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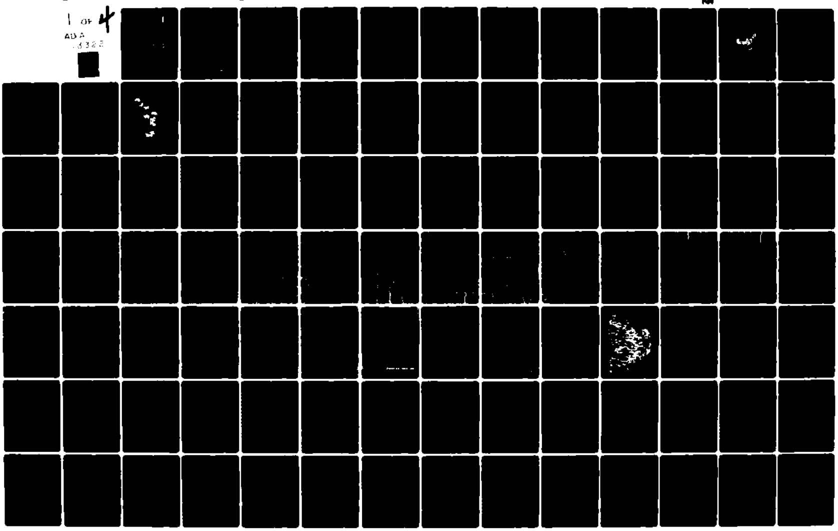

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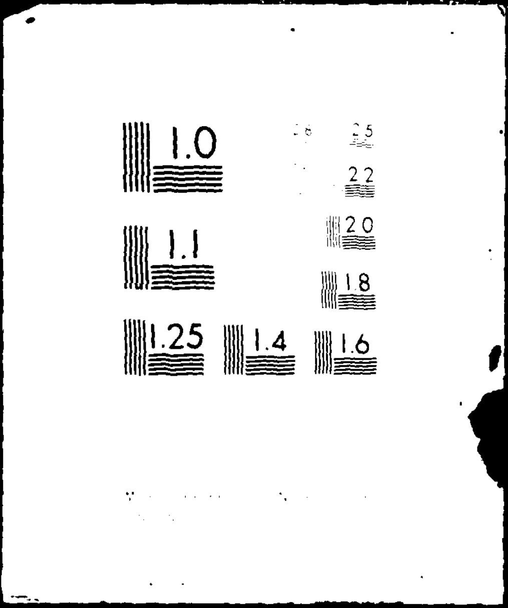

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MX SITING INVESTIGATION
GEOTECHNICAL EVALUATION

VOLUME IA
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

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

This report presents results of geotechnical verification investigation which has been conducted during FY79 in portions of ~~[illegible]~~ Nevada and Utah, including summary of depth to water, depth to rock, terrain variability, soils characteristics, seismic and resistivity surveys for Whirlwind, Snake East, and Hamblin CDP.

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MX SITING INVESTIGATION
GEOTECHNICAL EVALUATION
VOLUME IA, 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

Prepared by:

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Long Beach, California 90807

24 August 1979

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:

<u>Geotechnical Results</u>

* 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.

<u>Geotechnical Data Volumes</u>

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.

TABLE OF CONTENTS

Table of Contents (Cont.)

LIST OF TABLES

Table of Contents (Cont.)

LIST OF TABLES (Cont.)

LIST OF FIGURES

Table of Contents (Cont.)

LIST OF FIGURES (Cont.)

LIST OF DRAWINGS

1.0 INTRODUCTION

1.1 PURPOSE AND BACKGROUND

This report presents the results of a geotechnical Verification investigation which has been conducted during the 1979 fiscal year in portions of the states of Nevada and Utah (Figure 1-1). A Verification investigation was also conducted in portions of Arizona; the results will be presented in a separate report. Verification is the final phase of a site selection process which was begun in 1977 to identify several regions, each containing between 6000 and 7300 square miles (mi^2) (15,500 and 18,900 km^2), which will be "suitable" (see Appendix Section A2.0 for criteria) for deploying the MX advanced Intercontinental Ballistic Missile System.

Preceding phases of the site selection process were:

1. SCREENING: Nationwide literature and map studies to identify potential suitable areas based on a set of geotechnical, cultural, and environmental criteria. The study was conducted in three phases: Coarse, Intermediate, and Fine. At the completion of the Fine Screening studies, approximately 74,000 mi^2 (192,000 km^2) of area had been identified as potentially suitable in seven states in the western United States.
2. CHARACTERIZATION: Field studies in representative areas, in combination with more detailed literature and map studies, to better define the geotechnical conditions and refine suitable area boundaries that had been identified during the Screening studies.

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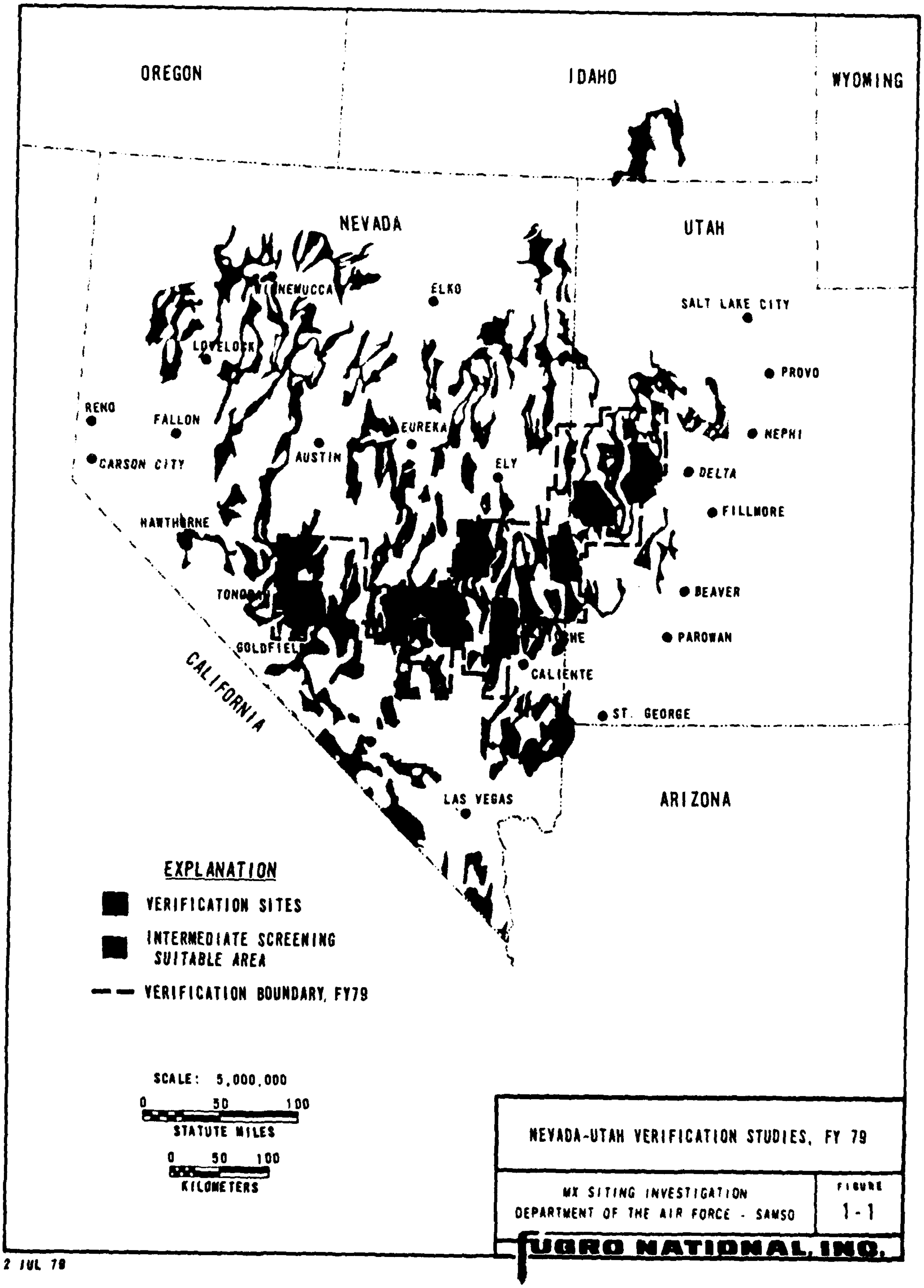

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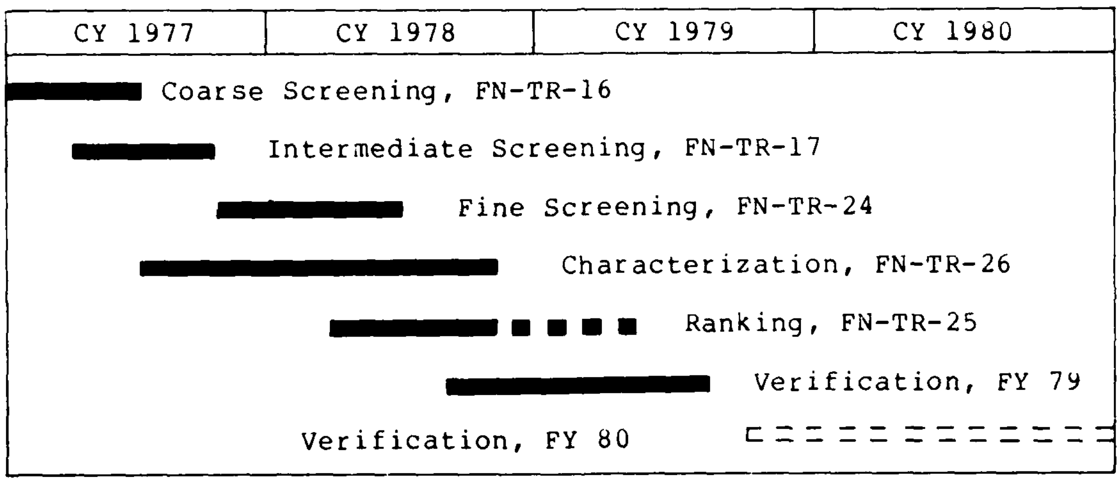
3. GEOTECHNICAL RANKING: A comparison of seven Candidate Siting Regions, based on the relative cost of geotechnically related construction items. The rankings were performed for the hybrid trench, vertical shelter, and horizontal shelter MX basing modes.

The schedule of these studies is shown in the following diagram, which also identifies the Fugro National technical report for each.



The primary objective of the Verification studies is to refine and improve confidence in suitable area boundaries that were determined from the previous programs. In contrast to previous studies which were based primarily on published information, the Verification studies are based on field investigations. These studies have concentrated on refining suitable area boundaries and obtaining geotechnical data for preliminary engineering design use prior to site-specific studies. The design and scope of these studies are based on the results of the Ranking studies which pointed out those geotechnical-related factors that have the greatest influence on construction costs.

1.2 OBJECTIVES FY 79

The FY 79 geotechnical Verification studies in the Nevada-Utah area have four major objectives.

1. Verify and refine suitable area boundaries in the study area for hybrid trench, vertical shelter, and horizontal shelter.
2. Provide preliminary physical and engineering characteristics of the soils.
3. Identify problem areas or areas with data gaps where additional field work will be necessary.
4. Recommend additional areas for study, if needed, for deployment of the MX system.

1.3 STUDY APPROACH AND SCOPE

1.3.1 Study Approach

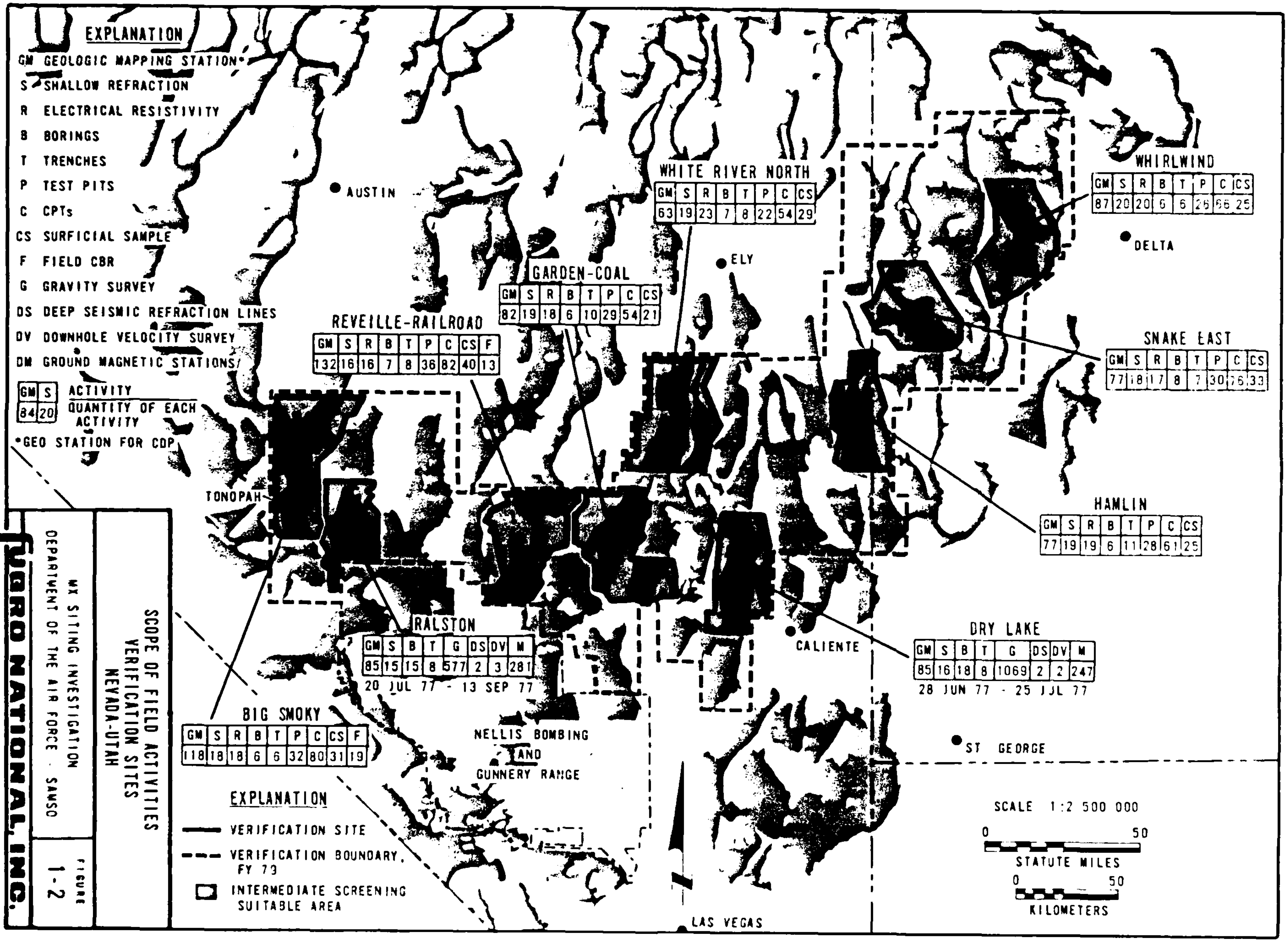
The suitable area identified during previous studies was based primarily on available literature and very limited site-specific investigation. To verify that these areas are, in fact, suitable and to improve the boundaries between suitable and unsuitable areas, it was considered essential that actual conditions be determined from field studies. Because of the large size of the area required for deployment of the MX system, it was not possible to carry out detailed studies in all potentially suitable areas in Nevada and Utah during FY 79. Thus, the FY 79 program focused on a portion of the overall area which could be studied during the year. The whole Nevada-Utah study area was divided into 22 Candidate Deployment Parcels (CDPs). CDPs are discrete geographic units devised for organization and management of geotechnical, environmental, and cultural data collected during FY 79 and future siting studies. The CDPs do not imply final boundaries or areas for MX deployment. The suitable area within each CDP, prior to the Verification studies, typically varied between 200 and 500 mi^2 (520 and 1300 km^2).

Within the 22 CDPs, two levels of study were performed. Studies involving subsurface investigative techniques were conducted in portions of seven CDPs; these were termed "Verification Sites." These sites are located in the following CDPs: Whirlwind, Snake East, Hamlin, White River North, Garden-Coal, Reveille-Railroad, and Big Smoky (Figure 1-2). In addition to the seven sites, Dry Lake and Ralston sites, also shown in Figure 1-2 were investigated during the earlier Characterization program (FN-TR-26e) and are now considered Verification sites.

Those suitable areas within the Nevada-Utah study area and outside the Verification sites were termed "Geologic Reconnaissance Sites." Field activities were limited to geologic inspection and no subsurface information was obtained.

1.3.1.1 Verification Site Studies

The Verification Site studies consisted of a combination of geologic, geophysical, and soils engineering investigations designed to differentiate suitable and unsuitable area and to obtain basic information about the geotechnical characteristics



SCOPE OF FIELD ACTIVITIES
VERIFICATION SITES
NEVADA-UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 1-2

FUGRO NATIONAL, INC.

of the basin-fill materials. The field program is shown schematically in Table 1-1. The parameters which were evaluated are shown as column headings and the applicable investigative techniques are listed below. The techniques are described in detail in the Appendix.

1.3.1.2 <u>Geologic Reconnaissance Site Studies</u>

Reconnaissance Site studies were limited to two activities:

- o photogeologic mapping; and
- o limited field-checking to verify photo interpretations.

Reconnaissance Site studies provided a means of detecting unsuitable area which had not been identified during previous studies because of inadequate data or maps. Surface rock was identified on the aerial photos and confirmed by field observations. Areas interpreted to have a high probability of shallow rock or water were identified for Verification Site studies planned during the FY 80 program. Areas of questionable or unsuitable terrain were field-checked.

The Reconnaissance Site studies have provided a means of improving suitable area boundaries and a basis for planning more extensive Verification Site studies. Suitable area boundaries will be refined again, taking into account depth to rock and ground water based on subsurface information during the FY 80 Verification Site studies.

1.3.2 <u>Scope</u>

Table 1-2 lists the types and number of activities that were performed in the Verification sites. Figure 1-2 lists the

OBJECTIVES → VERIFICATION OF INTERMEDIATE FINE SCREENING SU

DATA FOR EVALUATIONS → TERRAIN PARAMETERS | 50'–150' DEPTH TO ROCK

FIELD TECHNIQUES AND APPLICATIONS →

TERRAIN PARAMETERS

Geologic mapping

- Identification and limits of areas with slopes greater than 10° grade
- Identification and limits of areas with high incidence of 10° slopes (rolling terrain)

50'–150' DEPTH TO ROCK

Geologic mapping

- Surface limits of rock
- Subsurface limits of rock from topographic and geologic interpretation
- Geomorphic expression and erosion history

Seismic refraction surveys

- Subsurface projection of rock limits
- Delineation of rock from high (>>7000 fps) p-wave velocities

Borings

- Occurrence of rock

Gravity profiles (DMA)

- Overall basin shape and relationships
- Range bounding faults

Existing data

- Published literature

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TE FINE SCREENING SUITABLE AREA

CHARACTERISTICS OF

50' 150' TH TO ROCK	50' 150' DEPTH TO GROUND WATER	EXTENT AND CHARACTERISTICS OF SOILS	GEOPHYSICAL PROPERTIES

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Existing data

- Available well records and interpretation

Borings

- Occurrence of ground water

Electrical resistivity seismic refraction surveys

- Provide supplemental data to support presence or absence of ground water

Geologic mapping

- Obtain water depths from wells encountered in field

Geologic mapping

- Extent of surficial soil units
- Surficial soil types

Borings

- Identification of subsurface soil types
- In situ soil density and consistency
- Samples for laboratory testing

Trenches, test pits, and surficial samples

- Identification of surface and subsurface soil types
- Degree of induration and cementation of soils
- In situ moisture and density of soils
- Samples for laboratory testing

Cone penetrometer tests

- In situ soil strength

Laboratory tests

- Physical properties
- Engineering properties - shear strength, compressibility
- Chemical properties

Seismic refraction surveys

- Compressional wave velocities

Electrical resistivity surveys

- Electrical conductivity of soils
- Layering of soil

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RISTICS OF BASIN FILL

RECOMMENDATIONS FOR FUTURE VERIFICATION STUDIES

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ROAD DESIGN DATA

Trenches, test pits, and Surficial samples

- Identification of soil types
- In situ soil density and moisture
- Thickness of low strength surficial soil

Cone penetrometer tests

- In situ soil strength
- Thickness of low strength surficial soils

Field CBR tests

- In situ soil strength
- In situ soil density

Laboratory tests

- Physical properties
- Compaction and CBR data
- Suitability of soils for use as road subgrade, subbase, or base

Existing data

- Suitability of soils for use as road subgrade, subbase, or base
- Behavior of compacted soils

EXCAVATABILITY AND STABILITY

Borings

- Subsurface soil types
- Presence of cobbles and boulders
- In situ density of subsurface soils
- Stability of vertical walls

Trenches and test pits

- Subsurface soil types
- Subsurface soil density and cementation
- Stability of vertical walls
- Thickness of low strength surficial soils
- Presence of cobbles and boulders

Laboratory tests

- Physical properties
- Engineering properties

Geologic mapping

- Distribution of soil types

Seismic refraction surveys

- Excavatability

FIELD TECHNIQUES
VERIFICATION STUDIES
NEVADA-UTAH

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE SAMSO	TABLE 1-1

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TECHNIQUE	ACTIVITIES		REMARKS	APPENDIX REFERENCE*
	Average Number Per Site	Total for Seven Sites		
Geologic Mapping (Stations)	91	636	Reconnaissance mapping performed in all non-verification site areas	A3.0
Seismic Refraction Measurements	19	130	Seismic refraction survey and electrical resistivity sounding performed in parallel at each location	A4.1
Electrical Resistivity Soundings	19	133		A4.2
Gravity Surveys	**	**	Field surveys performed by Defense Mapping Agency (DMATC)	A4.3
Borings	6	45	Rotary wash to 160 feet	A5.1
Trenches and Test Pits	8 29	56 203	Excavated with a backhoe	A5.2
Cone Penetrometer Tests (CPT)	67	471	Truck mounted, electronic	A5.3
Field CBR Tests	16	31	Performed only in Reveille-Railroad and Big Smoky valleys	A5.4
Laboratory Tests	-	-	See CDP sections for listing of lab tests	A5.6

Notes: * Detailed descriptions of these tasks are included in the specified Appendix.

** Data not available for this report.

GEOTECHNICAL ACTIVITIES
VERIFICATION STUDIES
NEVADA-UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 1-2

FUGRO NATIONAL, INC.

number of activities that were performed in each Verification site.

Field work was started on 16 October 1978 and continued until 20 December. During January, February and March 1979, when inclement weather existed in the study area, office studies (data reduction and analysis) were performed. Field studies were resumed in Nevada on 19 March and continued for four more weeks. The total field time in Nevada-Utah was approximately 70 days.

Prior to starting Verification field studies, a program plan was developed, logistics were planned, and photogeologic mapping was initiated. Access was arranged through the U.S. Bureau of Land Management (BLM) district offices in Ely and Battle Mountain, Nevada and Richfield and Cedar City, Utah. At BLM's request, all field activities were performed along existing roads or trails to minimize site disturbance. Archaeologic and environmental surveys were performed at each proposed activity location. Activity locations were changed in those few instances where a potential environmental or archaeological disturbance was identified.

1.4 ANALYSIS OF SUITABLE AREA

The primary objectives of the FY 79 Verification Studies have been to verify suitable areas and to refine suitable area boundaries in the Nevada-Utah study area based on field studies. The reader must be aware of the limitations of the investigations to date and must recognize that additional revisions regarding the suitability of some areas will be required as the studies continue. The suitable area reported here is based on two different levels of investigation. A higher level of confidence is associated with the Verification sites because the studies there were more extensive and included subsurface information obtained from test pits, trenches, borings, and geophysical surveys. These sites cover approximately 35 percent of the total area studied. In the remaining 65 percent of the area, studies were limited to geologic photo interpretation and field reconnaissance.

Because of the differences in the amount of data collected for Verification and Reconnaissance sites, different procedures were used to determine suitable area. These differences are explained in the following three sections.

1.4.1 Depth to Rock

In the Verification sites, 50- and 150-foot depth to rock contours were estimated and are shown on the Depth to Rock maps in the individual CDP sections (Sections 4.0 to 10.0). The contours are based on limited boring and geophysical data in combination with geologic interpretation. The interpretation considers the presence or absence of range-bounding faults, bedding plane attitudes, evidence of erosional features such as pediments, and the presence or absence of young volcanic rocks.

In the Reconnaissance sites, 50- and 150-foot depth to rock contours were not determined since geologic field studies were limited and there were no subsurface data. In these areas, suitable area is based on soil-rock contacts which can be located relatively accurately on aerial photos. A rock reduction factor was used to estimate actual suitable area; the technique is described in Section 2.0.

1.4.2 Depth to Water

The location of 50- and 150-foot depth to ground-water contours has been estimated for all the suitable areas within the Nevada-Utah study area shown in Figure 1-1. The reliability of the interpretations are highly variable, depending on the source of available data. In some of the Verification sites, refinements in contour locations were made using water well, boring or geophysical data. Such refinements were very limited and it can be expected that suitable area boundaries will change as new data are collected.

Depth to water maps have been prepared for all Verification sites and are presented in the individual CDP sections. Data used to determine the locations of depth to water contours are also shown on these maps.

1.4.3 Terrain

During Screening studies, areas were excluded because of unsuitable terrain. The major exclusion criterion was a maximum permissible grade of 10 percent and/or a preponderance of 10 percent slopes over a given area as in rolling or highly dissected terrain. In many of the areas studied, detailed topographic maps have not been made and the available maps have contour intervals of 20 feet (6 m) or more. Such maps do not show topographic conditions with sufficient detail to make an accurate evaluation of terrain suitability.

To provide preliminary information about terrain conditions, terrain maps have been produced and are presented in the individual CDP discussions. These "interpretive" maps are based on an evaluation of existing maps, aerial photos, field observations, and the distribution of geologic units. More accurate topographic maps will be necessary to improve suitable area boundaries and provide detailed terrain data for basing mode layout studies.

1.5 ANALYSES OF BASIN-FILL CHARACTERISTICS

In addition to the primary objective of refining suitable area boundaries, a secondary objective was to provide preliminary physical and engineering properties of the basin-fill materials. These data will be used for preliminary engineering design studies, assist planning of future site-specific studies, and provide data to other MX participants.

The investigation of engineering properties were designed primarily to obtain information needed for construction activities. Particular emphasis has been placed on the surficial soil conditions as related to road construction, a major cost item. Moderate emphasis has been placed on soil conditions in the upper 20 feet (6 m) since this would be the approximate depth of excavation for the trench or horizontal shelter concept. Limited data have been obtained from borings drilled to a depth of 160 feet (49 m), which is the depth of interest for the vertical shelter basing mode. The length of the seismic refraction lines was also chosen to obtain information to 160-feet (49-m).

To assist in determining the distribution of surficial soils, a surficial geologic map has been prepared. It is based on the interpretation of aerial photos and field mapping. Other data used to define surficial soil conditions include surficial soil samples, test pits, trenches, cone penetrometer tests, and field CBR tests. Samples obtained at these activity locations were tested in the laboratory to determine physical and engineering properties. The cone penetrometer and field CBR tests were used to measure in situ soil properties.

Data obtained from test pits, trenches, borings, seismic refraction lines, and laboratory tests were used to estimate soil properties to a depth of 20 feet. Since most test pits were excavated to only 5 feet (1.5 m), the amount of data from greater depths is typically limited to that obtained from 6 to 8 trenches and 5 to 7 borings. These 11 to 15 data points represent a very small percentage of the total area in a typical Verification site (300 mi^2; 780 km^2). Thus, the range of properties presented in the report are subject to revision.

The soil parameters between a depth of 20 and 160 feet are based on data obtained from only 5 to 7 borings within each Verification site. Considering that the typical spacing between borings was 5 to 7 miles (8 to 11 km), the data presented may not be representative of an entire CDP.

1.6 REPORT ORGANIZATION AND DATA PRESENTATION

1.6.1 Report Organization

Results of the FY 79 Verification Studies in the Nevada-Utah study area are contained in nine volumes. Two additional volumes will be prepared to present data from the two Characterization sites (Dry Lake and Ralston).

Volume IA. Sections 1.0, 2.0, and 3.0 contain Introduction, Results and Conclusions, and Recommendations for Future Studies in the Nevada-Utah study area. Sections 4.0 through 6.0 contain summary geotechnical discussions for Whirlwind, Snake East and Hamlin Verification sites. The following specific topics are included within each of these sections.

- o Geographic Setting
- o Scope (of site studies)
- o Geologic Setting
- o Surface Soils (Characterization)
- o Subsurface Soils (Characterization)
- o Terrain
- o Depth to Rock
- o Depth to Water
- o Results and Conclusions (Suitable Area and Construction Considerations)
- o Recommendations for Future Studies

Volume IB. Sections 7.0 through 10.0 contain summary geotechnical discussions for White River North, Garden-Coal, Reveille-Railroad, and Big Smoky Verification sites. Section 11.0 briefly explains previous work performed in Dry Lake and Ralston sites. The Appendix included with Volume IB contains a glossary of terms, exclusion criteria, and details of the field and office techniques used in the Verification program.

Volumes II through X. These volumes contain detailed "Geotechnical Data" from the seven Verification sites and the two Characterization sites. Each volume contains detailed logs of all the field and laboratory activities pertaining to one CDP. The identification of each volume is listed below.

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

1.6.2 Data Presentation

1.6.2.1 Maps

A suitable area map (Drawing 2-1 in pocket) for the Nevada-Utah study area (scale 1:500,000) is included in Section 2.0. It shows the suitable area for the hybrid trench and vertical shelter basing modes as determined from FY 79 Verification field studies.

The pertinent data for each Verification site is given on a set of six foldout maps at a scale of 1:125,000. The order in which these maps appear within each section (4.0 through 10.0) is listed below and includes the drawing number (the X should be replaced by the appropriate Section number).

- o Activity Locations - Drawing X-1
- o Surficial Geologic Units - Drawing X-2
- o Terrain - Drawing X-3
- o Depth to Rock - Drawing X-4
- o Depth to Water - Drawing X-5
- o Suitable Area, Hybrid Trench and Vertical Shelter - Drawing X-6

Drawings X-3, X-4, and X-5 present the data which were used to determine the suitable area boundaries shown in Drawing X-6. The suitable area determined for each Verification site has been transferred to the smaller scale map (Drawing 2-1) in Section 2.0. The remaining suitable area in Drawing 2-1 is based on the Reconnaissance studies as previously discussed (Section 1.4).

1.6.2.2 Tables and Figures

The most important table in the report is Table 2-1 in Section 2.0. It lists the revised suitable area for each of the 22 CDPs and the combined total. Other tables and figures included in the individual CDP sections are as follows:

- Scope of Activities - Table X-1
- Characteristics of Surficial Soils - Table X-2
- Thickness of Low Strength Surficial Soil - Table X-3
- Seismic Refraction and Electrical Resistivity - Table X-4
- Characteristics of Subsurface Soils - Table X-5

The figures in each CDP section include a location map of the Verification site, plots showing range in gradation of soils, and soil profiles.

2.0 RESULTS AND CONCLUSIONS

2.1 SUITABLE AREA

Tables 2-1A, 2-1B, and 2-1C present a listing of suitable areas based on the results of the FY 79 Verification Studies. The suitable area interpretations were compiled on maps at a scale of 1:125,000. The suitable area boundaries were digitized and input to a computer program to calculate the area within the boundaries. Table 2-1A presents the FY 79 suitable area for the seven Verification sites and the two previously studied Characterization sites. Table 2-1B presents the FY 79 estimated suitable area for the Geologic Reconnaissance sites in those CDPs where Verification studies were performed. Table 2-1C shows the estimated suitable area in those CDPs where no Verification studies have been performed (i.e., the entire CDP is a Geological Reconnaissance site). In the Reconnaissance sites, the digitized suitable area is based on soil-rock contacts since no subsurface data were available to assist in determining the location of 50- and 150-foot (15- and 46-m) depth to rock contours. The actual suitable area will be less than the digitized area when 50- and 150-foot rock depths are determined. To provide an estimate of the area that may be lost due to 50- and 150-foot rock conditions, a rock reduction factor has been applied. The factor is based on the average reduction that was calculated for the FY 79 Verification Sites. The reduction factor is 0.82 and 0.74 for the hybrid trench and vertical shelter basing modes, respectively.

TABLE 2-1A			
VERIFICATION SITES	STATE	FY 79 SUITABLE AREA	
		TRENCH mi^2 (km^2)	VERTICAL SHELTER mi^2 (km^2)
1. WHIRLWIND	UTAH	265 (685)	225 (585)
2 SNAKE EAST	UTAH	190 (490)	135 (350)
3 HAMLIN	NEVADA	245 (635)	150 (390)
4 DRY LAKE	NEVADA	320 (830)	300 (775)
5. WHITE RIVER NORTH	NEVADA	255 (660)	125 (325)
6. GARDEN-COAL	NEVADA	295 (765)	250 (650)
7. REVEILLE-RAILROAD	NEVADA	290 (750)	155 (400)
8 RALSTON	NEVADA	225 (585)	200 (520)
9. BIG SMOKY	NEVADA	410 (1060)	155 (400)
TOTAL. TABLE 2-1A		2495(6460)	1695 (4395)

TABLE 2-1B			
GEOLOGIC RECONNAISSANCE SITES (1)	STATE	FY 79 ESTIMATED SUITABLE AREA (2)	
		TRENCH mi^2 (km^2)	VERTICAL SHELTER mi^2 (km^2)
1. WHIRLWIND	UTAH	45 (115)	20 (50)
2. SNAKE EAST	UTAH	160 (415)	120 (310)
3. HAMLIN	UTAH-NEVADA	95 (245)	65 (170)
4. DRY LAKE	NEVADA	140 (365)	125 (325)
5. WHITE RIVER NORTH	NEVADA	105 (270)	70 (180)
6. GARDEN-COAL	NEVADA	150 (390)	130 (335)
7. REVEILLE-RAILROAD	NEVADA	160 (415)	135 (350)
8. RALSTON	NEVADA	140 (365)	100 (260)
9. BIG SMOKY	NEVADA	125 (325)	65 (170)
TOTAL. TABLE 2-1B		1120 (2905)	830 (2150)

NOTES:

(1) Geological Reconnaissance Sites- those CDPs or portions of CDPs where Verification Site studies were not performed in FY 79.

(2) FY 79 Estimated Suitable Area- an area reduction factor was applied to suitable area in the CDPs or portions of the CDPs where FY 79 Verification studies were not performed. It provides estimates of the amount of suitable area expected to be remaining when suitable area boundaries are based on 50- and 150-foot depth to rock contours.

TABLE 2-1C			
GEOLOGIC RECONNAISSANCE CDPs (1)	STATE	FY 79 ESTIMATED SUITABLE AREA (2)	
		TRENCH mi^2 (km^2)	VERTICAL SHELTER mi^2 (km^2)
1. CAVE	NEVADA	105 (270)	90 (235)
2. DELAMAR	NEVADA	155 (400)	140 (365)
3. DUGWAY	UTAH	170 (440)	125 (325)
4. FISH SPRINGS	UTAH	100 (260)	55 (140)
5. LAKE	NEVADA	195 (505)	105 (270)
6. PATTERSON WASH	NEVADA	145 (375)	90 (235)
7. PENOYER	NEVADA	225 (585)	155 (400)
8. SNAKE WEST	UTAH-NEVADA	135 (350)	85 (220)
9. SPRING	NEVADA	135 (350)	95 (245)
10. STONE CABIN	NEVADA	310 (805)	220 (570)
11. TIKABOO	NEVADA	140 (365)	125 (325)
12. TULE	UTAH	445 (1155)	315 (815)
13. WHITE RIVER SOUTH	NEVADA	35 (90)	30 (80)
TOTAL, TABLE 2-1C		2295 (5950)	1630 (4225)

TOTAL, TABLE 2-1A	2495 (6460)	1695 (4395)
TOTAL, TABLE 2-1B	1120 (2905)	830 (2150)
TOTAL, TABLE 2-1C	2295 (5950)	1630 (4225)
TOTAL, VERIFICATION STUDIES, FY 79	5910 (15,315)	4155 (10,770)

t

contours.

ESTIMATED SUITABLE AREA
FY 79 VERIFICATION STUDIES
NEVADA-UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 2-1

FUGRO NATIONAL, INC.

2

The total suitable area at the start of the Verification program and remaining as a result of the FY 79 Verification Studies is summarized in the following table:

	Nevada-Utah Suitable Area, mi^2 (km^2)	
	Trench	Vertical Shelter
Start of Verification	7720 (20,000)	6750 (17,480)
Completion of FY 79 Verification	5910 (15,310)	4155 (10,760)
Area Lost	1810 (4690)	2595 (6720)
Percent Loss	23	38

The distribution of suitable area in the Nevada-Utah study area is shown in Drawing 2-1. The modification of suitable area boundaries from previous Intermediate/Fine Screening studies (FN-TR-17 and 24) results from a more detailed application of the geotechnical criteria and shifting from literature based information to field data. All criteria applied to determine suitable area are listed in the Appendix, Section A2.0. The three major criteria which have affected suitable area boundaries are:

- o 50 and 150 foot water depths;
- o 50 and 150 foot rock depths; and
- o adverse terrain.

2.1.1 Depth to Ground Water

The depth to ground water criterion has had the greatest impact on suitable area during the Verification program. With the addition of data obtained in this study, the configuration of ground-water contours changed significantly from previous Screening studies. In some cases, the contours were highly modified but did not account for appreciable net area changes.

This is especially true for the trench basing mode (50 feet; 15 m) in Hamlin, Garden-Coal and Big Smoky sites.

The impact on area reductions was generally greatest for the vertical shelter basing mode (150 feet; 46 m) because ground-water data were generally not adequate to define the deeper conditions. Significant reductions in suitable area were recorded in White River North, Reveille-Railroad, and Big Smoky CDPs. In some cases, suitable area was gained through Verification studies. Net gains were recorded in southern Whirlwind (both trench and vertical shelter), in the northern portion of Garden Valley (vertical shelter), and central Railroad Valley (trench).

As previously stated in Section 1.4, there are very few reliable data points regarding ground-water depths. Many of the suitable area boundaries are based on published data, some of which are at least 30 years old. Sources of data and pertinent information regarding the data used to compile the depth to water maps in each CDP are located in Section 2.0 of each Geotechnical Data volume.

The limited number of borings and geophysical surveys conducted during the Verification program could not always verify the regional ground-water interpretation. It is already planned to perform additional field studies in those CDPs where actual ground-water conditions are not known with sufficient accuracy to define reliable suitable area boundaries. The areas to be investigated are discussed in Section 3.0.

2.1.2 Depth to Rock

In determining suitable area based on depth to rock, two different approaches have been used. In the Verification sites, limited subsurface information has been obtained and 50- and 150-foot (15- and 46-m) depth to rock contours have been interpreted. In determining the location of rock contours, the decision was made to place contours at projected depths to rock comparable to those exposed in the adjacent mountains. A seismic velocity greater than 7000 fps (2134 mps) was not always used to define bedrock although it was stated as a criterion in previous studies. It was discovered that some soil-like materials have seismic velocities between 7000 and 9000 fps (2134 and 2745 mps). Seismic velocities were generally used as indicators of rock when velocities were greater than 9000 fps.

In Reconnaissance sites, suitability is based on soil-rock contacts since there is no subsurface data. Studies in the Verification sites have indicated that loss of suitable area resulting from using the 50- or 150-foot depth to rock contour instead of the exposed rock contact is variable ranging up tc 20 percent of the total area studied. Reduction factors were applied to the Reconnaissance sites on the basis of geologic similarities to the Verification sites.

In most cases, contours closely parallel the rock/alluvium contacts. Along mountain fronts controlled by high-angle range bounding structures (Basin and Range faults), slopes were interpreted as being steeper than normal and hence contours were tightly spaced. In areas of low relief volcanic rock and areas typified by erosional morphology (pediments, embayed reentrants and rock outliers), contours were more widely spaced to provide a more conservative estimate of suitable area.

Some changes in suitable area based on depth to rock can be expected as more field data are collected during future Verification studies. Changes may also occur when the results of gravity profiles have been evaluated. These data are being acquired by the Defense Mapping Agency (DMA), but were not available at the time this report was prepared. This data will be included in a supplemental report.

2.1.3 Terrain

Due to the variability in existing topographic coverage, terrain evaluations (primarily drainage depth measurements) did not provide satisfactory resolution. Decisions regarding terrain suitability have been based primarily on aerial photo interpretations and field observations. Fortunately, areas excluded because of unsuitable terrain, for the most part, are of small size and generally localized in perimeter areas adjacent to mountain fronts or along major drainages.

It is likely that additional areas may be judged to be unsuitable when more accurate topographic maps are made. However, it is expected that such reductions will affect only a small percentage of the total area.

2.2 BASIN-FILL CHARACTERISTICS

2.2.1 Soil Characteristics

In this section, general descriptions and characteristics of the soils in the Verification sites are discussed. The discussion presents soil types and their areal extent, location in the sites, and physical and engineering properties. The discussion includes strength characteristics of surficial soils to provide information for preliminary road design.

2.2.1.1 Surficial Soils

Surface soils are predominantly coarse grained (granular) consisting of sands and gravels. Fine-grained soils (silts and clays) exist over limited portions of most sites. Soils from different geologic units were combined into three categories based on their physical and engineering properties.

1. Silty sands and clayey sands;
2. Gravels and gravelly sands; and
3. Silts and clays.

Characteristics of these surficial soils are summarized in the following paragraphs.

Silty sands and clayey sands (silty sands are the major component) are the predominant surficial soils occurring primarily in alluvial fans which extend from the basin margin to the basin center or playa edge. Silty and clayey sands in these deposits are graded coarse to fine, with increasing gravel content toward the basin margin. Fines content is highest near the playa decreasing toward the basin margin. Soil plasticity ranges generally from none to slight. Cementation of these soils varies from none to weak.

Gravels and gravelly sands are the second most predominant surficial soils. They consist of sandy, silty, and clayey gravels and sands with appreciable gravel content. Gravels are generally restricted to alluvial fans immediately adjacent to steep mountain fronts. Clean gravels, however, are also common in central basin areas of Utah valleys where isolated mounds and ridges of older lacustrine shoreline deposits occur. Gravelly sands occur principally in alluvial fans near basin margins but may also occur in the central portions of the valley. The sands generally extend to the mountain front with increasing gravel content toward the mountain front, locally grading into gravels. These soils are generally poorly graded and contain particle sizes ranging from coarse to fine. Cementation of these soils varies from none to weak.

Silts and clays are the least extensive surficial soils. They consist of sandy silts and clays and silty clays with appreciable amounts of fine sand. They occur generally in the central basin in older lacustrine deposits, playas, and axial drainages. Their plasticity generally ranges from none to medium and they are uncemented.

a. Low Strength Surficial Soil: Analysis of the results of cone penetrometer tests (CPTs) in conjunction with the results of other engineering activities revealed that "low strength" surficial soil, which will perform poorly as a road subgrade at its present consistency, exists in all the sites. Criteria were developed to define low strength soil using CPT results (see Section A5.7 in Appendix for details). Using these criteria, the extent of low strength surficial soil in each site was estimated. The coarse-grained soils exhibit low strengths to depths ranging from 0.2 to 14.1 feet (0.1 to 4.3 m) with an average of 2.3 feet (0.7 m) below ground surface. The fine-grained soils exhibit low strengths to depths ranging from 0.3 to 11.0 feet (0.1 to 3.4 m) with an average of 2.8 feet (0.9 m).

b. Subgrade Strength: Results of laboratory California Bearing Ratio (CBR) tests on surficial samples from all the sites indicate that compacted coarse-grained soils will generally exhibit moderate (CBR = 15 to 30) to high (CBR >30) CBR values depending on amounts of gravels and fines in the soil, whereas predominantly fine-grained soils exhibit low (<15) CBR values. Correlation between laboratory CBR and percent fines (Section A5.7 in Appendix for details) indicates that CBR values for coarse-grained soils increase with an increase in percent fines up to a certain stage and then starts decreasing gradually. Using this correlation, laboratory CBR values of a soil can be estimated.

Field CBR values of in situ surficial soils determined in two sites were analyzed in conjunction with the CPT results. A preliminary correlation between field CBR and cone resistance was developed (see Section A5.7 in Appendix for details). Using this correlation, field CBR values of in situ soils can be estimated from the CPT results.

2.2.1.2 Subsurface Soils

Soils in the subsurface are predominantly coarse-grained alluvial fan deposits consisting of gravelly, silty, and/or clayey sands and sandy, silty and/or clayey gravels. Fine-grained soils (silts and clays) probably occur in about 10 to 15 percent of the subsurface and are generally restricted to buried playa and lacustrine deposits along the valley axis. Variation in areal extent of playas in the geologic past has resulted in local interfingering of coarse- and fine-grained deposits in the subsurface near playa margins.

The coarse-grained soils are generally dense to very dense below depths of approximately 10 feet (3 m), are poorly graded with coarse to fine sand and/or gravel, exhibit low compressibilities, and possess moderate to high shear strengths. The fine-grained soils exhibit low to high plasticity and generally contain appreciable amounts of fine sand. Variable calcium carbonate cementation exists in the subsurface soils.

The soils in the construction zone (120 feet; 37 m) have a wide range of seismic velocities (1060 to >7000 fps; 323 to >2135 mps) depending on their composition, consistency, cementation, and moisture content. Soils in the upper 50 feet (15 m) have electrical conductivities ranging from 0.003 to 0.100 mhos per meter (Fine Screening criteria; electrical conductivity of soil should be greater than 0.004 mhos per meter). Chemical test results indicate that potential for sulfate attack of soils on concrete will range from "negligible" to "severe."

2.2.2 Construction Considerations

In this section geotechnical factors and conditions which would affect the construction of the MX system, both hybrid trench and vertical shelter concepts, are discussed.

2.2.2.1 Roads

The surficial soils in the Verification sites are predominantly coarse grained. In a dense state, these soils provide good subgrade support for roads. However, most of these soils consist of alluvial deposits which are not well compacted near the surface. The thickness of these low strength surficial soils ranges from a few inches to several feet, the average being about 2.3 feet (0.7 m). In this condition, the materials will not provide adequate support for heavy wheel loads. These granular soils can be recompacted to a higher density and will then provide very good support.

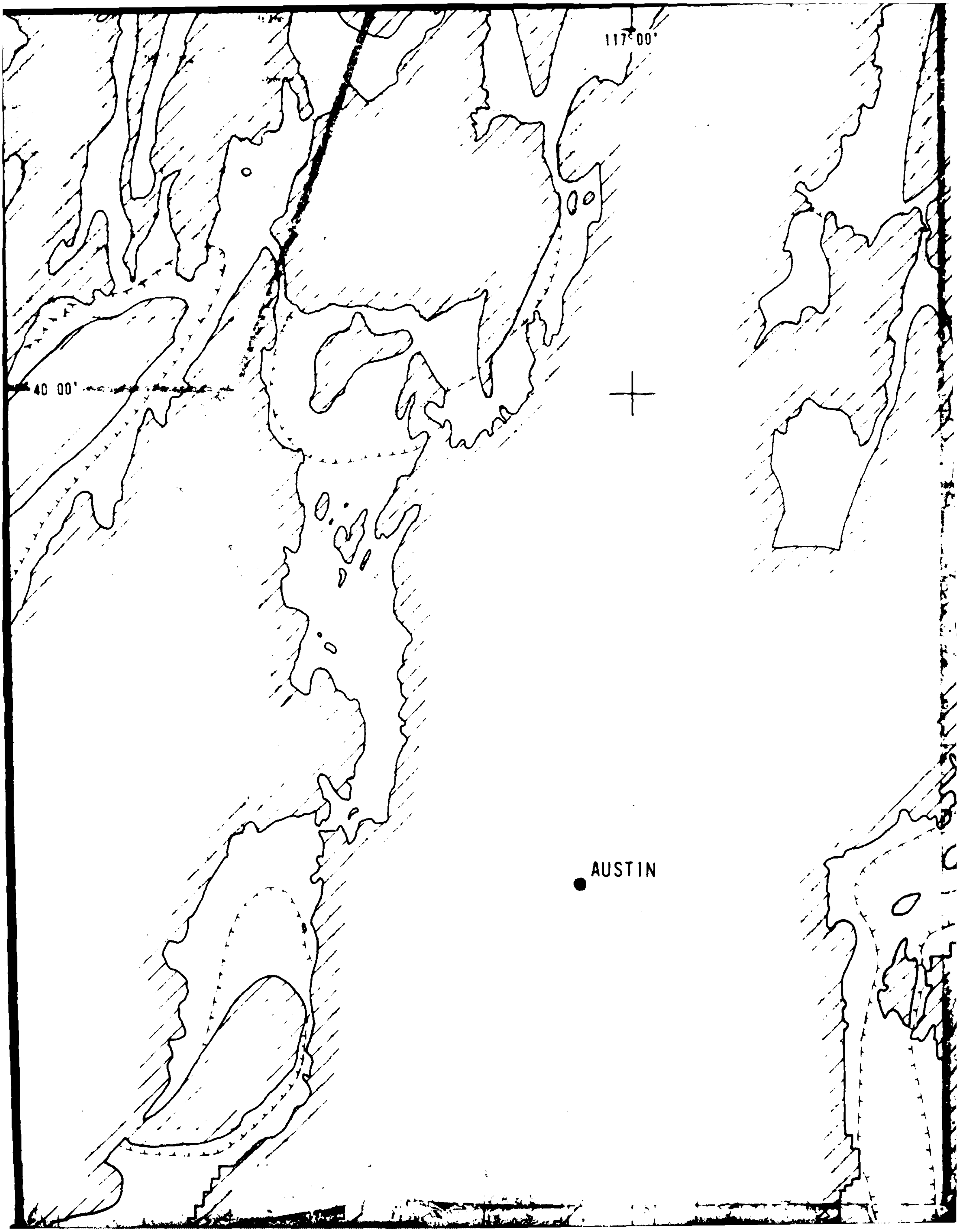
In some areas, the surficial soil may consist of a fine-grained deposit which is only a few feet thick; in this case, the weak material could be removed and replaced with a granular material. In a few areas, such as playas, there may be a relatively thick layer of weak, fine-grained material which has low bearing strength, even if compacted to a high density. In these areas, either a thick section of subbase and base course or soil stabilization techniques will be necessary.

The studies in the Verification sites do indicate that there are significant quantities of sands and gravels which can be used for road subbase and base course. Those deposits with less than 15 to 25 percent fines could be used for subbase material in the natural state. Processing will generally be required to meet standard specifications for base course.

2.2.2.2 Excavatability and Stability

Hybrid trench: Within the depth of excavation for the hybrid trench, compressional wave velocities indicate easy to moderately difficult excavation. An MX trencher could be used for excavating 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 weak surface layer, vertical walls will generally be stable in a major portion of the site areas. In the remaining area, the trench walls will have to be supported or sloped back for stability.

Vertical shelter: The range of compressional wave velocities in he upper 120 feet (37 m) combined with information from the borings indicates that conventional excavation equipment or large diameter augers could be used for excavation of the vertical shelters. Most of the excavations will be in coarse-grained soils with only intermittent cemented zones or cohesive soils. Therefore, walls of the shelter excavations will generally require support or the application of other stabilizing techniques.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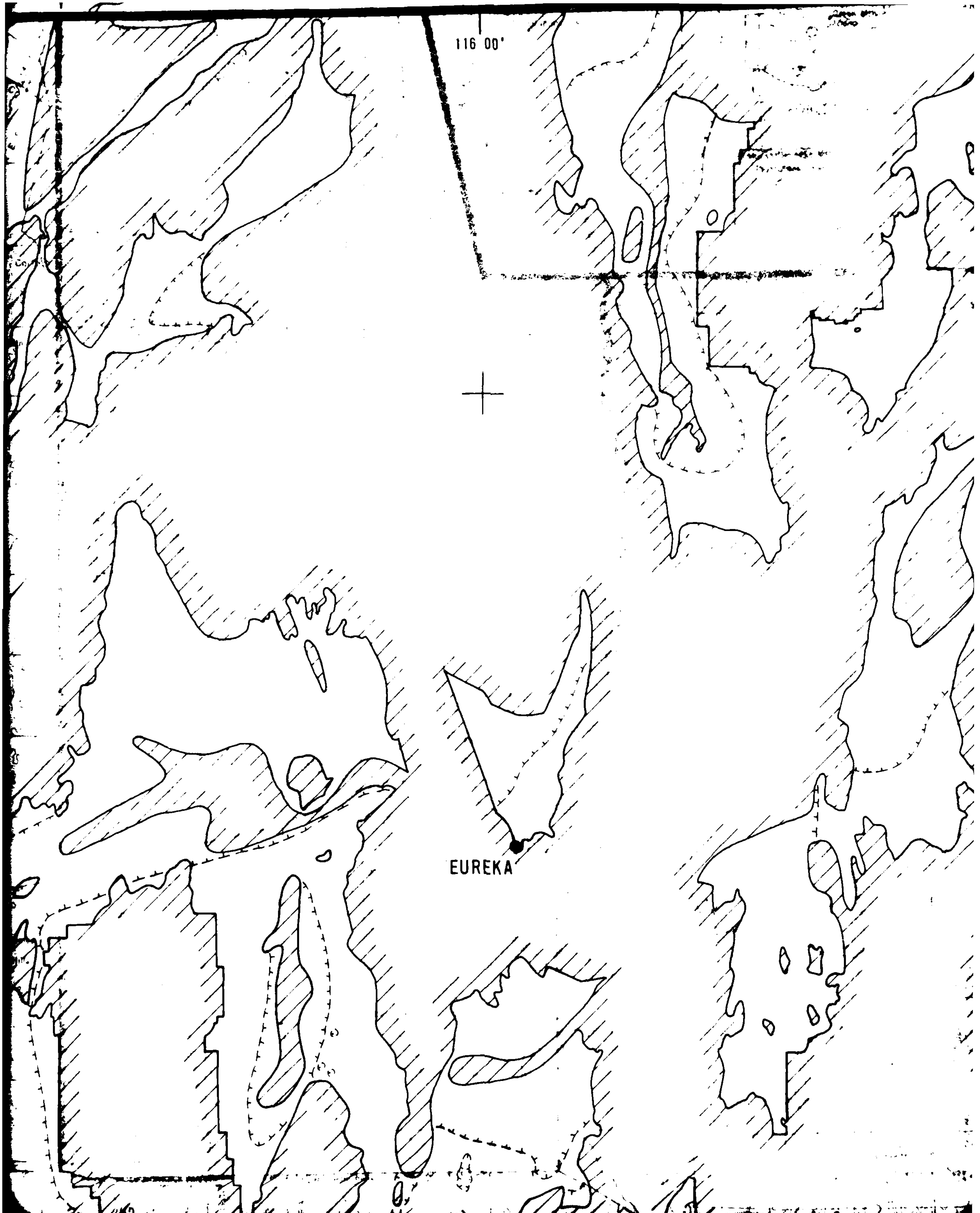
40°00'
AUSTIN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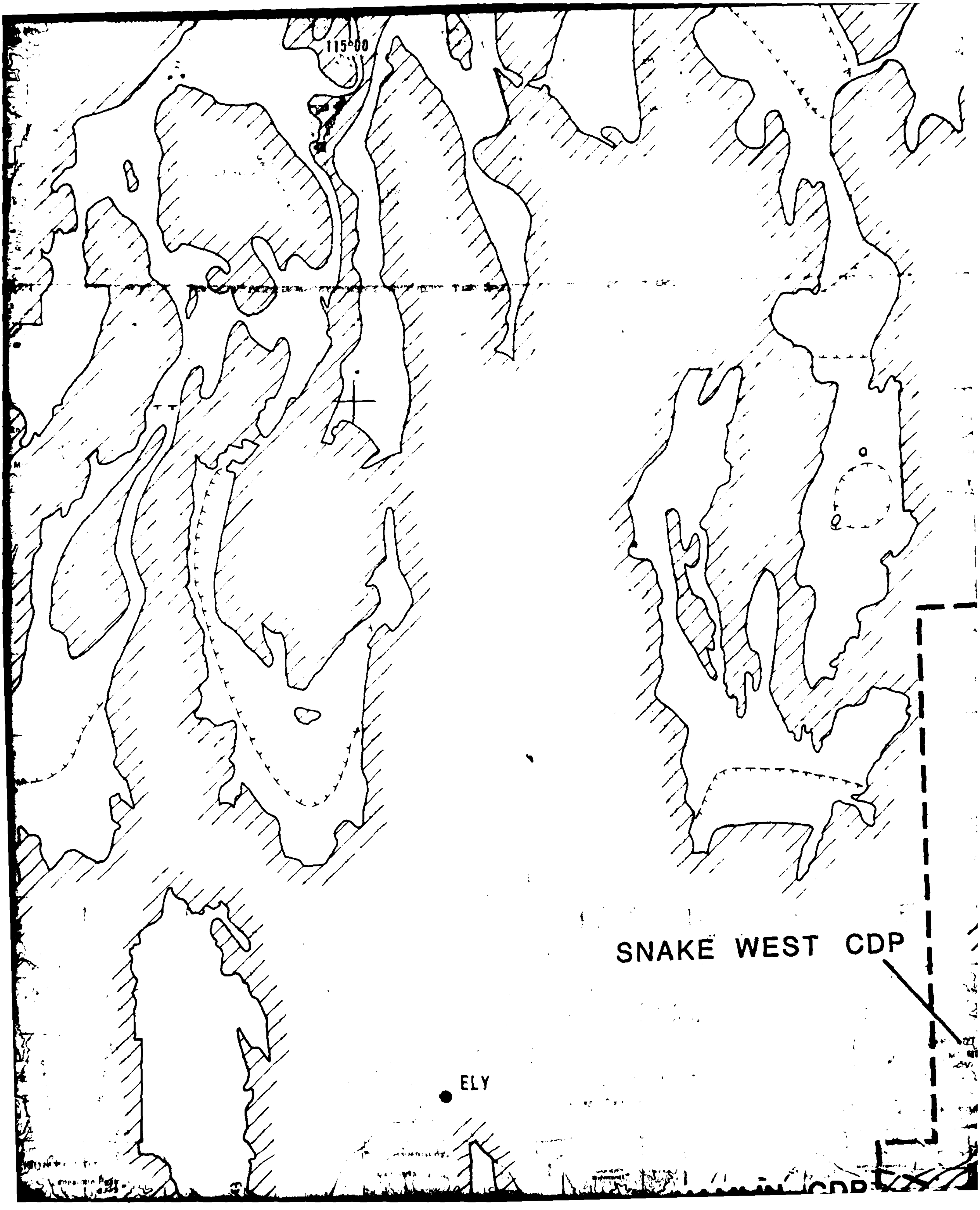
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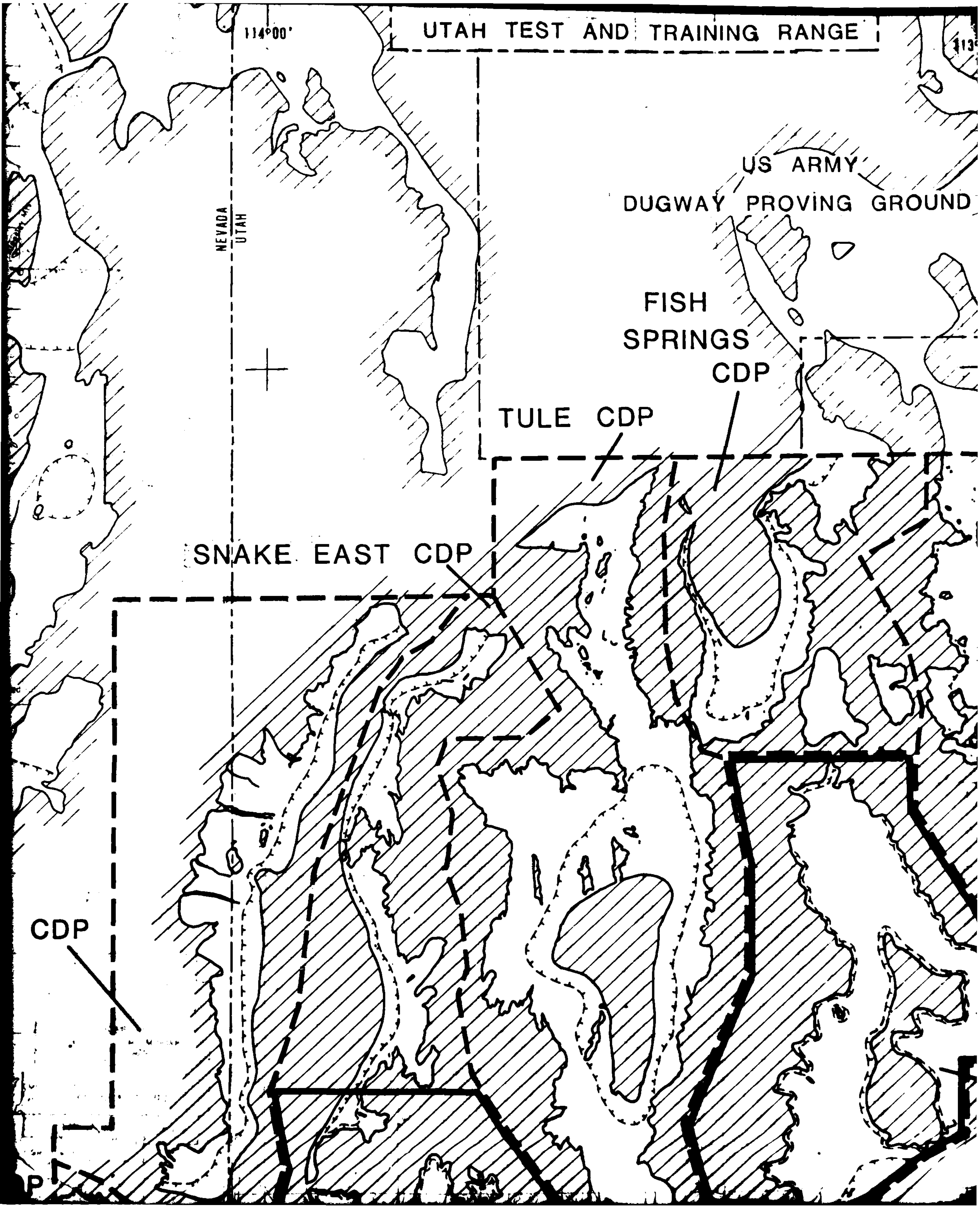
SNAKE WEST CDP
ELY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US ARMY
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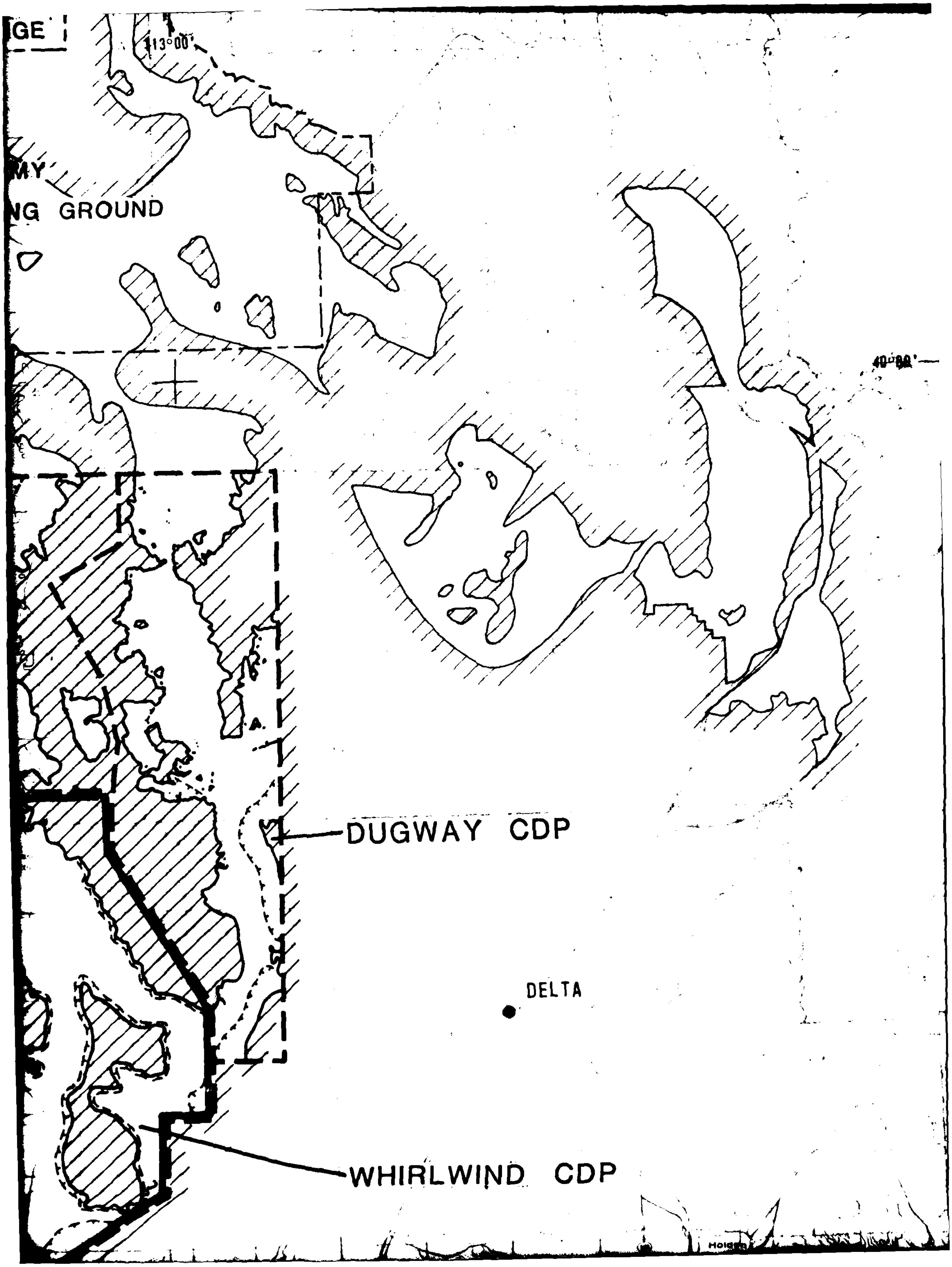
NEVADA
UTAH
FISH
SPRINGS
CDP
TULE CDP
SNAKE EAST CDP
CDP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MY
NG GROUND
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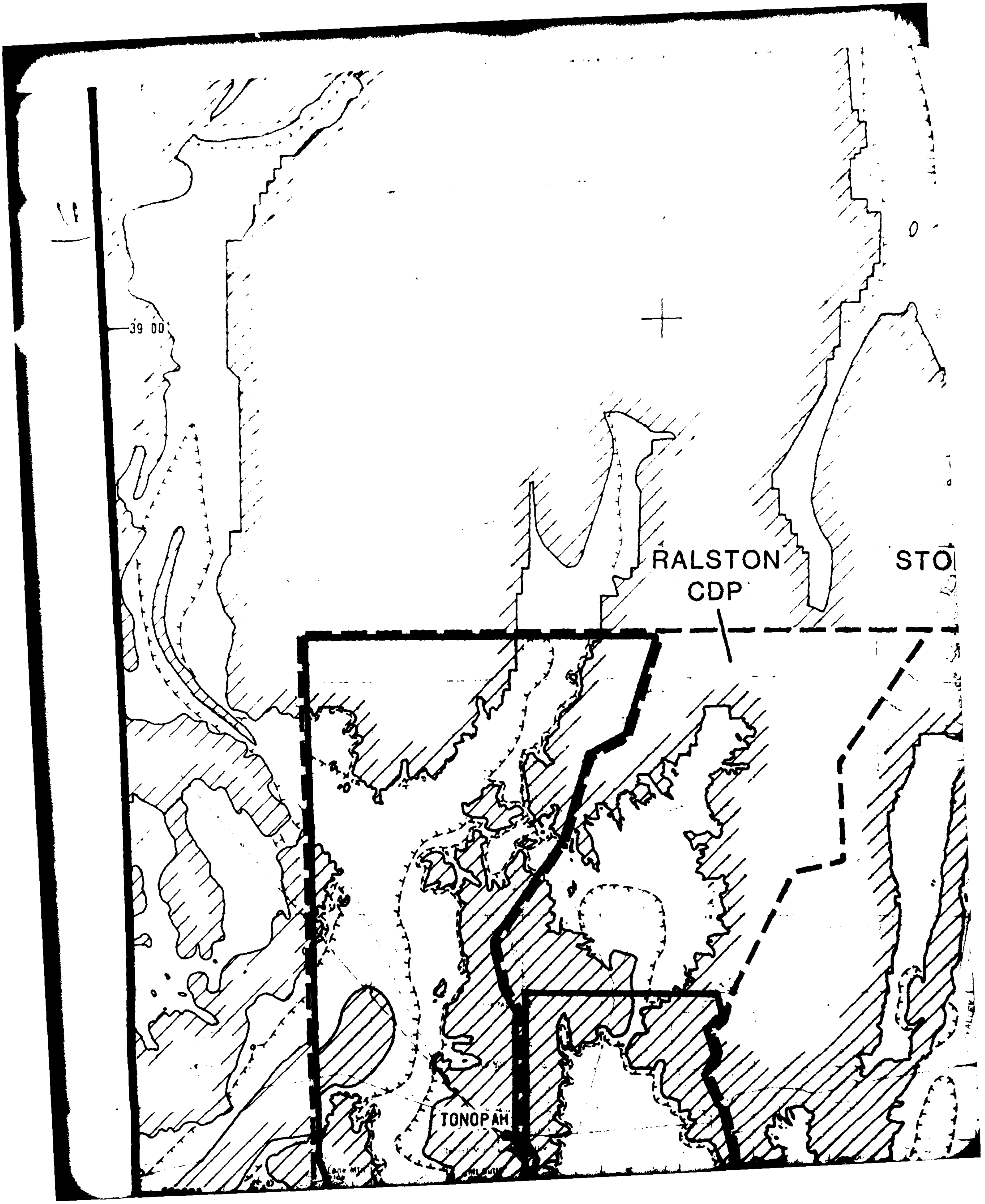
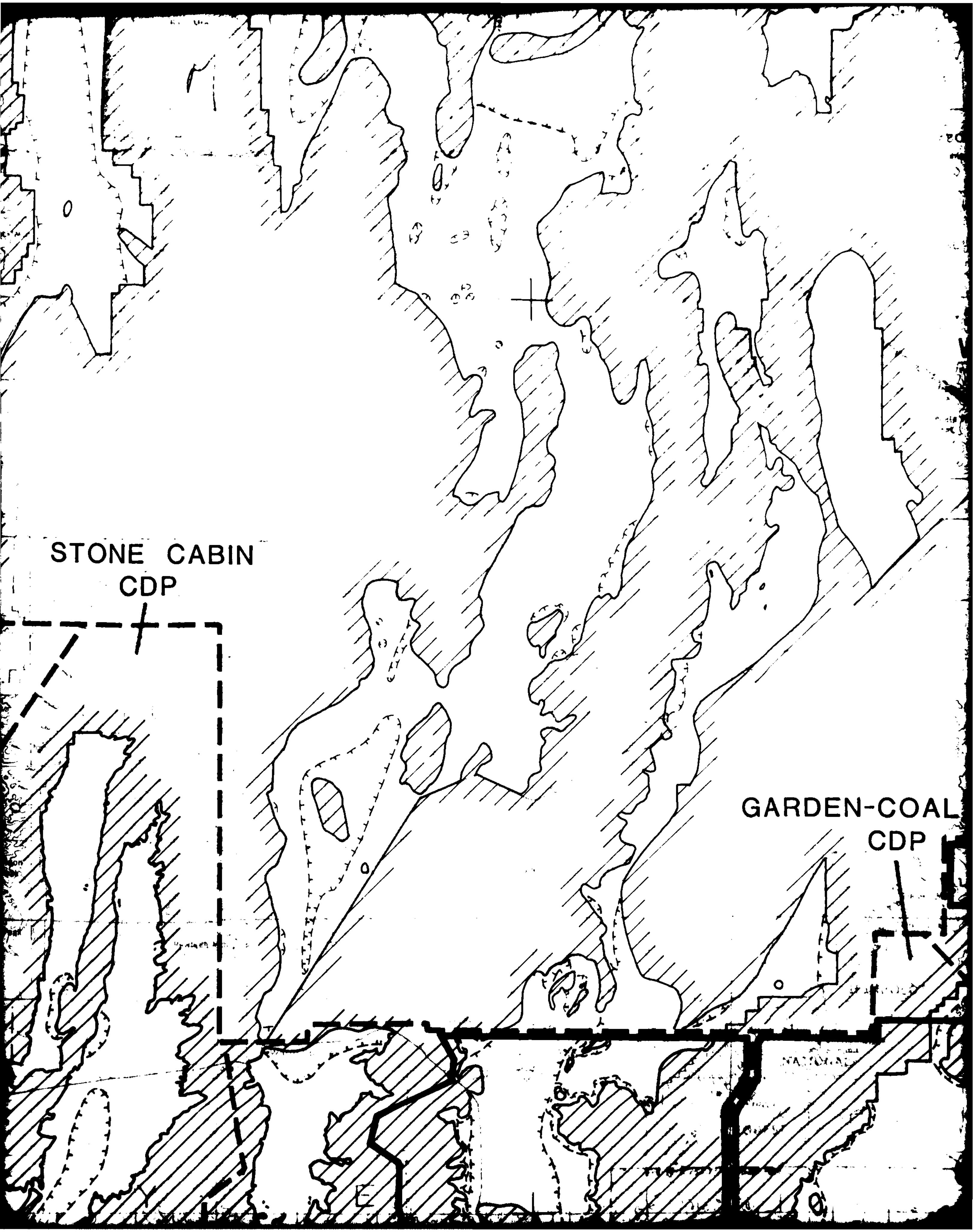
DUGWAY CDP
DELTA
WHIRLWIND CDP



