where steep range front faults occur along the east flank of the Toiyabe Range and the west flank of the San Antonio Mountains, rock at depths exceeding 150 feet are interpreted very near the mountain front.

10.8 DEPTH TO WATER

The estimated configuration of the 50-foot (15-m) and 150-foot (46-m) depth to water contours for the Big Smoky Site is shown in Drawing 10-5. The interpretation is based on available published well data and other pertinent references summarized in Section 2.0, Volume VIII.

Big Smoky Valley is composed of two hydrographic areas: a northern part outside of the suitable area boundary and a southern part called Tonopah Flat. A low alluvial divide separates the two and topographically closes off northern Big Smoky. Tonopah Flat, which encompasses the site area, receives surface drainage from Ione Valley to the west, but has no surface water outlet (Rush and Schroer, 1970).

Water-table elevations in Tonopah Flat generally decrease toward the playas in the south and southwest. Numerous wells are clustered in the site providing good data control in some areas and none in others. Additional well-point data would be helpful in the northeast and northwest corners and along the eastern edge of the site.

Water exclusions are extensive within the site. Most of the suitable area (75 to 80 percent) is expected to be underlain by water at depths less than 150 feet. Places where water is interpreted to be less than 50 feet deep (approximately 15 percent) are found in broad areas of the southeast and southwest. Most ground water is unconfined; however, localized shallow water occurring around San Antonio Ranch and at the northeast edge of the site are attributed to perched conditions.

10.9 RESULTS AND CONCLUSIONS

10.9.1 Suitable Area

Suitable area resulting from FY 79 Verification Studies in Big Smoky is shown in Drawing 10-6. The site contains approximately 410 mi^2 (1060 km^2) of usable area for a hybrid trench and 155 mi^2 (400 km^2) for a vertical shelter concept. A significant reduction in area from previously reported Intermediate/Fine Screening studies has occurred due primarily to:

1. Expansion of areas underlain by shallow water, particularly at depths of 150 feet throughout the center of the valley; and
2. Expansion of exclusions due to shallow rock, chiefly in the eastern part of the site.

10.9.2 Construction Considerations

Geotechnical factors and conditions pertaining to construction of the MX system in suitable area are discussed in this section. Both the hybrid trench and vertical shelter basing modes are considered in this discussion.

10.9.2.1 Grading

Mean surficial slopes in the suitable area are approximately 2 percent (range of 0 to 7 percent). Thus, minimal preconstruction grading will be required for roads and trenches. Steeper slopes, ranging between 4 to 7 percent, will be encountered in intermediate and old fans and in fans influenced by range-bounding faults in the northeast and east-central portions of the site. More extensive grading will be necessary for vertical shelters sited in these steeper areas.

10.9.2.2 Roads

Surficial soils exhibit low strength to an average depth of 2.4 feet (0.7 m) with a maximum depth approaching 10 feet (3.0 m). The subgrade supporting properties of low strength, coarse-grained soils are inadequate but can be sufficiently improved by mechanical compaction. Compaction to a depth of 2 to 3 feet (0.6 to 0.9 m) appears necessary, with compaction to greater depth required in less than 10 percent of the site. Based on results of laboratory CBR tests, compacted coarse-grained soils will provide good to very good subgrade support for roads. Due to the low incidence of fine-grained soils in the surficial zone, few roadway sections will be underlain by these soils. Where existent, fine-grained soils will be inadequate for direct support of roadways. Required support can be attained by using a select granular subbase layer over the compacted fine-grained soil subgrade. As an alternative, these soils could be partially or totally removed, depending upon their thickness, and replaced by a sufficient thickness of coarse-grained soil to obtain the required subgrade support. Well-graded gravelly sands and sandy gravels with less than 25 percent fines (passing a No. 200 sieve) will be suitable as road subbase and base course material. Soils of this type are widely distributed over the site with occurrence in some active drainage channels and in fans from the valley center to mountain fronts. Mine waste piles (dredgings) near Manhattan, in the northeast portion of the site, may also provide a source for processed base course.

Drainage incisions are generally less than 6 feet (1.8 m) deep within 80 percent of the suitable area. In the remaining area, depths of drainage incisions range from 6 to 15 feet (1.8 to 4.6 m). Therefore, the cost of drainage structures for roads and trenches will be low to moderate.

10.9.2.3 Excavatability and Stability

Subsurface soils in the suitable site area are predominantly coarse-grained with fine-grained soils estimated in less than 15 percent of the construction zone. Subsurface soils are generally dense to very dense below 10 feet (3 m) with intermittent calcium carbonate cementation.

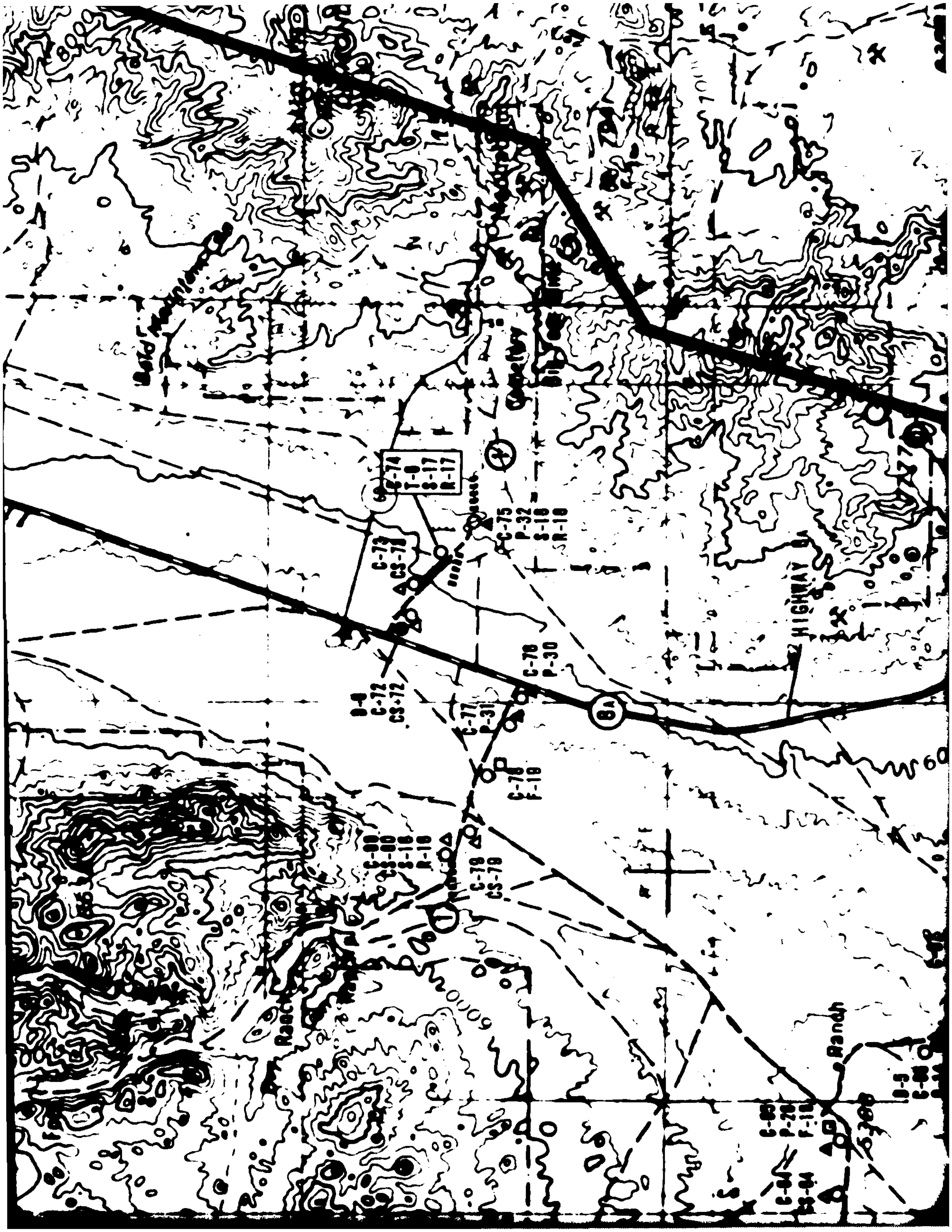
Hybrid Trench: Compressional wave velocities in the upper 20 feet (6 m) indicate easy to moderately difficult excavation in the suitable area. MX trenchers could be used to excavate continuous trenches suitable for cast-in-place construction. Because of low strength surficial soil, the top 2 to 5 feet (0.6 to 1.5 m) in all trench excavations will generally have to be sloped back for stability. Below this zone, vertical trench walls will remain temporarily stable in approximately 85 percent of the suitable area. In the remaining areas, the fines content or degree of cementation is inadequate to provide temporary stability for vertical cuts without caving or excessive overbreak. Therefore, trench walls in these areas will have to be shored or sloped for stability.

Vertical Shelter: Within the depth of excavation for vertical shelters, compressional wave velocities indicate that large diameter auger drills are feasible for vertical shelter excavation, with difficult excavation in only limited zones. Most excavation will be in uncemented, cohesionless granular soils. Therefore, the vertical walls of these shelters may not remain stable to depths of 120 feet (36.6 m) and will probably require the use of slurry or other stabilizing techniques.

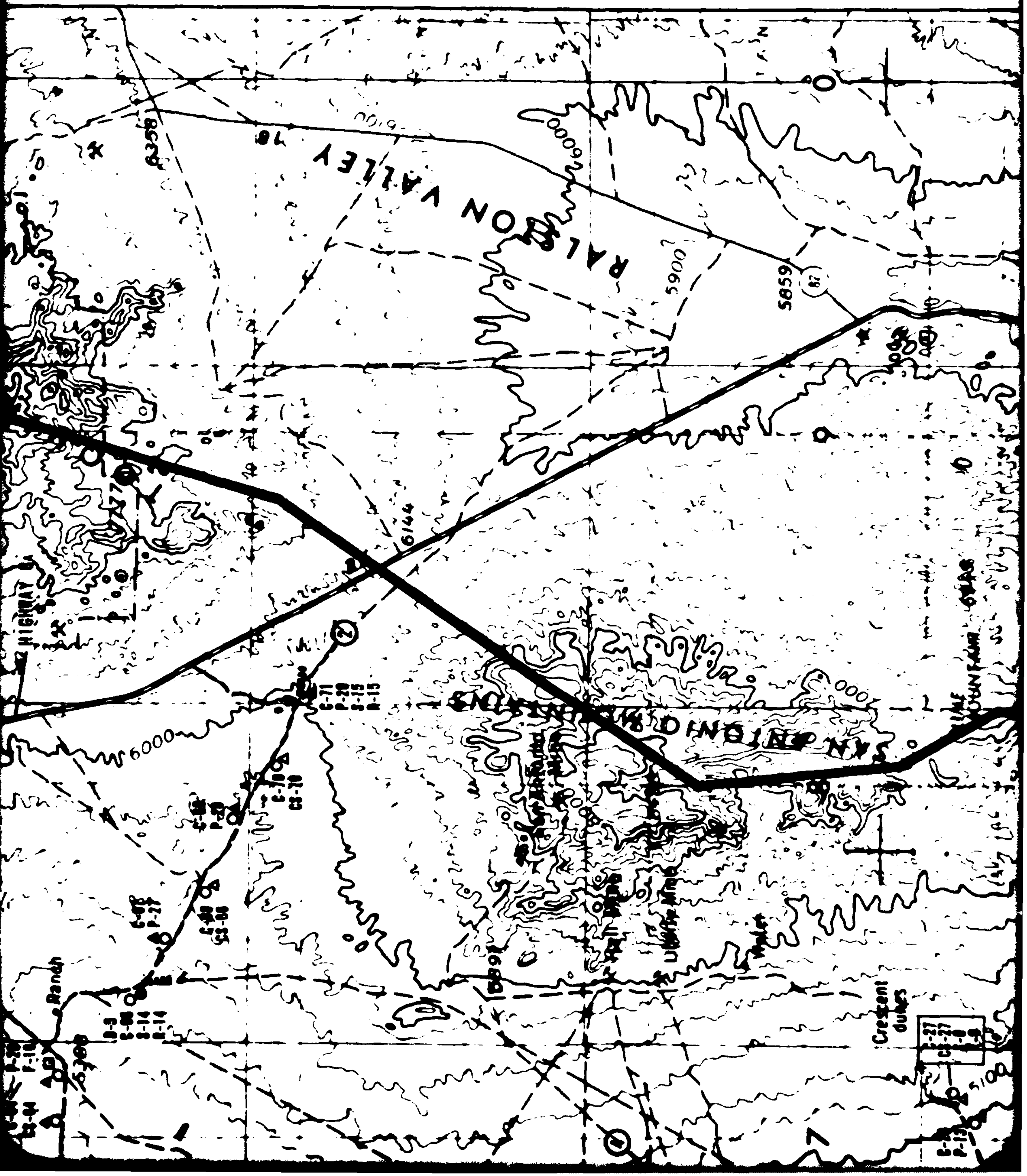
10.10 RECOMMENDATIONS FOR FUTURE STUDIES

The following geotechnical conditions have been identified as requiring additional information.

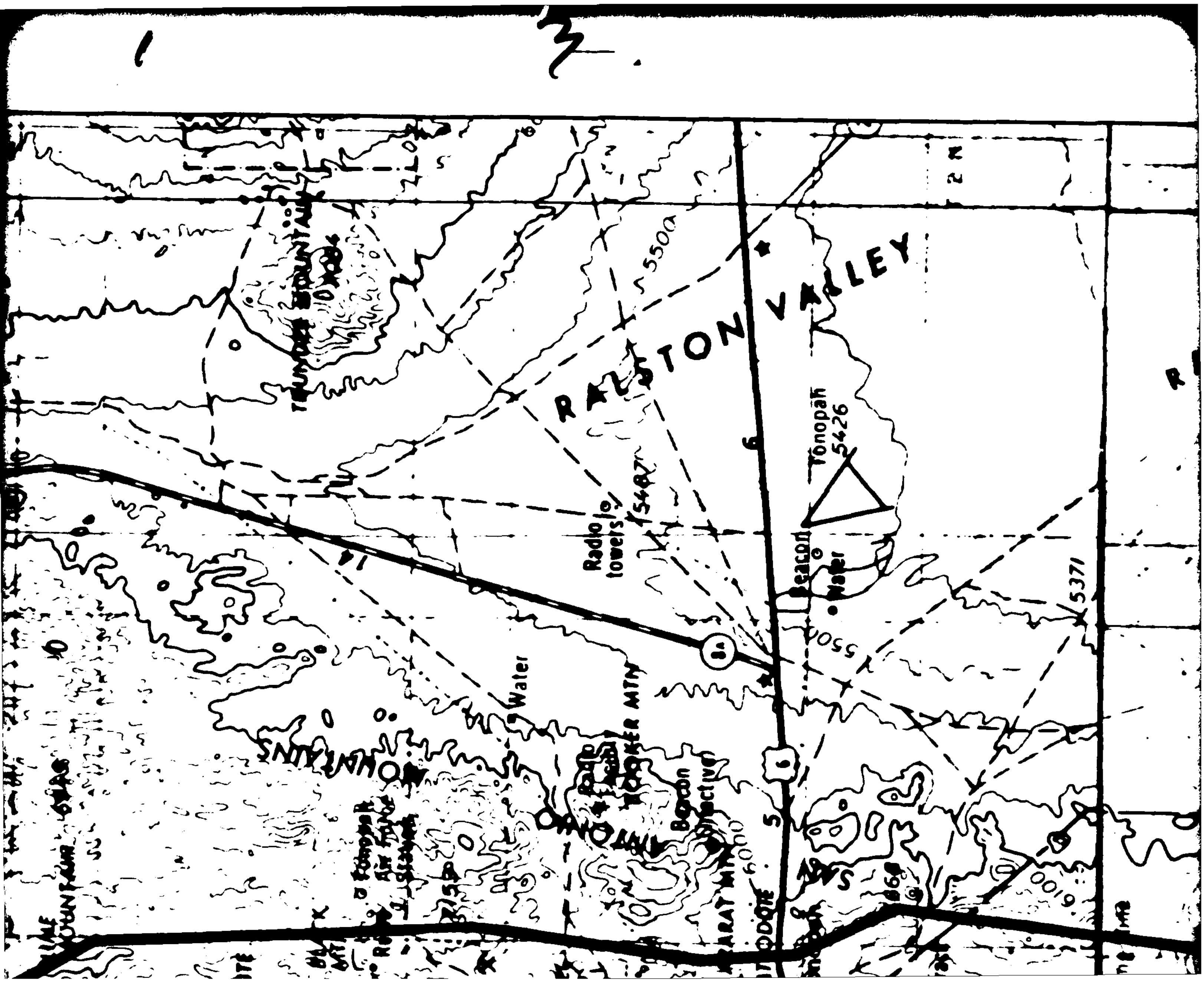
1. In eastern Big Smoky, the limits of extensive shallow rock area are unknown. Additional borings and seismic refraction surveys would help define these limits.
2. Additional ground-water data could be used in the far northern and eastern portions of the site where depth to water data is absent and definition of the 150-foot contour is obscure. Ground-water observation wells at selected localities are recommended to provide better contour control.

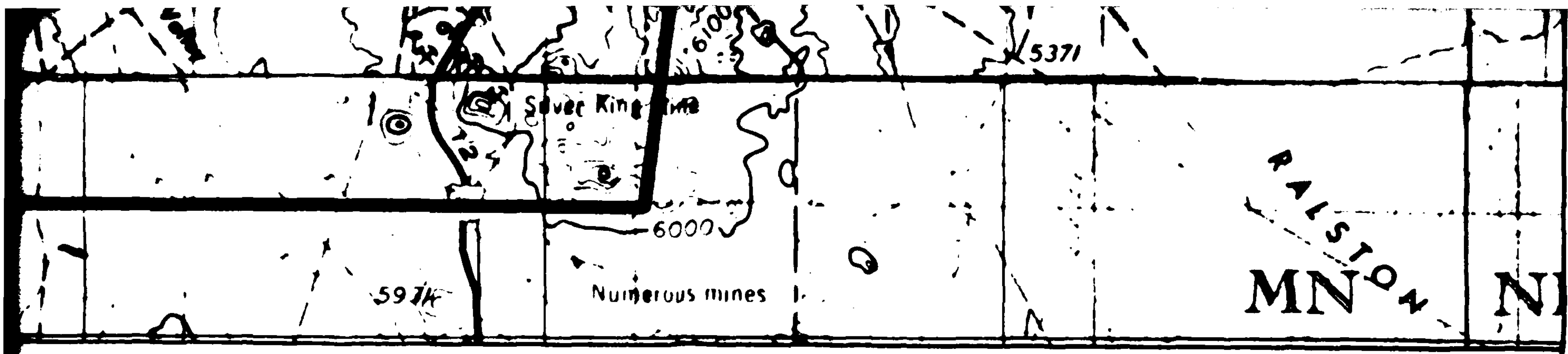

HIGHWAY

1 2



RALSTON VALLEY
5859
5900
6000
6144
HIGHWAY
Ranch
Crescent dunes


RALSTON VALLEY
Tonopah
5426
Radio towers
5487
Beacon
Water
5500
5371
Water
MOUNTAINS
6000
6100
14
6
5



EXPLANATION

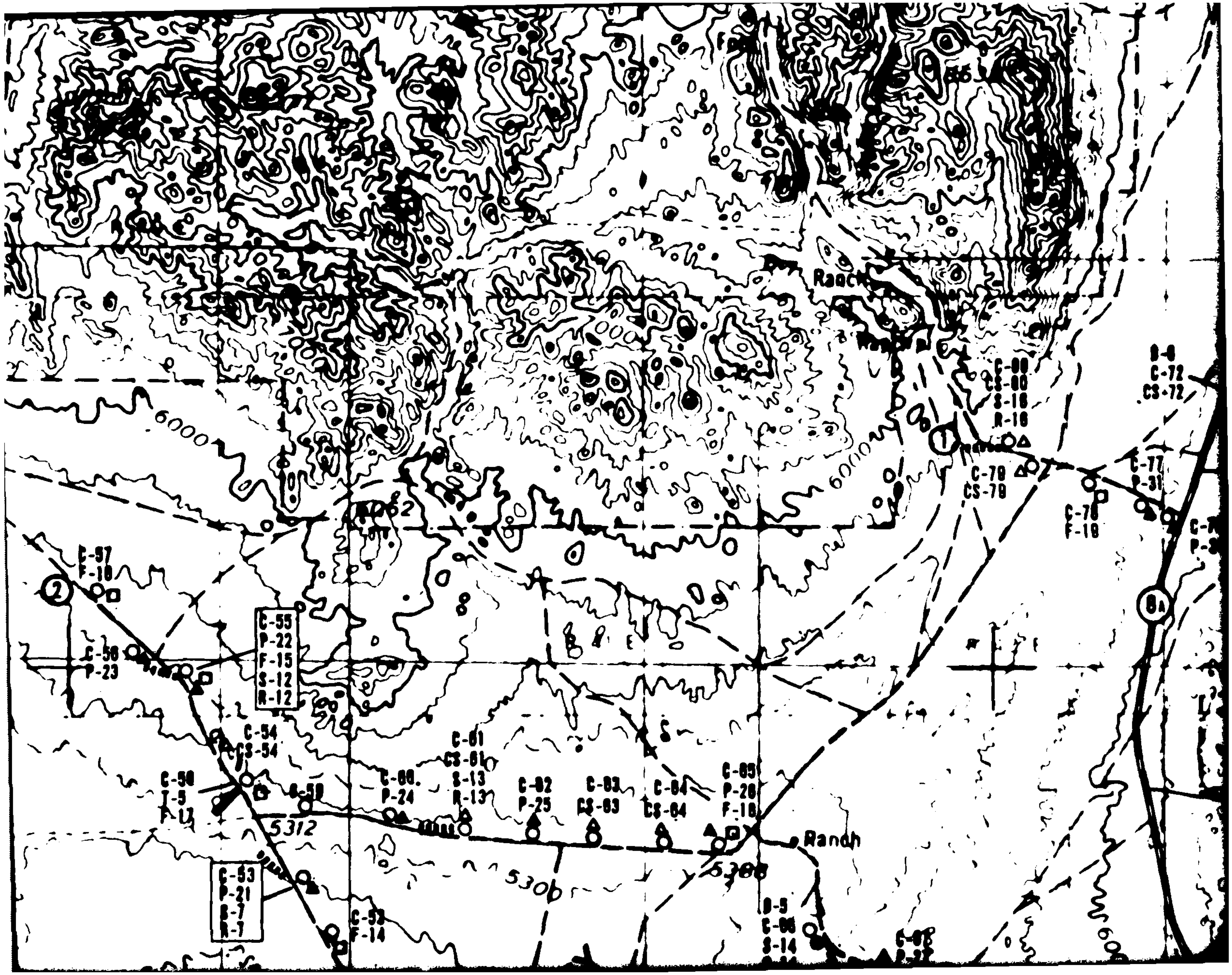
- B-1 BORING
- C-1 CONE PENETROMETER TEST (CPT)
- CS-1 SURFACE SAMPLE AT CPT LOCATION
- T-1 TRENCH
- P-1 TEST PIT
- S-1 SEISMIC REFRACTION LINE
- R-1 ELECTRICAL RESISTIVITY LINE
- F-1 FIELD CALIFORNIA BEARING RATIO (CBR) TEST
- (1) ACTIVITY LINE

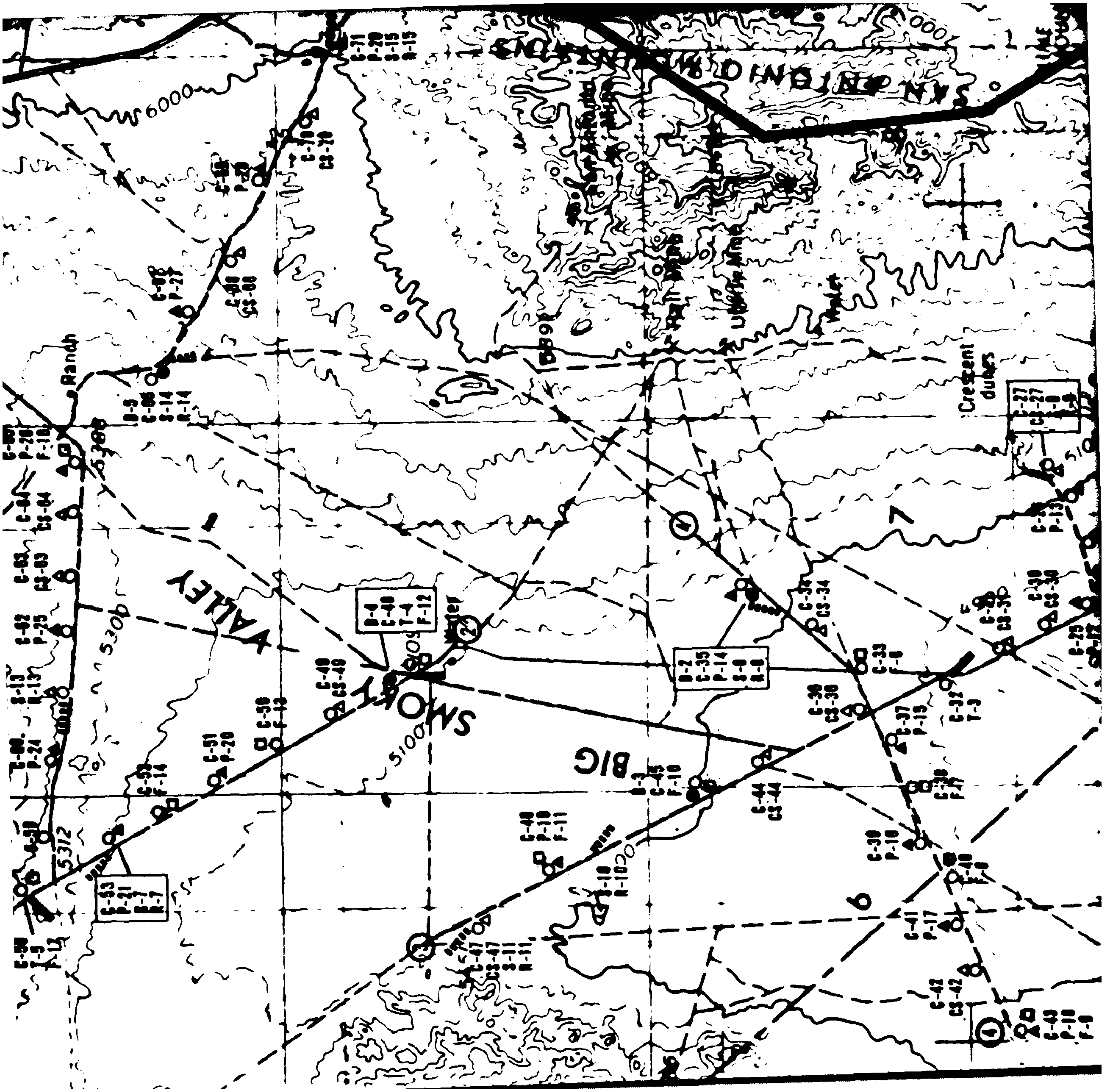
ltiple activities were performed at the same location.
eet location is designated by either (1) the boring
or (2) the CPT symbol, if no boring was drilled.

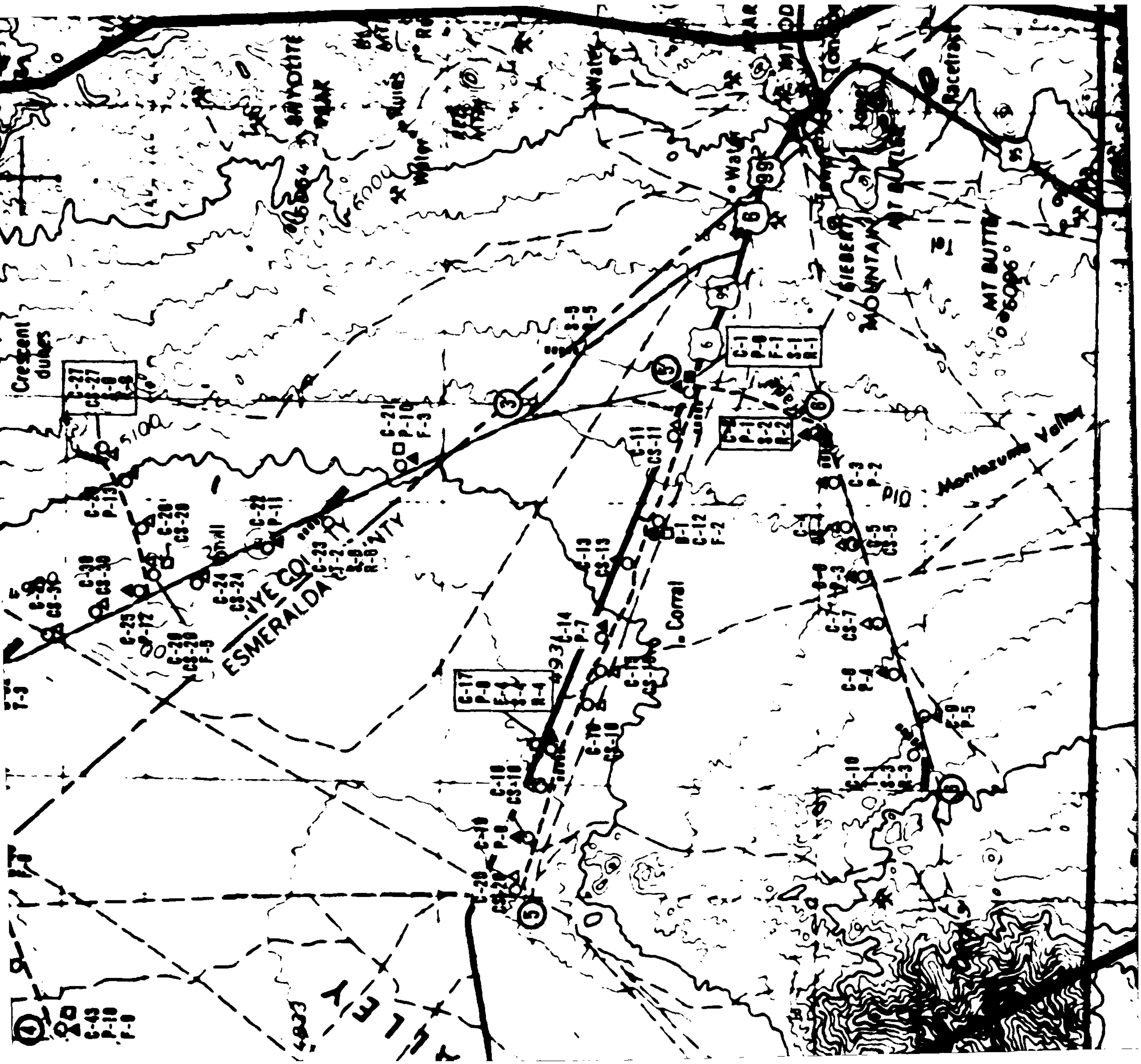
SCALE 1:125,000

0 2 4
STATUTE MILES

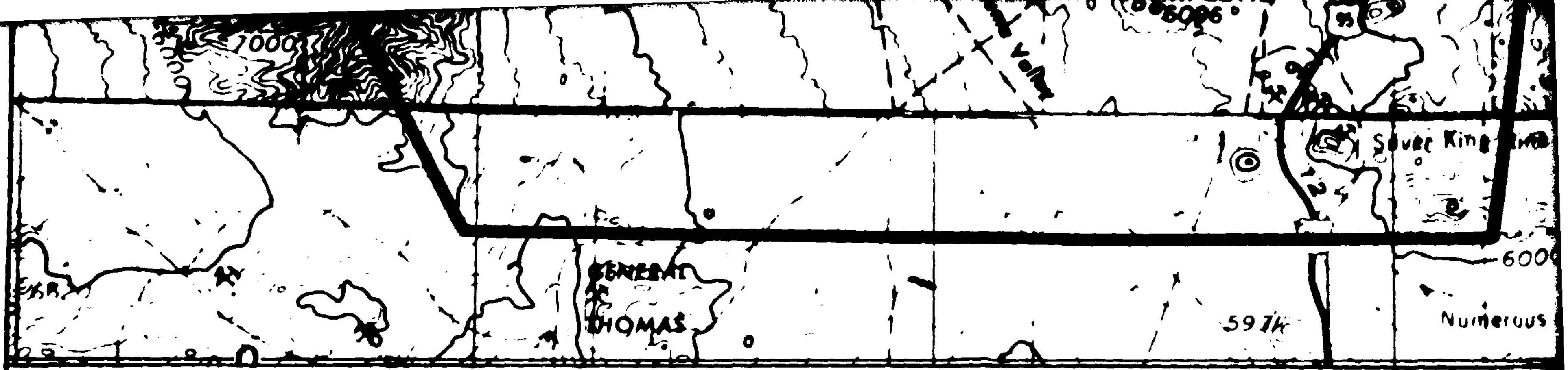
0 2 4
KILOMETERS


6000
6000
5312
5306
5308
Ranch
Ranch
C-80
CS-80
S-16
R-16
C-72
CS-72
C-77
P-31
C-79
CS-79
C-78
F-18
C-57
F-18
C-56
P-23
C-55
P-22
F-15
S-12
R-12
C-54
CS-54
C-58
C-60
P-24
C-61
CS-61
S-13
R-13
C-62
P-25
C-63
CS-63
C-64
CS-64
C-65
P-26
F-18
C-53
P-21
C-52
F-14
C-66
S-14


SMOKY
VALLEY
BIG
Ranch
Crescent dunes
6000
5300
5100
5312



Crescent dunes
NYE CO
ESMERALDA COUNTY
Montezuma Valley
MT BUTLER
Corral



EXPLANATION

- ● B-1 BORING
- ○ C-1 CONE PENETROMETER TEST (CPT)
- △ CS-1 SURFACE SAMPLE AT CPT LOCATION
- ▬ T-1 TRENCH
- ▲ P-1 TEST PIT
- ▪▪▪▪▪ S-1 SEISMIC REFRACTION LINE
- R-1 ELECTRICAL RESISTIVITY LINE
- □ F-1 FIELD CALIFORNIA BEARING RATIO (CBR) TEST
- (1)- - - - - -(1') ACTIVITY LINE

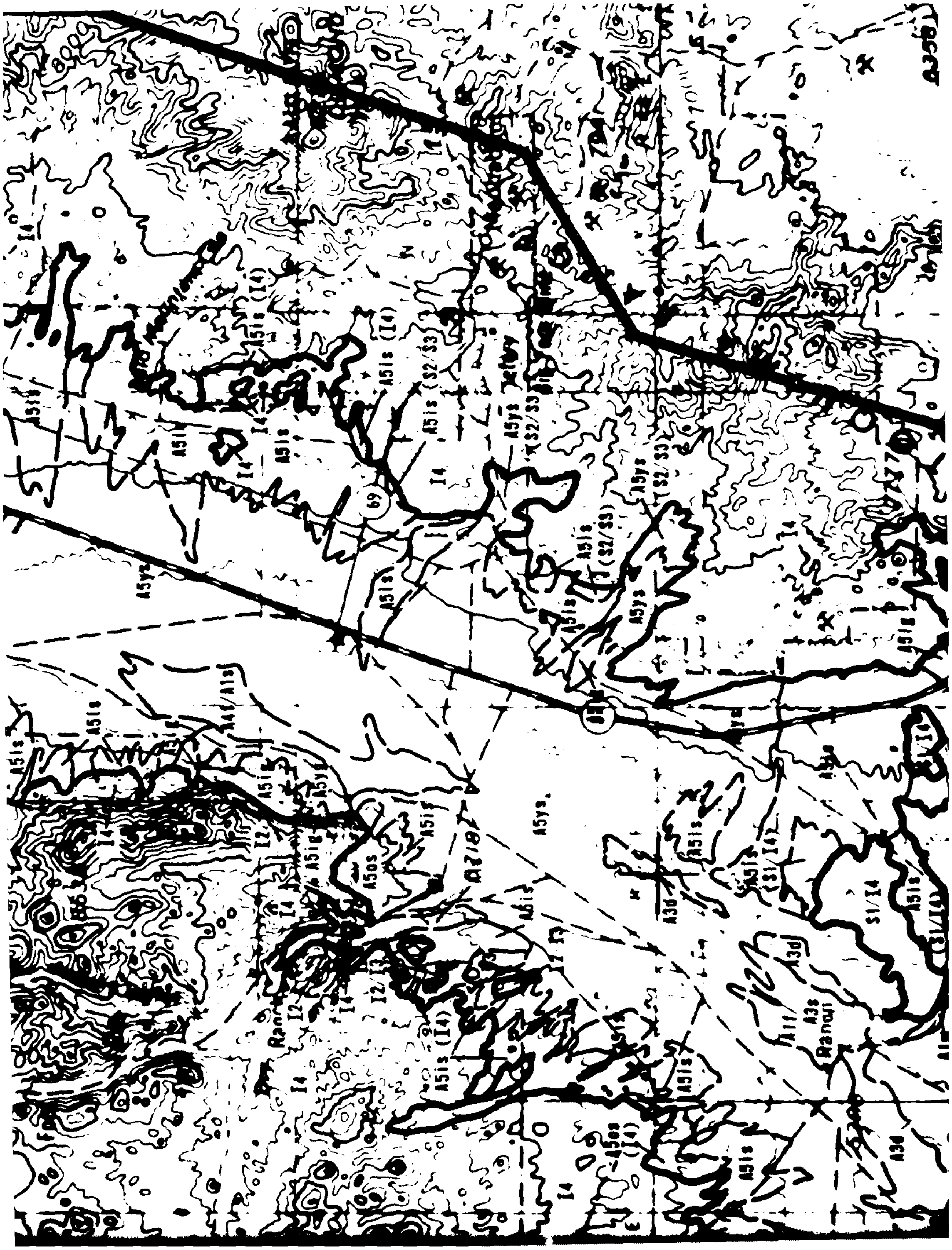
NOTE: Where multiple activities were performed at the same location, the correct location is designated by either (1) the boring symbol or (2) the CPT symbol, if no boring was drilled.