39 00
RALSTON
CDP
STO
TONOPAH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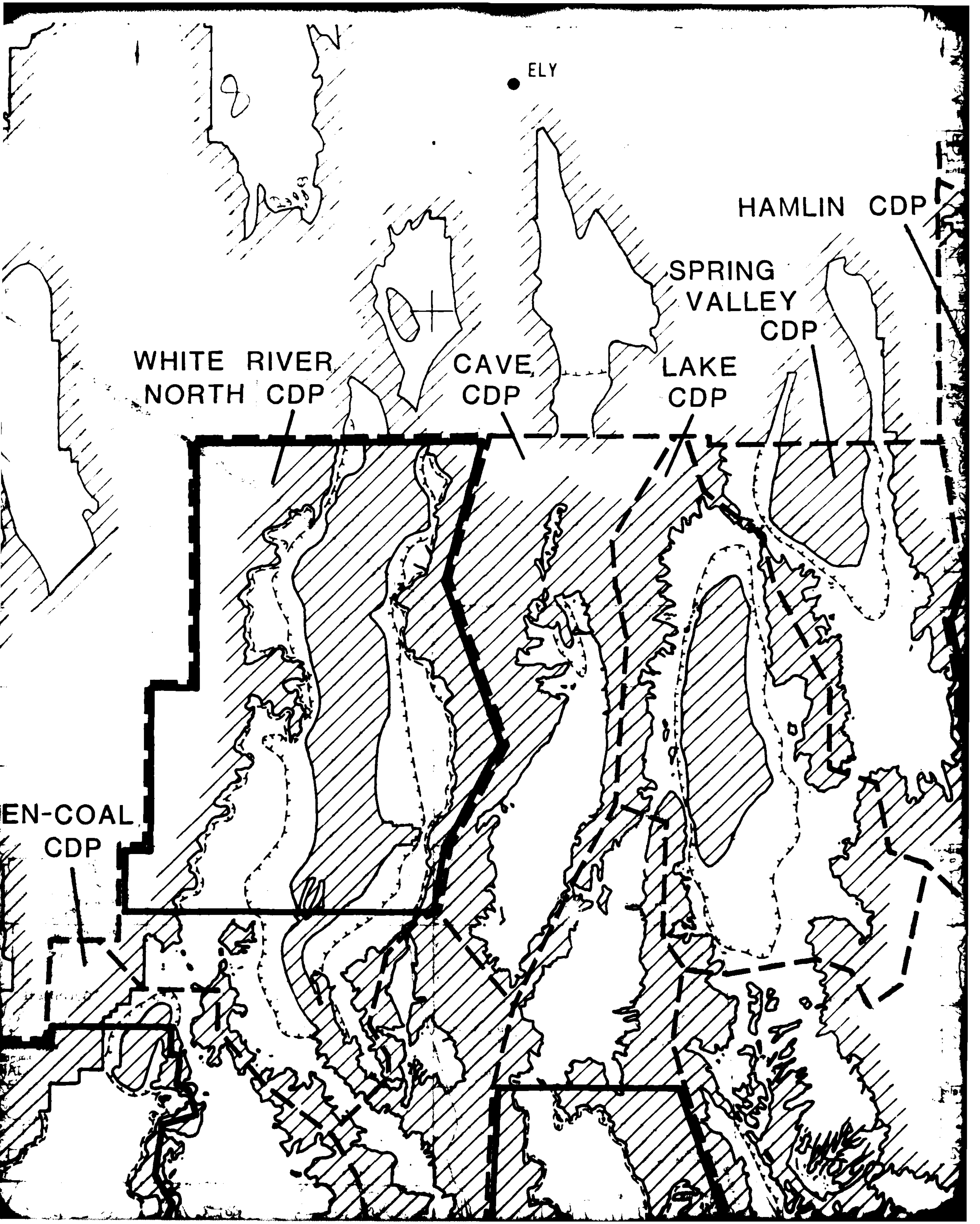
CDP
GARDEN-COAL
CDP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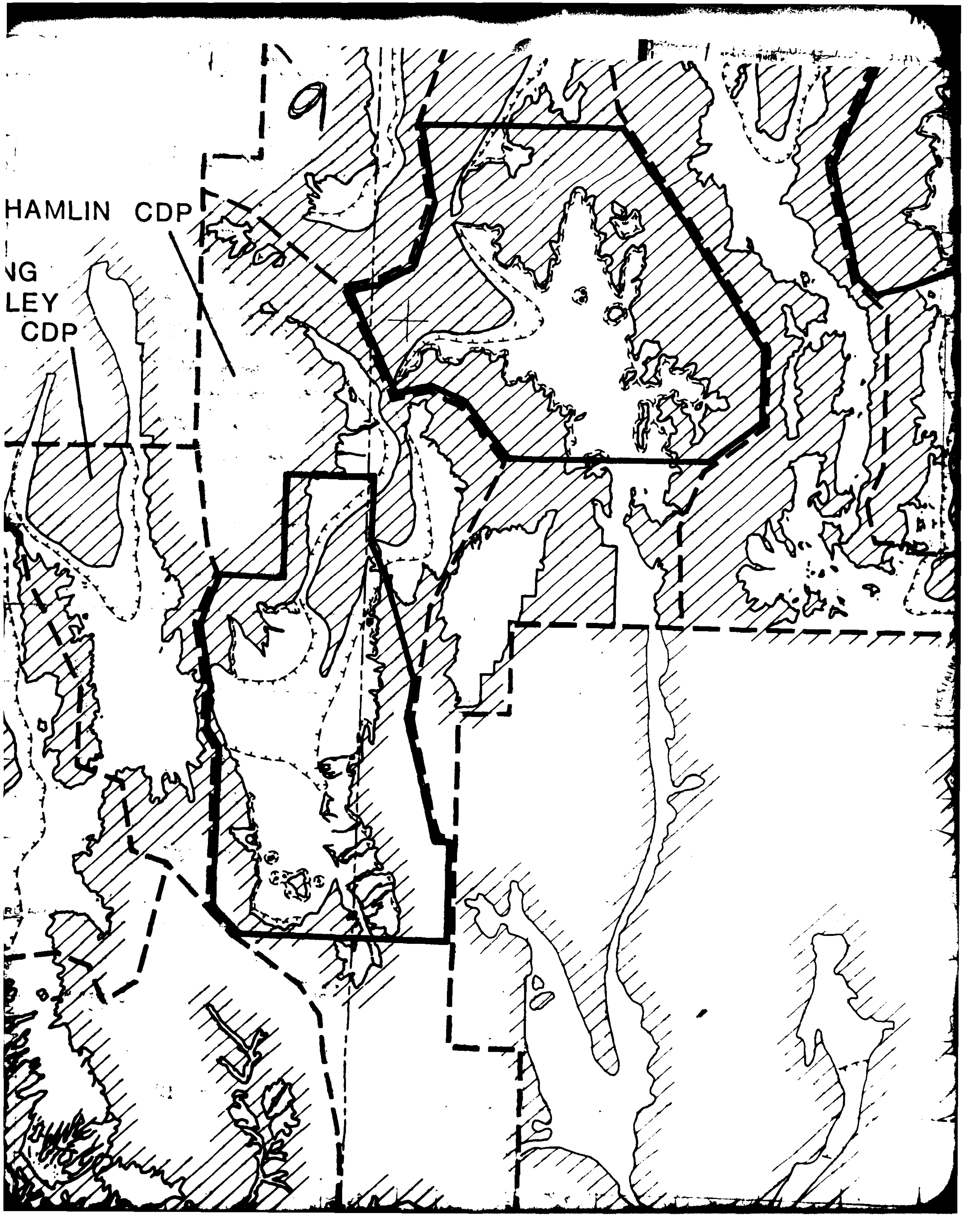
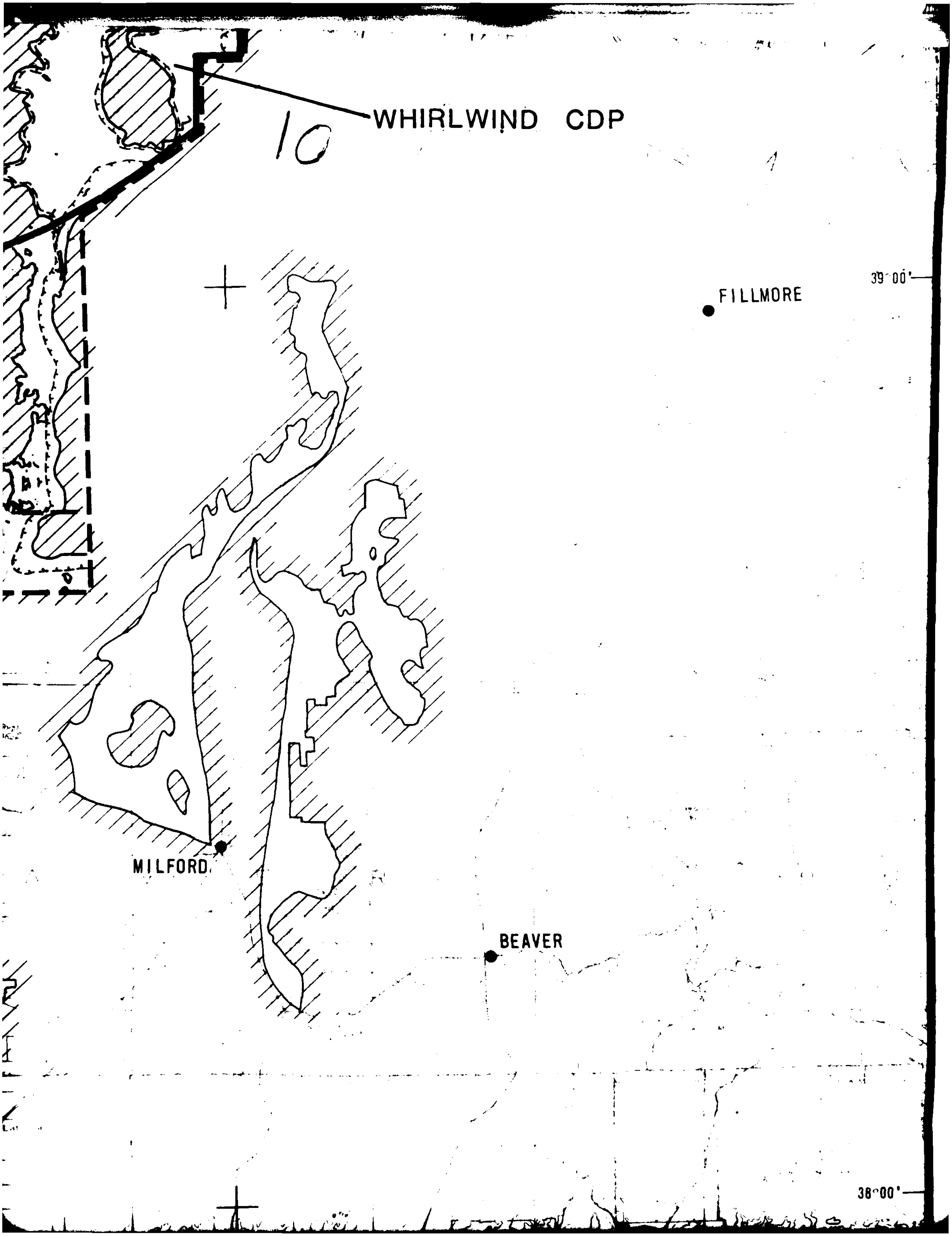
HAMLIN CDP
SPRING VALLEY CDP
WHITE RIVER NORTH CDP
CAVE CDP
LAKE CDP
EN-COAL CDP


9
HAMLIN CDP
NG
LEY
CDP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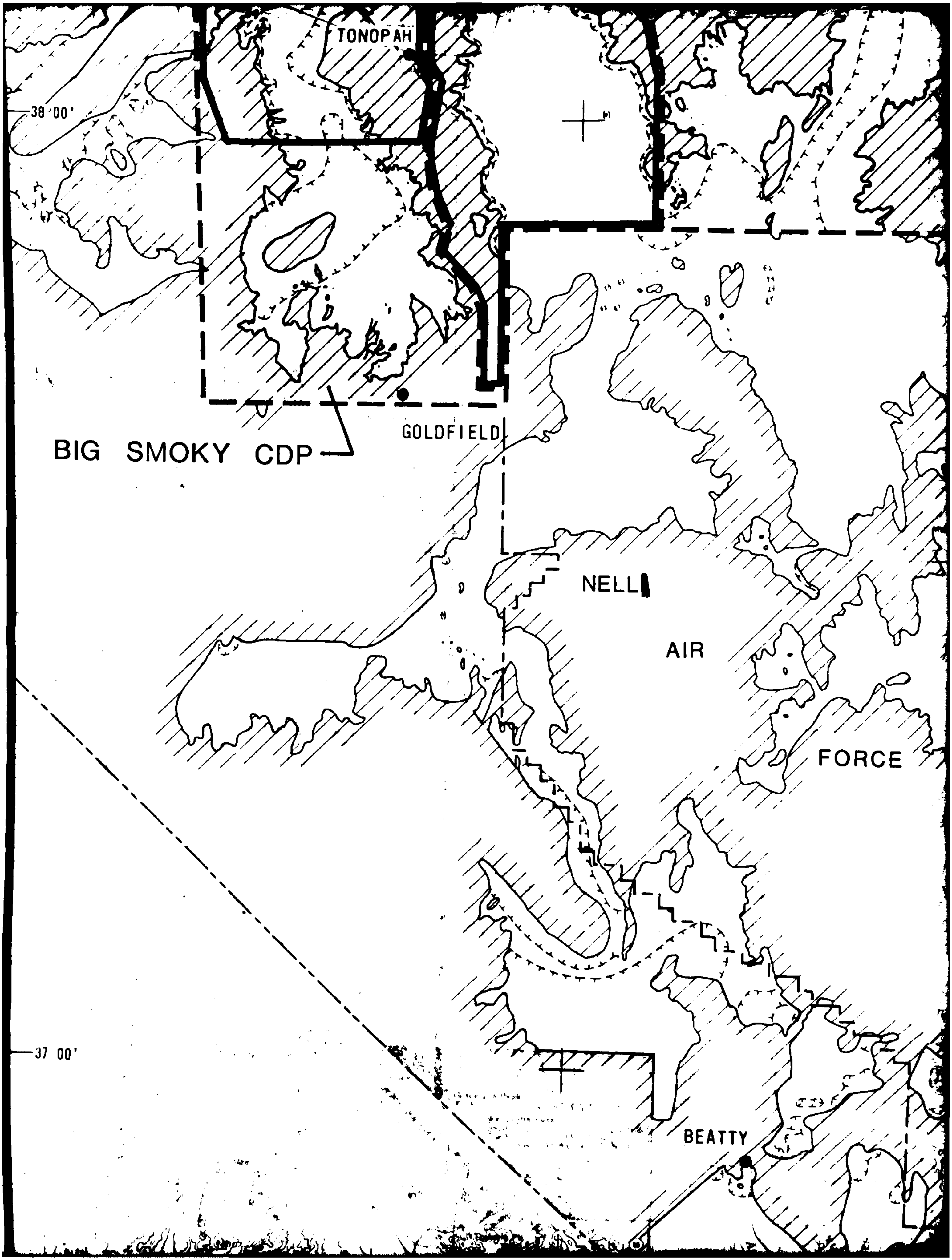
FILLMORE
MILFORD
BEAVER
38°00'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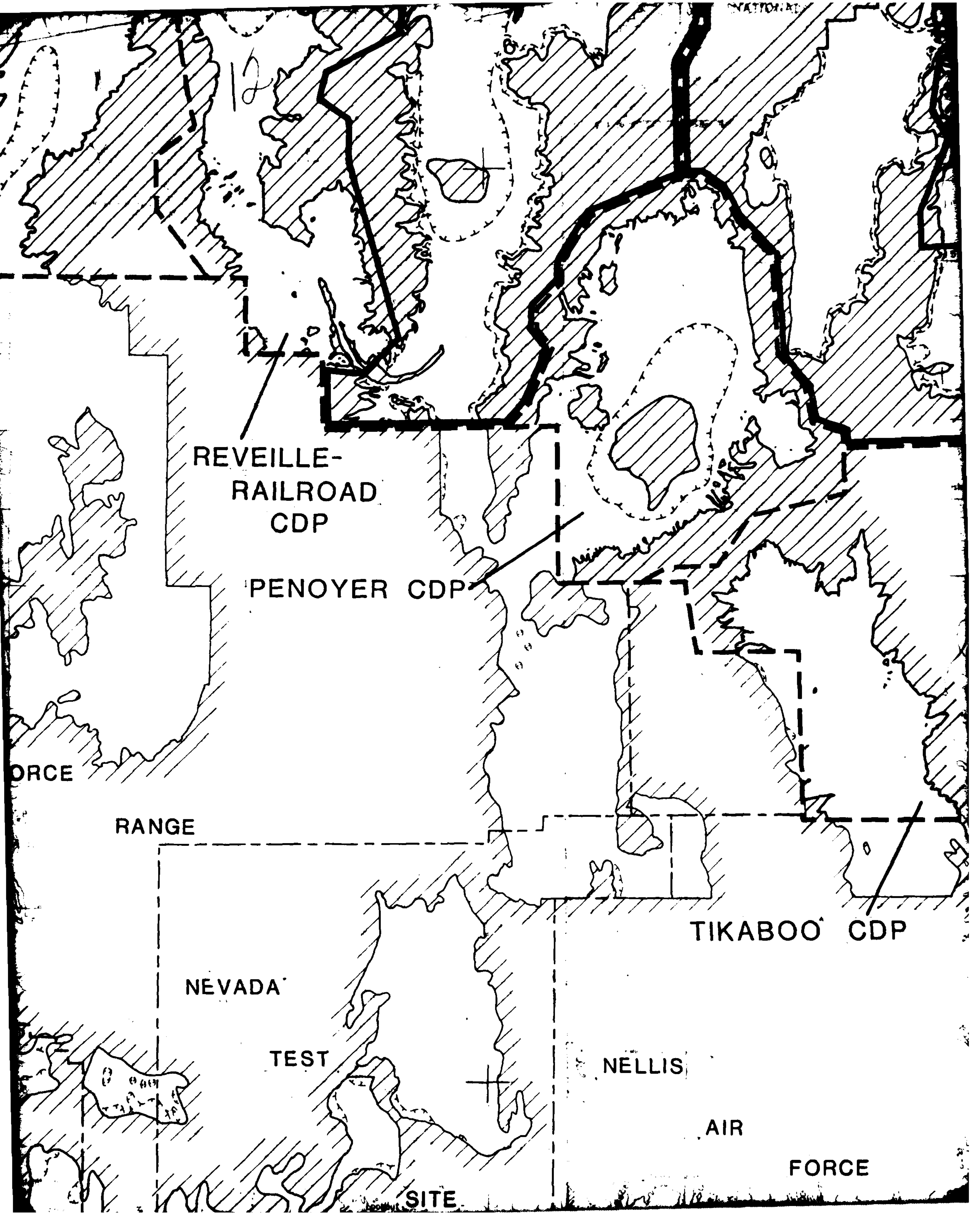
BIG SMOKY CDP
GOLDFIELD
NELLIS
AIR
FORCE
37 00'
BEATTY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REVEILLE-
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CDP
PENOYER CDP
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RANGE
TIKABOO CDP
NEVADA
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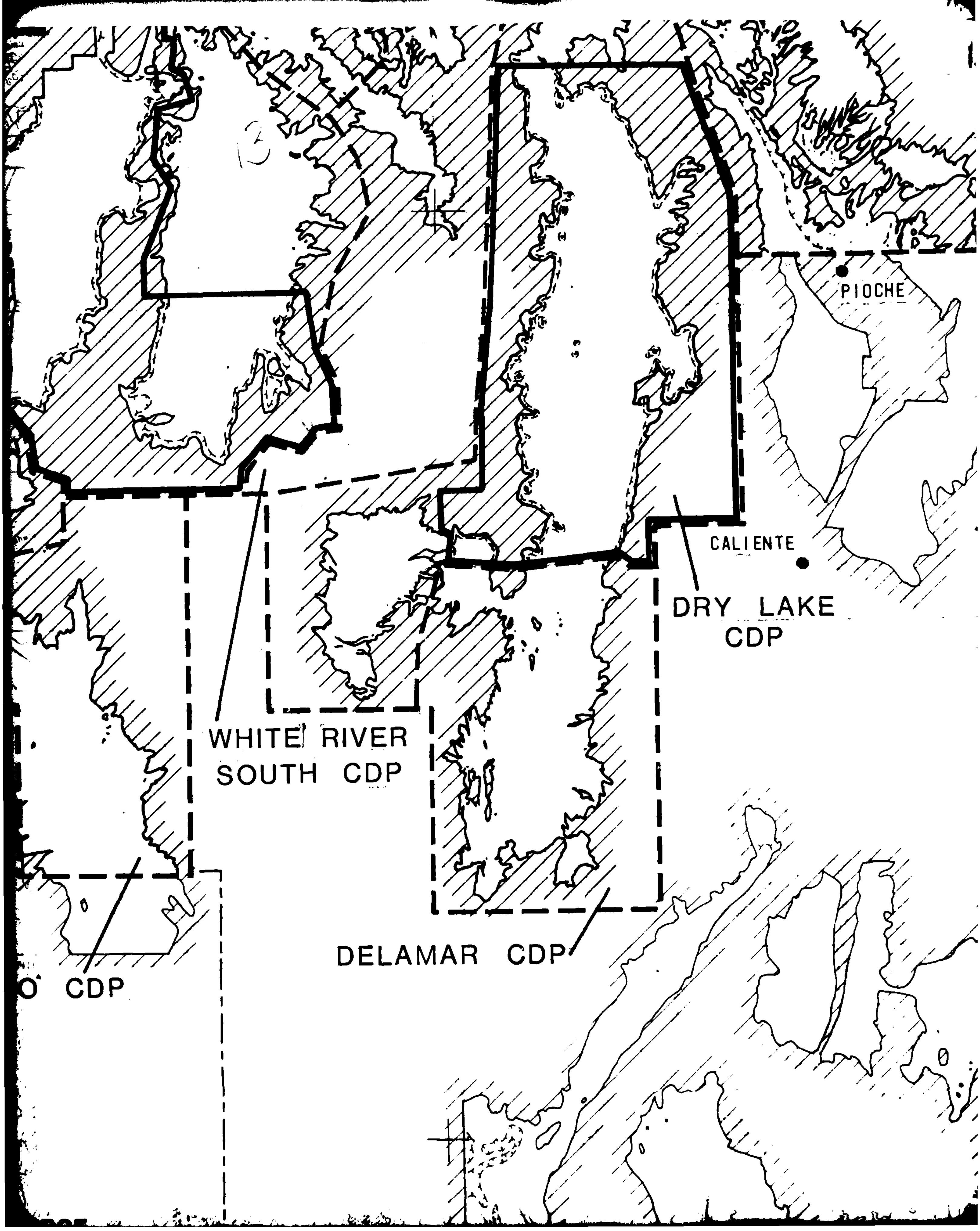
SITE
NELLIS
AIR
FORCE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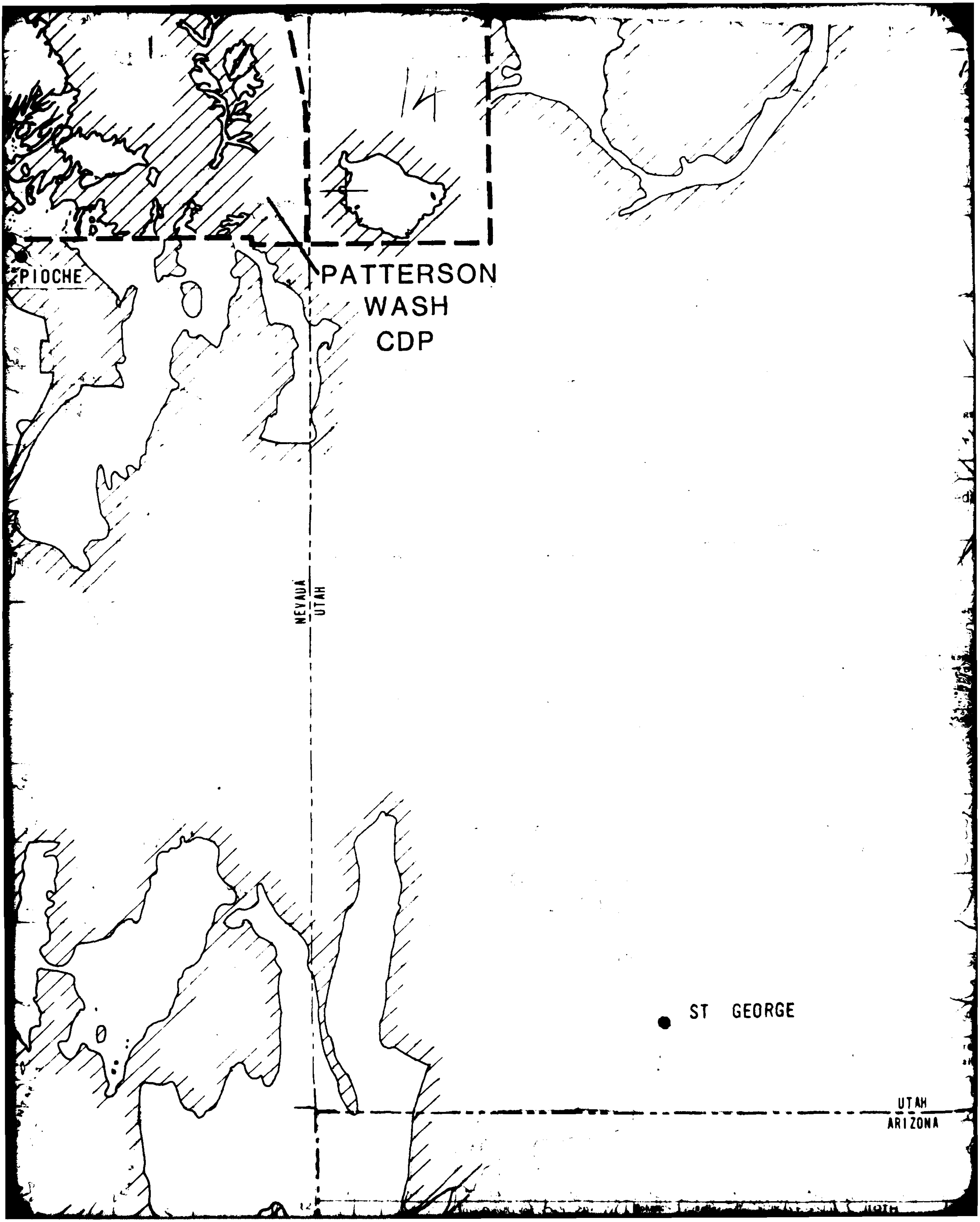
WHITE RIVER SOUTH CDP
DELAMAR CDP
O CDP
13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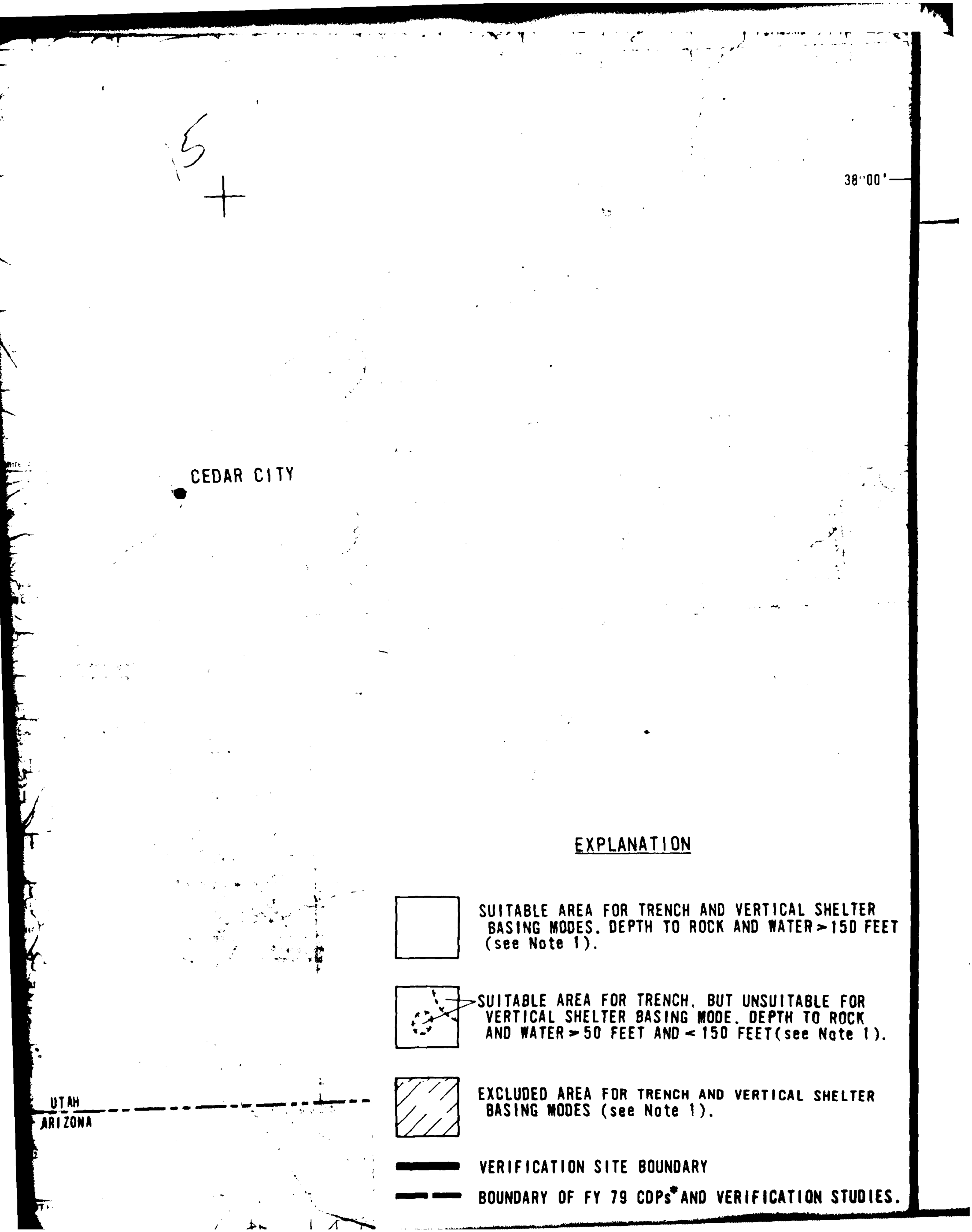
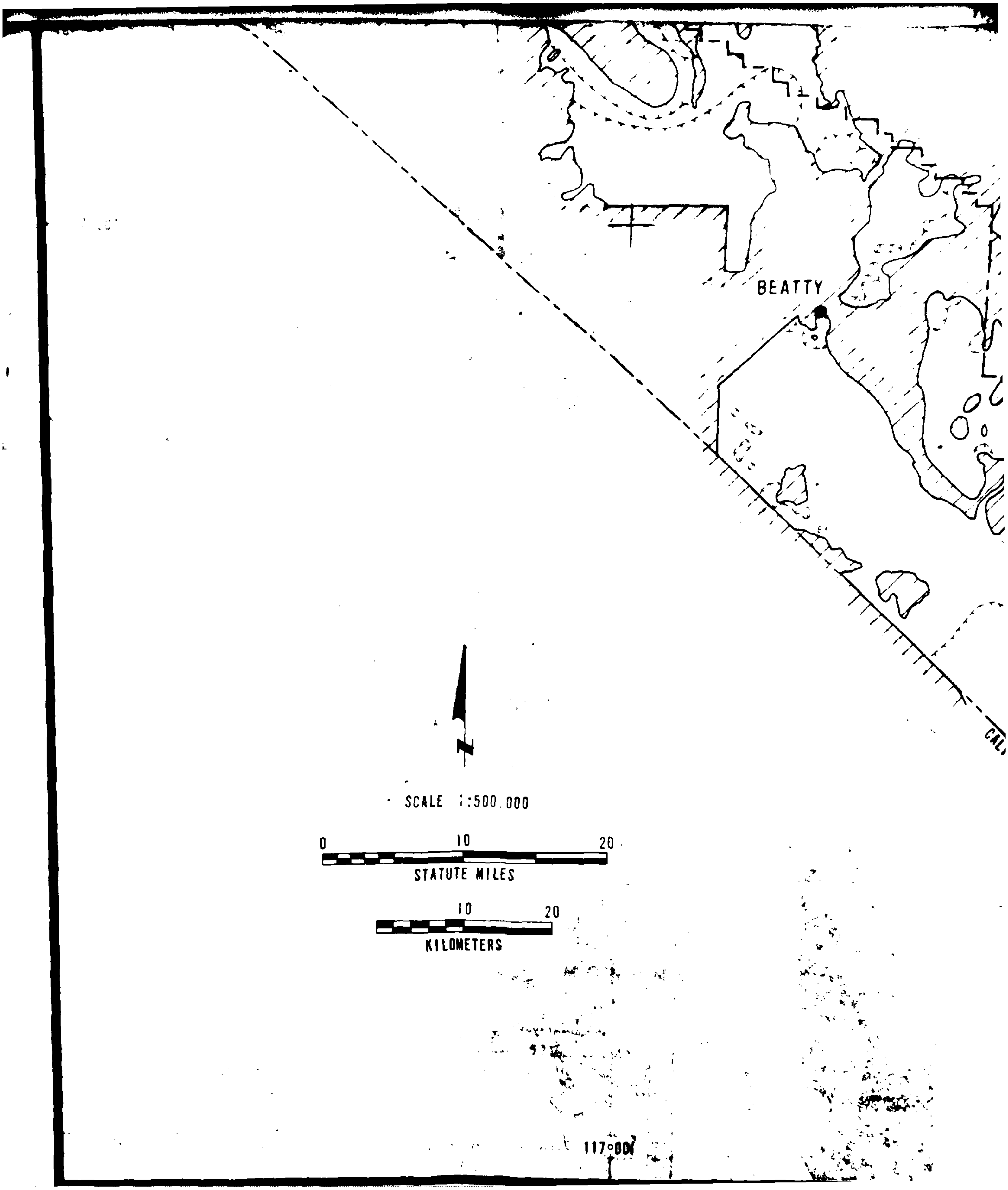
PATTERSON WASH CDP
NEVADA
UTAH
ST GEORGE
UTAH
ARIZONA


38°00'
CEDAR CITY
UTAH
ARIZONA
EXPLANATION
SUITABLE AREA FOR TRENCH AND VERTICAL SHELTER BASING MODES. DEPTH TO ROCK AND WATER > 150 FEET (see Note 1).
SUITABLE AREA FOR TRENCH, BUT UNSUITABLE FOR VERTICAL SHELTER BASING MODE. DEPTH TO ROCK AND WATER > 50 FEET AND < 150 FEET (see Note 1).
EXCLUDED AREA FOR TRENCH AND VERTICAL SHELTER BASING MODES (see Note 1).
VERIFICATION SITE BOUNDARY
BOUNDARY OF FY 79 CDPs* AND VERIFICATION STUDIES.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10
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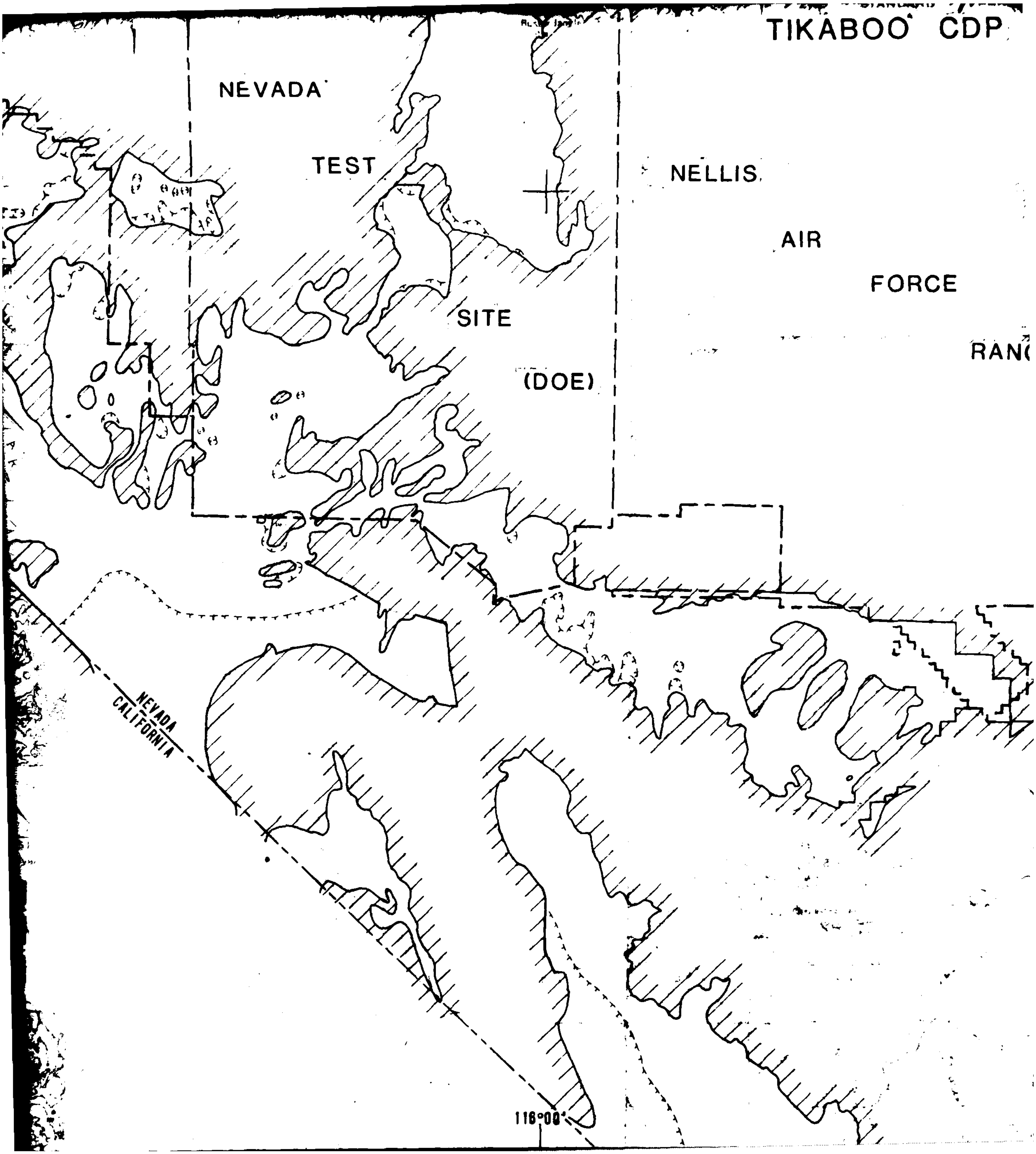
STATUTE MILES
10
20
KILOMETERS
117°00'


TIKABOO CDP
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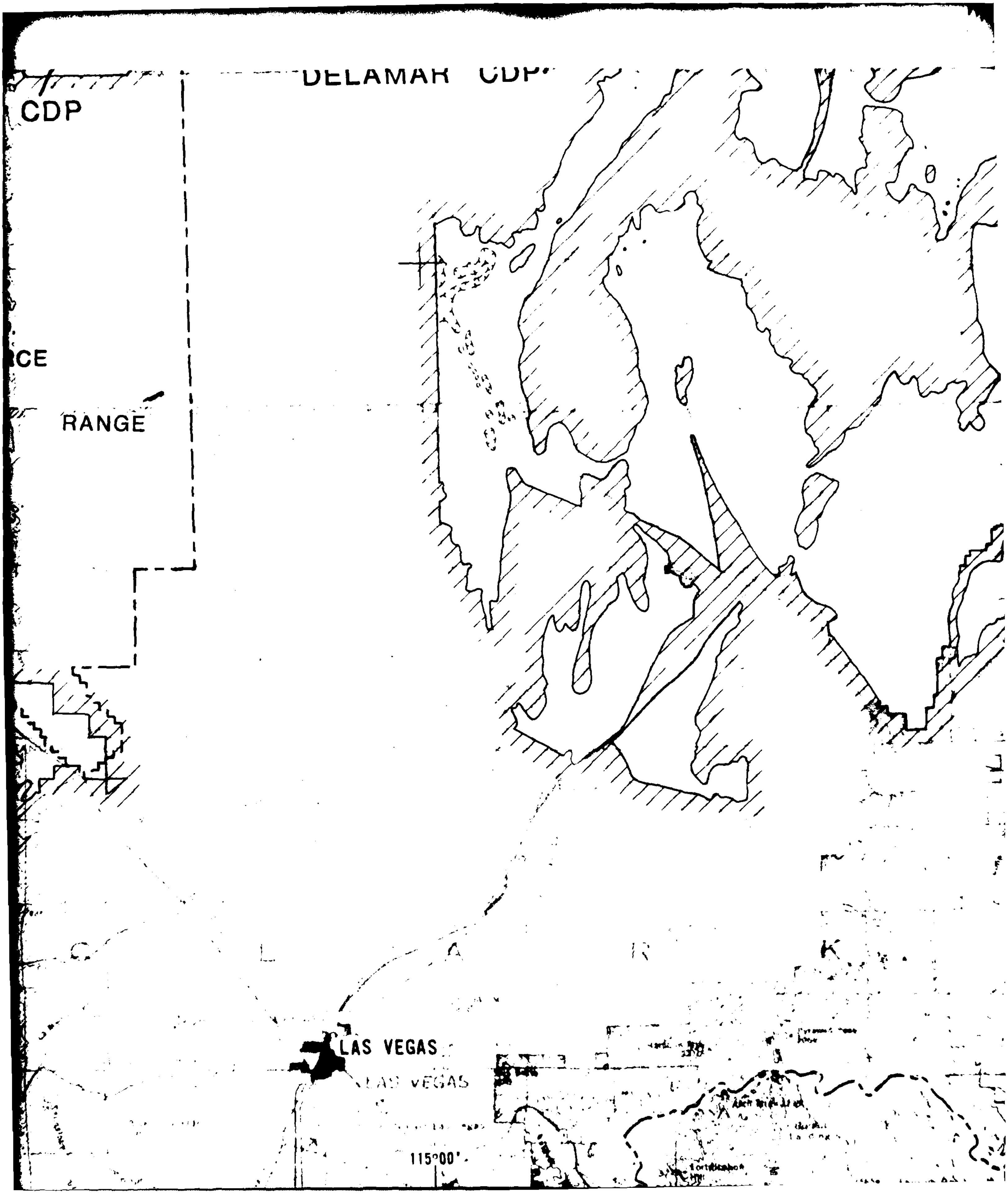
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CDP
CE
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C L A R K
LAS VEGAS
LAS VEGAS
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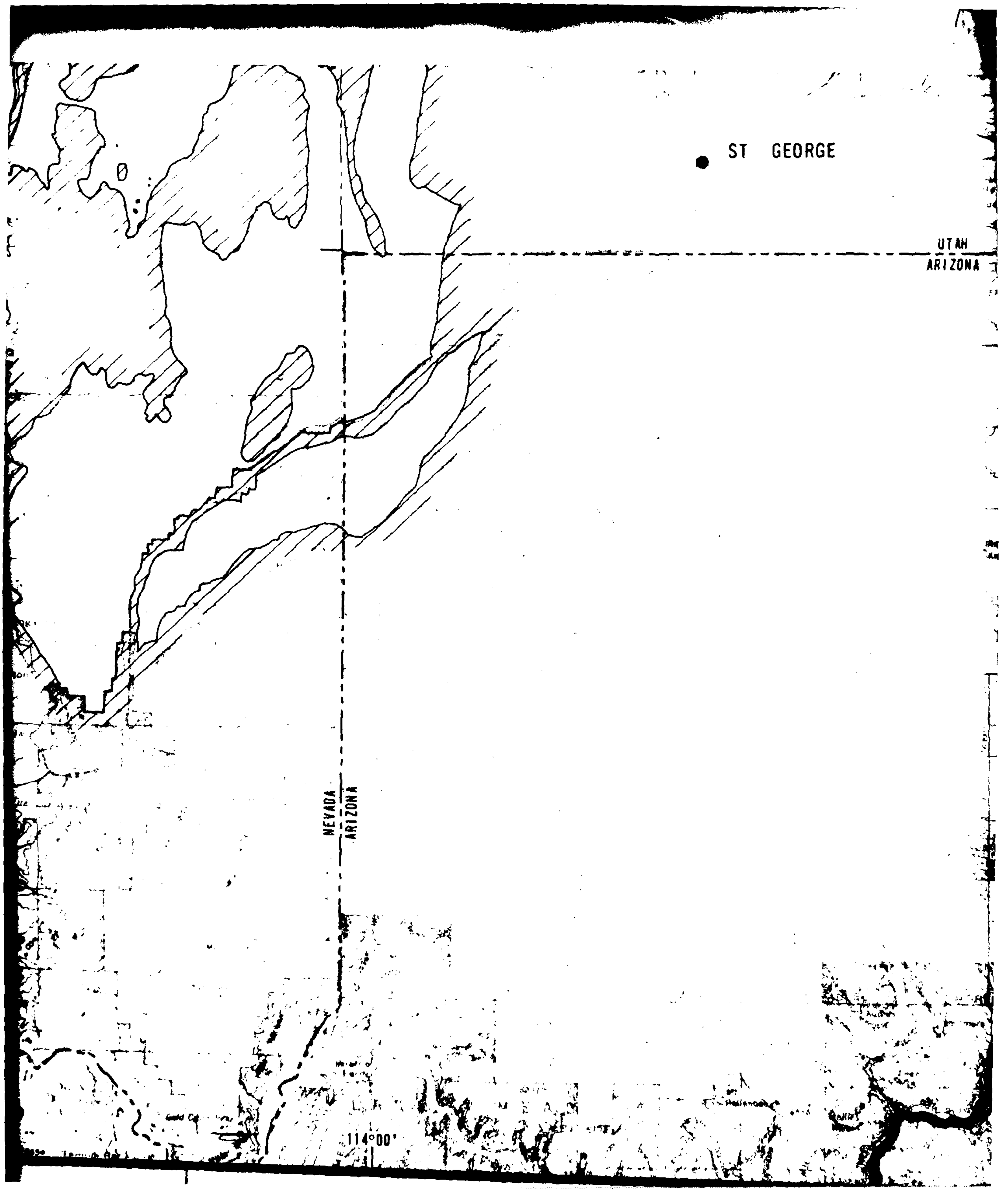

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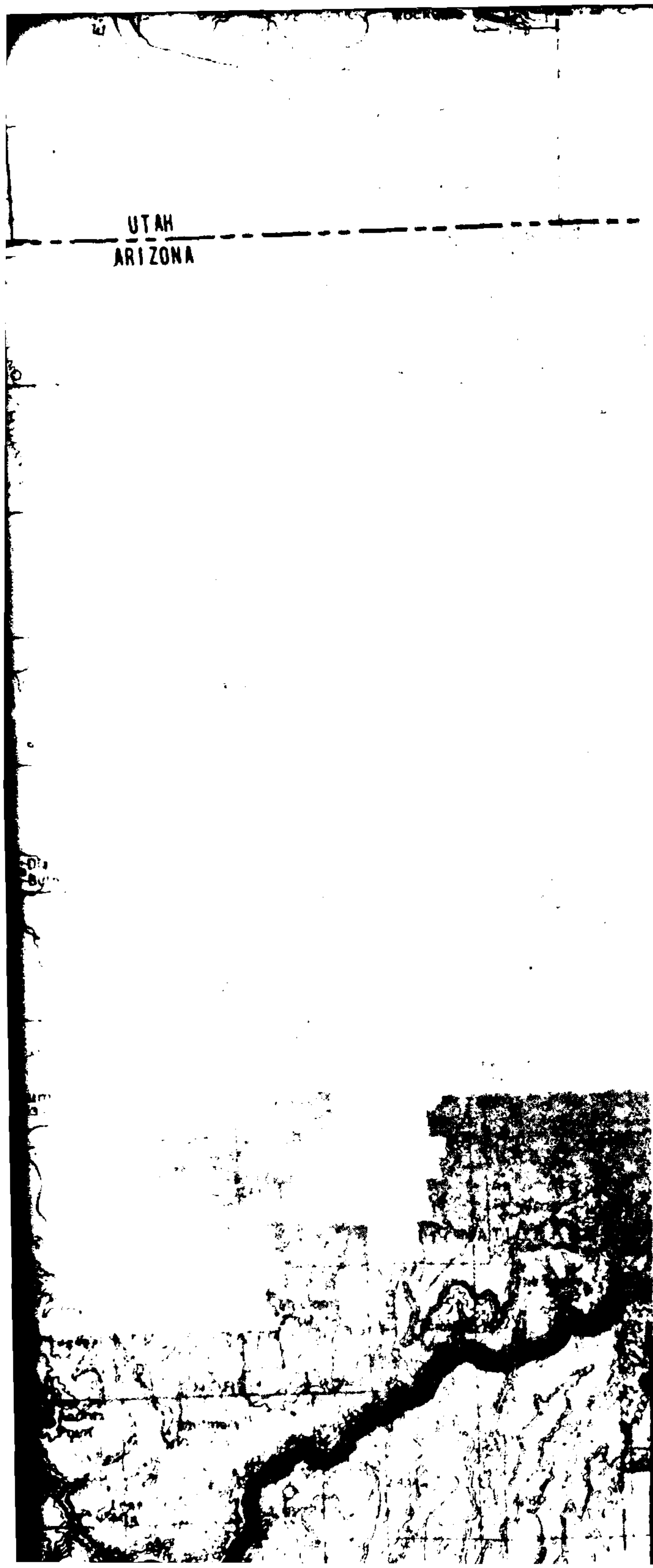


SUITABLE AREA FOR TRENCH, BUT UNSUITABLE FOR VERTICAL SHELTER BASING MODE. DEPTH TO ROCK AND WATER > 50 FEET AND < 150 FEET (see Note 1).

EXCLUDED AREA FOR TRENCH AND VERTICAL SHELTER BASING MODES (see Note 1).

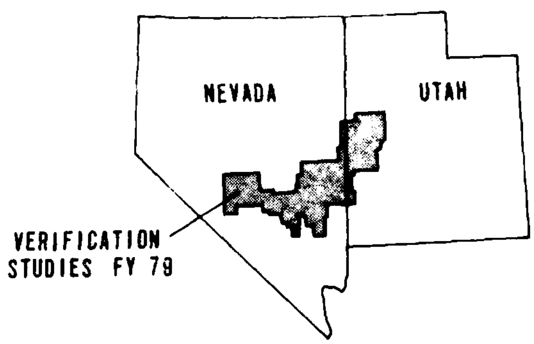
VERIFICATION SITE BOUNDARY

BOUNDARY OF FY 79 CDPs* AND VERIFICATION STUDIES.

NOTE: 1. See Appendix Section 2.0 for details of geotechnical exclusion criteria.

*2. CDP=Candidate Deployment Parcel. These are discrete geographic units devised for organization of geotechnical data collected during FY 79 and future siting studies. CDPs do not imply final boundaries or areas for MX deployment.

LOCATION MAP



SUITABLE AREA, NEVADA-UTAH VERIFICATION STUDIES, FY 79

MX SITING INVESTIGATION

DRAWING

3.0 RECOMMENDATIONS FOR FUTURE STUDIES

3.1 STUDIES IN CDPs CONTAINING VERIFICATION SITES

3.1.1 Data Gap Studies, Verification Sites

Additional studies should be made in the Verification sites to expand on the presently limited data base developed and used in our current analyses. The additional studies will be restricted to those portions of the FY 79 Verification sites where additional information concerning one or two geotechnical parameters is needed for evaluation. The recommended data gap studies are summarized in Table 3-1.

3.1.2 Additional Studies, Geological Reconnaissance Sites

Most Verification sites covered about two thirds of the total suitable area within a CDP. In the remaining area of the CDPs, only Geologic Reconnaissance studies were done. We recommend that the field activities listed in Table 1-1 be performed in these reconnaissance areas. We also recommend that the density of activities be equal to or greater than those of FY 79 Verification Studies.

3.2 STUDIES IN REMAINING CDPs

Twenty-two CDPs have been identified within the FY 79 Nevada-Utah study area (Drawing 2-1). Verification studies were performed in portions of seven CDPs and two sites were previously studied during the Characterization program. There are 13 CDPs where field work has been limited to geologic reconnaissance. Detailed Verification studies should be performed in these 13 remaining CDPs.

VERIFICATION SITE	LOCATIONS WHERE ADDITIONAL SUBSURFACE DATA ARE NEEDED	
	DEPTH TO ROCK (1)	DEPTH TO WATER (2)
WHIRLWIND	CENTRAL	SOUTHERN
SNAKE EAST	SOUTHEASTERN	WESTERN
HAMLIN	----	WEST CENTRAL
GARDEN-COAL	WEST CENTRAL	NORTHERN
WHITE RIVER NORTH	SOUTHWESTERN	SOUTHERN
REVEILLE-RAILROAD	NORTHEASTERN	NORTHERN CENTRAL
BIG SMOKY	EASTERN	NORTHERN SOUTHERN

(1) Recommended geotechnical techniques are borings and seismic refraction surveys.

(2) Recommended geotechnical techniques are primarily ground-water observation wells. Seismic refraction surveys and electrical resistivity soundings will be performed in selected areas.

RECOMMENDED DATA GAP STUDIES IN FY 79 NEVADA-UTAH VERIFICATION SITES

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TABLE 3-1

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The FY '0 Verification Studies have resulted in the loss of approximately 1810 and 2595 mi^2 (4690 and 6720 km^2) of land previously considered suitable (from Screening studies) for the hybrid trench and vertical shelter basing modes, respectively. It is recommended that Verification studies be performed in areas adjoining the presently defined Nevada-Utah study area; the recommended areas are shown in Figure 3-1. The studies should be similar to FY 79 Verification Studies outlined in Section 1.3. The same basic techniques would be used, except that the distance between activity locations should decrease resulting in greater confidence in the selection of suitable area boundaries. Increasing the density of activities should minimize the need for future data gap studies.

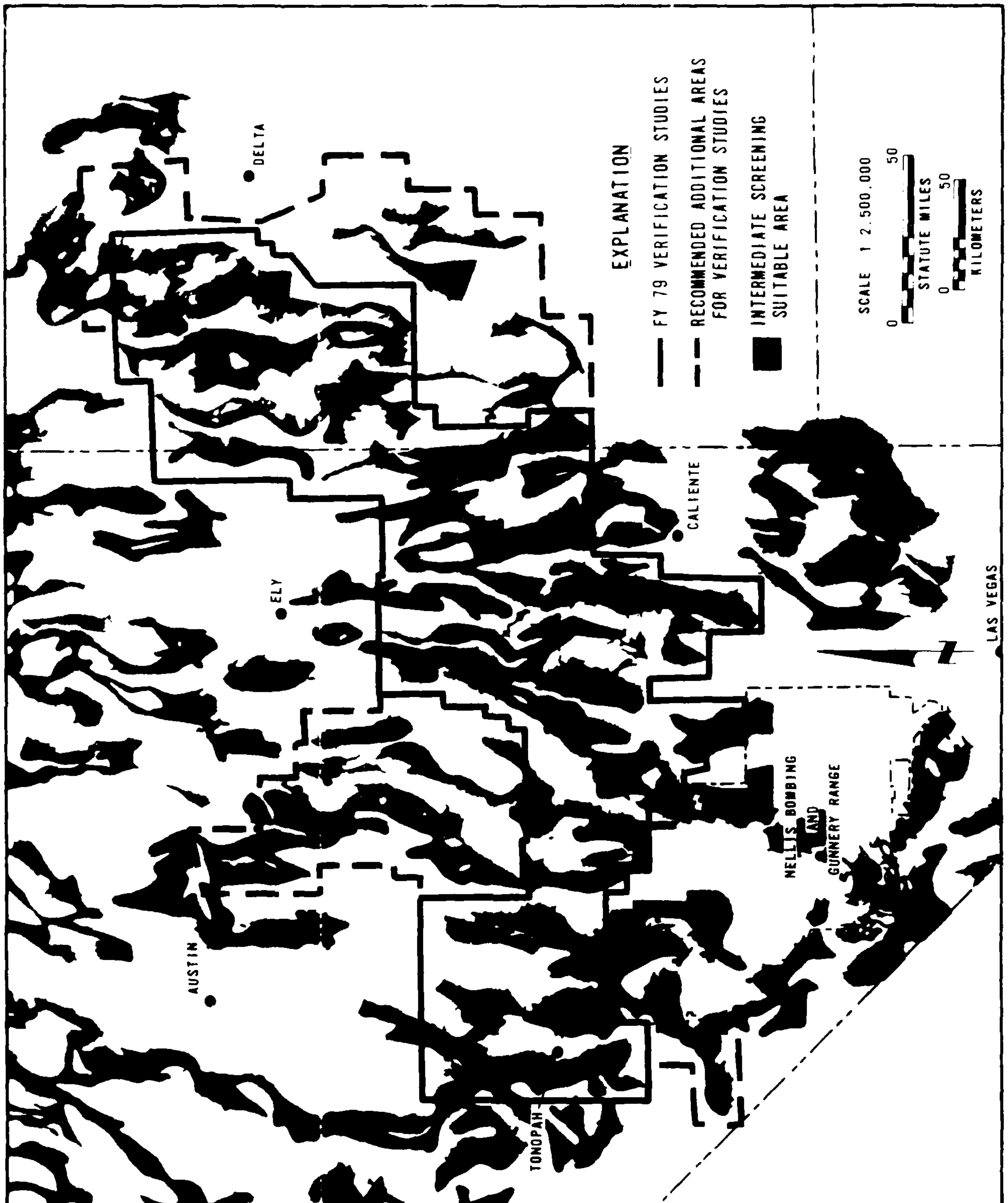
3.3 MISCELLANEOUS STUDIES

3.3.1 Characterization Sites

Characterization studies were basically oriented toward the trench concept. Therefore, limited information about surficial soils was obtained during the Characterization studies in Dry Lake and Ralston CDPs. In order to obtain additional information about surficial soils in these CDPs, we recommend that cone penetrometer and field CBR tests be made, test pits excavated and surficial samples obtained.

3.3.2 Stability of Vertical Shelter Excavations

In order to better evaluate the stability of vertical shelter excavations in the valley soils, we recommend that large diameter bucket auger borings (36 inches [91 cm] in diameter) be



RECOMMENDED ADDITIONAL AREAS FOR VERIFICATION STUDIES
NEVADA-UTAH

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FIGURE 3-1

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2 JUL 79

drilled in a few CDPs. These borings will be located in different geologic units so that various soil types and soil consistencies are encountered during drilling. Stability of the walls of these large-diameter borings will be studied during and after drilling to provide an indication of the stability of the vertical shelter excavation walls.

4.0 WHIRLWIND CDP

4.1 GEOGRAPHIC SETTING

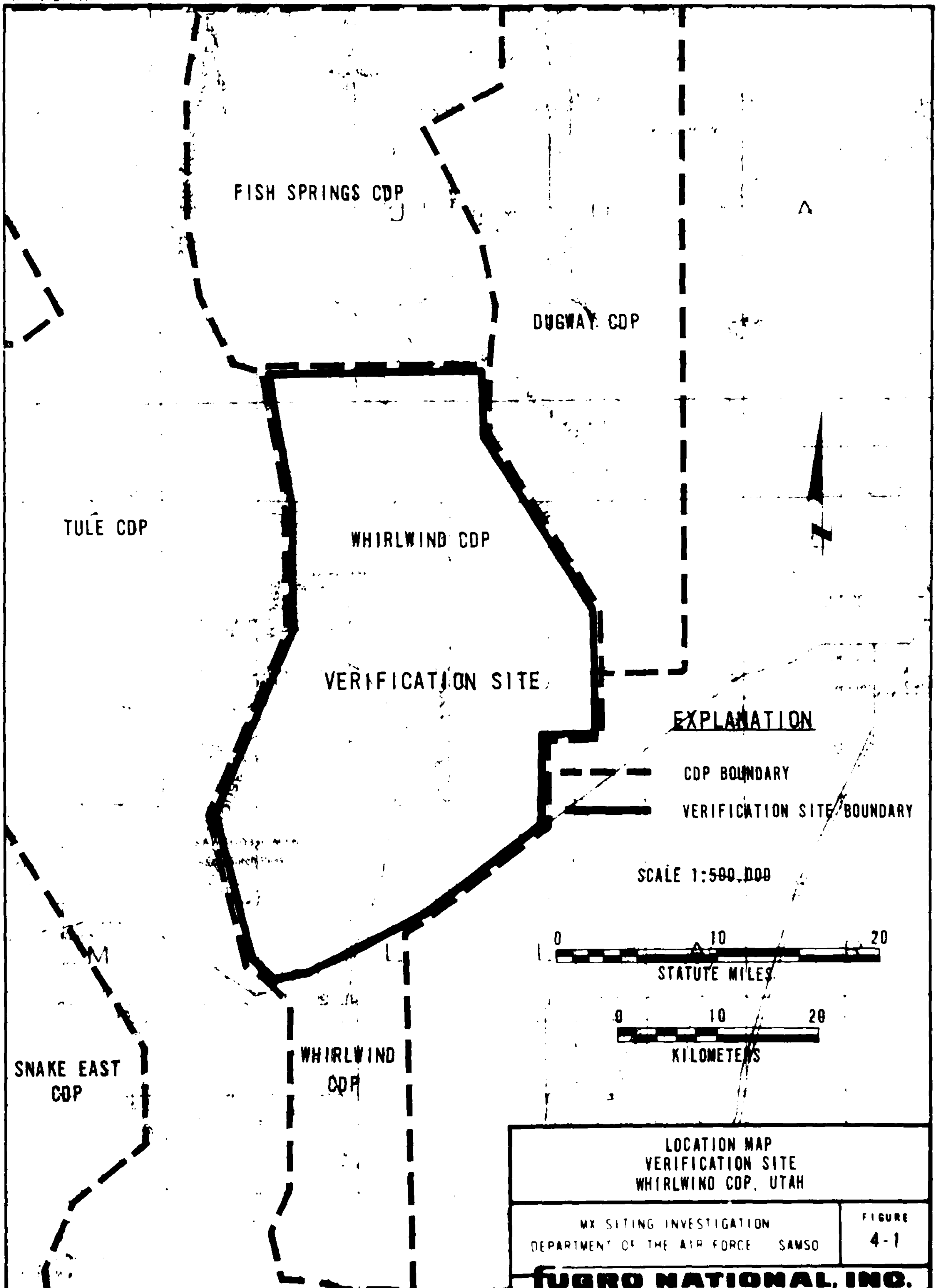
Whirlwind CDP is situated in western Millard and western Juab counties, Utah (Figure 4-1). The CDP is bounded on the east and west by the Little Drum Mountains and the House Range, respectively, and extends southward along the west side of Sevier Lake to about the southern end of the lake. The northern boundary is about 3 miles (5 km) north of the Juab/Millard County line. The Verification site includes all of the CDP north of U.S. Highway 6/50, the only paved highway traversing the CDP. Access into the site is good due to an extensive network of unpaved roads maintained by the Bureau of Land Management (BLM). The entire CDP is undeveloped desert rangeland. The nearest support town is Delta, Utah, approximately 30 miles (48 km) east of the site on U.S. Highway 6/50.

4.2 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 4-1. Locations of the geophysical and engineering activities are shown in Drawing 4-1 (end of Section 4.0).

4.3 GEOLOGIC SETTING

The Little Drum Mountains consist of early Tertiary andesite, trachyte, and latite flows overlain to the north by late Tertiary basalt and basaltic andesite (Hintze, 1963; Stokes, 1963). The House Range to the east consists of faulted,



FISH SPRINGS CDP
DUGWAY CDP
TULE CDP
WHIRLWIND CDP
VERIFICATION SITE
SNAKE EAST CDP
WHIRLWIND CDP
EXPLANATION
CDP BOUNDARY
VERIFICATION SITE BOUNDARY
SCALE 1:500,000
0
10
20
STATUTE MILES
0
10
20
KILOMETERS
LOCATION MAP
VERIFICATION SITE
WHIRLWIND CDP, UTAH
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO
FIGURE
4-1
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2 JUL 79

GEOLOGY AND GEOPHYSICS

TYPE OF ACTIVITY	NUMBER OF ACTIVITIES
Geologic mapping stations	87
Shallow refraction	20
Electrical resistivity	20
Gravity profiles	5

ENGINEERING-LABORATORY TESTS

TYPE OF TEST	NUMBER OF TESTS
Moisture density	85
Specific gravity	1
Sieve analysis	69
Hydrometer	5
Atterberg limits	14
Consolidation	0
Unconfined compression	0
Triaxial compression	0
Direct shear	5
Compaction	7
CBR	7
Chemical analysis	10

ENGINEERING

NUMBER OF BORINGS	NOMINAL DEPTH FEET (METERS)
5	160 (49)
1	30 (9)

NUMBER OF TRENCHES	NOMINAL DEPTH FEET (METERS)
6	14 (4)

NUMBER OF TEST PITS	NOMINAL DEPTH FEET (METERS)
26	5 (2)

NUMBER OF CPTs	RANGE OF DEPTH FEET (METERS)
66	1-21 (0.3-6)

TYPE OF ACTIVITY	NUMBER OF ACTIVITIES
Surficial soil samples	25
Field CBR tests	0

SCOPE OF ACTIVITIES
VERIFICATION SITE, WHIRLWIND CDP, UTAH

MX SITING INVESTIGATION
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TABLE 4-1

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eastward-dipping Cambrian limestone and dolomite with interbedded shale. Ordovician limestone with interbedded conglomerate crops out in the southern House Range west of Sevier Lake outside the Verification site. Tertiary volcanic rocks similar to those in the southern Little Drum Mountains occur along the valley axis in Red Knolls and Long Ridge. Tertiary conglomerates overlie these volcanic rocks and are the principal units exposed in Long Ridge. These conglomerates may also compose much of the deep subsurface section in the valley.

Hintze (1963) and Stokes (1963) show no basin-margin faults in Whirlwind Valley. The House Range to the west is considered by Gehman (1958) to be the gently eastward dipping limb of a faulted anticline. The steep west face of the range represents the eroded fault scarp along which uplift has taken place. Few faults are mapped within the Little Drum Mountains although relations are complex due to the variety of volcanic rock types present. No faults displacing surficial basin-fill deposits have been reported and none were observed during the field studies.

Surficial basin-fill deposits are predominantly alluvial fan and lacustrine deposits (Drawing 4-2). The lacustrine deposits are associated with Pleistocene Lake Bonneville and occur principally in the southern and central parts of the valley. Shoreline deposits consisting of rounded gravels are particularly well developed at elevations of approximately 5150 to 5200 feet (1570 to 1585 m) and 4800 feet (1463 m) above mean sea level, but occur at all elevations below 5200 feet.

Above 5200 feet, alluvial fan deposits of intermediate and older age are the major surficial units. Older alluvial fan deposits are located adjacent to mountain fronts and do not extend more than 2 miles (3.2 km) into the valley. Intermediate alluvial fan deposits are found locally below the highest Lake Bonneville shorelines but not below the lower 4800-foot shoreline. Younger alluvial fan deposits occur below the Lake Bonneville shorelines and consist, in part, of reworked lake deposits. All alluvial deposits consist chiefly of sand but localized fine-grained and gravelly soils are present, particularly along the west side. Younger alluvial fans are generally uncemented; intermediate alluvial fans are weakly cemented; and older alluvial fans are moderately to strongly cemented.

Fine-grained playa and older lake deposits occur at the surface only along the valley axis. These deposits are generally less than 3 feet (1 m) thick except in southern Whirlwind near Sevier Lake where fine-grained lakebed deposits of unknown thickness occur. Based on data from five borings and inferences regarding depositional conditions in the valley, it is estimated that silt and clay deposits constitute less than 10 percent of the soils to a depth of 160 feet (49 m). Interbedded sand and gravel of probable alluvial and lacustrine origin are the dominant deposits in the subsurface.

4.4 SURFACE SOILS

Surficial soils of the Whirlwind Site are predominantly coarse grained (granular). Soils from predominant surficial geologic units (Drawing 4-2) have been grouped into the following three categories based on their physical and engineering characteristics.

1. Silty sands and clayey sands (from geologic units A4os, A5ys, A5is, and A5os).
2. Gravels and gravelly sands (from geologic units A4os, A4og, A5ys, and A5is).
3. Silts and clays (from geologic units A4os, A5ys, and A5os).

4.4.1 Characteristics

Based on laboratory and field test results, the characteristics of surficial soils were evaluated and are presented in Table 4-2. In addition to the physical characteristics, road design data consisting of laboratory compaction and California Bearing Ratio (CBR) test results, average depth and range of low strength surficial soils, and suitability of the soils for road use are included in the table. The range of gradation of these soils is presented in Figure 4-2.

Silty sands and clayey sands have an approximate areal extent ranging from 40 to 60 percent. They are concentrated in the central and southern portions of the site, are predominantly poorly graded, and contain appreciable amounts of fine gravel. Soil plasticity ranges from none to medium.

Gravels and gravelly sands have an approximate areal distribution of 35 to 55 percent. They consist of sandy gravels, silty gravels, clayey gravels, and gravelly sands. These soils occur in isolated topographic mounds and ridges along the valley axis,

SOIL DESCRIPTION			Silty Sands and Clayey Sands		Sandy Gravels, Silty Clayey Gravels, and
USCS SYMBOLS			SM, SC		GM, GC, SM
PREDOMINANT SURFICIAL GEOLOGIC UNITS			A4os, A5ys, A5is, A5os		A4os, A4og, A5ys,
ESTIMATED AREAL EXTENT		%	40-60		35-55
PHYSICAL PROPERTIES					
COBBLES 3 - 12 inches (8 - 30 cm)		%	0-5		0-10
GRAVEL		%	1-20	[11]	35-64
SAND		%	40-69	[11]	11-46
SILT AND CLAY		%	16-45	[11]	16-33
LIQUID LIMIT			31-38	[2]	35
PLASTICITY INDEX			NP-13	[3]	12
ROAD DESIGN DATA					
MAXIMUM DRY DENSITY		pcf (kg/m³)	128.0-132.8 (2050-2127)	[3]	137.0-139.7 (2195-2238)
OPTIMUM MOISTURE CONTENT		%	7.8-9.5	[3]	6.1-7.0
CBR AT 90% RELATIVE COMPACTION		%	18-33	[3]	21-41
SUITABILITY AS ROAD SUBGRADE (1)			fair to good		good to very good
SUITABILITY AS ROAD SUBBASE OR BASE (1)			poor to fair		fair to good
THICKNESS OF LOW STRENGTH SURFICIAL SOIL (2)	RANGE	ft (m)	0.2-4.7 (0.1-1.4)	[30]	0.3-5.8 (0.1-1.7)
	AVERAGE	ft (m)	1.9 (0.6)	[30]	1.4 (0.4)

(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 4-3 for details.