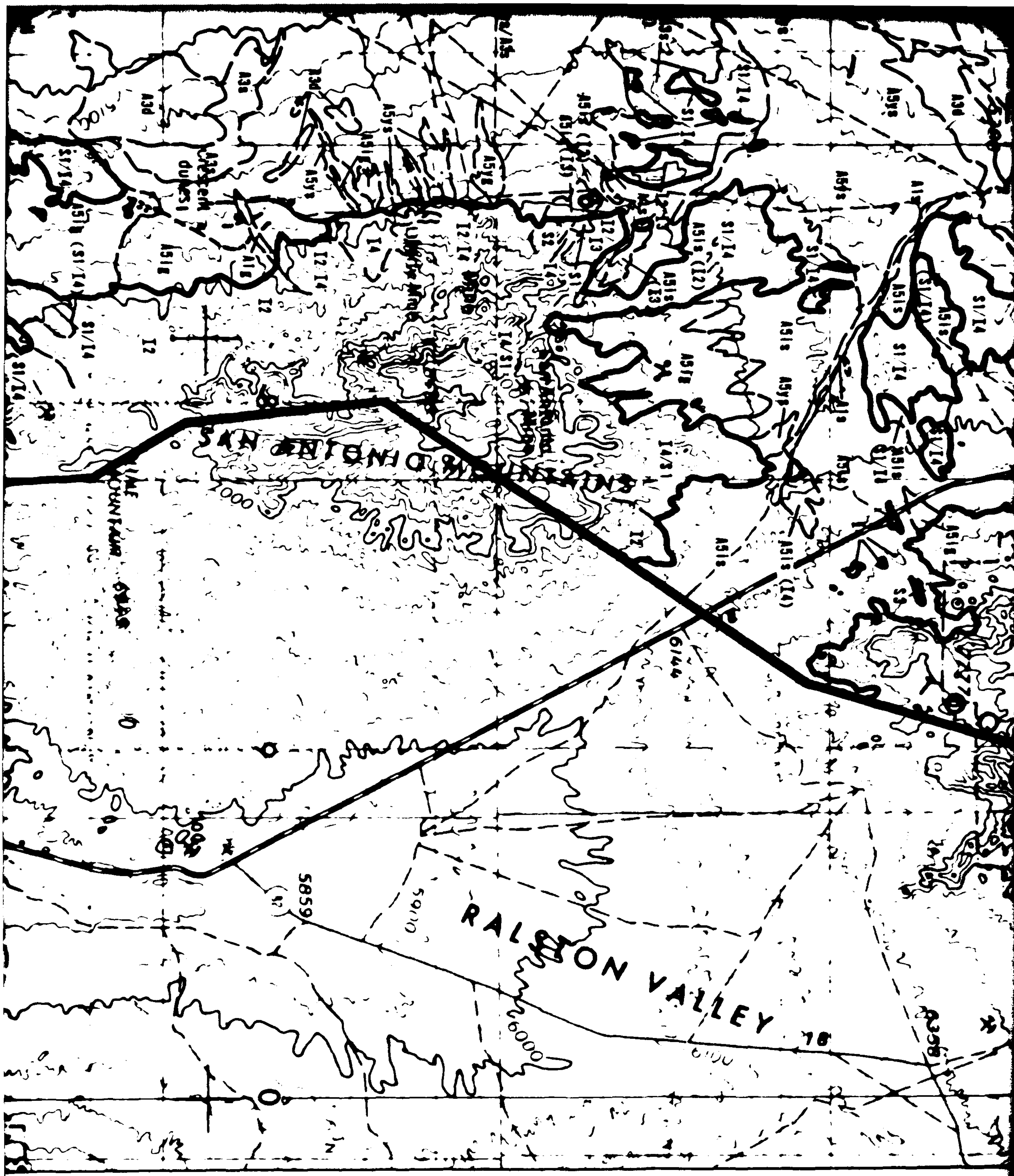
ACTIVITY LOCATIONS
VERIFICATION SITE, BIG SMOKY CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

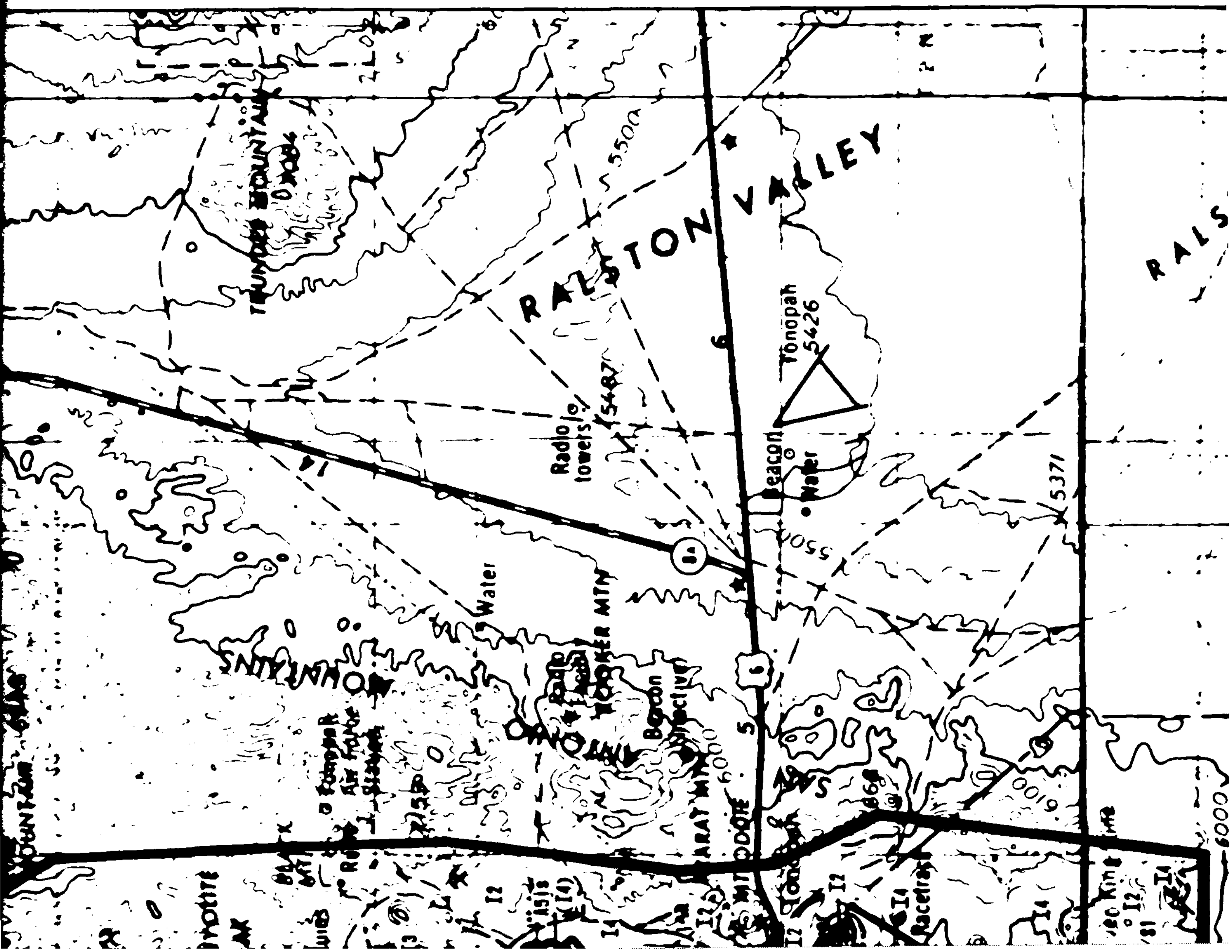
DRAWING 10-1

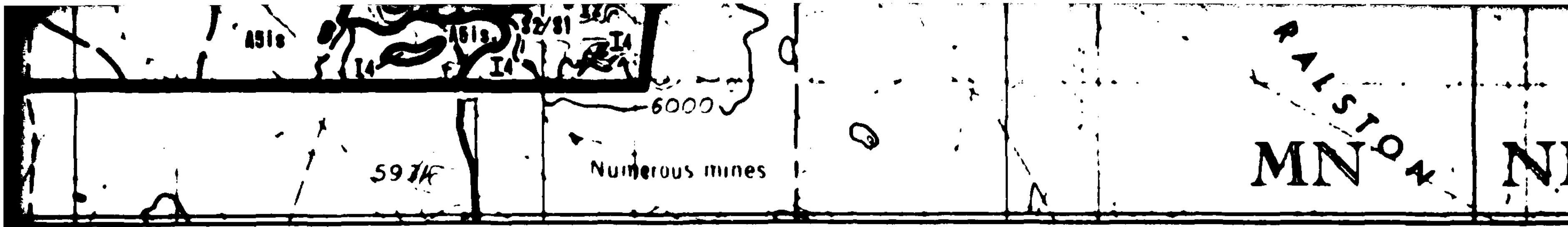
FUGRO NATIONAL, INC.


A5ys
A5is (I4)
A5is (S2/S3)
A5os
A3d
I4
S1/I4
Ranqui


RALSTON VALLEY
SAN ANTONIO MOUNTAINS
5859
6144

1 3


RALSTON VALLEY
RALS
Tonopah
5426
Radio towers
5487
Beacon
Water
5371
5500
6000
6100
14
6



EXPLANATION

AL BASIN-FILL DEPOSITS*

m stream channel and floodplain deposits of: A1f, sandy
ilty sand (SM); and A1g sandy gravel (GM,GP).

d and silty sand (SP, SM) in A3s, thin sheets and sand (SP)
unes.

playa deposits of: A4f, sandy silt (ML) and A4s.

Active, younger alluvial fan deposits of: A5ys, uncemented
and gravelly sand (SM) and A5yg, sandy gravel (GM).

its - Inactive, intermediate-age alluvial fan deposits of:
d and gravelly sand (SM) and A5ig, weakly cemented sandy

ROCK UNITS

, and andesite plugs and flows

ded ash-flow tuff, and lithic air-fall tuff

ite

1

4

gravelly sand (SM) and A5yg, sandy gravel (GM).

- Inactive, intermediate-age alluvial fan deposits of:
and gravelly sand (SM) and A5ig, weakly cemented sandy

ROCK UNITS

and andesite plugs and flows

ash-flow tuff, and lithic air-fall tuff

te

to marble

faceous

bols indicates a mixture of ethier surficial basin-fill or
ale.

ce unit at shallow depth.

SYMBOLS

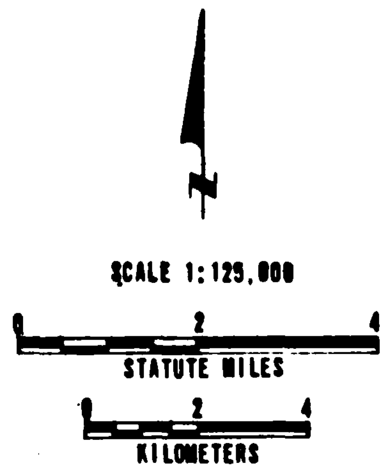
fill.

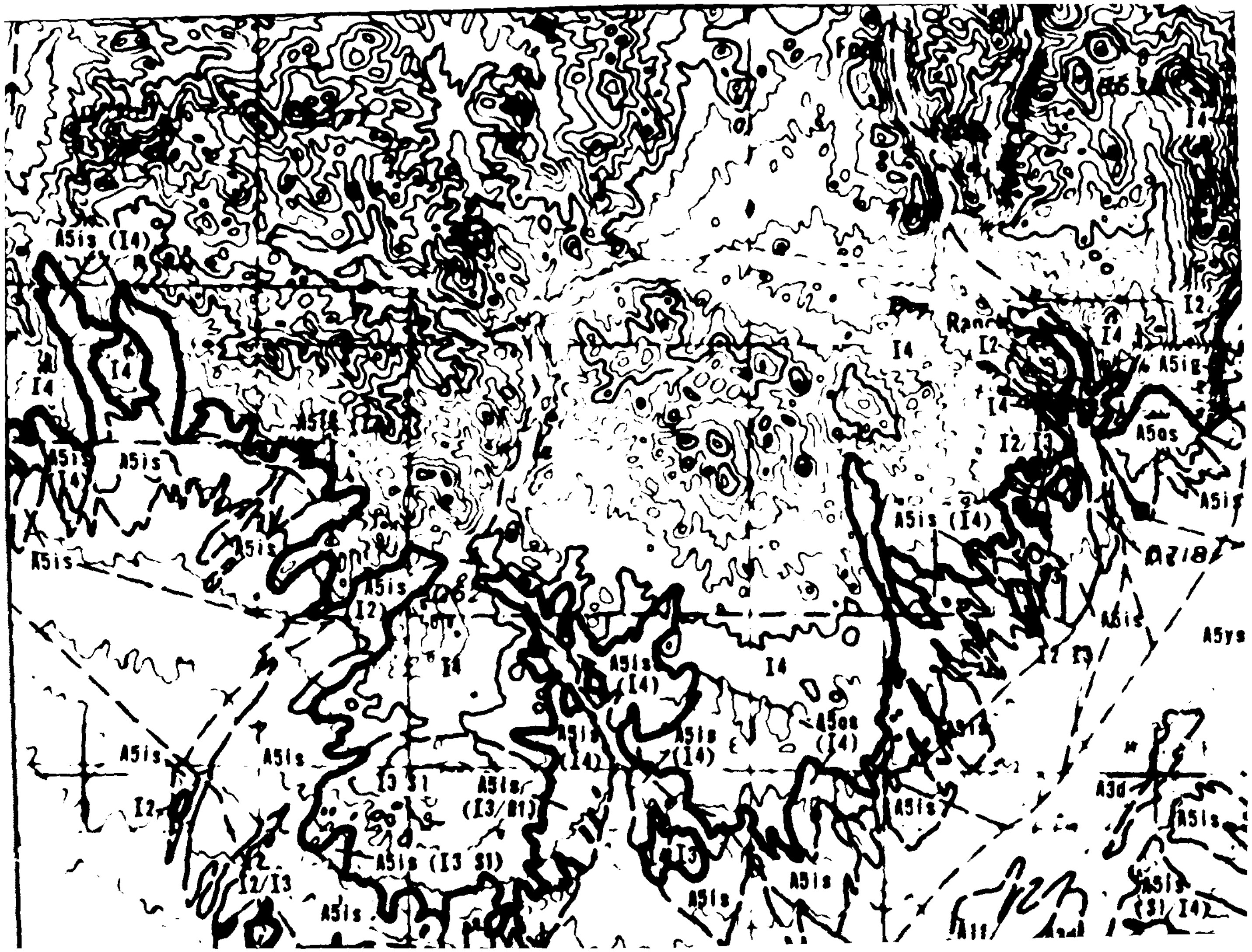
-fill or rock units.

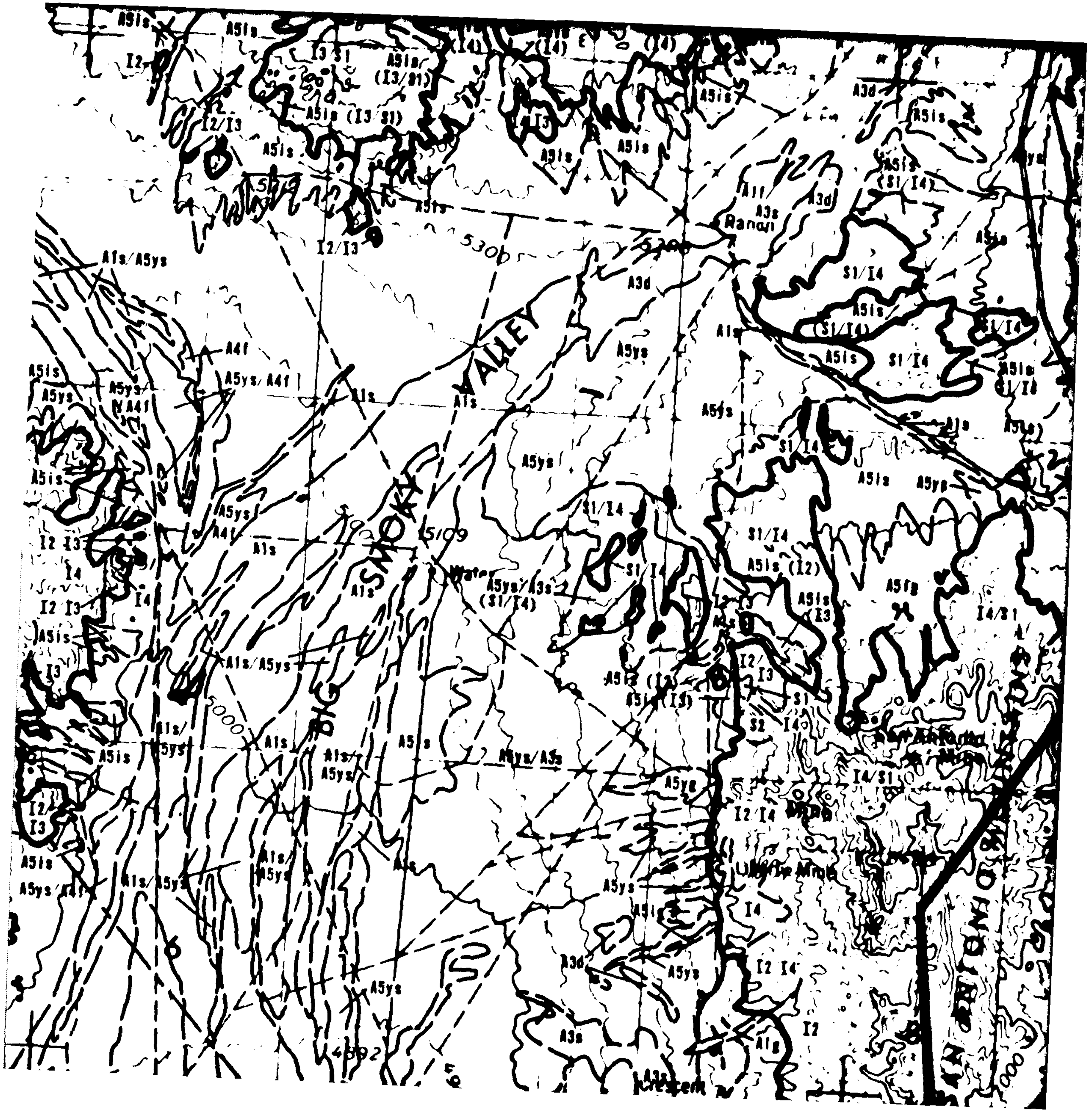
of faults offsetting surficial basin-fill deposits, ball on

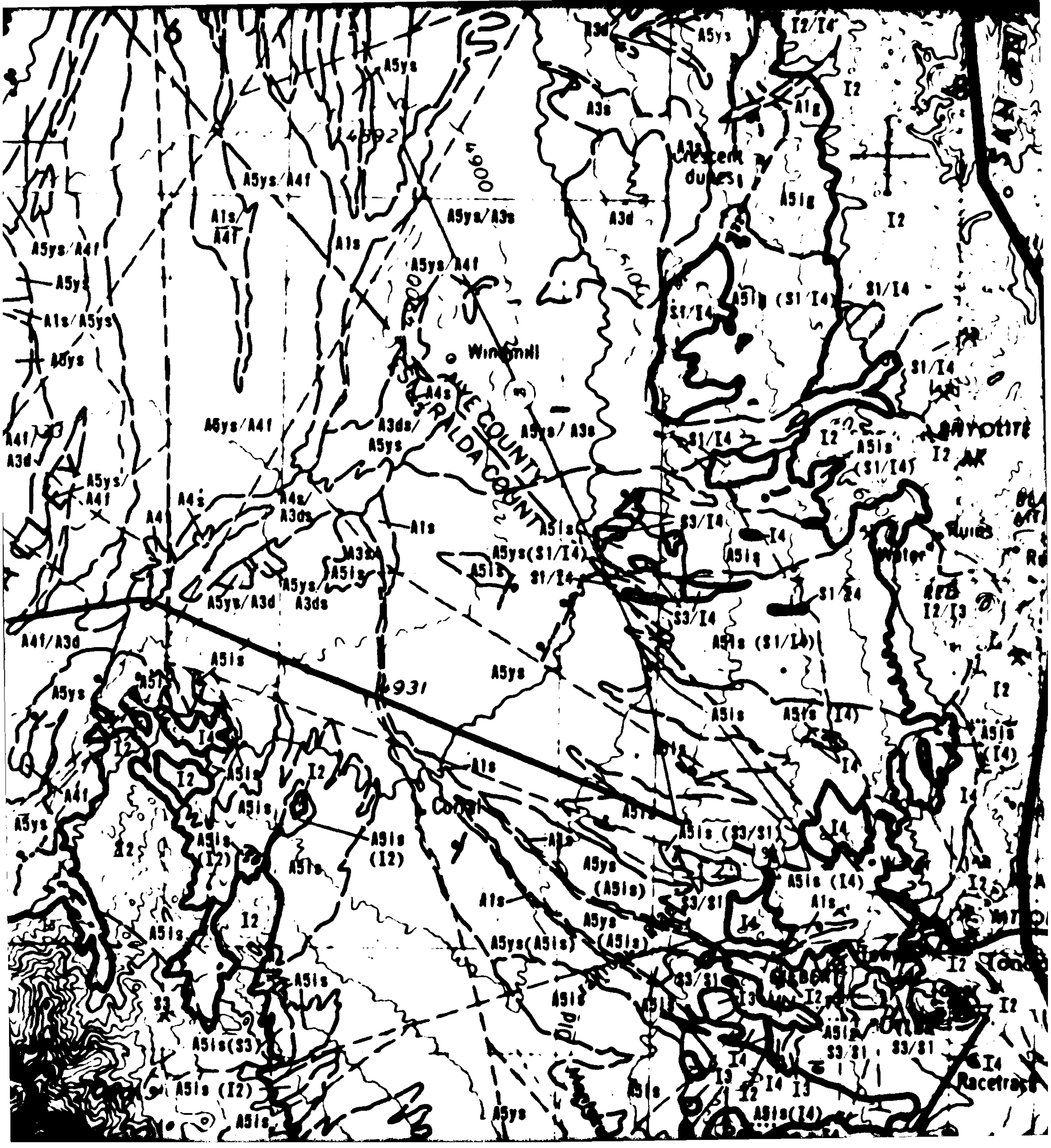
only to the upper several feet of soil. Due to variability of
ap presentation, unit descriptions refer to the predominant soil
soil types can be expected within each geologic unit.
stations is presented in Volume XIII, Drawing 1. A tabulation of
description of all geologic units is included in Volume XIII

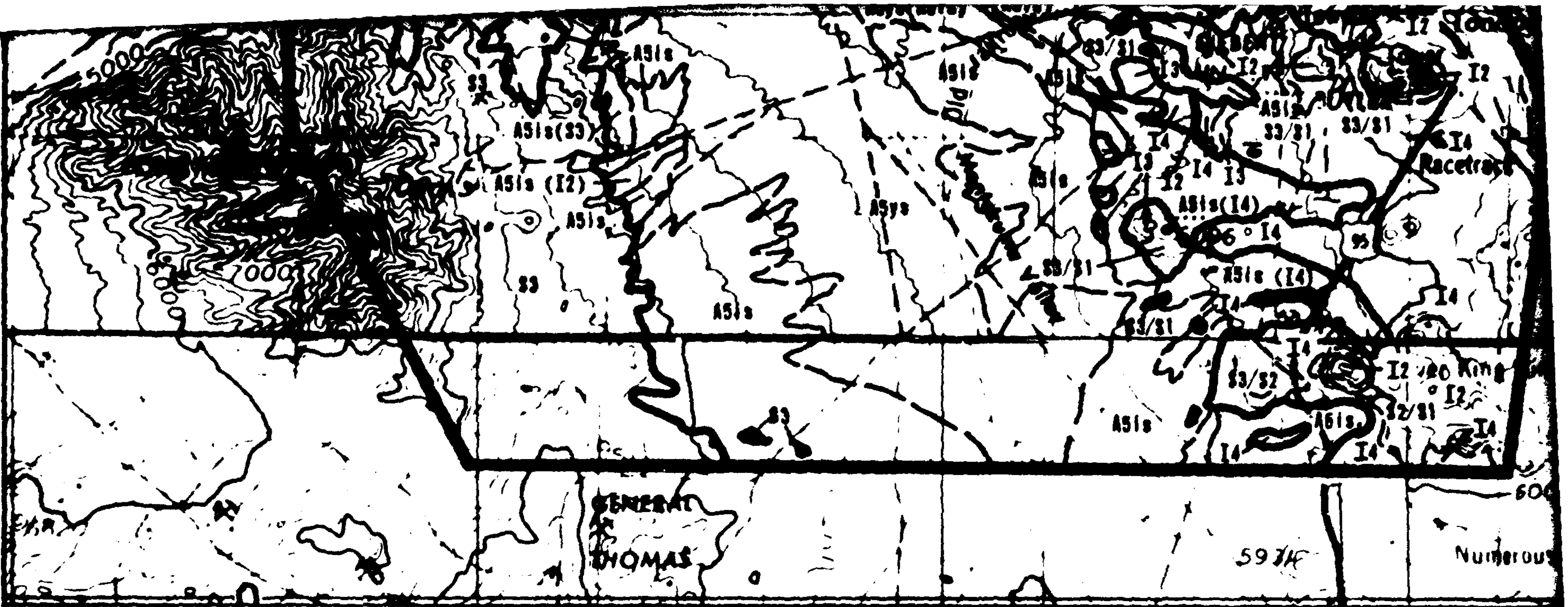
From: Albers and Stewart (1972), Kleinhampl and Ziony (1967).




A5is (I4)
I4
A5is
I2
A5os
A5ys
A5os (I4)
A5is (I3/B1)
A5is (I3 S1)
I2/I3
A3d


BIG SMOKY VALLEY
Ranai
5300
5000
Water
A5ys/A3s
(S1/I4)
S1/I4
A5is
A5ys
A1s
A3d
A1s/A5ys
A5ys/A4f
A4f
I2/I3
A5fs
I4/S1
I2 I4
I4
A3s
Crescent


NYE COUNTY
ESMERALDA COUNTY
Windmill
Crescent dunes
4900
4892
4931
Coral
Racetrack
A5ys/A4f
A1s/A4T
A5ys/A3s
A5ys/A3d
A4f/A3d
A1s/A5ys
A5ys(S1/I4)
A5ls (S3/S1)
A5ls (I4)
A5ls (I2)
A5ls(S3)
A5ys(A5ls)
S1/I4
S3/I4
S3/S1
I2
I4



EXPLANATION

SURFICIAL BASIN-FILL DEPOSITS*

A1f / A1s / A1g	Younger Fluvial Deposits - Modern stream channel and floodplain deposits of: A1f, sandy silt (ML); A1s, silty and gravelly sand (SM); and A1g sandy gravel (GM, GP).
A3s / A3d	Eolian Deposits - Windblown sand and silty sand (SP, SM) in A3s, thin sheets and sand (SP) in A3d, active and stabilized dunes.
A4f / A4s	Younger Playa Deposits - Active playa deposits of: A4f, sandy silt (ML) and A4s, silty sand (SM)
A5ys / A5yg	Younger Alluvial Fan Deposits - Active, younger alluvial fan deposits of: A5ys, uncemented to weakly cemented silty sand and gravelly sand (SM) and A5yg, sandy gravel (GM).
A5is / A5ig	Intermediate Alluvial Fan Deposits - Inactive, intermediate-age alluvial fan deposits of: A5is, weakly cemented silty sand and gravelly sand (SM) and A5ig, weakly cemented sandy gravel (GP, GM).

A5yg	to weakly cemented silty sand and gravelly sand (SM) and A5yg, sandy gravel (GM).
A5is / A5ig	Intermediate Alluvial Fan Deposits - Inactive, intermediate-age alluvial fan deposits of: A5is, weakly cemented silty sand and gravelly sand (SM) and A5ig, weakly cemented sandy gravel (GP, GM).

ROCK UNITS

Igneous (I)

I2	Rhyolite, quartz latite, latite, and andesite plugs and flows
I3	Basalt
I4	Rhyolite and quartz latite welded ash-flow tuff, and lithic air-fall tuff

Sedimentary (S)

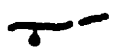
S1	Tuffaceous sandstone and diatomite
S2	Limestone, locally metamorphosed to marble
S3	Shale and siltstone, locally tuffaceous

A1s/A5ys	Combination of geologic unit symbols indicates a mixture of either surficial basin-fill or rock units inseparable at map scale.
A5ys(I2)	Parenthetic unit underlies surface unit at shallow depth.

SYMBOLS


Contact between rock and basin-fill.


Contact between surficial basin-fill or rock units.


Fault, trace of surface rupture of faults offsetting surficial basin-fill deposits, ball on downthrown side.

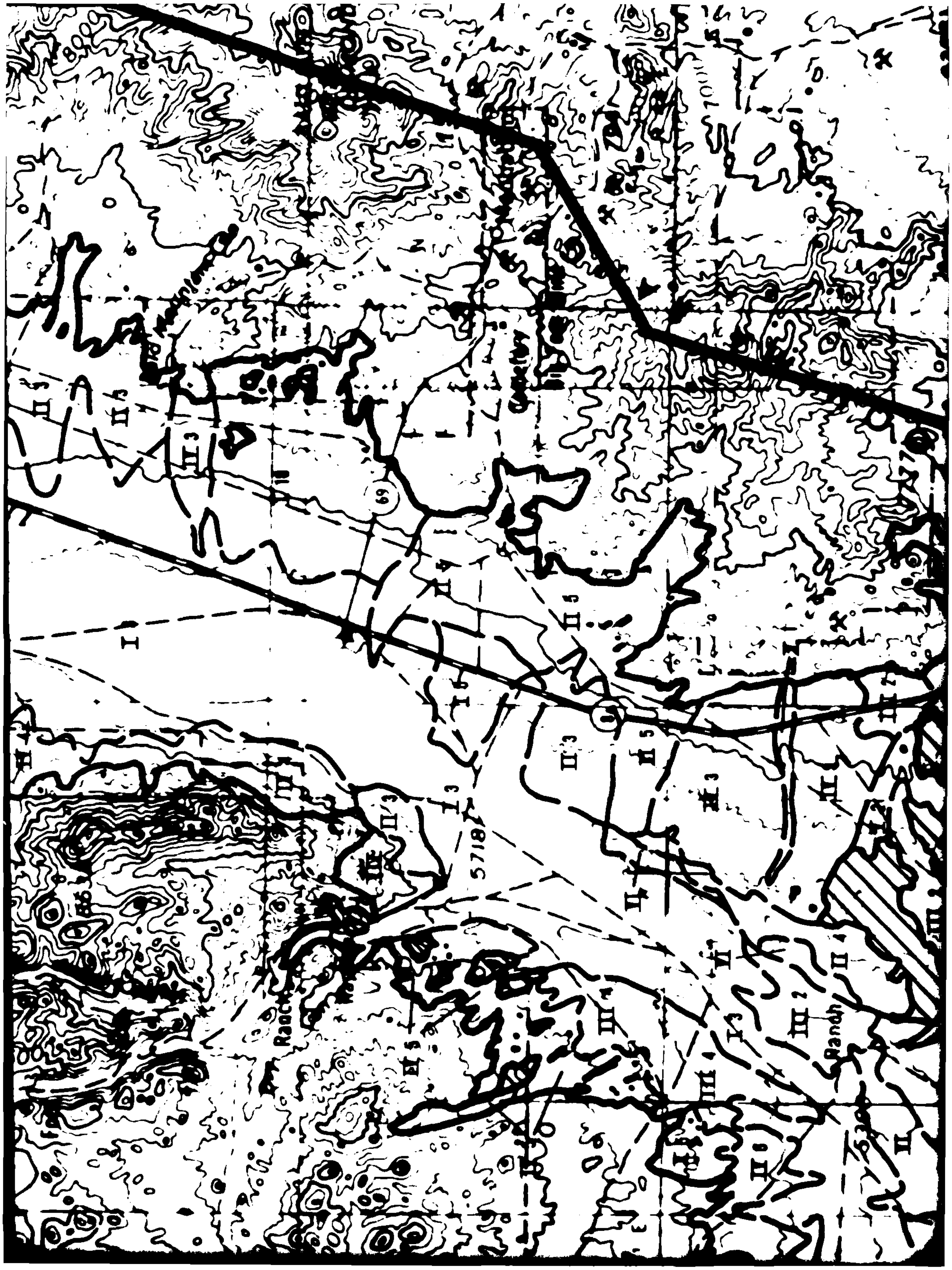
NOTES:

1. Surficial basin-fill units pertain only to the upper several feet of soil. Due to variability of surficial deposits and scale of map presentation, unit descriptions refer to the predominant soil types. Varying amounts of other soil types can be expected within each geologic unit.
2. The distribution of geologic data stations is presented in Volume III, Drawing 1. A tabulation of all station data and generalized description of all geologic units is included in Volume III Section 1.0.
3. Geology in areas of exposed rock from: Albers and Stewart (1972), Kleinhampl and Ziony (1967).