NOTES:
- [ ] - M
- NDA - No
  not

dy Gravels, Silty Gravels, yey Gravels, and Gravelly Sands	Sandy Silts, Silts, Sandy Clays, and Clays	
GM, GC, SM	ML, CL	
A4os, A4og, A5ys, A5is	A4os, A5ys, A5os	
35-55	5-15	
0-10	0	
35-64 [10]	0-1 [2]	
11-46 [10]	25-40 [2]	
16-33 [10]	60-97 [5]	
35 [1]	25-50 [4]	
12 [1]	3-15 [4]	
137.0-139.7 (2195-2238) [3]	115.0 (1842) [1]	
6.1-7.0 [3]	16.0 [1]	
21-41 [3]	9 [1]	
good to very good	poor	
fair to good	not suitable	
0.3-5.8 (0.1-1.7) [9]	0.4-11.0 (0.1-3.3) [17]	
1.4 (0.4) [9]	1.8 (0.5) [17]	

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

CHARACTERISTICS OF SURFICIAL SOILS
VERIFICATION SITE, WHIRLWIND CDP, UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 4-2

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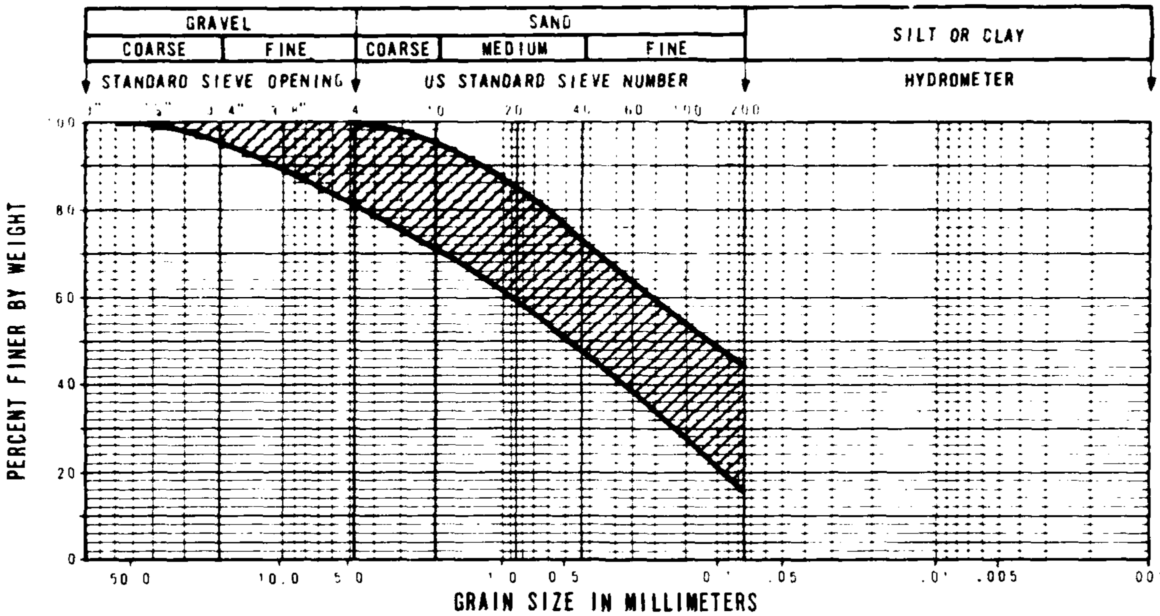
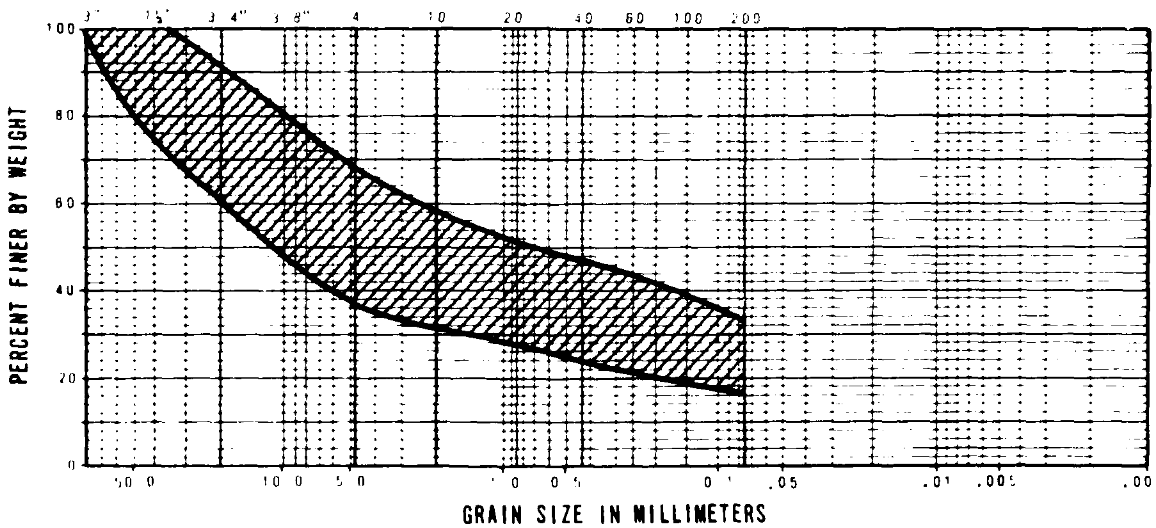


SOIL DESCRIPTION: Silty Sands and Clayey Sands
from 0 to 2 feet (0.0 to 0.6m)



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

RANGE OF GRADATION OF SURFICIAL SOILS
VERIFICATION SITE, WHIRLWIND CDP, UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 4-2
1 OF 2

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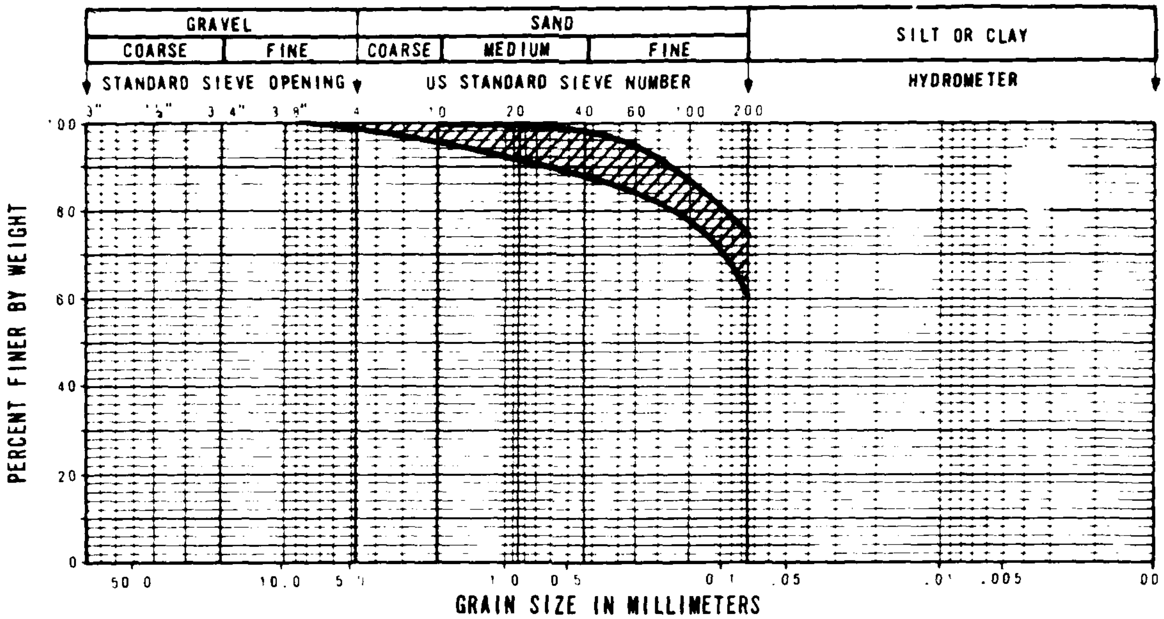
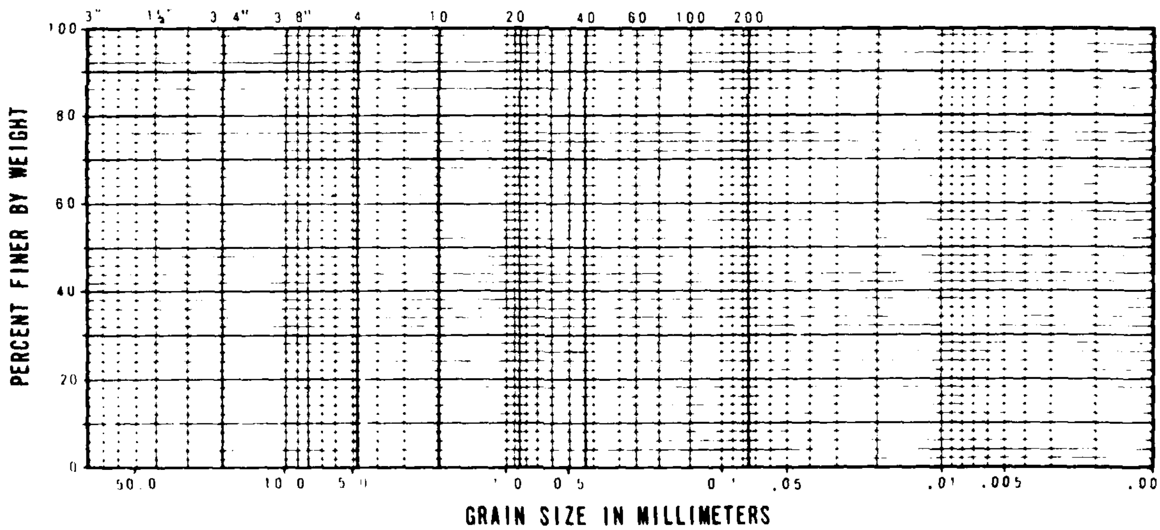


SOIL DESCRIPTION: Sandy Silts, Silts, Sandy Clays, and Clays from 0 to 2 feet (0.0 to 0.6m)



RANGE OF GRADATION OF SURFICIAL SOILS
VERIFICATION SITE, WHIRLWIND CDP, UTAH

MX SITING INVESTIGATION
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FIGURE 4-2
2 OF 2

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particularly in the south and along the mountain fronts. The volcanic source rocks in the east and sedimentary source rocks in the west cause the composition of gravel to vary across the valley. Volcanic gravels are more friable than sedimentary gravels and are, therefore, less durable. The gravelly site soils are generally poorly graded and contain a significant amount of silty and clayey fines.

The areal extent of silts and clays ranges from 5 to 15 percent. These soils are found in the center of the site and near Lake Sevier to the south. Isolated pockets are also found in the alluvial fans along the western valley flank; the extent of these deposits is not known. These soils exhibit low to high plasticity and contain appreciable amounts of fine sand.

4.4.2 Low Strength Surficial Soil

Based on the Cone Penetrometer Test (CPT) results and soil type, thickness of low strength surficial soil at each test location was estimated and is presented in Table 4-3. Range and mean values for the three surficial soil categories are included in Table 4-2. For granular soils, the range is 0.2 to 5.8 feet (0.1 to 1.8 m) with an average of 1.8 feet (0.5 m). The variation in the extent of low strength granular surficial soils is predominantly due to variable calcium carbonate cementation. For fine-grained soils, the range is 0.4 to 11.0 feet (0.1 to 3.5 m) with an average of 1.8 feet (0.5 m). In-situ density and the amount of fine sand present in the surficial fine-grained soils affect the extent of low strength soil.

CONE PENETROMETER TEST NUMBER[1]	THICKNESS OF LOW STRENGTH SURFICIAL SOIL[2]		SOIL TYPE[3]
	FEET	METERS	
C-1	3.1	0.9	SM SC
C-2	1.1	0.3	SM SP
C-3	1.3	0.4	CL
C-4	1.3	0.4	CL
C-5	8.3	2.5	SP-SC
C-6	5.8	1.7	GM SM ML
C-7	0.7	0.2	SM
C-8	0.9	0.3	CL
C-9	2.8	0.8	CL GM
C-10	2.2	0.7	GP-GM
C-11	0.4	0.1	CL
C-12	0.9	0.3	CL
C-13	1.2	0.4	SM
C-14	0.2	0.1	CL
C-15	0.7	0.2	CL
C-16	1.2	0.4	CL
C-17	1.0	0.3	CL GP
C-18	1.7	0.5	CL GP
C-19	11.0	3.3	ML
C-20	1.1	0.3	SM
C-21	1.7	0.5	SP
C-22	1.6	0.5	SM
C-23	1.7	0.5	SC GM
C-24	2.6	0.8	SC
C-25	1.7	0.5	GM
C-26	1.6	0.5	GM
C-27	0.7	0.2	CL
C-28	1.4	0.4	CL

CONE PENETROMETER TEST NUMBER[1]	THICKNESS OF LOW ST SURFICIAL SOIL	
	FEET	MET
C-29	0.9	0.
C-30	0.9	0.
C-31	0.6	0.
C-32	0.6	0.
C-33	1.1	0.
C-34	1.2	0.
C-35	2.5	0.
C-36	2.9	0.
C-37	4.7	1.
C-38	3.2	1.
C-39	3.2	1.
C-40	0.9	0.
C-41	2.0	0.
C-42	0.5	0.
C-43	3.5	1.
C-44	1.3	0.
C-45	0.7	0.
C-46	0.3	0.
C-47	1.0	0.
C-48	2.6	0.
C-49	1.3	0.
C-50	1.2	0.
C-51	1.3	0.
C-52	4.0	1.
C-53	1.5	0.
C-54	1.1	0.
C-55	1.0	0.
C-56	0.9	0.

(1) For Cone Penetrometer Test locations see Drawing 4-1, 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: • For fin
strength
of the s

• SM GM -

• NDA - N

...NESS OF LOW STRENGTH SURFICIAL SOIL (2)		SOIL TYPE (3)
...ET	METERS	
.9	0.3	SC
.9	0.3	SC
.6	0.2	SC
.6	0.2	CL
.1	0.3	SM-SC
.2	0.4	SM-SC GM
.5	0.8	SW SM
.9	0.9	SM
.7	1.4	SM
.2	1.0	SM SP
.2	1.0	SM
.9	0.3	SM
.0	0.6	SM
.5	0.2	CL
.5	1.1	CL
.3	0.4	CL
.7	0.2	SC
.3	0.1	GC
.0	0.3	GC
.6	0.8	SM SC
.3	0.4	SM
.2	0.4	SM
.3	0.4	ML
.0	1.2	SM
.5	0.4	SC-SM
.1	0.3	SP-SM
.0	0.3	SM
.9	0.3	SM

CONE PENETROMETER TEST NUMBER (1)	THICKNESS OF LOW STRENGTH SURFICIAL SOIL (2)		SOIL TYPE (3)
	FEET	METERS	
C-57	1.2	0.4	SC-SM
C-58	0.8	0.2	GC
C-59	0.8	0.2	GM
C-60	1.6	0.5	SM
C-61	1.1	0.3	SM
C-62	3.9	1.2	SM
C-63	3.5	1.0	SM ML
C-64	1.8	0.5	CH SM
C-65	0.7	0.2	CL
C-66	0.7	0.2	SC

...ES: • 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, WHIRLWIND CDP, UTAH

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TABLE 4-3

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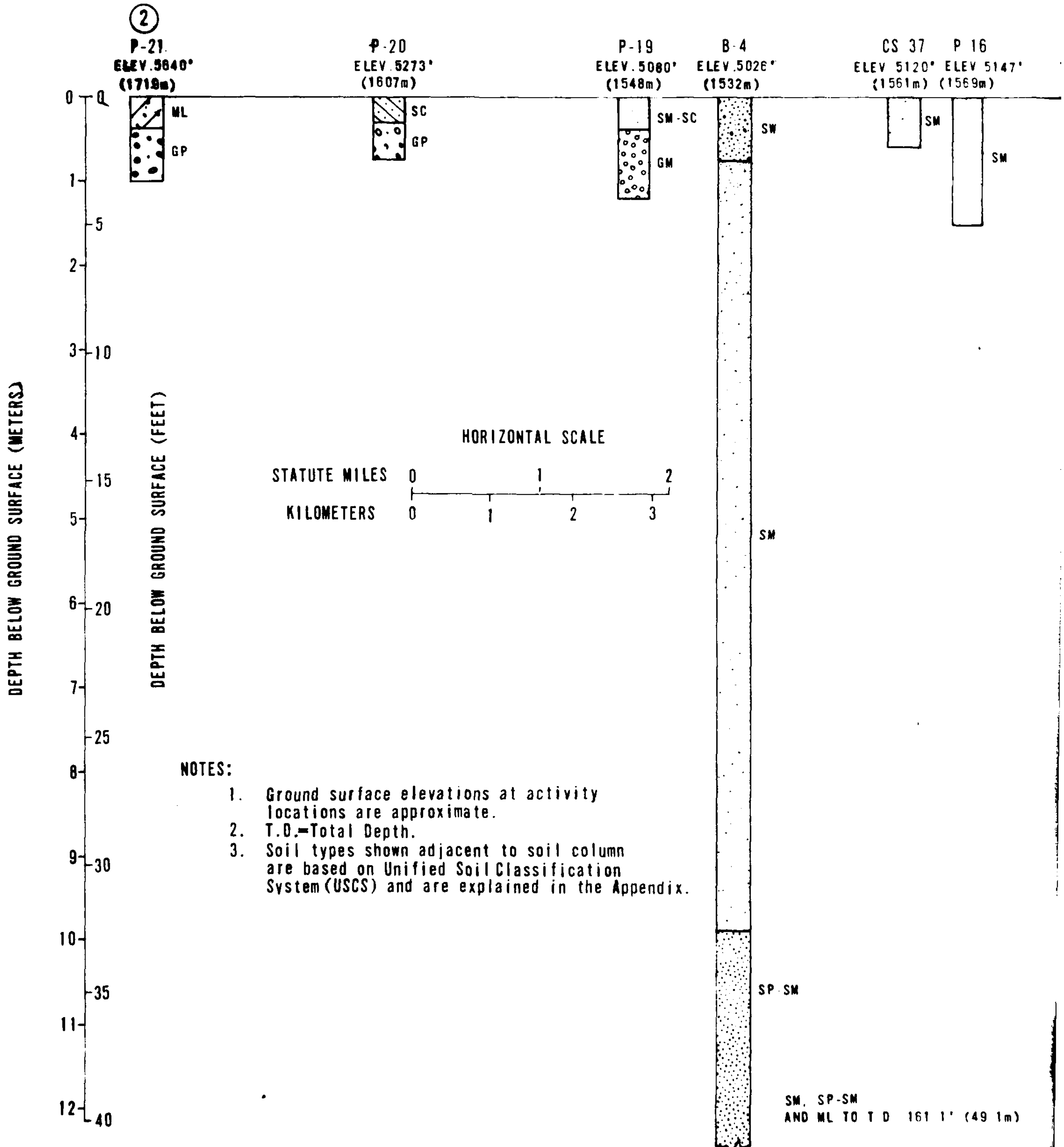
4.5 SUBSURFACE SOILS

Figures 4-3 through 4-5 illustrate the composition of soils with depth as determined from borings, trenches, and test pits. The predominant subsurface soils are sandy gravels and gravelly sands. These soils are interbedded with silty sands and clayey sands in the northeastern portion of the site to a depth of approximately 70 feet (21 m). Subsurface silt and clay layers, when present, are usually less than 5 feet (1.5 m) thick. Small amounts of fine-grained soils found in the subsurface show very little cementation and are firm to very stiff. The soils in the subsurface, below 5200 feet (1585 m) elevation, are mixed alluvial fan and lacustrine deposits. Above this elevation, the subsurface soils are primarily alluvial fan deposits.

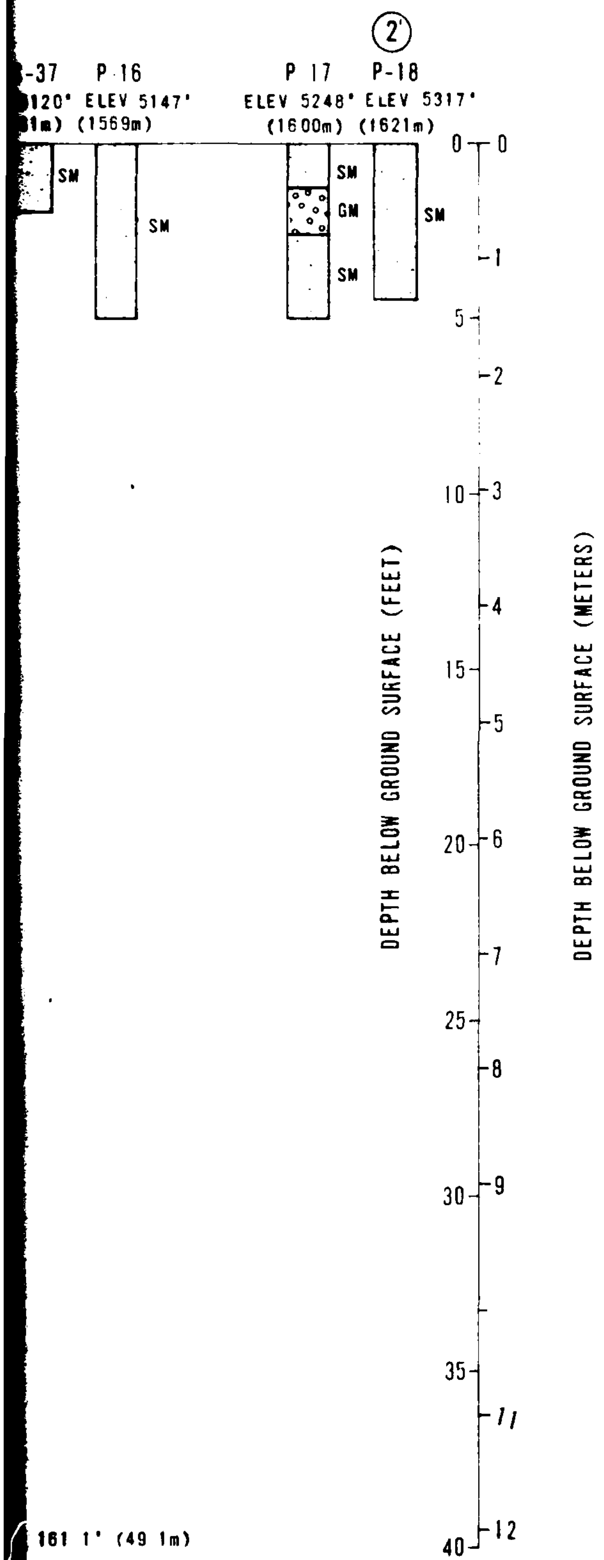
Results of seismic refraction and electrical resistivity surveys are presented in Table 4-4. Characteristics of the subsurface soils, determined from field and laboratory tests, are summarized in Table 4-5. Range of gradation of these soils is shown in Figure 4-6.

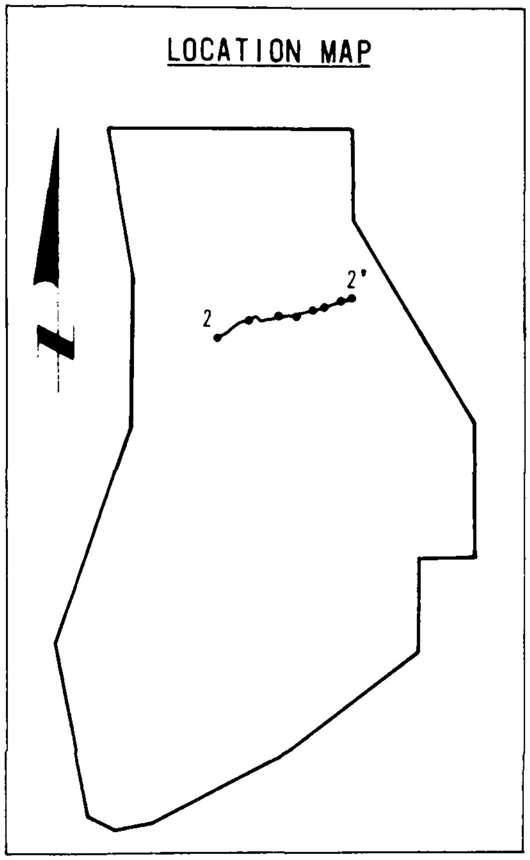
Coarse-grained soils are generally poorly graded and are very dense below 20 feet (6 m). Calcium carbonate cementation varies from none to moderate in the upper 20 feet; below 20 feet cementation is weak. The soils have very low compressibilities and moderate to high shear strengths. The wide range of seismic velocities encountered in these coarse-grained soils is explained by their wide variability in density, composition, and cementation.



NOTES:

1. Ground surface elevations 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.





EXPLANATION

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

SOIL PROFILE 2-2'
VERIFICATION SITE, WHIRLWIND CDP, UTAH

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DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 4-3

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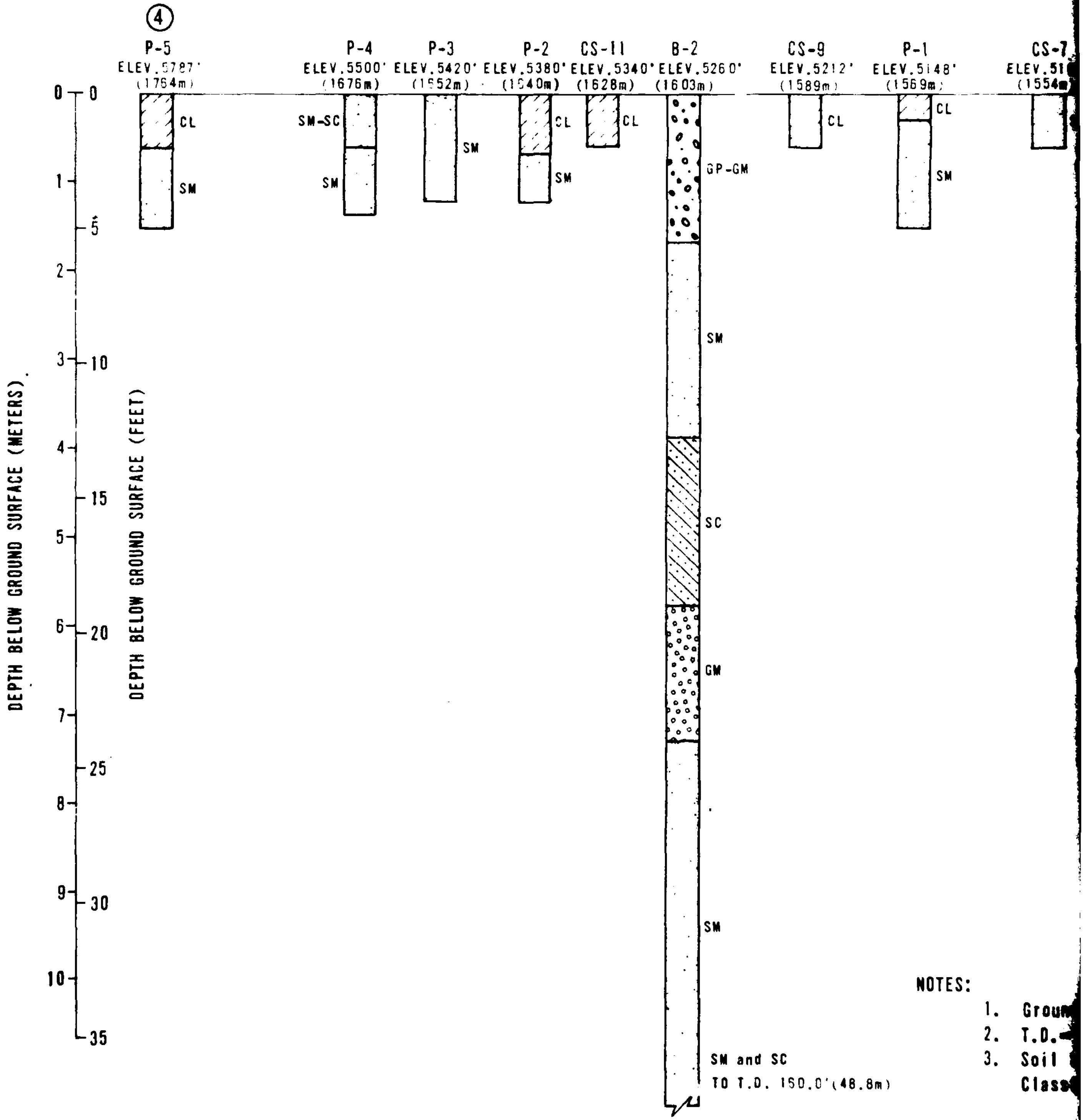
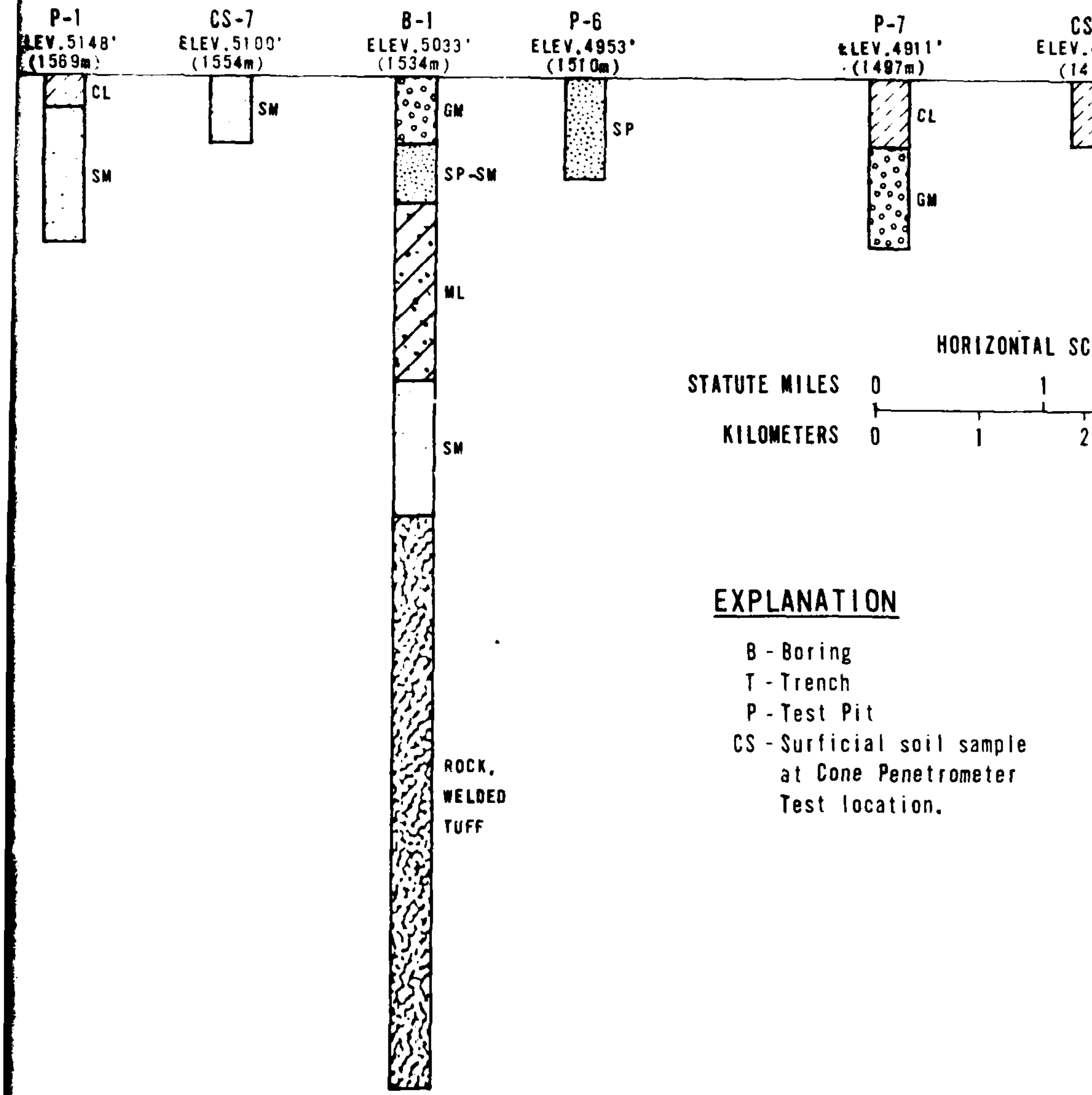
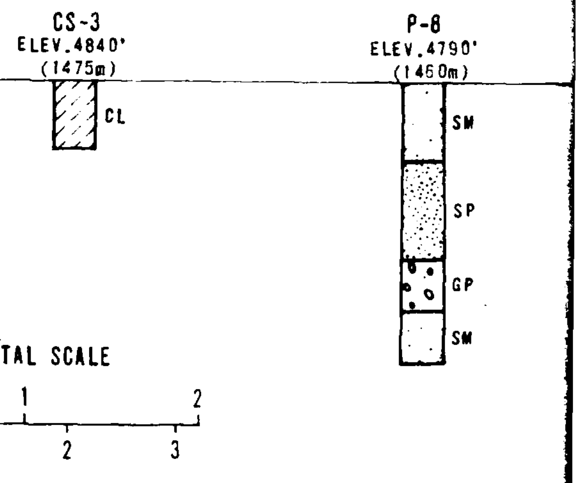


NOTES:

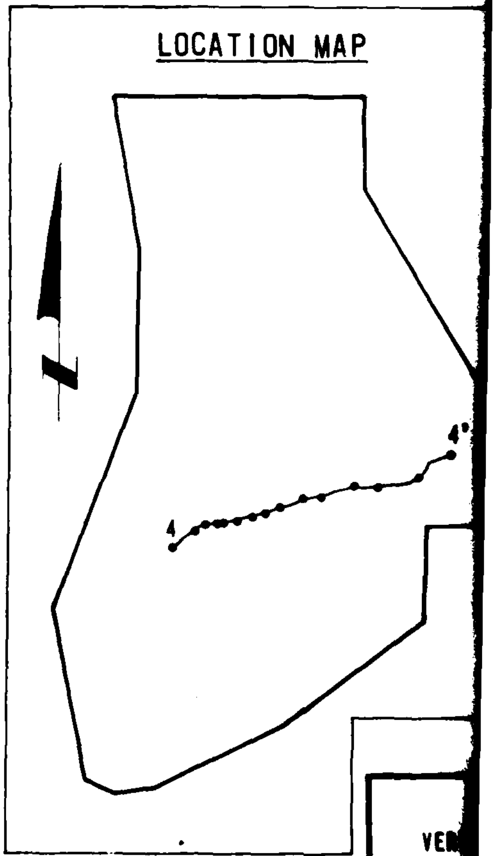
1. Groun
2. T.D.
3. Soil
Class





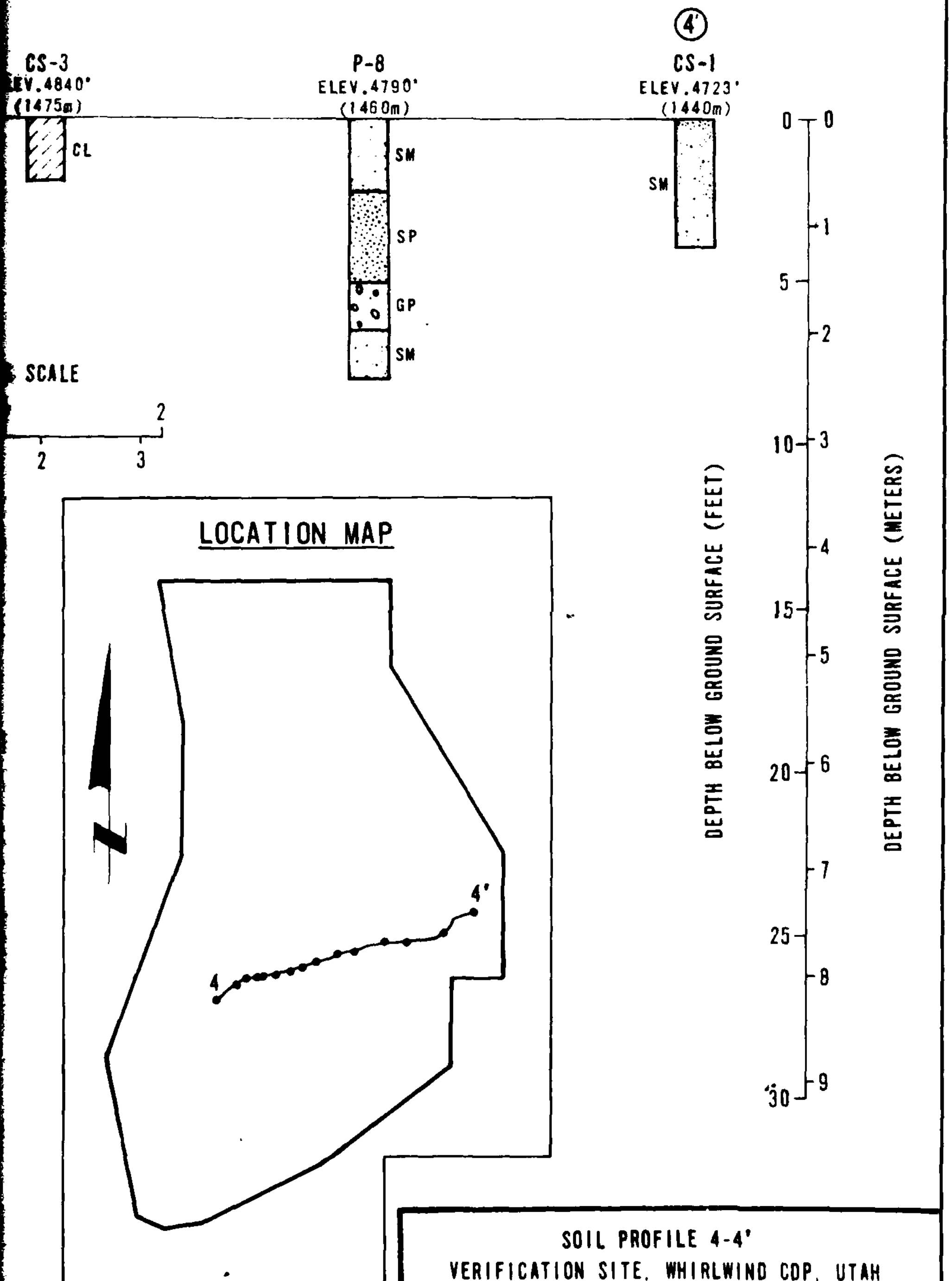
EXPLANATION

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.

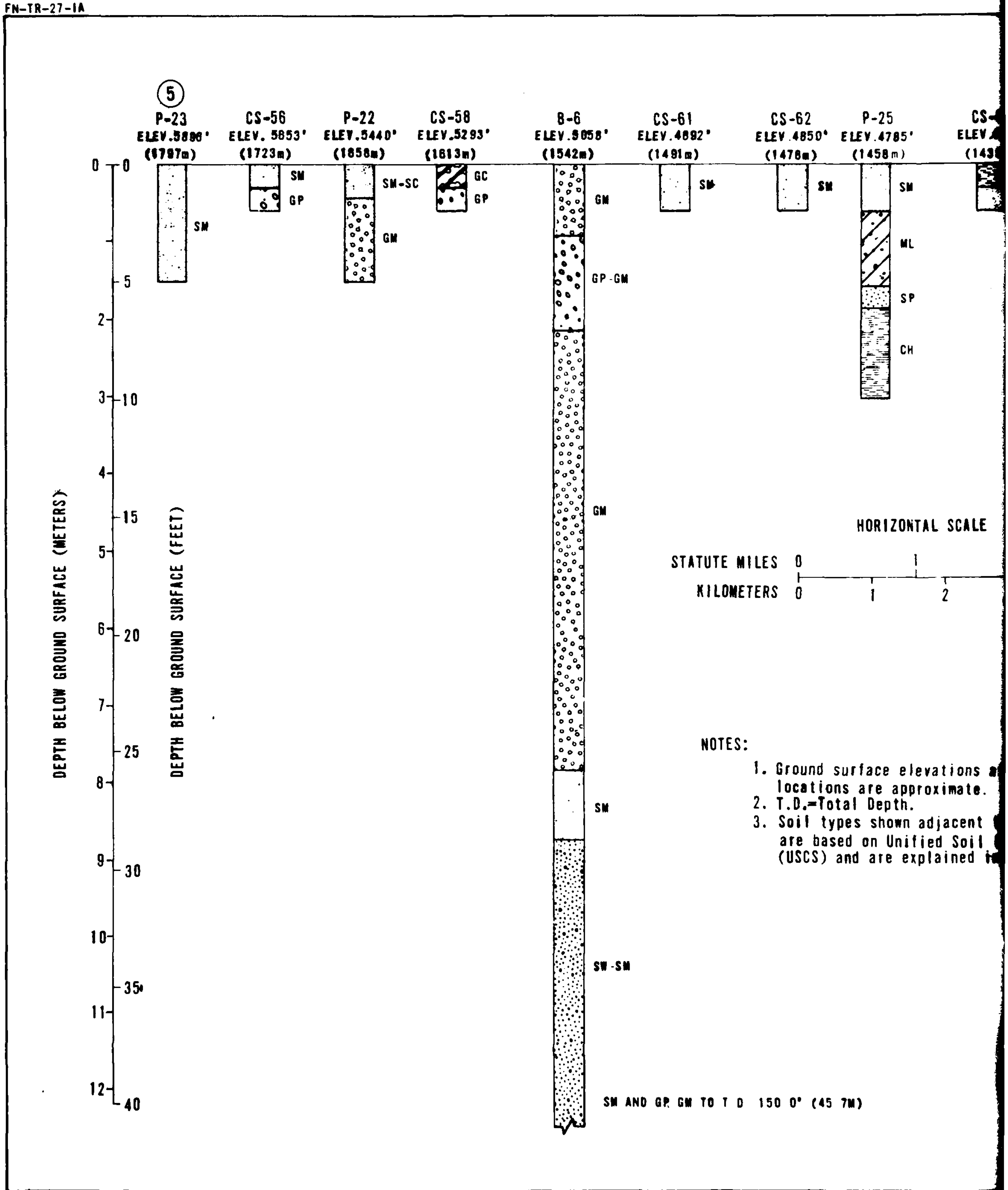


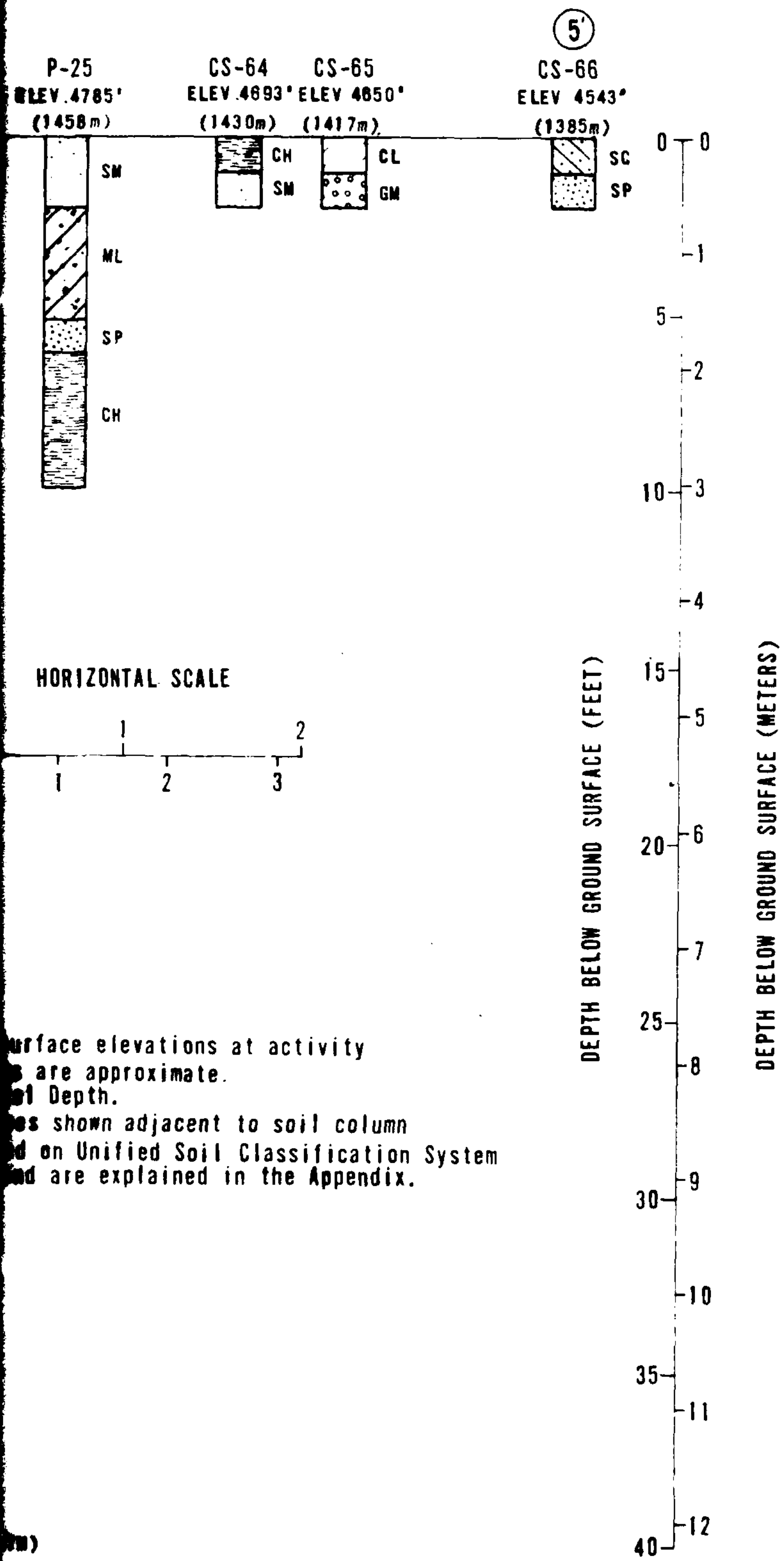
SOIL PROFILE 4-4'
VERIFICATION SITE, WHIRLWIND CDP, UTAH

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAMSO	FIGURE 4-4

FUGRO NATIONAL, INC.

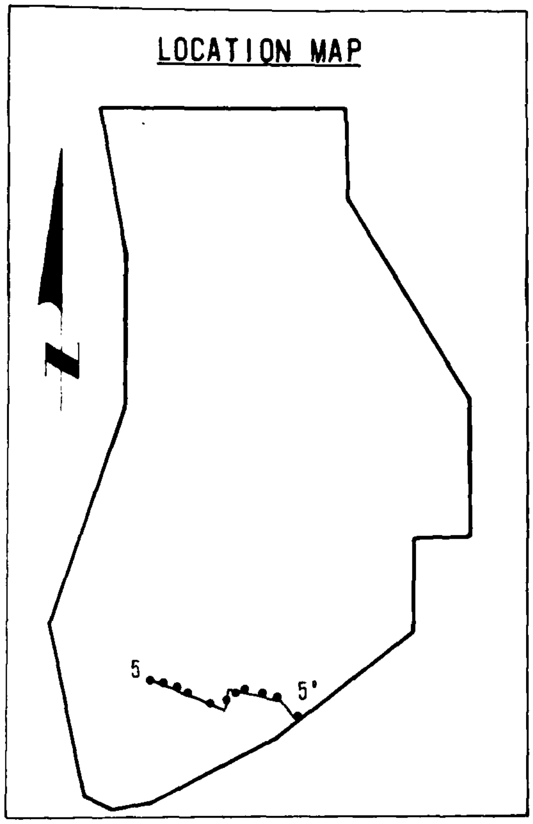
3


5
P-23
ELEV.5896'
(1797m)
CS-56
ELEV. 5653'
(1723m)
P-22
ELEV.5440'
(1658m)
CS-58
ELEV.5293'
(1613m)
B-6
ELEV.5058'
(1542m)
CS-61
ELEV.4892'
(1491m)
CS-62
ELEV.4850'
(1478m)
P-25
ELEV.4785'
(1458m)
DEPTH BELOW GROUND SURFACE (METERS)
DEPTH BELOW GROUND SURFACE (FEET)
0 2 3 4 5 6 7 8 9 10 11 12
0 5 10 15 20 25 30 35 40
SM
GP
SM-SC
GM
GC
GP
GP-GM
SW-SM
ML
SP
CH
SM AND GP GM TO T D 150 0' (45 7M)
HORIZONTAL SCALE
STATUTE MILES 0 1
KILOMETERS 0 1 2
NOTES:
1. Ground surface elevations
locations are approximate.
2. T.D.=Total Depth.
3. Soil types shown adjacent
are based on Unified Soil
(USCS) and are explained



urface elevations at activity
are approximate.
l Depth.
es shown adjacent to soil column
d on Unified Soil Classification System
nd are explained in the Appendix.

m)



EXPLANATION

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

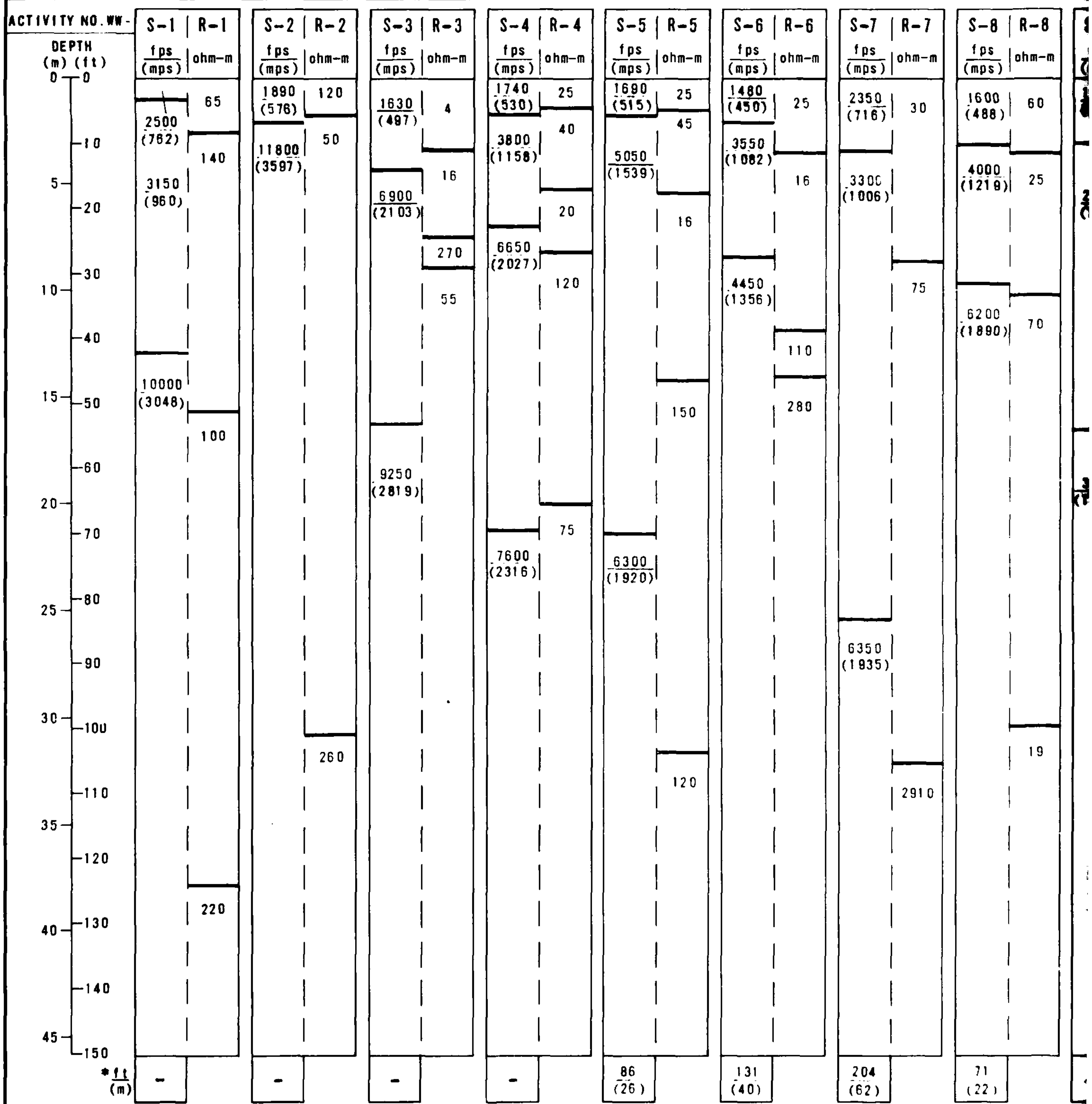
SOIL PROFILE 5-5'
VERIFICATION SITE, WHIRLWIND CDP, UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 4-5

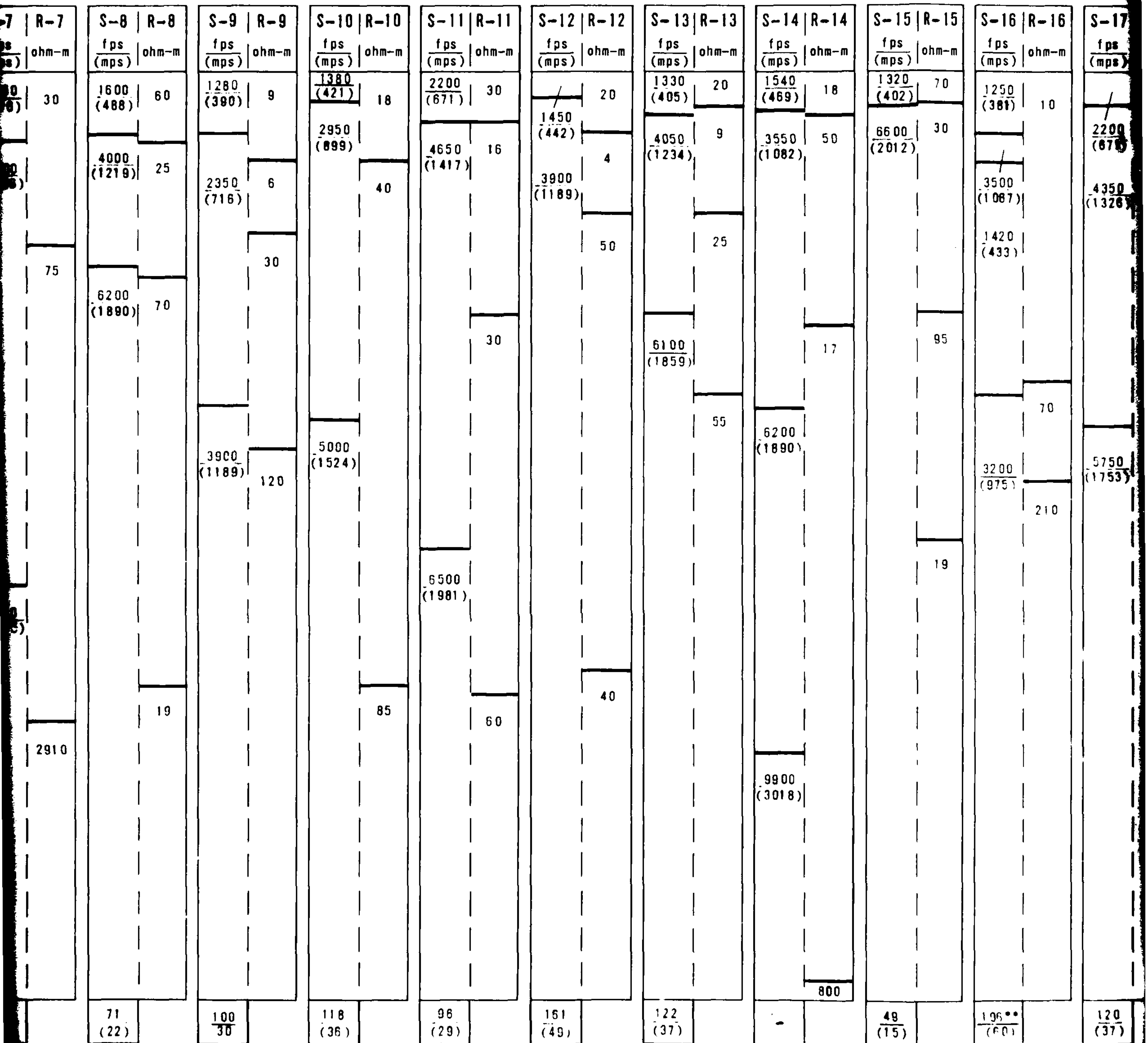
FUGRO NATIONAL, INC.

12

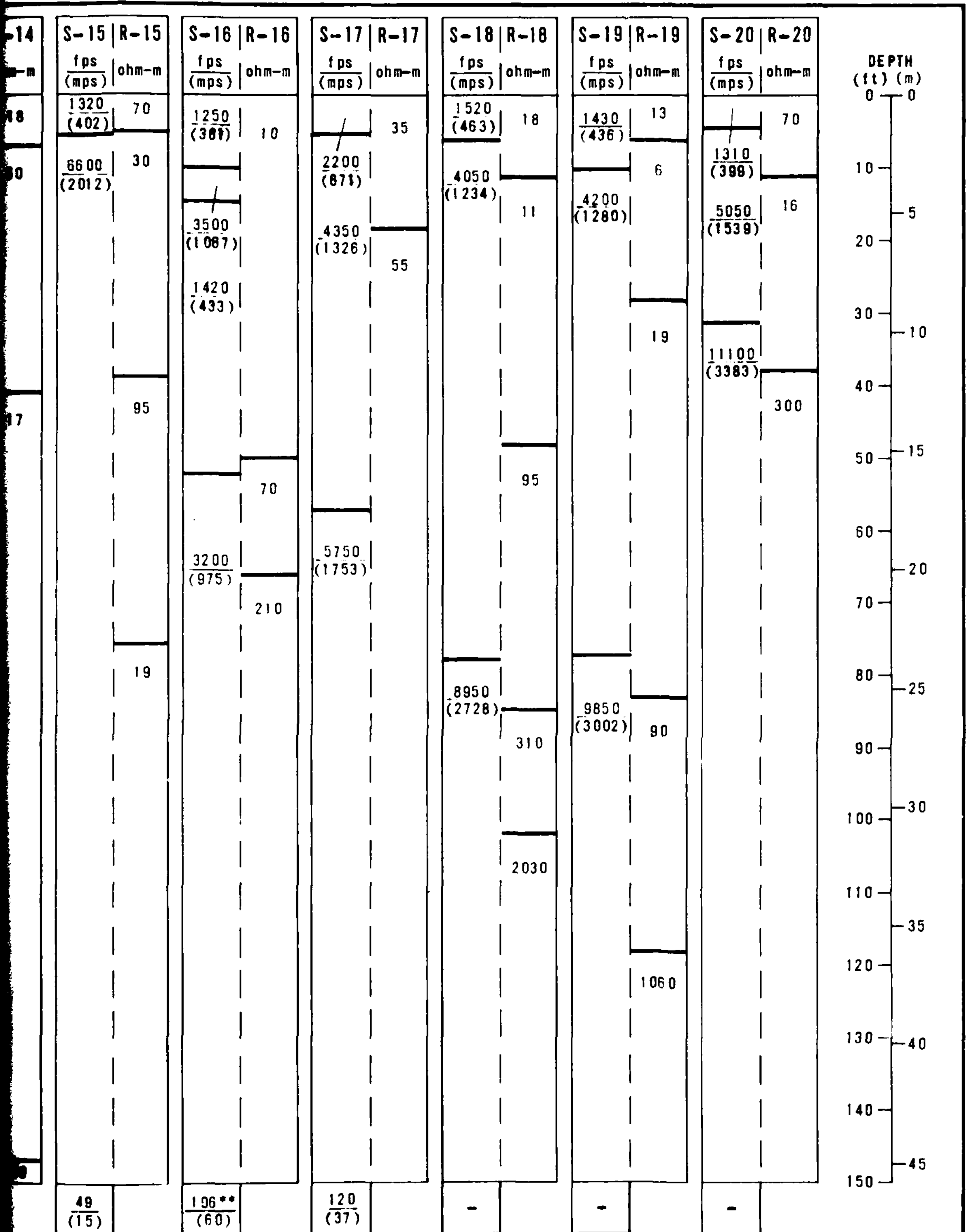


* Approximate depth above which there is no indication of material with a velocity as great as 7000 fps (2134 mps) See Appendix for an explanation of how this exclusion depth is calculated when the observed velocities are all less then 7000 fps (2134 mps).

** Interpreted depth to observed 9100 fps layer


R-7
ohm-m
30
75
2910
S-8 | R-8
fps (mps) | ohm-m
1600 (488)
60
4000 (1219)
25
6200 (1890)
70
19
71 (22)
S-9 | R-9
fps (mps) | ohm-m
1280 (390)
9
2350 (716)
6
30
3900 (1189)
120
100 30
S-10 | R-10
fps (mps) | ohm-m
1380 (421)
18
2950 (899)
40
5000 (1524)
85
118 (36)
S-11 | R-11
fps (mps) | ohm-m
2200 (671)
30
4650 (1417)
16
30
6500 (1981)
60
96 (29)
S-12 | R-12
fps (mps) | ohm-m
20
1450 (442)
4
3900 (1189)
50
40
161 (49)
S-13 | R-13
fps (mps) | ohm-m
1330 (405)
20
4050 (1234)
9
25
6100 (1859)
55
122 (37)
S-14 | R-14
fps (mps) | ohm-m
1540 (469)
18
3550 (1082)
50
17
6200 (1890)
9900 (3018)
800
S-15 | R-15
fps (mps) | ohm-m
1320 (402)
70
6600 (2012)
30
95
19
49 (15)
S-16 | R-16
fps (mps) | ohm-m
1250 (381)
10
3500 (1067)
1420 (433)
70
3200 (975)
210
196** (60)
S-17
fps (mps)
2200 (671)
4350 (1326)
5750 (1753)
120 (37)

, 2



SEISMIC REFRACTION AND ELECTRICAL RESISTIVITY
VERIFICATION SITE, WHIRLWIND CDP, UTAH

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE SAMSO	TABLE 4-4

FUGRO NATIONAL, INC.

AFV-18

DEPTH RANGE	2' - 20' (0.6 - 6.0m)	
SOIL DESCRIPTION	Coarse-grained soils	Fine-grained
	Sandy Gravels, Gravelly Sands, and Silty Sands	Sandy Silts, Silts and Clays
USCS SYMBOLS	GP, GM, SP, SW, SM, SC	ML, CL
ESTIMATED EXTENT IN SUBSURFACE %	90-95	5-10
PHYSICAL PROPERTIES		
DRY DENSITY pcf (kg/m³)	100 5-131 7 (1610-2110) [21]	98.8 (1583)
MOISTURE CONTENT %	1 1-11 1 [22]	16 0
DEGREE OF CEMENTATION	none to moderate	none to weak
COBBLES 3-12 inches (8-30 cm) %	0-10	0
GRAVEL %	0-64 [17]	0-2
SAND %	25-86 [17]	8-12
SILT AND CLAY %	3-35 [17]	74-92
LIQUID LIMIT	22 [1]	NDA
PLASTICITY INDEX	3 [1]	Nonplastic
COMPRESSIONAL WAVE VELOCITY fps (mps)	1250-2250 (381-686) [20]	NDA
SHEAR STRENGTH DATA		
UNCONFINED COMPRESSION S_u - ksf (kN/m²)	NDA	NDA
TRIAXIAL COMPRESSION c - ksf (kN/m²), $\phi°$	NDA	NDA
DIRECT SHEAR c - ksf (kN/m²), $\phi°$	c=0 45 (22) ϕ =30 * [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 6 borings, 14 trenches, and 26 test pits, and results of 20 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 20 seismic refraction surveys.

- [ ] - Numbe
- NDA - No data

* Test re

6.0m)	20' - 160' (6.0 - 49.0m)	
Fine-grained soils	Coarse-grained soils	Fine-grained soils
Sandy Silts, Silts, and Clays	Sandy Gravels, Gravelly Sands, Sands, Silty Sands, and Clayey Sands	Sandy Silt
ML, CL	GP, GM, SP, SW, SM, SC	ML
5-10	90-95	5-10
98.6 (1583) [1]	105.8-143.7 (1695-2302) [50]	101.7 (1629) [1]
16.0 [1]	4 5-13 9 [51]	14 1 [1]
none to weak	none to weak	none
0	0-10	0
0-2 [3]	0-50 [19]	0 [1]
8-12 [3]	41-90 [19]	26 [1]
74-92 [5]	8-38 [19]	74 [1]
NDA	NDA	NDA
Nonplastic [2]	NDA	Nonplastic [1]
NDA	2950-6950 (899-2118) [20]	NDA
NDA	NDA	NDA
NDA	NDA	NDA
NDA	c = 2.2 (105) ø = 31 * [2]	NDA

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

* Test results do not represent group average

CHARACTERISTICS OF SUBSURFACE SOILS
VERIFICATION SITE WHIRLWIND CDP UTAH

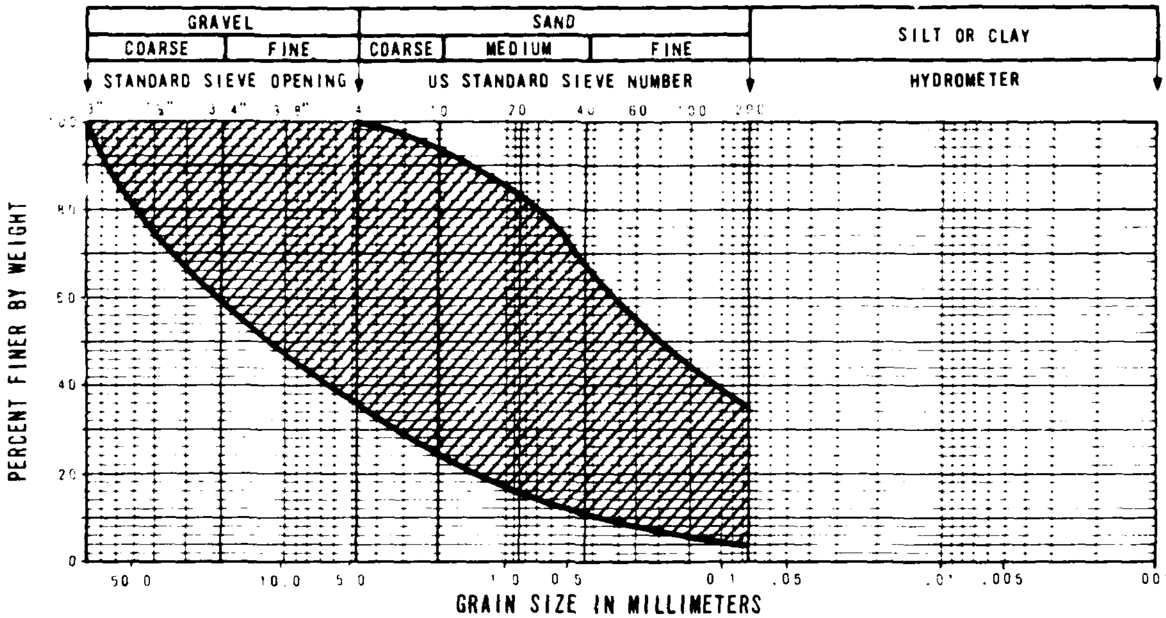
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 4-5

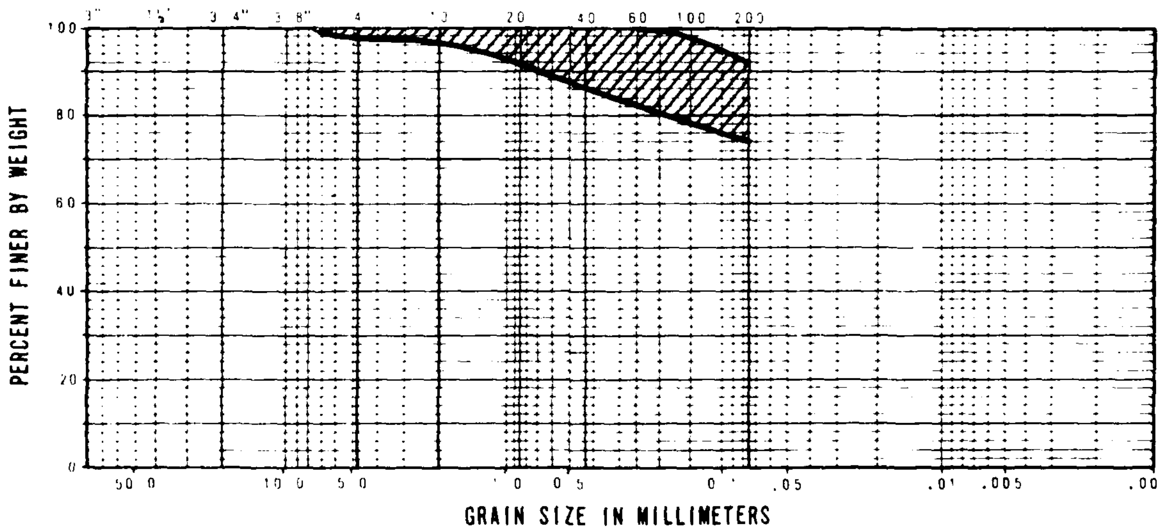
FUGRO NATIONAL, INC.

AFV-20

12



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



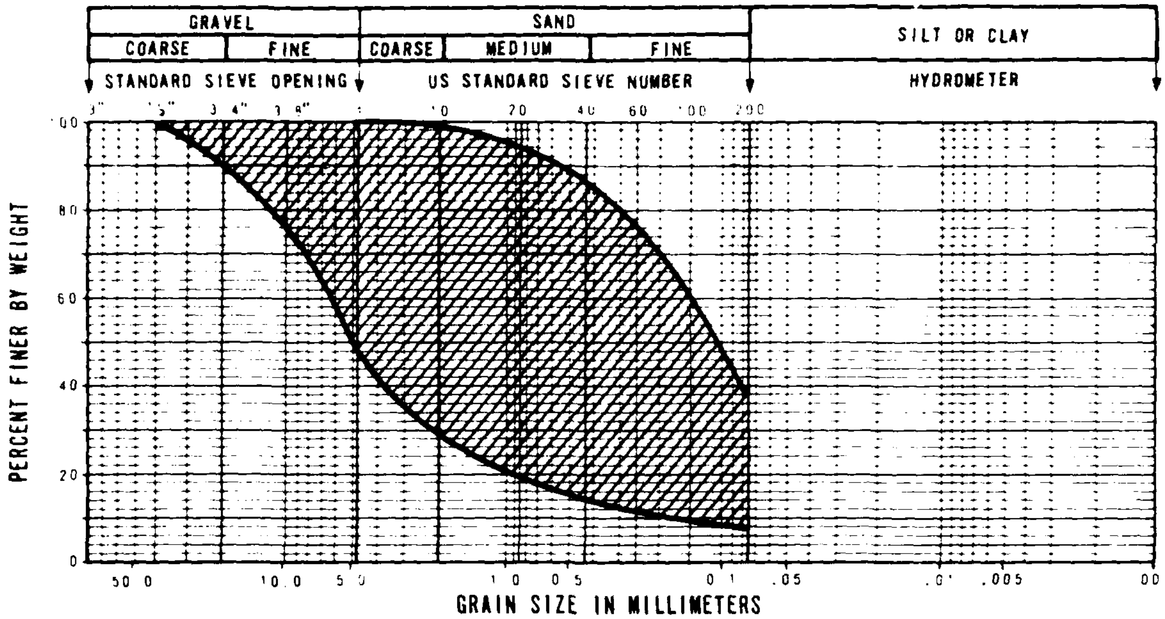
SOIL DESCRIPTION: Fine-grained soils from 2 to 20 feet (0.6 to 6m)

RANGE OF GRADATION OF SUBSURFACE SOILS
VERIFICATION SITE, WHIRLWIND COP, UTAH

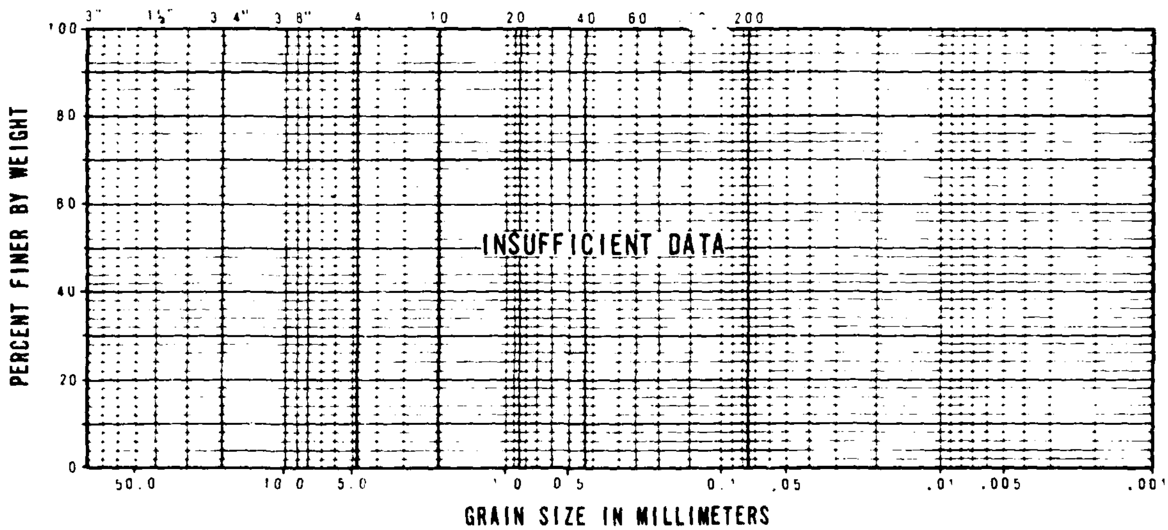
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 4-6
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, WHIRLWIND COP, UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 4-6
2 OF 2

FUGRO NATIONAL, INC.

Average electrical conductivity of the soils in the upper 50 feet (15 m) ranges from 0.0078 to 0.1000 mhos per meter and averages 0.0344 mhos per meter. All electrical conductivities measured exceeded the minimum value of 0.004 mhos per meter specified in the Fine Screening criteria. Chemical test results indicate that potential for sulfate attack of soils on concrete will be "mild."

4.6 TERRAIN

Terrain conditions are depicted in Drawing 4-3. In general, terrain categories I through V correspond to alluvial fan or mixed alluvial fan and lacustrine deposits with varying amounts of stream incision. Where incision is extreme, as in northern Whirlwind, terrain conditions are unsuitable and have been excluded (category VII). Category VI generally refers to hummocky, irregular older lacustrine deposits, particularly in shoreline features of Lake Bonneville.

Drainage in the site is to the south into Sevier Lake except in the extreme northern part where drainage is north into Fish Springs Valley. Elevations along the valley axis range from 4520 feet (1378 m) at Sevier Lake to 5105 feet (1556 m) at the drainage divide in northern Whirlwind. Terrain generally slopes uniformly with variable stream incision except in southern Whirlwind. Here, chaotic topography is due to irregular shoreline deposits of Lake Bonneville, shallow rock, and deep incision resulting from lowering of the local base level (Sevier Lake). Slopes are highly variable in this area and locally exceed 10 percent.

Intermediate and older alluvial fans near mountain fronts (terrain categories III through V) exhibit incision generally from 6 to 15 feet deep (2 to 5 m) with variable spacing. Slopes generally are less than 5 percent and average 2 to 3 percent in these areas.

Incision depths are generally less than 6 feet along the site axis north of Long Ridge (terrain categories I and II). Drainages are relatively closely spaced, i.e., four to eight drainages per mile versus two to four drainages per mile near mountain fronts. Slopes are in the range of 1 to 2 percent.

4.7 DEPTH TO ROCK

Generalized contours depicting depth to rock are shown in Drawing 4-4. All data used are shown in the map, clearly illustrating that little data were available. Where no subsurface data were available, contours were drawn by extrapolation from geologically similar areas with data. Approximately 15 percent of the site is underlain by rock less than 50 feet (15 m) deep and about 5 percent by rock less than 150 feet (46 m).

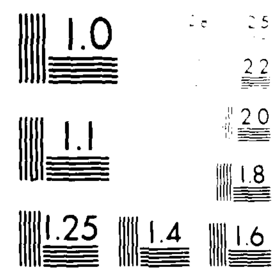
The House Range to the west consists of gently eastward dipping beds. Basinward projections of the dip slopes were used to derive the depth to rock contours. These projections are calibrated with data from five seismic lines which encountered rock at less than 150 feet. Similarly, in Long Ridge and Red Knolls, dips are gentle to the west. Rock was encountered at depths of only 15 feet (5 m) 1 mile (1.6 km) west of Long Ridge. This is reflected in the shallower rock projected on the west

AD-A113 322 FUGRO NATIONAL INC LONG BEACH CA F/G 13/2
MX SITING INVESTIGATION GEOTECHNICAL EVALUATION. VOLUME IA. NEV--ETC(U)
AUG 79 F04704-80-C-0006
UNCLASSIFIED FN-TR-27-1A NL

2 OF 4
AD A
113322

2 OF 4

AD A
113322



side (dip slope) than on the east side where possible faulting along the scarp slope has resulted in a steep front. Depth to rock along the heterogeneous volcanic rock of the Little Drum Mountains is more difficult to interpret, particularly since no rock at less than 150 feet was encountered in borings or geophysical surveys. Dip is generally moderate to the west in the southern Little Drum Mountains. Units are more variable, unstratified, and of lower relief to the north. Contours generally reflect dip-slope projections in the south and topographic-slope projections in the north.

4.8 DEPTH TO WATER

Drawing 4-5 shows the approximate configuration of the 50-foot (15-m) and 150-foot (46-m) depth to water contours in the Whirlwind Site. Conditions depicted represent water levels in the unconfined basin-fill aquifer. These interpretations are based on seven water well points (Bolke, 1978; Mower and Feltis, 1964; Utah State Engineers Office, 1979) and 14 estimates of depth to water (Snyder, 1963). Data are generally very poor and estimated depths to water commonly are given within a range of 100 feet (31 m). Dates of water-level readings are not given at many wells and those with dates recorded are more than 40 years old. Consequently, interpretations are tentative.

Water is generally at depths exceeding 150 feet throughout the site. At the northern edge of the site, it ranges from 700 to 800 feet (214 to 244 m) deep, decreasing to about 250 feet (76 m) near the central area. Shallow water occurs only in the southeast near Sevier Lake. As the data were interpreted, less than 1 percent of the site is underlain by water less than 50 feet deep and less than 5 percent is underlain by water less than 150 feet deep. Ground water within the site is not presently being utilized.

4.9 RESULTS AND CONCLUSIONS

4.9.1 Suitable Area

Resulting suitable area, as defined by FY 79 Verification Studies in the Whirlwind Site, is shown in Drawing 4-6. The site contains approximately 265 mi^2 (685 km^2) of usable area for a hybrid trench and 225 mi^2 (585 km^2) for a vertical shelter concept. These results are significantly different from those reported in previous Intermediate/Fine Screening studies due to:

1. Additional terrain exclusions in northern Whirlwind;
2. Additional shallow rock exclusions in the central, northern, and peripheral parts of the site; and
3. Reduction in shallow water exclusions in southern Whirlwind.

4.9.2 Construction Considerations

Geotechnical factors and conditions which would affect the construction of the MX system in the suitable area are discussed. Both the hybrid trench and vertical shelter basing modes are considered.

4.9.2.1 Grading

Surficial slopes in the Whirlwind Site are generally less than 5 percent with a maximum of 10 percent near the mountain fronts. Slopes average 2 percent and exceed 5 percent in less than

10 percent of the suitable area. Therefore, minimal preconstruction grading will be necessary.

4.9.2.2 <u>Roads</u>

Subgrade supporting properties of low strength, surficial, granular soils can generally be improved by mechanical compaction. Our studies indicate that compaction of surficial soils to an average depth of 1.8 feet (0.5 m) appears necessary. Laboratory California Bearing Ratio (CBR) test results indicate that the compacted coarse-grained soils will have good to very good subgrade supporting properties. CBR tests indicate that, generally, their compacted subgrade supporting properties of fine-grained surficial soils will be inadequate. Therefore, a select granular subbase course should be used over these compacted fine-grained soils to provide the necessary strength. As an alternative, these soils could be removed partially or totally (depending on their thickness) and replaced by a sufficient thickness of coarse-grained soil to obtain required subgrade support.

Well-graded gravelly sands and sandy gravels with less than 25 percent fines (passing a No. 200 sieve) can be used for subbase and base courses. Although these [illegible] are present in surface and subsurface areas, their extent is [illegible] known.

Drainage incision depths range from 0 to 20 feet (6.0 m) with localized incisions of up to 50 feet. Average incision depth is less than 6 feet (1.8 m) indicating that the overall cost of drainage structures will be low.

4.9.2.3 Excavatability and Stability

Subsurface soils in the suitable area are predominantly coarse grained with fine-grained soils estimated in less than 10 percent of the construction zone. The subsurface soils are generally dense to very dense.

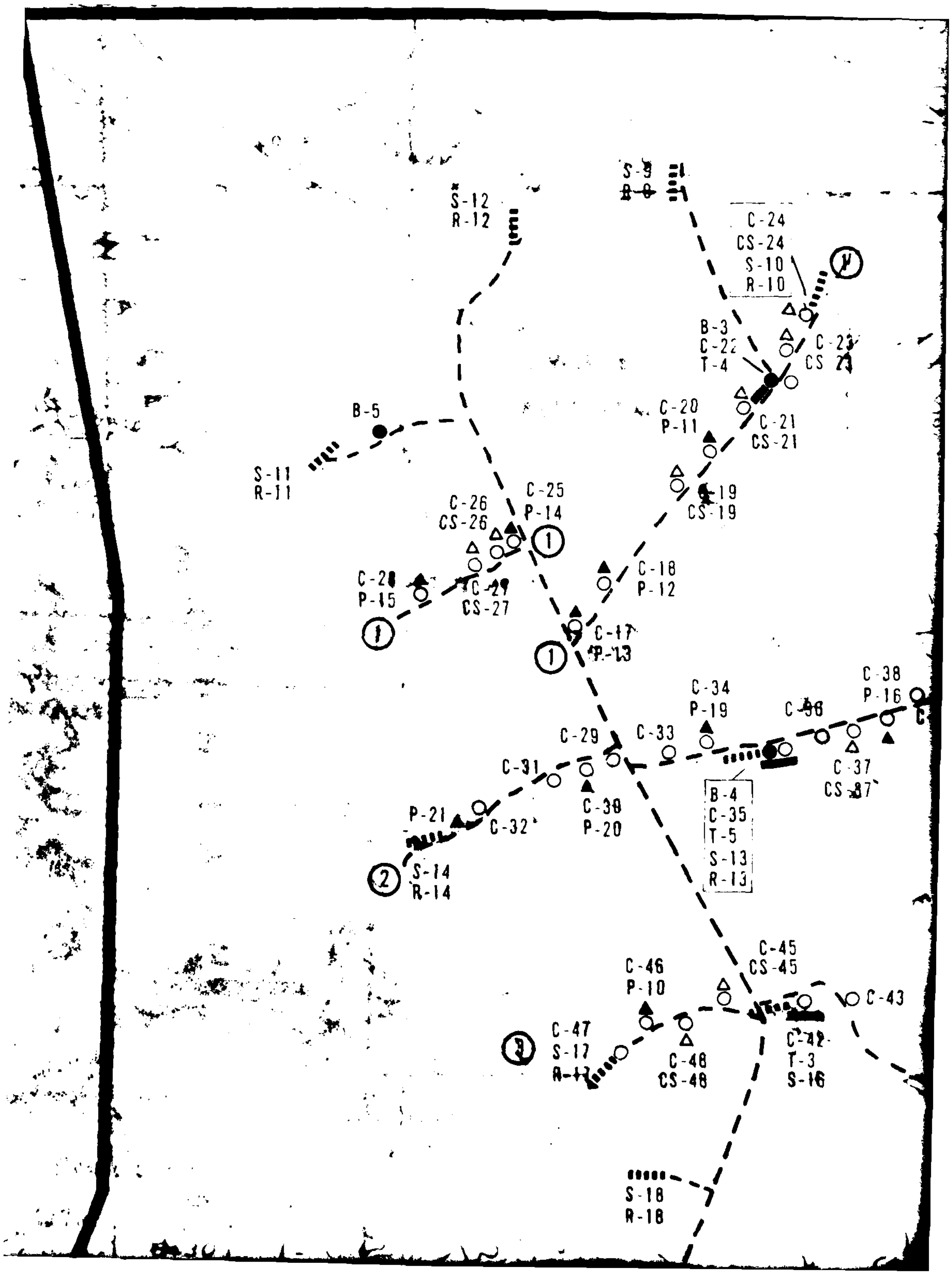
Hybrid Trench: The compressional wave velocities indicate moderately difficult excavation in the upper 20 feet (6.0 m) over a major portion of the suitable area. MX trenchers could be used for excavating continuous trenches suitable for cast-in-place construction. Because of low strength surficial soil, 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. It is estimated that vertical trench walls below these depths will be stable in approximately 70 percent of the suitable area. In the remaining area, trench walls will have to be sloped or shored.

Vertical Shelter: Results of our investigation indicate that large diameter augers could be used for vertical shelter excavations with difficult excavation expected in approximately 5 percent of the suitable area. Since all the excavations will be in granular soils, vertical walls of the excavations to depths of 120 feet will probably not remain stable without the use of a slurry or other stabilizing techniques.

4.10 RECOMMENDATIONS FOR FUTURE STUDIES

Geotechnical conditions identified as requiring additional investigation are listed on the following page.

1. The extent of shallow rock is highly suspect in the vicinity of Red Knolls and Long Ridge. Additional borings and seismic lines are recommended to further define shallow rock conditions.
2. The location of ground-water contours are based on very limited data, particularly in the southern part of the site. Observation wells and geophysical surveys are recommended in selected portions of the site to provide more accurate ground-water elevations.
3. Suitable area and basin-fill characteristics have been described on a reconnaissance level (surface conditions only, no subsurface investigation or laboratory testing) in the Whirlwind CDP, south of the present site boundaries and west of Sevier Lake. A full Verificaton program is recommended to define subsurface conditions and surface details in this area.


S-12
R-12
C-24
CS-24
S-10
R-10
B-3
C-22
T-4
CS 23
B-5
C-20
P-11
C-21
CS-21
S-11
R-11
CS-19
C-26
CS-26
C-25
P-14
C-18
P-12
P-15
CS-27
C-34
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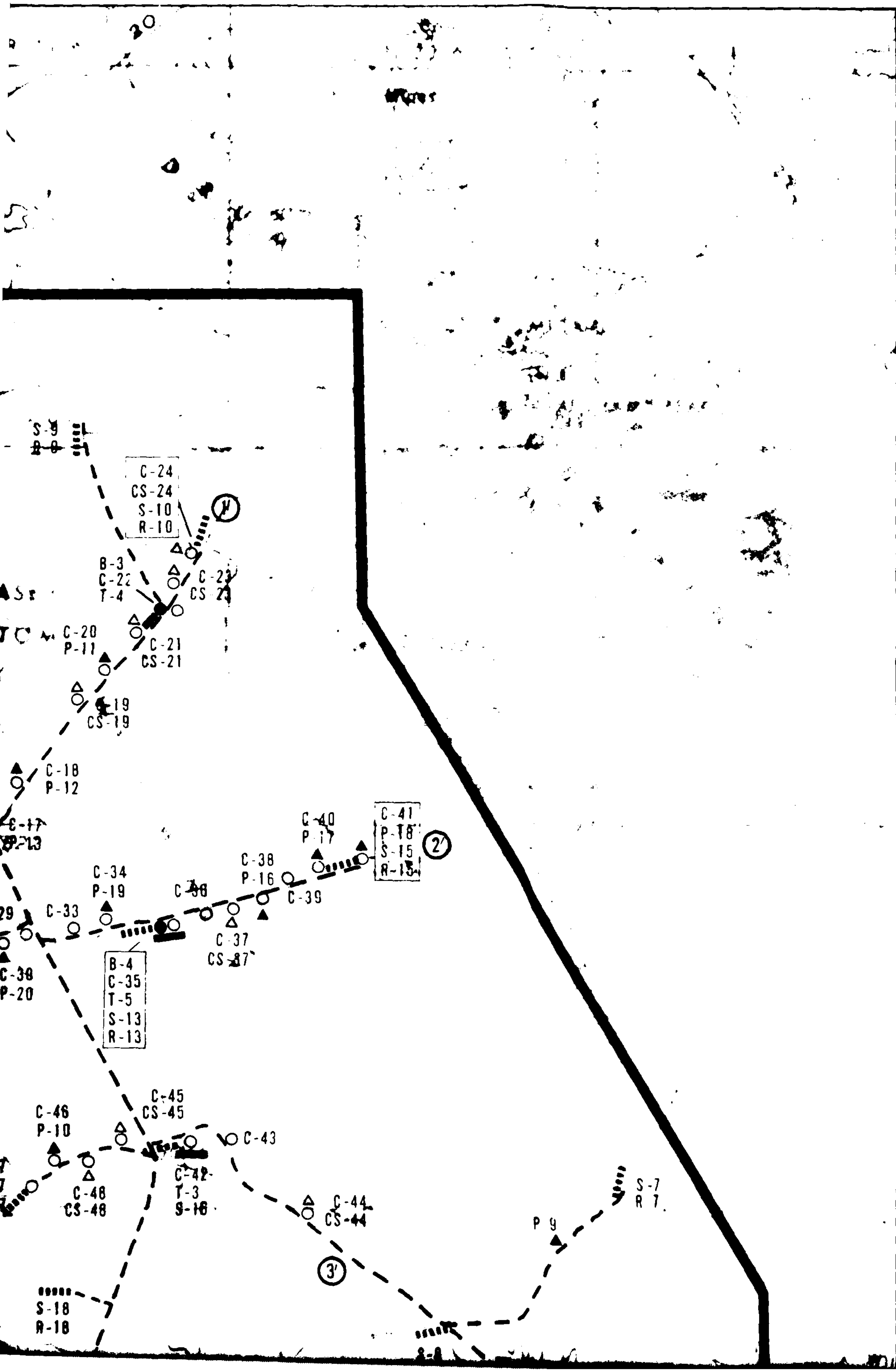
C-38
P-16
C-29
C-33
C-31
C-37
B-4
C-35
T-5
S-13
R-13
P-21
C-32
P-20
S-14
R-14
C-45
CS-45
C-46
P-10
C-43
C-47
S-17
C-48
CS-48
T-3
S-18
R-18

12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C-24
CS-24
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R-10
B-3
C-22
T-4
C-20
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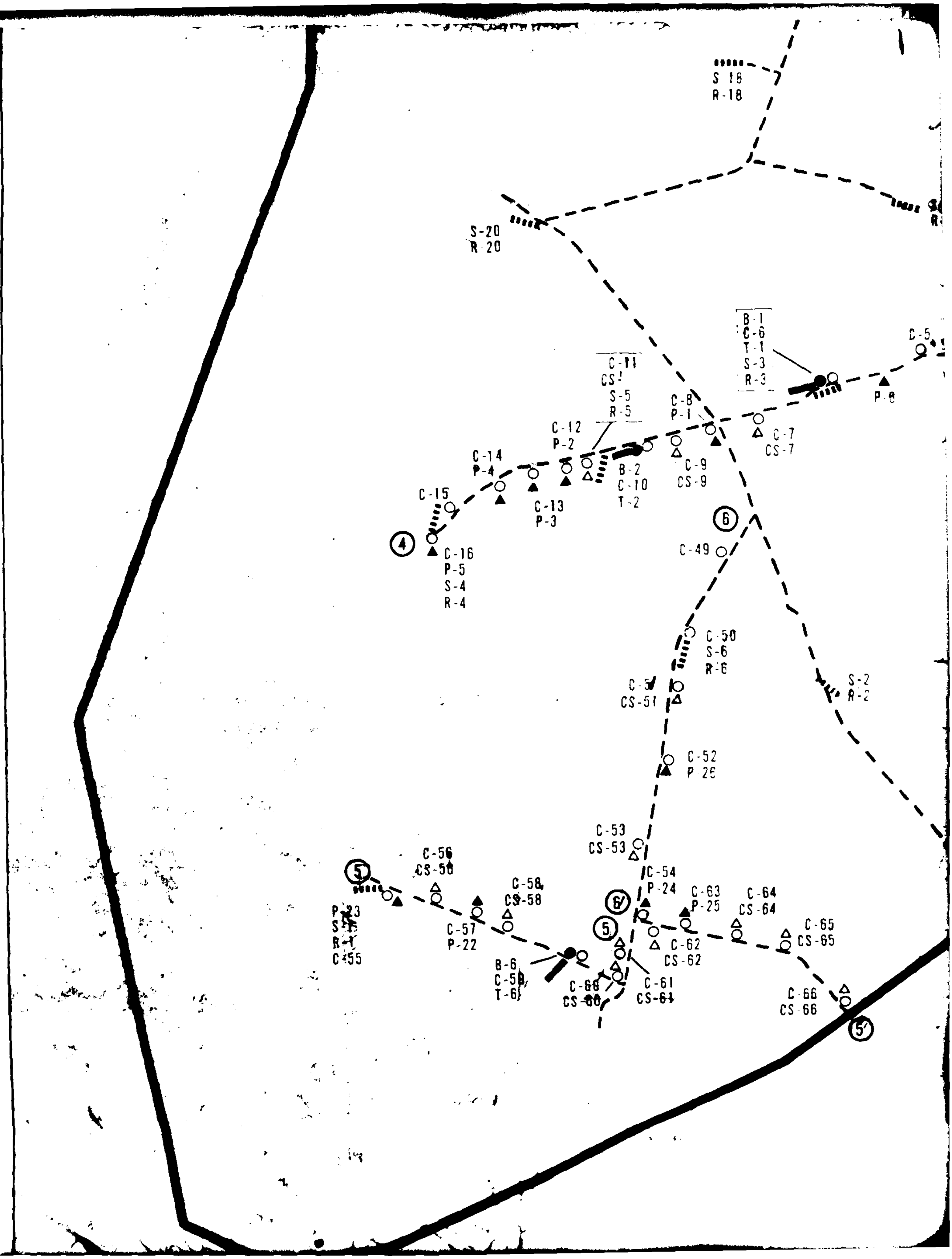
C-21
CS-21
CS-19
C-18
P-12
C-40
P-17
C-41
S-15
C-38
P-16
C-39
C-34
P-19
C-33
C-37
B-4
C-35
T-5
S-13
R-13
P-20
C-46
P-10
C-45
CS-45
C-43
C-48
CS-48
C-44
CS-44
S-7
R 7
S-18
R-18

32


S-18
R-18
S-20
R-20
B-1
C-6
T-1
S-3
R-3
C-5
P-6
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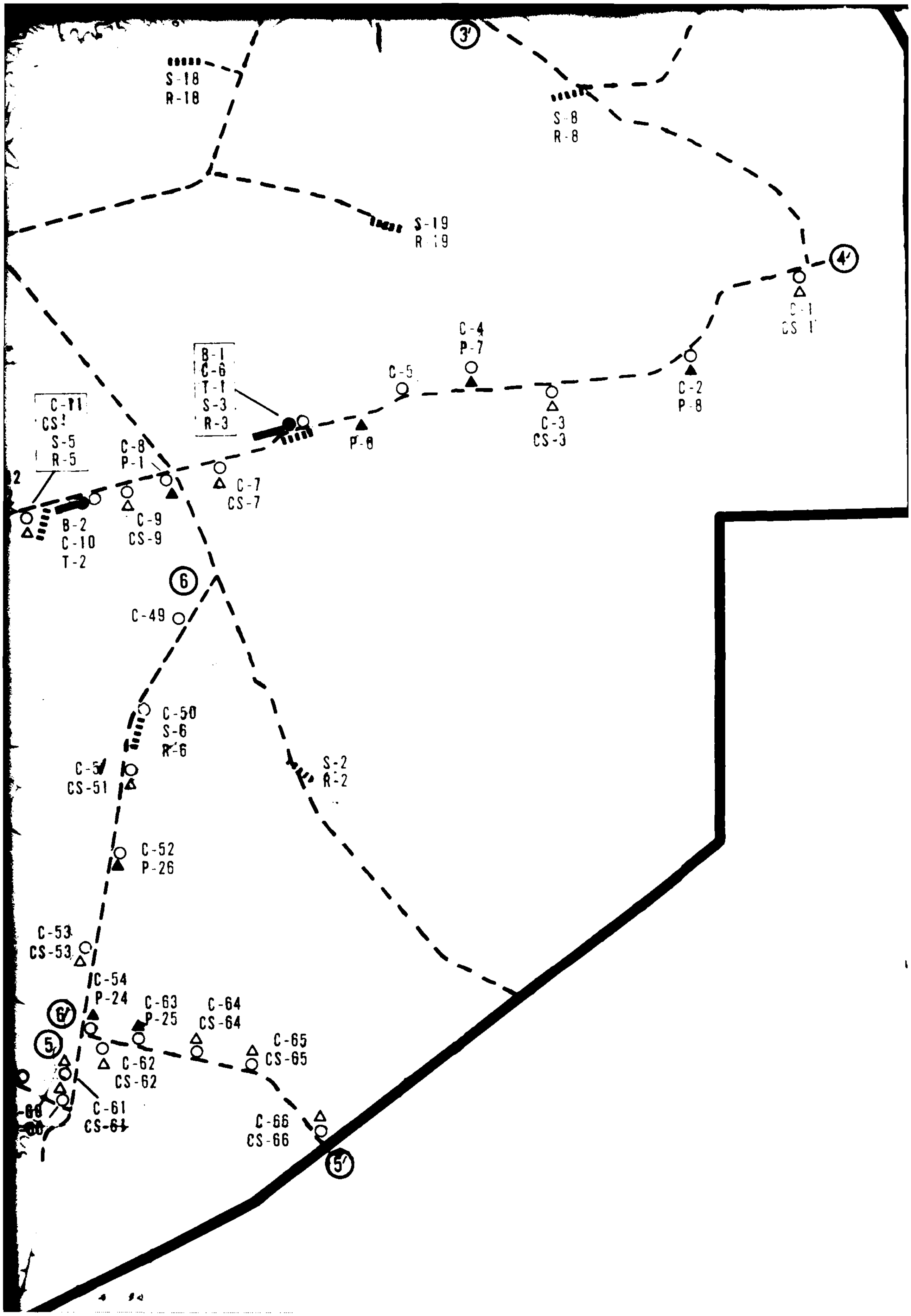
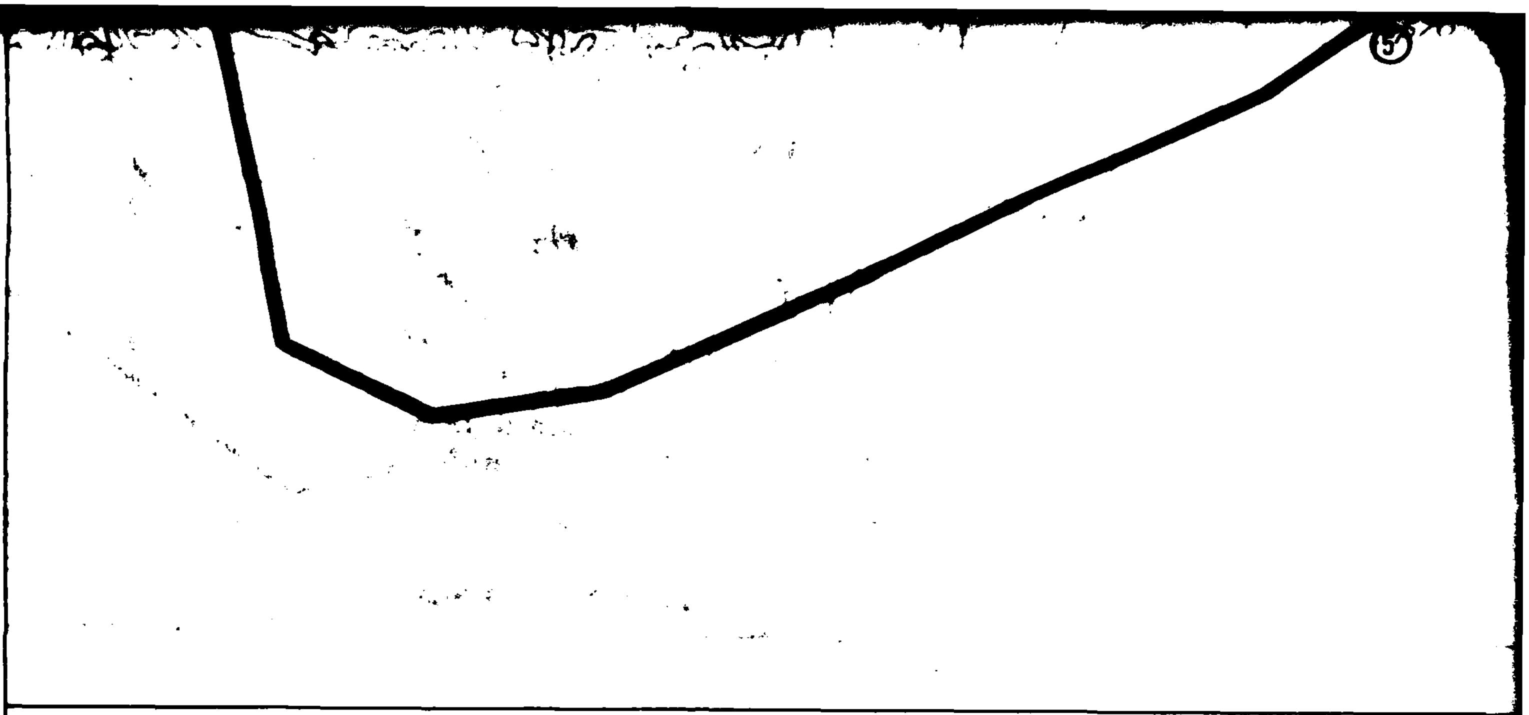
S-5
R-5
C-8
P-1
C-7
CS-7
C-12
P-2
C-14
P-4
B-2
C-10
T-2
C-9
CS-9
C-15
C-13
P-3
4
C-16
P-5
S-4
R-4
6
C-49
C-50
S-6
R-6
S-2
R-2
CS-51
C-52
P-26
C-53
CS-53
5
C-56
C-57
P-22
C-54
P-24
C-63
P-25
C-64
CS-64
C-65
CS-65
C-62
CS-62
B-6
C-61
CS-61
C-66
CS-66
5'


3'
S-18
R-18
S-8
R-8
S-19
R-19
4'
C-1
CS-1
C-4
P-7
C-5
B-1
C-6
T-1
S-3
R-3
C-2
P-8
C-3
CS-3
P-6
C-11
CS-11
S-5
R-5
C-8
P-1
C-7
CS-7
C-9
CS-9
B-2
C-10
T-2
6
C-49
C-50
S-6
R-6
S-2
R-2
C-51
CS-51
C-52
P-26
C-53
CS-53
C-54
P-24
6'
C-63
P-25
C-64
CS-64
C-65
CS-65
5
C-62
CS-62
C-61
CS-61
C-66
CS-66
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 R-1	SEISMIC REFRACTION LINE 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, WHIRLWIND COP, UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

DRAWING
4-1

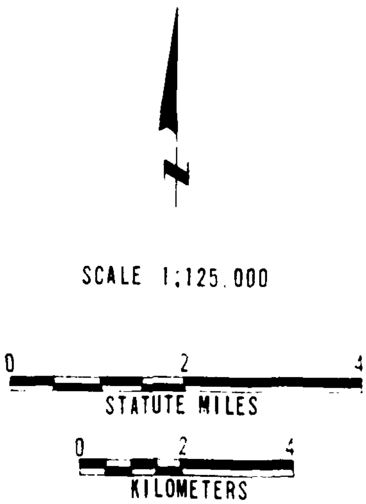
FUGRO NATIONAL, INC.

5

CPT)

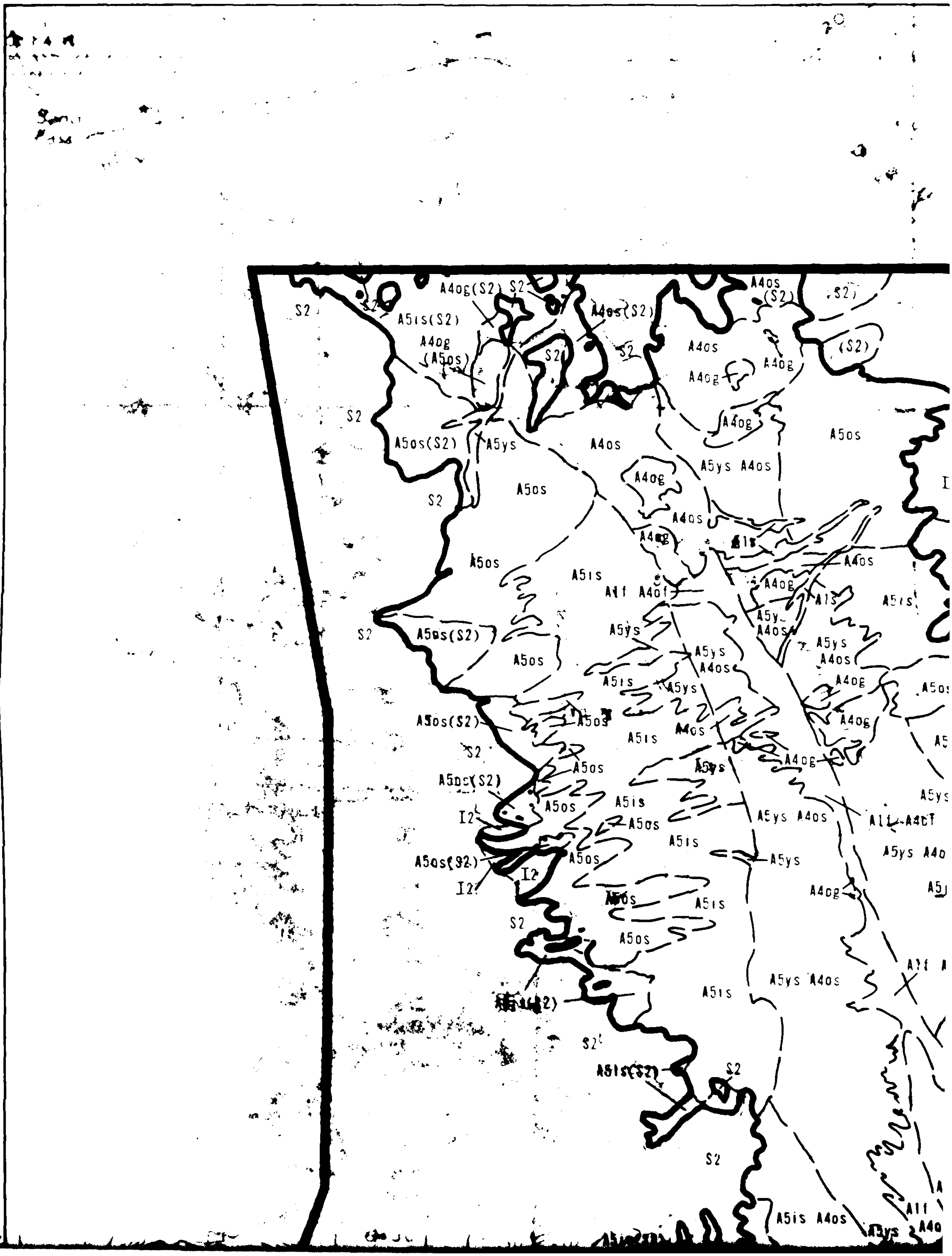
CATION

NE



he same location
(1) the boring
s drilled

16



A4og(S2)
S2
A4os(S2)
A4os
(S2)
S2
A5is(S2)
A4og
(A5os)
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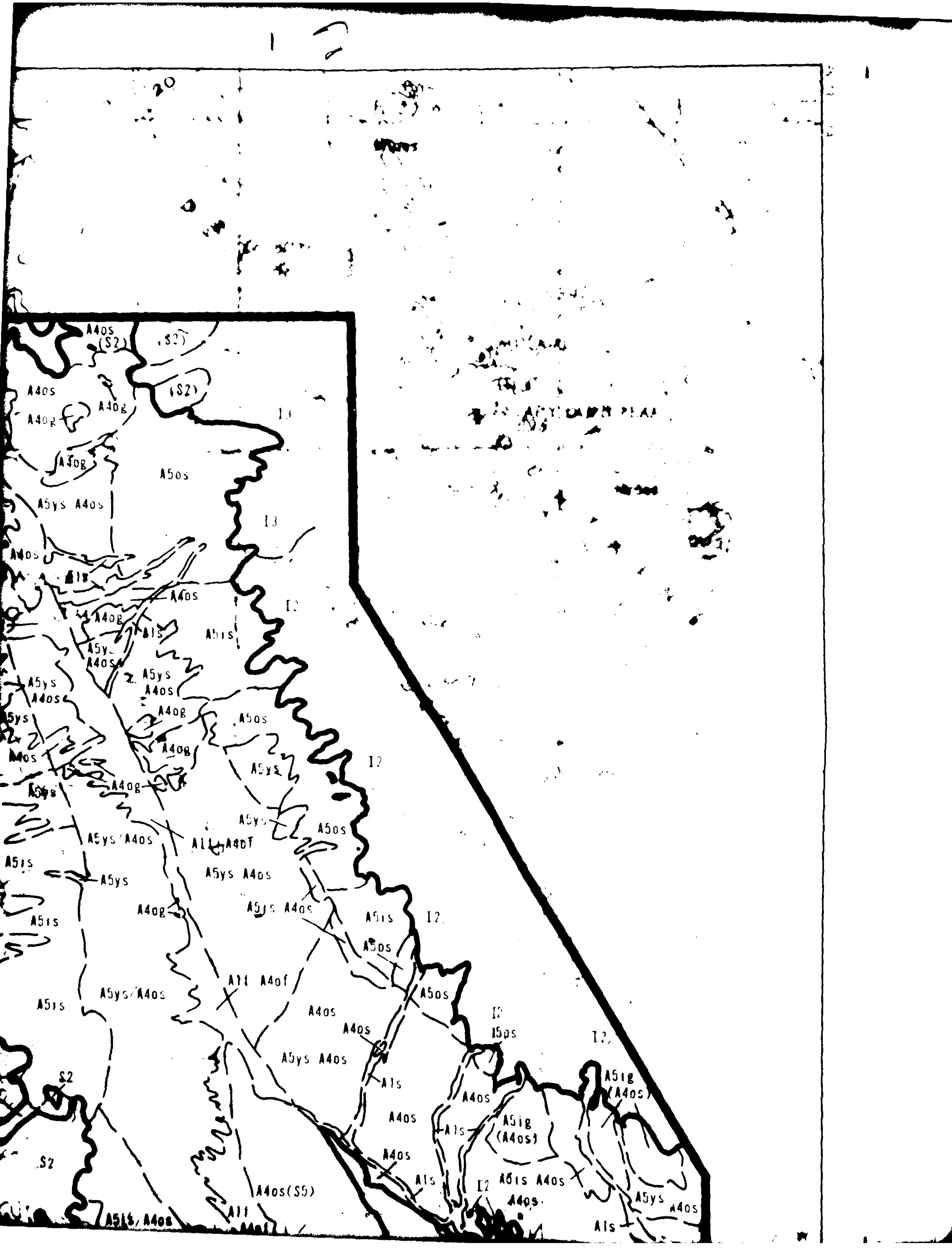
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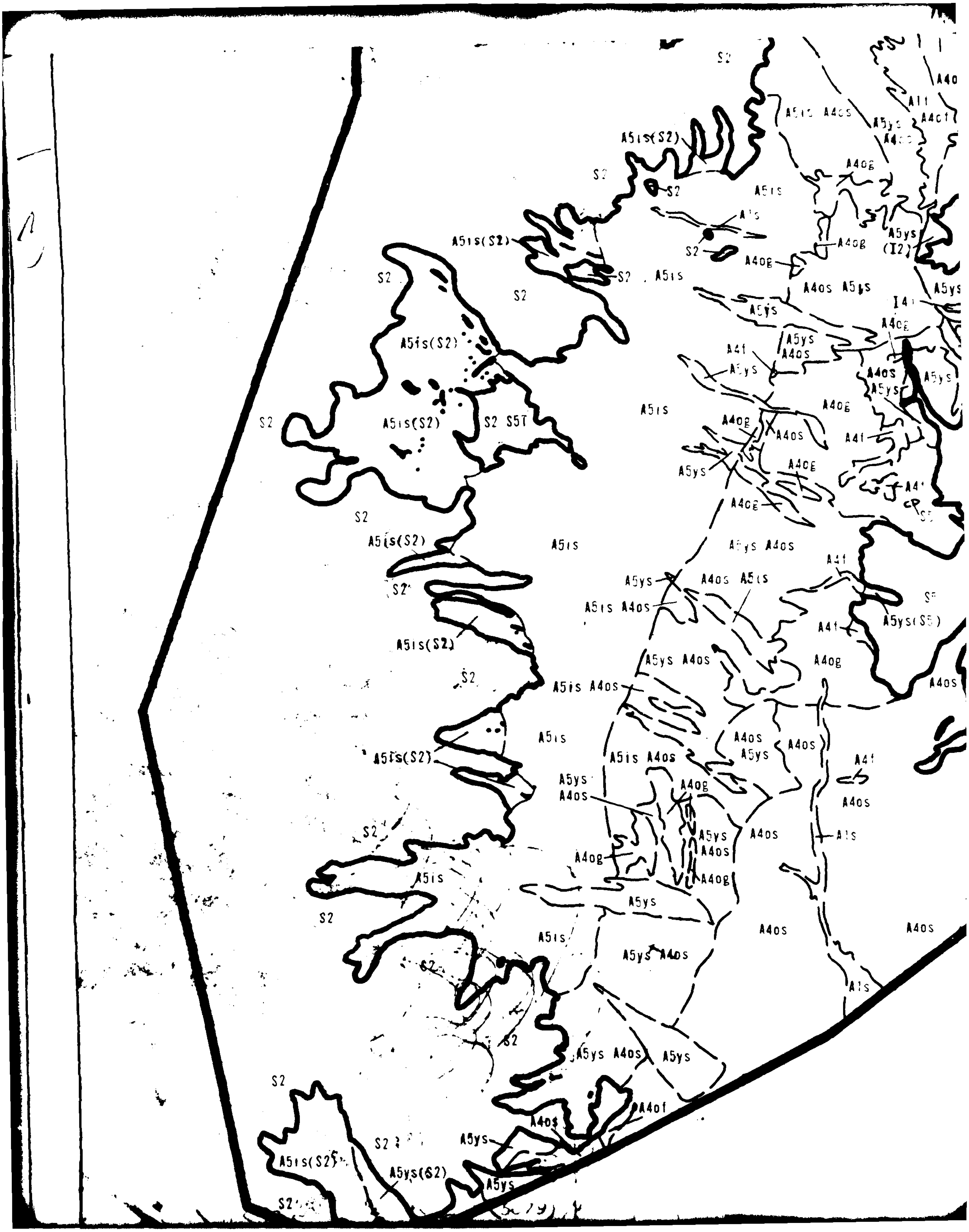

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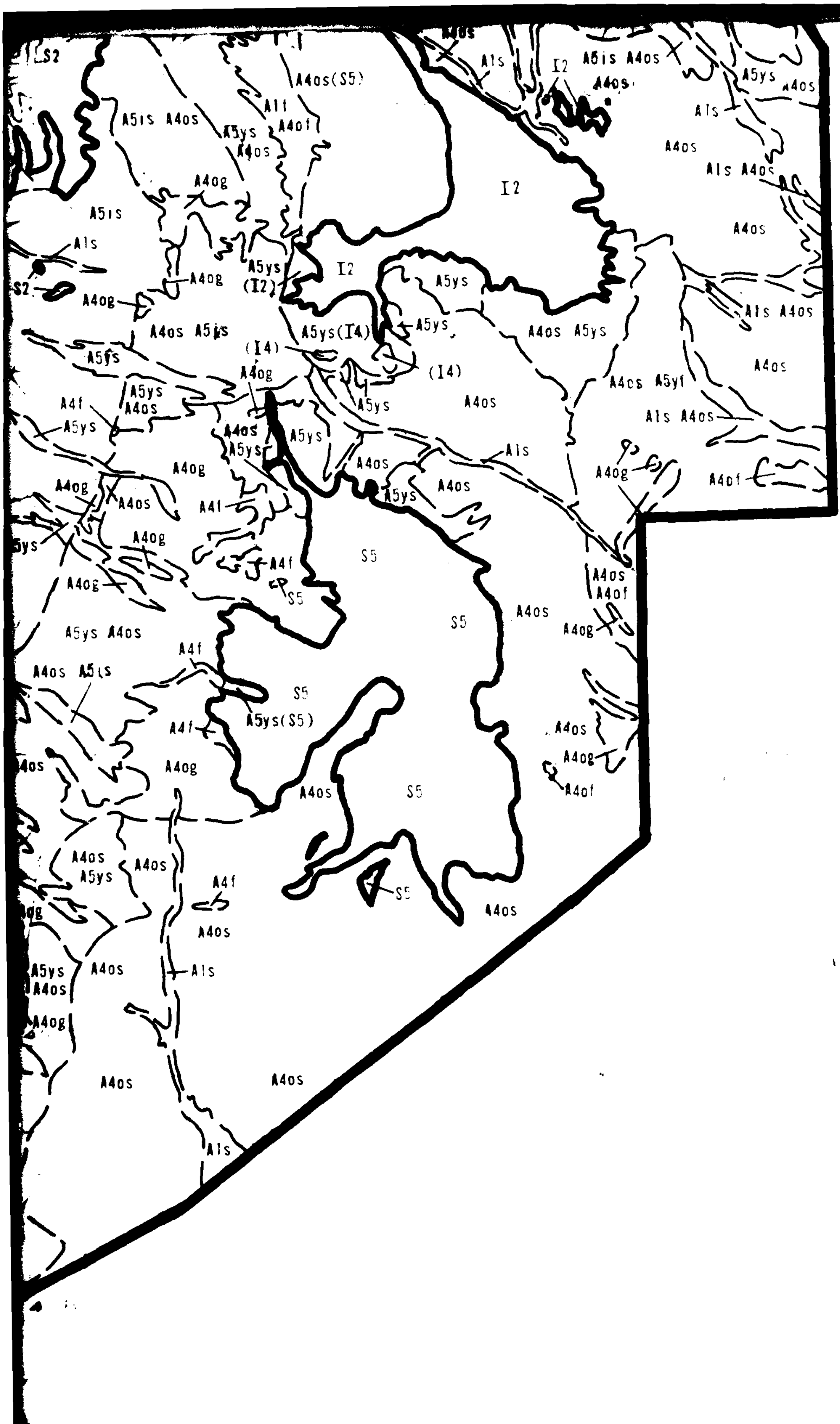
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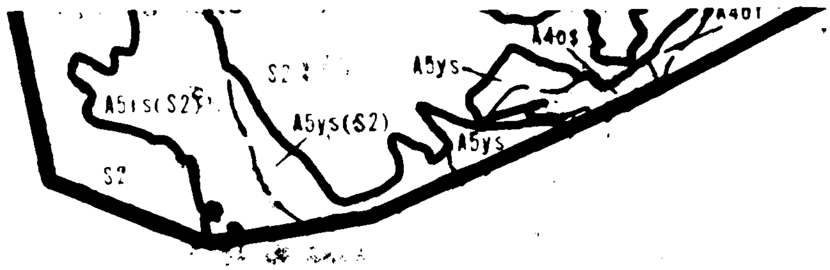


EXPLANATION

SURFICIAL BASIN-FILL DEPOSITS

A1f / A1s	Younger Fluvial Deposits - Modern stream channel and flood-plai silt (ML) and A1s silty sand (SM)
A4of / A4os / A4og	Older Lacustrine Deposits - Older bed lake and abandoned shorel clay (CL); A4os, uncemented and weakly cemented silty sand and and A4og, weakly cemented sandy gravel (GM)
A5ys	Younger Alluvial Fan Deposits - Active younger alluvial fan d gravelly sand (SM)
A5is / A5ig	Intermediate Alluvial Fan Deposits - Inactive intermediate-ag A5is, moderately cemented silty sand and gravelly sand (SM) a sandy gravel (GM)
A5os	Older Alluvial Fan Deposits - Older highly eroded alluvial fa strongly cemented silty sand (SM)

ROCK UNITS

Igneous (I)

I2	Andesite, trachyte, and latite flows
I3	Basalt and basaltic andesite flows

Sedimentary (S)

S2	Limestone and dolomite with interbedded shale
S5	Conglomerate

A5ys A5is Combination of geologic unit symbols indicates a mixture of ei or rock units inseparable at map scale

A5ys(I2) Parenthetic unit underlies surface unit at shallow depth

SYMBOLS

LANATION

SIN-FILL DEPOSITS

am channel and flood-plain deposits of Alf, sandy

lake and abandoned shoreline deposits of A4of, sandy
y cemented silty sand and gravelly sand (SM,SP);
l (GM)

, younger alluvial fan deposits of silty sand and

nactive intermediate-age alluvial fan deposits of
and gravelly sand (SM) and A5ig, moderately cemented

ighly eroded alluvial fan deposits of moderately and

CK UNITS

d shale

ndicates a mixture of either surficial basin-fill
le

t at shallow depth

SCALE 1:125 000

0 2 4

STATUTE MILES

YMBOLS

S5 **Conglomerate**

A5ys A5is Combination of geologic unit symbols indicates a mixture of either s
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

NOTES: 1 Surficial basin-fill units pertain only to the upper several feet of soil. B
surficial deposits and scale of map presentation, unit descriptions refer to
soil types. Varying amounts of other soil types can be expected within each

2 The distribution of geologic data stations is presented in Volume II. Drawin
all station data and generalized description of all geologic units is inclu
Section 1.0

3 Geology in areas of exposed rock from Hintze (1963 Stokes (1963

SURFICIAL GEOLOGIC UNITS
VERIFICATION SITE, WHIRLWIND CDP, UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

DRAWING
4-2

FUGRO NATIONAL, INC.

Interbedded shale

symbols indicates a mixture of either surficial basin-fill
t map scale

rface unit at shallow depth

SYMBOLS

in fill

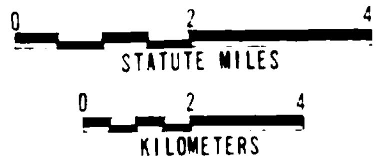
in fill or rock units

only to the upper several feet of soil Due to variability of
p presentation, unit descriptions refer to the predominant
her soil types can be expected within each geologic unit

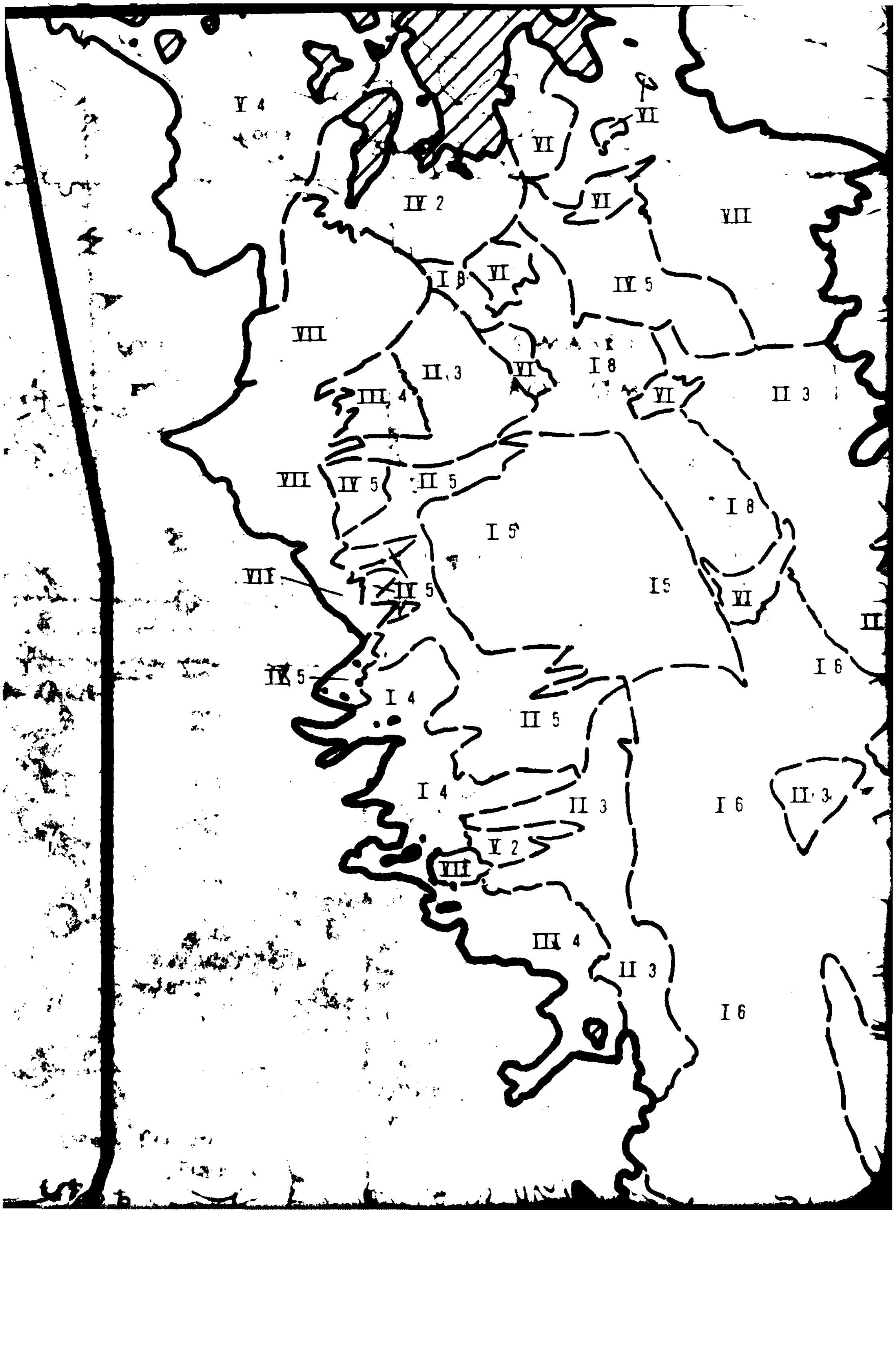
stations is presented in Volume II. Drawing 1. A tabulation of
description of all geologic units is included in Volume II.

from Hintze (1953) Stokes (1953)

SCALE 1:125 000



8



V 4
VI
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IV 2
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VII
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IV 5
II 5
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I 5
VII
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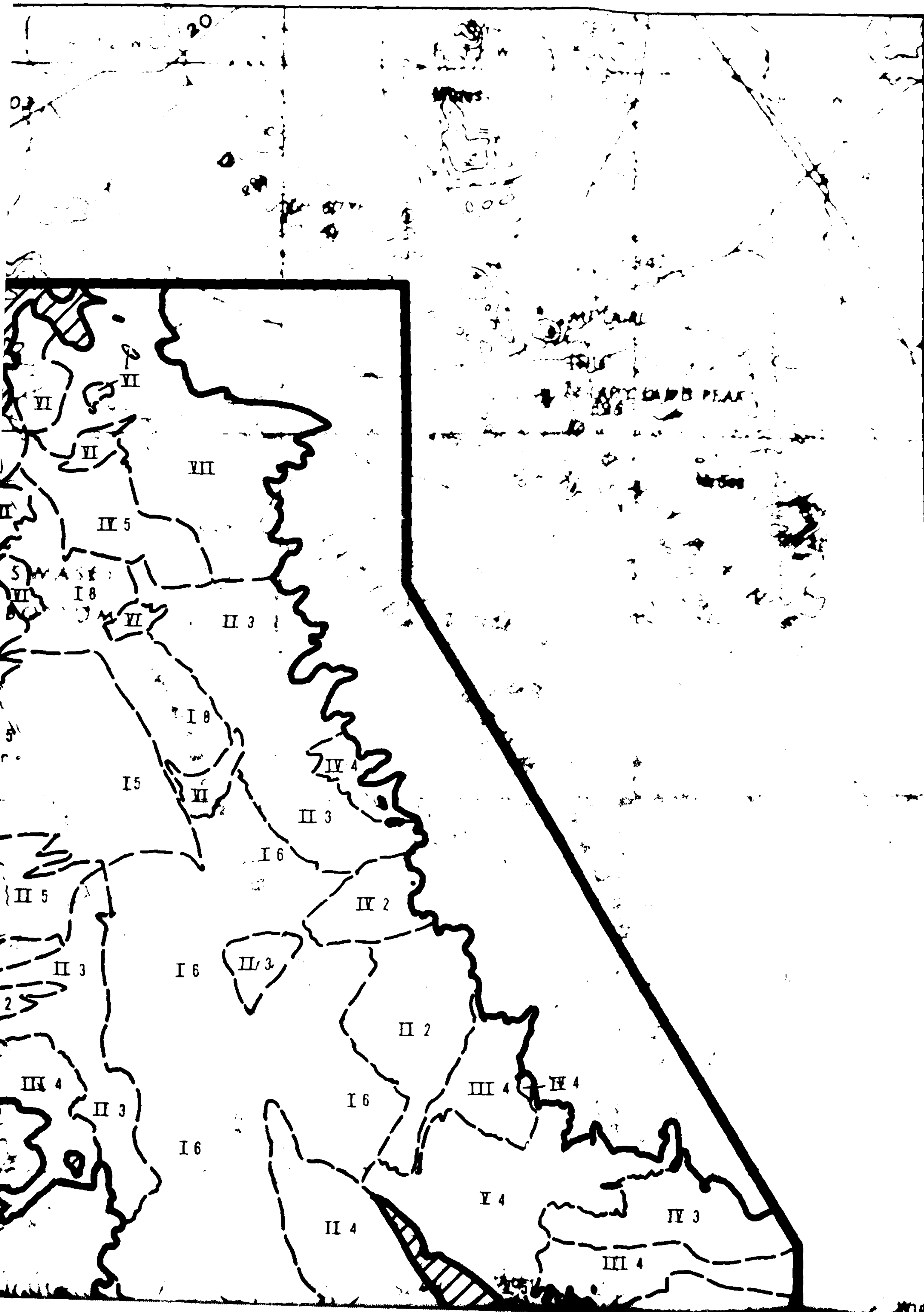

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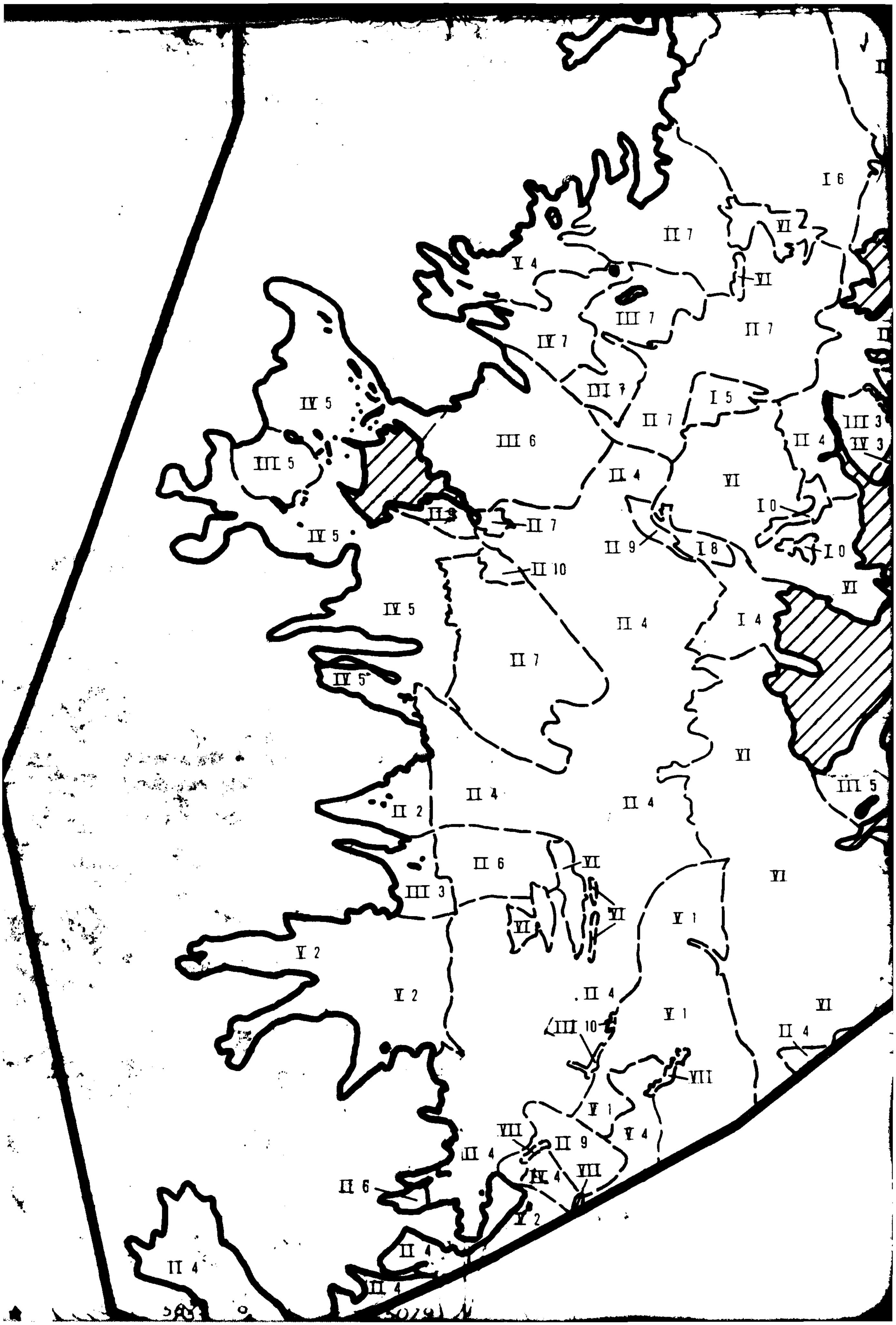
FN-TR-7-1A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I 0
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IV 5
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IV 5
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III 5
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II 4
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III 3
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V 1
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II 4
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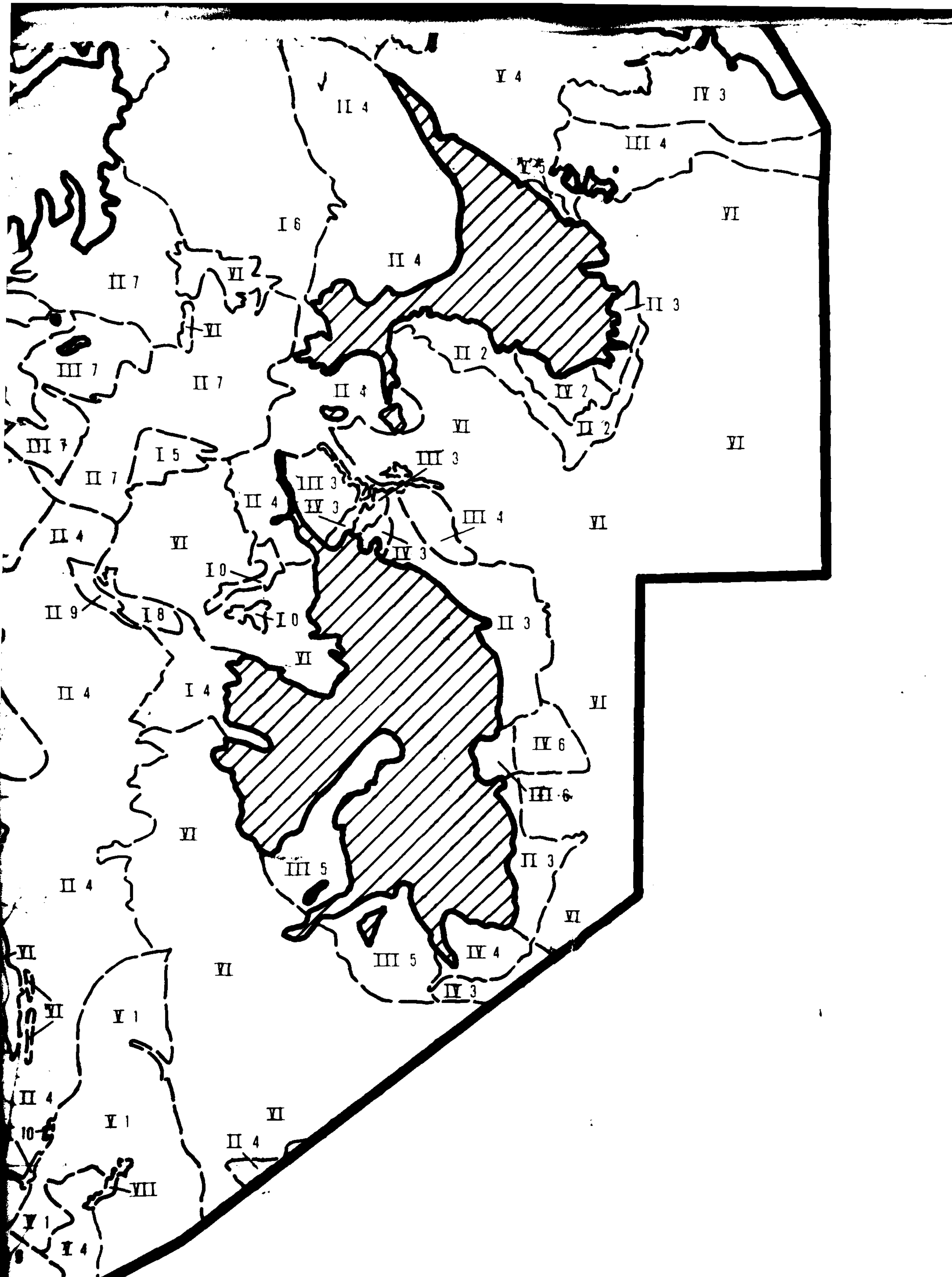
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I 5
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IV 3
III 4
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IV 3
I 0
II 9
I 8
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II 3
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I 4
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IV 6
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VI
III 5
II 3
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III 5
VI
IV 3
VI
V 1
II 4
V 1
VI
II 4
VIII
V 1
V 4
III

4

EXPLANATION

Terrain Category (see table below) ------ III 3 ------ Drainage spacing, i.e. the maximum n of drainages of the corresponding c occurring in a random traverse of o 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, WHIRLWIND
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMS
UGRO NATIONA

XPLANATION

——— 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)

tegories

sin-fill

isolated exposed rock.

this map are from. (1) field observations
phic maps and (3) 1:60 000 and 1:25 000
e scale of presentation and variability of
map is generalized

N

SCALE 1:125 000

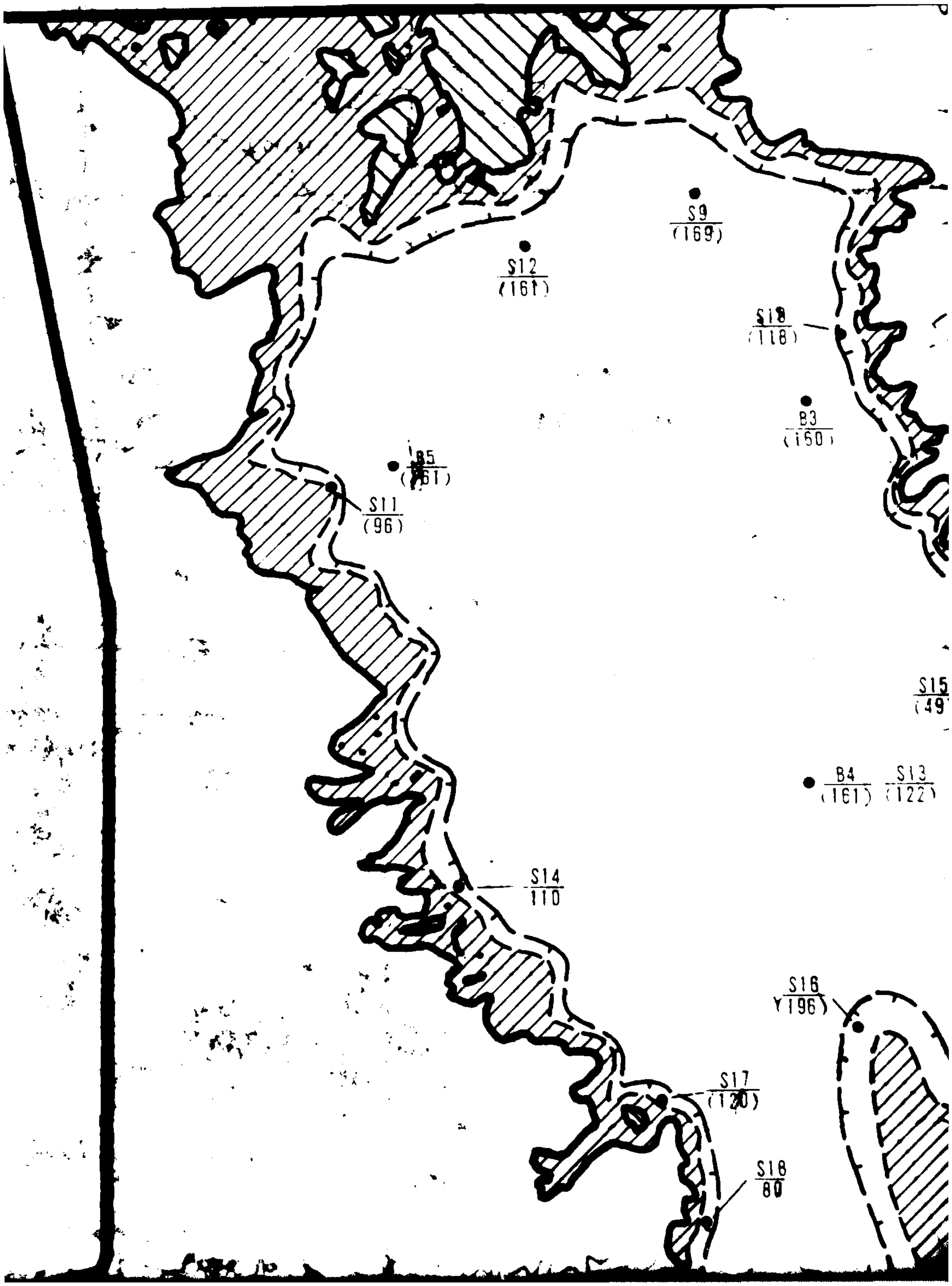
0 2 4

STATUTE MILES

0 2 4

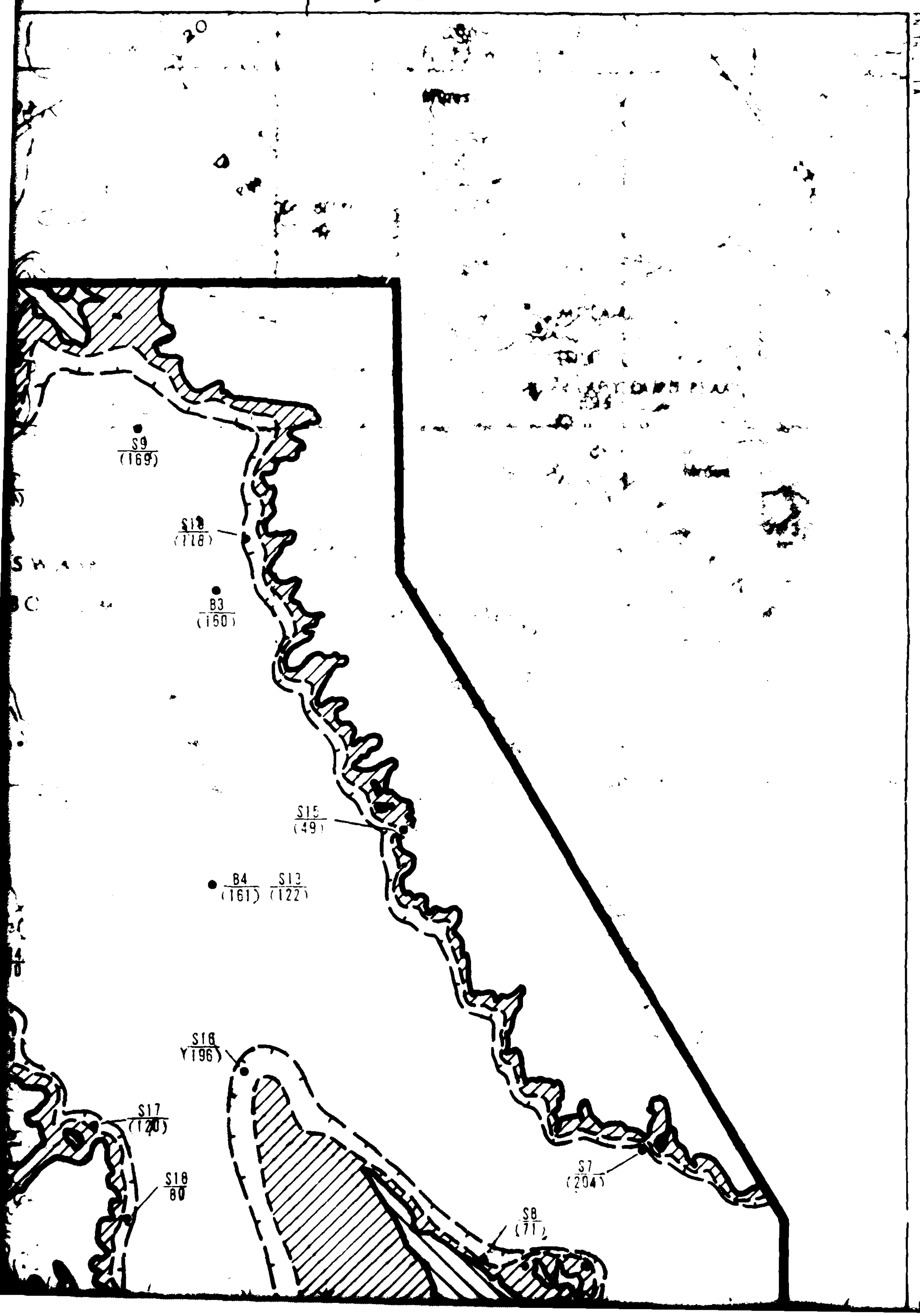
KILOMETERS

6



S9 (169)
S12 (161)
S10 (118)
B3 (150)
B5 (161)
S11 (96)
S15 (49)
B4 (161)
S13 (122)
S14 110
S16 (196)
S17 (120)
S18 80

2


S9
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(160)
S15
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B4
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S13
(122)
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S17
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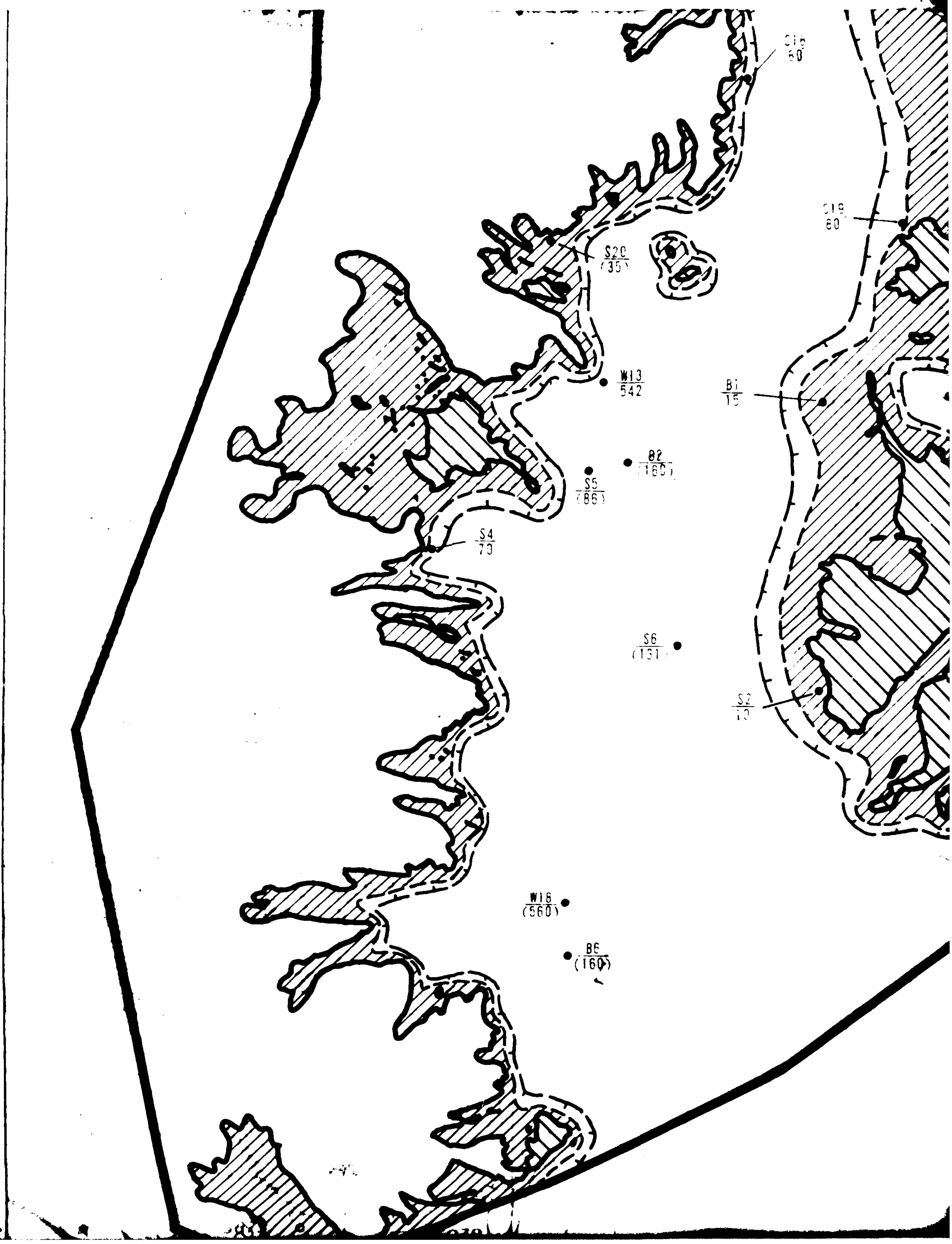
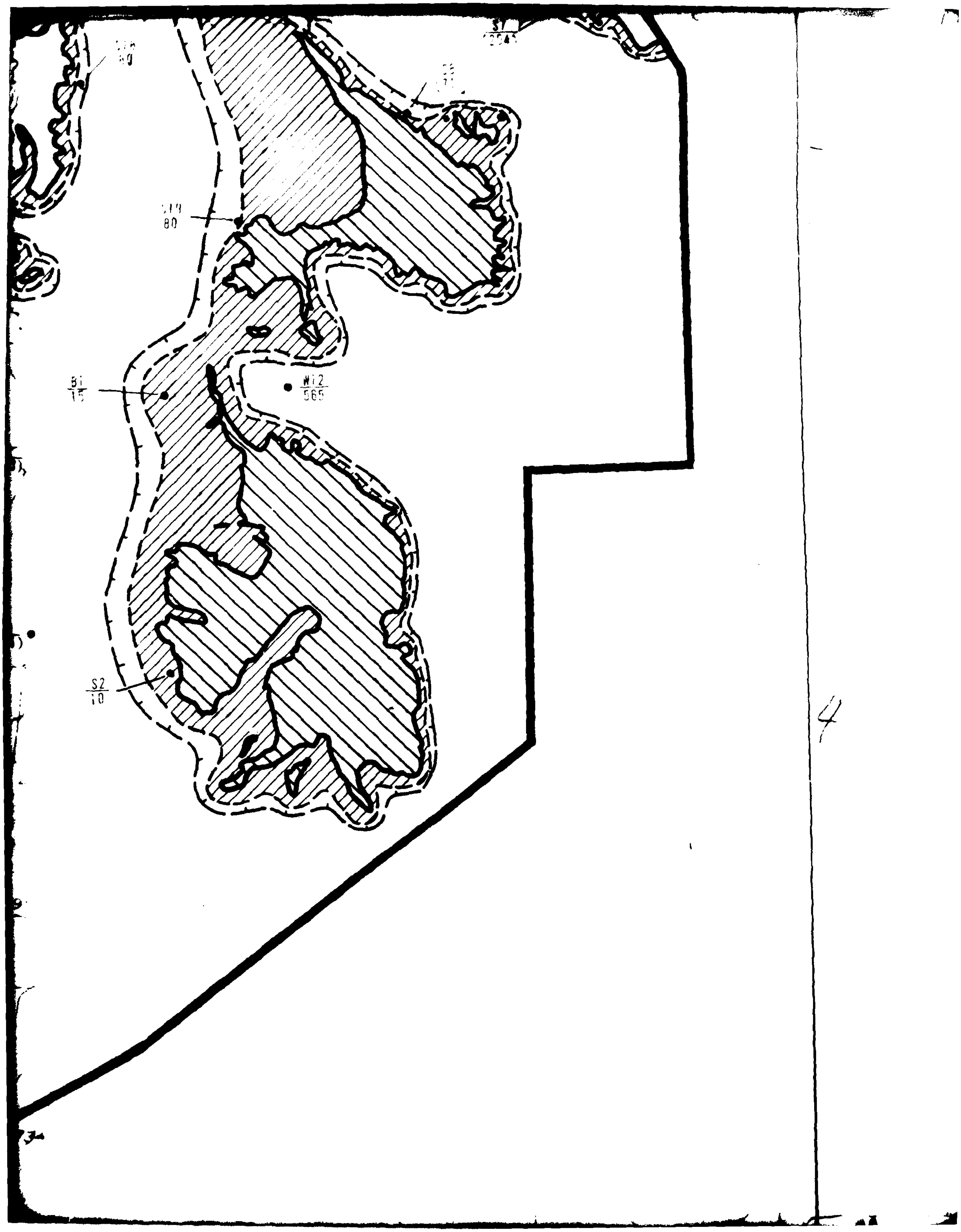
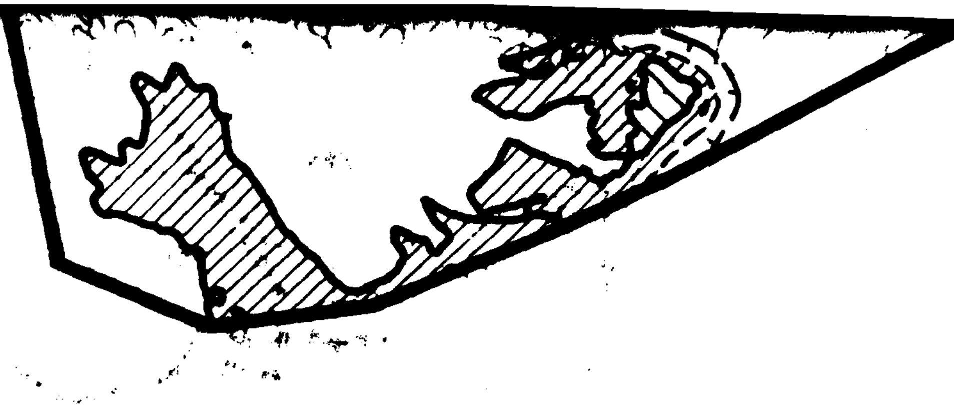
S7
(204)
S8
(71)



60
60
S20
(35)
W13
542
B1
15
B2
(160)
S5
(86)
S4
70
S6
(131)
S2
10
W16
(560)
B6
(160)


80
B1
15
W12
565
S2
10



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 indicates areas of isolated exposed rock

$\frac{S4}{75}$ 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, WHIRLWIND COP, UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

DRAWING
4-4

FUGRO NATIONAL, INC.