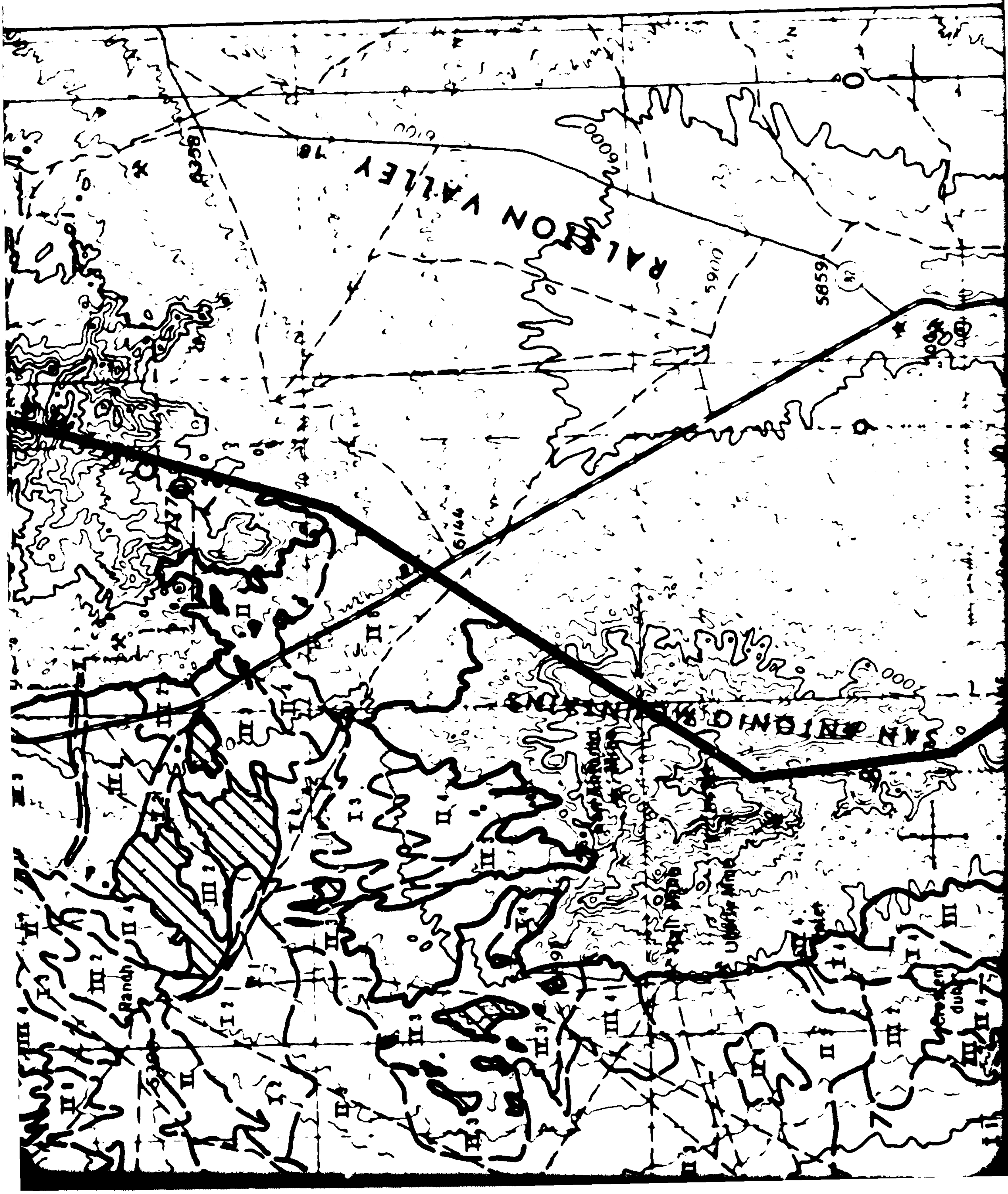
SURFICIAL GEOLOGIC UNITS VERIFICATION SITE, BIG SMOKY CDP, NEVADA	
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAMSO	DRAWING 10-2

FUGRO NATIONAL, INC.

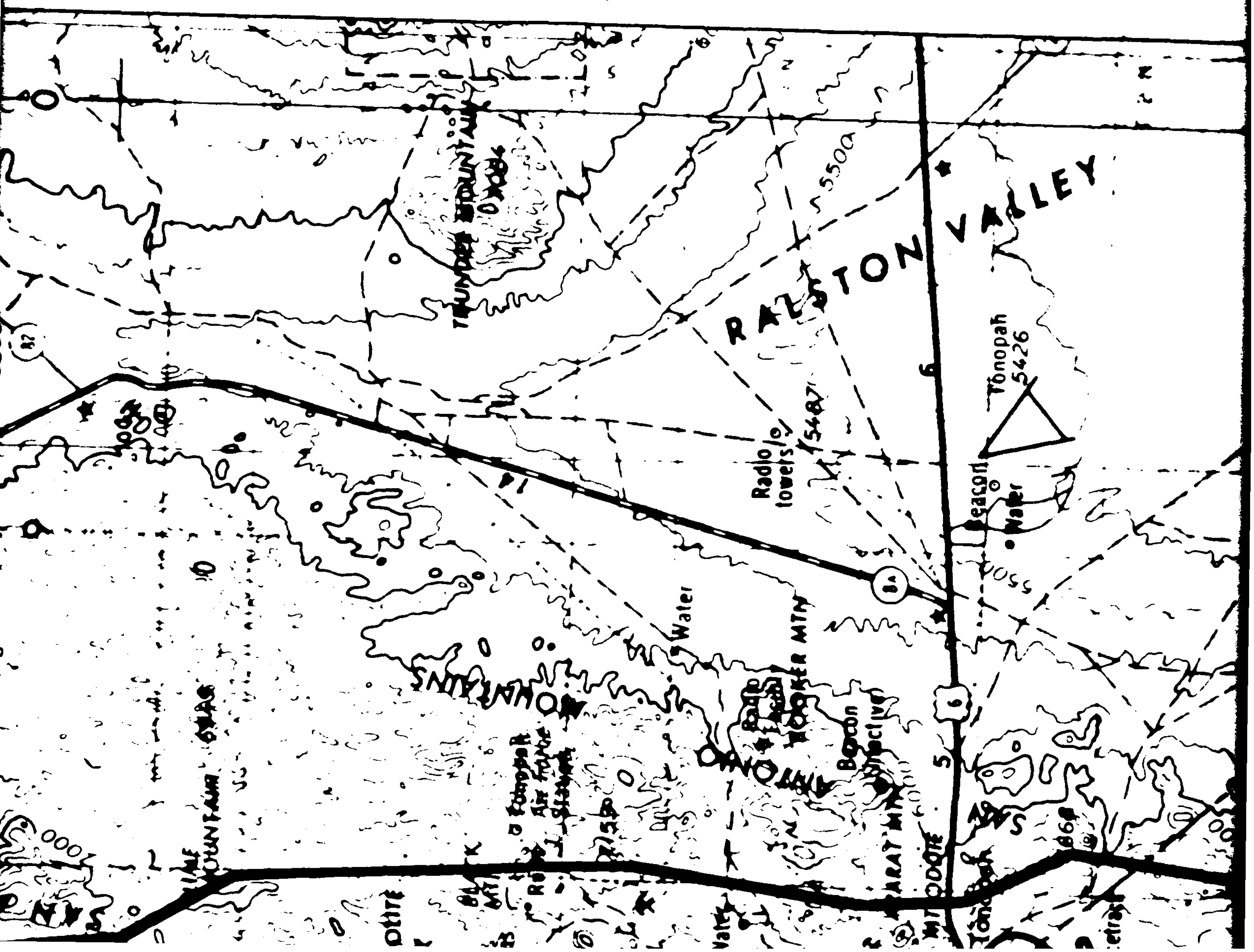
10


Cemetery
5718
Ranch
Ranch

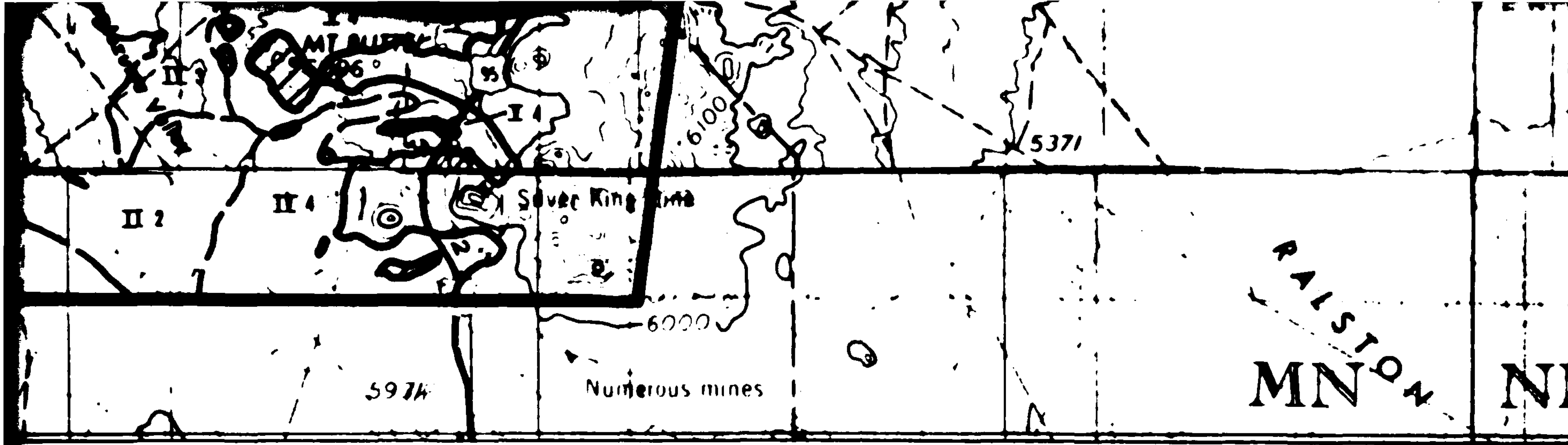
2



1 3



RALSTON VALLEY
Tonopah
5426
Radio towers
5487
5500
Beacon
Water



EXPLANATION

III 3 — Drainage spacing, i.e. the maximum number of drainages of the corresponding category occurring in a random traverse of one statute mile (1.6km)

DRAINAGE DEPTH/DESCRIPTION

Less than 3 feet (1m)

3-6 feet (1-2m)

6-10 feet (2-3m)

10-15 feet (3-5m)

Greater than 15 feet (5m)

Complex, highly variable terrain not defined by drainage incision (e.g. dunal or hummocky terrains).

Unsuitable terrain (see Appendix A2.0, Exclusion Criteria)

terrain categories

EXPLANATION

I 3 – – – – – – Drainage spacing, i.e. the maximum number of drainages of the corresponding category occurring in a random traverse of one statute mile (1.6km)

DRAINAGE DEPTH/DESCRIPTION

Less than 3 feet (1m)

3-6 feet (1-2m)

6-10 feet (2-3m)

10-15 feet ([illegible])

Greater than 15 feet (5m)

Complex, highly variable terrain not defined by drainage incision (e.g. dunal or hummocky terrains).

Unsuitable terrain (see Appendix A2.6, Exclusion Criteria)

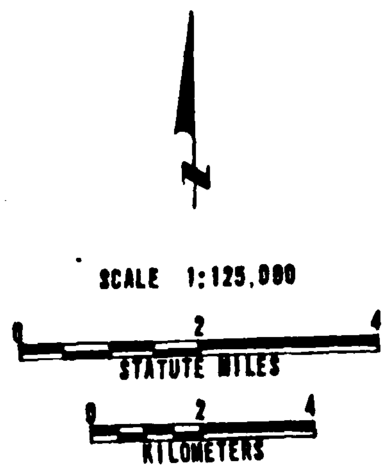
terrain categories

rock and basin-fill

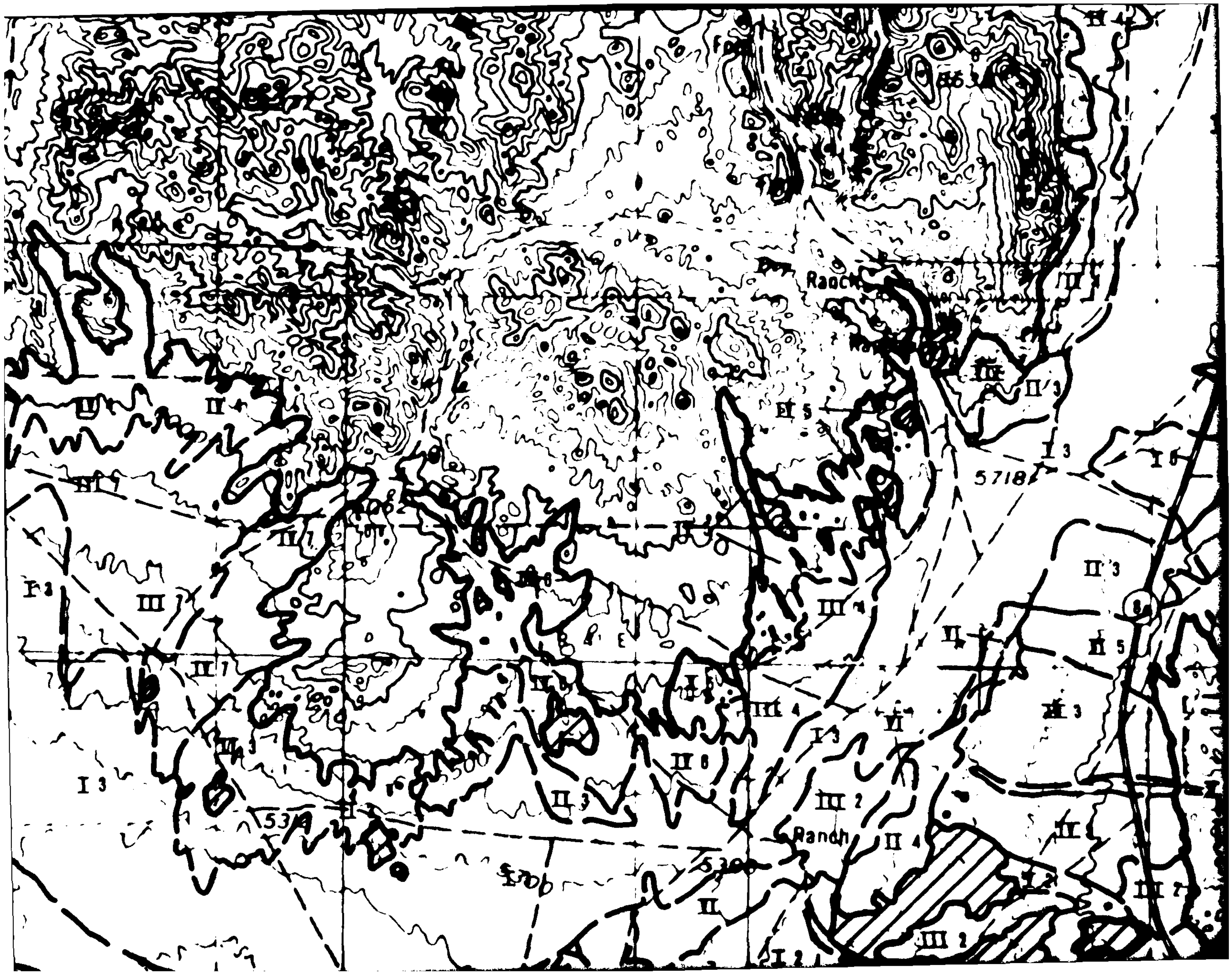
–

s areas of isolated exposed rock.

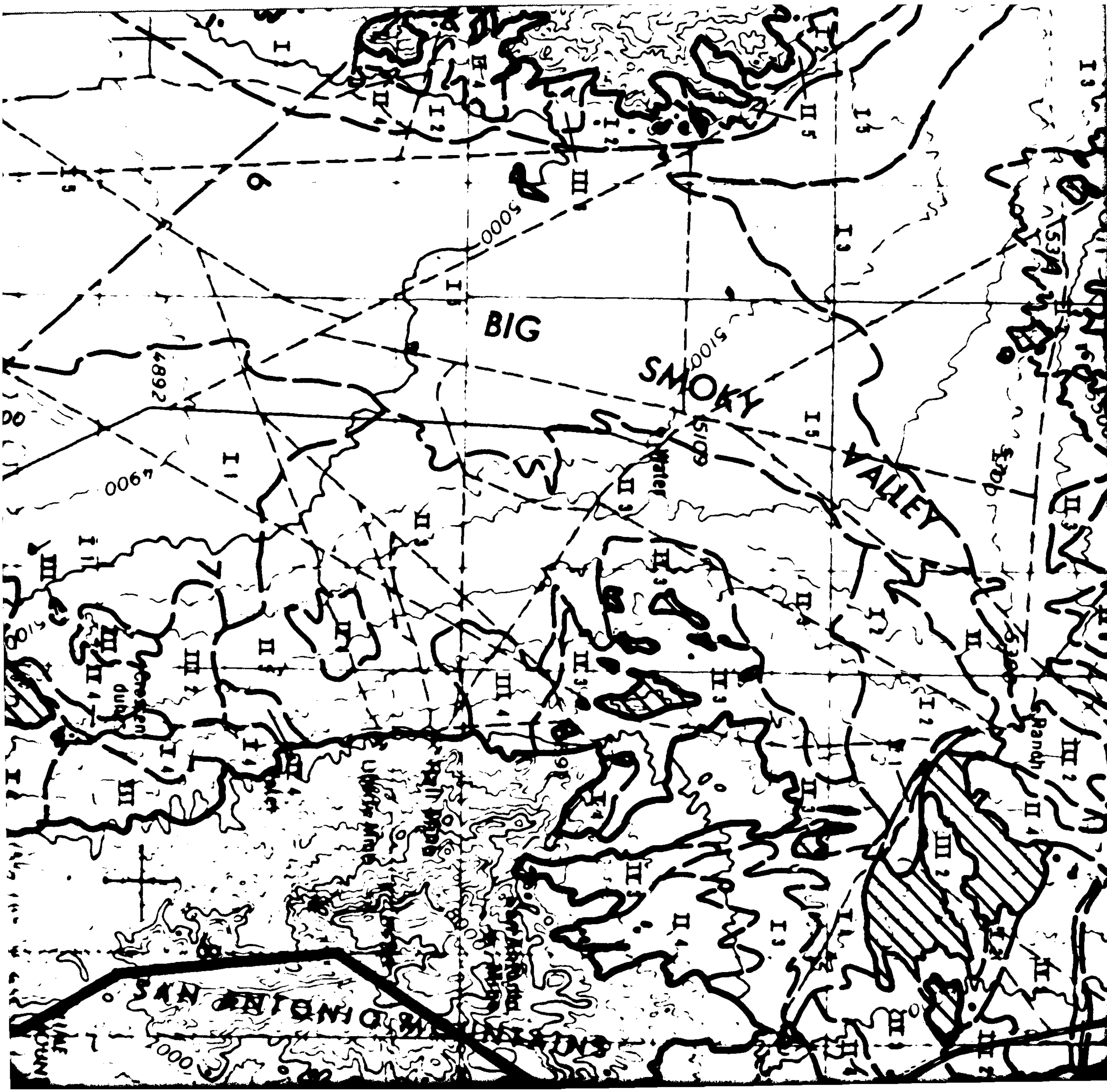
SCALE 1:125,000

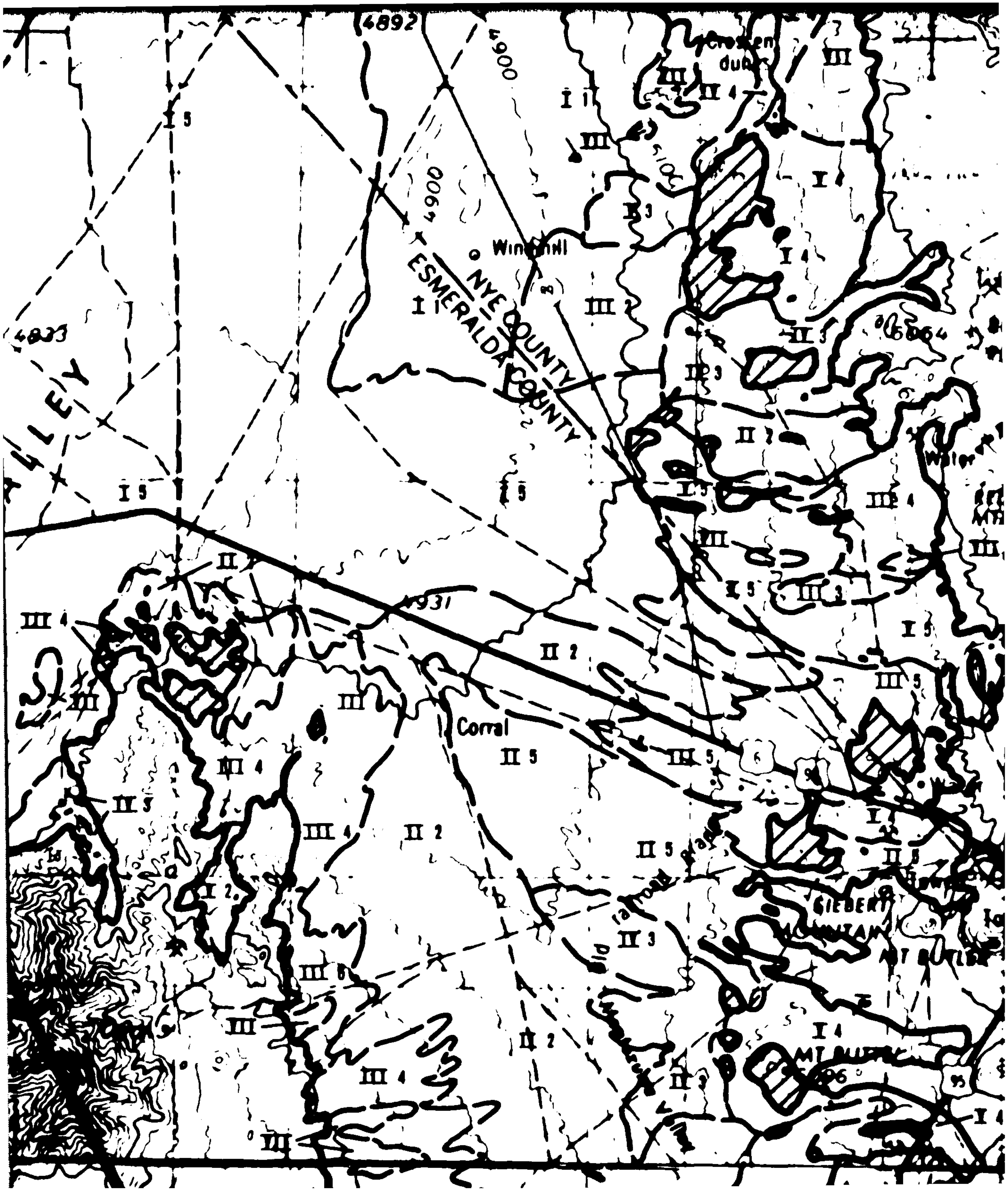


constructing this map are from: (1) field observations, USGS topographic maps, and (3) 1:80,000 and 1:25,000 graphs. Due to scale of presentation and variability of itions, this map is generalized.

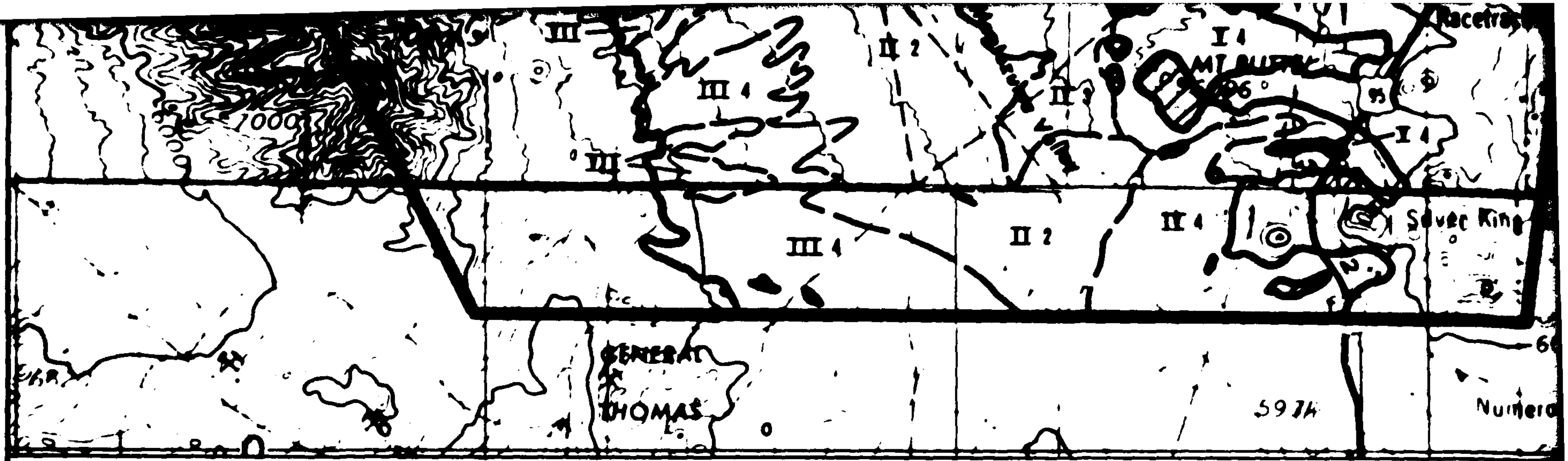


Ranch
Ranch
5718


BIG
SMOKY
VALLEY
5000
5100
5109
4892
4900
Water
Ranch



4892
4900
4833
VALLEY
Windmill
NYE COUNTY
ESMERALDA COUNTY
4931
Corral
old railroad grade
GILBERT
MT BUTLER



EXPLANATION

Terrain Category (see table below) — III 3 — Drainage spacing, i.e. the maximum number of drainages of the corresponding category occurring in a random traverse of one statute mile (1.6km)

TERRAIN CATEGORY	DRAINAGE DEPTH/DESCRIPTION
I	Less than 3 feet (1m)
II	3-8 feet (1-2m)
III	8-10 feet (2-3m)
IV	10-15 feet (3-5m)
V	Greater than 15 feet (5m)
VI	Complex, highly variable terrain not defined by drainage incision (e.g. dunal or hummocky terrains).
VII	Unsuitable terrain (see Appendix A2.0, Exclusion Criteria)

—— Contact between terrain categories

EXPLANATION

Terrain Category (see table below) - - - - - III 3 - - - - - Drainage spacing, i.e. the maximum number of drainages of the corresponding category occurring in a random traverse of one statute mile (1.6km)

TERRAIN CATEGORY	DRAINAGE DEPTH/DESCRIPTION
I	Less than 3 feet (1m)
II	3-6 feet (1-2m)
III	6-10 feet (2-3m)
IV	10-15 feet (3-5m)
V	Greater than 15 feet (5m)
VI	Complex, highly variable terrain not defined by drainage incision (e.g. dunal or hummocky terrains).
VII	Unsuitable terrain (see Appendix A2.0, Exclusion Criteria)

Contact between terrain categories

Contact between rock and basin-fill

Shading indicates areas of isolated exposed rock.

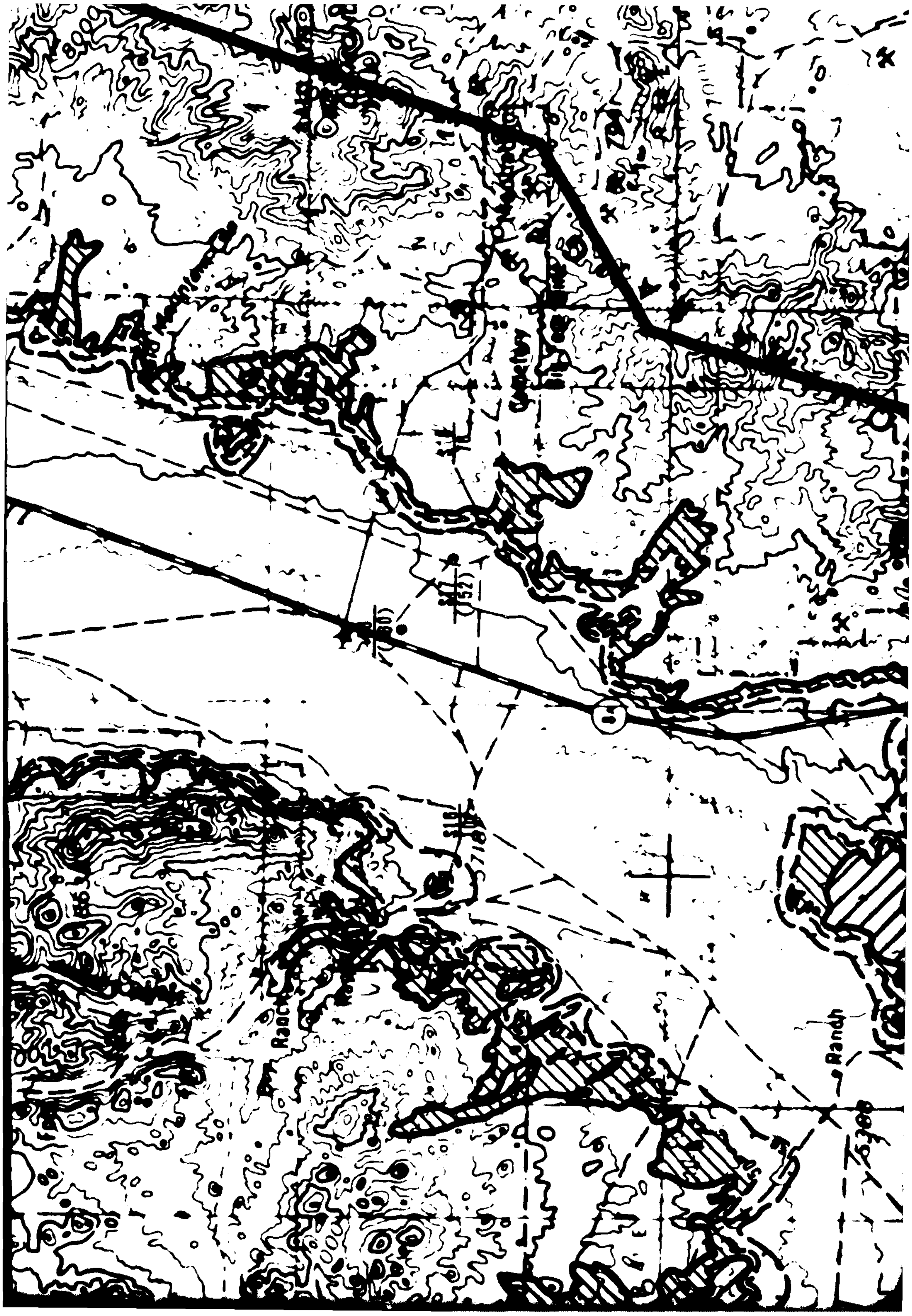
NOTE: Data used in constructing this map are from: (1) field observations, (2) 1:62,500 USGS topographic maps, and (3) 1:60,000 and 1:25,000 aerial photographs. Due to scale of presentation and variability of terrain conditions, this map is generalized.

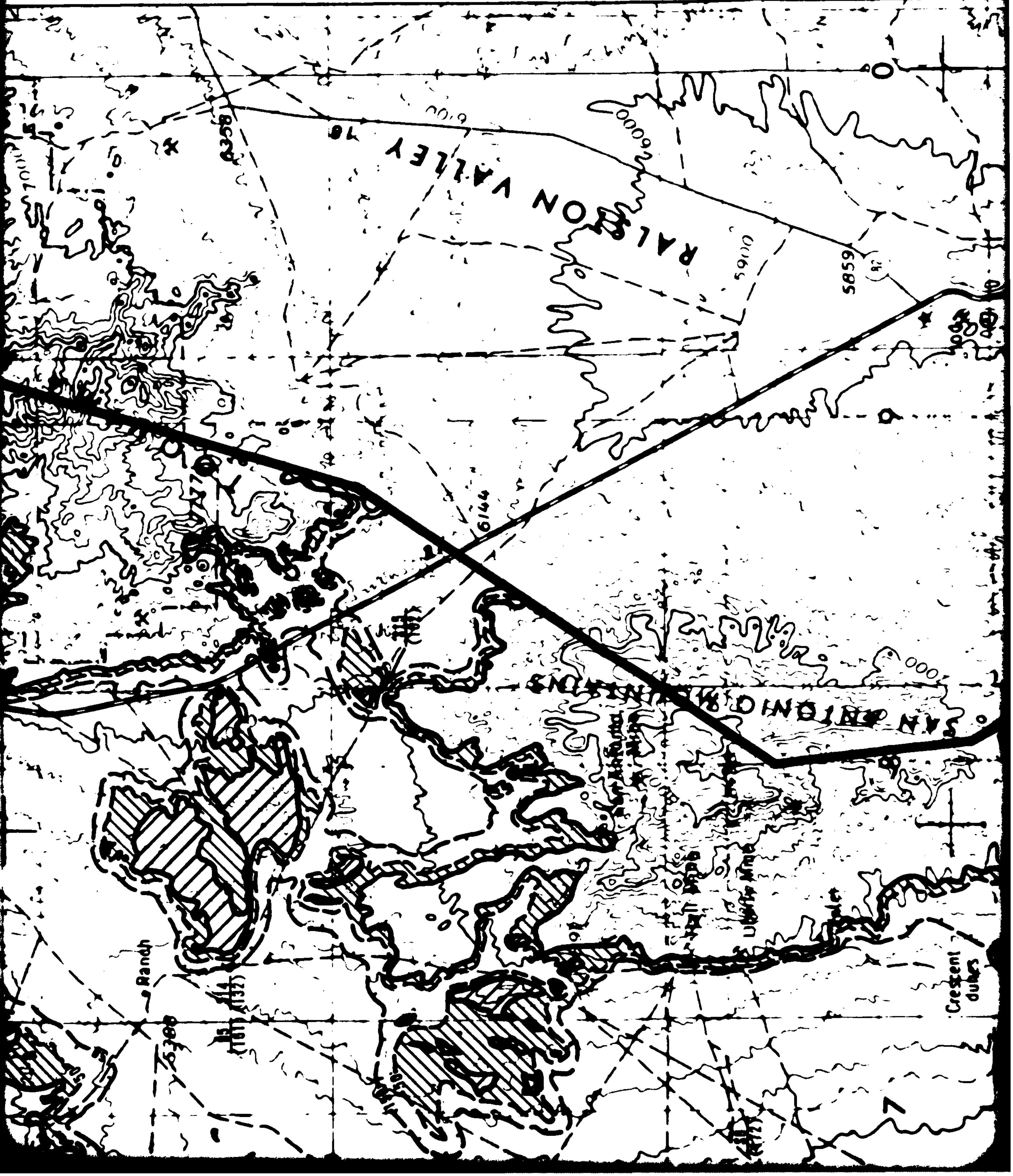
TERRAIN
VERIFICATION SITE, BIG SMOKY CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

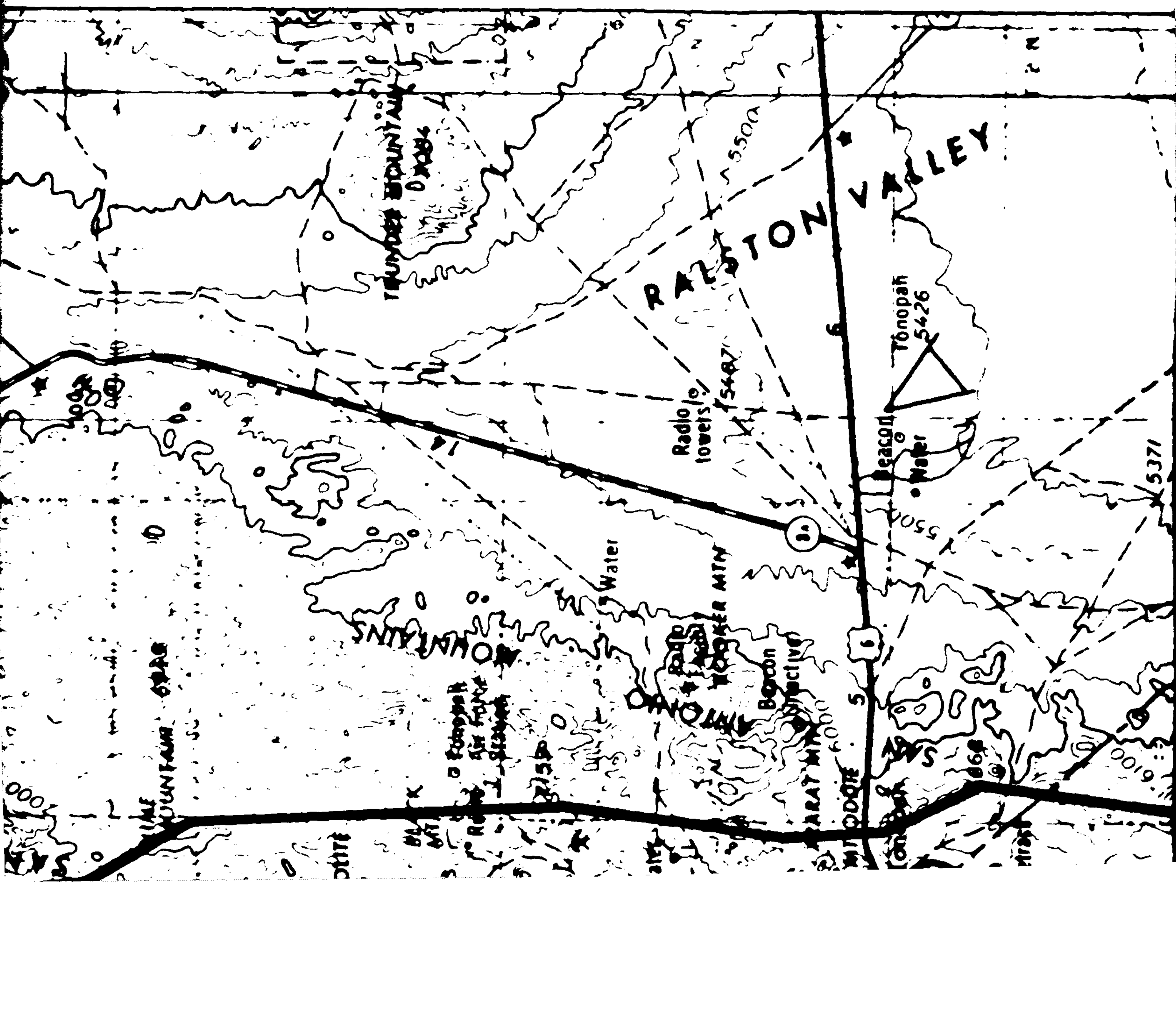
DRAWING 10-3

FUGRO NATIONAL, INC.