5

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ck at a depth of approximately
ading indicates rock less
.

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

and basin-fill

reas of isolated exposed rock

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

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

based on geologic interpretations
data points shown on the map Some
ur locations can be expected as
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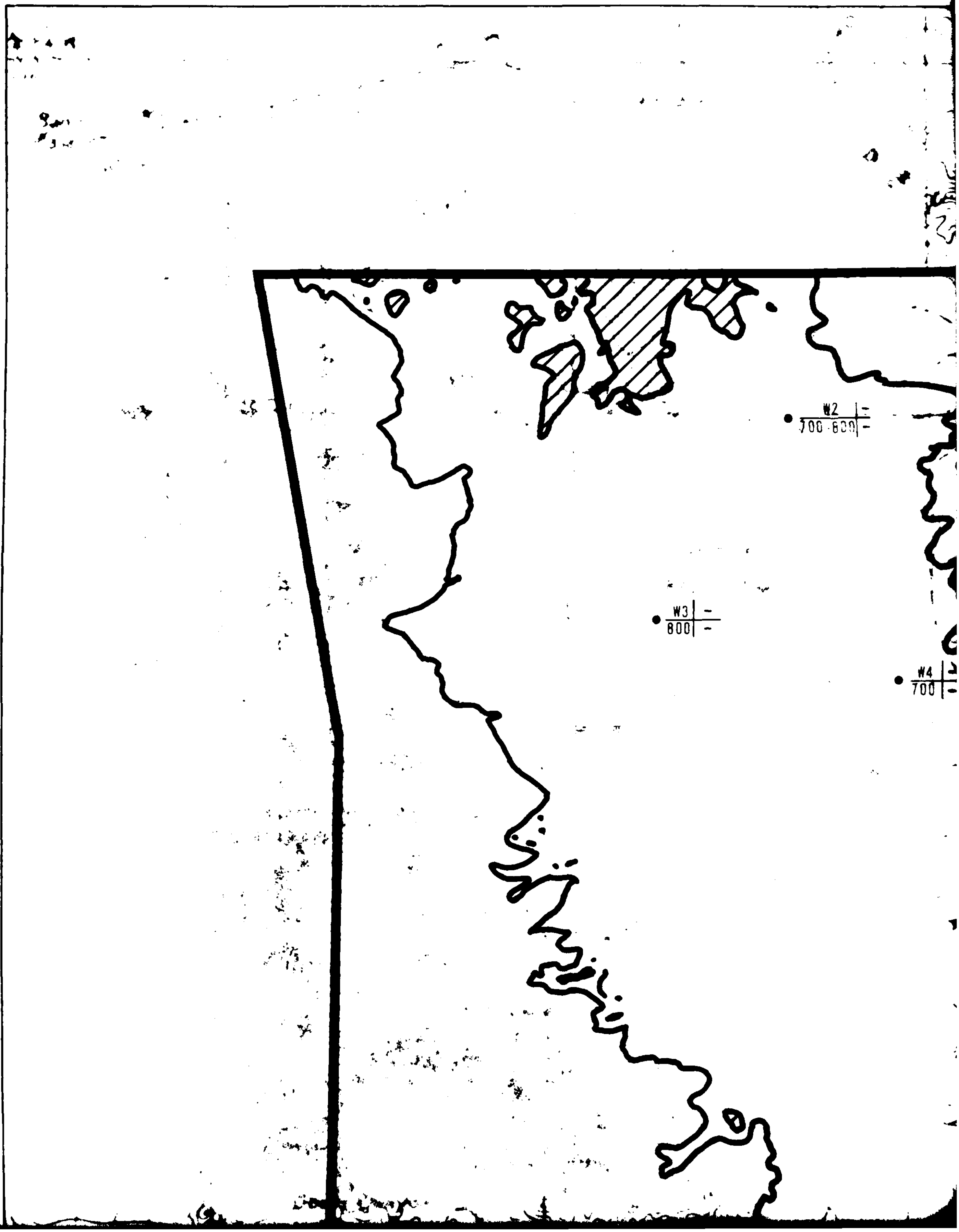
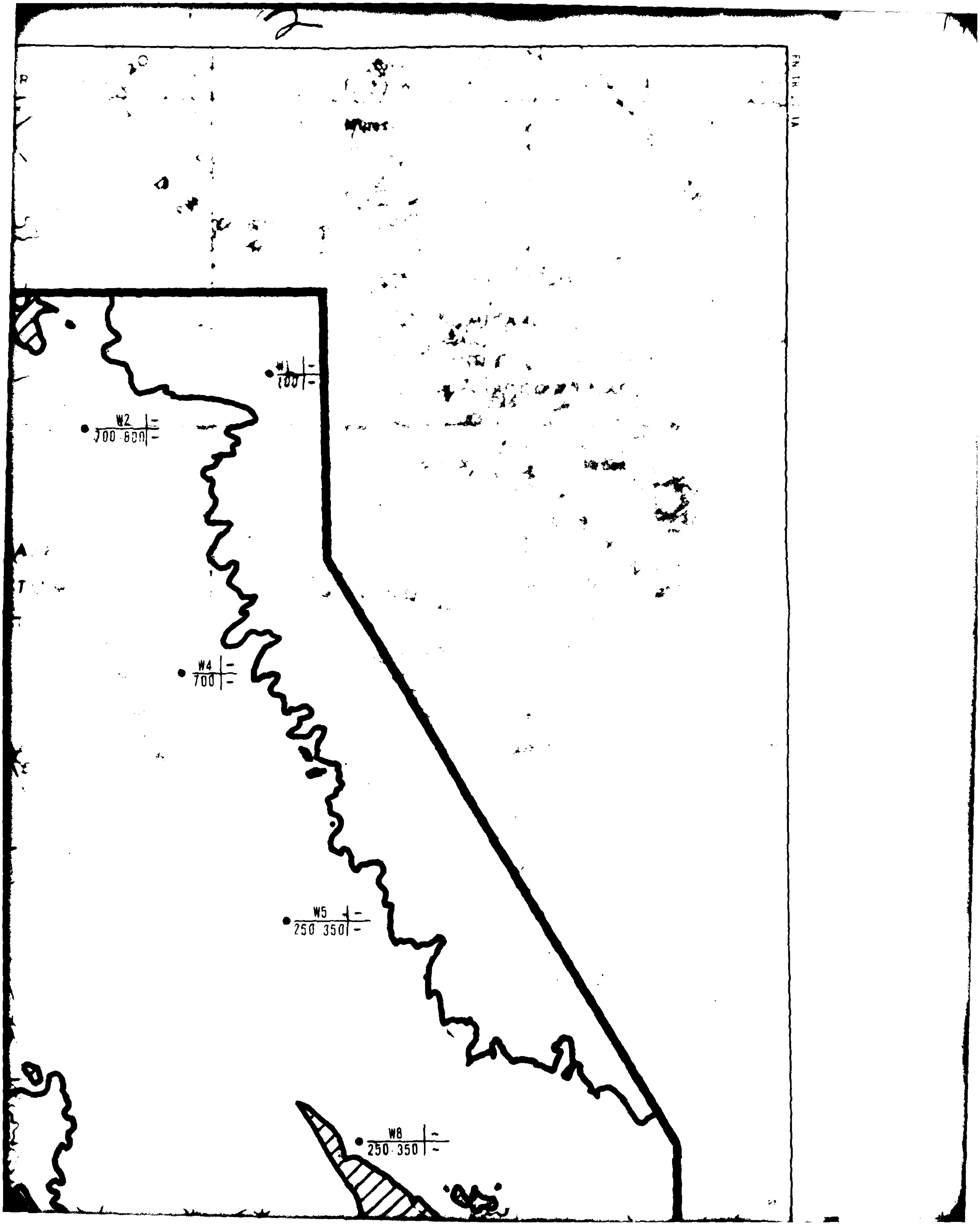
0 2 4
STATUTE MILES

0 2 4
KILOMETERS

16

2 JUL 79




W2
700-800
W4
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W5
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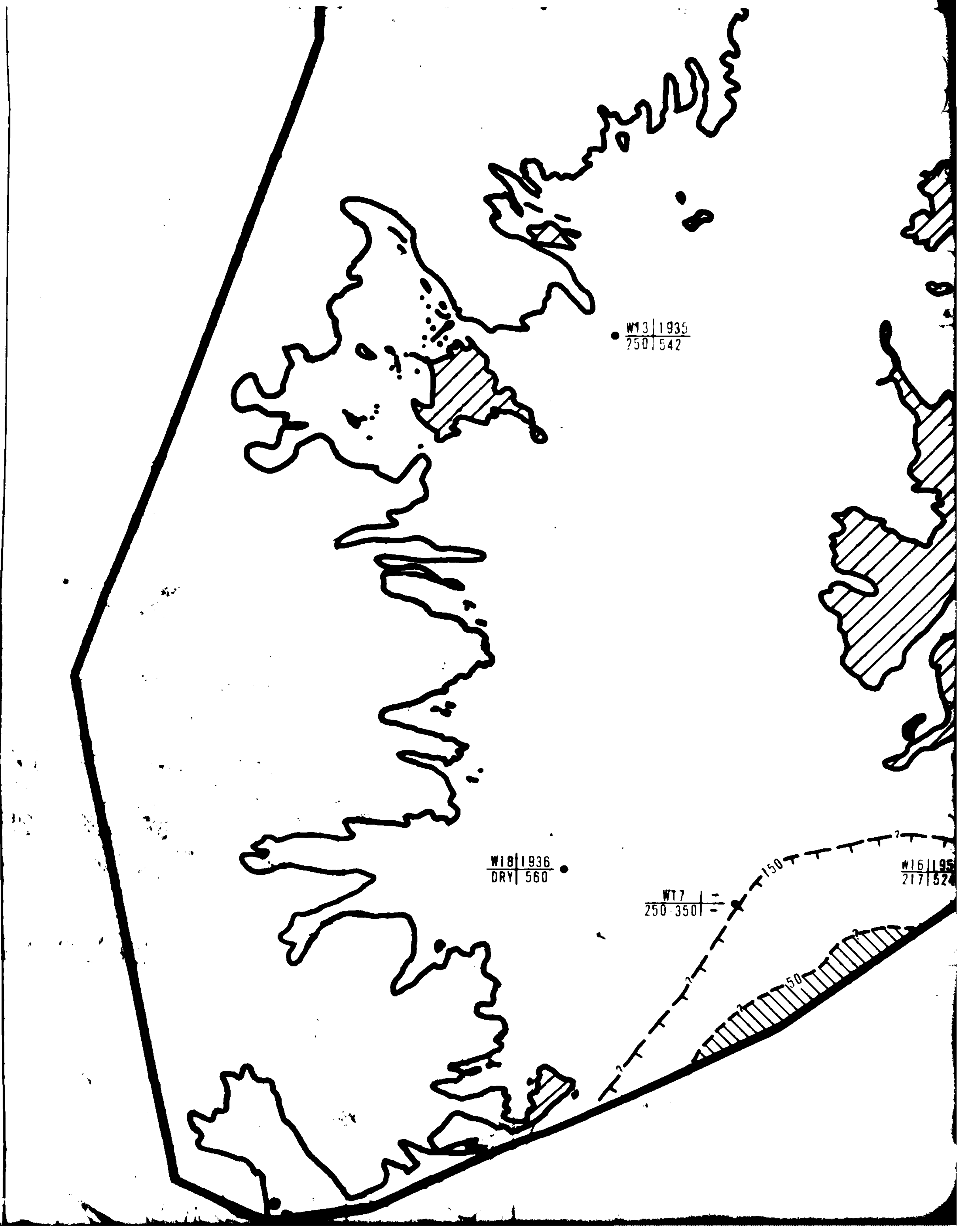
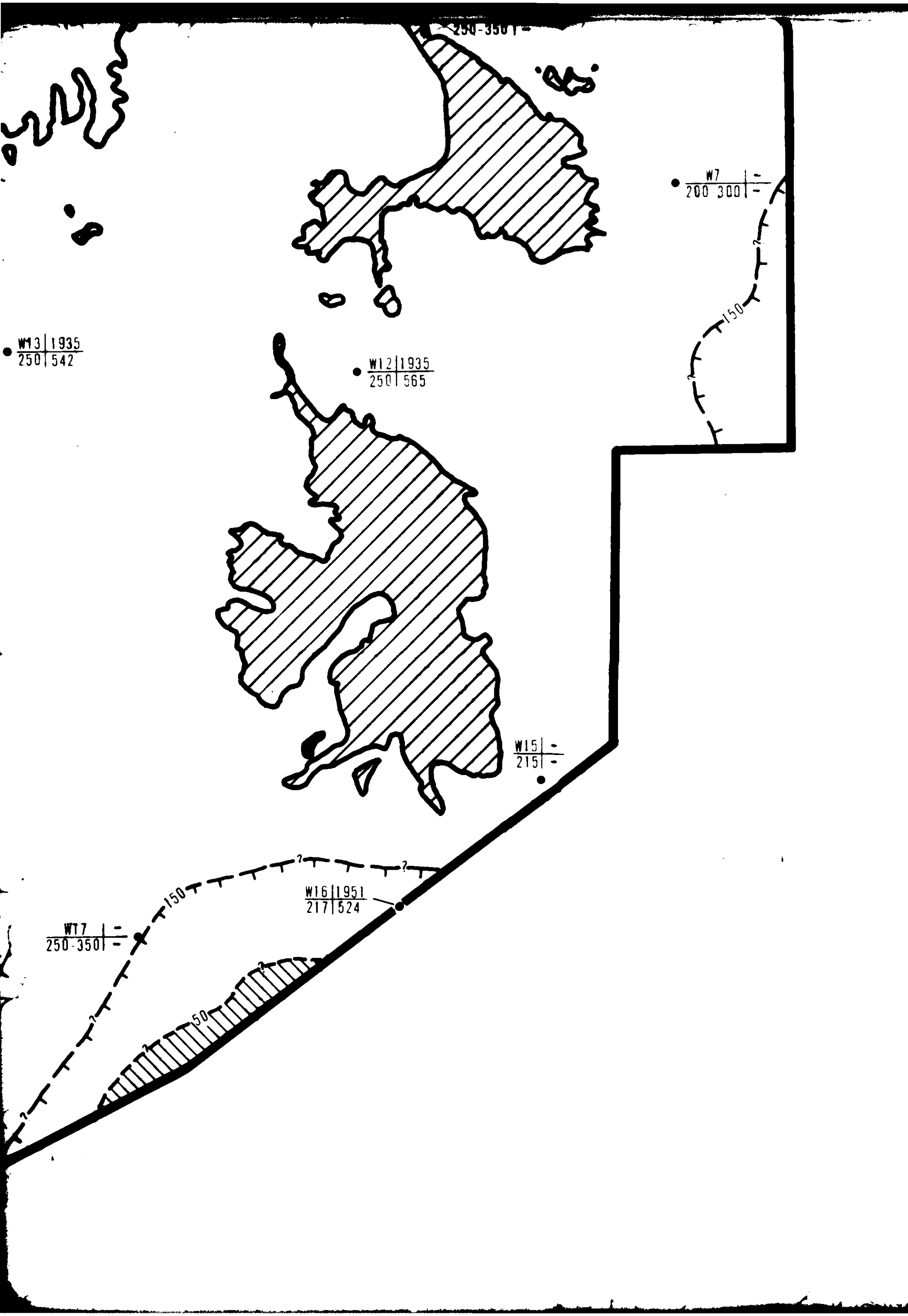
W8
250-350


W13 | 1935
250 | 542
W18 | 1936
DRY | 560
W17 | -
250-350 | -
150
50
W16
217


250-350 | -
W7 | -
200 300 | -
150
W13 | 1935
250 | 542
W12 | 1935
250 | 565
W15 | -
215 | -
W16 | 1951
217 | 524
150
W17 | -
250-350 | -
50

4

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	
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
75 | 700	
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, WHIRLWIND CDP, UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

DRAWING 4-5

FUGRO NATIONAL, INC.

5

N

it a depth of approximately
lata are extremely sparse.
feet (15m) to ground water.

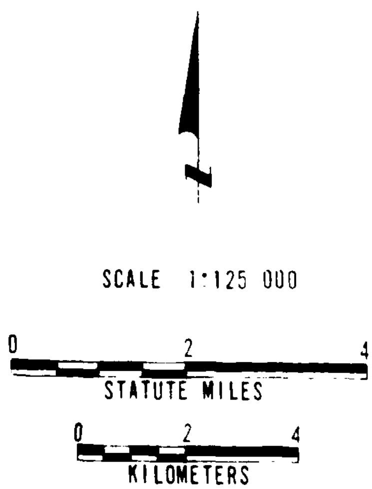
it a depth of approximately
data are extremely sparse.
150 feet (46m) to ground water.

fill.

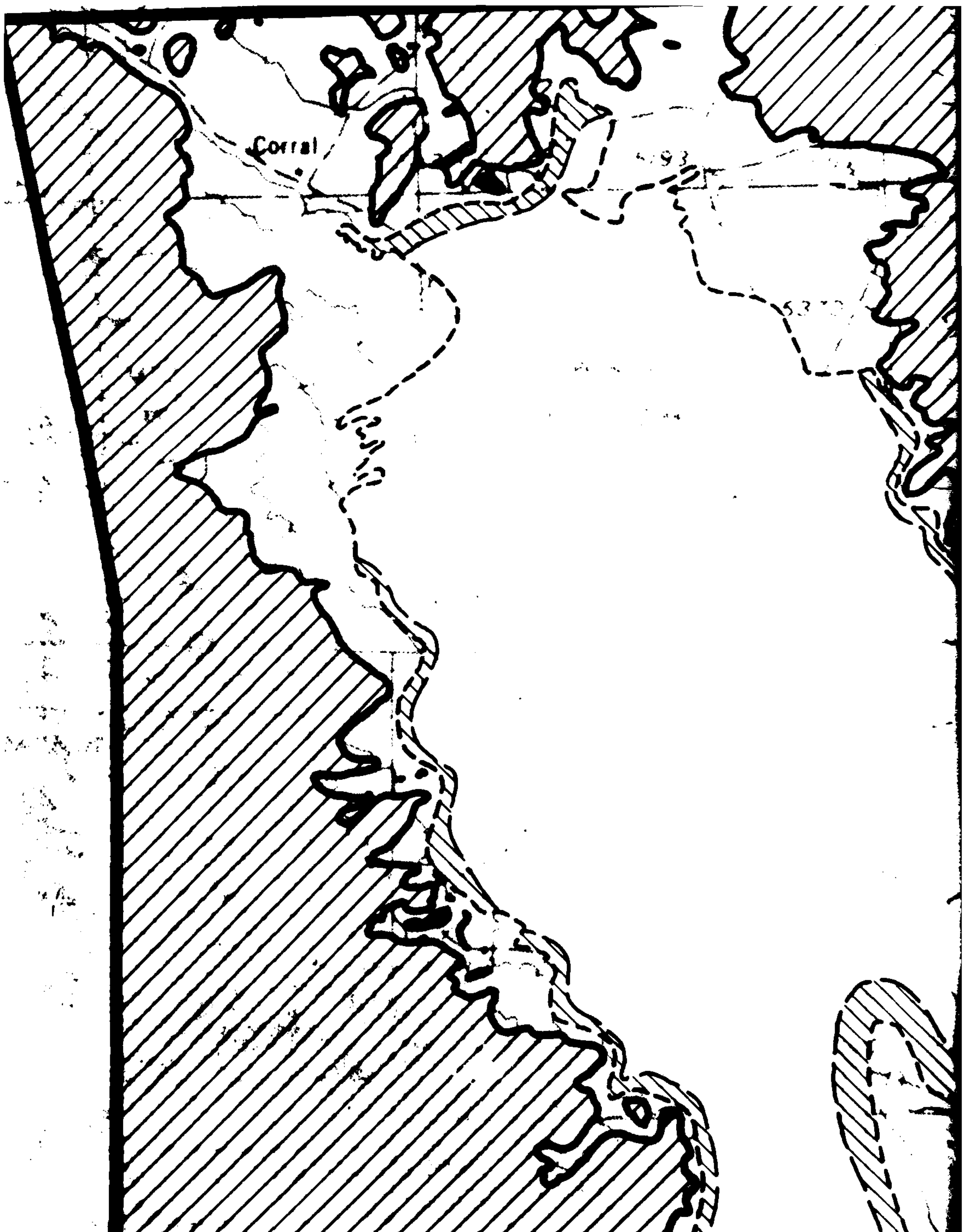
ated exposed rock.

seismic resistivity); see Volume II.	Year of water level measurement
	Depth of well (feet)

lv on the data points shown on the map
been used and it can be expected that
e as additional data are obtained



16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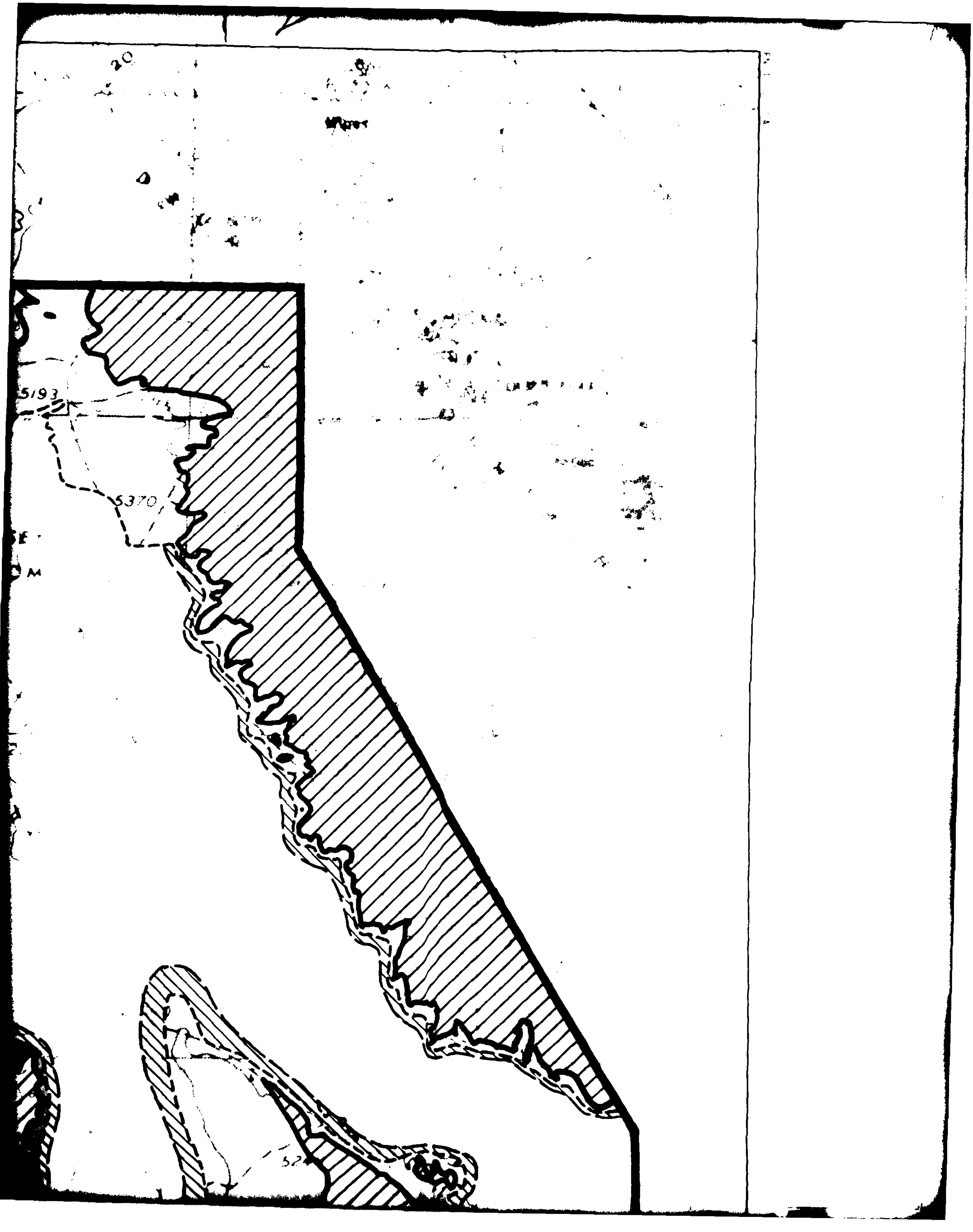
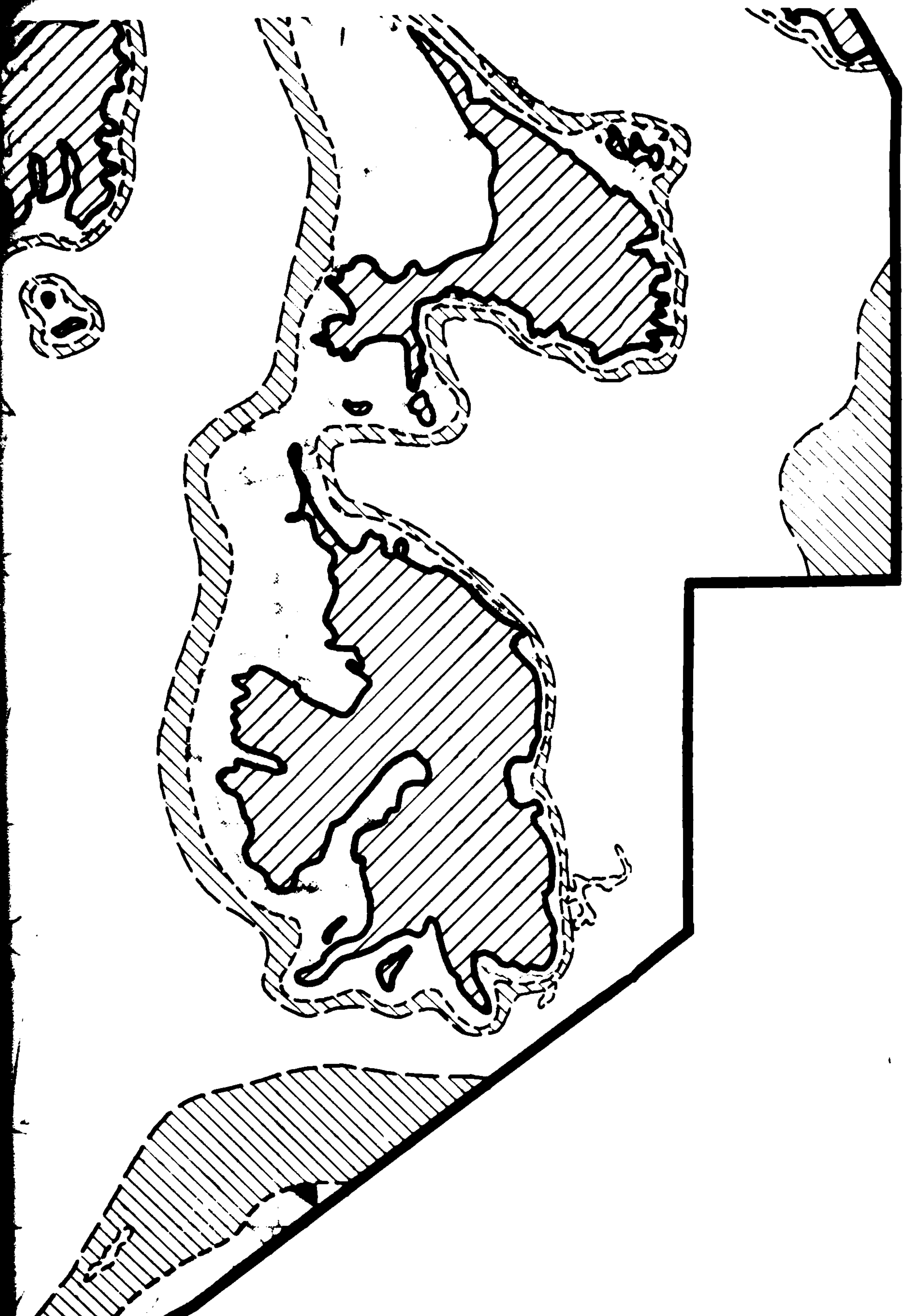
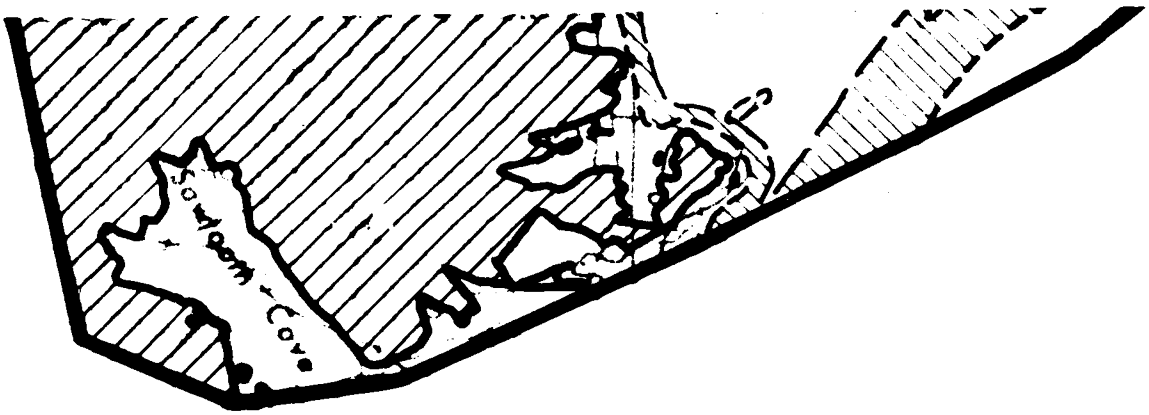


5193
5370





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 (45m).

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. (See Section A2.0 in Appendix for details of exclusion criteria)

Indicates areas of exposed rock.

Contact between rock and basin fill

SUITABLE AREA
HYBRID TRENCH AND VERTICAL SHELTER
VERIFICATION SITE, WHIRLWIND CDP, UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

DRAWING
4-6

FUGRO NATIONAL, INC.

ATION

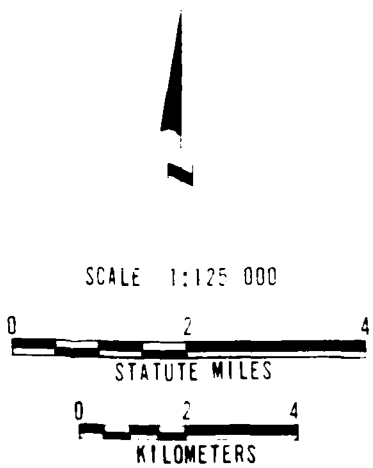
d trench and vertical shelter
rock and water greater than

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

hybrid trench and vertical
determined from application
ter, topographic terrain, and
ee Section A2.0 in Appendix
n criteria.)

ed rock.

basin fill.



5.0 SNAKE EAST CDP

5.1 GEOGRAPHIC SETTING

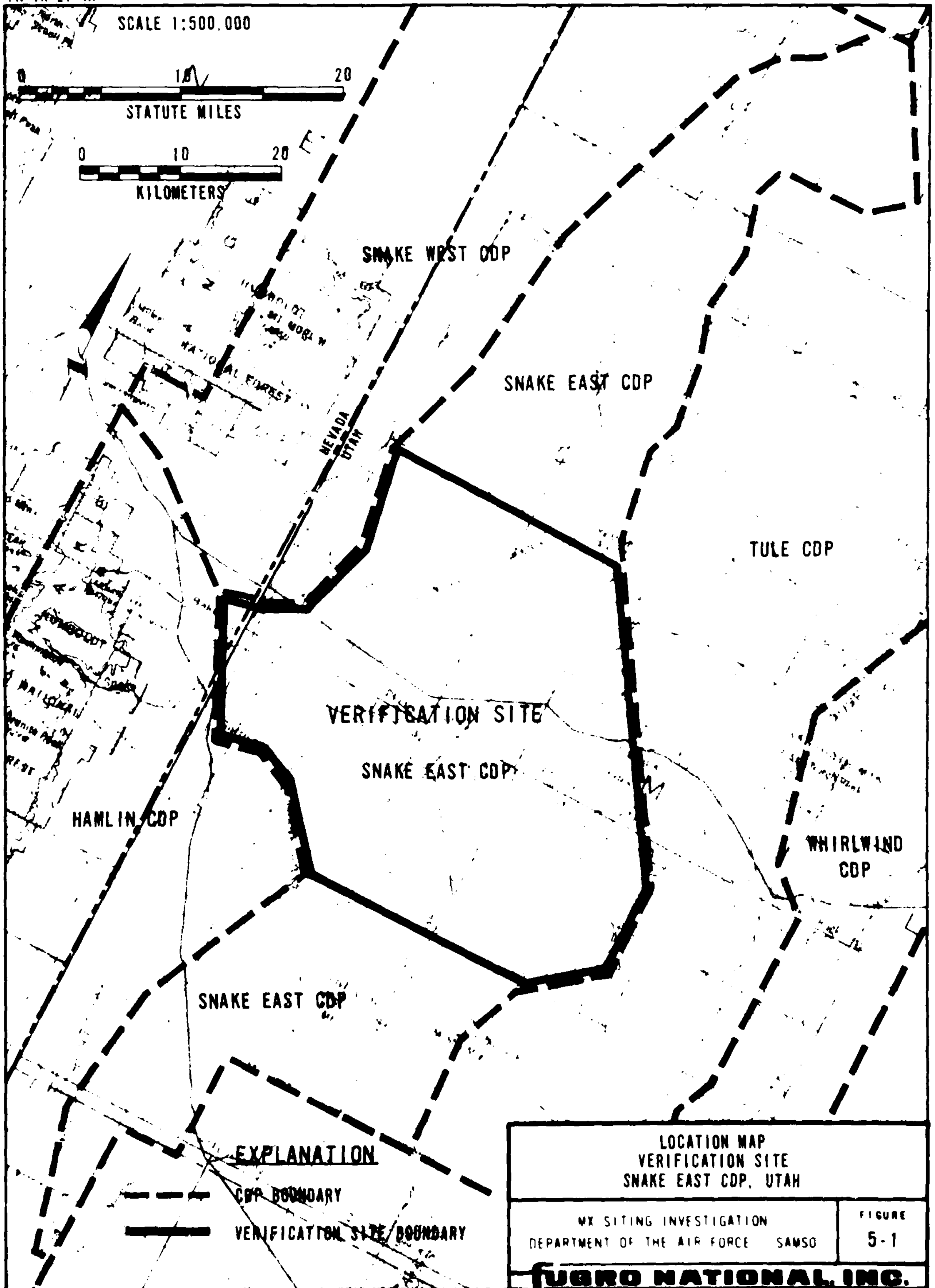
The Snake East CDP is located in western Millard and southwestern Juab counties, Utah, and in eastern White Pine County, Nevada (Figure 5-1). It is bounded on the east by the Conger and Confusion ranges, on the west by the axis of Snake Valley, and extends north and south from the Granite Mountains to the Burbank Hills and Desert Range Experimental Station, respectively. The Verification site is located primarily in Ferguson Desert and southeastern Snake Valley between north latitudes 38°51' and 39°13' (Figure 5-1). The CDP is located approximately 80 miles (130 km) from both Ely, Nevada, and Delta, Utah, on U.S. Highway 6/50. An extensive network of graded unpaved roads provides access throughout the CDP. Land is generally used for rangeland and minor agricultural activities.

5.2 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 5-1. Locations of the geophysical and engineering activities are shown in Drawing 5-1 (end of Section 5.0).

5.3 GEOLOGIC SETTING

Paleozoic limestones and dolomites with interbedded shale and sandstone are the dominant rock types in the Conger and Confusion ranges and Burbank Hills. Localized Tertiary basalt and conglomerate are located along the north side of the Burbank



LOCATION MAP
VERIFICATION SITE
SNAKE EAST CDP, UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 5-1

FUGRO NATIONAL, INC.

2 JUL 79

GEOLOGY AND GEOPHYSICS

TYPE OF ACTIVITY	NUMBER OF ACTIVITIES
Geologic mapping stations	77
Shallow refraction	18
Electrical resistivity	17
Gravity profiles	15

ENGINEERING-LABORATORY TESTS

TYPE OF TEST	NUMBER OF TESTS
Moisture/density	122
Specific gravity	4
Sieve analysis	92
Hydrometer	5
Atterberg limits	25
Consolidation	2
Unconfined compression	4
Triaxial compression	6
Direct shear	7
Compaction	7
CBR	7
Chemical analysis	12

ENGINEERING

NUMBER OF BORINGS	NOMINAL DEPTH FEET (METERS)
6	160 (49)
1	70 (21)
1	100 (30)
NUMBER OF TRENCHES	**NOMINAL DEPTH FEET (METERS)**
7	14 (4)
NUMBER OF TEST PITS	**NOMINAL DEPTH FEET (METERS)**
26	5 (2)
4	10 (3)
NUMBER OF CPTs	**RANGE OF DEPTH FEET (METERS)**
76	2-39 (1-12)
TYPE OF ACTIVITY	**NUMBER OF ACTIVITIES**
Surficial soil samples	33
Field CBR tests	0

SCOPE OF ACTIVITIES
VERIFICATION SITE, SNAKE EAST CDP, UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 5-1

FUGRO NATIONAL, INC.

Hills and these conglomerates may be extensive in the subsurface. Basin-fill sediments are derived chiefly from the Confusion Range located on the east side and the Conger Range and Burbank Hills to the west.

The mountains surrounding the site exhibit a strong north-northeast structural grain, primarily a product of Laramide deformation. Thrust faulting and west-dipping homoclinal beds are prevalent in the carbonate rocks of the Confusion Range. Basin and Range block faulting is obscure, but Hintze (1963) indicates several inferred basin-margin faults along the east side of the site concealed by alluvium. No active faults were observed in the Snake East CDP, and deeply embayed canyon reentrants with numerous outcrops suggest tectonic stability.

Basin-fill sediments at the site are primarily alluvial fan and lacustrine deposits. Much of the present morphology of alluvial surfaces and grain-size relationships of surface and subsurface soils below elevation 5200 feet (1585 m) m.s.l. has been modified by the presence of Lake Bonneville during late-Pleistocene time. An exploratory oil well located west of the site (T.20S, R.19W, sec. 19cd) indicates the basin-fill sediments attain a thickness of up to 4200 feet (1280 m) (Hood and Rush, 1965). Surficial basin-fill deposits (Drawing 5-2) generally consist of the following units (from oldest to youngest):

- Intermediate alluvial fan deposits - These fans form the most extensive deposits in the basin-fill sequence, covering about one-half of the site. Deposits are weakly cemented sands ranging from gravelly sand near the mountain fronts to silty sand toward the basin center.

- Older lacustrine deposits - These deposits consist of isolated sandy and gravelly shoreline deposits and sandy and fine-grained lakebed deposits of Lake Bonneville. They constitute about one-quarter of the site and occur along the valley axis and western edge of the site below elevation 5200 feet (1585 m).

- Eolian deposits, young alluvial fan deposits, and playa deposits - These units represent active deposits overlying preexisting intermediate alluvial fan deposits and older lacustrine deposits. Generally, eolian deposits are composed of sand, younger alluvial fan deposits of sands and gravels, and playa deposits of silts and clays although characteristics of these surficial units tend to merge with each other and sometimes with older units. Collectively, they constitute one-fourth of the total surficial basin fill in the site. Younger alluvial fan and playa deposits occur topographically below the highest Lake Bonneville shoreline. Eolian deposits overlie intermediate alluvial fan deposits in eastern Snake Valley.

5.4 SURFACE SOILS

The surficial soils of the Snake East site are predominantly coarse grained (granular) with appreciable amounts of fines. Soils from predominant surficial geologic units (Drawing 5-2) can be combined into the following three categories based on their physical and engineering characteristics:

1. Silty sands and clayey sands (from geologic units A4os, A5ys, and A5is);
2. Gravelly sands and sandy gravels (from geologic units A5ys, and A5is); and
3. Sandy silts and sandy clays (from geologic units A4of).

5.4.1 Characteristics

The characteristics of the surficial soils are summarized in Table 5-2. In addition to the physical properties, road design data, which consist of laboratory compaction and CBR test results, evaluation of the soils for road use, and extent of

SOIL DESCRIPTION		Silty Sands and Clayey Sands		Sandy Gravels and
USCS SYMBOLS		SM, SC		SM, GM
PREDOMINANT SURFICIAL GEOLOGIC UNITS		A4os, A5ys, A5is		A5ys, A5is
ESTIMATED AREAL EXTENT	%	60-80		15-25
PHYSICAL PROPERTIES				
COBBLES 3 - 12 inches (8 - 30 cm)	%	0-5		0-5
GRAVEL	%	0-25	[27]	18-64
SAND	%	34-75	[27]	23-69
SILT AND CLAY	%	19-48	[29]	7-26
LIQUID LIMIT		21-28	[2]	52
PLASTICITY INDEX		NP-7	[4]	18
ROAD DESIGN DATA				
MAXIMUM DRY DENSITY	pcf (kg/m3)	127.0-132.3 (2034-2119)	[5]	NDA
OPTIMUM MOISTURE CONTENT	%	7.5-10.3	[5]	NDA
CBR AT 90% RELATIVE COMPACTION	%	12-42	[5]	NDA
SUITABILITY AS ROAD SUBGRADE (1)		fair to good		good to very go
SUITABILITY AS ROAD SUBBASE OR BASE (1)		fair		fair to good
THICKNESS OF LOW STRENGTH SURFICIAL SOIL (2) — RANGE	ft (m)	0.7-5.5 (0.2-1.7)	[46]	0.8-3.2 (0.2-1.0)
THICKNESS OF LOW STRENGTH SURFICIAL SOIL (2) — AVERAGE	ft (m)	1.8 (0.5)	[46]	1.5 (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 5-3 for details.

NOTES: • [ ] -

• NDA - N...
n...

ıdy Gravels and Gravelly Sands		Sandy Silts and Sandy Clays		
, GM		ML, CL		
ys, A5is		A4of		
-25		5-10		
5		0-4		
-64	[8]	0-4	[2]	
-69	[8]	36-47	[2]	
28	[8]	53-64	[4]	
	[1]	23-38	[3]	
	[1]	NP-17	[4]	
IA		119.5-127.0 (1914-2034)	[2]	
IA		12.8-14.0	[2]	
IA		8-10	[2]	
ood to very good		poor		
ir to good		not suitable		
8-3.2 (.2-1.0)	[15]	0.3-5.0 (0.1-1.5)	[9]	
5 (.5)	[15]	2.3 (0.7)	[9]	

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

CHARACTERISTICS OF SURFICIAL SOILS
VERIFICATION SITE, SNAKE EAST CDP, UTAH

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TABLE 5-2

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AFV-19

1 2

low strength surficial soils, are included in the table. Gradation ranges of the surficial soils are shown in Figure 5-2.

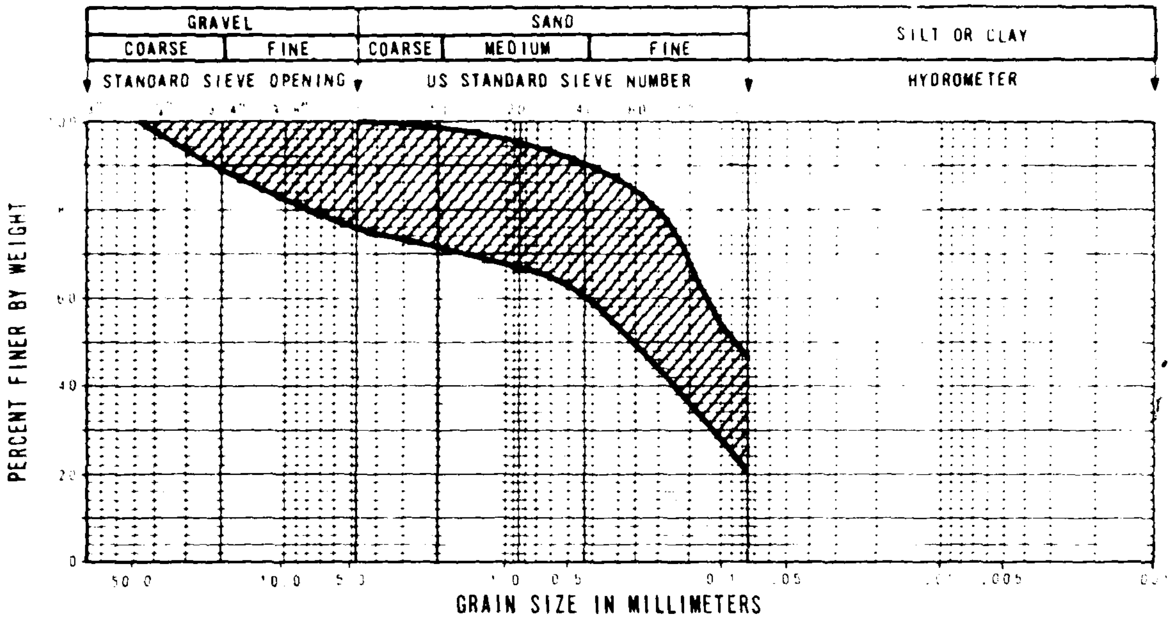
Silty sands and clayey sands are the predominant surficial soils covering between 60 and 80 percent of the site. These fine to coarse sands consist primarily of intermediate and young alluvial fan deposits. Gravel content of these soils is higher near the mountain fronts, decreasing gradually with increasing distance from the mountain fronts. Fines content in these soils is highest near the valley center. They range from nonplastic to slightly plastic.

Gravelly sands and sandy gravels are found in approximately 15 to 25 percent of the site. These soils are present mainly in the alluvial fans near the mountains and in the Pleistocene Lake Bonneville bar and shoreline deposits. Gravels are composed predominantly of durable carbonate sedimentary rocks. These soils are generally poorly graded and contain nonplastic fines.

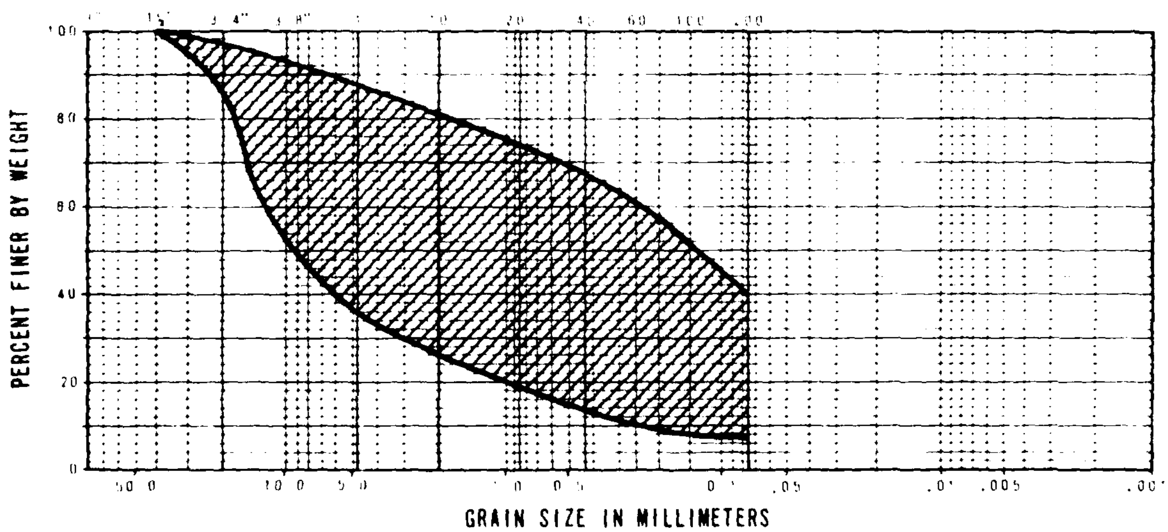
Sandy silts and sandy clays cover approximately 5 to 10 percent the site near the valley center. Most of these soils are lakebed deposits extending along a narrow band from the northwest to southeast corner of the site (Drawing 5-2). These soils have appreciable amounts of fine sand and their plasticity ranges from none to high.

5.4.2 Low Strength Surficial Soil

Based on cone penetrometer test results and soil classification, thickness of low strength surficial soil at each CPT location



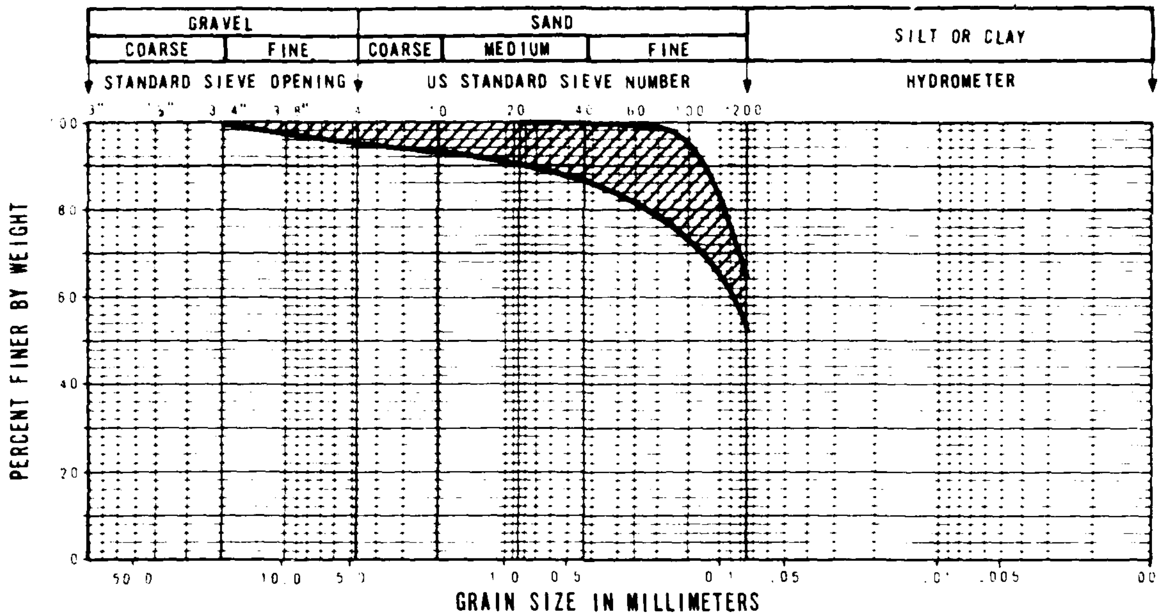
SOIL DESCRIPTION: Silty Sands and Clayey Sands
from 0 to 2 feet (0.0 to 0.6m)



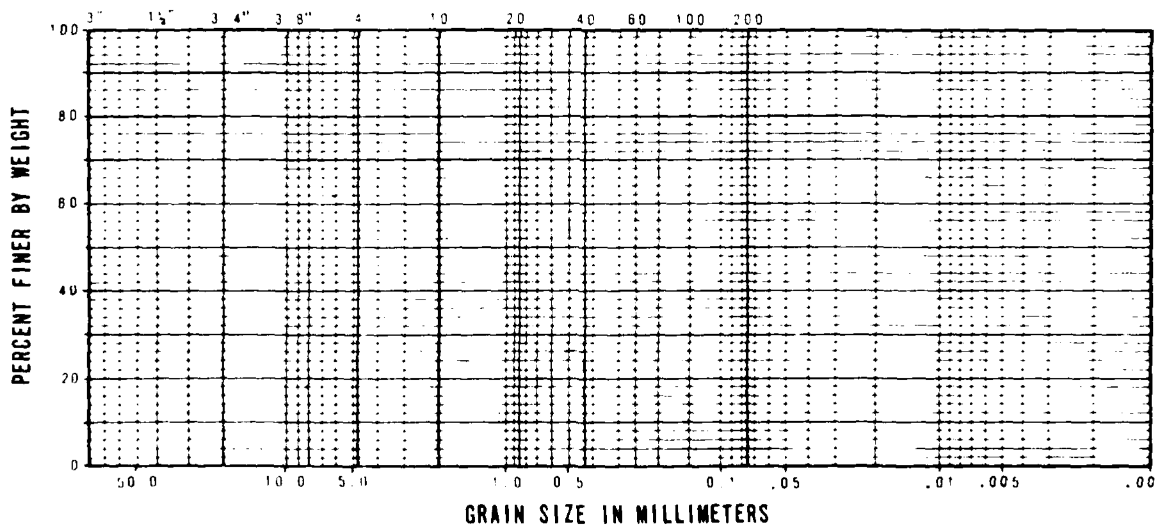
SOIL DESCRIPTION: Gravelly Sands and Sandy Gravels
from 0 to 2 feet (0.0 to 0.6m)

RANGE OF GRADATION OF SURFICIAL SOILS VERIFICATION SITE, SNAKE EAST CDP, UTAH	
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE SAMSO	FIGURE 5-2

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, SNAKE EAST CDP, UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 5-2

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was estimated and is presented in Table 5-3. Range and average values for the three soil categories are presented in Table 5-2. Depending on the extent of calcium carbonate cementation, the granular soils at the site exhibit low strength to depths ranging from 0.7 to 5.5 feet (0.2 to 1.7 m) with an average depth of 1.7 feet (0.5 m). Fine-grained soils exhibit low strength to depths ranging from 0.3 to 5.0 feet (0.1 to 1.5 m) and averaging 2.3 feet (0.7 m) below ground surface.

5.5 SUBSURFACE SOILS

Subsurface soils are predominantly coarse grained (granular), consisting of sandy gravels, gravelly sands, silty sands, and clayey sands. Fine-grained soils consisting of silts and clays occur as interbeds in the lakebed deposits along the central portion of the site. The composition of subsurface soils with depth, as determined from borings, test pits, and trenches, is illustrated by soil profiles shown in Figures 5-3 through 5-5.

Results of seismic refraction and electrical resistivity surveys are summarized in Table 5-4. Characteristics of the subsurface soils, as determined from field and laboratory tests, are presented in Table 5-5. Ranges of gradation of the soils are shown in Figure 5-6.

The coarse-grained subsurface soils are generally poorly graded with coarse to fine sands and gravels. These soils are chiefly alluvial fan deposits but may contain interbedded lacustrine deposits at elevations below 5200 feet. They are dense to very dense below depths of approximately 10 feet (3 m). Variable

CONE PENETROMETER TEST NUMBER (1)	THICKNESS OF LOW STRENGTH SURFICIAL SOIL (2)		SOIL TYPE (3)
	FEET	METERS	
C-1	2.2	0.7	SC-SM GP-GM
C-2	4.4	1.3	CL CH
C-3	1.5	0.5	GP
C-4	1.2	0.4	SM GM
C-5	1.5	0.5	SM GM
C-6	1.0	0.3	SM
C-7	0.9	0.3	SM
C-8	1.6	0.5	SM GP
C-9	1.5	0.5	SM GP
C-10	2.9	0.9	CL ML SW-SM
C-11	2.2	0.7	SM
C-12	2.8	0.8	SM GP-GM
C-13	2.3	0.7	SM GP
C-14	2.0	0.6	SM
C-15	2.1	0.6	CL GM
C-16	2.7	0.8	CL GM
C-17	1.3	0.4	SM GP-GM
C-18	0.9	0.3	CL GC
C-19	1.0	0.3	SM GP
C-20	1.8	0.5	GM
C-21	3.2	1.1	SM GP-GM
C-22	1.1	0.3	SM SC
C-23	0.9	0.3	SM CL
C-24	1.2	0.4	CH
C-25	5.0	1.5	CL
C-26	2.9	0.9	SM GM
C-27	2.2	0.7	SM GM
C-28	4.0	1.2	SM ML

CONE PENETROMETER TEST NUMBER (1)	THICKNESS OF LOW STR… SURFICIAL SOIL …	
	FEET	METE…
C-29	2.0	0.
C-30	1.1	0.
C-31	0.9	0.
C-32	2.5	0.
C-33	1.1	0.
C-34	1.4	0.
C-35	1.2	0.
C-36	1.4	0.
C-37	2.3	0.
C-38	1.6	0.
C-39	0.7	0.
C-40	1.0	0.
C-41	0.8	0.
C-42	0.9	0.
C-43	0.7	0.
C-44	1.0	0.
C-45	1.3	0.
C-46	2.0	0.
C-47	2.2	0.
C-48	1.2	0.
C-49	1.3	0.
C-50	1.2	0.
C-51	0.9	0.
C-52	1.1	0.
C-53	1.8	0.
C-54	1.8	0.
C-55	9.0	2.
C-56	1.8	0.

(1) For Cone Penetrometer Test locations, see Drawing 5-1, 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:
- For fin… strength… of the …
- SM GM – …
- NDA – …

KNESS OF LOW STRENGTH SURFICIAL SOIL (2)		SOIL TYPE (3)
EET	METERS	
2.0	0.6	SM
1.1	0.3	SM GP-GM
0.9	0.3	SM
2.5	0.8	SC-SM
1.1	0.3	SM GP-GM
1.4	0.4	SM
1.2	0.4	SM
1.4	0.4	SM GP-GM
2.3	0.7	SM GP-GM
1.6	0.5	SM GP-GM
0.7	0.2	SM
1.0	0.3	SM
0.8	0.3	GM
0.9	0.3	SM
0.7	0.2	SM
1.0	0.3	SM
1.3	0.4	SM GP-GM
2.0	0.6	SM GP
2.2	0.7	SM SP
1.2	0.4	SM GP
1.3	0.4	SM GM
1.2	0.4	SM GM
0.9	0.3	SM
1.1	0.3	GM SM
1.8	0.5	SM
1.8	0.5	SM
9.0	2.7	SM
1.8	0.5	SM

CONE PENETROMETER TEST NUMBER (1)	THICKNESS OF LOW STRENGTH SURFICIAL SOIL (2)		SOIL TYPE (3)
	FEET	METERS	
C-57	2.0	0.6	SM
C-58	1.0	0.3	SM
C-59	1.1	0.3	SM
C-60	0.9	0.3	SM GP
C-61	5.5	1.7	SM
C-62	0.3	1.0	ML CL
C-63	1.8	0.5	SM GP
C-64	1.9	0.6	SM
C-65	1.2	0.4	SM SP
C-66	1.4	0.4	CL SM
C-67	2.9	0.9	SM
C-68	1.7	0.5	SM GP-GM
C-69	1.3	0.4	SM
C-70	1.2	0.4	SC GP
C-71	2.9	0.9	SC GP
C-72	1.0	0.3	SM SP-SM
C-73	1.1	0.3	SM SP-GM
C-74	1.7	0.5	SM
C-75	2.9	0.9	SM
C-76	1.0	0.3	GM

TES:
- 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, SNAKE EAST CDP, UTAH

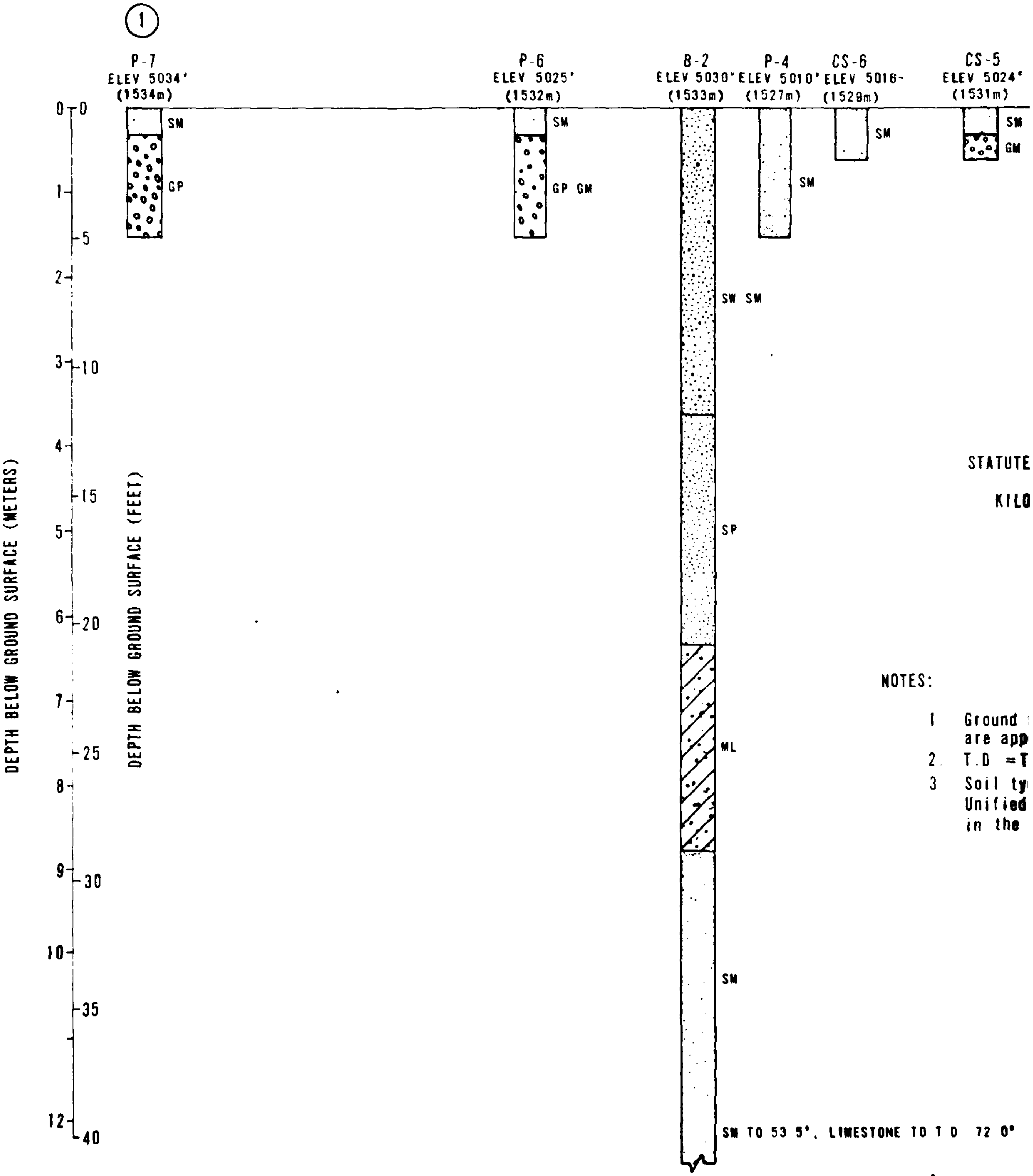
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 5-3

FUGRO NATIONAL, INC.