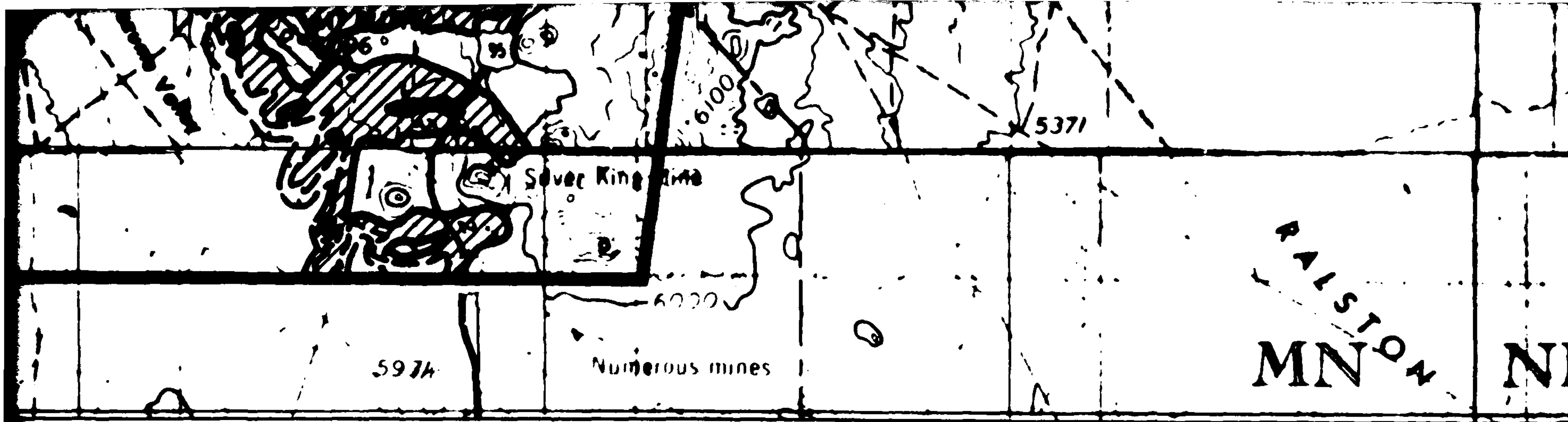



RALSTON VALLEY
SAN ANTONIO MOUNTAINS
6144
5859
Ranch
Crescent dunes

3



RALSTON VALLEY
Tonopah
5426
Radio towers
5487
Beacon
Water
5371
5500
Water
6000



ATION

e rock at a depth of approximately
- shading indicates rock less
15m).

e rock at a depth of approximately
) - hachuring indicates rock less
(40m).

rock and basin-fill.

es areas of isolated exposed rock.

gre boring (B), seismic refraction
ctrical resistivity sounding (R).
(B).

feet) or, when in parentheses, depth
ock does not occur (feet).

e are based on geologic interpretations
ited data points shown on the map. Some
contour locations can be expected as
ata are obtained.

SCALE 1:125,000

4

59 74

Numerous mines

MN

N

ATION

rock at a depth of approximately
- shading indicates rock less
15m).

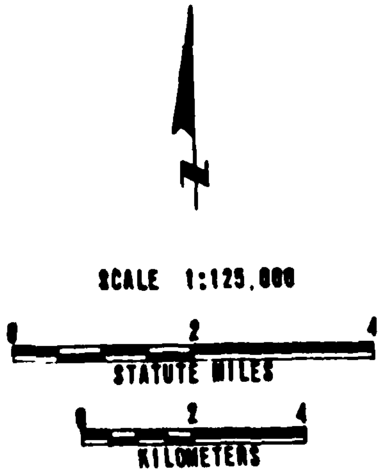
rock at a depth of approximately
) - hachuring indicates rock less
(40m).

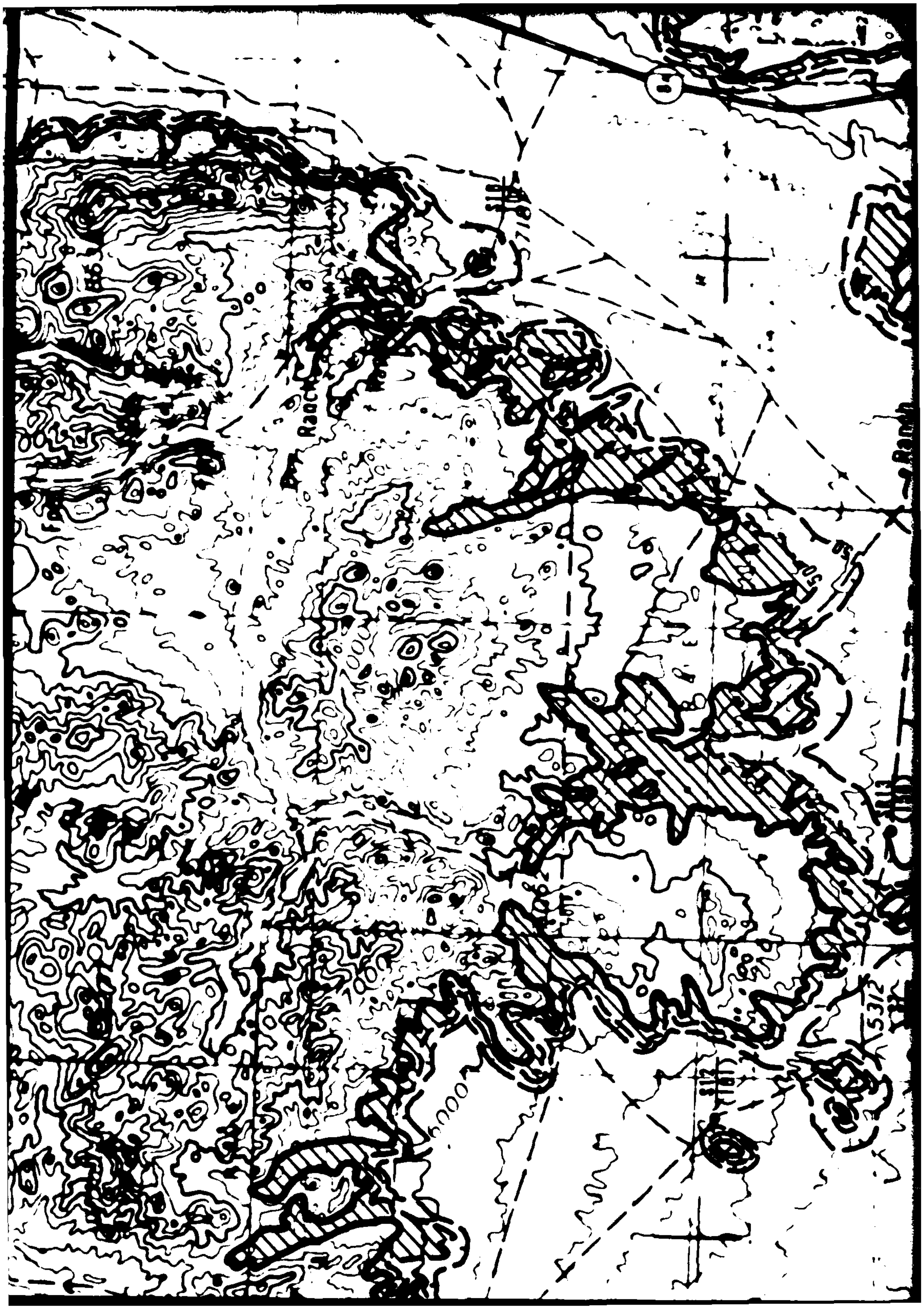
rock and basin-fill.

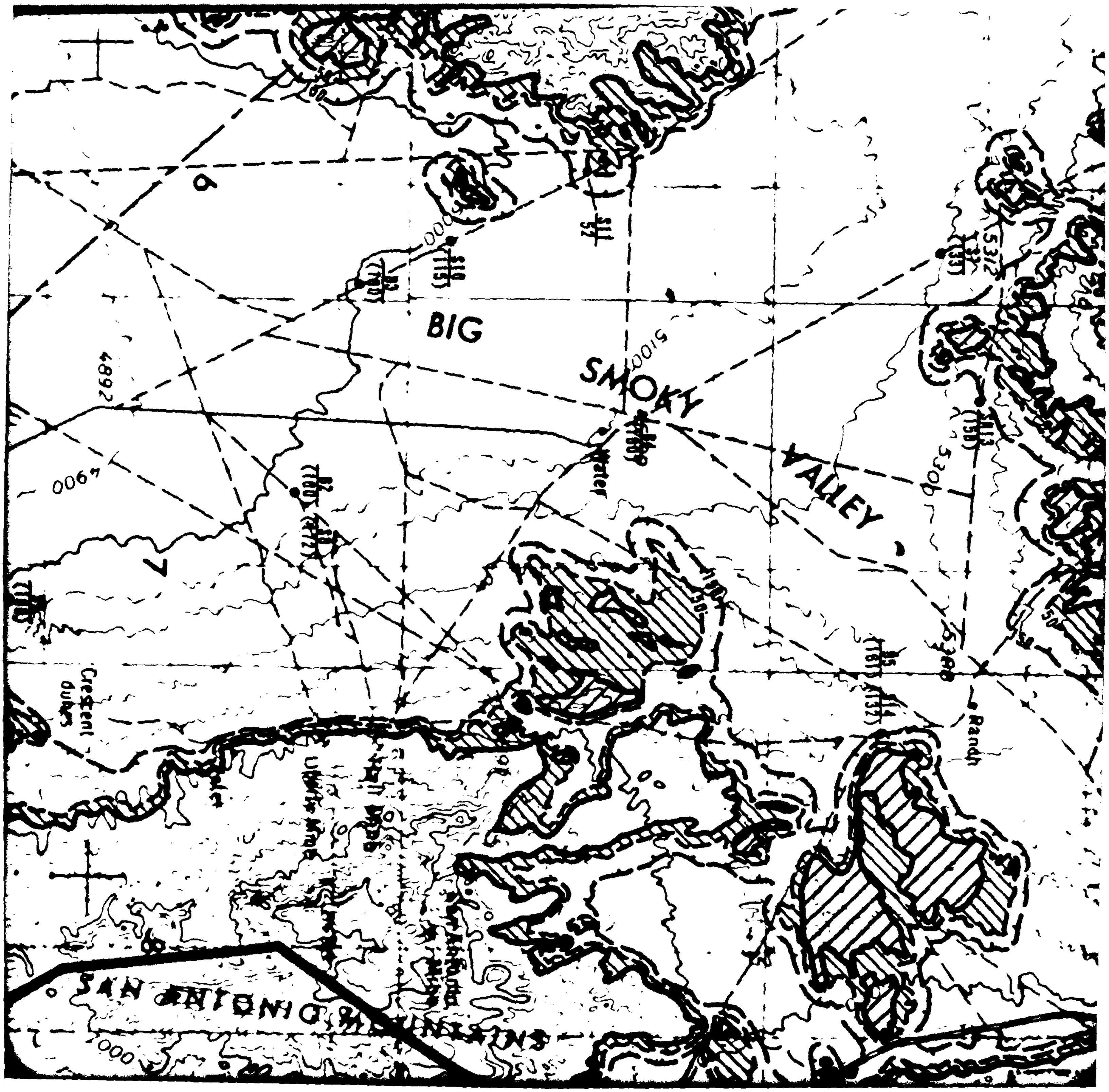
es areas of isolated exposed rock.

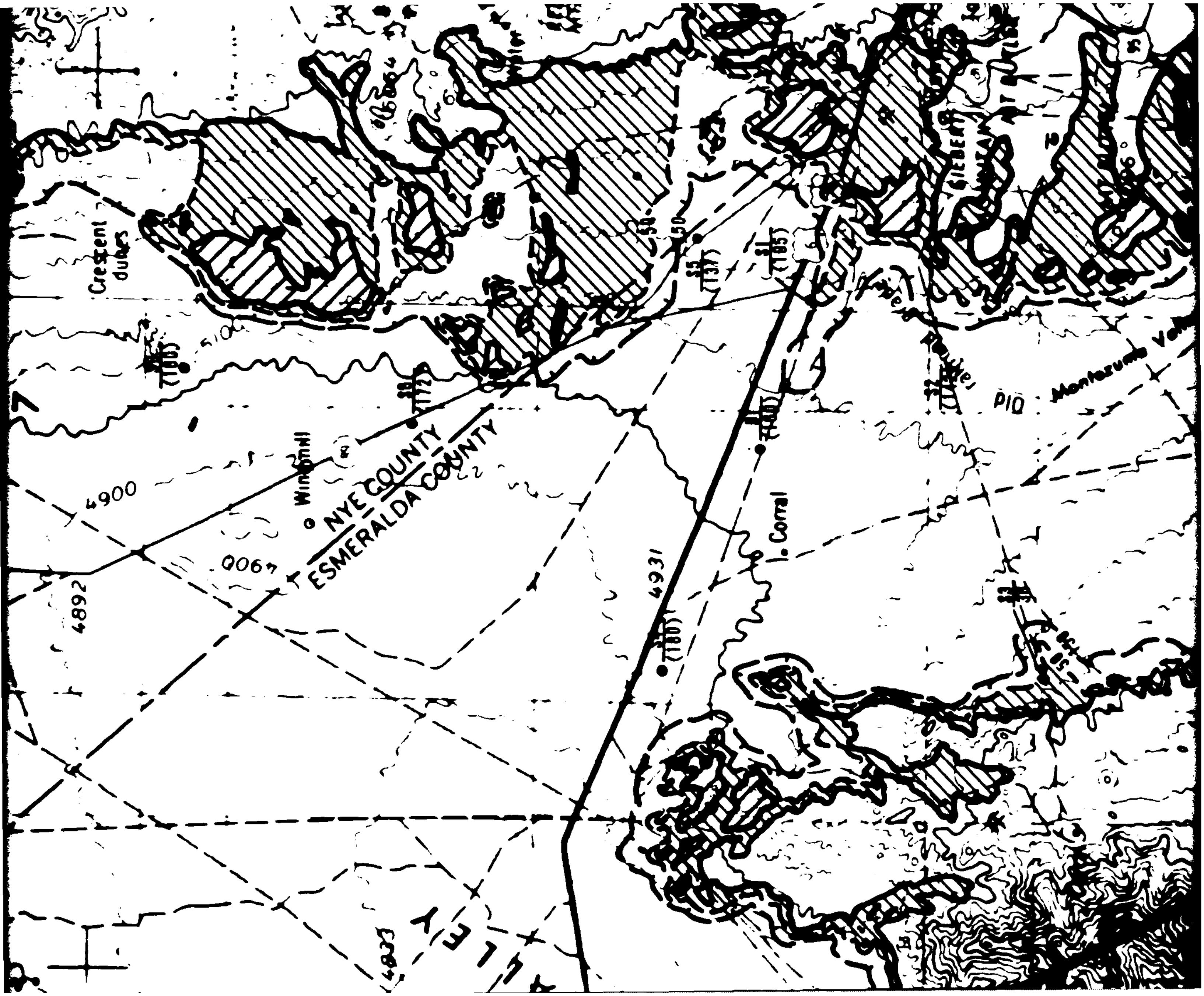
ugro boring (B), seismic refraction
ctrical resistivity sounding (R),
(W).
(feet) or, when in parentheses, depth
rock does not occur (feet).

re are based on geologic interpretations
mited data points shown on the map. Some
contour locations can be expected as
data are obtained.

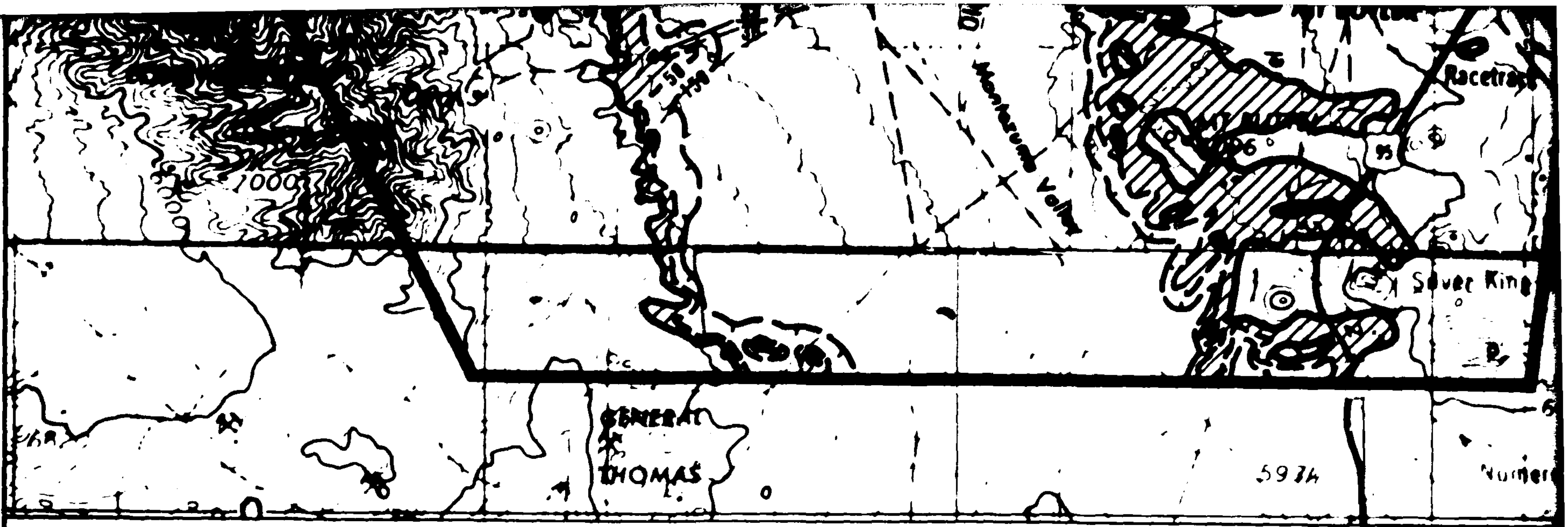





BIG
SMOKY
VALLEY
SAN ANTONIO MOUNTAINS
Crescent dunes
Randh
Water
5100
4900
4892
5300
5312
6
7



Crescent dunes
NYE COUNTY
ESMERALDA COUNTY
Windmill
Corral
4900
4892
4931



EXPLANATION

Contour indicates rock at a depth of approximately 50 feet (15m) - shading indicates rock less than 50 feet (15m).

Contour indicates rock at a depth of approximately 150 feet (46m) - hachuring indicates rock less than 150 feet (46m).

Contact between rock and basin-fill.

Shading indicates areas of isolated exposed rock.

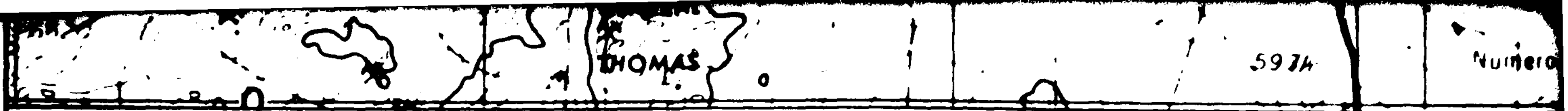
Data Source - Fugro boring (B), seismic refraction line (S), electrical resistivity sounding (R), or water well (W).

Depth to rock (feet) or, when in parentheses, depth above which rock does not occur (feet).

VERIFICATION

MX SITING
DEPARTMENT OF THE

FUGRO



EXPLANATION

Contour indicates rock at a depth of approximately 50 feet (15m) - shading indicates rock less than 50 feet (15m).

Contour indicates rock at a depth of approximately 150 feet (46m) - hachuring indicates rock less than 150 feet (46m).

Contact between rock and basin-fill.

Shading indicates areas of isolated exposed rock.

Data Source - Fugro boring (B), seismic refraction line (S), electrical resistivity sounding (R), or water well (W).

Depth to rock (feet) or, when in parentheses, depth above which rock does not occur (feet).

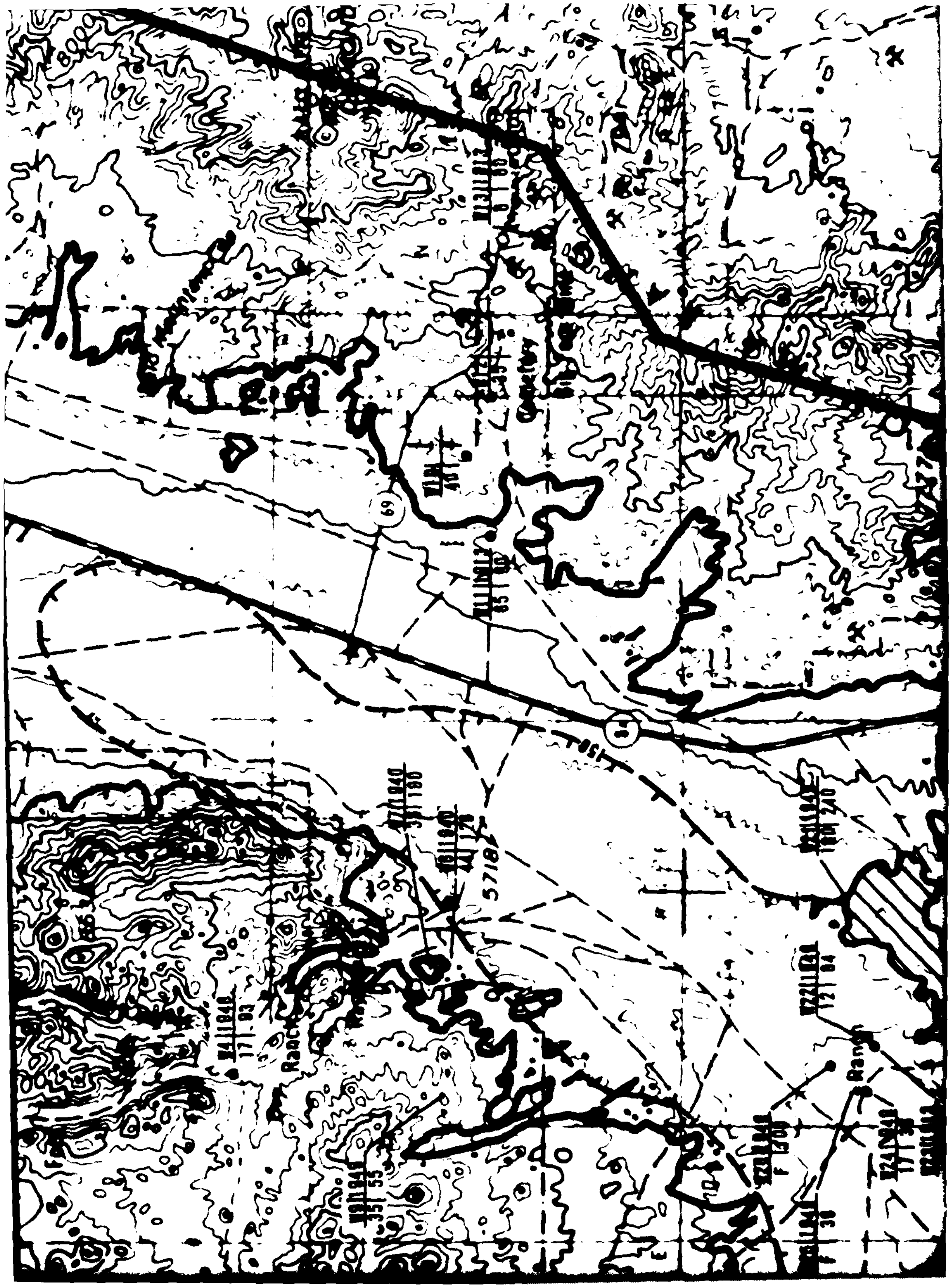
NOTE: The contours are based on geologic interpretations and the limited data points shown on the map. Some changes in contour locations can be expected as additional data are obtained.

DEPTH TO WATER
VERIFICATION SITE, BIG SMOKY CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

DRAWING 10-4

FUGRO NATIONAL, INC.



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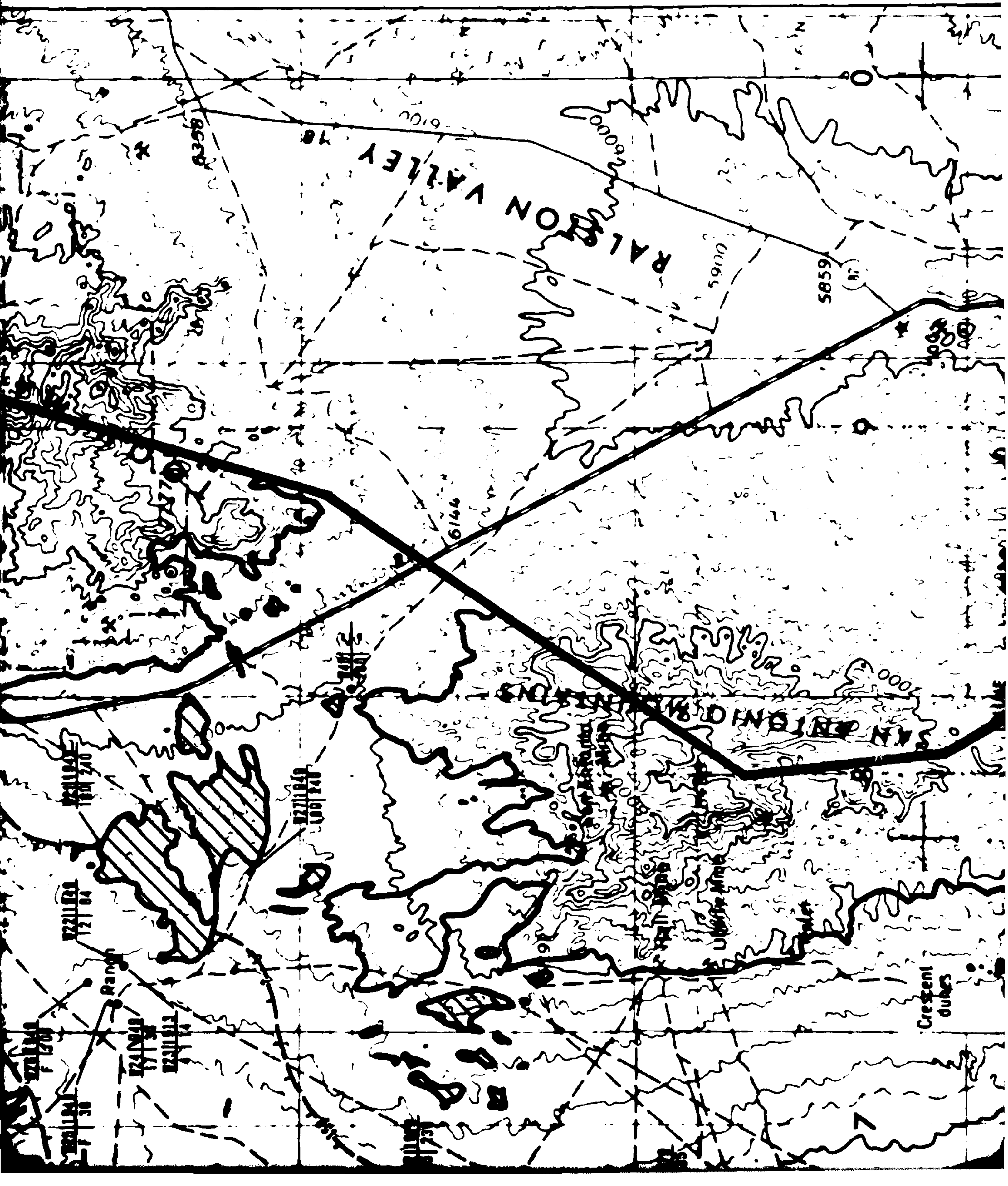
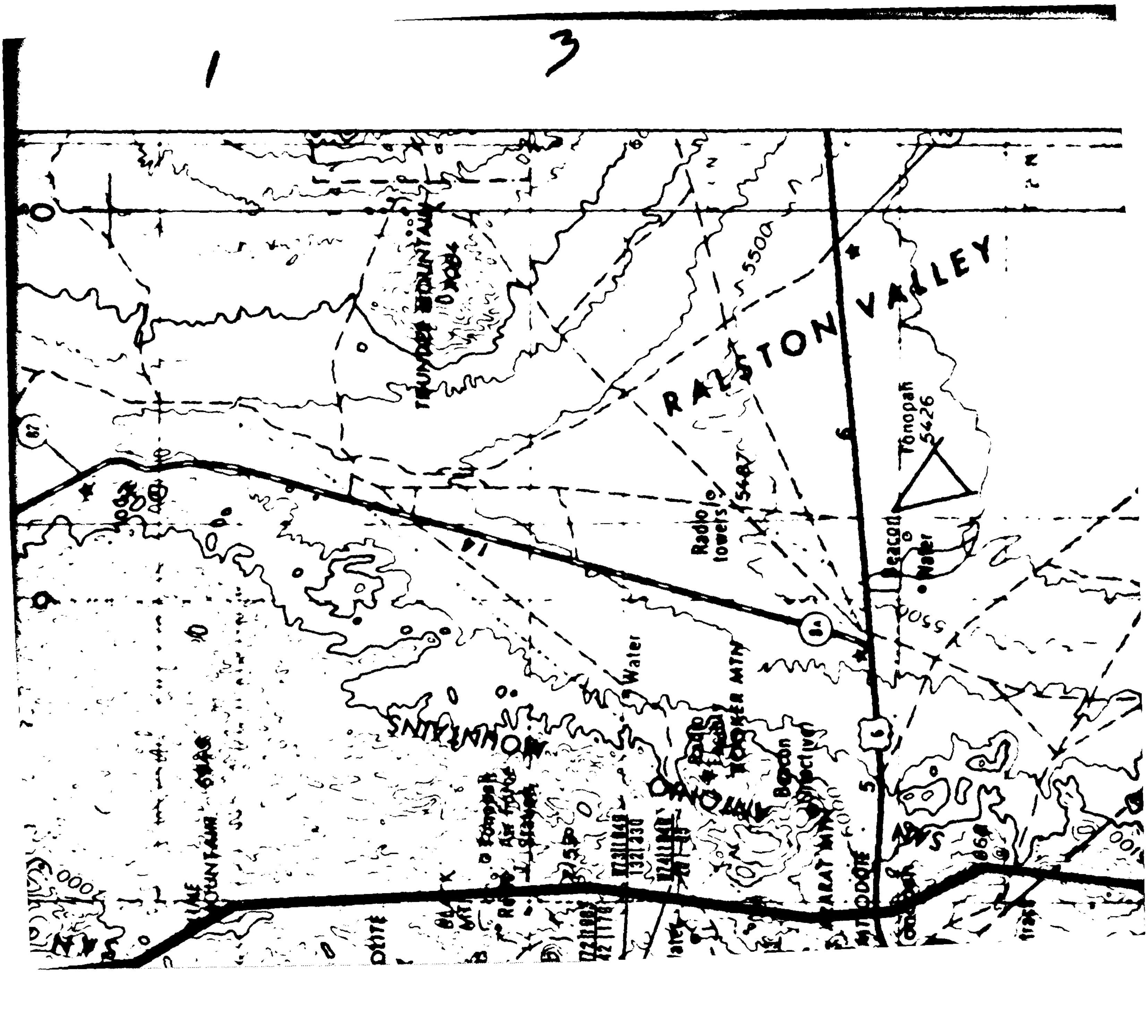
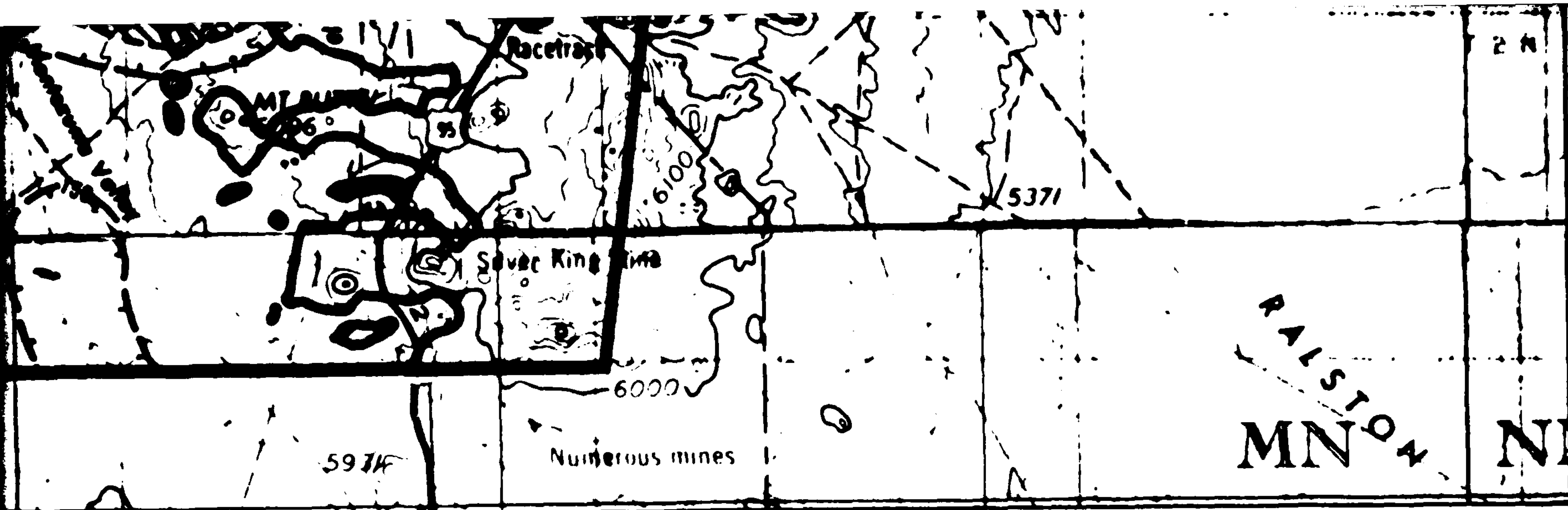

RALSTON VALLEY
SAN ANTONIO MTNS
6358
5859
6144
Crescent dunes


1
3
RALSTON VALLEY
Tonopah
5426
Radio towers
5487
Beacon
Water
5500
Water
MOUNTAINS
6



LANATION

nd water at a depth of approximately
ed where data are extremely sparse.
than 50 feet (15m) to ground water.

nd water at a depth of approximately
fied where data are extremely sparse.
less than 150 feet (46m) to ground water.

and basin-fill.

e of isolated exposed rock.

oring (B), seismic
electrical resistivity
or well (W); see Volume XIII

	Year of water level measurement
	Depth of well (feet)

SCALE 1:125,000

NATION

water at a depth of approximately
where data are extremely sparse.
than 50 feet (15m) to ground water.

water at a depth of approximately
d where data are extremely sparse.
s than 150 feet (46m) to ground water.

basin-fill.

of isolated exposed rock.

ing (D), seismic lectrical resistivity well (W); see Volume III	Year of water level measurement
	Depth of well (feet)

sed entirely on the data points shown on the map.
tation has been used and it can be expected that
will change as additional data are obtained.