AFV-21

1 2



STATUTE

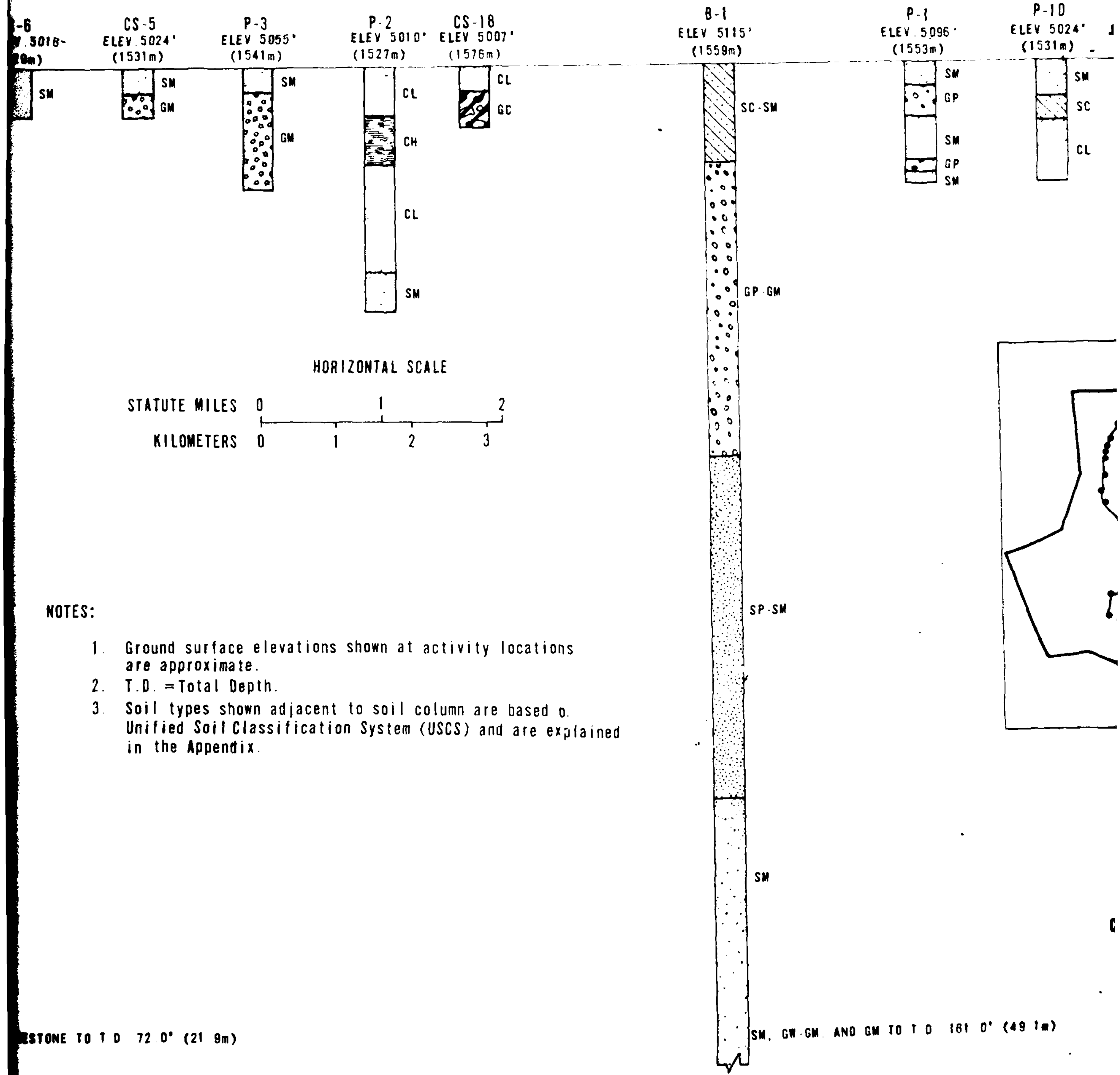
KILO

NOTES:

1 Ground
are app

2. T.D =T

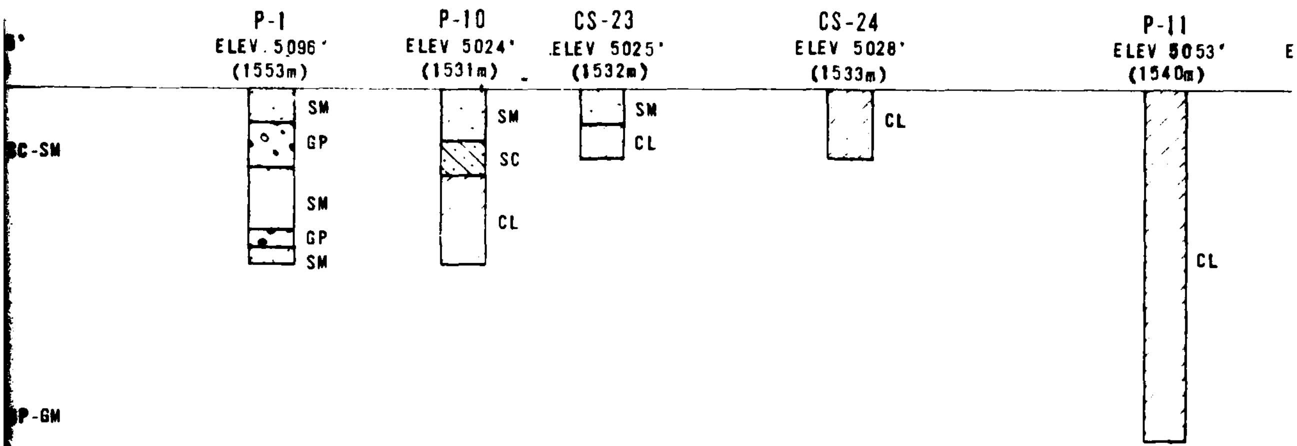
3 Soil ty
Unified
in the

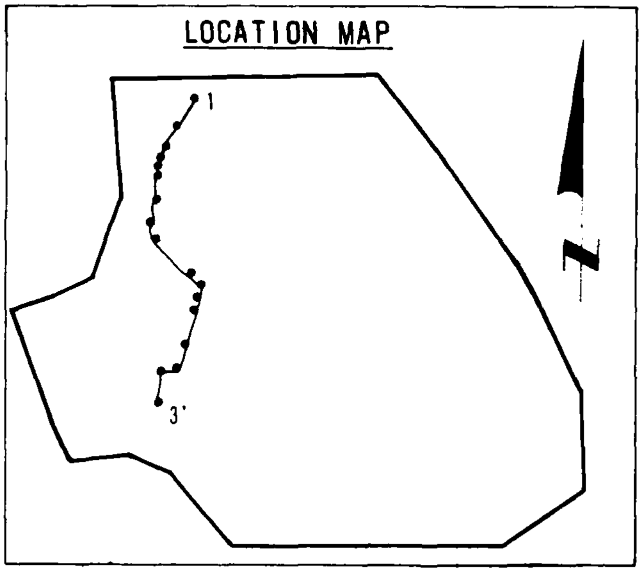


NOTES:

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 o. Unified Soil Classification System (USCS) and are explained in the Appendix.

17





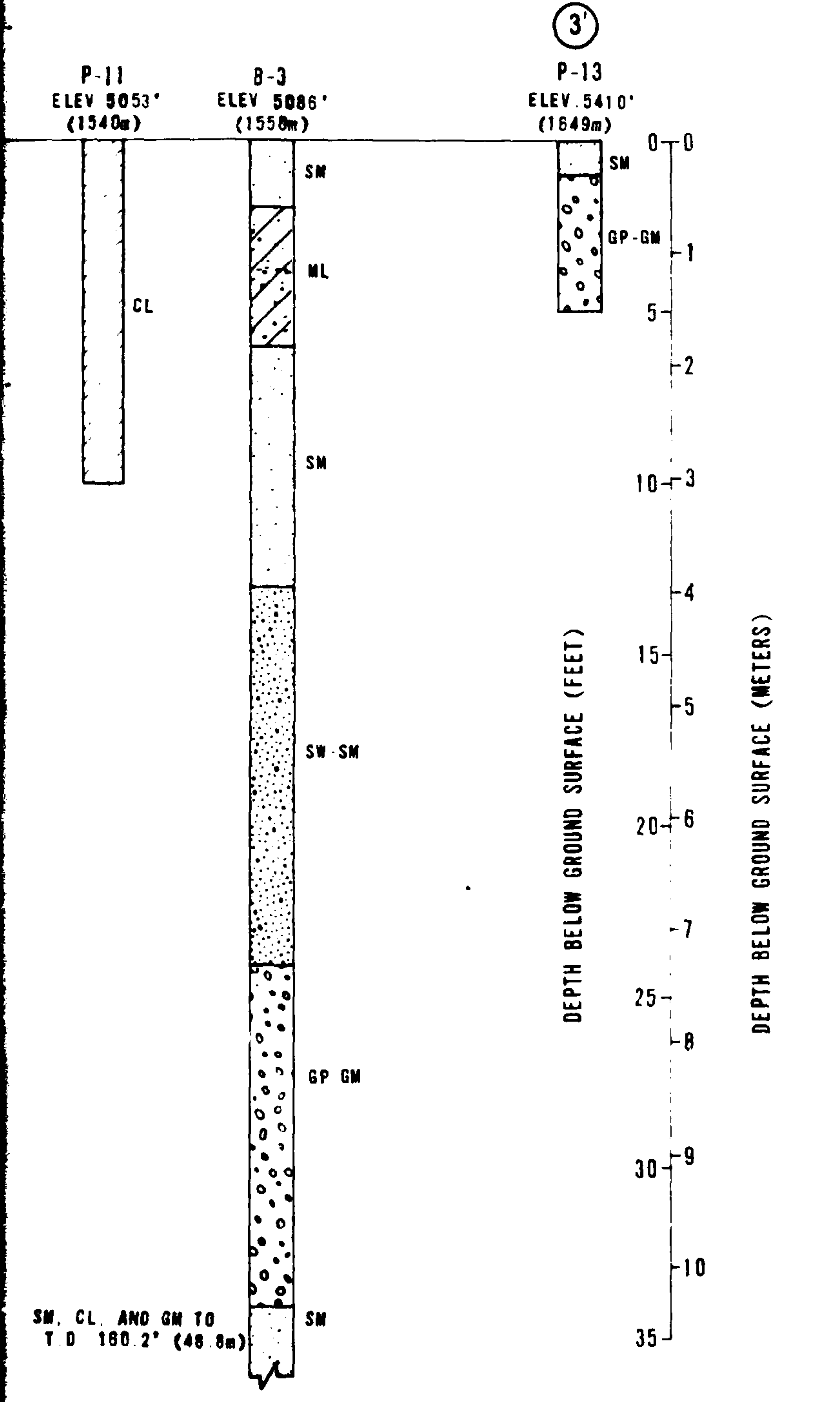
EXPLANATION

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

SM, CL, AND GM TO T.D 160.2' (48.

GW-GM, AND GM TO T D 161 0' (49 1m)

1 3

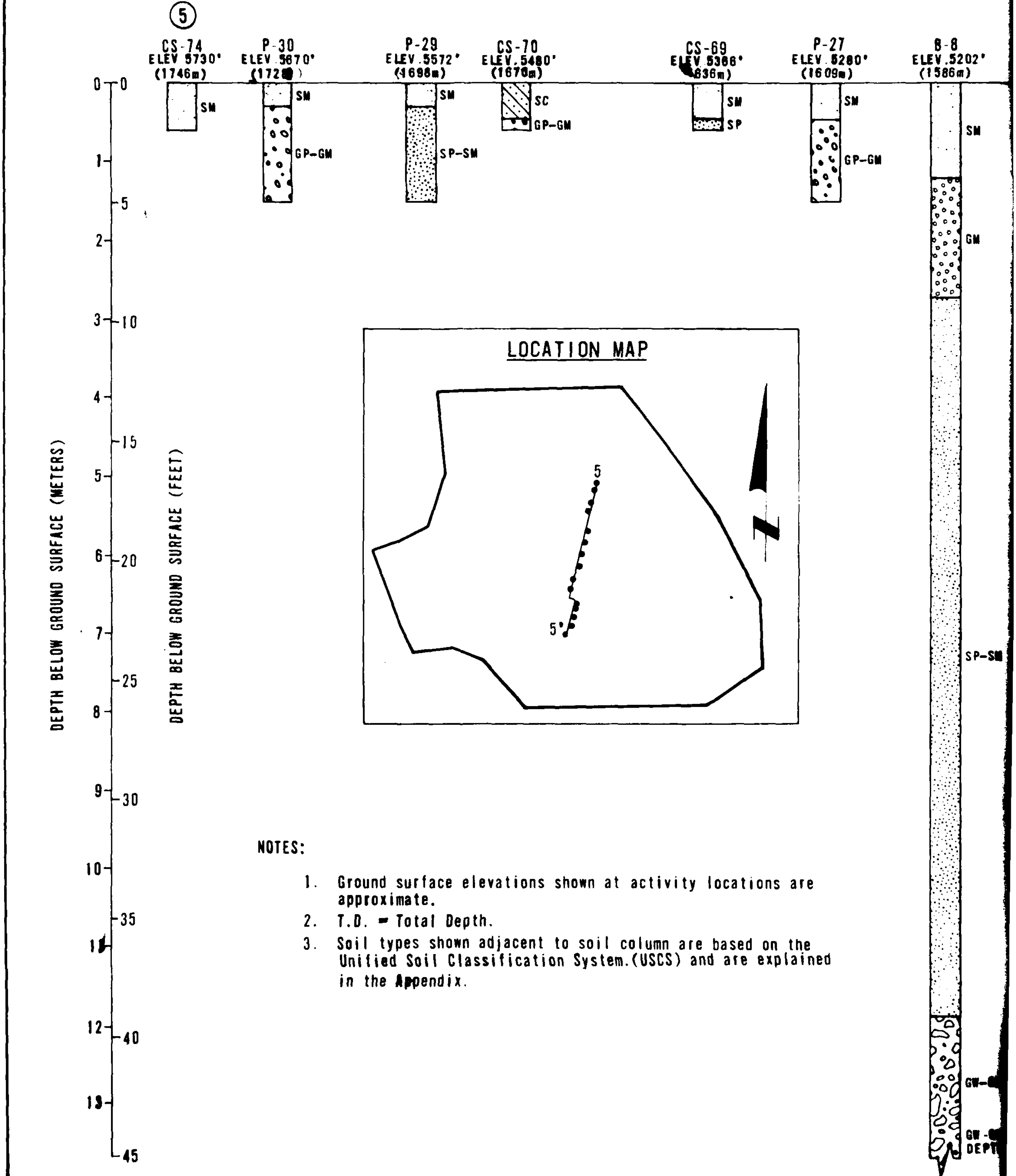


SOIL PROFILE 1-3'
VERIFICATION SITE, SNAKE EAST CDP, UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

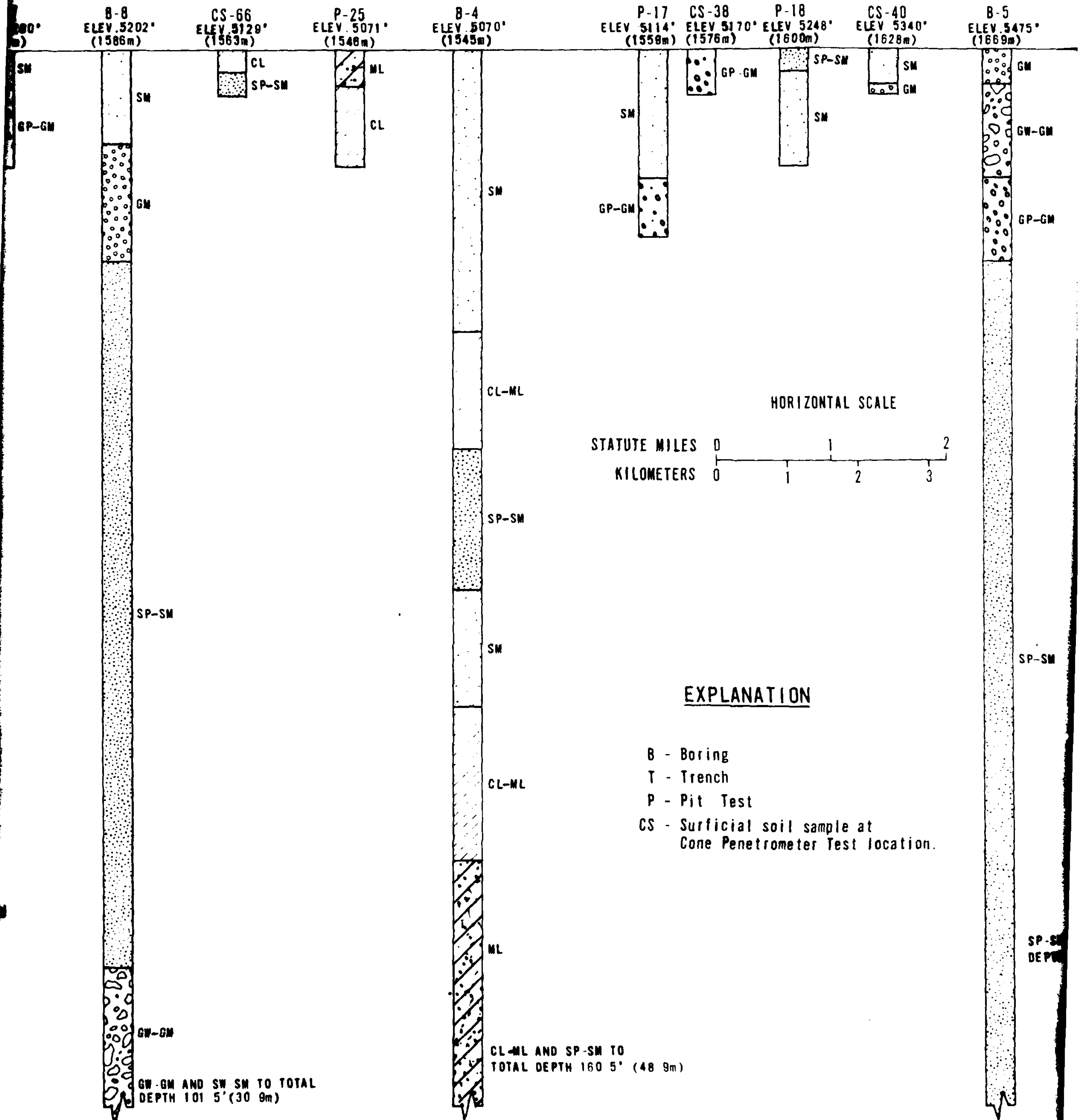
FIGURE 5-3

FUGRO NATIONAL, INC.

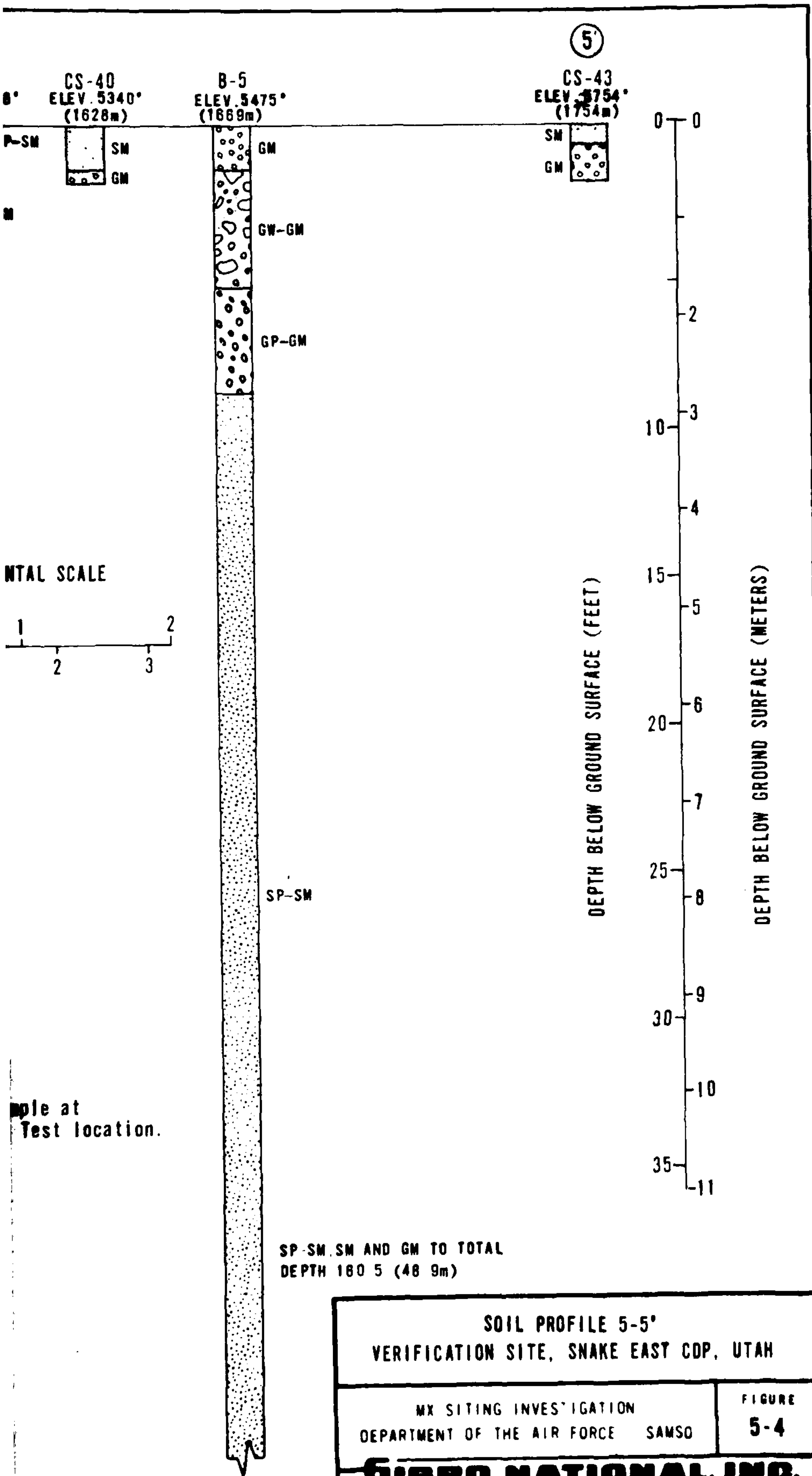


NOTES:

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 the Unified Soil Classification System.(USCS) and are explained in the Appendix.


B-8 ELEV.5202' (1586m)
SM
GM
SP-SM
GW-GM
GW-GM AND SW SM TO TOTAL DEPTH 101 5'(30 9m)
CS-66 ELEV.5129' (1563m)
CL
SP-SM
P-25 ELEV.5071' (1546m)
ML
CL
B-4 ELEV.5070' (1545m)
SM
CL-ML
SP-SM
SM
CL-ML
ML
CL-ML AND SP-SM TO TOTAL DEPTH 160 5' (48 9m)
P-17 ELEV 5114' (1559m)
SM
GP-GM
CS-38 ELEV 5170' (1576m)
GP-GM
P-18 ELEV 5248' (1600m)
SP-SM
SM
CS-40 ELEV 5340' (1628m)
SM
GM
B-5 ELEV.5475' (1669m)
GM
GW-GM
GP-GM
SP-SM
HORIZONTAL SCALE
STATUTE MILES 0 1 2
KILOMETERS 0 1 2 3
EXPLANATION
B - Boring
T - Trench
P - Pit Test
CS - Surficial soil sample at Cone Penetrometer Test location.

1-2

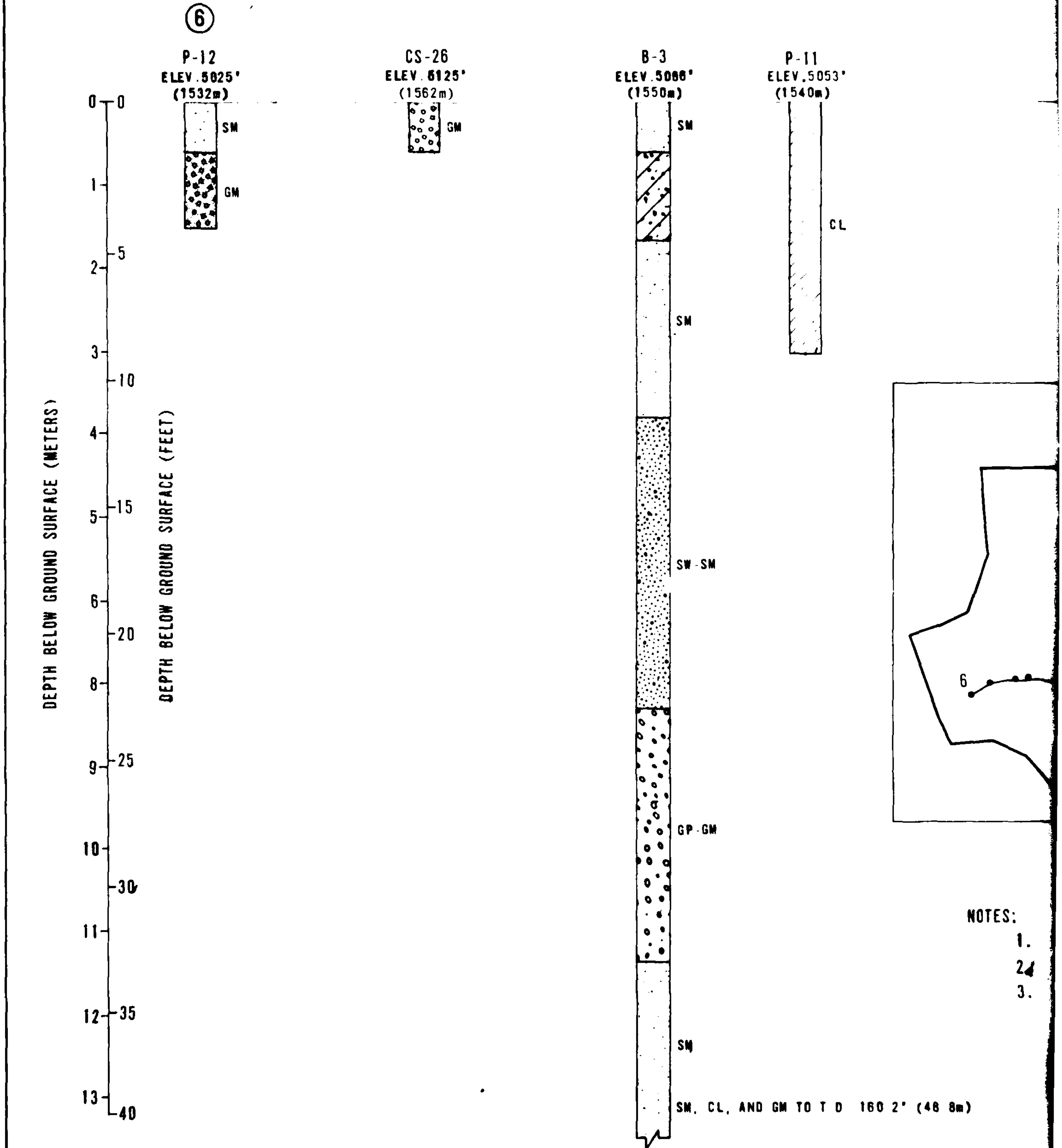


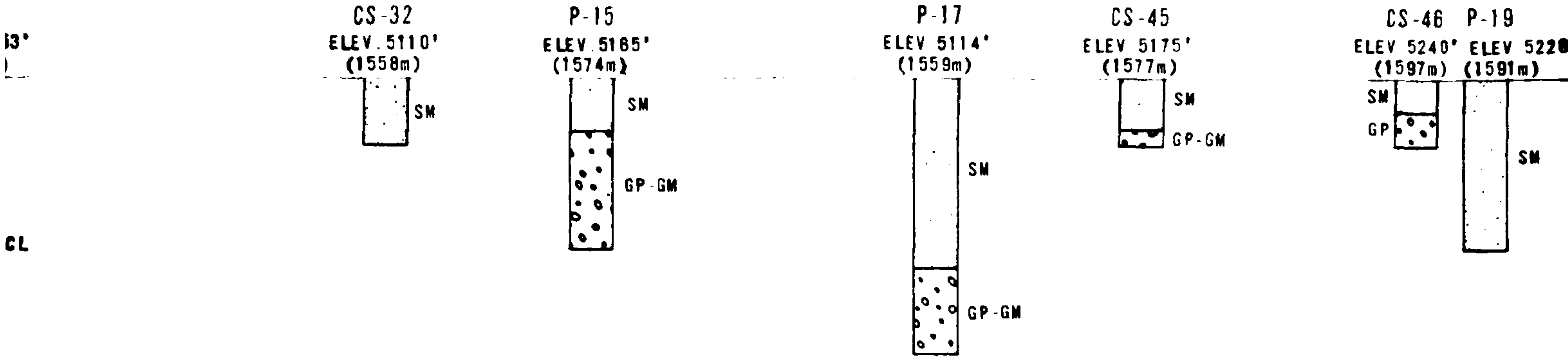
SOIL PROFILE 5-5'
VERIFICATION SITE, SNAKE EAST CDP, UTAH

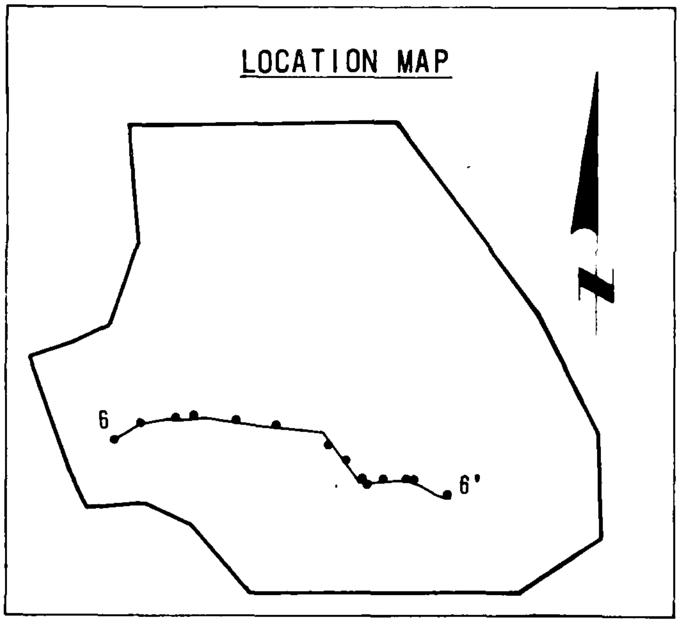
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

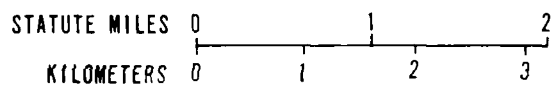
FIGURE 5-4

FUGRO NATIONAL, INC.


6
P-12
ELEV.5025'
(1532m)
CS-26
ELEV.5125'
(1562m)
B-3
ELEV.5086'
(1550m)
P-11
ELEV.5053'
(1540m)
DEPTH BELOW GROUND SURFACE (METERS)
DEPTH BELOW GROUND SURFACE (FEET)
SM
GM
GM
SM
SM
SW-SM
GP-GM
SM
SM, CL, AND GM TO T D 160 2' (48 8m)
CL
6
NOTES:
1.
2.
3.







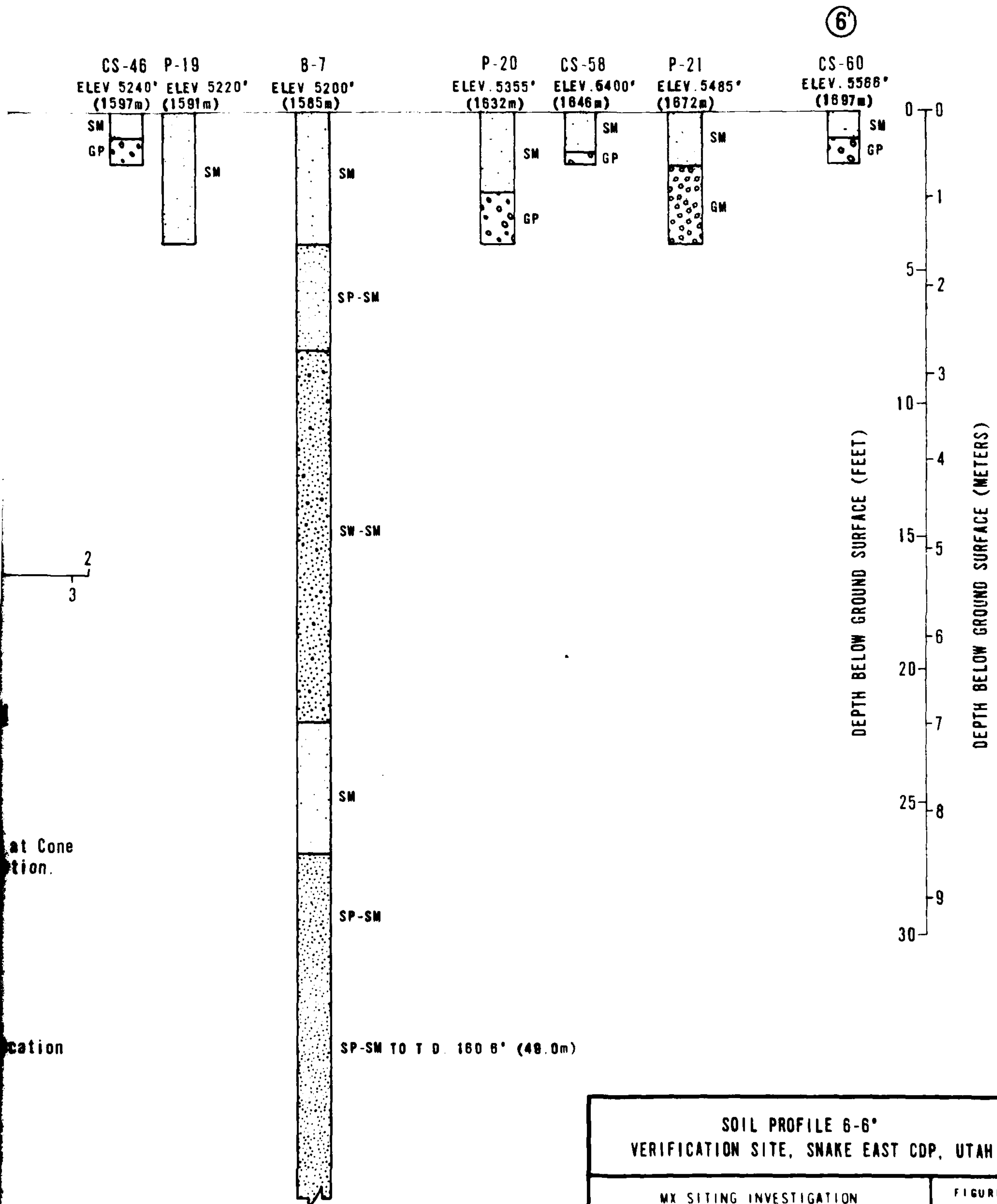
EXPLANATION

B - Boring
T - Trench
P - 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 the Unified Soil Classification System (USCS) and are explained in the Appendix.

B 160 2' (48 8m)

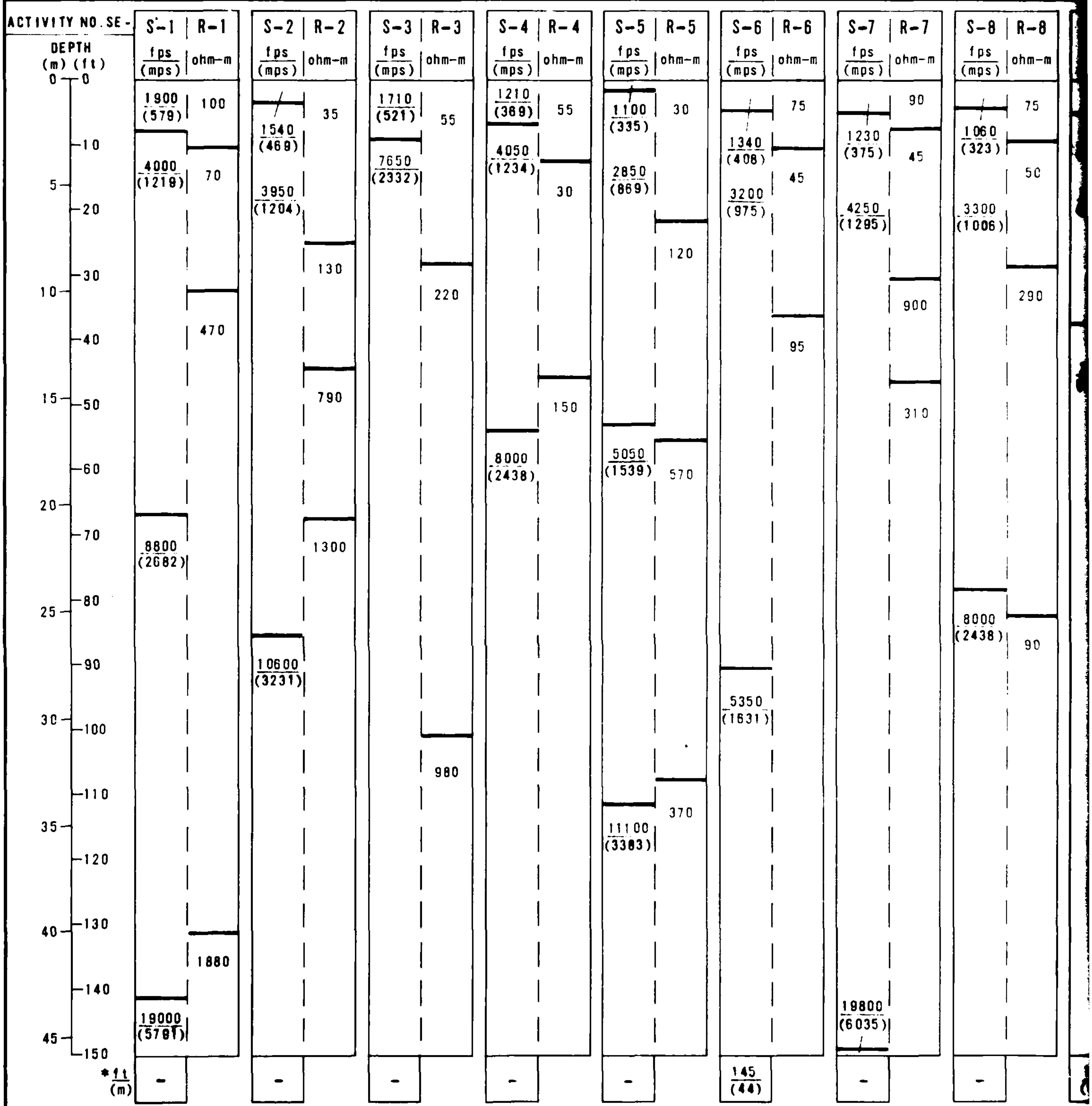


SOIL PROFILE 6-6'
VERIFICATION SITE, SNAKE EAST CDP, UTAH

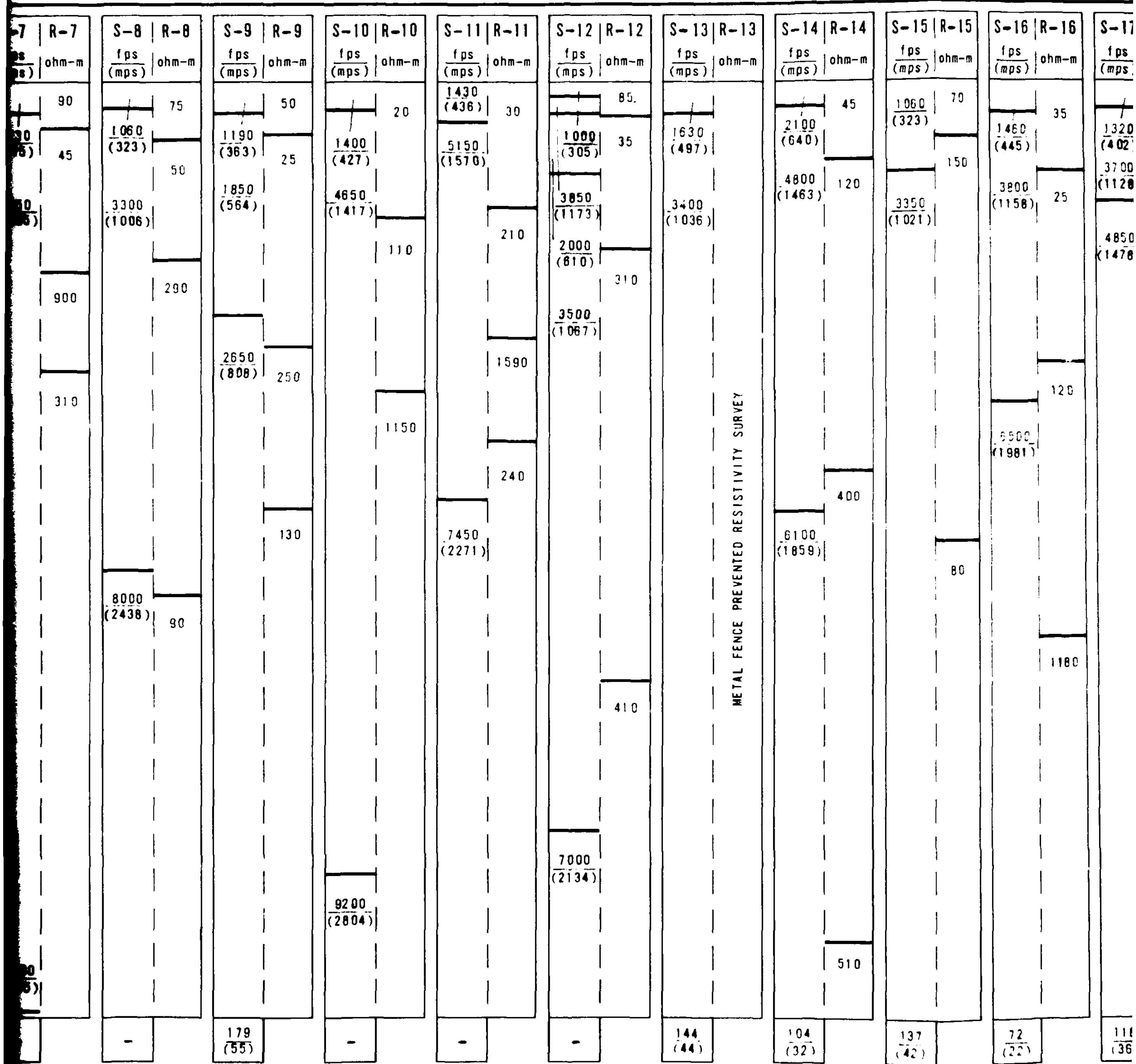
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE
5-5

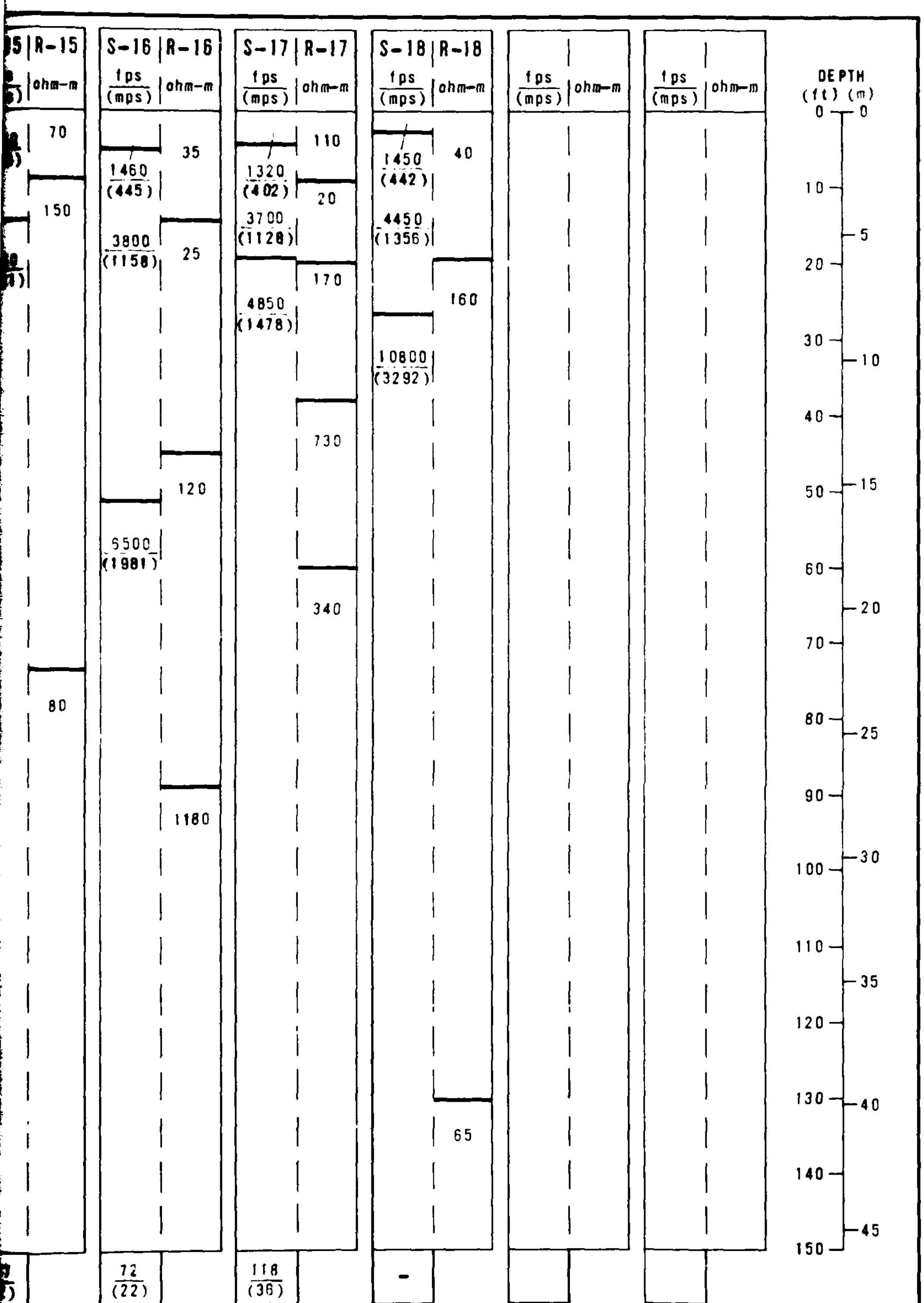
FUGRO NATIONAL, INC.



* 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 then 7000 fps (2134 mps).



R-7
ohm-m
90
45
900
310
S-8 R-8
fps (mps) ohm-m
1060 (323)
3300 (1006)
8000 (2438)
75
50
290
90
S-9 R-9
1190 (363)
1850 (564)
2650 (808)
50
25
250
130
179 (55)
S-10 R-10
1400 (427)
4650 (1417)
9200 (2804)
20
110
1150
S-11 R-11
1430 (436)
5150 (1570)
7450 (2271)
30
210
1590
240
S-12 R-12
1000 (305)
3850 (1173)
2000 (610)
3500 (1067)
7000 (2134)
85.
35
310
410
S-13 R-13
1630 (497)
3400 (1036)
METAL FENCE PREVENTED RESISTIVITY SURVEY
144 (44)
S-14 R-14
2100 (640)
4800 (1463)
6100 (1859)
45
120
400
510
104 (32)
S-15 R-15
1060 (323)
3350 (1021)
70
150
80
137 (42)
S-16 R-16
1460 (445)
3800 (1158)
6500 (1981)
35
25
120
1180
72 (22)
S-17
1320 (402)
3700 (1128)
4850 (1478)



SEISMIC REFRACTION AND ELECTRICAL RESISTIVITY VERIFICATION SITE, SNAKE EAST CDP, UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 5-4

FUGRO NATIONAL, INC.

AFV-18

3

DEPTH RANGE	2' - 20' (0.6 - 6.0m)	
SOIL DESCRIPTION	Coarse-grained soils	Fine-grai
	Sandy Gravels, Gravelly Sands, Silty Sands, and Clayey Sands	Sandy Silts, Cl Sandy Clays, an
USCS SYMBOLS	GP, SP, SM, SC	ML, CL
ESTIMATED EXTENT IN SUBSURFACE %	90-95	5-10
PHYSICAL PROPERTIES		
DRY DENSITY pcf (kg/m³)	87.3-131.1 (1390-2100) [27]	85.1-90.9 (1363-1456)
MOISTURE CONTENT %	1.5-11.1 [27]	6.9-16.8
DEGREE OF CEMENTATION	none to moderate	none to low
COBBLES 3-12 inches (8-30 cm) %	0-5	0
GRAVEL %	4-66 [16]	0
SAND %	32-81 [16]	33
SILT AND CLAY %	0-38 [16]	67
LIQUID LIMIT	27 [1]	33
PLASTICITY INDEX	7 [1]	9
COMPRESSIONAL WAVE VELOCITY fps (mps)	1210-5150 (369-1570) [16]	1060-2850 (323-869)
SHEAR STRENGTH DATA		
UNCONFINED COMPRESSION S_u - ksf (kN/m²)	NDA	0.8 (38)
TRIAXIAL COMPRESSION c - ksf (kN/m²), ϕ°	NDA	NDA
DIRECT SHEAR c - ksf (kN/m²), ϕ°	NDA	c = 1.87 (90)

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, 7 trenches, and [30] 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.

- [ ] -
- NDA - No

6.0m)	20' – 160' (6.0 – 49.0m)	
Fine-grained soils	Coarse-grained soils	Fine-grained soils
andy Silts, Clayey Silts, andy Clays, and Silty Clays	Sandy Gravels, Gravelly Sands, and Silty Sands	Sandy Silts, Clayey Silts, Sandy Clays, and Silty Clays
L, CL	GP, SP, SM	ML, CL
-10	80-95	5-20
5.1-90.9 (1363-1456) [2]	96.3-138.5 (1543-2219) [64]	87 4-122.2 (1400-1957) [6]
.9-16 8 [2]	4.1-15.6 [64]	13.6-32.5 [6]
one to low	none to moderate	none to moderate
	0-5	0
[1]	5-54 [25]	0 [3]
3 [1]	40 77 [25]	6-41 [3]
7 [1]	6-44 [26]	59-94 [4]
3 [1]	21 [1]	27-46 [6]
[1]	1 [1]	5 18 [6]
060-2850 (323-869) [3]	3200-5350 (975-1631) [16]	1850-2850 (564-869) [2]
.8 (38) [1]	0 6 (29) [1]	1.1-2 0 (53-96) [2]
DA	c = 0, φ = 39 [3]	c = 0, φ = 37 [2]
= 1.87 φ = 22 (0) [3]	c = 0, φ = 38 [3]	NDA

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

CHARACTERISTICS OF SUBSURFACE SOILS
VERIFICATION SITE, SNAKE EAST CDP, UTAH

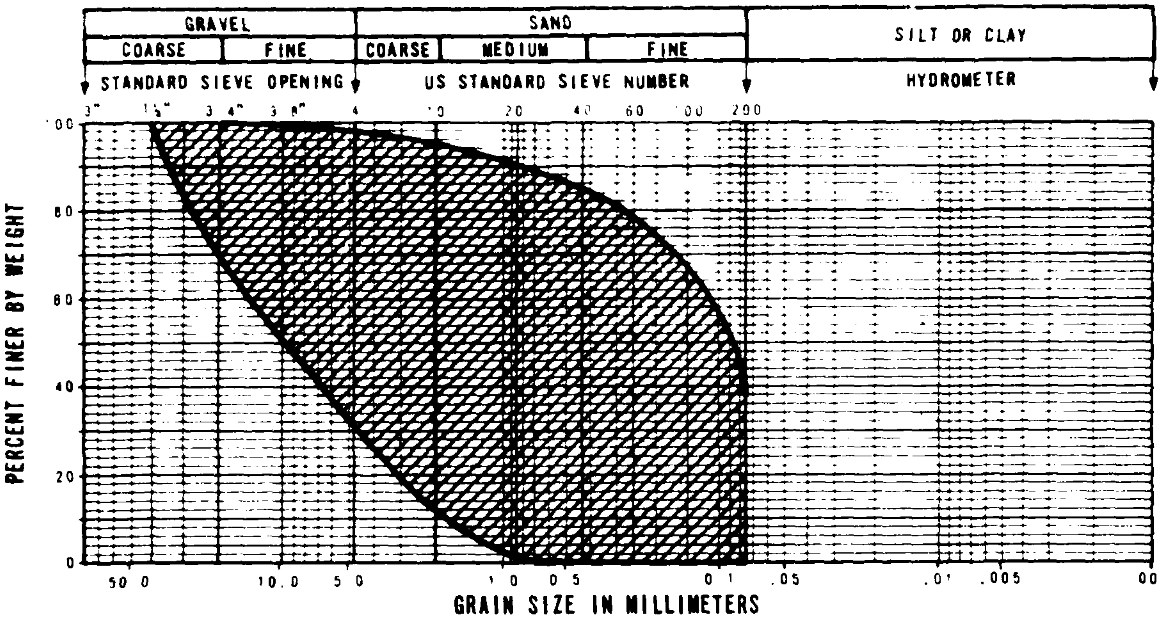
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 5-5

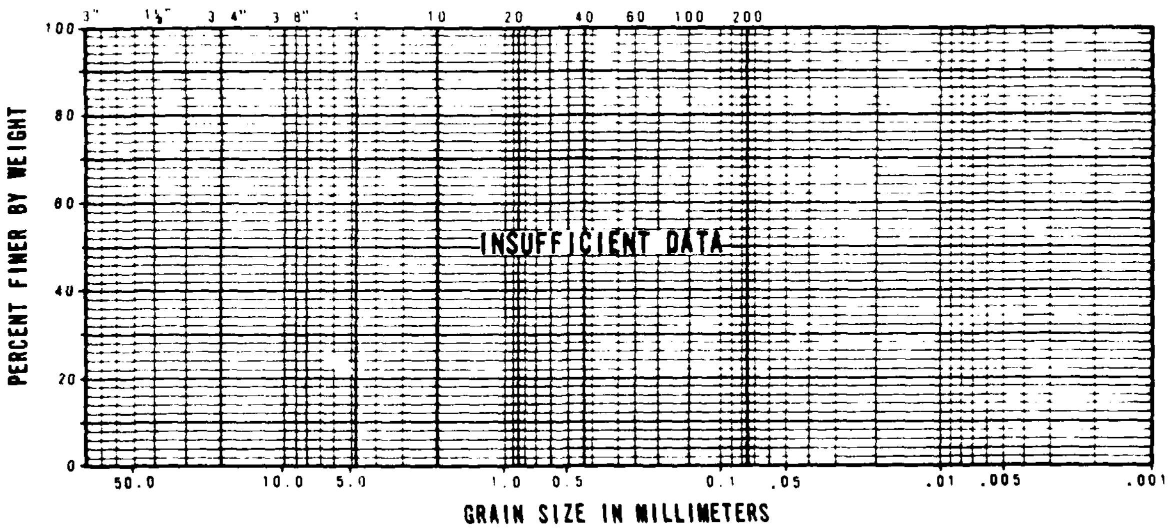
FUGRO NATIONAL, INC.

AFV-20

2



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



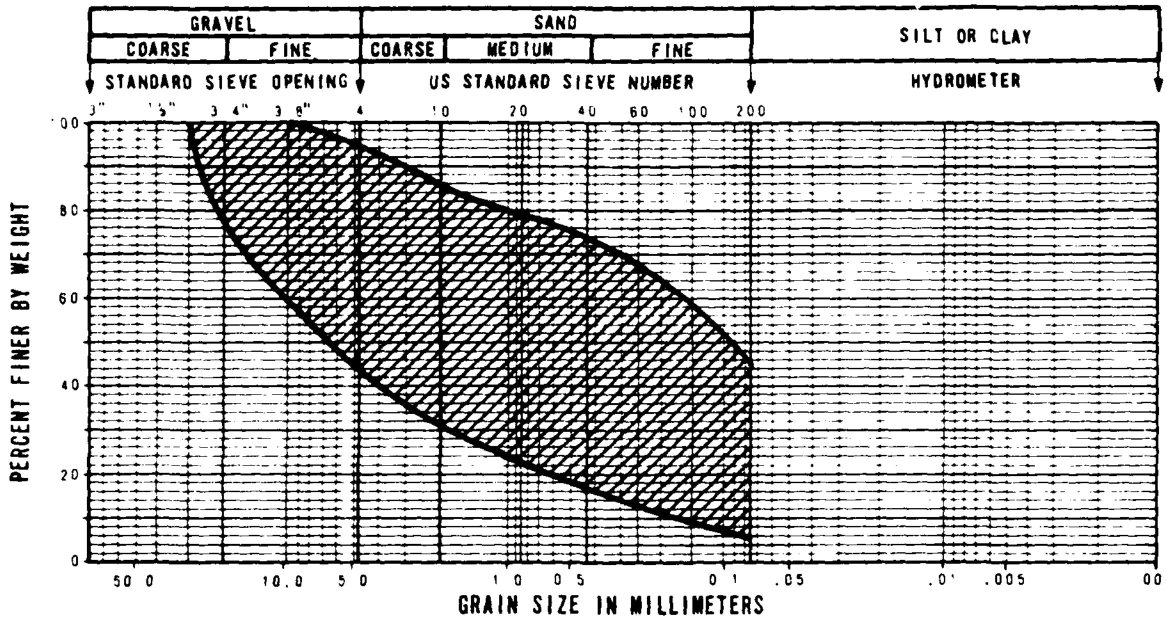
SOIL DESCRIPTION: Fine-grained soils from 2 to 20 feet (0.6 to 6m)

RANGE OF GRADATION OF SUBSURFACE SOILS
VERIFICATION SITE, SNAKE EAST CDP, UTAH

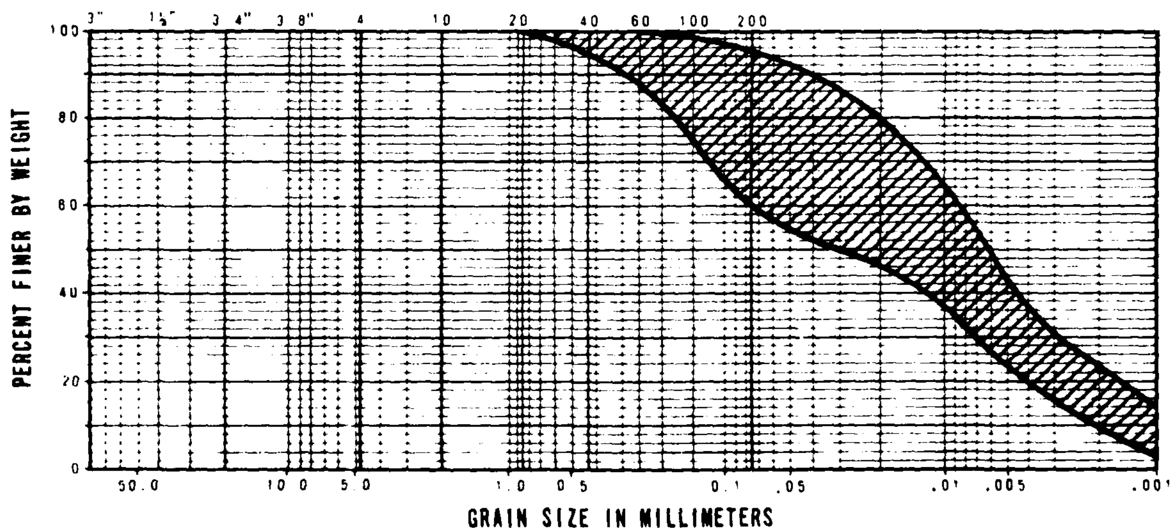
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 5-6
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, SNAKE EAST CDP, UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 5-6
2 OF 2

FUGRO NATIONAL, INC.

calcium carbonate cementation occurs in granular subsoils but well-developed, continuous cementation was not observed. Below 10 feet, granular soils exhibit very low compressibilities and moderate to high shear strengths. Fine-grained interbeds consist of mixtures of silt and clay and generally contain appreciable amounts of fine sand. The fine-grained soils have low plasticity and have consistencies ranging from firm to hard. They exhibit moderate compressibilities and low to moderate shear strengths. Seismic wave velocities of the fine-grained soils are substantially lower than those of the coarse-grained soils (Table 5-5).

Electrical conductivity of the soils in the upper 50 feet (15 m) ranges from 0.0025 to 0.0274 mhos per meter (average 0.0098 mhos per meter). At three (18 percent) out of 17 activity locations, the electrical conductivity was below the minimum value of 0.004 mhos per meter specified in the Fine Screening criteria. Chemical test results indicate that the potential for sulfate attack of soils on concrete will be negligible.

5.6 TERRAIN

The Snake East Site is a topographically open yet poorly drained alluvial basin in which the central portion of the site forms a low-gradient, playa-like area where standing water is common. Drainage is generally from southeast to northwest and surface elevations within the site range from approximately 5400 feet (1646 m) above mean sea level in the south to approximately 4900 feet (1494 m) in the north. A diversity of terrain conditions exists and categories of terrain are differentiated in Drawing 5-3.

Terrain characteristics are heavily influenced by surficial geologic units. Terrain categories II through IV generally correspond to intermediate alluvial fans. Slope varies from 1 to 7 percent with a mean value of about 3 percent. Surfaces are most deeply incised along the Conger and Confusion ranges to the northeast where drainage incisions to depths greater than 20 feet (6 m) were observed. Average drainage depth is about 6 feet (2 m) and the number of drainages per mile varies between four and six near the mountains. Incision lessens considerably in the fan units in the south near the Burbank Hills.

Mixed alluvial and lacustrine deposits corresponding to terrain category II occur along the valley axis. These areas form a transition between the deeply incised intermediate fans and the relatively unincised central flood plain. Slope varies from 1 to 3 percent with a mean value of about 2 percent. Incision depths generally range from 3 to 6 feet (1 to 2 m) with spacing averaging approximately four per mile.

Lake deposits (A4o) in the poorly drained area of central and northwest Snake East are relatively flat and unincised (terrain category I). Slopes may range from 1 to 5 percent (mean value about 2 percent), owing to lakeshore features of Lake Bonneville. Drainage depths generally average about 3 feet (1 m) and are spaced approximately three to four per mile.

5.7 DEPTH TO ROCK

Drawing 5-4 shows the approximate configuration of 50- and 150-foot (15- and 46-m) depth to rock contours in the Snake East Site. This interpretation is based on limited po[illegible] data from borings, seismic refraction surveys, site-specific published data, and rock depths inferred from geologic and geomorphic relationships. Generally, less than 10 percent of the soil-covered portion of the site is interpreted to be underlain by rock at depths of less than 50 feet. An additional 5 percent of the site is interpreted to contain shallow rock between depths of 50 and 150 feet.

The depth to rock interpretation, in most cases, represents subsurface projections of surface rock tempered by limited confirmatory data from borings and seismic lines. For this reason, contours generally parallel exposed rock in the site. Shallow rock is suspected in the southeast where deeply embayed canyon reentrants and clusters of rock outcrops occur. In the Conger Range, located in the northwest portion of the site, numerous limestone outcrops indicate a fairly broad area of shallow rock. Flat-lying surficial volcanic rocks in the northern Burbank Hills and eastern Buckskin Hills possibly indicate widespread shallow rock.

Three seismic refraction surveys identified a high velocity (8100 fps; 2469 mps) layer in the western portion of the site. Coincident boring data identified this material as a thin claystone layer (5± feet thick; 1 to 2 m). The layer was interpreted to extend across the western side of the site from north of the Burbank Hills to south of the Buckskin Hills. Seismic line S-7, located near an outcrop south and west of the Buckskin Hills, indicates that limestone has formed a shallow rock shelf.

5.8 DEPTH TO WATER

Drawing 5-5 shows the approximate configuration of 50- and 150-foot (15- and 46-m) depth to water contours in the Snake East Site. The conditions depicted represent unconfined ground-water conditions. These interpretations rely heavily on existing evaluations by the U.S. Geological Survey (Snyder, 1963; Hood and Rush, 1965), the Utah State Engineers Office (1979), and the Utah State Department of Natural Resources (1978), supplemented by an evaluation of 28 selected water-well points. Despite the apparent abundance of data points, overall confidence in the 50- and 150-foot depth interpreta tion is low because the water depth measurements were made many years ago and there are indications that some readings may represent potentiometric surfaces. Ground-water depths gradually increase south and east of the Snake Valley portions of the site. The deepest reported ground-water depths are located in the north-central portions of Ferguson Desert (600 feet; 183 m).

Springs and evidence of perched water are also documented north of the site boundary in the vicinity of Salt Marsh Lake. A clay-rich hardpan from Salt Marsh Lake deposits has retarded ground-water infiltration to the unconfined water table. An analogous situation likely exists along the northwest boundary of the site adjacent to ill-defined Baker Creek.

At present, ground water is being developed only in the western portion of the site. Ground water is being used chiefly for agriculture and livestock.

5.9 RESULTS AND CONCLUSIONS

5.9.1 Suitable Area

Resulting suitable area, as defined by FY 79 Verification Studies in the Snake East Site, is shown in Drawing 5-6. The site contains approximately 190 mi^2 (490 km^2) of usable area for the hybrid trench basing mode and 135 mi^2 (350 km^2) for the vertical shelter basing mode. These results are somewhat different than those reported in previous Intermediate/Fine Screening studies due chiefly to:

1. Additional terrain exclusions in the southwestern portions of the site;
2. Additional shallow rock exclusions around the margins of the site; and
3. Additional shallow water exclusions in western Snake East.

It must also be noted that two small areas on the east side of the site and one area directly south of the site lie within designated wilderness inventory areas as defined by the Bureau of Land Management (BLM, 1979a; BLM, 1979b).

5.9.2 Construction Considerations

In this section, geotechnical factors and conditions which would affect the construction of the MX system in the suitable area are discussed. Both the hybrid trench and vertical shelter basing modes are considered.

5.9.2.1 Grading

Surficial slopes range from 0 to 5 percent (average about 2 percent) within the suitable area, thus requiring minimum preconstruction grading for roads and trenches.

5.9.2.2 Roads

Subgrade supporting properties of low strength, surficial, granular soils can generally be improved by mechanical compaction. Our studies indicate that compaction of granular soils to an average depth of 1.7 feet (0.5 m) is necessary. The laboratory CBR tests indicate that the compacted granular soils will provide good to very good subgrade support for roads. Supporting qualities of the fine-grained soils are inadequate for direct support of the base or subbase course of the road system. The CBR tests indicate that mechanical compaction will not ade quately strengthen these fine-grained soils. Therefore, required road subgrade support must be attained either by using a select granular subbase layer over the compacted fine-grained soil subgrade or by partially or totally removing these soils (depending on their thickness) and replacing them with 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 will be suitable for use as road subbase and base course. Although these soils are present in the subsurface, their extent is not known.

Drainage incision is generally less than 6 feet (1.8 m) in a major portion (60 to 80 percent) of the suitable area; in the remainder, the depth of drainage ranges from 6 to 12 feet (1.8 to 3.6 m). Therefore, the cost of drainage structures for roads and trenches will be small.

5.9.2.3 Excavatability and Stability

Subsurface soils in the suitable site area are predominantly coarse grained with fine-grained soils estimated to make up less than 10 percent of the construction zone. Subsurface soils are generally dense to very dense below 10 feet (3 m) with variable 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 trench excavations will generally have to be sloped back for stability. Below this zone, vertical trench walls will remain temporarily stable in approximately 70 percent of the suitable area. In the remaining area, the apparent cohesion and/or degree of cementation of the subsurface soils is inadequate to provide temporary stability for vertical cuts. Therefore, trench walls in these areas will have to be shored or sloped.

Vertical shelter: Within the depth of excavation for vertical shelters, investigations indicate that large diameter augers could be used with difficult excavation expected in approximately 10 percent of the suitable area. Most of the excavations will be in granular soils with only intermittent cemented or cohesive soil intervals. Therefore, the vertical walls of these shelters will probably not remain stable to depths of 120 feet (37 m) without the use of a slurry or other stabilizing techniques.

5.10 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. Depth to rock contours are poorly defined on the east side of the site near Ecks and Pyramid Knolls. Additional borings and seismic refraction surveys are recommended to further define shallow rock.
2. Depth to water contours that define the western suitable area boundary are approximate and require further refinement. It is recommended that observation wells be installed and additional geophysical studies be performed to provide more accurate ground-water depths.
3. A full verification investigation is recommended to establish suitable area boundaries and basin-fill characteristics both north and south of the present Snake East Site.