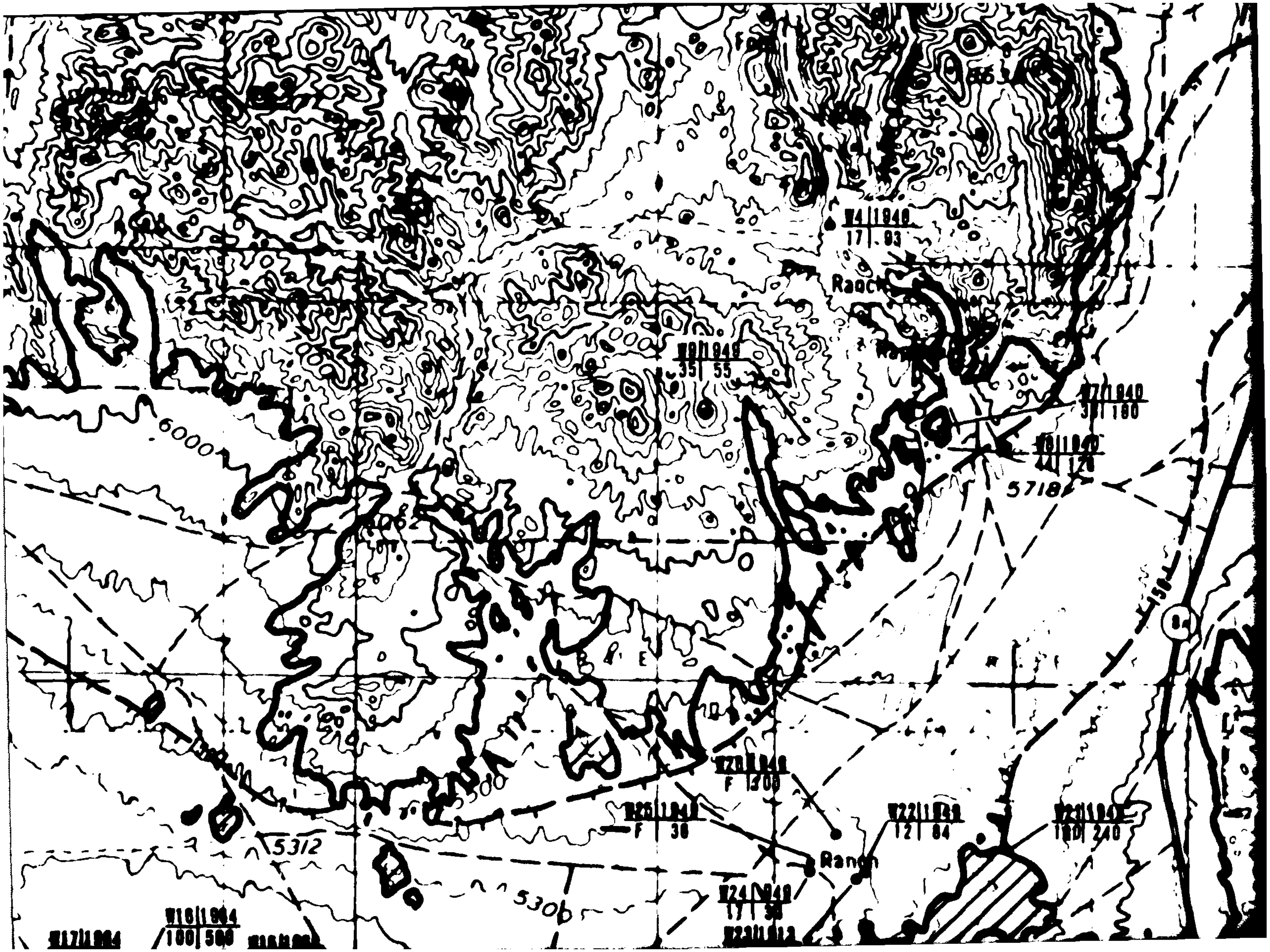
tions of some older wells (as described by the literature),
ader lines with no points.

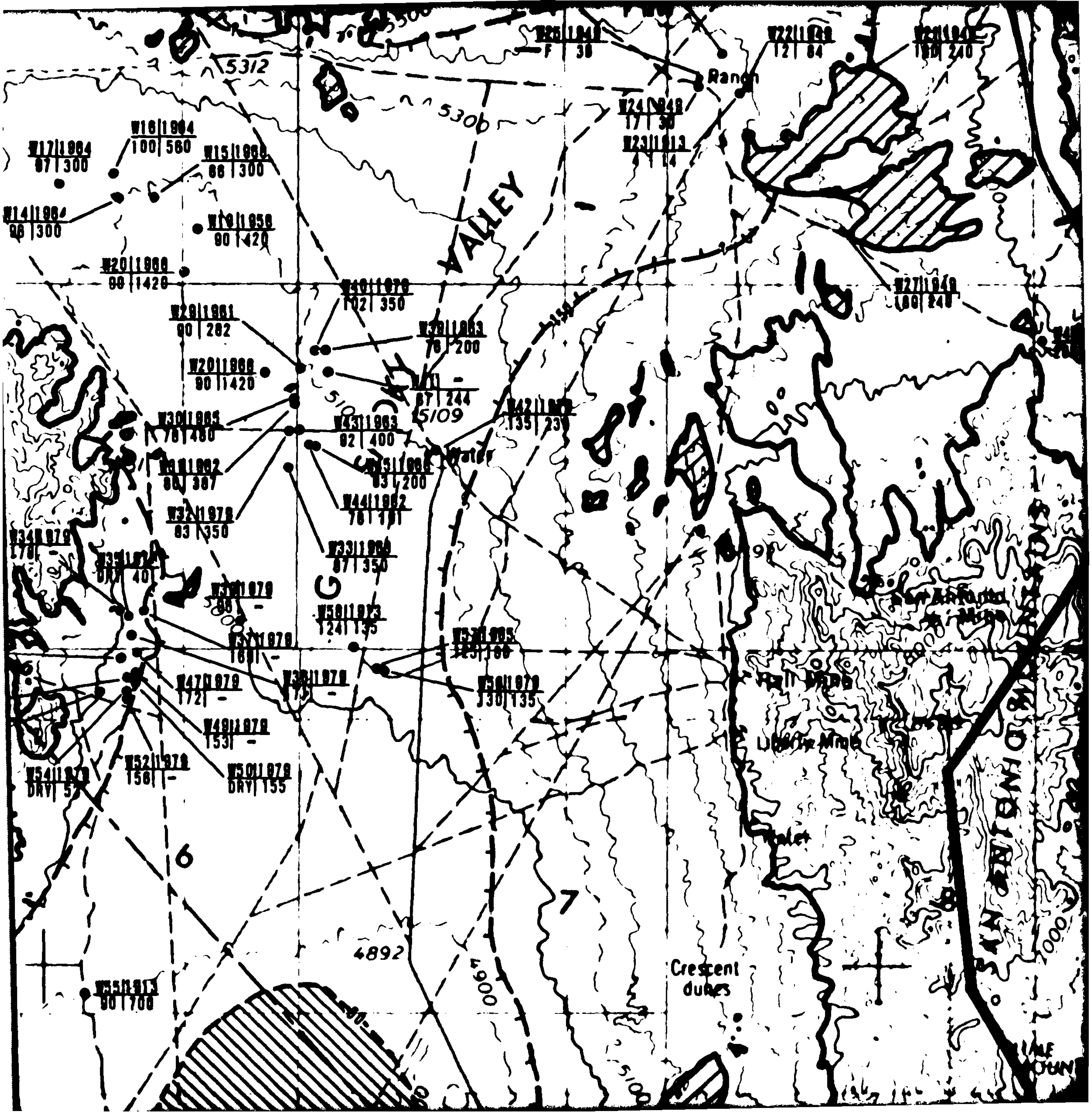
N

SCALE 1:125,000

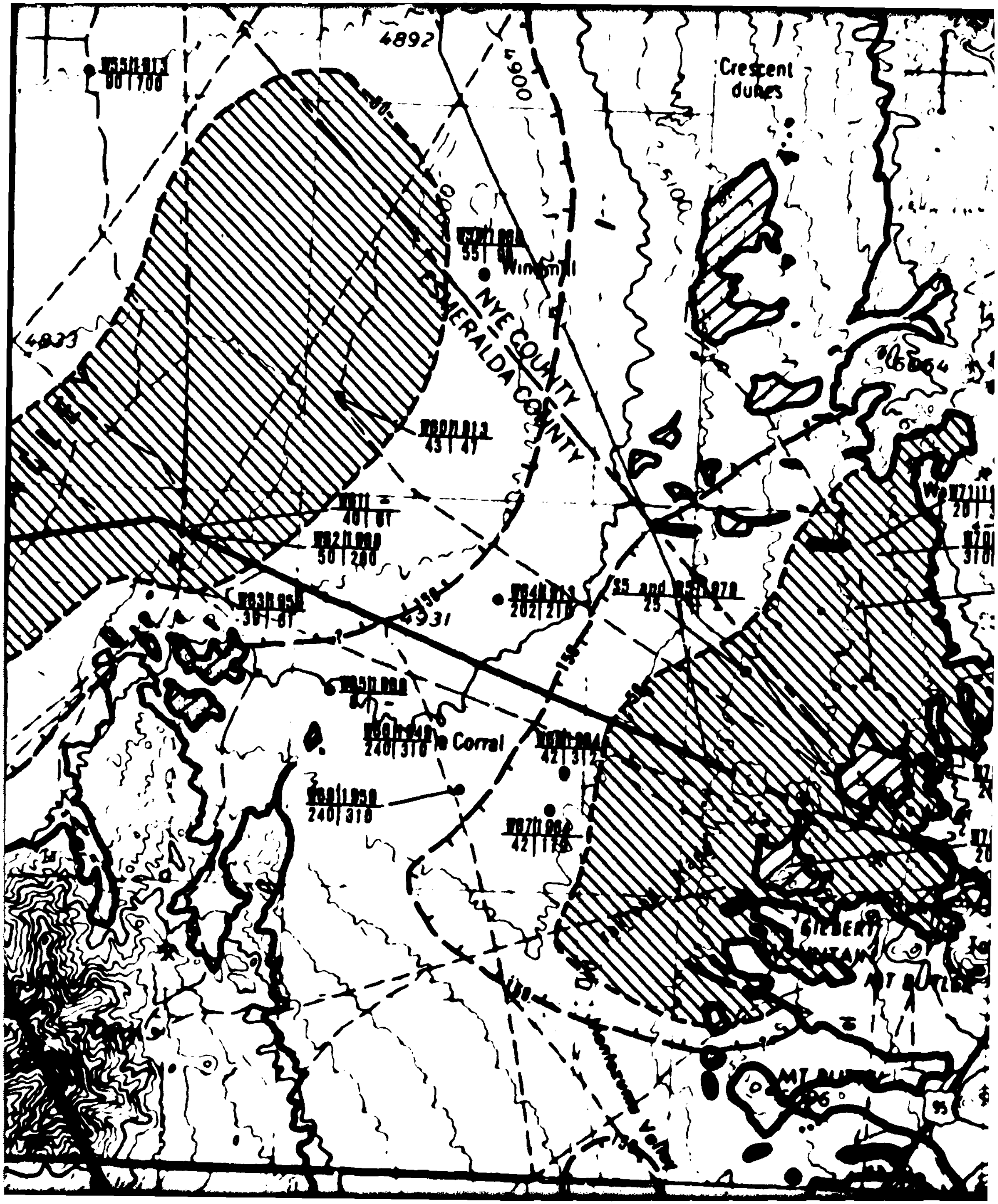
0 2 4
STATUTE MILES

0 2 4
KILOMETERS

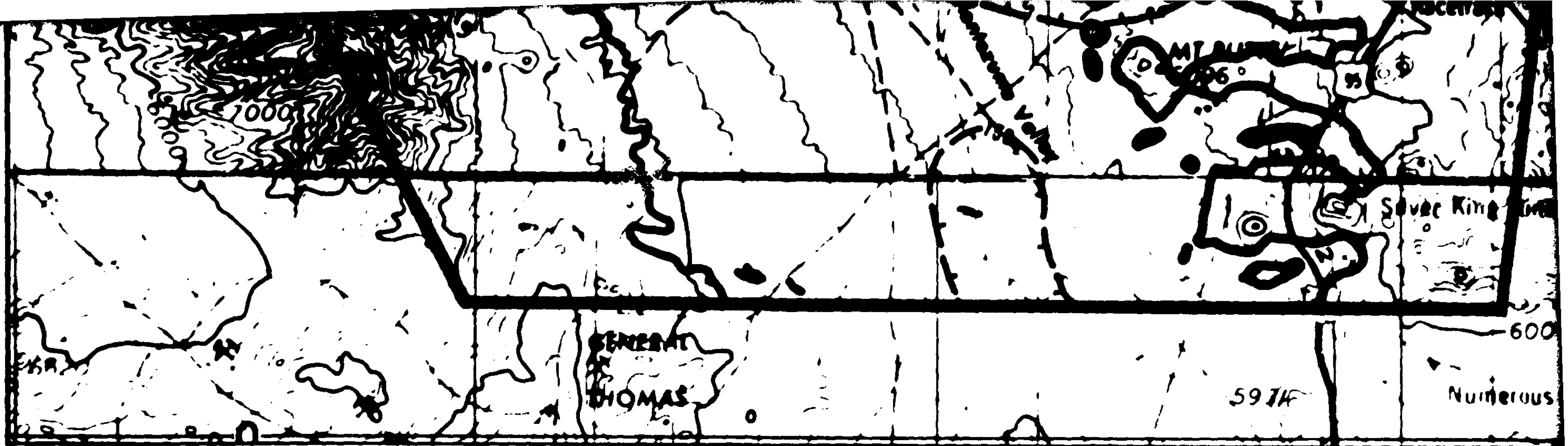

6000
5718
5312
5306
Ranch
W4|1940
17|93
W9|1940
35|55
W7|1940
30|180
W25|1940
F|30
W24|1940
17|90
W16|1964
100|500
W21|1940
180|240



VALLEY
Ranch
Water
Crescent dunes
5312
5300
5109
4892
4900
5100
6
7
G
W26|1949
F | 38
W22|1949
12 | 84
W24|1949
17 | 30
W23|1913
4 | 14
W17|1964
97 | 300
W16|1964
100 | 560
W15|1966
88 | 300
W14|1964
98 | 300
W19|1958
90 | 420
W20|1966
90 | 1420
W40|1979
102 | 350
W29|1961
90 | 282
W39|1963
78 | 200
W30|1965
78 | 480
W43|1963
82 | 400
W42|1963
135 | 239
W44|1962
78 | 191
W32|1979
83 | 350
W33|1960
97 | 350
W58|1973
124 | 135
W54|1979
DRY | 57
W52|1979
158 | -
W49|1979
153 | -
W50|1979
DRY | 155
W47|1979
172 | -
W56|1979
130 | 135
W55|1913
90 | 700
W27|1949
180 | 240



Crescent dunes
4892
4900
5100
NYE COUNTY
ESMERALDA COUNTY
Windmill
4933
4931
Corral
GILBERT
MT BUTLER



EXPLANATION

Contour indicates ground water at a depth of approximately 50 feet (15m) - queried where data are extremely sparse. Shading indicates less than 50 feet (15m) to ground water.

Contour indicates ground water at a depth of approximately 150 feet (46m) - queried where data are extremely sparse. Hachuring indicates less than 150 feet (46m) to ground water.

Contact between rock and basin-fill.

Shading indicates areas of isolated exposed rock.

● W2|1973 / 75|700

Data Source - Fugro boring (B), seismic refraction line (S), electrical resistivity sounding (R), or water well (W); see Volume XIII Section 2.0.	Year of water level measurement
Depth to water (feet)	Depth of well (feet)

NOTE: The contours are based entirely on the data points shown on the map.

DEPTH
VERIFICATION SITE,

MX SITING INVES
DEPARTMENT OF THE AIR

FUGRO NA

EXPLANATION

Contour indicates ground water at a depth of approximately 50 feet (15m) - queried where data are extremely sparse. Shading indicates less than 50 feet (15m) to ground water.

Contour indicates ground water at a depth of approximately 150 feet (46m) - queried where data are extremely sparse. Hachuring indicates less than 150 feet (46m) to ground water.

Contact between rock and basin-fill.

Shading indicates areas of isolated exposed rock.

W2 | 1973
75 | 700

Data Source - Fugro boring (B), seismic refraction line (S), electrical resistivity sounding (R), or water well (W); see Volume III, Section 2.0.	Year of water level measurement
Depth to water (feet)	Depth of well (feet)

NOTE: The contours are based entirely on the data points shown on the map. Extensive interpretation has been used and it can be expected that contour locations will change as additional data are obtained.

The approximate locations of some older wells (as described by the literature), are indicated by leader lines with no points.

DEPTH TO WATER
VERIFICATION SITE, BIG SMOKY CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

DRAWING 10-5

FUGRO NATIONAL, INC.

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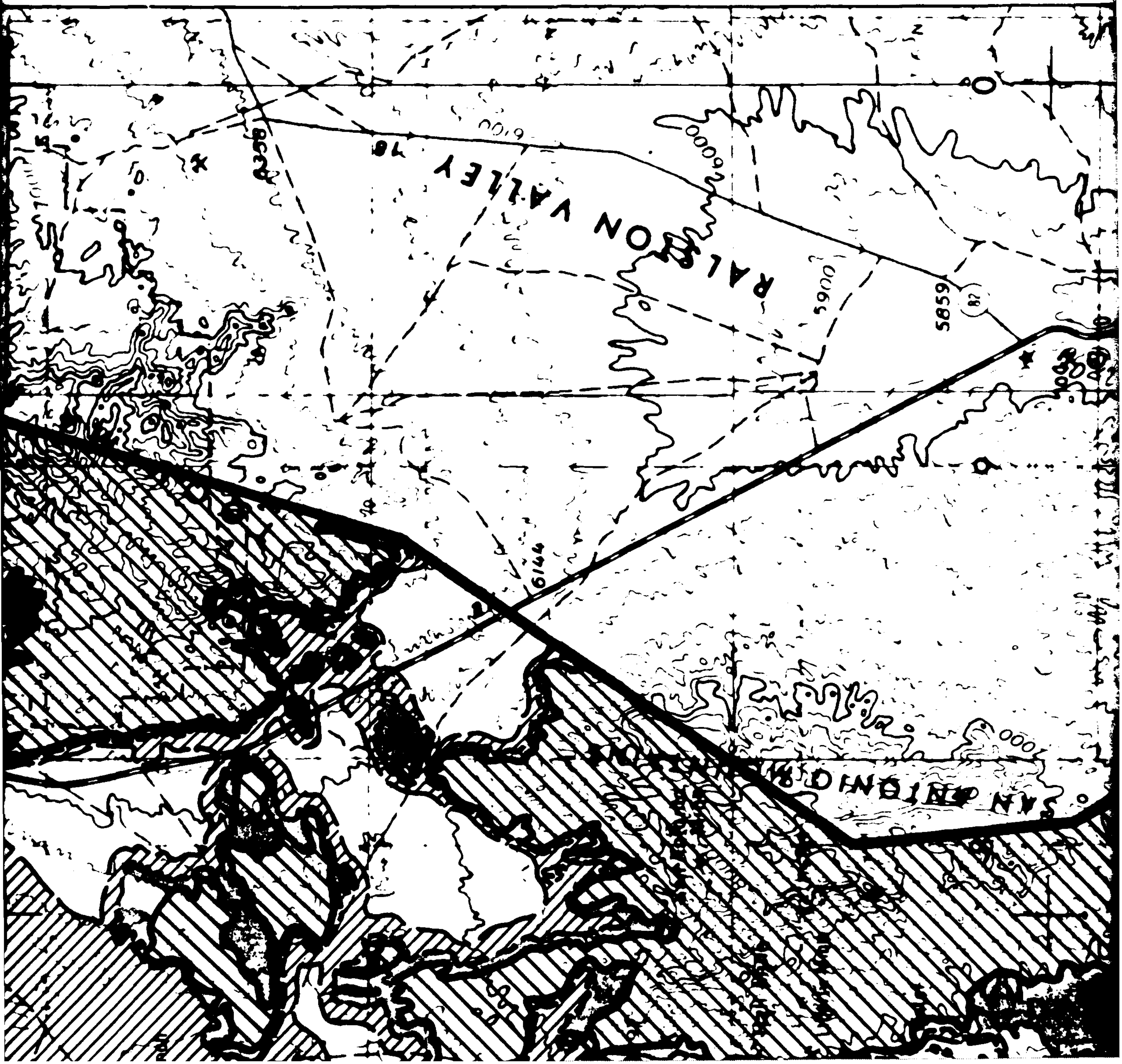
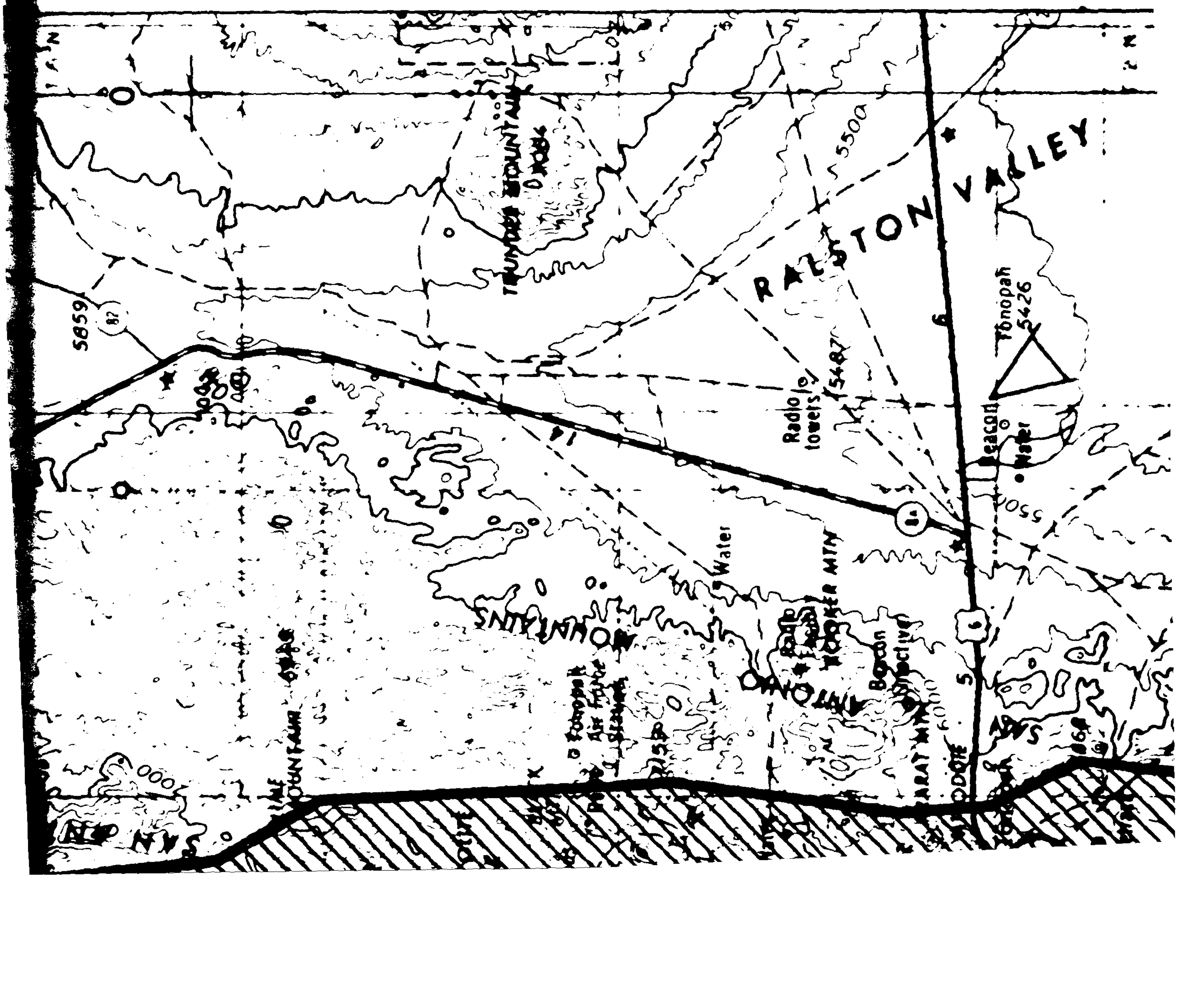
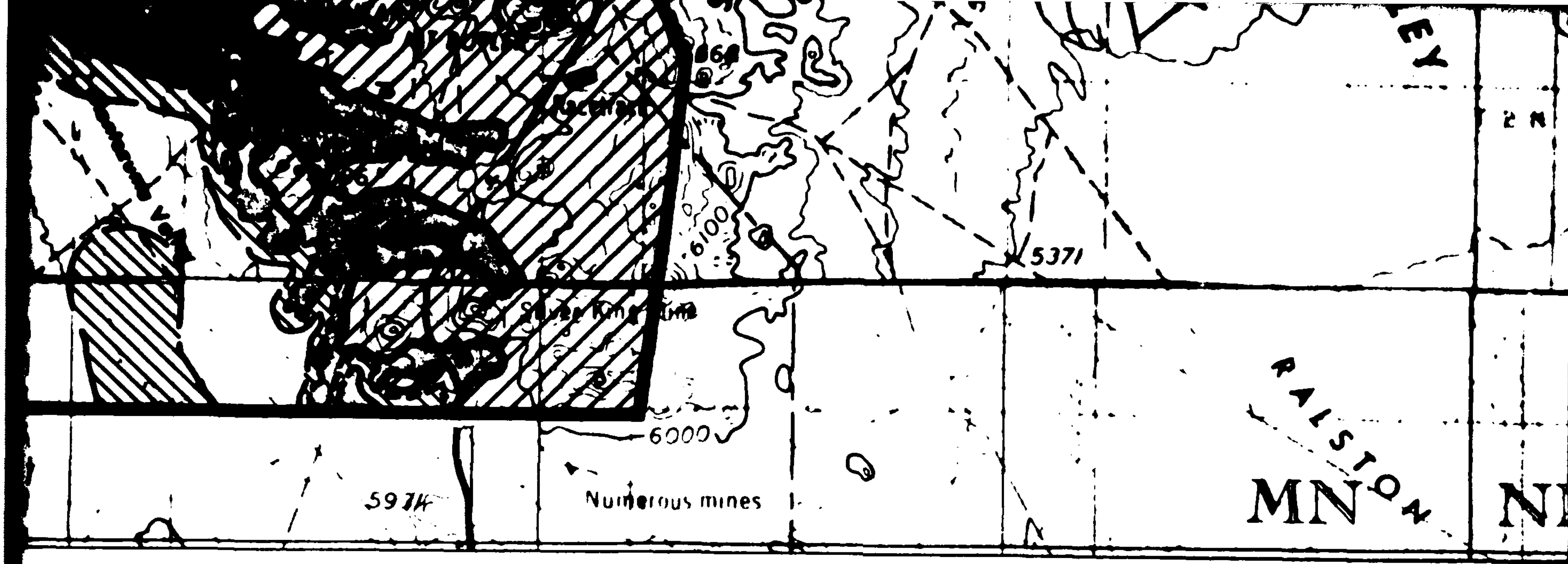


1 3



RALSTON VALLEY
THUNDER MOUNTAIN
5500
5859
14
6
Tonopah
5426
Radio
towers
5487
Beacon
Water
Water
5



NATION

brid trench and vertical shelter
to rock and water greater than

brid trench and not suitable for
depth to rock and water greater
d less than 150 feet (46m).

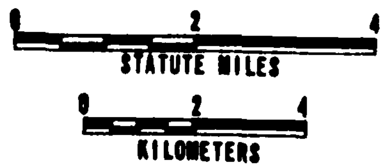
both hybrid trench and vertical
as determined from application
water, topographic terrain, and

posed rock.

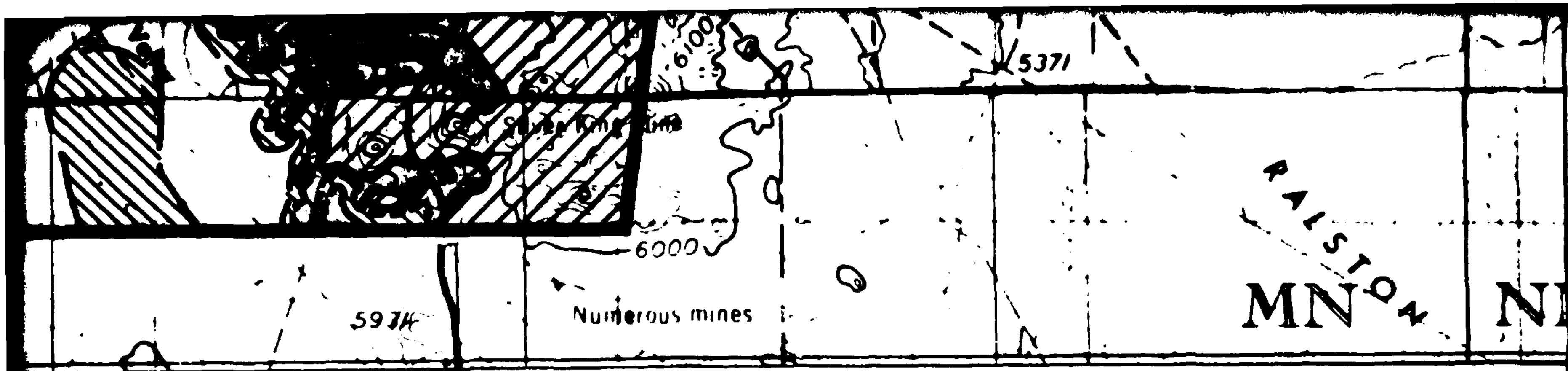
and basin-fill.

ble A2-1 for details regarding suitable criteria.

SCALE 1:125,000



1 — 4



ATION

ld trench and vertical shelter
to rock and water greater than

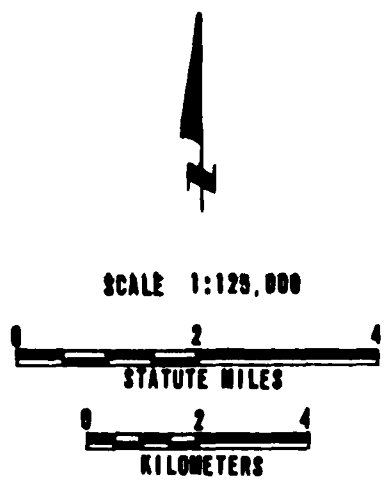
ld trench and not suitable for
th to rock and water greater
less than 150 feet (40m).

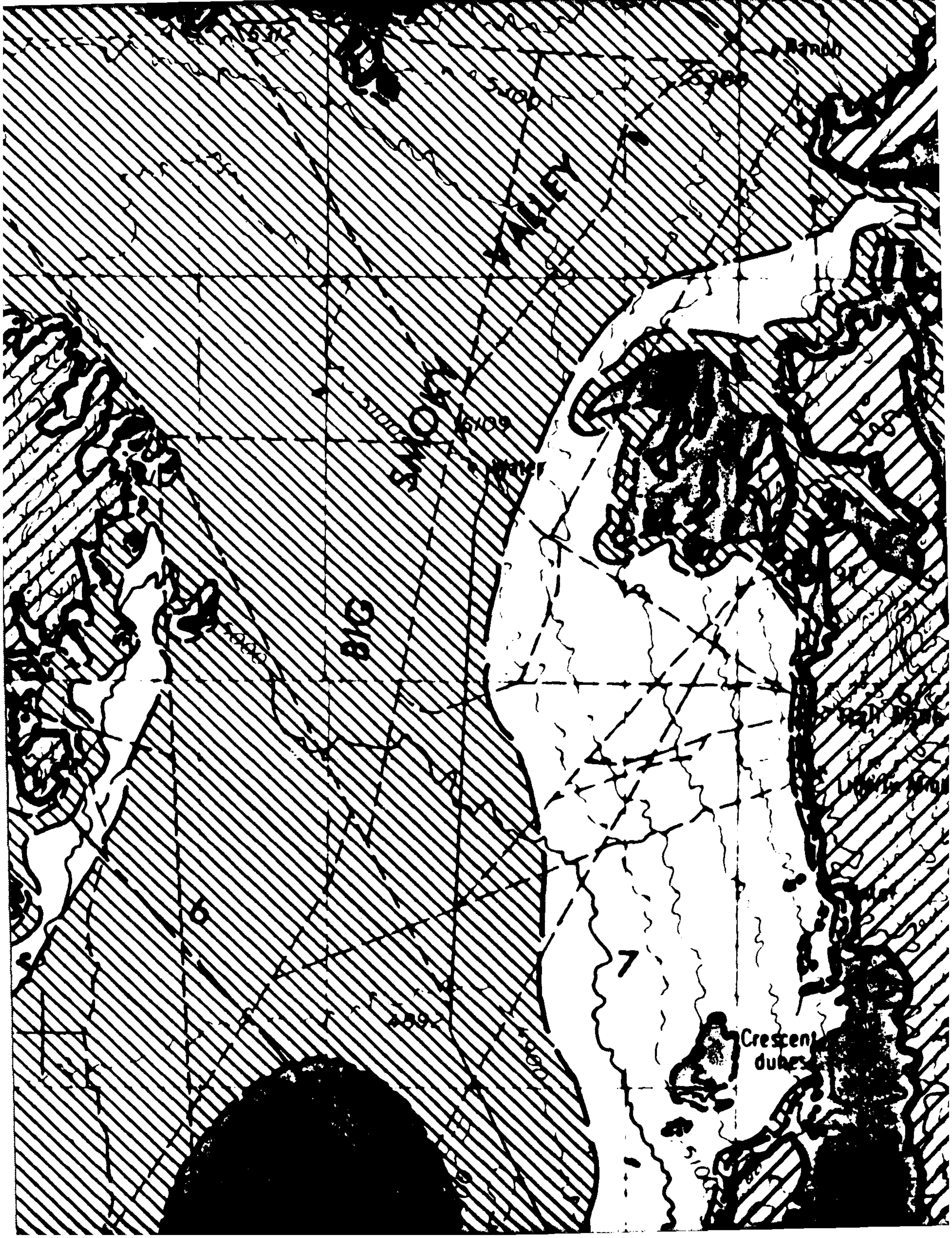
th hybrid trench and vertical
determined from application
ater, topographic/terrain, and

osed rock.

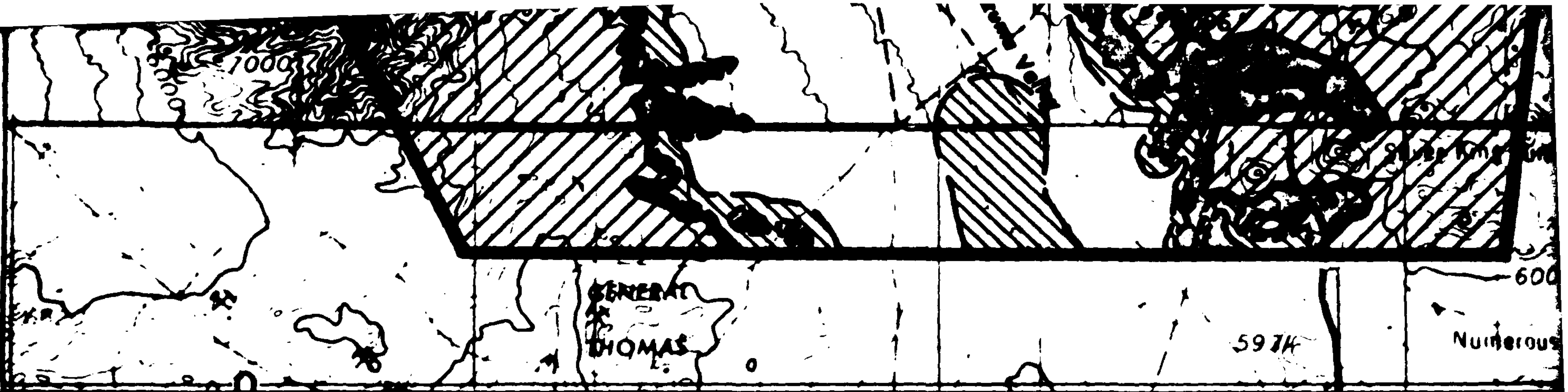
nd basin-fill.

e A2-1 for details regarding suitable criteria.




Crescent dunes
7
6
5100

Crescent dunes
5100
NYE COUNTY
ESMERALDA COUNTY
4931
Corral



EXPLANATION

- Area suitable for hybrid trench and vertical shelter basing modes. Depth to rock and water greater than 150 feet (46m).
- Area suitable for hybrid trench and not suitable for vertical shelter. Depth to rock and water greater than 50 feet (15m) and less than 150 feet (46m).
- Area unsuitable for both hybrid trench and vertical shelter basing modes as determined from application of depth to rock and water, topographic/terrain, and cultural exclusions.
- Indicates areas of exposed rock.
- Contact between rock and basin-fill.

NOTE: See Appendix A2.0 Section Table A2-1 for details regarding suitable criteria.

SUITABLE AREA
HYBRID TRENCH AND VERTICAL SHELTER
VERIFICATION SITE, BIG SMOKY EDP. NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

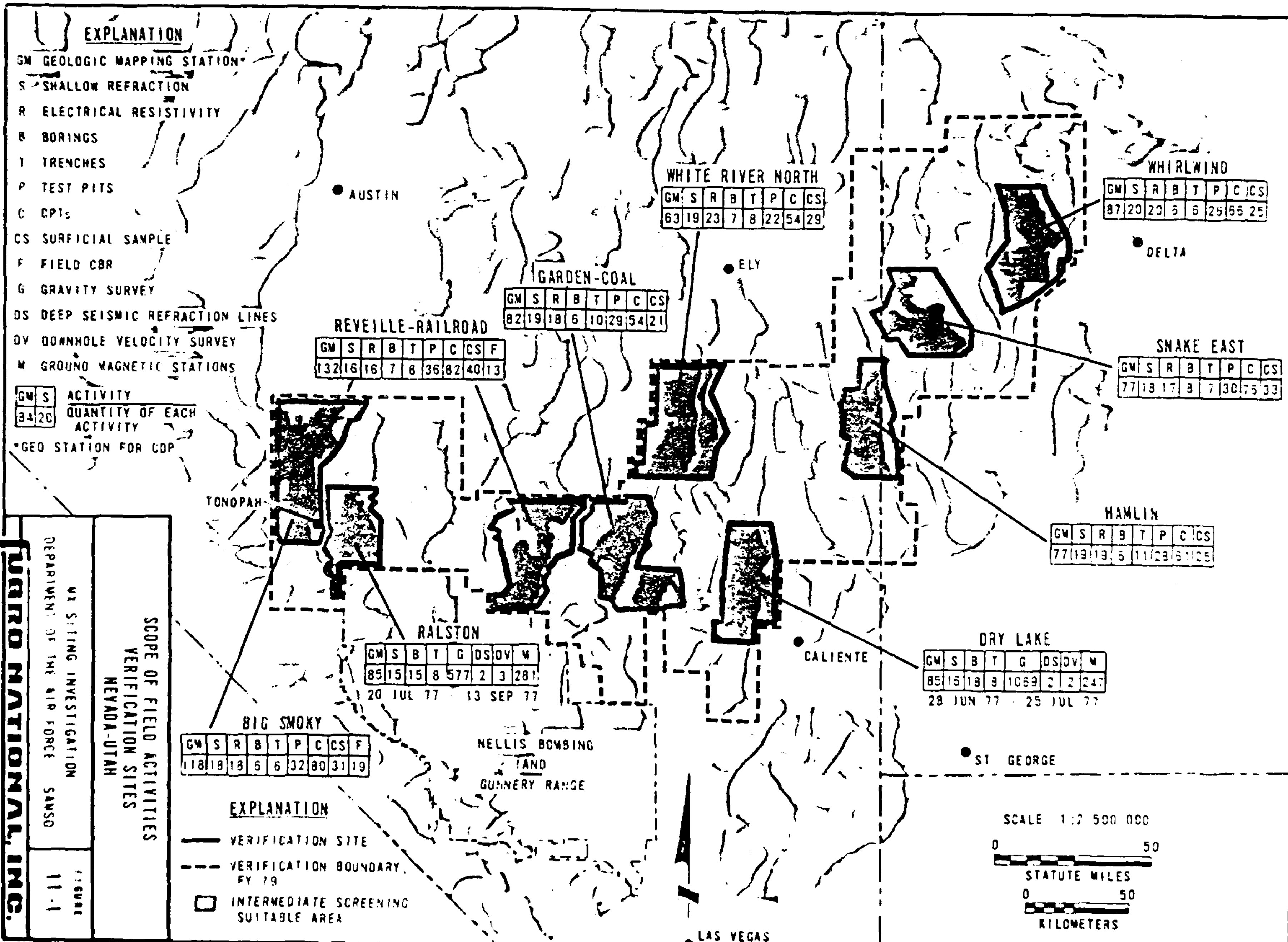
DRAWING 10-6

FUGRO NATIONAL INC.

11.0 DRY LAKE AND RALSTON CDPs

In 1977, field investigations were performed in portions of Dry Lake and Ralston CDPs during the Characterization program. The number and type of activities differed from those performed for the FY 79 Verification Studies as shown in Figure 11-1. Eighteen borings, varying in depth from 30 to 300 feet (9 to 92 m), were drilled in Dry Lake Valley and 15 borings, varying in depth from 25 to 450 feet (8 to 137 m), were drilled in Ralston Valley. At both sites, deep seismic refraction lines, downhole velocity surveys, and gravity and ground magnetic surveys were also performed. The results of these previous studies are summarized in a report titled "MX Siting Investigation, Geotechnical Summary, Prime Characterization Sites, Great Basin Candidate Siting Province," dated 15 February 1979 (FN-TR-26e).

The portions of Dry Lake and Ralston CDPs which have been investigated are now considered Verification sites; the locations are shown in Figures 11-2 and 11-3, respectively. However, additional field studies will be required to obtain information about the shallow soil conditions. It is planned to perform cone penetration tests, excavate test pits, and obtain surficial soil samples during the FY 80 program. When these field studies are completed, Geotechnical Data Volumes will be prepared. Information about the Dry Lake and Ralston Verification sites will be in Volumes IX and X, respectively.



SCOPE OF FIELD ACTIVITIES
VERIFICATION SITES
NEVADA-UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE II-1

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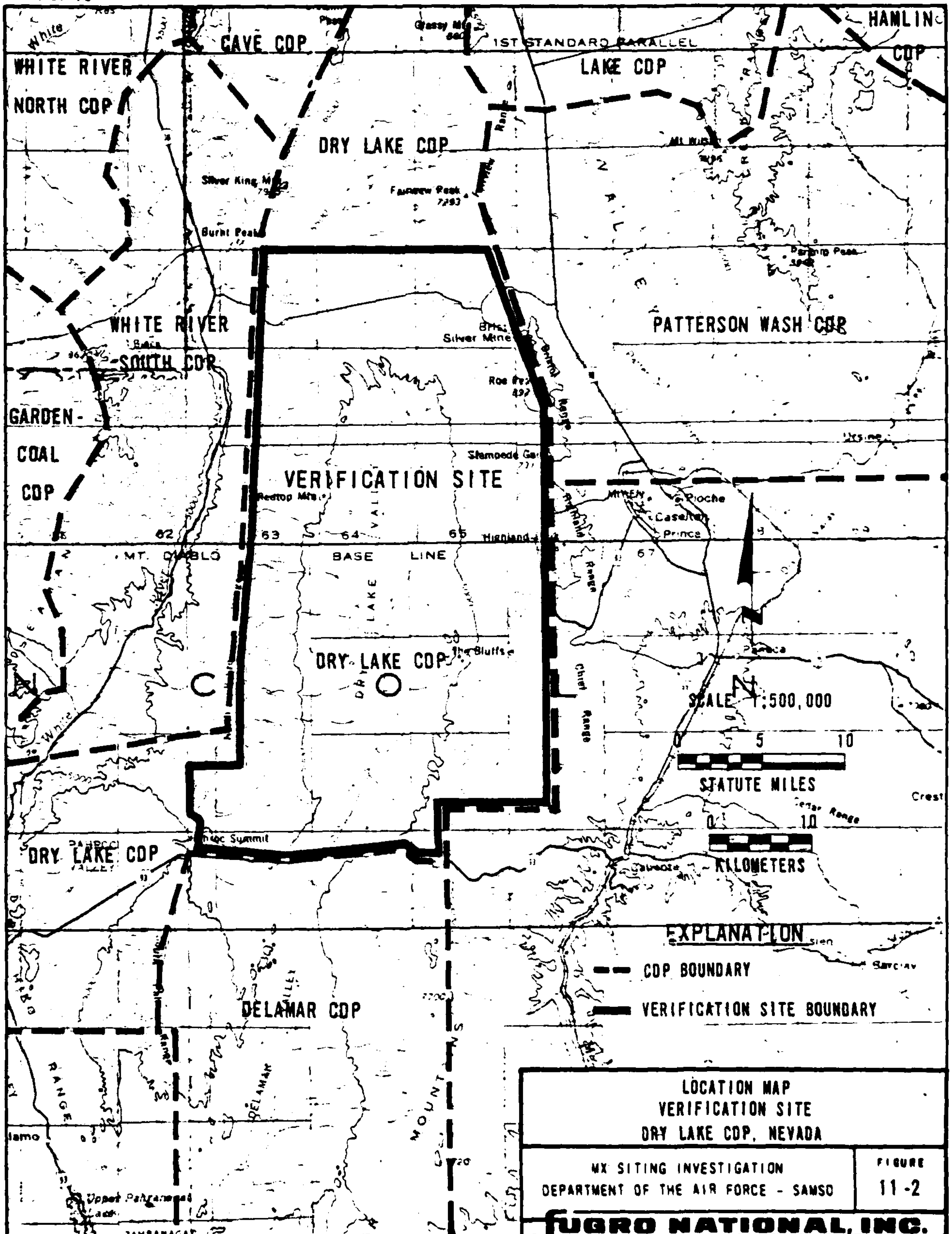

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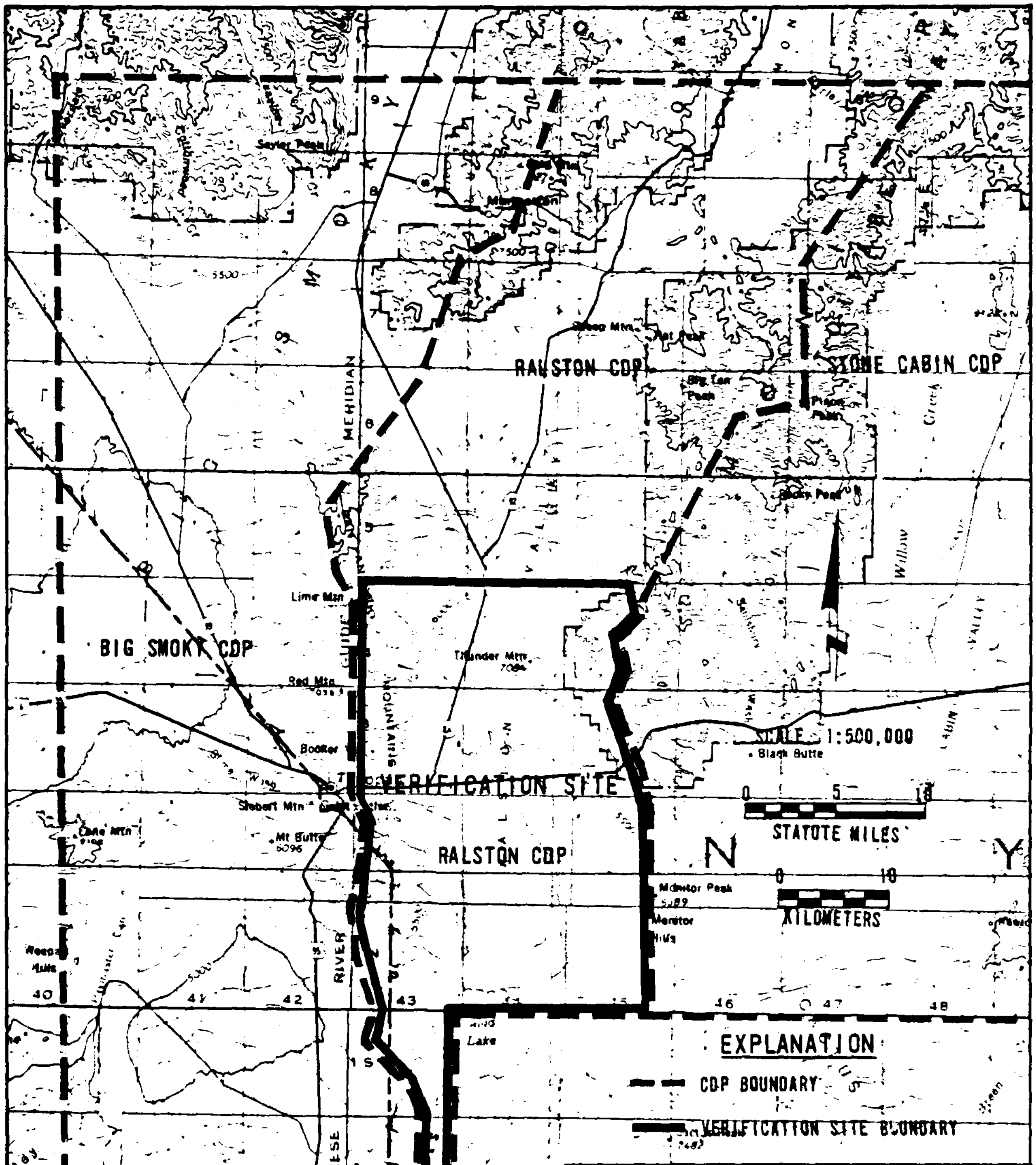

LOCATION MAP
VERIFICATION SITE
RALSTON CDP, NEVADA

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FIGURE 11-3

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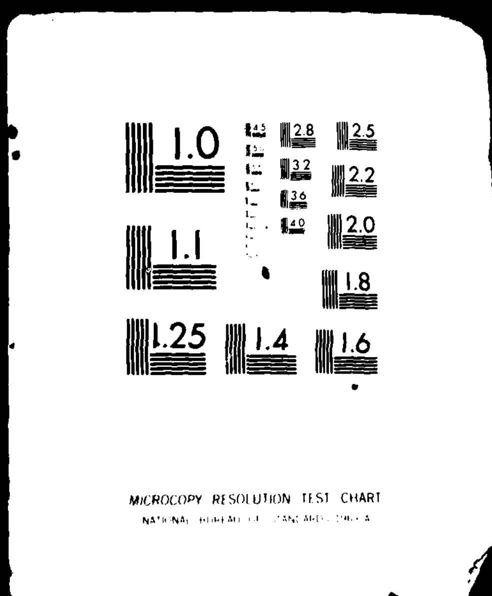

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APPENDIX

APPENDIX

TABLE OF CONTENTS

APPENDIX

TABLE OF CONTENTS (Cont.)

LIST OF TABLES

LIST OF FIGURES

A1.0 GLOSSARY OF TERMS

ACTIVE FAULT - A fault which has had surface displacement within Holocene time (about the last 11,000 years).

ACTIVITY NUMBER - A designation composed of the valley abbreviation followed by the activity type and a unique number; may also be used to designate a particular location in a valley.

ALLUVIAL FAN DEPOSITS - Alluvium deposited by a stream or other body of running water as a sorted or semisorted sediment in the form of a cone or fan at the base of a mountain slope.

ALLUVIUM - A general term for unconsolidated clay, silt, sand, gravel, and boulders deposited during relatively recent geologic time by a stream or other body of running water as a sorted or semisorted sediment in the bed of a stream or on its flood plain or delta, or as a cone or fan at the base of a mountain slope.

ANOMALY - 1) A deviation from uniformity in physical properties; especially a deviation from uniformity in physical properties of exploration interest. 2) A portion of a geophysical survey which is different in appearance from the survey in general.

APPARENT RESISTIVITY (See Resistivity) - The ground resistivity calculated from measurements and a geometric factor (based on homogeneous and isotropic ground). This value includes the effect of all material influenced by the current induced into the ground and does not necessarily represent the true resistivity of any particular material or zone.

AQUIFER - A permeable saturated zone below the earth's surface capable of conducting and yielding water as to a well.

ARRIVAL - An event; the appearance of seismic energy on a seismic record; a lineup of coherent energy signifying the arrival of a new wave train.

ATTERBERG LIMITS - A general term applied to the various tests used to determine the various states of consistency of fine-grained soils. The four states of consistency are solid, semisolid, plastic, and liquid.

Liquid limit (LL) - The water content corresponding to the arbitrary limit between the liquid and plastic states of consistency of a soil (ASTM D423-66).

Plastic limit (PL) - The water content corresponding to an arbitrary limit between the plastic and the semisolid states of consistency of a soil (ASTM D424-59).

GLOSSARY OF TERMS (Cont.)

Plasticity index (PI) - Numerical difference between the liquid limit and the plastic limit indicating the range of moisture content through which a soil-water mixture is plastic.

BASIN-FILL MATERIAL/BASIN-FILL DEPOSITS - Heterogenous detrital material deposited in a sedimentary basin.

BASE LEVEL - The theoretical limit or lowest level toward which erosion constantly progresses; the level at which neither erosion or deposition takes place.

BEDROCK - A general term for the rock, usually solid, that underlies soil or other unconsolidated, surficial material.

BORING - A method of subsurface exploration whereby an open hole is formed in the ground through which soil-sampling or rock-drilling may be conducted.

BOUGUER ANOMALY - The residual value obtained after latitude, elevation, and terrain corrections have been applied to gravity data.

BOULDER - A rock fragment, usually rounded by weathering and abrasion with an average diameter of 12 inches (305 mm) or more.

BULK SAMPLE - A disturbed soil sample (bag sample) obtained from cuttings brought to the ground surface by a drill rig auger or obtained from the walls of a trench excavation.

c - Cohesion (Shear strength of a soil not related to interparticle friction).

CALCAREOUS - Containing calcium carbonate; presence of calcium carbonate is commonly identified on the basis of reaction with dilute hydrochloric acid.

CALICHE - Gravel, sand, or other material cemented principally by calcium carbonate.

CALIFORNIA BEARING RATIO (CBR) - Is the ratio (in percent) of the resistance to penetration developed by a subgrade soil to that developed by a specimen of standard crushed rock base material (ASTM D1883-73). During the CBR test, the load is applied on the circular penetration piston (3 inches^2 base area; 19 cm^2) which is penetrated into the the soil sample at a constant penetration rate of 0.05 inch/ minute (1.2 mm/min). The bearing ratio reported for the soil is normally the one at 0.1 inch (2.5 mm) penetration.

GLOSSARY OF TERMS (Cont.)

CANDIDATE DEPLOYMENT PARCEL (CDP) - An area of 150 (200) to 500 square nautical miles (660 square statute miles) potentially suitable for MX siting. Each parcel should have a specific geographic description. (In the Basin and Range Physiographic province a parcel may correspond to a geographic valley and in Texas to some agri-economic unit.)

CLAY - Fine-grained soil (passes No. 200 sieve; 0.074 mm) that can be made to exhibit plasticity within a range of water contents and that exhibits considerable strength when air dry.

CLAY SIZE - That portion of the soil finer than 0.002 mm.

CLOSED BASIN - A catchment area draining to some depression or lake within its area, from which water escapes only by evaporation.

COARSE-GRAINED (or granular) - A term which applies to a soil of which more than one-half of the soil particles, by weight, are larger than 0.074 mm in diameter (No. 200 U.S. sieve size).

COARSER-GRAINED - A term applied to alluvial fan deposits which are predominantly composed of material (gravel) larger than 3 inches (76 mm) in diameter.

COBBLE - A rock fragment, usually rounded or subrounded with an average diameter between 3 and 12 inches (76 and 305 mm).

COMPACTION TEST - A type of test to determine the relationship between the moisture content and density of a soil sample which is prepared in compacted layers at various water contents (ASTM D1557-70).

COMPRESSIBILITY-Property of a soil pertaining to its susceptibility to decrease in volume when subjected to load.

COMPRESSIONAL WAVE -An elastic body wave in which particle motion is in the direction of propagation; the type of seismic wave assumed in conventional seismic exploration. Also called P-wave, dilatational wave, and longitudinal wave.

CONDUCTIVITY - The ability of a material to conduct electrical current. In isotropic material, conductivity is the reciprocal of resistivity. Units are mhos per meter.

GLOSSARY OF TERMS (Cont.)

CONE PENETROMETER TEST - A method of evaluating the in-situ engineering properties of soil by measuring the penetration resistance developed during the steady slow penetration of a cone (60° apex angle, 10-cm^2 projected area) into soil.

Cone resistance or end bearing resistance, q_c - The resistance to penetration developed by the cone, equal to the vertical force applied to the cone divided by its horizontally projected area.

Friction resistance, f_s - The resistance to penetraton developed by the friction sleeve, equal to the vertical force applied to the sleeve divided by its surface area. This resistance consists of the sum of friction and adhesion.

Friction ratio, f_R - The ratio of friction resistance to cone resistance, f_s/q_c, expressed in percent.

CONSISTENCY - The relative ease with which a soil can be deformed.

CONSOLIDATION TEST - A type of test to determine the compressibility of a soil sample. The sample is enclosed in the consolidometer which is then placed in the loading device. The load is applied in increments at certain time intervals and the change in thickness is recorded.

CORE SAMPLE - A cylindrical sample obtained with a rotating core barrel with a cutting bit at its lower end. Core samples are obtained from indurated deposits and in rock.

DEGREE OF SATURATION - Ratio of volume of water in soil to total volume of voids.

DETECTOR - See GEOPHONE.

DIRECT SHEAR TEST - A type of test to measure the shear strength of a soil sample where the sample is forced to fail on a predetermined plane.

DISSECTION/DISSECTED (alluvial fans) - The cutting of stream channels into the surface of an alluvial fan by the movement (or flow) of water.

DRY UNIT WEIGHT/DRY DENSITY - Weight per unit volume of the solid particles in a soil mass.

ELECTRICAL CONDUCTIVITY - Ability of a material to conduct electrical current.

GLOSSARY OF TERMS (Cont.)

ELECTRICAL RESISTIVITY - Property of a material which resists flow of electrical current.

EOLIAN - A term applied to materials which are deposited by wind.

EPHEMERAL (stream) - A stream in which water flow is discontinuous and of short duration.

EXTERNAL DRAINAGE - Stream drainage system whose downgradient flow is unrestricted by any topographic impediments.

EXTRUSIVE (rock) - Igneous rock that has been ejected onto the earth's surface (e.g., lava, basalt, rhyolite, andesite; detrital material, volcanic tuff, pumice).

FAULT - A plane or zone of rock fracture along which there has been displacement.

FAULT BLOCK MOUNTAINS - Mountains that are formed by normal faulting in which the surface crust is divided into structural, partially to entirely fault-bounded blocks of different elevations.

FINE-GRAINED - A term which applies to a soil of which more than one-half of the soil particles, by weight, are smaller than 0.074 mm in diameter (passing the No. 200 U.S. size sieve).

FINER-GRAINED - A term applied to alluvial fan deposits, which are composed predominantly of material less than 3 inches (76 mm).

FLUVIAL DEPOSITS - Material produced by river action; generally loose, moderately well-graded sands and gravel.

FORMATION - A mappable assemblage of rocks characterized by some degree of homogeneity or distinctiveness.

FREE AIR ANOMALY - Gravity data which have been corrected for latitude and elevation (free air correction) but not for the density of rock between the datum and the plane of measurement (Bouguer correction).

FUGRO DRIVE SAMPLE - A 2.50-inch-(6.4-cm) diameter soil sample obtained from a drill hole with a Fugro drive sampler. The Fugro drive sampler is a ring-lined barrel sampler containing 12 one-inch-(2.54-cm) long brass sample rings. The sampler is advanced into the soil using a drop hammer.

GLOSSARY OF TERMS (Cont.)

GEOMORPHOLOGY - The study, classification, description, nature, origin, and development of present landforms and their relationships to underlying structures, and of the history of geologic changes as recorded by these surface features.

GEOPHONE - The instrument used to transform seismic energy into electrical voltage; a seismometer, jug, or pickup.

GRABEN - An elongated crustal block that has been downthrown along faults relative to the rocks on either side.

GRAIN-SIZE ANALYSIS (GRADATION) - A type of test to determine the distribution of soil particle sizes in a given soil sample. The distribution of particle sizes larger than 0.074 mm (retained on the No. 200 sieve) is determined by sieving, while the distribution of particle sizes smaller than 0.074 mm is determined by a sedimentation process, using a hydrometer.

GRANULAR - See Coarse-Grained.

GRAVEL - Particles of rock that pass a 3-in. (76.2-mm) sieve and are retained on a No. 4 (4.75 mm sieve).

GRAVITY - The force of attraction between bodies because of their mass. Usually measured as the acceleration of gravity.

GYPSIFEROUS - Containing gypsum, a mineral consisting mostly of sulfate of lime.

HORST - An elongated crustal block that has been uplifted along faults relative to the rocks on either side.

INTERIOR DRAINAGE - Stream drainage system that flows into a closed topographic low (basin).

INTRUSIVE (rock) - A rock formed by the process of emplacement of magma (liquid rock) in preexisting rock, (e.g., granite, granodiorite, quartz monzonite).

LACUSTRINE DEPOSITS - Materials deposited in a lake environment.

LARAMIDE OROGENY - A time of deformation extending from late Cretaceous (about 100 million years ago) to the end of the Paleocene (about 50 million years ago) which accounted for much present Basin and Range structure.

LINE - A linear array of observation points, such as a seismic line.

GLOSSARY OF TERMS (Cont.)

LIQUID LIMIT - See ATTERBERG LIMITS.

LOW STRENGTH SURFICIAL SOIL - Soil which will perform poorly as a road subgrade, at its present consistency, when used dirctly beneath a road section.

MILLIGAL - A unit of acceleration used with gravity measurements; 1 milligal = 10^{-5} m/s^2. Abbreviated mgal.

MOISTURE CONTENT - The ratio, expressed as a percentage, of the weight of water contained in a soil sample to the ovendry weight of the sample.

NEOTECTONICS - The study of the recent structural history of the earth's crust, usually during the late Tertiary and the Quaternary periods.

N VALUE - Penetration resistance, described as the number of blows required to drive the standard split-spoon sampler for the second and third 6 inches (0.15 m) with a 140-pound (63.5-kg) hammer falling 30 inches (0.76 m) (ASTM D1586-67).

OPTIMUM MOISTURE CONTENT - Moisture content at which a soil can be compacted to a *maximum dry unit weight by a given* compactive effort.

P-WAVE - See Compressional Wave.

PATINA - A dark coating or thin outer layer produced on the surface of a rock or other material by weathering after long exposure (e.g., desert varnish).

PAVEMENT/DESERT PAVEMENT - When loose material containing pebble-sized or larger rocks is exposed to rainfall and wind action, the finer dust and sand are blown or washed away and the pebbles gradually accumulate on the surface, forming a mosaic which protects the underlying finer material from wind attack. Pavement can also develop in finer-grained materials. In this case, the armored surface is formed by dissolution and cementation of the grains involved.

PERMEABLE - The ability of liquid to pass through soil and/or rock material.

pH - An index of the acidity or alkalinity of a soil in terms of the logarithm of the reciprocal of the hydrogen ion concentration.

GLOSSARY OF TERMS (Cont.)

PHI (Ø) - Angle of internal friction.

PIEZOMETRIC SURFACE - An imaginary surface representing the static head of ground water and defined by the level to which water will rise in a well.

PITCHER TUBE SAMPLE - An undisturbed, 2.87-inch-(73-mm) diameter soil sample obtained from a drill hole with a Pitcher tube sampler. The primary components of this sampler are an outer rotating core barrel with a bit and an inner stationary, spring-loaded, thin-wall sampling tube which leads or trails the outer barrel drilling bit, depending upon the hardness of the material being penetrated.

PLASTIC LIMIT - See ATTERBERG LIMITS.

PLASTICITY INDEX - See ATTERBERG LIMITS.

PLAYA/PLAYA DEPOSITS - A term used in the southwest U.S. for a dried-up, flat-floored area composed of thin, evenly stratified sheets of fine clay, silt, or sand, and representing the lowest part of a shallow, completely closed or undrained, desert lake basin in which water accumulates and is quickly evaporated, usually leaving deposits of soluble salts.

POORLY GRADED - A descriptive term applied to a coarse-grained soil if it consists predominantly of one particle size (uniformly graded) or has a wide range of sizes with some intermediate sizes obviously missing (gap-graded).

RANGE-BOUNDED FAULT - Usually a normal fault in which one side has moved up relative to the other and which separates the mountain front from the valley.

RELATIVE AGE - The relationship in age (oldest to youngest) between geologic units without specific regard to number of years.

RESISTIVITY (True, Intrinsic) - The property of a material which resists the flow of electric current. The ratio of electric-field intensity to current density.

RESISTIVITY SOUNDING - Observation of electric fields caused by current introduced into the ground as a means of studying earth resistivity. Normally includes only those methods in which a very low frequency or direct current is used to measure apparent resistivity. "Sounding" implies that successive measurements are made with increased electrode spacing.

GLOSSARY OF TERMS (Cont.)

ROCK UNITS - Distinct rock masses with different characteristics (e.g., igneous, metamorphic, sedimentary).

ROTARY WASH DRILLING - A boring technique in which advancement of the hole through overburden is accomplished by rotation of a heavy string of rods while continuous downward pressure is maintained through the rods on a bit at the bottom of the hole. Water or drilling mud is forced down the rods to the bit, and the return flow brings the cuttings to the surface.

S-WAVE - See Shear Wave.

SAND - Soil passing through No. 4 (4.75 mm) sieve and retained on No. 200 (0.075 mm) sieve.

SAND DUNE - A low ridge or hill consisting of loose sand deposited by the wind, found in various desert and coastal regions and generally where there is abundant surface sand.

SEISMIC - Having to do with elastic waves. Energy may be transmitted through the body of an elastic solid as P-waves (compressional waves) or S-waves (shear waves).

SEISMIC LINE - A linear array of travel time observation points (geophones). In this study, each line contains 24 geophone positions.

SEISMIC REFRACTION DATA: deep/shallow - Data derived from a type of seismic shooting based on the measurement of seismic energy as a function of time after the shot and of distance from the shot, by determining the arrival times of seismic waves which have traveled nearly parallel to the bedding in high-velocity layers, in order to map the depth to such layers.

SEISMOGRAM - A seismic record.

SEISMOMETER - See Geophone.

SHEAR STRENGTH - The maximum resistance of a soil to shearing (tangential) stresses.

SHEAR WAVE - A body wave in which the particle motion is perpendicular to the direction of propagation. Also called S-Wave or transverse wave.

SHEET FLOW - A process in which stormborne water spreads as a thin, continuous veneer (sheet) over a large area.

GLOSSARY OF TERMS (Cont.)

SHEET SAND - A blanket deposit of sand which accumulates in shallow depressions or against rock outcrops, but does not have characteristic dune form.

SHOT - Any source of seismic energy; e.g., the detonation of an explosive.

SHOT POINT - The location of any source of seismic energy; e.g., the location where an explosive charge is detonated in one hole or in a pattern of holes to generate seismic energy. Abbreviated SP.

SILT - Fine-grained soil passing the No. 200 sieve (0.074 mm) that is nonplastic or very slightly plastic and that exhibits little or no strength when air-dried.

SILT SIZE - That portion of the soil finer than 0.02 mm and coarser than 0.002 mm.

SITE - Location of some specific activity or reference point. The term should always be modified to a precise meaning or be clearly understood from the context of the discussion.

SPECIFIC GRAVITY - The ratio of the weight in air of a given volume of soil solids at a stated temperature to the weight in air of an equal volume of distilled water at a stated temperature.

SPLIT-SPOON SAMPLE - A disturbed sample obtained with a split-spoon sampler with an outside diameter of 2.0 inches (5.1 cm). The sample consists of a split barrel which is driven into the soil using a drop hammer.

SPREAD - The layout of geophone groups from which data from a single shot are recorded simultaneously. Spreads containing 24 geophones have been used in Fugro's seismic refraction surveys.