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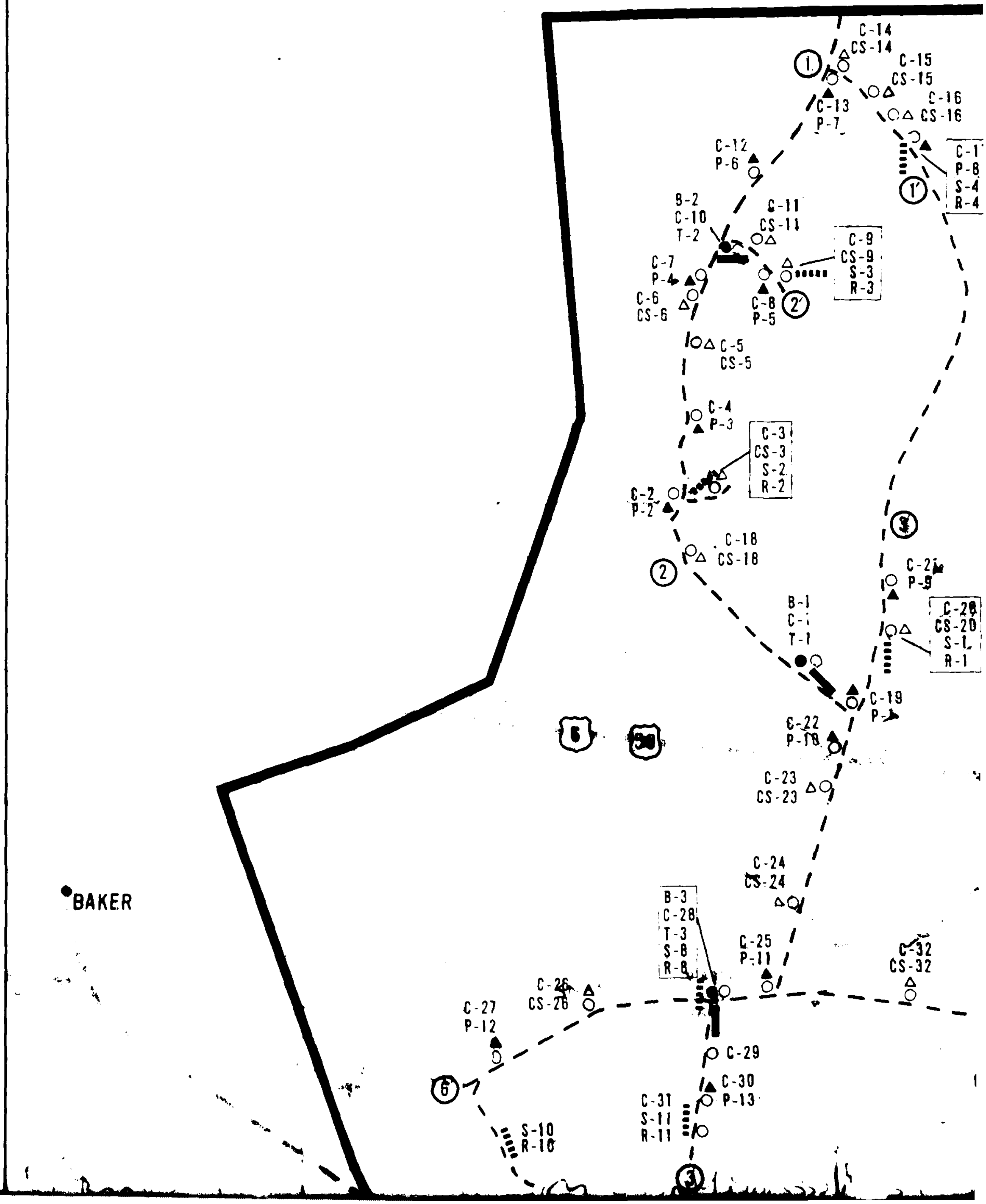
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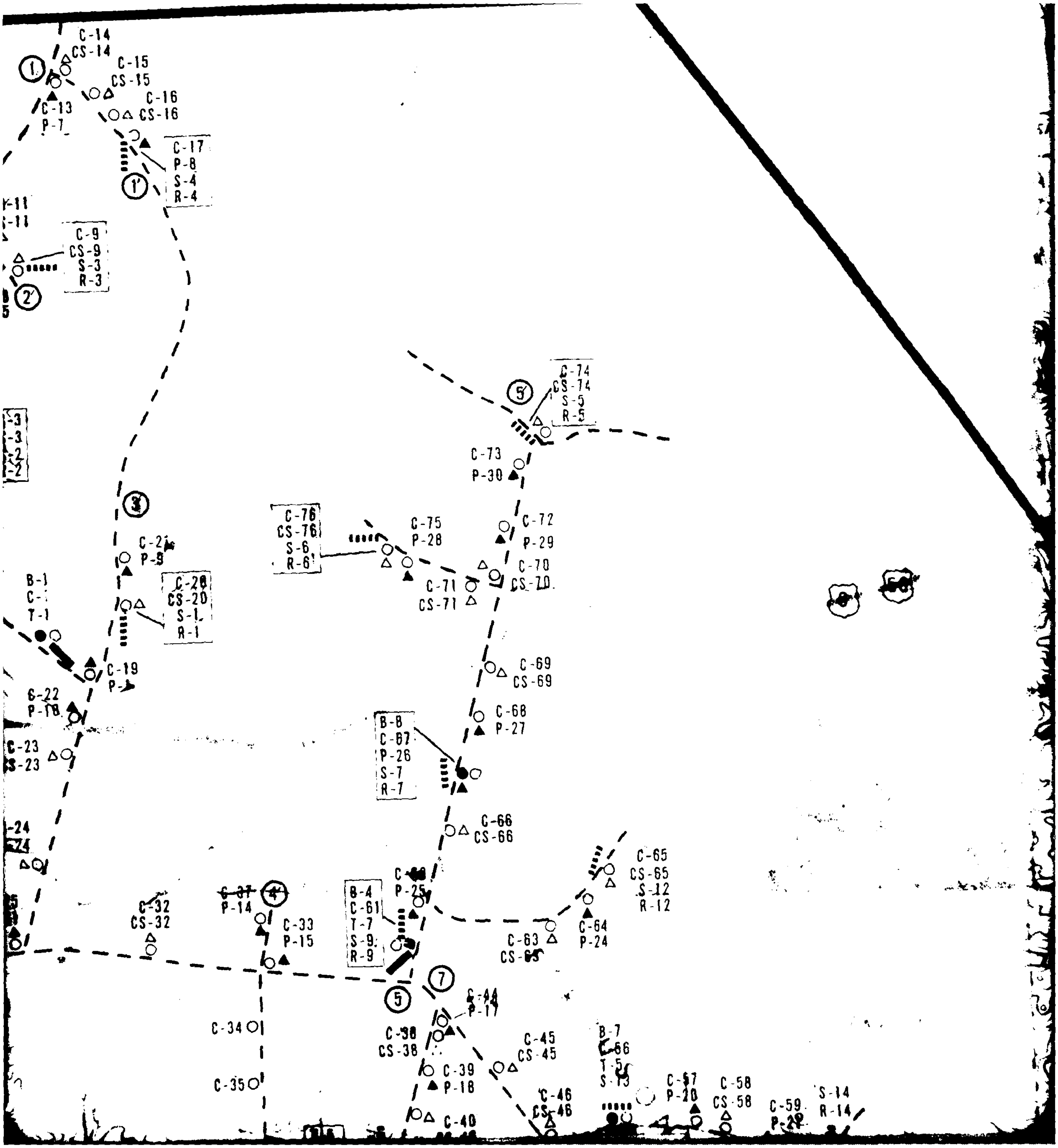
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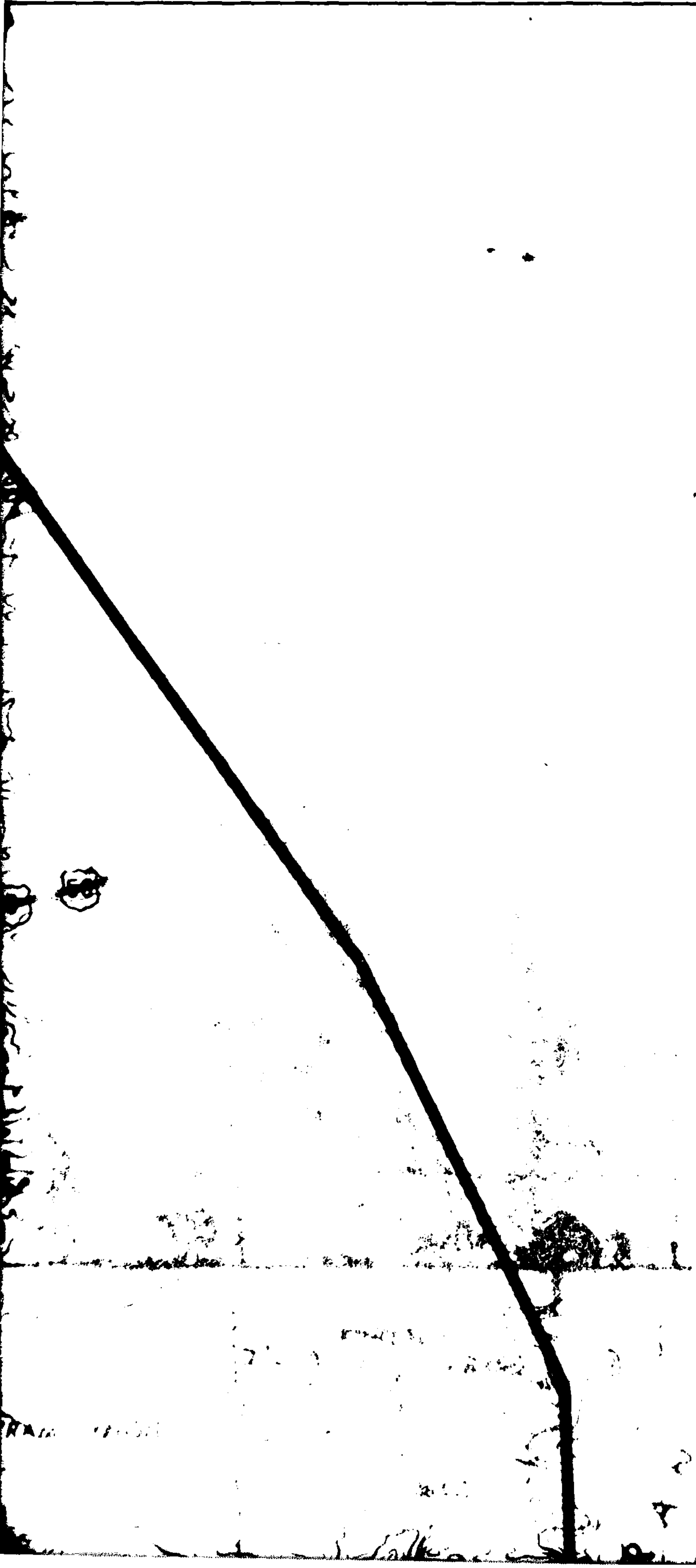

EXPLANATIO

●	B-1	BORING
○	C-1	CONE PENETROME
△	CS-1	SURFACE SAMPLE
▬	T-1	TRENCH
▲	P-1	TEST PIT
▪▪▪▪▪	S-1 R-1	SEISMIC REFRAC ELECTRICAL RES
(1)- - - - -(1')		ACTIVITY LINE

NOTE. Where multiple activities were p
the correct location is designat
symbol or (2) the CPT symbol, if

N

SCALE 1:12

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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		ACTIVITY LINE

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.

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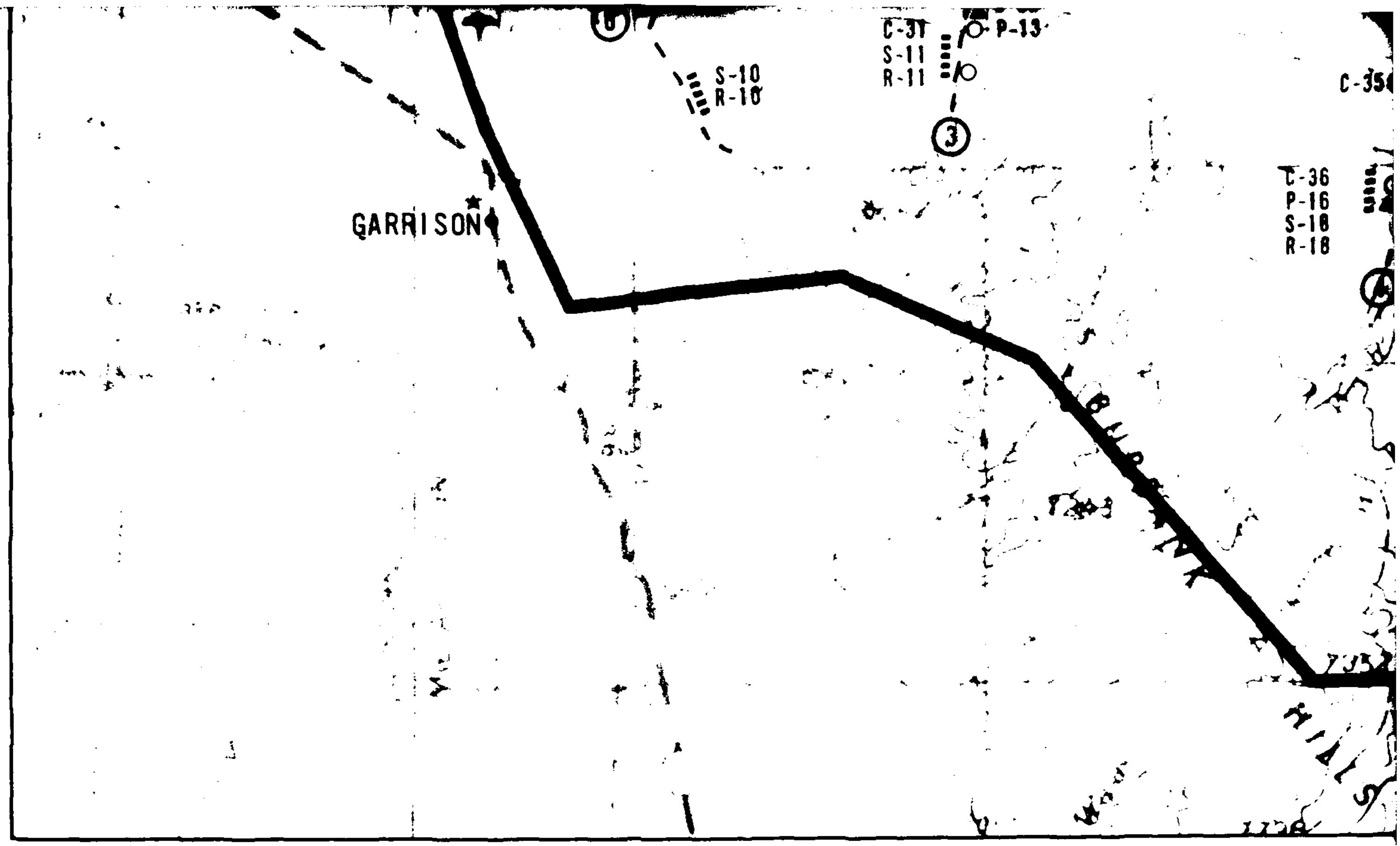
STATUTE MILES



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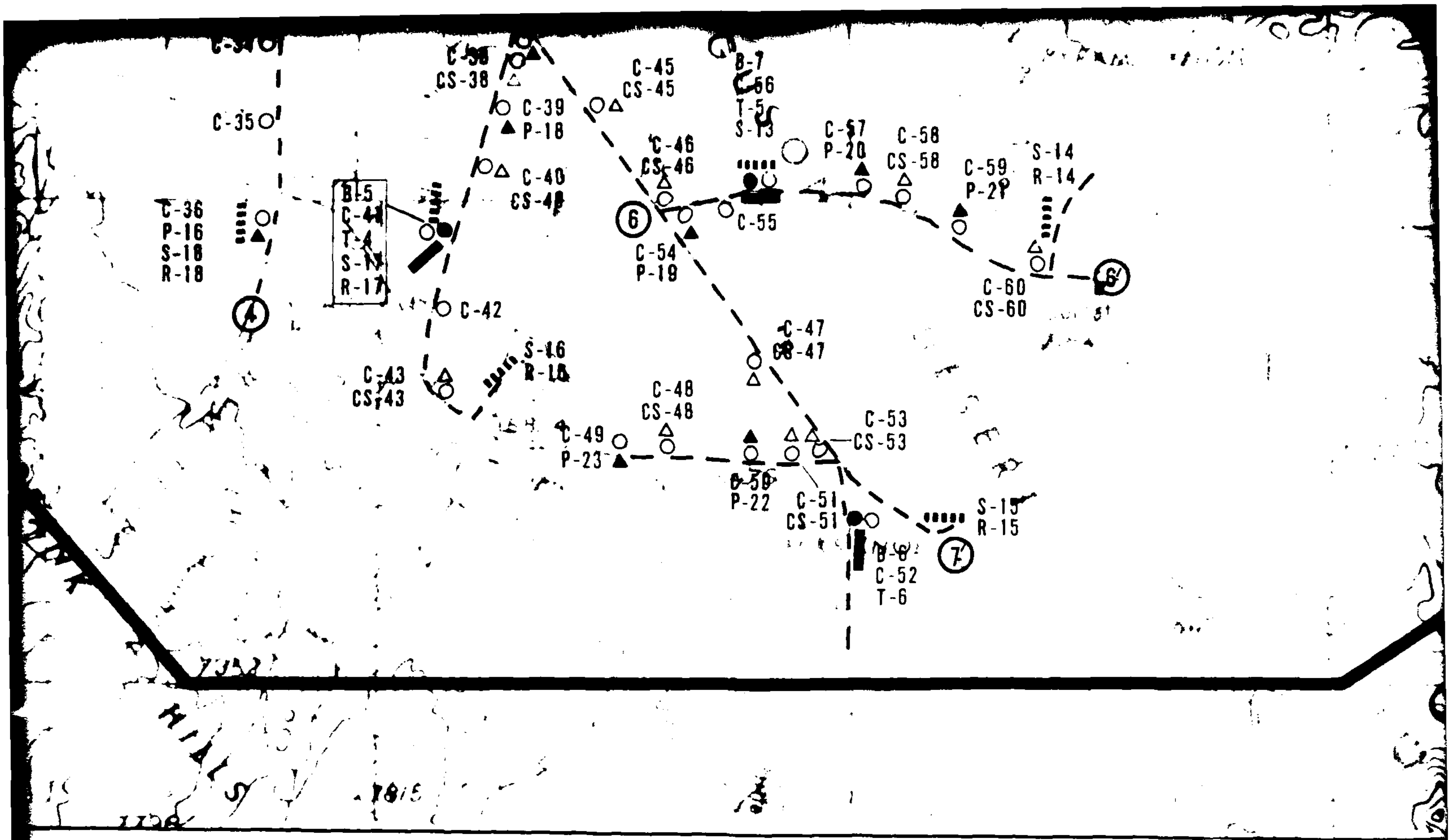
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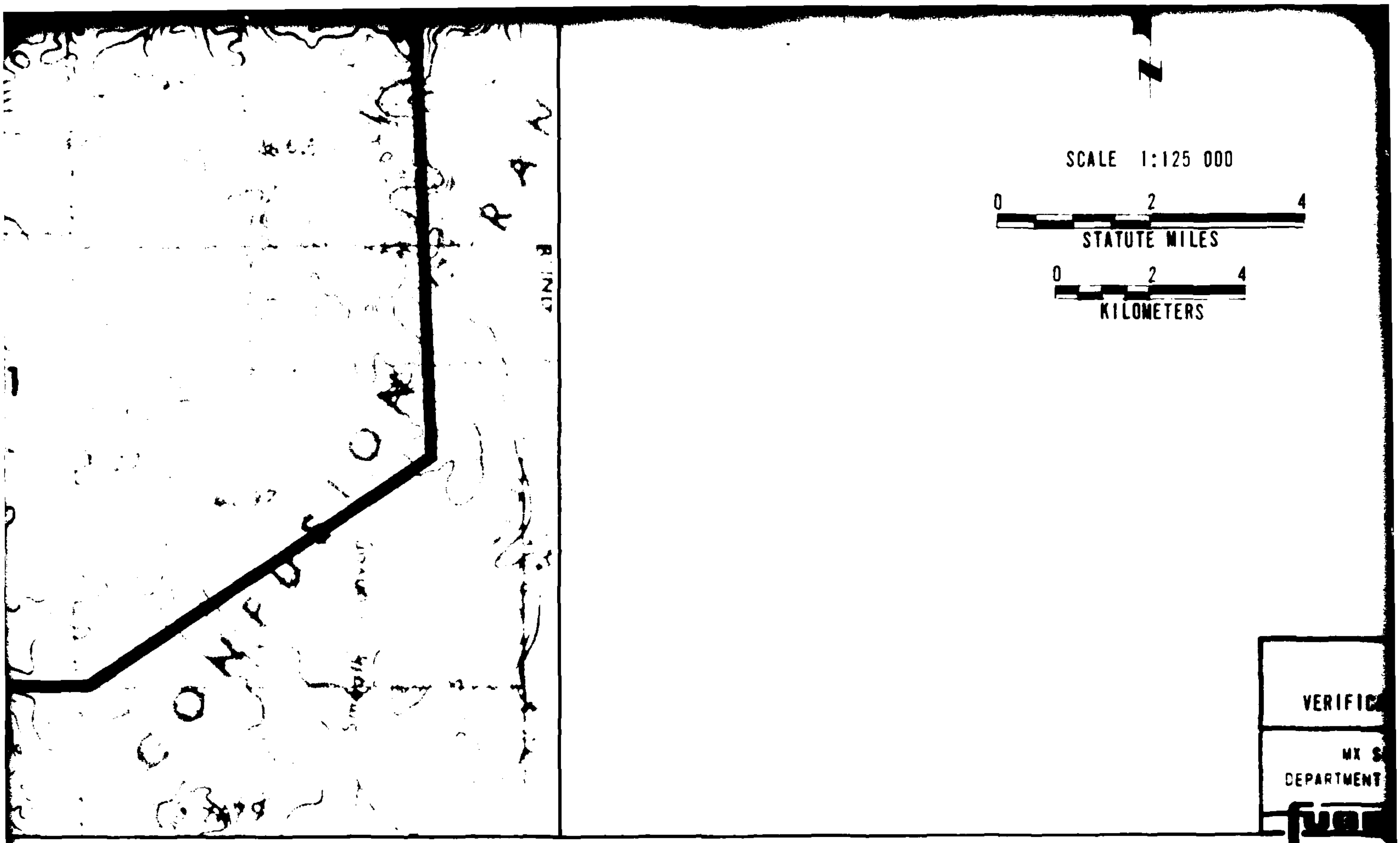
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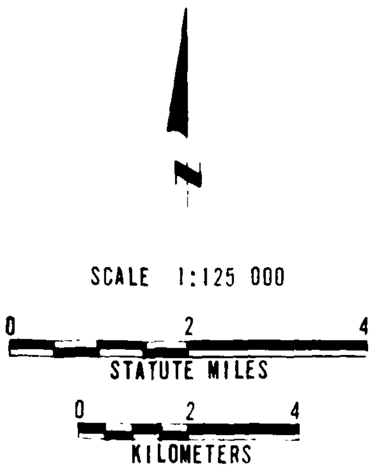
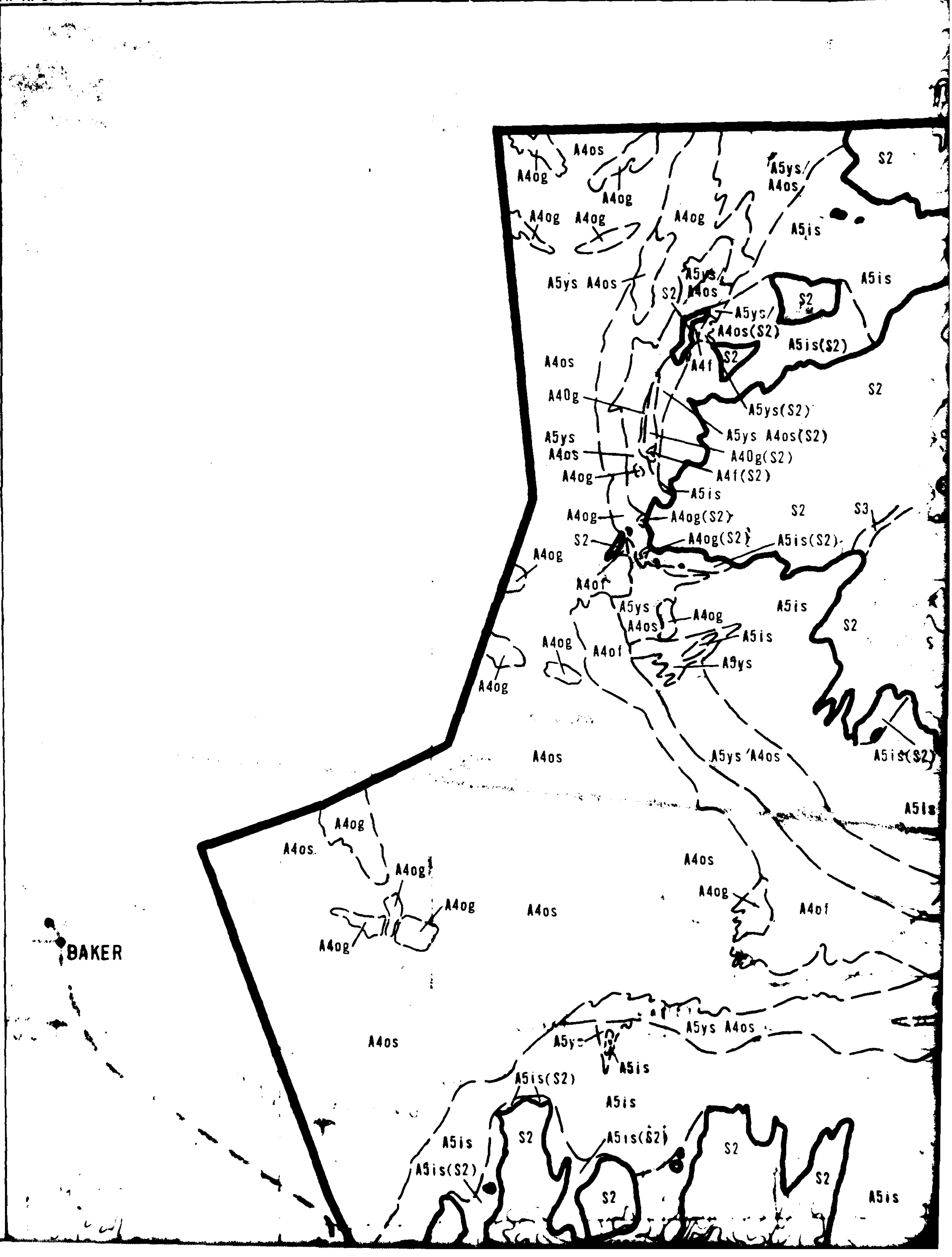


ACTIVITY LOCATIONS
VERIFICATION SITE, SNAKE EAST CDP, UTAH

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAMSO	DRAWING 5-1

FUGRO NATIONAL, INC.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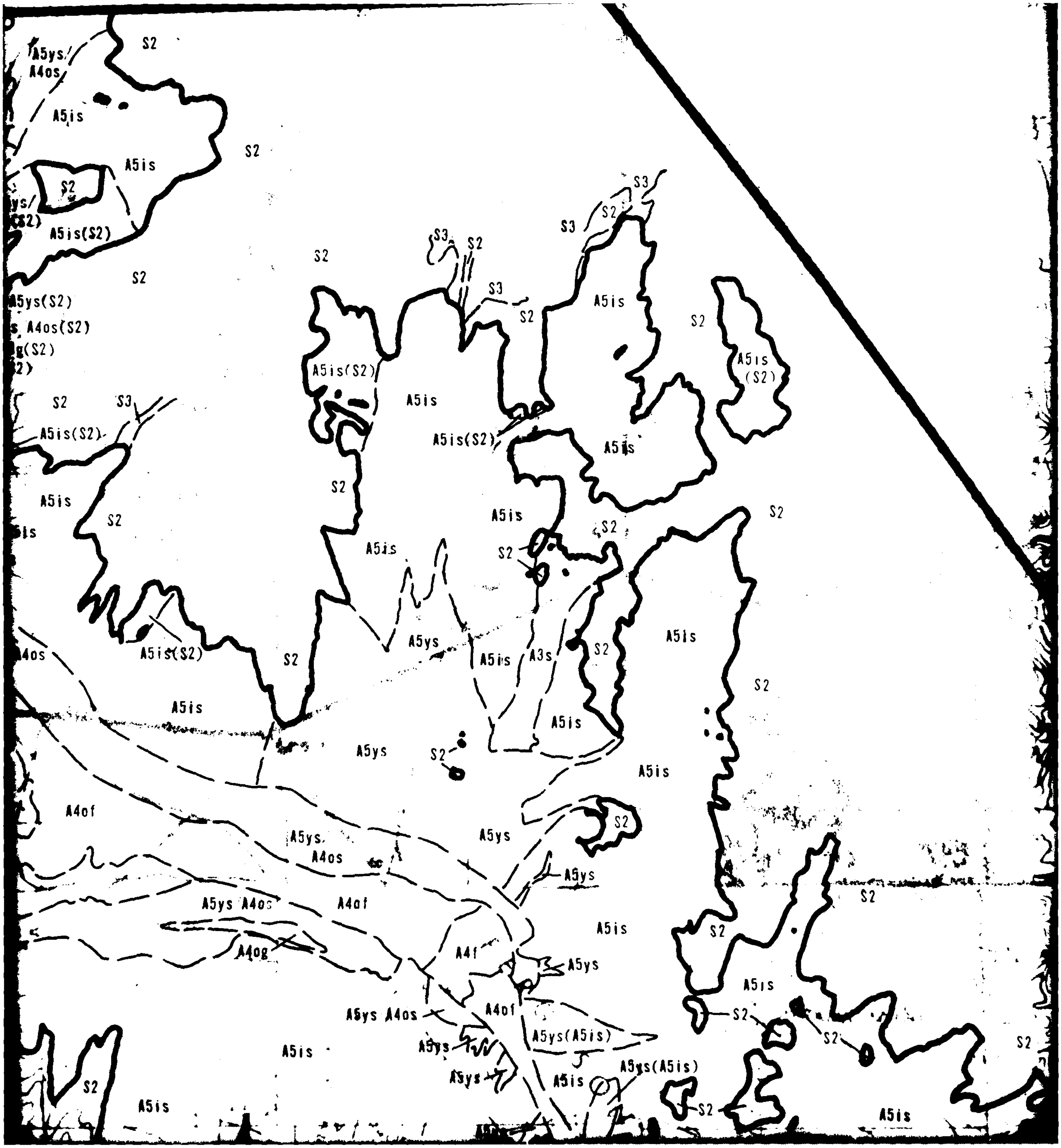
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13

EXPLANATI

SURFICIAL BASIN-FILL U

A3s — Eolian Deposits - Windblown sand

A4f — Younger Playa Deposits - Active

A4of / A4os / A4og — Older Playa and Lacustrine Depos older bed lake and abandoned s A4of, clay (CL); A4os, silty s sandy gravel (GP)

A5ys — Younger Alluvial Fan Deposits - fan deposits of silty sand (S

A5is — Intermediate Alluvial Fan Depos alluvial fan deposits of weakl silty sand (SM)

ROCK UNITS

Igneous (I)

I4 — Rhyolite, dacite and quartz la

Sedimentary (S)

S2 — Limestone and dolomite, locally and sandstone

S3 — Dark gray to black shale, minor

S5 — Conglomerate

A5ys/A5is — Combination of geologic unit sy surficial basin fill or rock u

A5ys(I2) — Parenthetic unit underlies surf

SYMBOLS

Contact between rock and basin

Contact between surficial basi

NOTES:

1 Surficial basin-fill units pertain only variability of surficial deposits and e refer to the predominant soil types. V expected within each geologic unit

2 The distribution of geologic data stat

Y 4

EXPLANATION

SURFICIAL BASIN-FILL UNITS

Eolian Deposits - Windblown sand (SP) in thin sheets

Younger Playa Deposits - Active playa deposits of clay (CL)

Older Playa and Lacustrine Deposits - Inactive playa, older bed lake and abandoned shoreline deposits of: A4of, clay (CL); A4os, silty sand (SM); and A4og, sandy gravel (GP)

Younger Alluvial Fan Deposits - Active, younger alluvial fan deposits of silty sand (SM)

Intermediate Alluvial Fan Deposits - Inactive, intermediate-age alluvial fan deposits of weakly cemented gravelly sand and silty sand (SM)

ROCK UNITS

Rhyolite, dacite and quartz latite ignimbrites

(S)

Limestone and dolomite, locally cherty with interbedded shale and sandstone

Dark gray to black shale, minor interbedded carbonate and sandstone

Conglomerate

Combination of geologic unit symbols indicates a mixture of either surficial basin fill or rock units inseparable at map scale

Parenthetic unit underlies surface unit at shallow depth

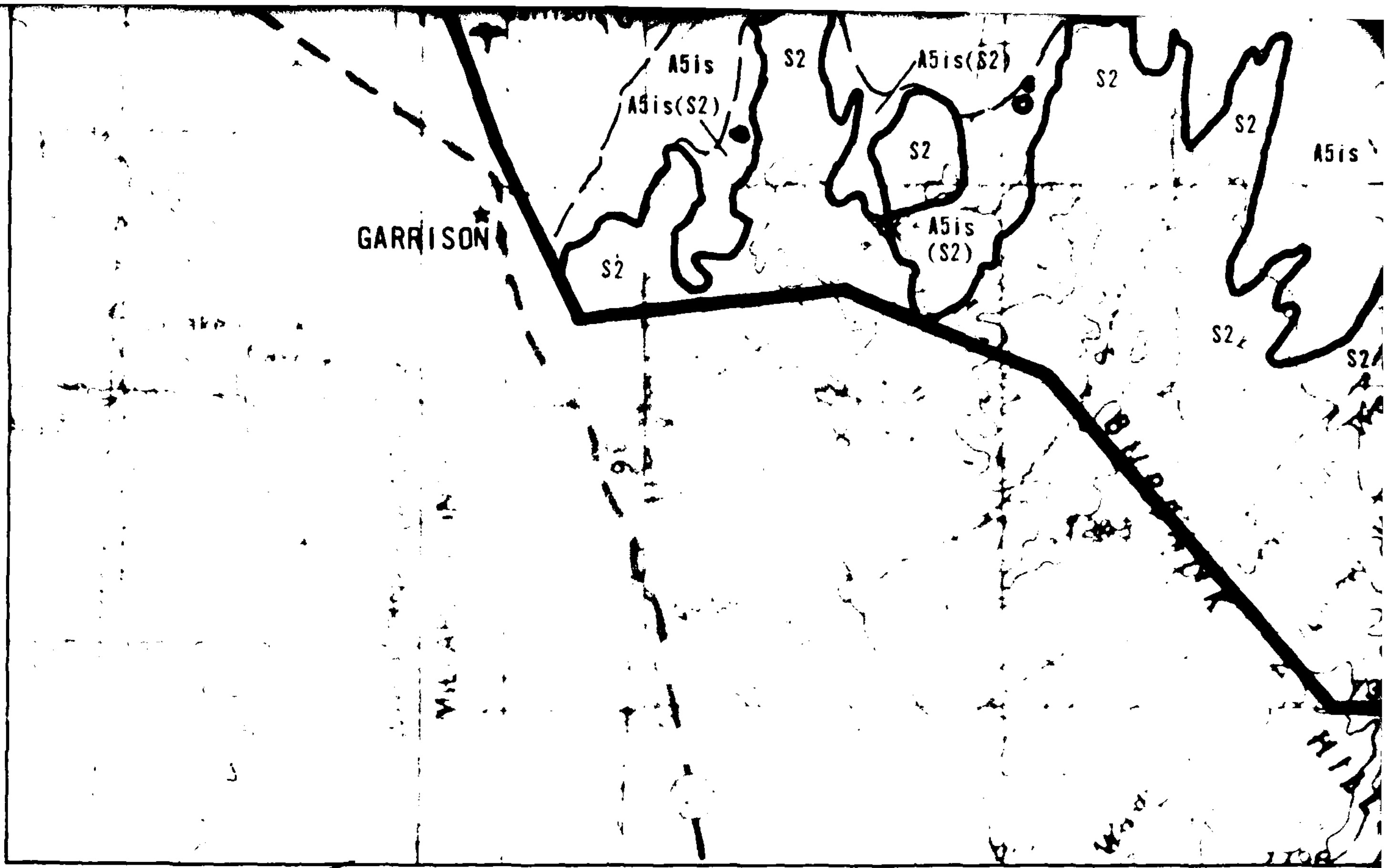
SYMBOLS

Contact between rock and basin fill

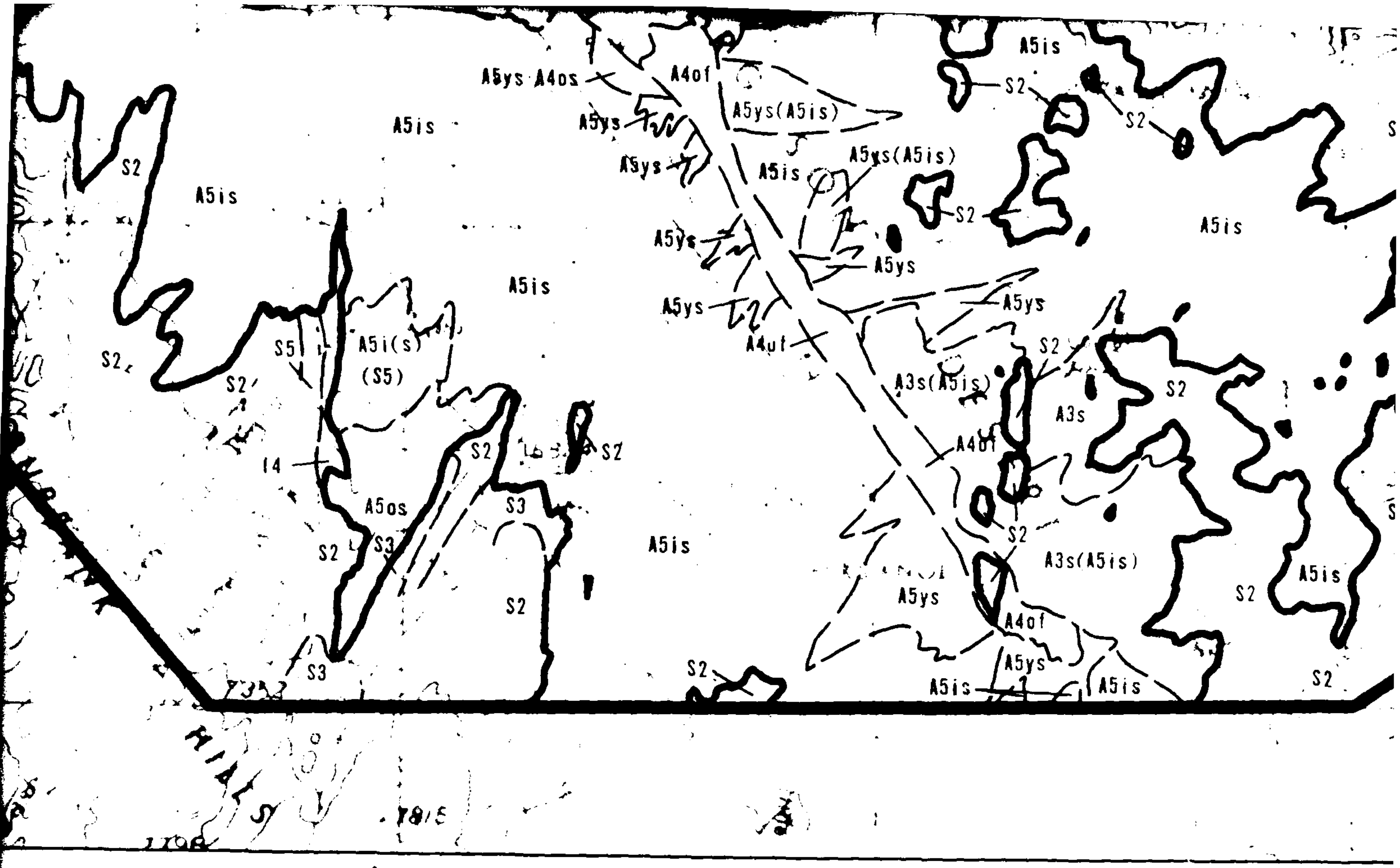
Contact between surficial basin-fill or rock units

...ial basin-fill units pertain only to the upper several feet of soil. Due to ...bility of surficial deposits and scale of map presentation, unit descriptions ... to the predominant soil types. Varying amounts of other soil types can be ...ted within each geologic unit

...tribution of geologic data stations is presented in Volume III, Drawing 1.



2 JUL 79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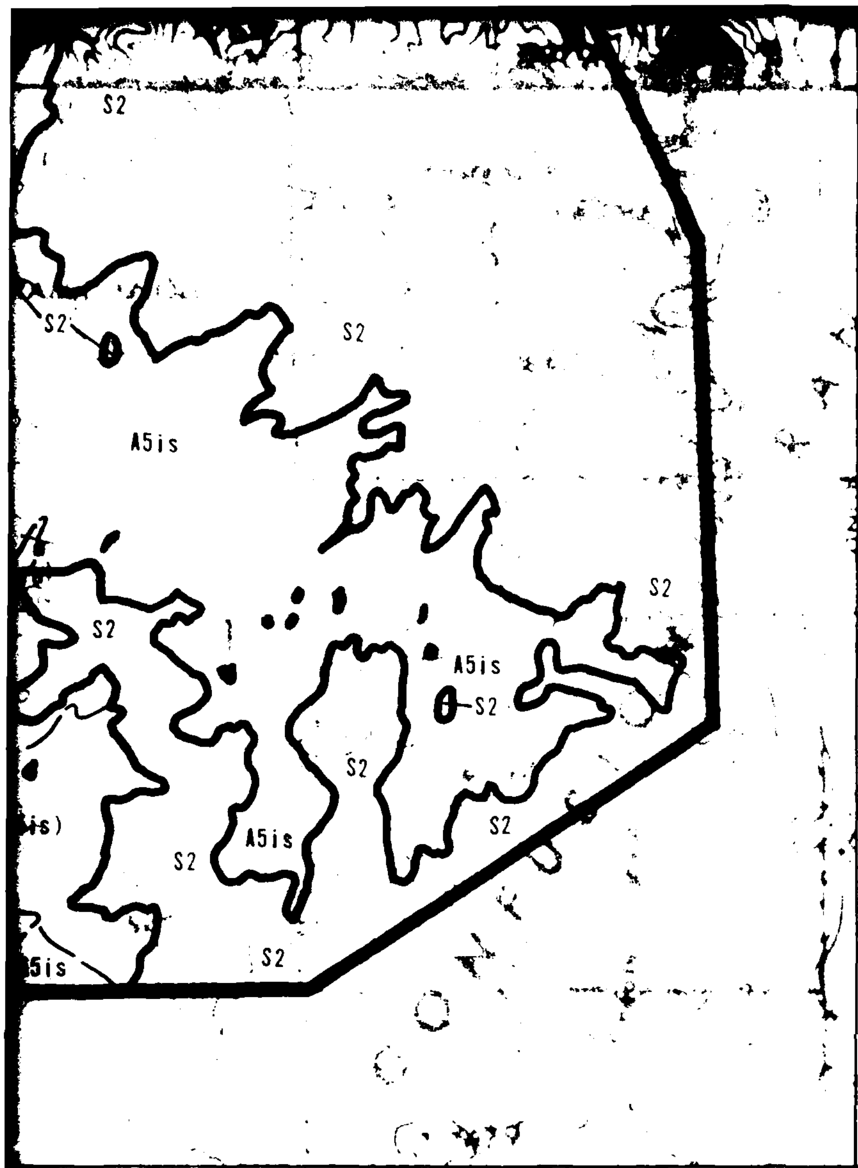

SYI

Contact between roc

Contact between sui

NOTES:

1. Surficial basin fill units ... variability of surficial ... refer to the predominant ... expected within each geol...

2. The distribution of geologi... A tabulation of all stat... included in Volume III. Se...

3. Geology in areas of exposed...

SCALE 1:12

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KILOMETE

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AD-A113 322 FUGRO NATIONAL INC LONG BEACH CA F/G 13/2
MX SITING INVESTIGATION GEOTECHNICAL EVALUATION. VOLUME IA. NEV--ETC(U)
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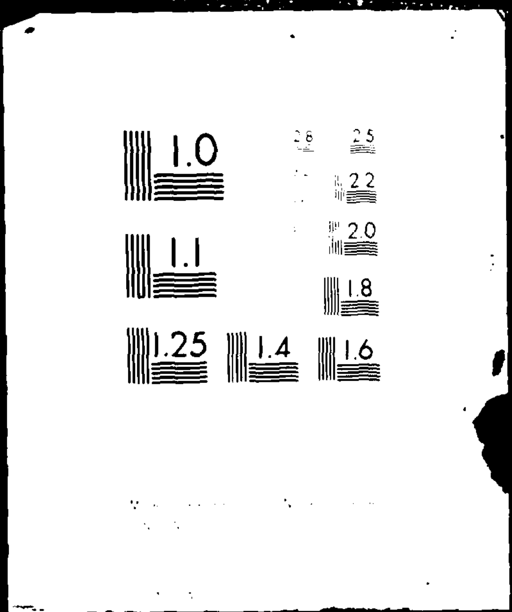

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. Geology i

Contact between rock and basin fill

Contact between surficial basin-fill or rock units

S:

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: Hintze (1963)

N

SCALE 1:125,000

0 2 4

STATUTE MILES

0 2 4

KILOMETERS

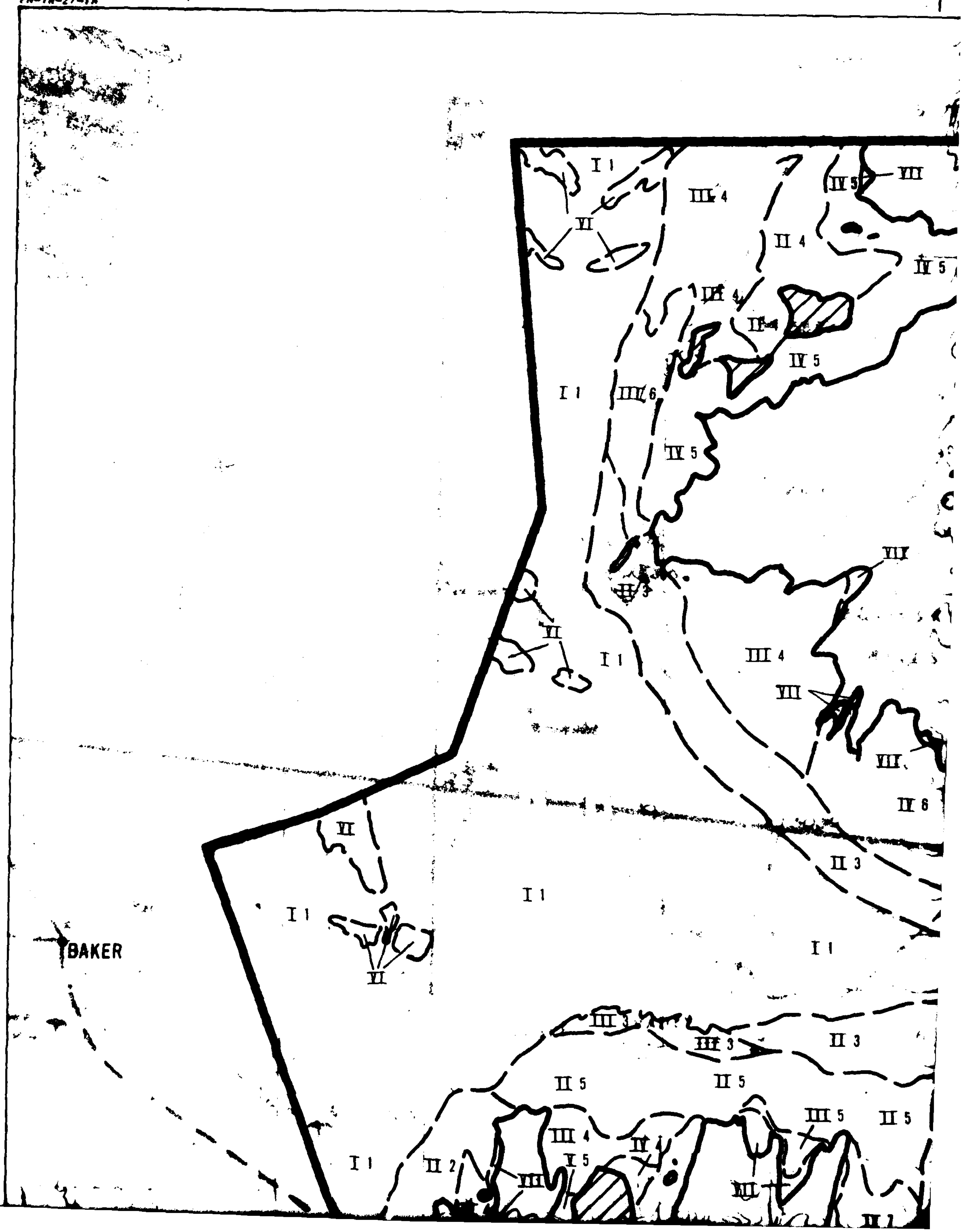
SURFICIAL GEOLOGIC UNITS
VERIFICATION SITE, SNAKE EAST CDP, UTAH

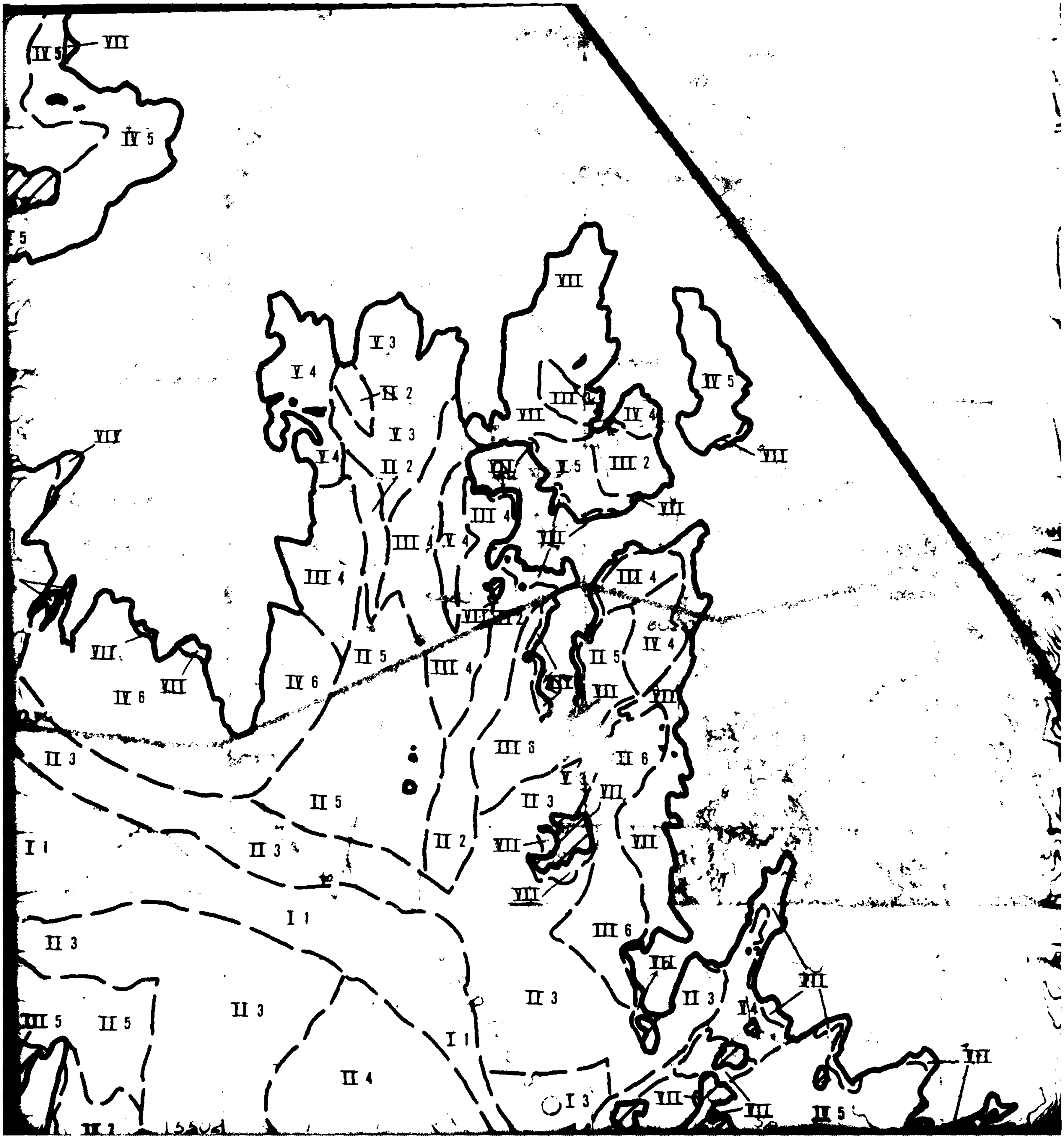
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

DRAWING 5-2

FUGRO NATIONAL, INC.

8


BAKER
I 1
III 4
IV 5
VII
II 4
VI
II 3
III 3
II 5
III 5
III 4
II 2
V 5
IV 6
III 6



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VII
IV 5
VII
V 3
V 4
IV 2
V 3
V 4
II 2
IV 5
III 2
IV 4
V 5
III 2
III 4
III 4
V 4
III 4
VII
II 5
IV 6
IV 6
III 4
II 5
IV 4
II 3
III 6
II 6
II 5
II 3
I 1
II 3
II 2
VII
I 1
II 3
III 6
II 3
II 3
III 5
II 5
II 3
II 4
I 1
I 3
II 5

13

Terrain Category
(see table below)

TERRAIN CATEGORY

I

II

III

IV

V

VI

VII

Contact

Contact

Shading

NOTE: Ba
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te

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EXPLANATION

Terrain Category ------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).
(see table below)

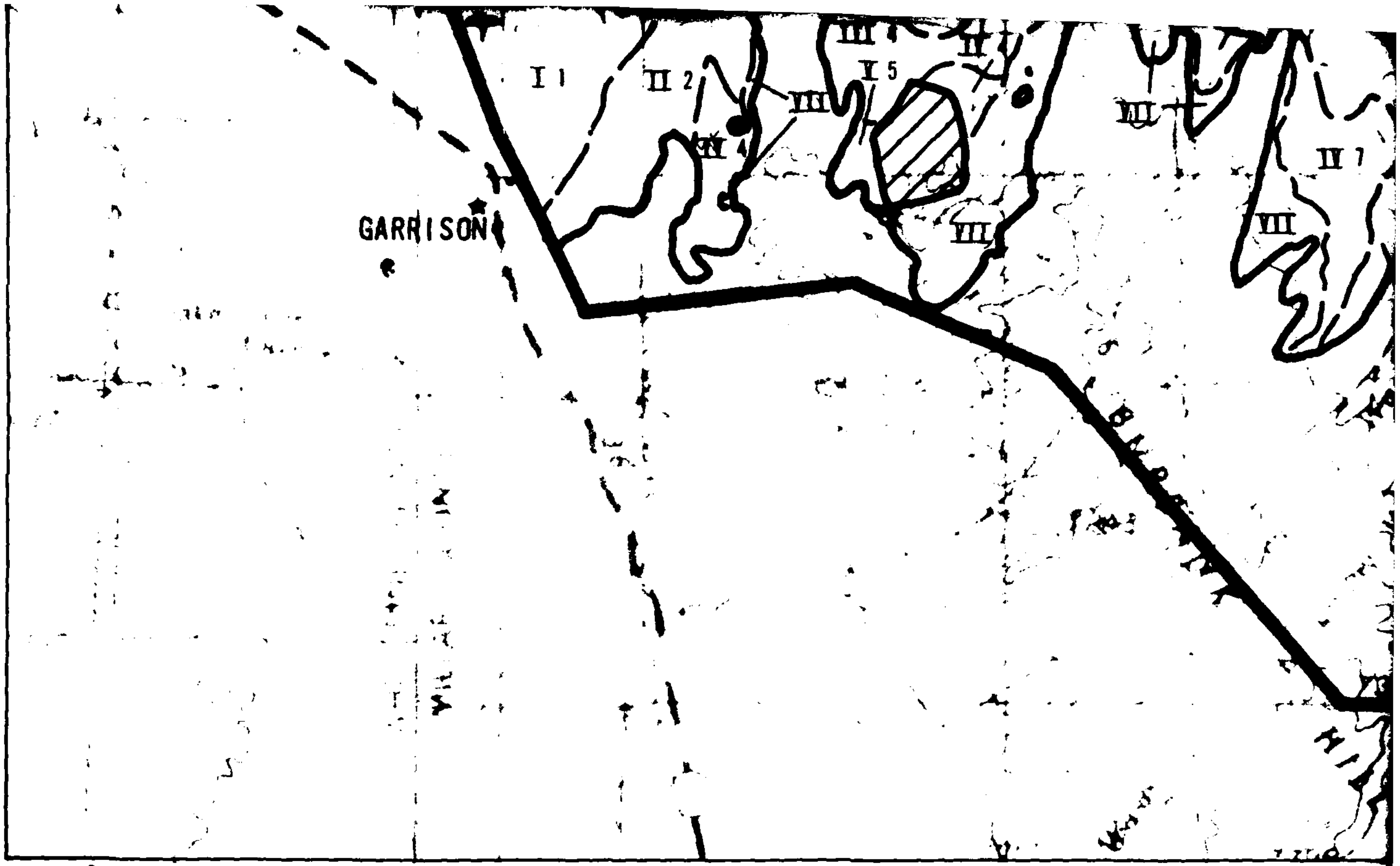
TERRAIN CATEGORY	DRAINAGE DEPTH/DESCRIPTION
I	Less than 3 feet (1m)
II	3-6 feet (1-2m)
III	6-10 feet (2-3m)
IV	10-15 feet (3-5m)
V	Greater than 15 feet (5m)
VI	Complex, highly variable terrain not defined by drainage incision (e.g. eunal or hummocky terrains).
VII	Unsuitable terrain (see Appendix A2.0.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



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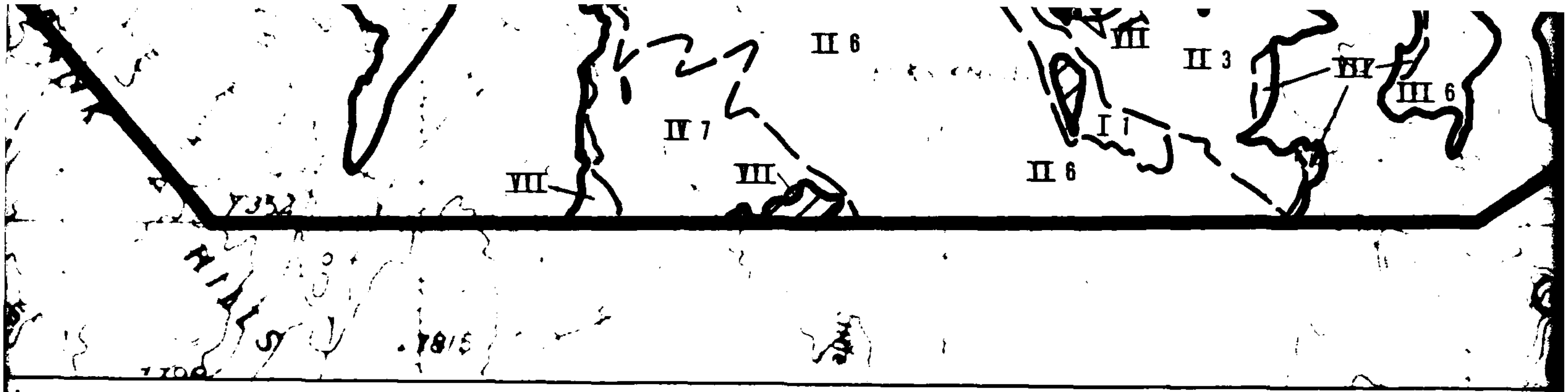
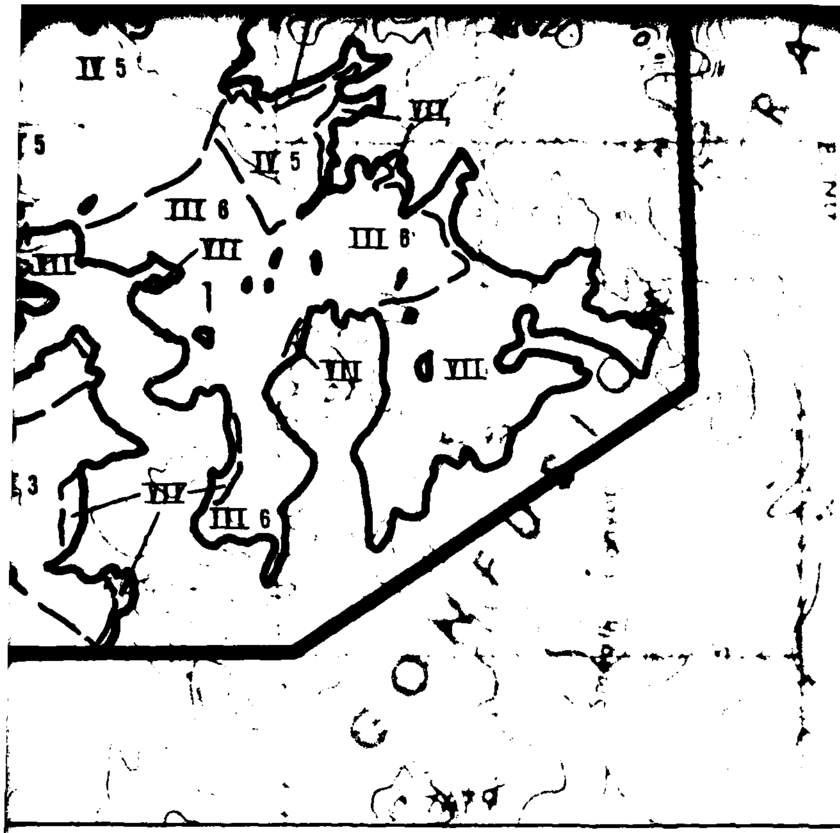


1- 6



17

SCALE 1:125,000

0 2 4

STATUTE MILES

0 2 4

KILOMETERS

TERRAIN

VERIFICATION SITE, SNAKE EAST CDP, UTAH

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - SAMSO	DRAWING 5-3

FUGRO NATIONAL, INC.

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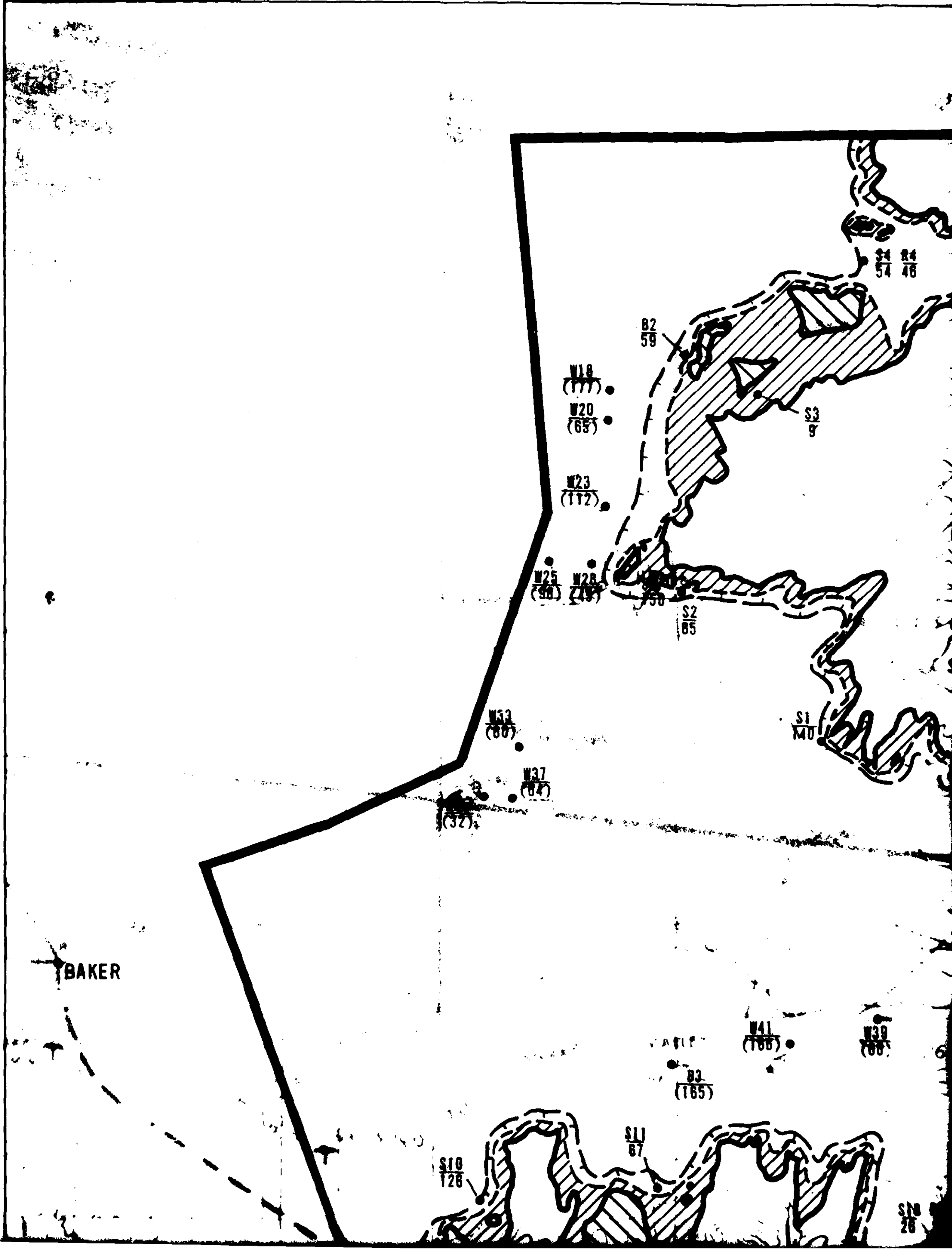
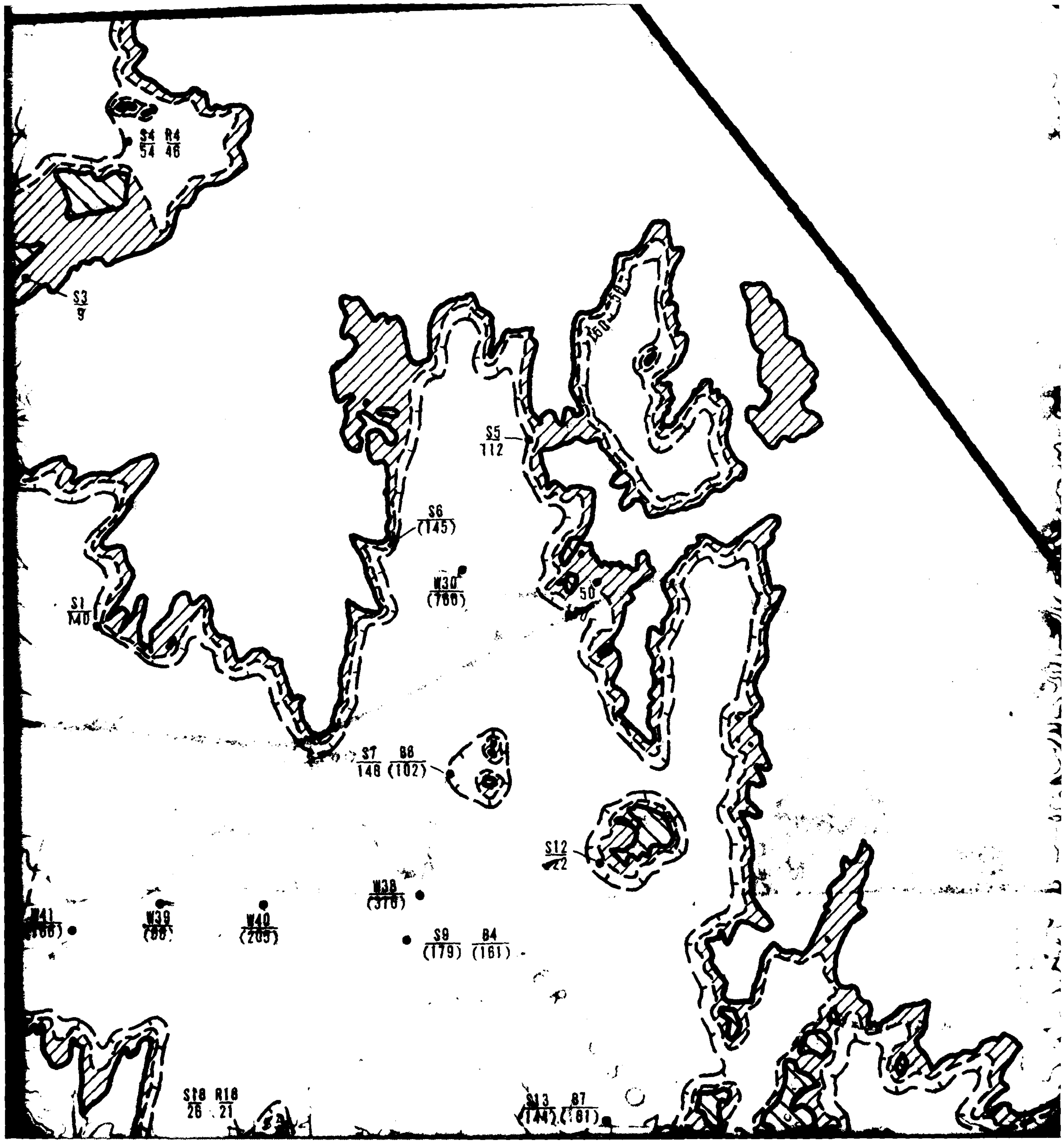

S4
54
R4
46
B2
59
W18
(177)
W20
(65)
S3
9
W23
(112)
W25
(98)
W28
(49)
S2
85
S1
140
W33
(80)
W37
(64)
(32)
BAKER
W41
(166)
W39
(60)
B3
(165)
S11
67
S10
126
S18
26



S4 54
R4 46
S3 9
S5 112
S6 (145)
W30 (760)
50
S7 148
B6 (102)
S12 22
W38 (310)
W39 (88)
W40 (205)
S9 (179)
B4 (161)
S18 26
R18 21
B7 (161)

Contour indicate
50 feet (15m)
than 50 feet (

Contour indicate
150 feet (46m)
than 150 feet

Contact between

Shading indicate

$\frac{S4}{75}$ Data source - Fu
line (S), elec
or water well
Depth to rock (f
above which r

NOTE: The contour
and the lim
changes in
additional

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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)

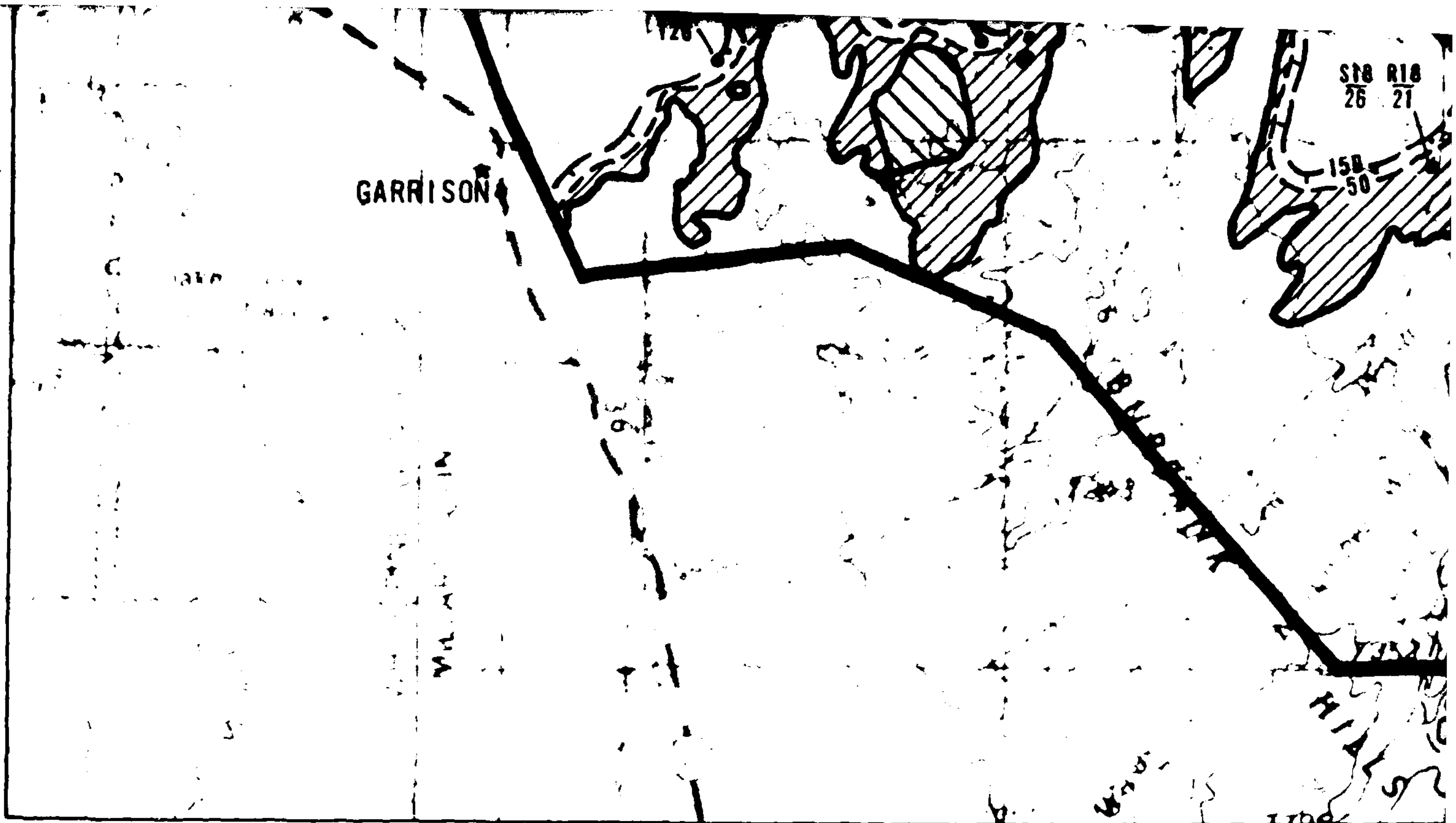
Contact between rock and basin-fill

Shading indicates 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.