STREAM CHANNEL DEPOSITS - See Fluvial Deposits.

STREAM TERRACE DEPOSITS - Stream channel deposits no longer part of an active stream system, generally loose, moderately well graded sand and gravel.

SULFATE ATTACK - The process during which sulfates, salts of sulfuric acid, contained in ground water cause dissolution and damage to concrete.

SURFICIAL DEPOSIT - Unconsolidated residual and alluvial deposits occurring on or near the earth's surface.

GLOSSARY OF TERMS (Cont.)

TEST PIT - An excavation made to depths of about 5 feet (1.5 m) by a backhoe. A test pit permits visual examination of undisturbed material in place.

TRENCH - An excavation by a backhoe to depths of about 15 feet (4.5 m). A trench permits visual examination of soil in place and evaluaton of excavation wall stability.

TRIAXIAL COMPRESSION TEST - A type of test to measure the shear strength of an undisturbed soil sample (ASTM D2850-70). To conduct the test, a cylindrical specimen of soil is surrounded by a fluid in a pressure chamber and subjected to an isotropic pressure. An additional compressive load is then applied, directed along the axis of the specimen called the axial load.

Consolidated-drained (CD) Test - A triaxial compression test in which the soil was first consolidated under an all-around confining stress (test chamber pressure) and was then compressed (and hence sheared) by increasing the vertical stress. Drained indicates that excess pore water pressures generated by strains are permitted to dissipate by the free movement of pore water during consolidation and compression.

Consolidated-undrained (CU) Test - A triaxial compression test in which essentially complete consolidation under the confining (chamber) pressure is followed by a shear at constant water content.

UNCONFINED COMPRESSION - A type of test to measure the compressive strength of an undisturbed sample (ASTM D2166-66). Unconfined compressive strength is defined as the load per unit area at which an unconfined prismatic or cylindrical specimen of soil will fail in a simple compression test.

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) - A system which determines soil classification for engineering purposes on the basis of grain-size distribution and Atterberg limits.

VALLEY FILL - See Basin-Fill Material/Basin-Fill Deposits.

VELOCITY - Refers to the propagation rate of a seismic wave without implying any direction. Velocity is a property of the medium and not a vector quantity when used in this sense.

VELOCITY LAYER - A layer of rock or soil with a homogenous seismic velocity.

GLOSSARY OF TERMS (Cont.)

VELOCITY PROFILE - A cross section showing the distribution of material seismic velocities as a function of depth and its configuration.

VERIFICATION SITE - A study area of approximately 200 to 400 mi^2 in which Verification Program activities are performed. The site is situated wholly within a larger Candidate Deployment Parcel (CDP).

WASH SAMPLE - A sample obtained by screening the returned drilling fluid during rotary wash drilling to obtain lithologic information between samples.

WATER TABLE - The upper surface of an unconfined body of water at which the pressure is equal to the atmospheric pressure.

WELL GRADED - A soil is identified as well graded if it has a wide range in grain size and substantial amounts of most intermediate sizes.

Definitions were derived from the following references:

American Society for Testing and Materials, 1976, Annual book of ASTM standards, Part 19: Philadelphia, American Soc. for Testing and Materials, 484 p.

Gary, M., McAfee, R., Jr., Wolf, C. L., eds., 1972, Glossary of geology: Washington, D.C., American Geol. Institute, 805 p.

Merriam, G., and Merriam, C., 1977, Webster's new collegiate dictionary: Springfield, Mass., G. and C. Merriam Co., 1536 p.

Sheriff, R. E., 1973, Encyclopedic dictionary of exploration geophysics: Tulsa, Oklahoma, Soc. of Exploration Geophysicists, 266 p.

A2.0 EXCLUSION CRITERIA

Table A2-1 lists the exclusion criteria applied during FY 79 Verification Studies. Many of the criteria have not significantly changed since Coarse Screening Studies. Most geotechnical criteria have been modified to accommodate the basing mode requirements of the hybrid trench and vertical shelter concepts as well as increasing levels of study detail.

CRITERIA		DEFINITION AND COMMENTS
SURFACE ROCK AND ROCK OCCURRING WITHIN 50 FEET (15m) AND 150 FEET (46m) OF THE GROUND SURFACE		Rock is defined as any earth material which is not rippable by conventional excavation methods. Where available, seismic P-wave velocities were evaluated in the determination of rock conditions.
SURFACE WATER AND GROUND WATER OCCURRING WITHIN 50 FEET (15m) AND 150 FEET (46m) OF THE GROUND SURFACE		Surface water includes all significant lakes, reservoirs, swamps, and major perennial streams. Water which would be encountered in a 50-foot and 150-foot excavation was considered in the application of this criterion. Depths to ground water resulting from deeper confined aquifers were not considered.
TOPOGRAPHIC	Percent Grade and Terrain	Areas having surface gradients exceeding 10 percent or a preponderance of slopes exceeding 10 percent as determined from maps at scales of 1:125 000, 1:62 500, and 1:24,000 and by field observation. Areas having drainage densities averaging at least two 10-foot deep drainages per 1000 feet (measured parallel to contours, as determined from maps at scales of 1:24,000 or in the field).
CULTURAL	Quantity/Distance:	Eighteen nautical mile exclusion arcs from cities having populations (1970) of 25,000 or more. Three nautical mile exclusion arcs from cities having populations (1970) of between 5,000 and 25,000.
	Land Use:	All significant federal and state forests, parks, monuments and recreation areas. All significant federal and wildlife refuges, grasslands, ranges, preserves and management areas. Indian reservations.
	Economic:	High potential economic resource areas including oil and gas fields, strippable coal, oil shale, uranium deposits, and known geothermal resource areas (KGRA) of sufficient density so as to prohibit use as a viable siting area. Industrial complexes such as active mining areas, tank farms and pipeline complexes of sufficient density so as to prohibit use as a viable siting area.

EXCLUSION CRITERIA
VERIFICATION STUDIES, NEVADA-UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE A2-1

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A3.0 ENGINEERING GEOLOGIC PROCEDURES

The principal objectives of the field geology investigation were to:

1. Delineate surficial extent of soil types and geologic units;
2. Assess terrain conditions; and
3. Make observations helpful in defining depth to rock and water.

Aerial photographs (1:60,000 black and white; 1:25,000 color) served as the base on which all mapping was done. Field activities were directed toward checking the photogeologic mapping.

Field checking consisted chiefly of collecting data about surficial soils at selected locations in order to refine contacts and defining engineering characteristics of photogeologic units. At each location, observations of grain size, color, clast lithology, surface soil development, and a variety of engineering parameters were recorded (see Section 1.0, Geotechnical Data). Observations were made in existing excavations (borrow pits, road cuts, stream cuts) or in hand-dug test pits. Extrapolation of this data to determine surficial extent was accomplished by geologic reconnaissance over existing roads.

Of the parameters listed, grain size is the most important for engineering purposes and for this reason is included in the geologic unit designation. However, grain size is not readily mapped on aerial photos, and much of the field work involved determination of the extent of surficial deposits of a particular grain-size category (gravel, sand, or fine-grained).

Terrain data were also taken at all geologic field stations. Drainage width and depth were estimated and predominant surface slope was measured. Slopes were measured over a distance of 100 to 150 feet (31 to 46 m) with an Abney hand level. For additional data, depths of major drainages encountered during geologic reconnaissance between stations were recorded on aerial photos.

In order to help refine depth to rock interpretations, observations were concentrated along the basin margin to identify shallow rock. Rock samples were taken at the end-points of DMA gravity profile lines to aid in gravity interpretations. Observations regarding depth to water were restricted to measurements in existing wells and borings.

A4.0 GEOPHYSICAL PROCEDURES

A4.1 SEISMIC REFRACTION SURVEYS

A4.1.1 Instruments

Field explorations were performed with a 24-channel SIE Model RS-44 seismic refraction system which consisted of 24 amplifiers coupled with a dry-write, galvanometer-type recording oscillograph. Seismic energy was detected by Mark Products Model L-10 geophones with natural frequency of 4.5 Hz. Geophones were fitted with short spikes to provide good coupling with the ground. Cables with two takeout intervals were used to transmit the detected seismic signal from the geophones to the amplifiers. Time of shot was transmitted from shotpoint to recording system via an FM radio link.

The degree of gain was set on the amplifiers by the instrument operators and was limited by the background noise at the time of the shot. The amplifiers are capable of maximum gain of 1.1 million. The oscillograph placed timing lines on the seismograms at 0.01-second intervals. The timing lines form the basis for measuring the time required for the energy to travel from the shot to each geophone.

A4.1.2 Field Procedures

Each seismic refraction line consisted of a single spread of 24 geophones with a distance of 410 feet (125 m) between end points. Geophone spacing provided six intervals of 25 feet (7.6 m) at both ends of the line and 11 central intervals of 10 feet (3 m). Six shots were made per spread at locations

65 feet (20 m), either 190 or 215 feet (58 or 66 m) and 305 feet 93 m) left and right of the spread center. The recording system was located between geophones 12 and 13.

The explosive used was "Kinestik" which was transported to the site as two nonexplosive components, a powder and a liquid. The components were mixed in the field to make an explosive compound. Charges ranged in size from one-third to five pounds and were buried from 1 to 5 feet (0.3 to 1.5 m) deep. Charges were detonated using Reynold's exploding bridge wire (EBW) detonators instead of conventional electric blasting caps. Use of EBWs provides maximum safety against accidental detonation and extremely accurate "time breaks" (instant of detonation). Relative elevations of geophones and shotpoints were obtained by level or transit where lines had more than 2 or 3 feet (0.6 to 0.9 m) of relief.

A4.1.3 Data Reduction

The travel times for compressional waves from the shots to the geophones were obtained from the seismograms by visual inspection. These times were plotted at their respective horizontal distances and best fit lines were drawn through the points to obtain apparent velocities for materials below the seismic line.

A combination of delay time and ray tracing methods was used in a computer program to obtain depth to refracting horizons from the time-distance information.

A4.2 ELECTRICAL RESISTIVITY SURVEYS

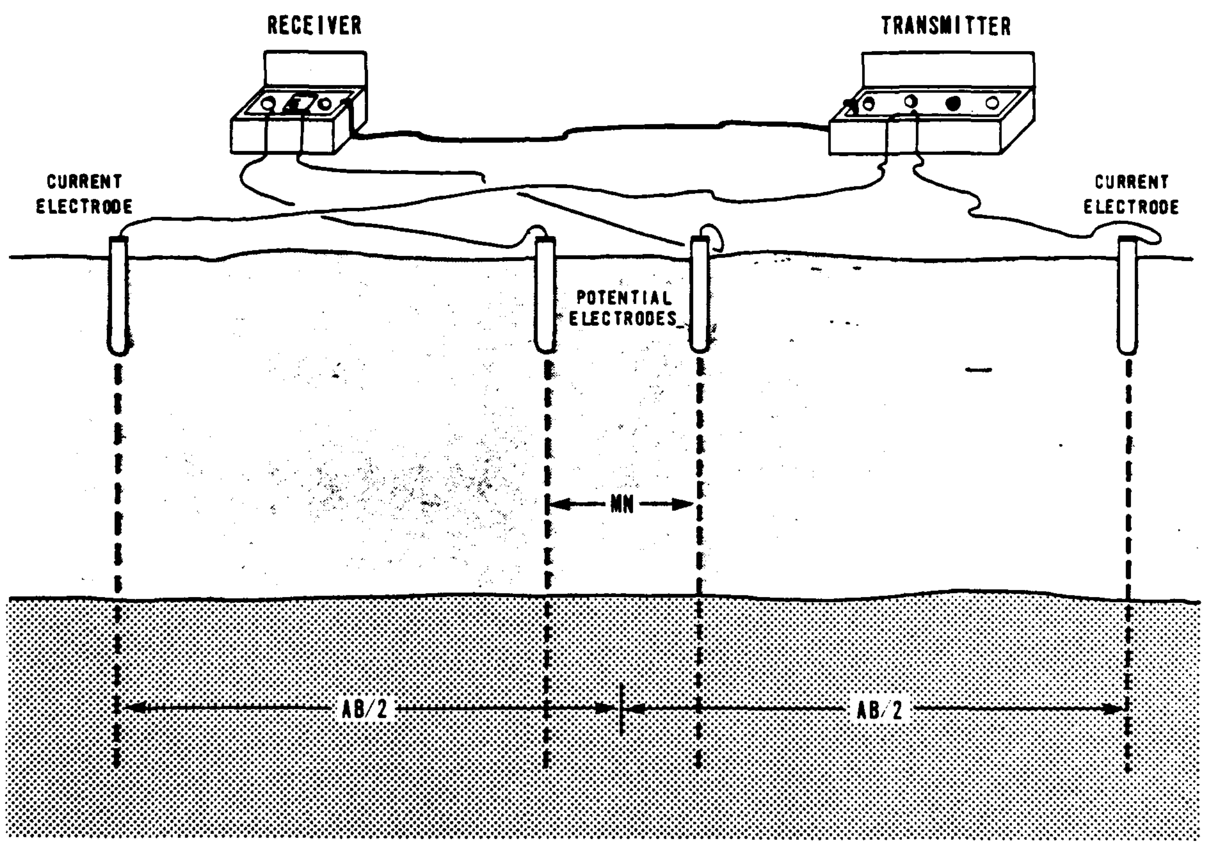
A4.2.1 Instruments

Electrical resistivity measurements were made with a Bison Instrument model 2350 B resistivity meter which provides current to the earth through two electrodes and measures the potential (voltage) drop across two other electrodes.

A4.2.2 Field Procedures

Electrical resistivity soundings were made using the Schlumberger electrode arrangement. Soundings are made by successive resistivity measurements which obtain information from deeper and deeper materials. The depth of penetration of the electrical current is increased by increasing the distance between the current electrodes. The arrangement of electrodes in the Schlumberger method is shown in Figure A4-1. The four electrodes are in a line with the two current electrodes on the ends. The distance between the current electrodes (AB) is always five or more times greater than the distance between the potential electrodes (MN).

The initial readings are made with MN equal to 5 feet (1.5 m) and AB equal to 30 feet (9 m). Successive readings were made with AB at 40, 50, 60, 80, 100, 120, 140, 160, 180, 200, 240, 300, 360, 400, 500, and 600 feet (12, 15, 18, 24, 30, 37, 43, 49, 55, 61, 73, 91, 110, 122, 152, and 183 m). MN spacing is sometimes increased one or two times as AB is expanded. This increase is required when the signal drops to a level below the meter's sensitivity. The potential drop is greater between



SCHLUMBERGER ARRAY
ELECTRICAL RESISTIVITY SOUNDINGS
VERIFICATION SITES, NEVADA-UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE A4-1

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more widely spaced electrodes (MN), so increasing MN increases the signal. When it becomes necessary to increase MN, the spacir., of AB is reduced to the spacing of the previous reading. MN is then incteased and a measurement is made. This provides two resistivity measurements at the same AB spacing but wich different MN spacings.

A4.2.3 Data Reduction

Each apparent resistivity value is plotted versus one-half the current electrode spacing (AB/2) used to obtain it. Log-log graph paper is used to form the coordinates for the graph. A smooth curve is drawn through the points. This sounding curve forms the basis for interpreting the resistivity layering at the sounding location.

A computer program that does iterative "curve-matching" is used to develop a layer model that has a theoretical resistivity curve that is similar to the field curve. A Science Accessories Corporation "grafpen" digitizer is used to digitize the field curve for computer program input.

A4.3 GRAVITY

A4.3.1 General

A gravity survey involves determination of changes in the gravitational field between contiguous points. The gravitational field being detected is the same as that influencing all objects on the surface of the earth. It is generally associated with the force which causes a one-gm mass to be accelerated at 980 cm/s^2. This force is normally referred to as a 1-g force

In a gravity survey, the variations are measured in terms of milligals. A gal is equal to 1 cm/s^2 or 0.00102 g.

Small and distinguishable changes in gravity occur from point to point. These changes are caused by geometrical effects, such as differences in elevation and latitude, and by variations in density of the materials beneath the points. For measurements at the surface of the earth, the largest factor influencing the pull of gravity is the density of all materials between the center of the earth and the point of measurement. To detect the changes produced by differing geological conditions, it is necessary to detect changes in the gravitational field as small as a few milligals.

The basic concept of the gravitational exploration method is the "anomaly." If the earth were made up of uniform, concentric shells, each of uniform density, the gravitational field would be the same at all points on the surface of the earth. The fact that the pull of gravity is not the same from place to place gives rise to "anomalies." A difference in gravity between two points which is not caused by the effects of known geometrical differences, such as in elevation, latitude, and surrounding terrain, is referred to as an anomaly.

An anomaly reflects differences in material densities beneath the two points. The relationship is straightforward. The gravitational attraction is smaller at a place underlain by low-density material than it is at a place underlain by a high-density material. The term "negative gravity anomaly" describes a situation in which the pull of gravity within a prescribed area is small compared to the area surrounding it. Low-density alluvial deposits in basins such as those in the Nevada-Utah region produce negative gravity anomalies in relation to the gravity values in the surrounding mountains which are formed by more dense rocks.

The objective of gravity exploration is to deduce the variations in geologic conditions that produce the gravity anomalies identified during a gravity survey.

A4.3.2 Instruments

Lacoste and Romberg Model G gravimeters were used to measure the gravitational field. The sensing element is a mass suspended by a zero-length spring. Deflections of the mass from a null position are proportional to changes in gravitational attraction. The instrument is sealed and compensated for atmospheric pressure changes. It is maintained at a constant temperature by a heater element and thermostat. Gravitational changes as small as 0.01 milligal can be measured.

A4.3.3 Field Procedures

Gravimeter readings were taken at points on bedrock outcrops as well as points within the suitable area portions of the CDPs. In a few of the CDPs, data were obtained in a quasi-grid pattern (approximately 1 mile [1.6 km] between readings) throughout the CDP. In others, data were taken only along lines extending across the CDPs. These lines or profiles were usually separated by 5 to 10 miles (8 to 16 km).

The gravimeter readings were calibrated in terms of absolute gravity by taking readings twice daily at nearby USGS gravity base stations. Gravimeter readings fluctuate because of small time-related deviations due to the effect of earth tides and instrument drift. Field readings were corrected to account for these deviations. The magnitude of the tidal correction was calculated using an equation suggested by Goguel (1954):

$$C = P + N\cos\phi\,(\cos\phi + \sin\phi) + S\cos\phi\,(\cos\phi - \sin\phi)$$

where C is the tidal correction factor, P, N, and S are time-related variables, and ϕ is the latitude of the observation point. Tables giving the values of P, N, and S are published annually by the European Association of Exploration Geophysicists.

The meter drift correction was based on readings taken at a designated base station at the start and end of each day. Any difference between these two readings after they were corrected for tidal effects was considered to have been the result of instrumental drift. It was assumed that this drift occurred at a uniform rate between the two readings. Corrections for drift were typically only a few hundredths of a milligal. Readings corrected for tidal effects and instrumental drift represented the observed gravity at each station. The observed gravity represents the total gravitational pull of the entire earth at the measurement station.

A4.3.4 Data Reduction

Several corrections or reductions were made to the observed gravity to isolate the portion of the gravitational pull which is due to the crustal and near-surface materials located beneath the station. The gravity remaining after these reductions is called the "Bouguer Anomaly." Bouguer Anomaly values are the basis for geologic interpretation. To obtain the Bouguer Anomaly, the observed gravity was adjusted to the value it would have had if it had been measured at the geoid, a theoretically defined surface which approximates the surface of mean sea level. The difference between the "adjusted" observed gravity and the gravity at the geoid calculated for a theoretically homogeneous earth is the Bouguer Anomaly. Because the real earth, except for the upper mantle and crust, is thought to be similar to the homogeneous model, the Bouguer Anomaly is taken to indicate the way crustal materials differ from the model.

Four separate reductions, to account for four geometrical effects, were made to the observed gravity at each station to arrive at its Bouguer Anomaly value.

a. <u>Free-Air Effect</u>: Gravitational attraction varies inversely as the square of the distance from the center of the earth. Gravity measured at a greater distance from the center of the earth than the geoid is necessarily smaller than gravity on the geoid. Since the Nevada-Utah study area is above sea level, observed gravity levels were corrected for this difference using the normal vertical gradient of:

$$FA = -0.09406 \text{ mg/ft } (-0.3086 \text{ mg/meter})$$

where FA is the free-air effect. The free-air correction was positive in sign since the correction is opposite the effect.

b. Bouguer Effect: Like the free-air effect, the Bouguer effect is a function of the elevation of the station, but it considers the influence of a slab of earth materials between the observation point on the surface of the earth and the corresponding point on the geoid. Normal practice was followed in this study which is to assume that the density of the slab is 2.67 grams per cubic centimeter. The Bouguer correction (B_c), which is opposite in sign to the free-air correction, was defined according to the following formula.

$$B_c = 0.01276\ (2.67)\ h_f \text{ (mg per foot)}$$

where h_f and h_m is the height above sea level in feet or meters, respectively.

c. Latitude Effect: Points at different latitudes will have different "gravities" for two reasons. The earth (and the geoid) is spheroidal, or flattened at the poles. Since points at higher latitudes are closer to the center of the earth than points near the equator, the gravity at the higher latitudes is larger. As the earth spins, the centrifugal acceleration causes a slight decrease in gravity. At the higher latitudes where the earth's radii are smaller, the centrifugal acceleration diminishes. The gravity formula for the Geodetic reference system, 1967, gives the theoretical value of gravity at the geoid as a function of latitude. It is:

$$g = 978.0381\ (1 - 0.0053204 \sin^2 \phi - 0.0000058 \sin^2 \phi) \text{ gals}$$

where g is the theoretical acceleration of gravity and ϕ is the latitude in degrees. The positive term accounts for the spheroidal shape of the earth. The negative term adjusts for the centrifugal acceleration.

The previous two corrections (free air and Bouguer) have adjusted the observed gravity to the value it would have had at the geoid. The theoretical value at the geoid for the latitude of the station is then subtracted from the adjusted observed gravity. The remainder is called the Simple Bouguer Anomaly (SBA). Most of this gravity represents the effect of material beneath the station, but part of it may be due to irregularities in terrain (upper part of the Bouguer slab) away from the station.

d. Terrain Effect: Topographic relief around the station has an effect on the gravitational force at the station. A nearby hill has upward gravitational pull and a nearby valley contributes no pull into a place where the Bouguer correction assumed there was mass to create a downward attraction. Therefore, relative to the SBA, the corrections are always positive. Corrections were made to the SBA when the terrain effects were 0.1 milligal or larger. Terrain corrected Bouguer values are called the Complete Bouguer Anomaly (CBA). When the CBA was obtained, the reduction of gravity at individual measurement points (stations) was complete.

A4.3.5 Interpretation

The first step in the interpretation was to separate the portion of the CBA that might be caused by the lightweight, basin-fill material overlying the heavier bedrock material which forms the surrounding mountains and presumably the basin floor. In order to make this separation, the gravity field's appearance was postulated, assuming the valley-fill sediments were replaced with bedrock material. The imaginary field is called a "regional" and is characterized by a gently undulating (long period) surface. Since the valley-fill sediments were, in fact, absent at the stations read in the mountains, the CBA values at these bedrock stations were used as the basis for constructing a regional field over the valley. The "regional" was derived by fitting a second order polynomial surface to the Bouguer Anomaly values of the bedrock stations.

The difference between the CBA and the regional field was taken to represent the effect of the lightweight alluvial materials. This difference is called the residual field or residual anomaly. The zero value of the residual anomaly is not exactly at the rock outcrop line but at some distance on the "rock" side of the contact. The reason for this is found in the explanation of the terrain effect. There is a component of gravitational attraction from material which is not directly beneath a point.

If the "regional" is well chosen, the magnitude of the residual anomaly is a function of the thickness of the anomalous (fill) material and the density contrast. The density contrast is the difference in density between the alluvial and bedrock material. If this contrast were known, a very accurate calculation of the thickness could be made. In most cases, the densities are not well known and they also vary within the study area. In these cases, it is necessary to use typical densities for materials similar to those in the study area. An iterative computer program was used to calculate a subsurface model which would yield a gravitational field to match (approximately) the residual gravity anomaly.

A5.0 ENGINEERING PROCEDURES

Soil engineering activities consisted of the following:

1. Field activities:
   - o Borings
   - o Trenches
   - o Test Pits
   - o Surficial Samples
   - o Cone Penetrometer Tests
   - o Field CBR Tests

2. Office activities:
   - o Laboratory Tests
   - o Data Analyses and Interpretations

In this section the procedures used in the various activities are described.

A5.1 BORINGS

A5.1.1 Drilling Equipment

The borings were drilled at designated locations using a truck-mounted Failing 1500 drilling rig with hydraulic pulldown and rotary wash techniques. Borings were nominally 4-7/8 inches (124 mm) in diameter and drilling fluid (typically a bentonite-water slurry) was used to stabilize the hole. A tricone drill bit was used for coarse-grained soils and a drag bit for drilling in fine-grained soils. Nominal maximum depth drilled was 160 feet (49 m). When rock was encountered in a boring, a minimum of 15 feet (4.6 m) of rock was cored before terminating the boring.

A5.1.2 Method of Sampling Soil and Rock

A5.1.2.1 Sampling Intervals

Soil samples were obtained at the following nominal depths as well as at depths of change in soil type.

0'- 2'	(0-0.6 m)	- Drive sample
2.5'- 5'	(0.8-1.5 m)	- Pitcher or drive
6'- 8'	(1.8-2.4 m)	- Pitcher or drive
10'- 30'	(3.0-9.1 m)	- Pitcher or drive - samples at 5' intervals, starting at a depth of 10'
30'-130'	(9.1-39.0 m)	- Pitcher or drive - samples at 10' intervals
130'-160'	(39.0-48.0 m)	- Pitcher or drive - samples at 15' intervals

A5.1.2.2 Sampling Techniques

a. Fugro Drive Samples: Fugro drive samplers were used to obtain relatively undisturbed soil samples. The Fugro drive sampler is a ring-lined barrel sampler with an outside diameter of 3.0 inches (76.2 mm) and inside diameter of 2.50 inches (63.5 mm). It contains 12 individual 1-inch- (25.4-mm) long rings and is attached to a 12-inch- (30-cm) long waste barrel. The sampler was advanced using a downhole hammer weighing 335 pounds (76 kg) with a drop of 18 inches (46 cm).

The number of blows required to advance the sampler for a 6-inch (15-cm) interval were recorded. Samples obtained were retained in the rings, placed in plastic bags with manually twisted top ends and sealed in plastic sample containers. Each sample was identified with a label indicating job number, boring number, sample number, depth range, Unified Soil Classification System (USCS), and date. Ring samples were placed in foam-lined steel boxes.

b. Pitcher Samples: The Pitcher sampler was used to obtain undisturbed soil samples. The primary components of this sampler are an outer rotating core barrel with a bit and an inner, stationary, spring-loaded, thin-wall sampling tube which leads or trails the outer barrel drilling bit, depending on the hardness of the material penetrated. The average inside diameter of the sampling tubes used was 2.87 inches (73 mm). Before placing the Pitcher tube in the outer barrel, the tube was inspected for sharpness or protrusions.

The Pitcher sampler was then lowered to the bottom of the boring and the thin-walled sampling tube advanced into the soil ahead of the rotating cutting bit by the weight of the drill rods and hydraulic pulldown. The thin-walled sampling tube was retracted into the core barrel and the sampler was brought to the surface. After removal of the sampling tube from the core barrel, the length of the recovered soil sample was measured and recorded. Before preparing and sealing the tube, the drilling fluid in the Pitcher tube was removed. Cap plugs were taped in place on the top and bottom of the Pitcher tube and sealed with wax. When Pitcher samples could not be retrieved without disturbance, they were clearly marked as "disturbed." Each sealed Pitcher tube was labeled as explained under "Fugro Drive Samples" and then placed vertically in foam-lined wooden boxes.

c. Wash Samples: Wash samples (cuttings) were obtained by screening the returning drilling fluid during the drilling operations to obtain lithologic information between samples.

Recovered wash samples were placed in plastic bags and labeled as explained previously.

d. <u>Split-Spoon Samples</u>: Split-spoon samplers were used to obtain disturbed, but representative soil samples. The split-spoon sampler consists of a barrel shoe, a split barrel or tube, a solid sleeve, and a sampler head. The inside diameter of the sampler shoe is 1.375 inches (35 mm) and the length is about 18 inches (45.7 cm). Sampling with the split barrel sampler is accomplished by driving the sampler into the ground with a 140-pound (63.6-kg) hammer dropped 30 inches (76 cm). The number of blows required to drive the sampler a distance of 12 inches (30.4 cm) was recorded as the Standard Penetration Resistance (N value). The disturbed samples obtained from the split-spoon sampler were placed in plastic bags and labeled as explained previously.

e. <u>Rock Samples</u>: A core barrel was used to obtain rock cores (samples). Rock coring is the process in which a sampler, consisting of a core barrel with a diamond cutting bit at its lower end, cuts an annular hole in a rock mass, thereby creating a cylinder or core of rock which is recovered in the core barrel. Rock cores were obtained by the use of rotary drilling methods utilizing NX double-tube core barrels (core size 2.125 inches; 54 mm). When rock was encountered in a boring, it was nominally cored into for a distance of 15 feet (4.5 m). The rock cores were removed from the core barrel (slid out or forced out with water), examined by a geologist, and placed in core boxes. The core boxes were labeled as explained in "Fugro Drive Samples."

A5.1.3 Logging

All soils were classified in the field by the procedures outlined in Section A5.5, "Field Visual Soil Classification," of this Appendix. Rock encountered in the borings was described according to classifications given in Travis (1955) and Folk (1974). The following general information was entered on the boring logs at the time of drilling: boring number; project name, number, and location; name of drilling company and driller; name of logger and date logged; and method of drilling and sampling, drill bit type and size, driving weight and average drop as applicable. As drilling progressed, the soil samples recovered were visually classified as outlined in Section A5.5, "Field Visual Soil Classification," and the description was entered on the logs. Section A5.5 also discusses other pertinent data and observations made which were entered on the boring logs during drilling.

A5.1.4 Sample Storage and Transportation

Samples were handled with care, drive sample containers being placed in foam-lined steel boxes, while Pitcher samples were transported in foam-lined wooden boxes. Core samples were placed in specially constructed wooden or cardboard boxes. Particular care was exercised by drivers while traversing rough terrain so as not to cause any disturbance to the undisturbed samples. Whenever ambient air temperatures fell below 32°F, all samples were stored in heated rooms during the field work and transported to Fugro National's Long Beach laboratory in heated cabins in back of pickup trucks.

A5.1.5 Ground-Water Observation Wells

When ground water was encountered during drilling of a boring or where the boring was located in an area estimated to have ground water within 150 feet (46 m) of the ground surface, the completed boring was cased with a 2-inch-diameter (51-mm) polyvinyl-chloride (PVC) pipe to 160 feet (49 m). This PVC pipe was slotted in the bottom 20 feet (6 m). After installation of the pipe, it was flushed until clear water came out. After equilibrium was reached, the water level was measured periodically in the observation wells and recorded.

A5.2 TRENCHES, TEST PITS, AND SURFICIAL SAMPLES

A5.2.1 Excavation Equipment

The trenches, tests pits, and surficial samples were excavated using a rubber tire-mounted Case 580 B or C backhoe with a maximum depth capability of 15 feet (5 m).

A5.2.2 Method of Excavation

Unless caving occurred during the process of excavation, the trench width was nominally 2 feet (0.6 m). Trench depths were typically 14 feet (4.2 m) and lengths ranged from 12 to 20 feet (3.6 to 6.0 m). Test pits were nominally 2 feet (0.6 m) wide, 5 feet (1.5 m) deep, and ranged from 5 to 10 feet (1.5 to 3.0 m) in length. Surficial sample excavations were typically 2 feet (0.6 m) wide, 2 feet (0.6 m) deep, and about 3 to 5 feet (0.9 to 1.5 m) long. The trench and test pit walls were vertical. However, where surface materials were unstable, the trench walls were sloped back to a safe angle to prevent sloughing during the completion of excavation and logging. The excavated material was deposited on one side at least 4 feet (1.2 m) from the edge of the trenches in order to minimize stress loads at the edges. The excavations were backfilled with the excavated material and the ground surface was restored to a condition as conformable with the surrounding terrain as practical.

A5.2.3 Sampling

The following sampling procedures were generally followed for all trenches, test pits, and surficial samples.

- Representative bulk soil samples (large or small) were obtained in the top 2 feet (0.6 m). If the soil type changed in the top 2 feet, bulk samples of both the soil types were obtained. In addition, bulk samples of all soil types encountered at different depths in the excavation were obtained. For each soil type in the top 2 to 3 feet (0.6 to 0.9 m), two large bulk samples (weighing about 50 pounds each; 11.4 kg) were taken. Bulk samples from other depths were limited to one bag. When soils from two locations were similar, only a small bag sample weighing about 2 pounds (1 kg) was taken from the second location.
- All large bulk samples were placed first in plastic bags and then in cloth bags. The small bulk samples were placed in small plastic bags. All sample bags of soil were tied tightly at the top to prevent spillage and tagged with the following information: project number; trench, test pit, or surficial sample number; bulk sample number; depth

range in feet; Unified Soil Classification symbol; and date. The samples were transported to the field office for storage and then to Fugro National's Long Beach office in pickup trucks.

A5.2.4 Logging

The procedures for field visual classification of soil and rock encountered from the trenches, test pits, and surficial samples were basically the same as the procedures for logging of borings (Section A5.1.3). For excavations shallower than 4 feet (1.2 m) technicians entered the excavations and logged them. Logging of the excavations deeper than 4 feet (1.2 m) was accomplished from the surface and by observing the backhoe bucket contents. All trench walls were photographed prior to backfilling.

Each field trench, test pit, and surficial sample log included trench, test pit, or surficial sample number; project name, number and location; name of excavator; type of excavation equipment; name of logger; and date logged. As excavations proceeded, the soil types encountered were visually classified and described as outlined in Section A5.5, "Field Visual Soil Classification." Section A5.5 also discusses other pertinent data and observations made which were entered on the logs during excavation.

A5.3 CONE PENETROMETER TESTS

A5.3.1 Equipment

The equipment consisted of a truck-mounted (15 tons gross weight) electronic cone penetrometer equipped with a 10-ton cone (cone end resistance capacity of 10 tons) and 5-ton friction cone (1-1/2-ton limit on the friction sleeve and 5-ton limit on the cone end resistance). All operating controls, recorder, cables, and ancillary equipment were housed in the specially designed vehicle which was completely self-contained. The penetrometer, the key element of the system, contained the necessary load cells and cable connections. One end of the unit was threaded to receive the first sounding rod. When carrying out the tests, hollow rods with an outside diameter of 3.6 cm and a length of 1.0 meter were used to push down the cone. The hydraulic thrust system was mounted over the center of gravity of the truck, permitting use of the full 15-ton truck weight as load reaction.

The cone had an apex angle of 60° and a base area of 10 cm^2. The resistance to penetration was measured by a built-in load cell in the tip and was relayed to the surface recorder via cables in the sounding rods. On the 5-ton friction cone, a friction sleeve, having an area of 150 cm^2, was fitted above the cone base. The local friction was measured by load cells mounted in the friction sleeve and recorded in the same manner as the end resistance. The end resistance and friction resistance were recorded on a strip chart.

A5.3.2 Test Method

Tests were performed in accordance with ASTM D3441-75T, "Tentative Method for Deep, Quasi-Static, Cone and Friction-Cone Penetration Tests of Soil." Basically, the test was conducted by positioning the electronic cone penetrometer truck over the designated area for testing, setting the outriggers on the ground surface, checking the level of the rig, then pushing the cone into the ground at a rate of 2 cm/s until refusal (defined as the capacity of the cone, friction sleeve, or hydraulics system) or the desired depth of penetration was reached.

As a general rule, the depth of penetration did not exceed 10 meters. If refusal was reached within the top 2 or 3 feet (0.6 or 1 m), the test was performed again a few feet away from the first location. If refusal was reached again within 3 feet (1 m), the soil was excavated at the CPT location to investigate the presence of gravel, cobbles, boulders, or cemented layers. Details of the test such as refusal reached, depth, cone used, etc., were entered on a log sheet.

Generally, the 10-ton cone was used for most of the tests. If the measured cone resistance was less than 100 tons per square foot (98 kg/cm^2) in the upper 5 to 6 feet (1.5 to 1.8 m), then another test using the 5-ton cone was performed at a location a few feet away from the first location.

A minimum of three cone penetrometer tests were performed at all field California Bearing Ratio (CBR) test locations in Reveille-Railroad and Big Smoky sites and also at certain locations in Garden-Coal site.

A5.4 FIELD CALIFORNIA BEARING RATIO (CBR) TESTS

A5.4.1 Equipment

The equipment used to conduct the field CBR tests was as described in the U.S. Army Corps of Engineers' Technical Manual 5-30. Other equipment for conducting a field density test by the sand cone method (ASTM D 1556-64, Test for Density of Soil in Place by the Sand-Cone Method) and the "Speedy Moisture Meter" for field determination of soil moisture content were also included. Picks, spades, and shovels were used to excavate the CBR test pits.

A5.4.2 Test Method

Field CBR tests were generally performed at two depths at each designated location. The procedures for conducting the CBR tests were as described in the U.S. Army Corps of Engineers' Technical Manual (TM) 5-30, pp. 2-86 to 2-96. Tests were performed in small hand-excavated test pits at depths ranging from 6 to 30 in. (15 to 76 cm) below ground surface. Testing was not attempted where numerous cobbles or heavily cemented soils were encountered. Three CBR tests were performed at each depth and the results recorded. Generally, a field density test (ASTM D1556-64, Test for Density of Soil in Place by the Sand-Cone Method) and moisture content determination (by Speedy Moisture Meter Method) were performed at the CBR test depths.

A5.4.3 Sampling

At each CBR test location, large bulk samples of soils at test depths were obtained. See Section A5.2.3, "Sampling," for trenches, test pits, and surficial samples for details.

A5.4.4 Logging

Field CBR test results, field density test results, and moisture content determinations were recorded at the time of each test. All soil samples were classified and logged in accordance with the procedures outlined in Section A5.5, "Field Visual Soil Classification."

A5.5 FIELD VISUAL SOIL CLASSIFICATION

A5.5.1 General

All field logging of soils encountered during drilling, excavation of trenches and test pits, obtaining surficial samples, and the sampling at CBR test locations were performed in accordance with the procedures outlined in this section. Soil samples were visually classified in the field in general accordance with the procedures of ASTM D 2488-69, Description of Soils (Visual-Manual Procedure). The ASTM procedure is based on the Unified Soil Classification System (see Table A5-1) and details several visual and/or manual methods which can be used in the field to estimate the USCS soil group or symbol for each sample. Rock cores were described in the field according to classifications given in Travis (1955) and Folk (1974). The following section details several of the guidelines used in the field for describing soils, drilling and excavating conditions, and unusual conditions encountered.

A5.5.2 Soil Description

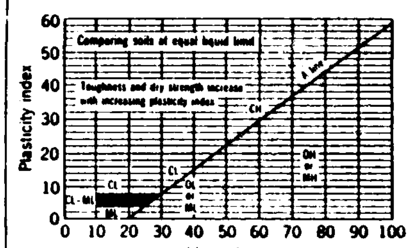
Soil descriptions entered on the logs of borings, trenches, test pits, and surficial samples generally included those listed on page A-43.

Major Divisions			Field Identification Procedures (Excluding particles larger than 3 in. and basing fractions on estimated weights)	Group Symbols[a]	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria
Coarse-grained soils: More than half of material is *larger* than No. 200 sieve size[b] (The No. 200 sieve size is about the smallest particle visible to naked eye)	Gravels: More than half of coarse fraction is larger than No. 4 sieve size (For visual classification, the ¼ in. size may be used as equivalent to the No. 4 sieve size)	Clean gravels (little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	*GW*	Well graded gravels, gravel-sand mixtures, little or no fines	Give typical name; indicate approximate percentages of sand and gravel, maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbols in parentheses	$C_U = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
		Clean gravels (little or no fines)	Predominantly one size or a range of sizes with some intermediate sizes missing	*GP*	Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for *GW*
		Gravels with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures see *ML* below)	*GM*	Silty gravels, poorly graded gravel-sand-silt mixtures	For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics	Atterberg limits below "A" line, or *PI* less than 4 / Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
		Gravels with fines (appreciable amount of fines)	Plastic fines (for identification procedures, see *CL* below)	*GC*	Clayey gravels, poorly graded gravel-sand-clay mixtures		Atterberg limits above "A" line, with *PI* greater than 7
	Sands: More than half of coarse fraction is smaller than No. 4 sieve size	Clean sands (little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes	*SW*	Well graded sands, gravelly sands, little or no fines	Example: *Silty sand*, gravelly; about 20% hard, angular gravel particles ½-in. maximum size; rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; (*SM*)	$C_U = \frac{D_{60}}{D_{10}}$ Greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
		Clean sands (little or no fines)	Predominantly one size or a range of sizes with some intermediate sizes missing	*SP*	Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for *SW*
		Sands with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures, see *ML* below)	*SM*	Silty sands, poorly graded sand-silt mixtures		Atterberg limits below "A" line or *PI* less than 5 / Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
		Sands with fines (appreciable amount of fines)	Plastic fines (for identification procedures, see *CL* below)	*SC*	Clayey sands, poorly graded sand-clay mixtures		Atterberg limits below "A" line with *PI* greater than 7

Laboratory classification criteria (coarse-grained soils): Use grain size curve in identifying the fractions as given under field identification. Determine percentages of gravel and sand from grain size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse grained soils are classified as follows: Less than 5%: *GW, GP, SW, SP*; More than 12%: *GM, GC, SM, SC*; 5% to 12%: *Borderline* cases requiring use of dual symbols

Identification Procedures on Fraction Smaller than No. 40 Sieve Size

Major Divisions	Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)	Group Symbols[a]	Typical Names	Information Required for Describing Soils
Fine-grained soils: More than half of material is *smaller* than No. 200 sieve size. Silts and clays liquid limit less than 50	None to slight	Quick to slow	None	*ML*	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses
	Medium to high	None to very slow	Medium	*CL*	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
	Slight to medium	Slow	Slight	*OL*	Organic silts and organic silt-clays of low plasticity	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions
Silts and clays liquid limit greater than 50	Slight to medium	Slow to none	Slight to medium	*MH*	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	
	High to very high	None	High	*CH*	Inorganic clays of high plasticity, fat clays	Example: *Clayey silt*, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (*ML*)
	Medium to high	None to very slow	Slight to medium	*OH*	Organic clays of medium to high plasticity	
Highly Organic Soils	Readily identified by colour, odour, spongy feel and frequently by fibrous texture			*Pt*	Peat and other highly organic soils	



Plasticity chart for laboratory classification of fine grained soils

From Wagner, 1957.

[a] *Boundary classifications*. Soils possessing characteristics of two groups are designated by combinations of group symbols. For example *GW-GC*, well graded gravel-sand mixture with clay binder.

[b] All sieve sizes on this chart are U.S. standard.

Field Identification Procedure for Fine Grained Soils or Fractions

These procedures are to be performed on the minus No. 40 sieve size particles, approximately 1/64 in. For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests.

Dilatancy (Reaction to shaking):

After removing particles larger than No. 40 sieve size, prepare a pat of moist soil with a volume of about one-half cubic inch. Add enough water if necessary to make the soil soft but not sticky.

Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.

Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

Dry Strength (Crushing characteristics):

After removing particles larger than No. 40 sieve size, mould a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun or air drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.

High dry strength is characteristic for clays of the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour.

Toughness (Consistency near plastic limit):

After removing particles larger than the No. 40 sieve size, a specimen of soil about one-half inch cube in size, is moulded to the consistency of putty. If too dry, water must be added and if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about one-eight inch in diameter. The thread is then folded and re-rolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.

After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.

The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line.

Highly organic clays have a very weak and spongy feel at the plastic limit.

UNIFIED SOIL CLASSIFICATION SYSTEM

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TABLE A5-1

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Coarse-Grained Soils	Fine-Grained Soils
USCS Name and Symbol	USCS Name and Symbol
Color	Color
Range in Particle Size	Consistency
Gradation (well, poorly)	Moisture Content
Density	Plasticity
Moisture Content	Reaction to HCl
Particle Shape	
Reaction to HCl	

Some additional descriptions or information recorded for both coarse- and fine-grained soils included: degree of cementation, secondary material, cobbles and boulders, and depth of change in soil type.

Definitions of some of the terms and criteria used to describe soils and conditions encountered during the investigations follow.

a. USCS Name and Symbol: Derived from Table A5-1, the Unified Soil Classification System. The soils were first designated as coarse- or fine-grained.

Coarse-grained soils are those in which more than half (by weight) of the particles are visible to the naked eye. In making this estimate, particles coarser than 3 in. (76 mm) in diameter were excluded. Fine-grained soils are those in which more than half (by weight) of the particles are so fine that they cannot be seen by the naked eye. The distinction between coarse- and fine-grained can also be made by sieve analysis with the number 200 sieve (.074 mm) size particle considered to be the smallest size visible to the naked eye. In some instances, the field technicians describing the soils used a number 200 sieve to estimate the amount of fine-grained particles. The coarse-grained soils are further divided into sands and gravels by estimating the percentage of the coarse fraction larger than the number 4 sieve (about 1/4 inch or 5 mm). Each coarse-grained soil is then qualified as silty, clayey, poorly graded, or well graded as discussed under plasticity and gradation.

Fine-grained soils were identified in the field as clays or silts with appropriate adjectives (clayey silt, silty clay, etc.) based on the results of dry strength, dilatancy, and plastic thread tests (see ASTM D 2488-69 for details of these tests).

Dual USCS symbols and adjectives were used to describe soils exhibiting characteristics of more than one USCS group.

b. Color: Color descriptions were recorded using the following terms with abbreviations in parentheses:

White (w)	Green (gn)
Yellow (y)	Blue (bl)
Orange (o)	Gray (gr)
Red (r)	Black (blk)
Brown (br)	

Color combinations as well as modifiers such as light (lt) and dark (dk) were used.

c. Range in Particle Size: For coarse-grained soils (sands and gravels), the size range of the particles visible to the naked eye was estimated as fine, medium, coarse, or a combined range (fine to medium).

d. Gradation: Well graded indicates a coarse-grained soil which has a wide range in grain size and substantial amounts of most intermediate particle sizes. A coarse-grained soil was identified as poorly graded if it consisted predominantly of one size (uniformly graded) or had a wide range of sizes with some intermediate sizes obviously missing (gap-graded).

e. Density or Consistency: The density or consistency of the in-place soil was estimated based on the number of blows required to advance the Fugro drive or split-spoon sampler, the drilling rate (difficulty) and/or hydraulic pulldown needed to drill, visual observations of the soil in the trench or test pit walls, ease (or difficulty) of excavation of trench or test pit, or trench or test pit wall stability. For fine-grained soils, the field guides to shear strength presented below were also used to estimate consistency.

- Coarse-grained soils - GW, GP, GM, GC, SW, SP, SM, SC (gravels and sands)

Consistency	N-Value (ASTM D 1586-67), Blows/Foot
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	>50

- Fine-grained Soils - ML, MH, CL, CH (Silts and Clays)

Consistency	Shear Strength (ksf)	Field Guide
Very Soft	<0.25	Sample with height equal to twice the diameter, sags under own weight
Soft	0.25-0.50	Can be squeezed between thumb and forefinger

Consistency	Shear Strength (ksf)	Field Guide
Firm	0.50-1.00	Can be molded easily with fingers
Stiff	1.00-2.00	Can be imprinted with slight pressure from fingers
Very Stiff	2.00-4.00	Can be imprinted with considerable pressure from fingers
Hard	Over 4.00	Cannot be imprinted by fingers

f. Moisture Content: The following guidelines were used in the field for describing the moisture in the soil samples:

Dry : No feel of moisture

Slightly Moist: Much less than normal moisture

Moist : Normal moisture for soil

Very Moist : Much greater than normal moisture

Wet : At or near saturation

g. Particle Shape: Coarse-grained soils

Angular : Particles have sharp edges and relatively plane sides with unpolished surfaces

Subangular: Particles are similar to angular but have somewhat rounded edges

Subrounded: Particles exhibit nearly plane sides but have well-rounded corners and edges

Rounded : Particles have smoothly curved sides and no edges

h. Reaction to HCl: As an aid for identifying cementation, some soil samples were tested in the field for their reaction to dilute hydrochloric acid. The intensity of the HCl reaction was described as none, weak, or strong.

i. Degree of Cementation: Based on the intensity of the HCl reaction and observation, the degree of cementation of a soil layer was described as weak to strong. Also, the following stages of development of caliche (cemented) profile were indicated where applicable.

Stage	Gravelly Soils	Nongravelly Soils
I	Thin, discontinuous pebble coatings	Few filaments or faint coatings
II	Continuous pebble coatings, some interpebble fillings	Few to abundant nodules, flakes, filaments
III	Many interpebble fillings	Many nodules and internodular fillings
IV	Laminar horizon overlying plugged horizon	Increasing carbonate impregnation

j. Secondary Material: Example - Sand with trace to some silt

Trace	5-12%	(by dry weight)
Little	13-20%	(by dry weight)
Some	>20%	(by dry weight)

k. Cobbles and Boulders: A cobble is a rock fragment, usually rounded or subrounded, with an average diameter between 3 and 12 inches (76 and 305 mm). A boulder is a rock fragment, usually rounded by weathering or abrasion, with an average diameter of 12 inches (305 mm) or more. The presence of cobbles and/or boulders was identified by noting the sudden change in drilling difficulty or cuttings in borings or by visual observation in excavations. An estimate of the size, range, and percentage of cobbles and/or boulders in the strata was recorded on the logs.

1. Depth of Change in Soil Type: *During drilling of borings,* the depth of changes in soil type was determined by observing samples, drilling rates, changes in color or consistency of drilling fluid, and relating these to depth marks on the drilling rods. In excavations, strata thicknesses were measured with a tape. All soil type interfaces were recorded on the logs by a horizontal line at the approximate depth mark.

In addition to the observations recorded relating to soil descriptions, remarks concerning drilling difficulty, loss of drilling fluid in the boring, water levels encountered, trench wall stability, ease of excavation, and other unusual conditions were recorded on the logs.

A5.6 LABORATORY TESTS

Laboratory tests were performed on selected representative undisturbed and bulk samples. All laboratory tests (except chemical tests) were performed in Fugro National's Long Beach laboratory. The chemical tests were conducted by Pomeroy, Johnson, and Bailey Laboratories of Pasadena, California. All tests were performed in general accordance with the American Society for Testing and Materials (ASTM) procedures. The types of tests performed and their ASTM designations are summarized as follows.

Type of Test	ASTM Designation
Unit Weight	D 2937-71
Moisture Content	D 2216-71
Particle-Size Analysis	D 422-63
Liquid Limit	D 423-66
Plastic Limit	D 424-59

Type of Test	ASTM Designation
Triaxial Compression	D 2850-70
Unconfined Compression	D 2166-66
Direct Shear	D 3080-72
Consolidation	D 2435-70
Compaction	D 1557-70
California Bearing Ratio (CBR)	D 1883-73
Specific Gravity	D 854-58
Water Soluble Sodium	D 1428-64
Water Soluble Chloride	D 512-67
Water Soluble Sulfate	D 516-68
Water Soluble Calcium	D 511-72
Calcium Carbonate	D 1126-67
Test for Alkalinity (pH)	D 1067-70

A5.7 DATA ANALYSIS AND INTERPRETATION

A5.7.1 Preparation of Final Logs and Laboratory and Field Test Summary Sheets

The field logs of all borings, trenches, test pits, and surficial sample excavations were prepared by systematically combining the information given on the field logs with the laboratory test results. The resultant logs include generally the following information: description of soil types encountered; sample types of intervals, lithology (graphic soil column); estimates of soil density or consistency; depth locations of changes in soil types; remarks concerning trench wall stability; drilling difficulty, cementation, and cobbles and boulders encountered; and the total depth of exploration. Laboratory test results presented in the logs include dry density and moisture content; percent of gravel, sand, and fines; and liquid limit and plasticity index. Also, miscellaneous information such as surface elevation, surficial geologic unit, date of activity, equipment used, and dimensions of the activity are shown on the log.

Field CBR test summary sheets were prepared and include the following information for each test site: depth of test; USCS soil type; grain-size distribution and plasticity (from lab testing); in-situ dry unit weight and moisture content; average field CBR values; and remarks concerning cementation and induration.

Laboratory data were summarized in tables. All samples which were tested in the laboratory were listed. Results of sieve analyses, hydrometer, Atterberg limits, in-situ dry strength and moisture content tests, and calculated degree of saturation and void ratio were entered on the tables. Test summary sheets for triaxial compression, unconfined compression, direct shear, consolidation, chemical, CBR, and compaction tests were prepared separately.

The Cone Penetrometer Test results consist of continuous plots of cone resistance and friction sleeve resistance (where friction cone was used), versus depth from ground surface. Beside the plot is shown a soil column with USCS soil types encountered at the test location. Other information presented on the log includes surface elevation and surficial geologic unit.

Separate volumes titled "Geotechnical Data" present the following finalized basic engineering data for each site.

Boring Logs	Section 6.0
Trench and Test Pit Logs	Section 7.0
Surficial Sample Logs	Section 8.0
Laboratory Test Results	Section 9.0
Field CBR Test Results	Section 10.0
Cone Penetrometer Test Results	Drawing 2

A5.7.2 Soil Characteristics

A5.7.2.1 General

The soil characteristics are discussed in two parts, surface soils and subsurface soils. The following three tables were prepared for each site and are presented in Sections 4.0 through 10.0 of the report.

1. Characteristics of Surficial Soils;
2. Thickness of Low Strength Surficial Soils; and
3. Characteristics of Subsurface Soils.

The following sections, A5.7.2.2 and A5.7.2.3, explain the data analyses and interpretation used in preparing the above tables.

A5.7.2.2 Surface Soils

In order to define the characteristics of the surficial soils, data from trenches, test pits, borings, surficial soil samples, cone penetrometer tests, field CBR tests, and surficial geologic maps were reviewed in conjunction with the laboratory test results. The soils were then grouped into three or four categories of soils with similar general characteristics. These categories, their descriptions, and associated characteristics were tabulated for each site. These tables (Characteristics of Surficial Soils, Table X-2) include soil descriptions by the Unified Soil Classification System, predominant surficial geologic units, the estimated areal extent (percent) of each category, important physical properties summarized from laboratory test results, and certain road design related data.

The important physical properties summarized include the estimated cobbles content, grain-size analyses, and Atterberg limits. Ranges for these properties were determined from the field logs and laboratory test results. These ranges are useful for categorizing soils, evaluating construction techniques, and providing data for preliminary engineering evaluations and for use by other MX participants.

Road design data presented in Table X-2 were developed from field and laboratory tests and consist of three distinct groups:

1. Laboratory test results;
2. Suitability of soils for road use; and
3. Low strength surficial soil.

These road design related data were considered important because roads (interconnecting and secondary) constitute a major portion of the geotechically related costs for the vertical shelter basing mode. The following paragraphs briefly discuss the development of road design data.

a. Laboratory Test Results: These include ranges of maximum dry density optimum moisture content (ASTM D 1557-70) and CBR (ASTM D 1883-73) at 90 percent relative compaction for each soil category. The maximum dry density and optimum moisture content are important quality control parameters during roadway construction. California Bearing Ratio is the ratio of the resistance to penetration developed by a subgrade soil to that developed by a specimen of standard crushed-rock base material and is the basis for many empirical road design methods used in this country.

b. <u>Suitability of Soils for Road Use</u>: Included in this group is suitability of soils for use as road subgrade, subbase, or base. Parameters used to make these qualitative assessments were characteristics related to CBR, frost susceptibility, drainage, and volume change potential. The following guidelines were used in estimating the suitability of soils for road use:

1. Suitability as a road subgrade.

   Very Good - soils which can be compacted with little effort to high CBR values (CBR >30), exhibit low frost susceptibility, fair to good drainage, and low volume change potential.

   Good - soils which can be compacted with some effort to moderate CBR values (CBR 15-30), exhibit moderate frost susceptibility, fair drainage, and medium volume change potential.

   Fair - soils which can be compacted with considerable effort to moderate CBR values (CBR 15-30), exhibit moderate to high frost susceptibility, fair to poor drainage, and medium volume change potential.

   Poor - soils which require considerable effort for compaction to even low CBR values (CBR <15), exhibit high frost susceptibility, poor drainage, or high volume change potential. These soils should generally be removed and replaced with better quality material.

2. Suitability as road subbase or base.

   Good - soils which exhibit negligible frost susceptibility, good drainage, and negligible volume change potential.

   Fair - soils which require some treatment or processing to upgrade for use.

   Poor - soils which would require relatively extensive processing or soil stabilization to upgrade for use.

   Not Suitable - soils which cannot be modified to give adequate roadway support.

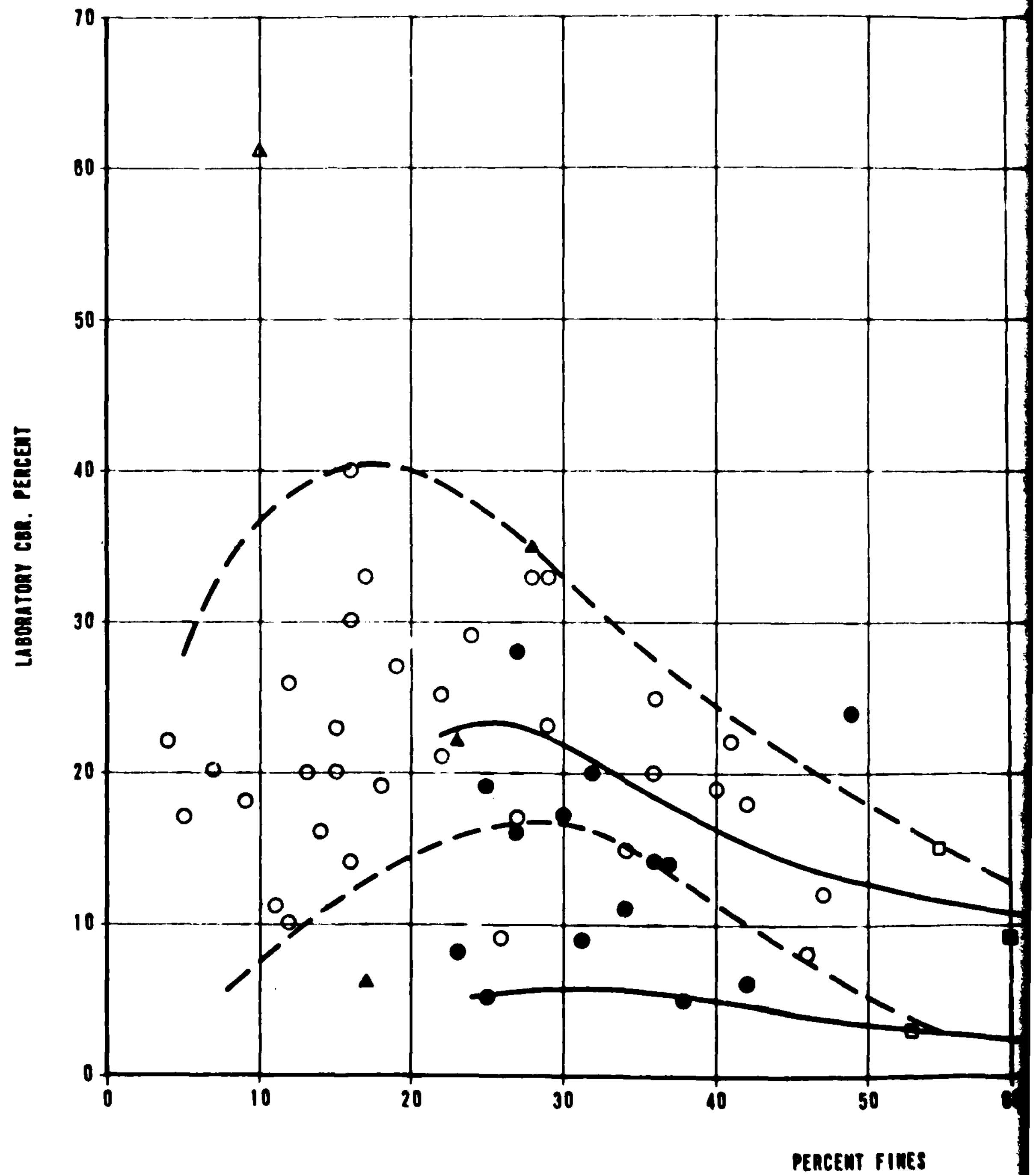
The parameters used in the aforementioned suitability ratings are discussed in the following paragraphs.

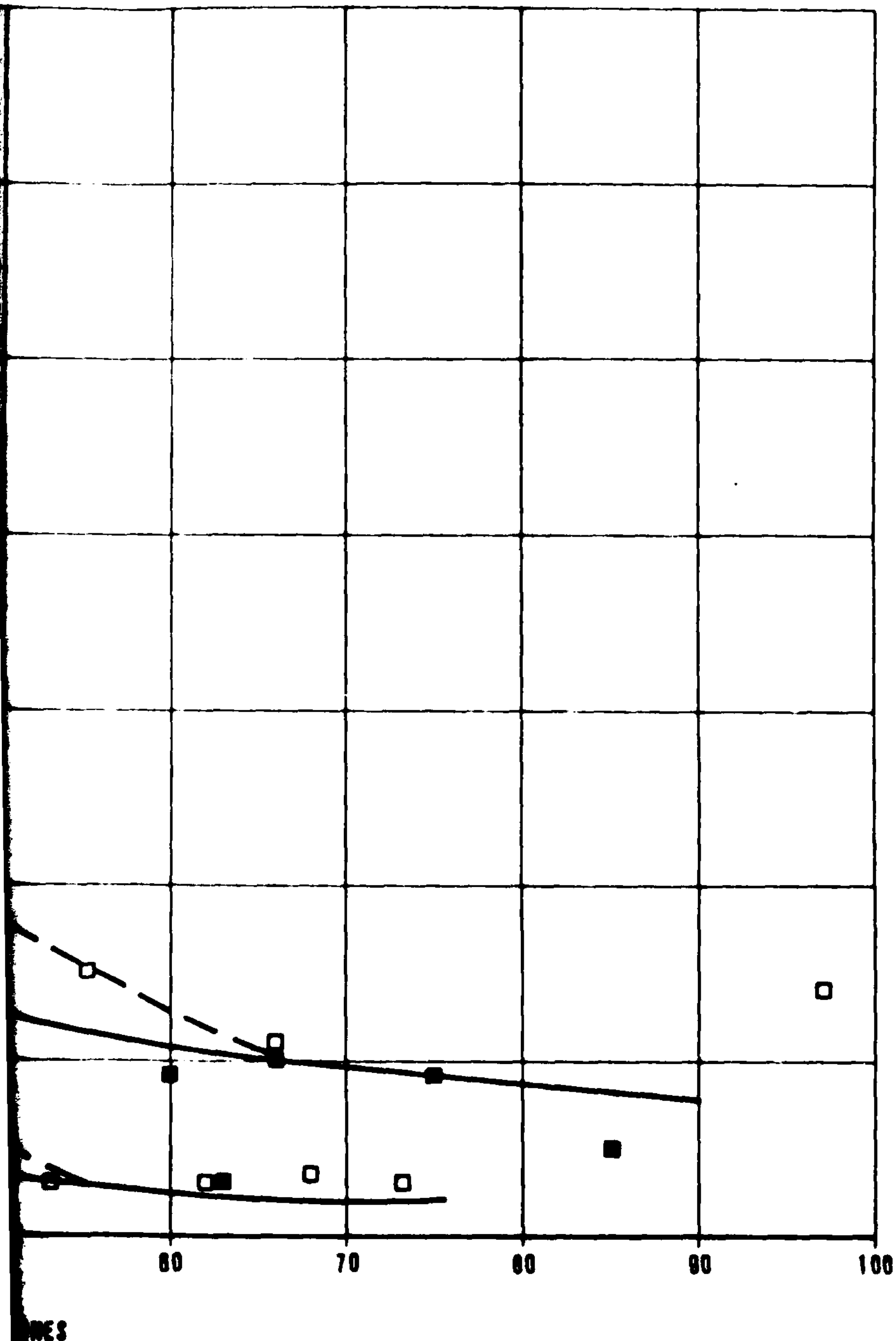
i. <u>CBR Characteristics</u>: California Bearing Ratio, which is commonly used for road design, is dependent on soil type. A limited number of CBR tests were performed on several soil types which were representative of the surficial soils in the various Verification Sites. Based on these test results, a relationship between CBR and percent fines (percent passing through No. 200 sieve) was established and is shown in Figure A5-1. Envelopes for clays and granular soils with plastic fines and silts and granular soils with nonplastic fines are shown in the figure. This plot was used to estimate the range of laboratory CBR values for the various surficial soil categories.

ii. <u>Other Characteristics</u>: These characteristics pertain to frost susceptibility, drainage, and volume change potential. They were estimated based on the physical properties of the soils, results of consolidation tests (for volume change potential), published literature, and our experience. Following are the definitions of these characteristics.

1. Frost susceptibility is defined as potential for detrimental ice segregation upon freezing or loss of strength upon thawing.

Low	- negligible to little potential
Moderate	- some potential
High	- considerable potential


70
60
50
40
30
20
10
0
LABORATORY CBR, PERCENT
0
10
20
30
40
50
60
PERCENT FINES



EXPLANATION

△ Gravels with nonplastic fines (GM,GW,GP,GP-GM,GW

▲ Gravels with plastic fines (GC,GC-GM)

○ Sands with nonplastic fines (SP,SW,SM,SP-SM,SW-S

● Sands with plastic fines (SC,SC-SM)

□ Silts (ML)

■ Clays (CL,CH,CL-ML)

– – – – Envelope for silts and granular soils with nonplastic fines

——— Envelope for clays and granular soils with plastic fines

NOTES:

1. Fines correspond to soil passing through No. 20 (0.074mm opening) sieve.
2. California Bearing Ratio at 90% relative compact
3. Soil types (GM,SC) are based on Unified Soil Classification System.

PLOT OF LABORATORY CBR VERSUS PERCENT F VERIFICATION SITES, NEVADA-UTAH

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2. Drainage characteristics pertain to internal movement of water through soil.

   Good - materials which drain rapidly and do not tend to plug with fines

   Fair - natural internal drainage is fairly rapid but there is some tendency for plugging of voids with fines

   Poor - internal drainage is somewhat slow and plugging with fines can often occur

   Practically Impervious - materials which exhibit almost no natural internal drainage

3. Volume change potential corresponds to soil swelling or shrinkage due to change in moisture content.

   Low - 0 to 2 percent volume change
   Medium - 2 to 4 percent volume change
   High - > 4 percent volume change

c. Low Strength Surficial Soil: Included in this group is extent of low strength surficial soil. The roads for the MX system will be built on existing ground surface with minimum cut and fill. Therefore, the costs of roads depend on the consistency (or strength) of the surficial soil. In order to evaluate the strength of the surficial soils, cone penetrometer test results were used.

Low strength surficial soil is defined as soil which will perform poorly (failure of subgrade) as a road subgrade at its present consistency when used directly beneath a road section. In order to define "low strength" using CPT results, the following four approaches were pursued. These approaches are subjective and qualitative and are based on our experience as well as published literature.

i. Field visual observations: During logging of the borings, the excavation of trenches, test pits, and obtaining surficial soil samples, consistency or compactness of the surficial soils was described qualitatively. A detailed comparison of the CPT results (cone end resistance) and the consistency of the soils was done for different soil types. Using engineering judgement, an upper limit cone resistance was established which encompassed a majority of the soils likely to perform poorly as road subgrades.

ii. Standard Penetration Test (SPT): SPT is very widely used and accepted in geotechnical engineering practice in this country. A study of available literature revealed that the ratio of cone resistance (q_c, tsf) to Standard Penetration Resistance (N, blows per foot) has a certain range for different soil types. Limited field SPTs were performed in Reveille-Railroad and Big Smoky sites. Ratios of q_c/N were computed for these tests and were found to be comparable to those reported in literature for similar soil types. Using the relationships applicable to the soils present in the Verification sites, an upper limit of cone resistance, equivalent to midrange of "medium dense" category, was established for defining the "low strength" of surficial soils.

iii. In-Situ Dry Density: A comparison was made between in-situ dry densities determined from Fugro Drive and Pitcher samples obtained from soil borings and CPT results at the same locations and depths. From this comparison, it was observed that identifiable trends do exist between cone resistance values and soil densities. An upper limit of cone resistance equivalent to midrange of "medium dense" category was established for defining the "low strength" of surficial soils.

iv. Field CBR Tests: Field CBR tests were performed only in Reveille-Railroad and Big Smoky sites. The tests were conducted at depths ranging between 6 and 30 inches (15 and 60 cm) below ground surface. At each CBR test location, three Cone Penetrometer Tests were done. A plot of average field CBR and average cone resistance was prepared and is presented in Figure A5-2. The plot shows the results of the tests in sands only, since tests in gravel and fine-grained soils were very few. Although there is considerable scatter, majority of the data points fall in a band which is shown in Figure A5-2. From this plot, a range of CPT resistance corresponding to low field CBR values (indicating low strength surficial soils) was established.

As a result of the preceding four approaches, the following criteria for defining low strength surficial soil were established:

q_c <120 tsf (117 kg/cm^2) for coarse-grained soils

q_c < 80 tsf (78 kg/cm^2) for fine-grained soils

These criteria are preliminary at this stage and may be revised as more data become available from future verification studies.

The criteria were used to determine the extent of low strength surficial soil at each CPT location. The results are tabulated in tables titled "Thickness of Low Strength Surficial Soil."

A5.7.2.3 Subsurface Soils

Characteristics of the subsurface soils were developed using data from seismic refraction surveys, borings, trenches, test pits, and laboratory tests. It should be emphasized that the data base for characteristics of subsurface soils is very limited since the total number of activities extending below 5 feet (1.5 m) was generally about 14 (6 borings and 8 trenches) in an area greater than 300 mi^2 (768 km^2).

The soils were divided into coarse-grained and fine-grained soils in two ranges of depth, 0 to 20 feet and 20 to 160 feet (0 to 6 m and 6 to 49 m). Physical and engineering properties of the soils were then tabulated as "Characteristics of Subsurface Soils" based on laboratory test results on representative samples. The tables include soil descriptions, Unified Soil Classification System symbols, the estimated subsurface extent of each soil group, comments on the degree of cementation, estimated cobbles content, and ranges of values from the following laboratory tests: dry density, moisture content, grain-size distribution, liquid limit, plasticity index, unconfined compression, triaxial compression, and direct shear.

The excavatability and stability of vertical excavation walls of a trench or a vertical shelter were evaluated from the subsurface data using seismic velocities, soil types, shear strength, presence of cobbles and boulders, and cementation. Problems encountered during trench and test pit excavations and drilling of borings were also considered in the evaluation.

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