SCALE 1:125.000



2 JUL 79

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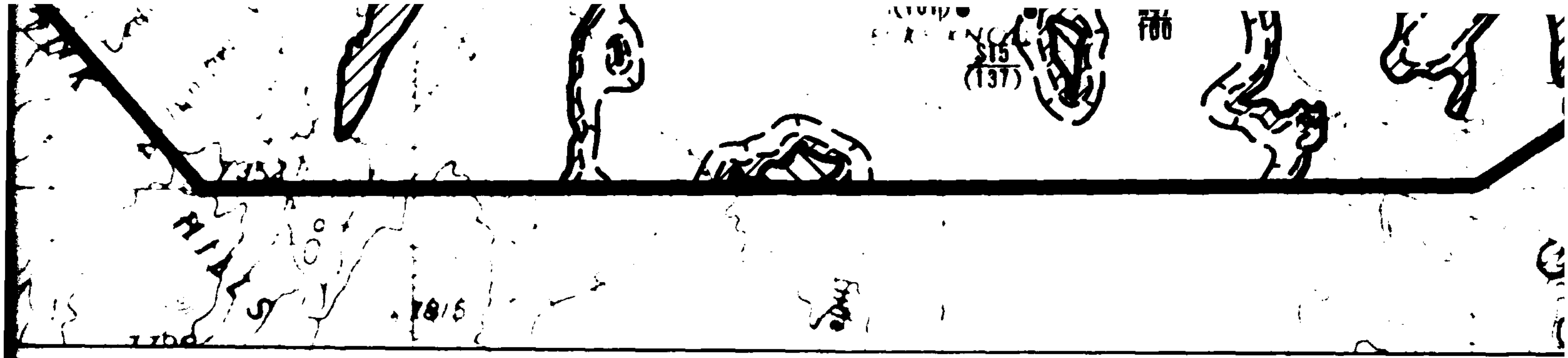

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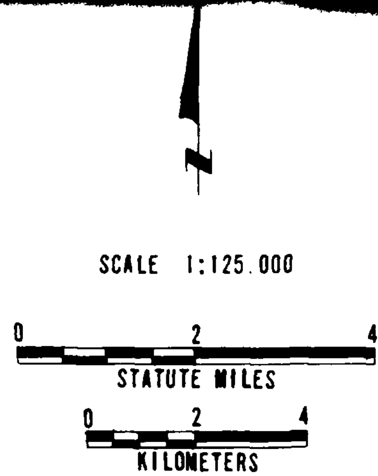
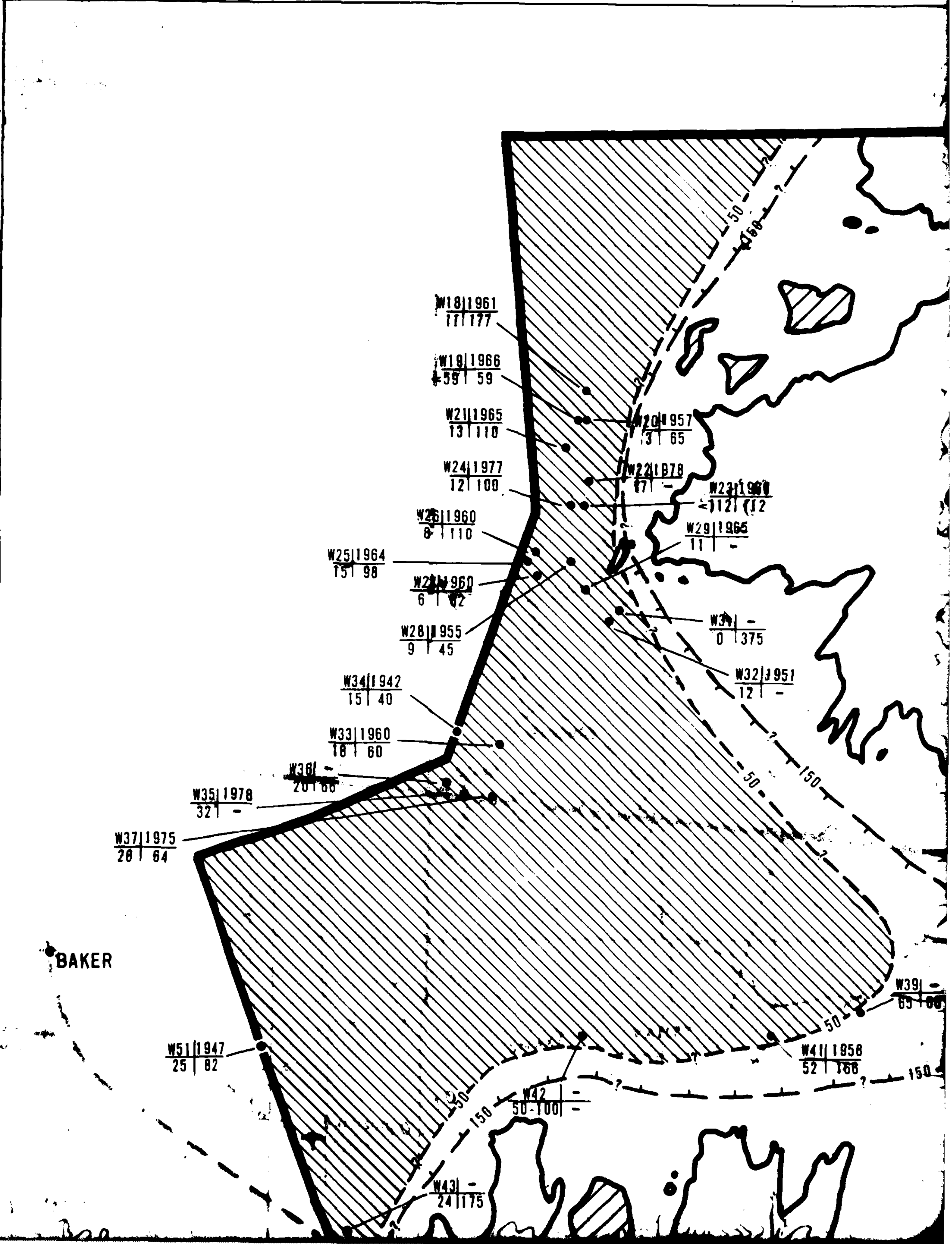


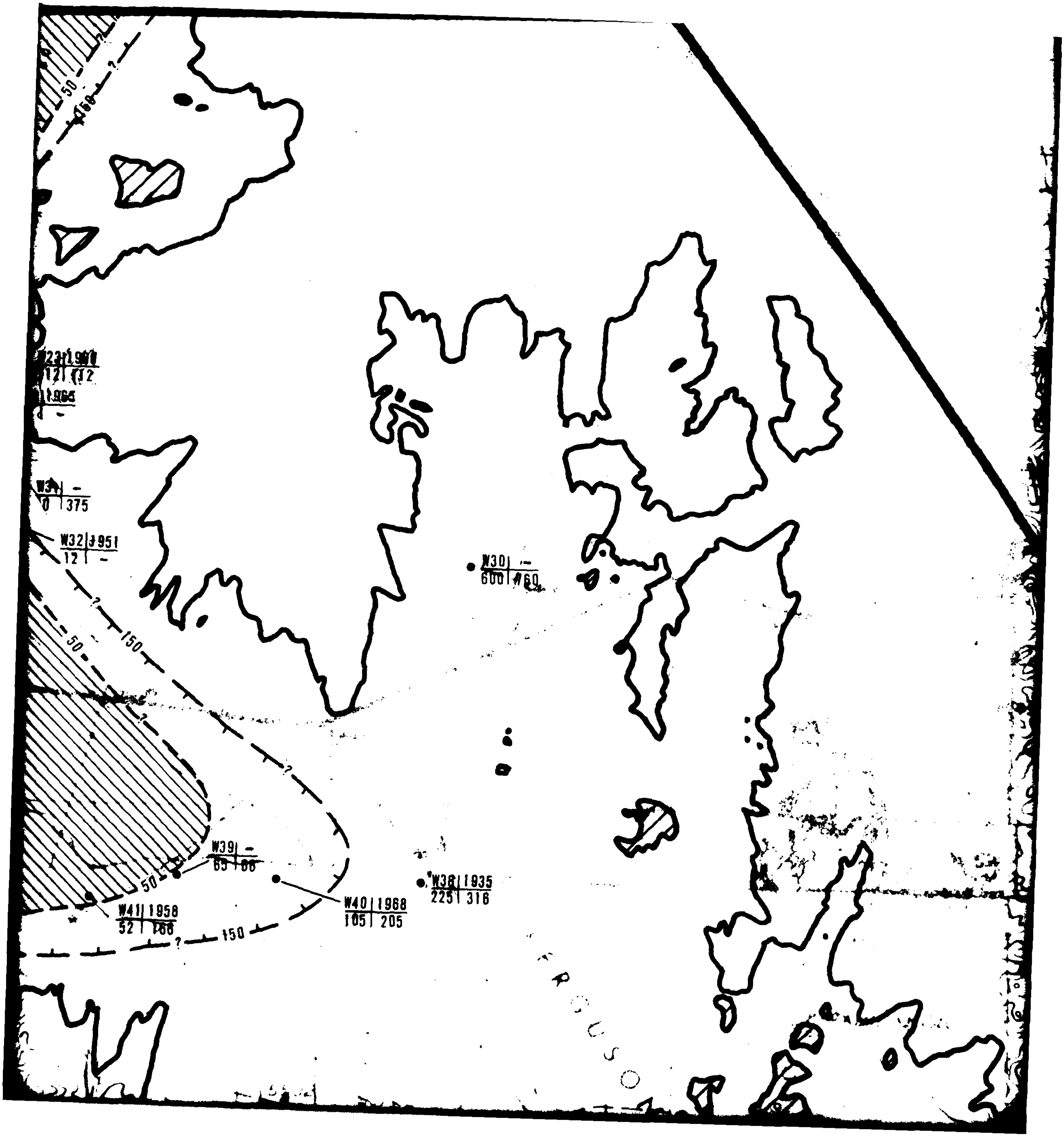
DEPTH TO ROCK
VERIFICATION SITE, SNAKE EAST CDP, UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

DRAWING 5-4

FUGRO NATIONAL, INC.


W18 | 1961
11 | 177
W19 | 1966
59 | 59
W20 | 1957
3 | 65
W21 | 1965
13 | 110
W22 | 1978
W24 | 1977
12 | 100
W29 | 1965
11 | -
W25 | 1964
15 | 98
W28 | 1955
9 | 45
W31 | -
0 | 375
W32 | 1951
12 | -
W34 | 1942
15 | 40
W33 | 1960
18 | 60
W35 | 1978
32 | -
W37 | 1975
28 | 64
BAKER
W51 | 1947
25 | 82
W39 | -
W41 | 1958
52 | 166
W42 | -
50-100 | -
W43 | -
24 | 175
50
150



W30 | –
600 | 460
W38 | 1935
225 | 316
W40 | 1968
105 | 205
W41 | 1958
52 | 166
W39 | –
65 | 66
W32 | 1951
12 | –
375
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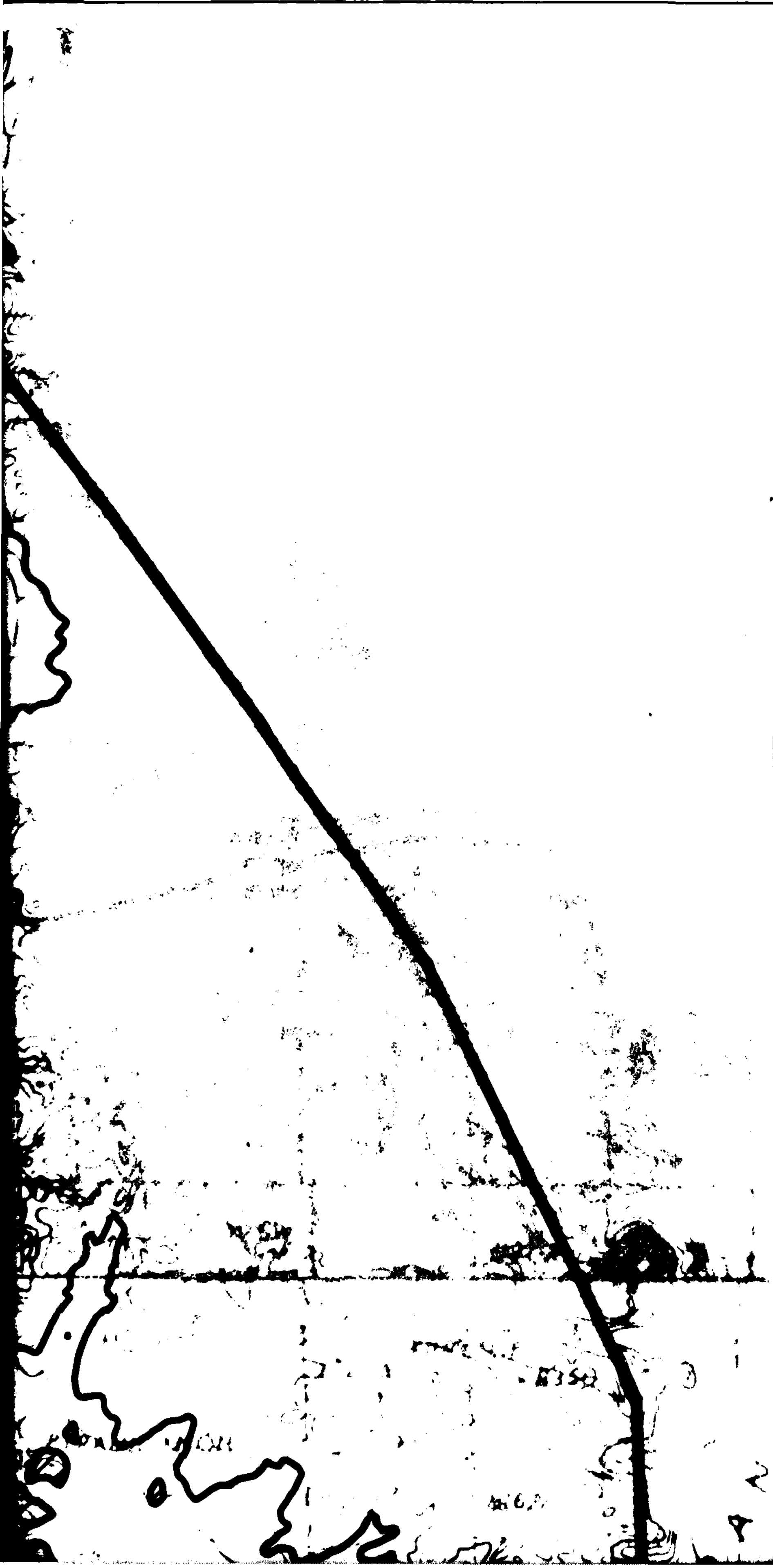

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W2 | 1973
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Depth

NOTE:

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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 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.

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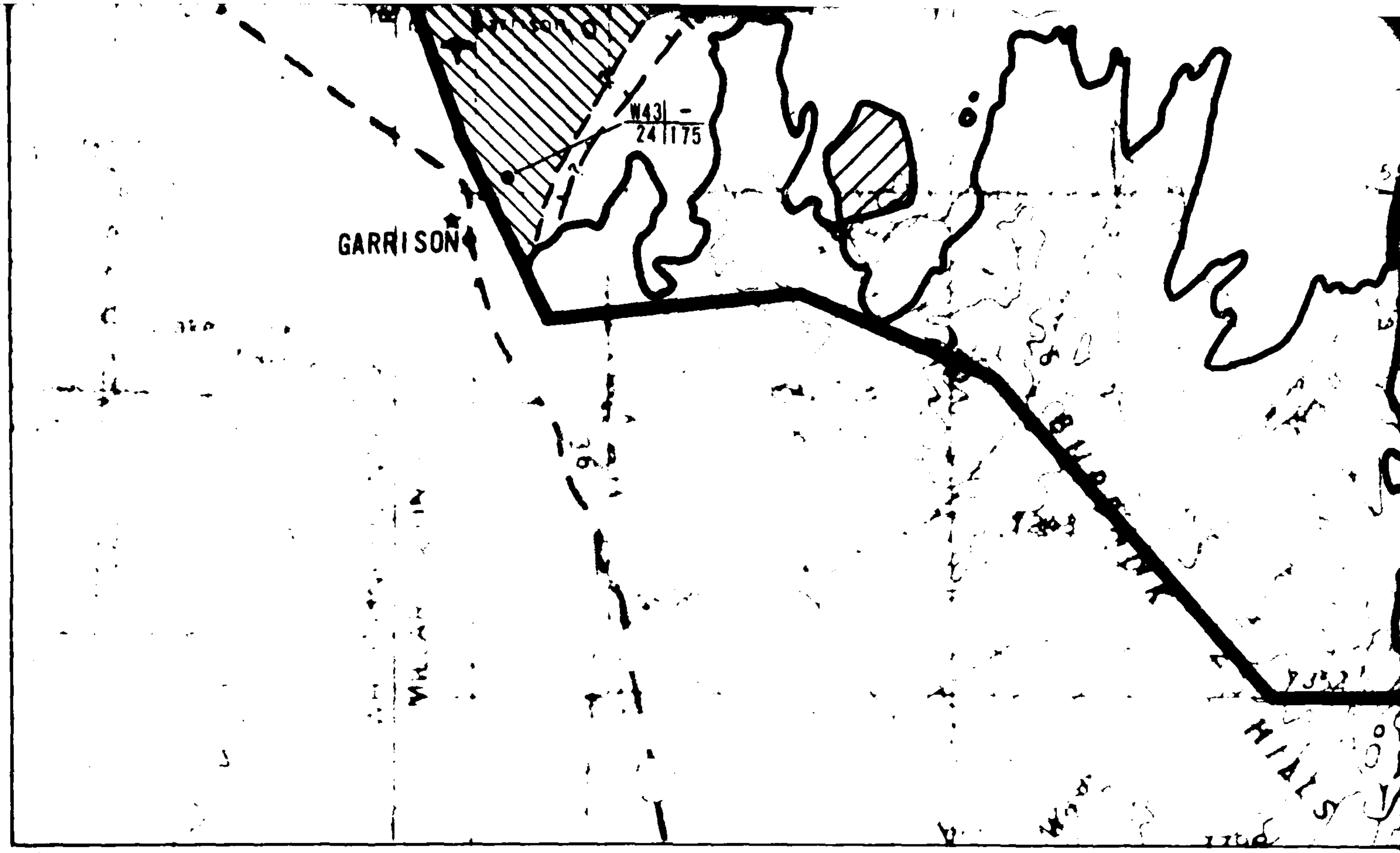
SCALE 1:125,000



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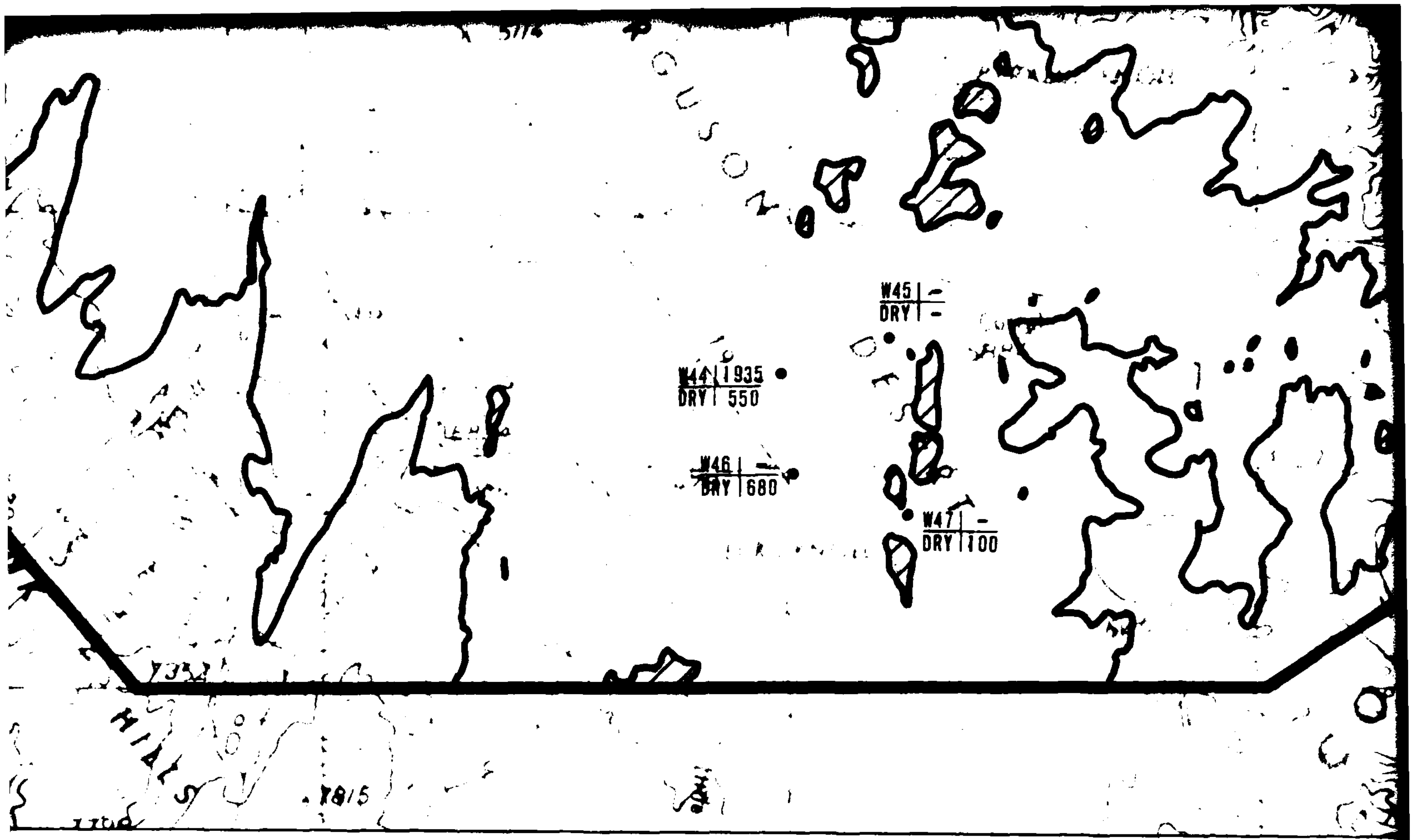

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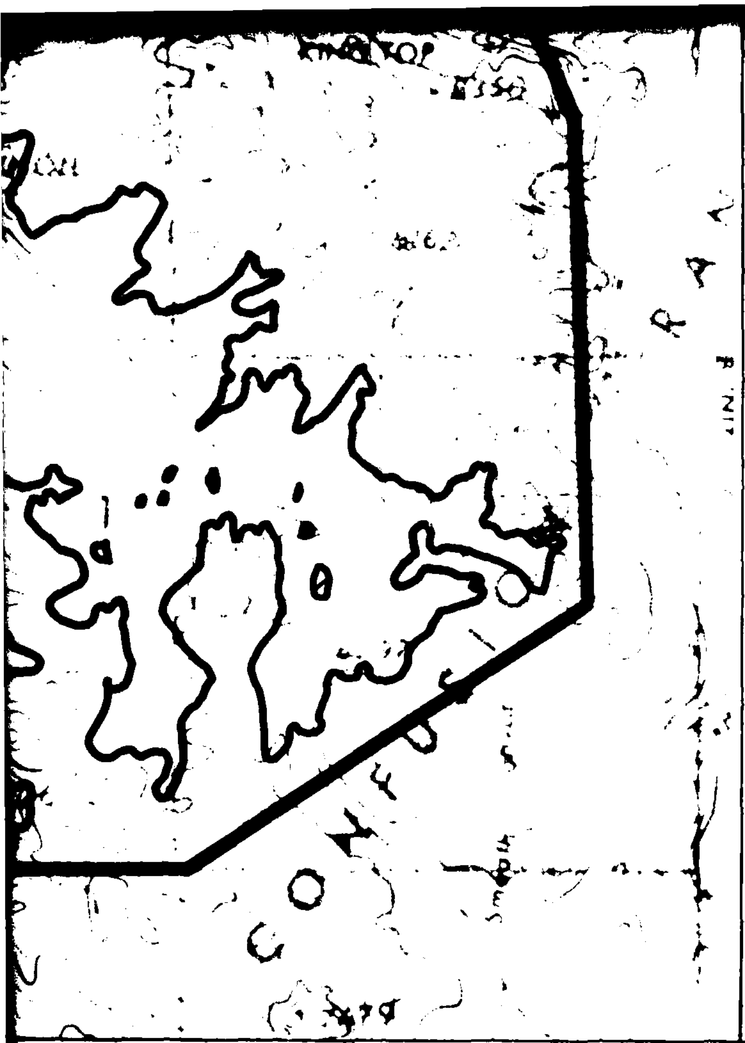

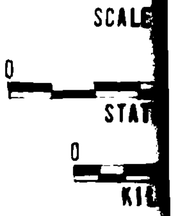

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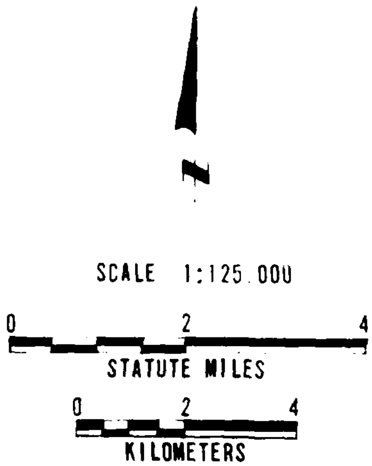

DEPTH TO WATER
VERIFICATION SITE, SNAKE EAST CDP, UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

DRAWING 5-5

FUGRO NATIONAL, INC.

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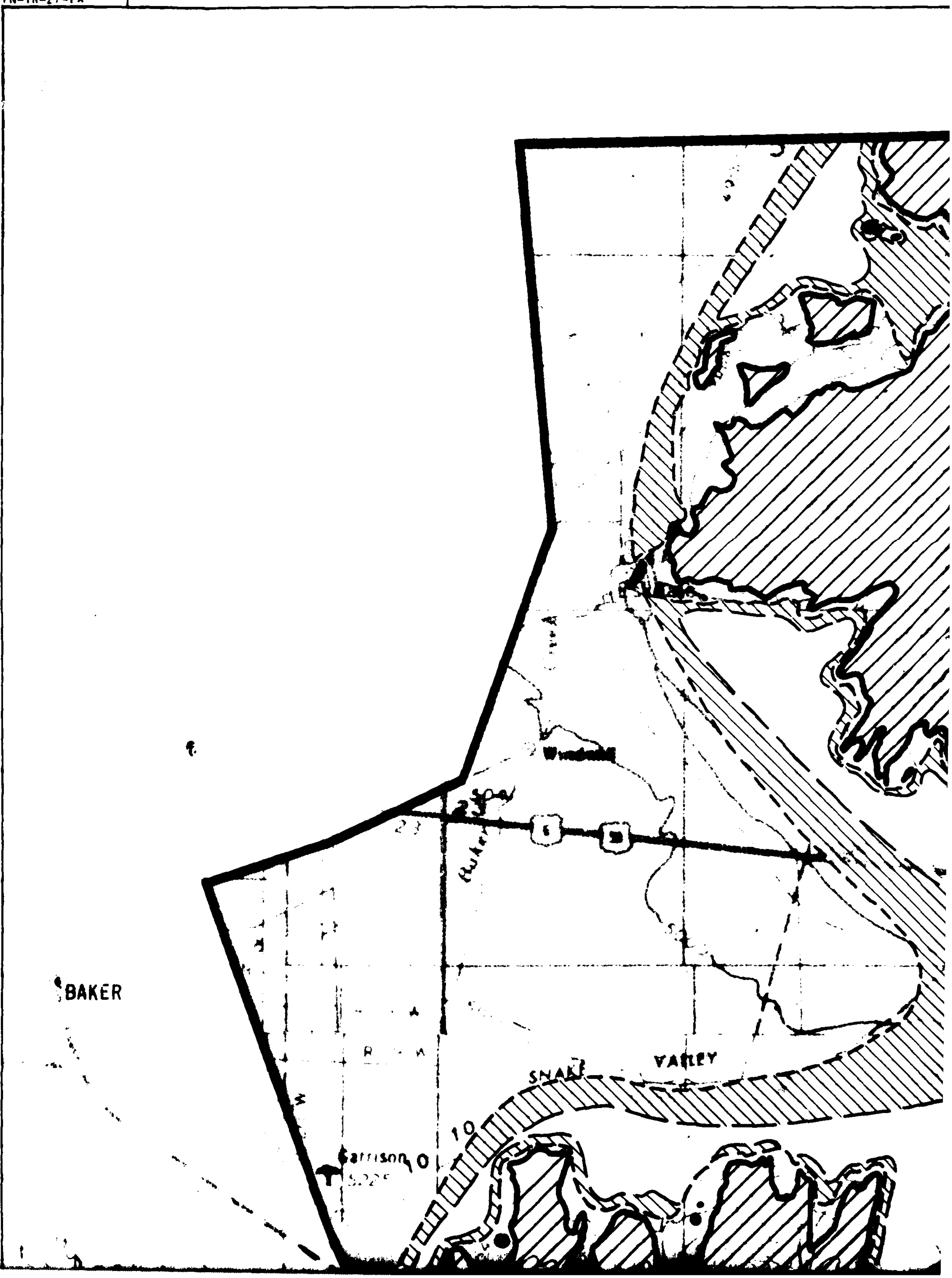
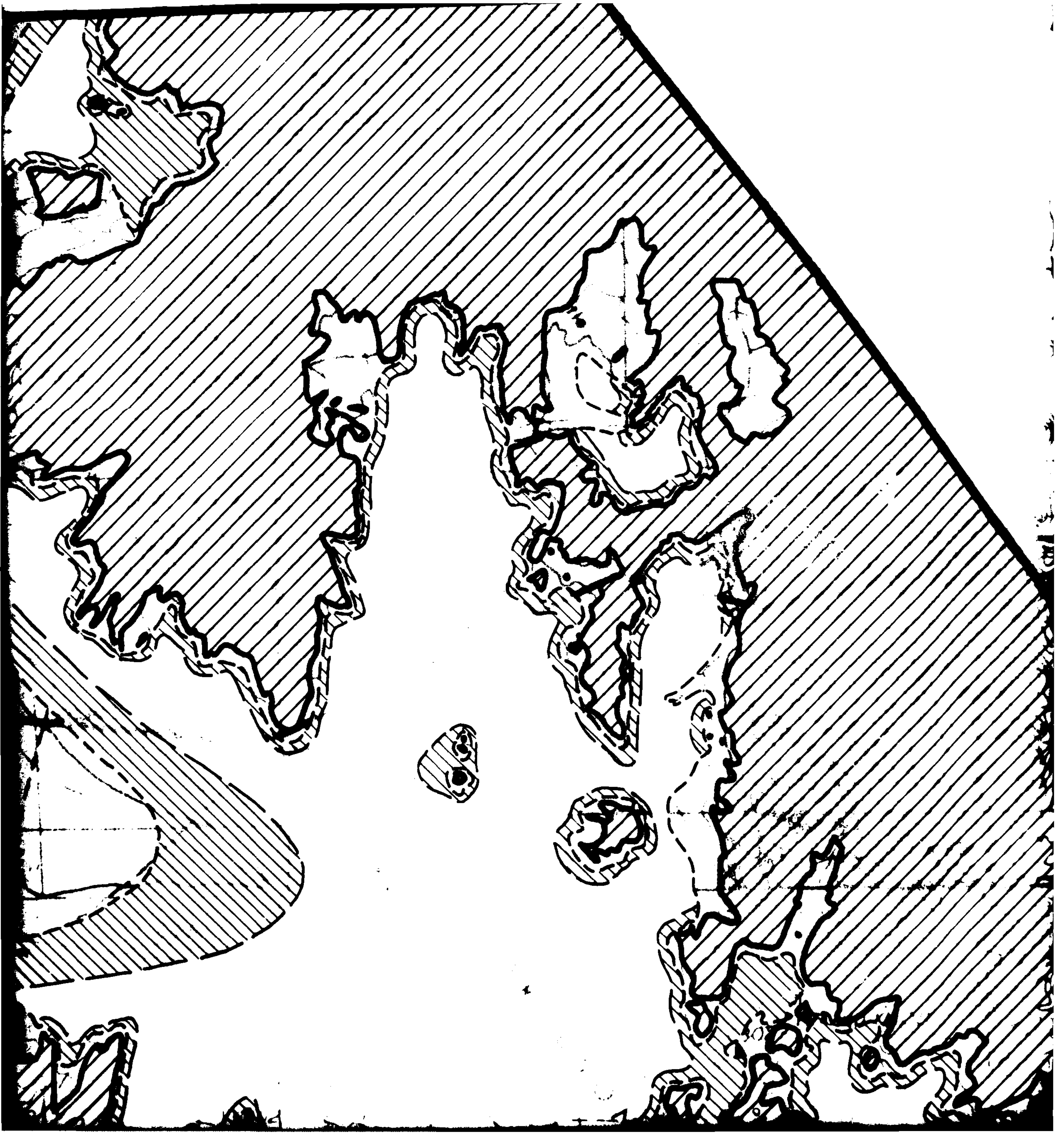

BAKER
SNAKE VALLEY
10
Garrison



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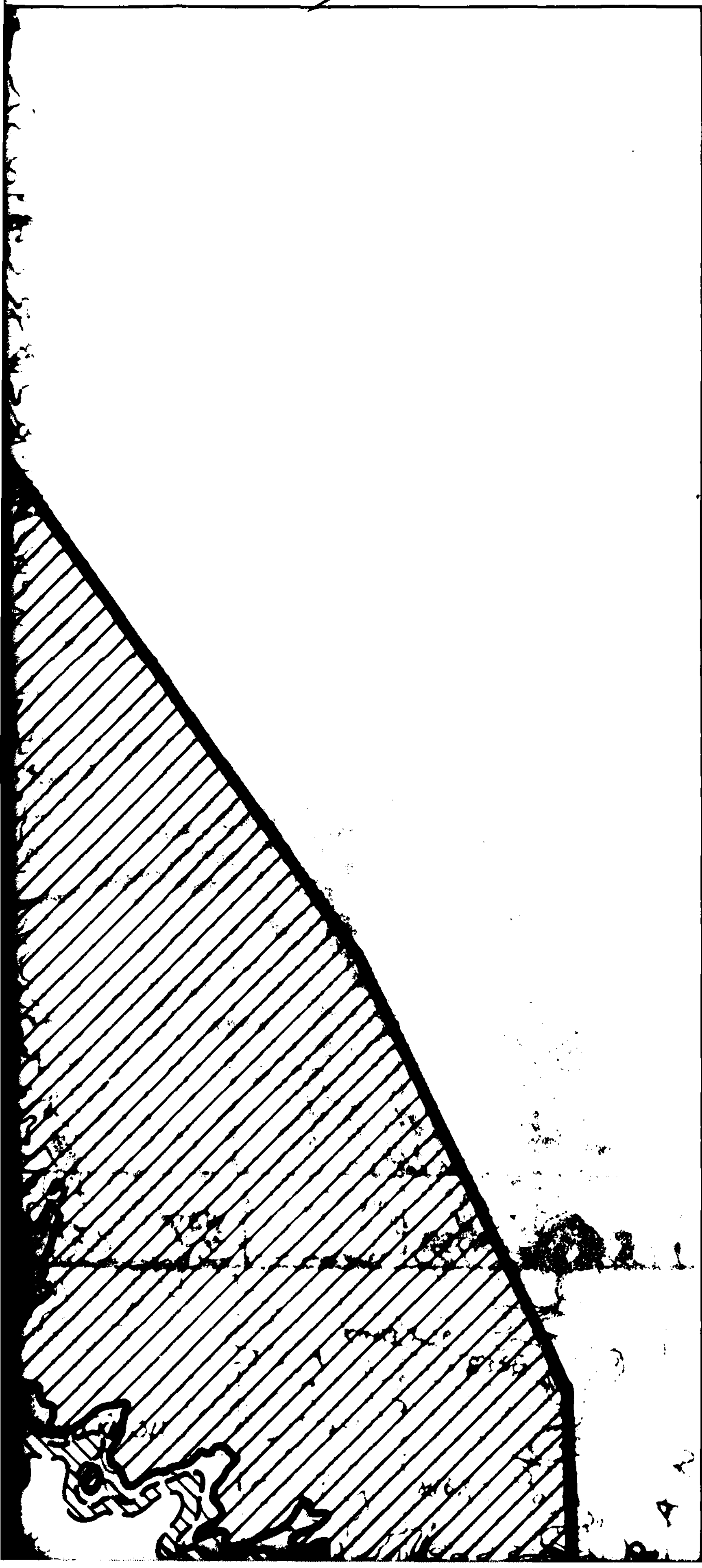

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EXPLANATION

Area suitable for hybrid trench and vertical shelter basing mode. 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. (See Section A2.0 in Appendix for details of exclusion criteria.)

Indicates areas of exposed rock.

Contact between rock and basin fill.

SCALE 1:125,000

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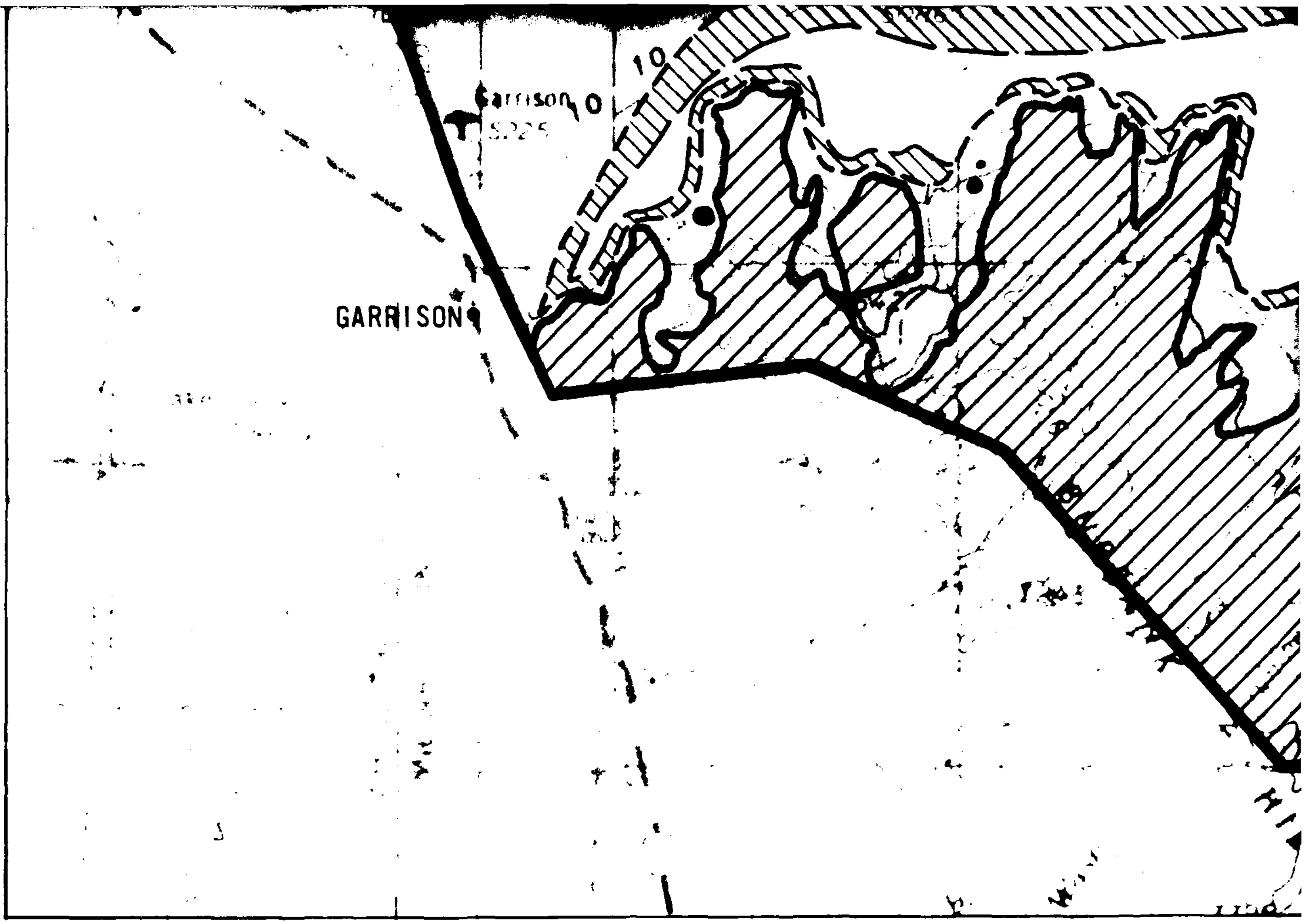

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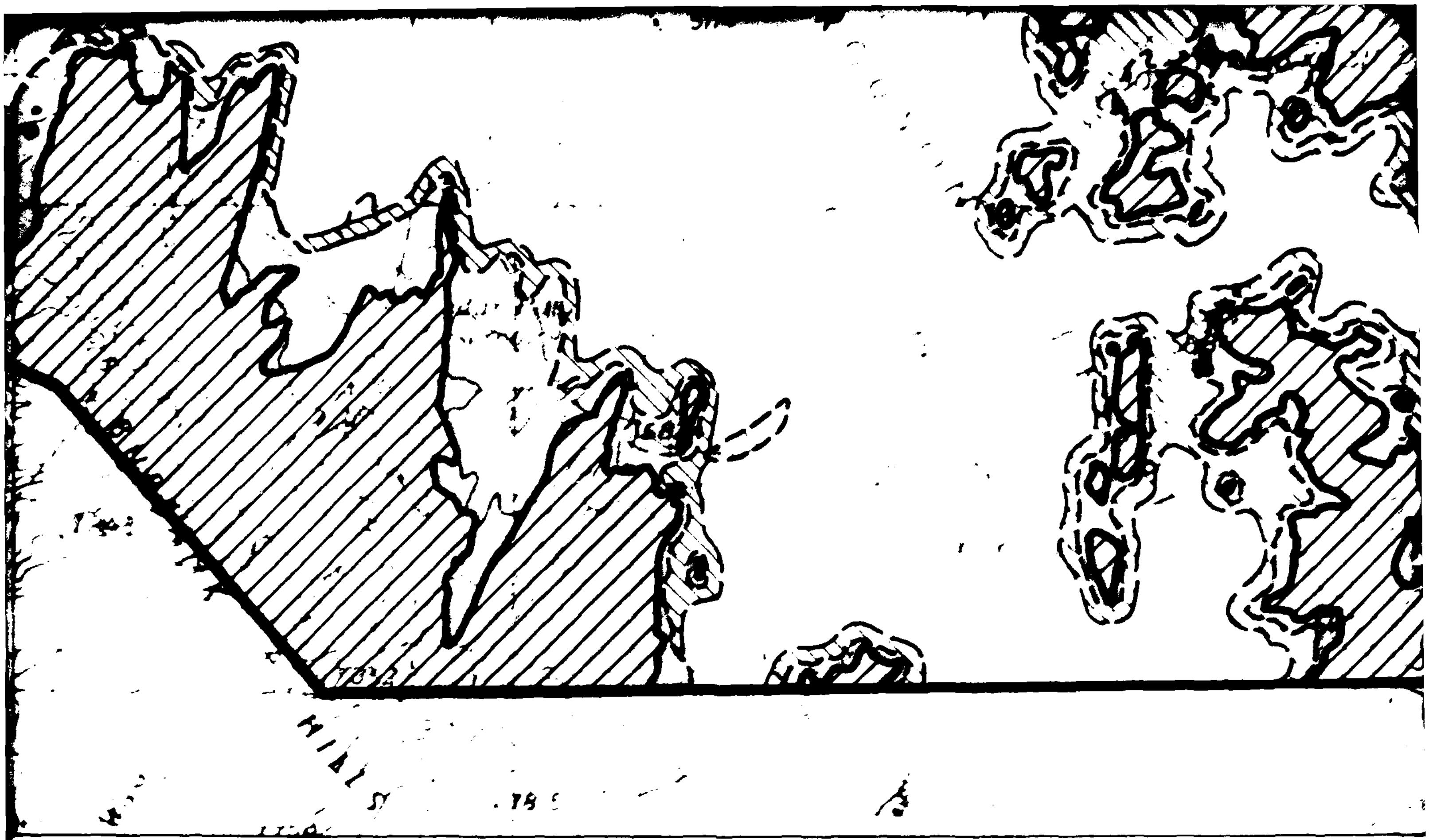

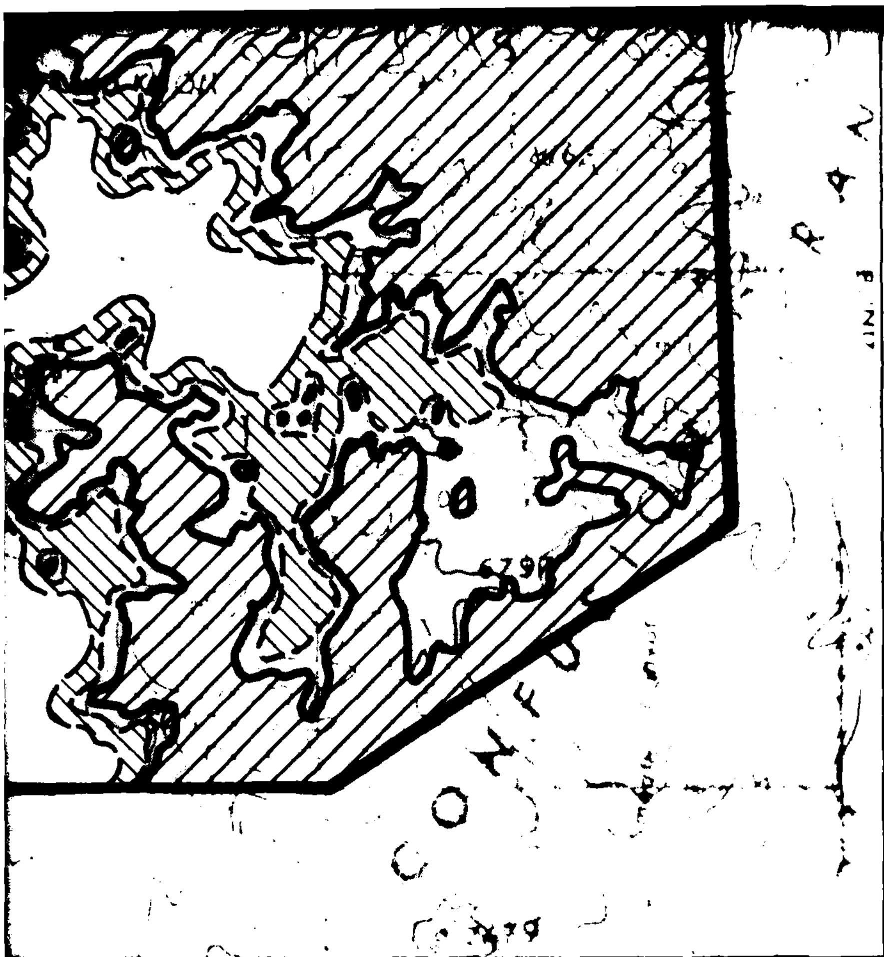

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SCALE 1:125,000

0 2 4

STATUTE MILES

0 2 4

KILOMETERS

SUITABLE AREA
HYBRID TRENCH AND VERTICAL SHELTER
VERIFICATION SITE, SNAKE EAST CDP, UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

DRAWING 5-6

FUGRO NATIONAL, INC.

6.0 HAMLIN CDP

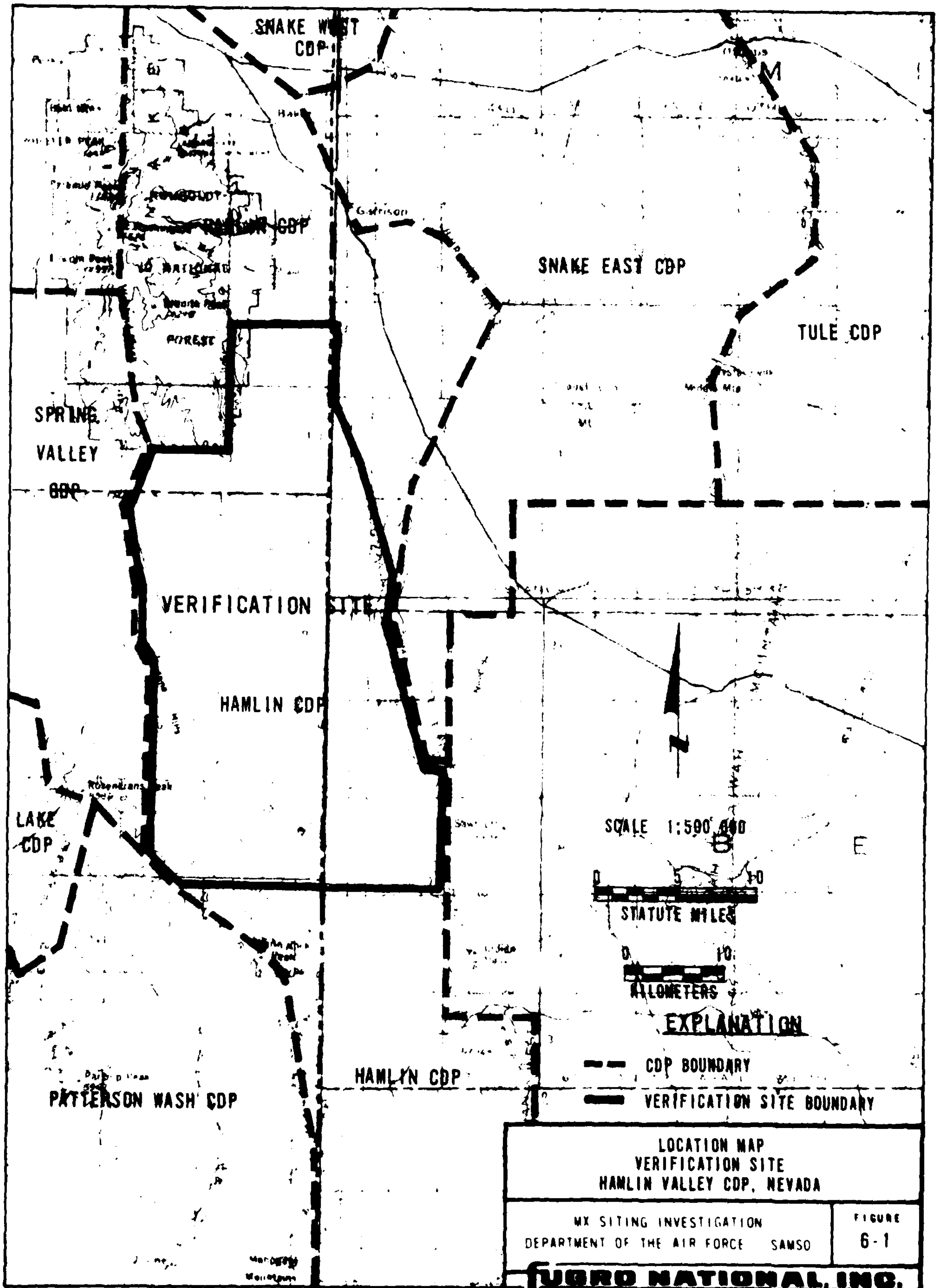
6.1 GEOGRAPHIC SETTING

Hamlin CDP is located principally in Lincoln and White Pine counties in east-central Nevada with portions in Millard, Beaver, and Iron counties, Utah (Figure 6-1). Baker, Nevada is located at the northern end of the CDP with the Burbank Hills and Needle Range forming the eastern boundary. The Snake Range, Limestone Hills, and White Rock Mountains form the western boundary of the CDP which extends south to the end of Hamlin Valley about 10 miles (16 km) north of Modena, Utah. The Verification site encompasses the northern part of the CDP, principally in Nevada from 38°20' to 38°50' north latitude.

No paved roads occur within the CDP, but access is generally good along well-maintained ranch and mine roads. The nearest towns are Baker, Nevada and Garrison, Utah, along Highway 21 near the northern end of the CDP. Ely, Nevada is located 48 miles (77 km) west and north of the CDP on Highway 93. Most of the CDP is undeveloped rangeland containing several ranches and agricultural fields located principally along Hamlin Wash.

6.2 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 6-1. Locations of the geophysical and engineering activities are shown in Drawing 6-1 (end of Section 6.0).



LOCATION MAP
VERIFICATION SITE
HAMLIN VALLEY CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 6-1

FUGRO NATIONAL, INC.

2 JUL 79

GEOLOGY AND GEOPHYSICS

TYPE OF ACTIVITY	NUMBER OF ACTIVITIES
Geologic mapping stations	77
Shallow refraction	19
Electrical resistivity	19
Gravity profiles	9

ENGINEERING-LABORATORY TESTS

TYPE OF TEST	NUMBER OF TESTS
Moisture/density	89
Specific gravity	0
Sieve analysis	84
Hydrometer	6
Atterberg limits	20
Consolidation	1
Unconfined compression	1
Triaxial compression	6
Direct shear	3
Compaction	6
CBR	6
Chemical analysis	12

ENGINEERING

NUMBER OF BORINGS	NOMINAL DEPTH FEET (METERS)
4	160 (49)
2	120 (37)
NUMBER OF TRENCHES	**NOMINAL DEPTH FEET (METERS)**
10	10-14 (3-4)
1	4 (1)
NUMBER OF TEST PITS	**NOMINAL DEPTH FEET (METERS)**
28	5 (2)
NUMBER OF CPTs	**RANGE OF DEPTH FEET (METERS)**
61	1-36 (0.3-11)
TYPE OF ACTIVITY	**NUMBER OF ACTIVITIES**
Surficial soil samples	25
Field CBR tests	0

SCOPE OF ACTIVITIES
VERIFICATION SITE, HAMLIN COP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 6-1

FUGRO NATIONAL, INC.

6.3 GEOLOGICAL SETTING

The Hamlin Site area is an elongate north-south trending alluvial basin. The White Rock Range and the central portion of the Needle Range are composed of undifferentiated Tertiary volcanic rocks. Other mountains along the valley periphery are composed of an assemblage of Paleozoic limestones, dolomites, shales, and sandstones (Hintze, 1963; Hose and Blake, 1976; Tschanz and Pampeyan, 1970).

Basin and Range block faulting has formed the strong north-south physiographic framework of the valley and has probably caused a recent upwarping of the southern end of the valley. Evidence for this event are the higher topographic level of lake beds being exhumed in the southwest portion of the site combined with anomalous north trending drainage. Numerous small faults offset alluvium in the same area.

Sediments in the site are predominantly alluvial fan and older lacustrine deposits. Surficial geologic units mapped in the site (Drawing 6-2) consist of the following (from oldest to youngest):

- Older alluvial fan deposits - This is the least extensive unit in the site, outcropping along the Needle and Snake Ranges. This unit was also encountered in borings and trenches in the shallow subsurface near the mountains. The unit is composed of admixtures of well-indurated gravels and sandy gravels.

- Lacustrine deposits - Lacustrine deposits cover approximately one-fifth of the site and are generally restricted to the west side of Hamlin Wash where they are being actively exhumed. In the southwest, they are overlain by intermediate fans. The deposits are composed of admixtures of sands, silts, and clays, but predominantly are clayey sands. These Plio-Pleistocene lake beds interfinger with older fan deposits.

- Intermediate alluvial fan deposits - This is the most extensive surficial unit in the site, forming a distinctive surface over much of the valley flanks, particularly in the southern portion of the site. The unit is composed of silty to clayey sands and generally grades into younger fan and terrace deposits except along incised reaches of Hamlin Wash.

- Younger alluvial fan, terrace, and stream channel deposits - These units are exposed over approximately one-fourth of the site, generally occurring in the central part of the valley and along drainage channels. Distinctive features of each unit are often obscure and difficult to distinguish at this scale of study. Younger fans and terrace materials are predominantly silty sand. Channel deposits range from a silty sand to sandy and clayey silts in areas of lower gradient.

6.4 SURFACE SOILS

Soils of the Hamlin Site are generally coarse-grained, ranging from sandy gravels to silty sands. Small amounts of fine-grained soils are also present. Soils from the predominant surficial geologic units (Drawing 6-2) can be combined into the following three categories:

1. Silty sands and clayey sands (from geologic units A2s, A4os, A5ys, A5is, and A5ig);
2. Sandy gravels and gravelly sands (from geologic units A4os, A5ys, A5is, and A5ig); and
3. Sandy silts, silts, and sandy clays (from geologic unit A4of).

6.4.1 Characteristics

The characteristics of surficial soils, based on field and laboratory test results, are summarized in Table 6-2. In addition to the physical properties, road design data consisting of laboratory compaction and California Bearing Ratio (CBR)

SOIL DESCRIPTION		Silty Sands and Clayey Sands		Sandy Gravels Gravelly Sands
USCS SYMBOLS		SM, SC		GP, GM, SM
PREDOMINANT SURFICIAL GEOLOGIC UNITS		A2s, A4os, A5ys, A5is, A5ig		A4os, A5ys, A5i
ESTIMATED AREAL EXTENT	%	35-55		35-55
PHYSICAL PROPERTIES				
COBBLES 3 – 12 inches (8 – 30 cm)	%	0-5		0-10
GRAVEL	%	1-25	[21]	22-50
SAND	%	44-74	[21]	35-64
SILT AND CLAY	%	19-36	[21]	11-24
LIQUID LIMIT		30-45	[3]	NDA
PLASTICITY INDEX		NP-18	[6]	NP
ROAD DESIGN DATA				
MAXIMUM DRY DENSITY	pcf (kg/m³)	116.1-129.5 (1860-2074)	[4]	133.7-141.9 (2142-2273)
OPTIMUM MOISTURE CONTENT	%	9.0-13.5	[4]	6.0-7.9
CBR AT 90% RELATIVE COMPACTION	%	14-32	[4]	61
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)	0.6-4.0 (0.2-1.2)	[42]	0.6-3.9 (0.2-1.2)
	AVERAGE ft (m)	1.3 (0.4)	[42]	1.3 (0.4)

(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 for details.

NOTES:
- [ ] –
- NDA –

Sandy Gravels and Gravelly Sands	Sandy Silts, Silts, and Sandy Clays	
GP, GM, SM	ML, CL	
A4os, A5ys, A5is, A5ig	A4of	
35-55	10-20	
0-10	0	
22-50 [11]	0-2 [3]	
35-64 [11]	3-42 [3]	
11-24 [11]	56-97 [4]	
NDA	23-37 [3]	
NP [1]	5-10 [3]	
133.7-141.9 (2142-2273) [2]	NDA	
.0-7.9 [2]	NDA	
1 [1]	NDA	
ood to very good	poor to fair	
air to good	not suitable	
.6-3.9 (0.2-1.2) [11]	0.9-3.7 (0.3-1.1) [3]	
.3 (0.4) [11]	2.5 (0.8) [3]	

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

CHARACTERISTICS OF SURFICIAL SOILS
VERIFICATION SITE, HAMLIN CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 6-2

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AFV-19

1 2

test results, depth range and average depths of low strength surficial soils, and suitability of the soils for road use are included in the table. The range of gradation of surficial soils is presented in Figure 6-2.

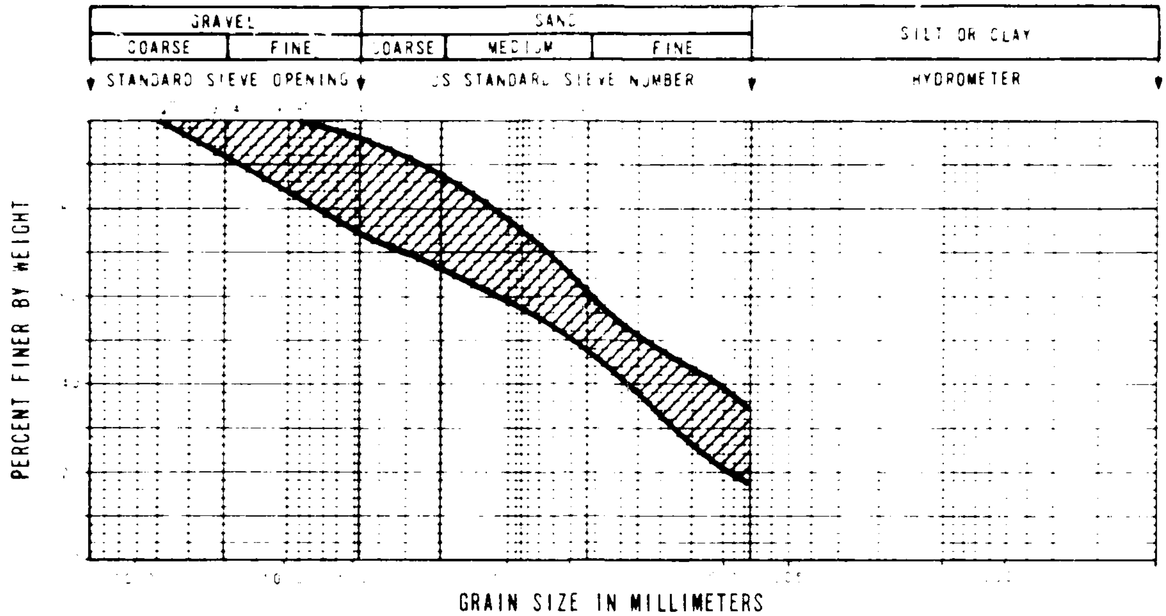
Silty sands and clayey sands have an areal extent ranging from 35 to 55 percent. The silty sands exhibit none to slight plasticity and are generally found in the northern and central portions of the site. Clayey sands of slight to high plasticity are found in the southern portions of the site. Both silty sands and clayey sands contain coarse to fine sand and fine gravel.

Sandy gravels and gravelly sands have an areal extent ranging from 35 to 55 percent in the site. They are found in the northern and central site portions and along the mountain fronts. These soils contain predominantly fine gravels and coarse to fine sands and have appreciable amounts of fines which are nonplastic to slightly plastic.

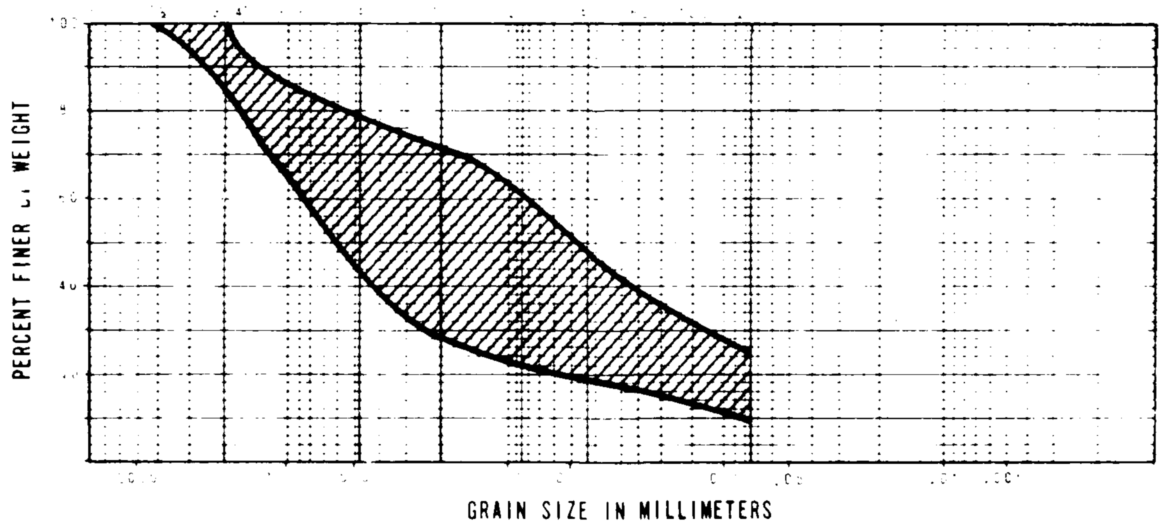
Sandy silts, silts, and sandy clays range from 10 to 20 percent in areal extent. Most of these soils are found in a limited band trending north to south through the center of the site. The sand component is predominantly fine-grained, and soil plasticity ranges from slight to medium.

6.4.2 Low Strength Surficial Soils

Cone Penetrometer Test (CPT) results were used in conjunction with soil classifications to estimate the thickness of low



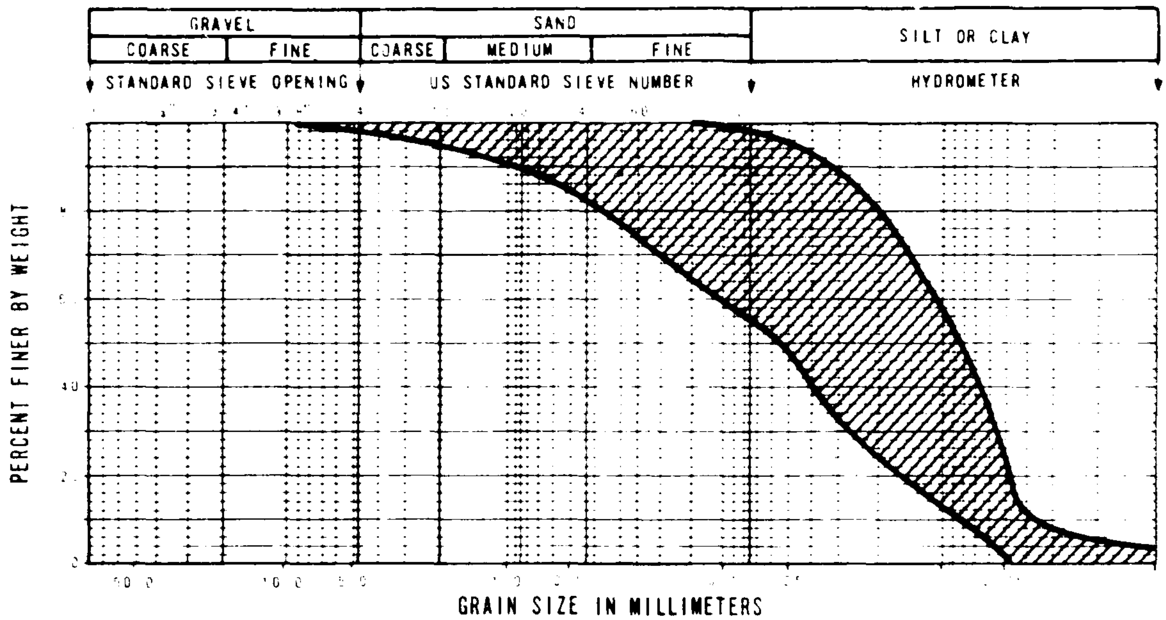
SOIL DESCRIPTION. Silty Sands and Clayey Sands
from 0 to 2 feet (0.0 to 0.6m)



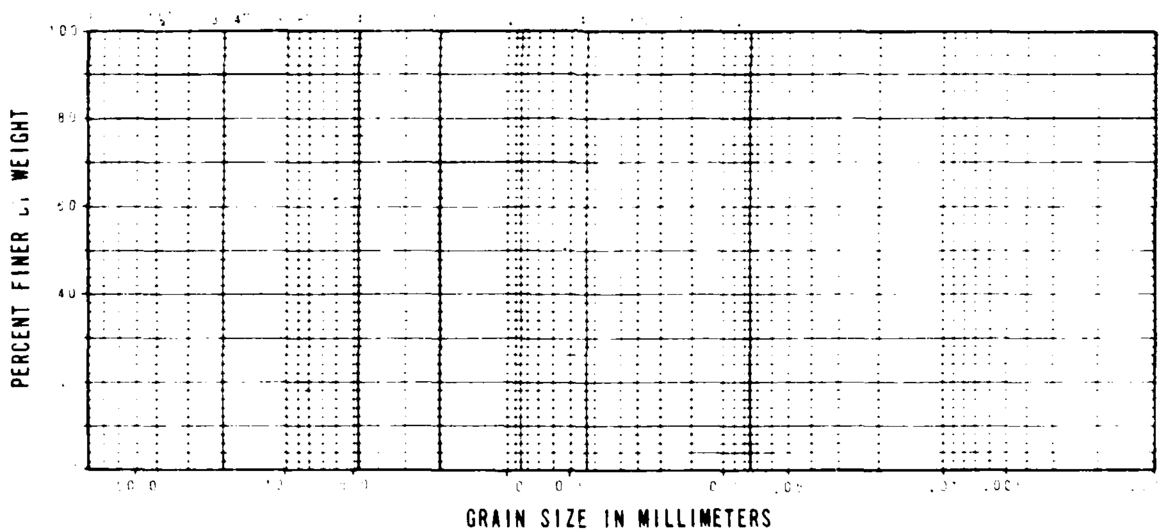
SOIL DESCRIPTION: Sandy Gravels and Gravelly Sands
from 0 to 2 feet (0.0 to 0.6m)

RANGE OF GRADATION OF SURFICIAL SOILS VERIFICATION SITE, HAMLIN COP, NEVADA	
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE SAMSO	FIGURE 6-2

FUGRO NATIONAL, INC.



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



RANGE OF GRADATION OF SURFICIAL SOILS
VERIFICATION SITE, HAMLIN CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE
6-2

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strength surficial soil and results are presented in Table 6-3. Range and mean values for the three soil groups are included in Table 6-2. Surficial granular soils showed a low strength thickness range of 0.6 to 4.0 feet (0.2 to 1.2 m) with an average of 1.3 feet (0.4 m). The variation in the thickness of low strength surficial granular soils is due to the degree of calcium carbonate cementation, which varies with the age of the deposit. Fine-grained soils exhibit low strengths to depths ranging from 0.9 to 3.7 feet (0.3 to 1.1 m) with an average of 2.5 feet (0.8 m). The extent of low strength, fine-grained soils is influenced by in situ density, soil moisture condition, and the amount of fine sand present.

6.5 SUBSURFACE SOILS

Figures 6-3 through 6-7 show the composition of soils with depth, as determined from borings, trenches, and test pits. The subsurface soils are predominantly coarse-grained, consisting of sandy gravels and gravelly sand. These soils are associated with alluvial fan deposits of varying age which are found along the valley flanks, the northwest and southwest portions of the site, and interfinger with lacustrine deposits in the central portions of the site. Gravel content increases approaching the mountain fronts. Some silty sands, clayey sands, and fine-grained soils of lacustrine origin were encountered near the central portion of the site, both east and west of Hamlin Wash.

Results of seismic refraction and electrical resistivity surveys are summarized in Table 6-4. The characteristics of subsurface

CONE PENETROMETER TEST NUMBER(1)	THICKNESS OF LOW STRENGTH SURFICIAL SOIL (2)		SOIL TYPE (3)
	FEET	METERS	
C-1	0.7	0.2	SM
C-2	1.3	0.4	SM
C-3	2.8	0.8	SM GM
C-4	4.0	1.2	SM SP-SM
C-5	0.8	0.2	SM
C-6	1.0	0.3	GP
C-7	0.8	0.3	GM
C-8	1.0	0.3	SM
C-9	1.2	0.4	SM
C-10	1.0	0.3	SM
C-11	1.1	0.3	SM
C-12	0.7	0.2	SM
C-13	1.0	0.3	SM
C-14	0.9	0.3	SM
C-15	1.6	0.4	SM GM
C-16	0.8	0.2	SM
C-17	0.9	0.3	GP-GM
C-18	0.8	0.2	SM GM
C-19	1.1	0.3	SM
C-20	0.9	0.3	SC
C-21	0.9	0.3	SM
C-22	0.8	0.2	SM
C-23	0.9	0.3	GP
C-24	0.6	0.2	GP-GM
C-25	0.8	0.2	SM GM
C-26	1.0	0.3	SM
C-27	1.1	0.3	SM SP-SM
C-28	0.9	0.3	SM

CONE PENETROMETER TEST NUMBER(1)	THICKNESS OF LOW STRE SURFICIAL SOIL (2	
	FEET	METER
C-29	1.0	0.3
C-30	2.4	0.7
C-31	2.8	0.8
C-32	1.6	0.5
C-33	1.2	0.4
C-34	3.7	1.1
C-35	1.1	0.3
C-36	1.3	0.4
C-37	2.0	0.6
C-38	0.6	0.2
C-39	0.9	0.3
C-40	0.9	0.3
C-41	1.0	0.3
C-42	3.9	1.2
C-43	1.1	0.3
C-44	1.0	0.3
C-45	2.1	0.6
C-46	1.3	0.4
C-47	1.1	0.3
C-48	0.9	0.3
C-49	1.7	0.5
C-50	0.8	0.2
C-51	1.3	0.4
C-52	1.1	0.3
C-53	1.0	0.3
C-54	1.3	0.4
C-55	1.1	0.3
C-56	0.8	0.2

(1) For Cone Penetrometer Test locations see Drawing 6-1. 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:
- For fine-
  strength
  of the s
- SM GM - i
- NDA - No

[illegible]KNESS OF LOW STRENGTH SURFICIAL SOIL (2)		SOIL TYPE (3)
FEET	METERS	
1.0	0.3	GM
2.4	0.7	SM GM
2.8	0.8	ML SM
1.6	0.5	SC
1.2	0.4	SM
3.7	1.1	CL GM
1.1	0.3	SM
1.3	0.4	SM
2.0	0.6	SM GP
[illegible].6	0.2	SM
[illegible].9	0.3	SM
[illegible].9	0.3	SM
[illegible].0	0.3	SM
[illegible].9	1.2	SM SP-SM
[illegible].1	0.3	SM
[illegible].0	0.3	SM
[illegible].1	0.6	SC
[illegible].3	0.4	SM
[illegible].1	0.3	SM
[illegible].9	0.3	SM ML
[illegible].7	0.5	SC-SM
[illegible].8	0.2	SM
[illegible].3	0.4	SC-SM
[illegible].1	0.3	SC
[illegible].0	0.3	SM
[illegible].3	0.4	SM
[illegible].1	0.3	SM
[illegible].8	0.2	SC-SM

CONE PENETROMETER TEST NUMBER (1)	THICKNESS OF LOW STRENGTH SURFICIAL SOIL (2)		SOIL TYPE (3)
	FEET	METERS	
C-57	1.0	0.3	SC-SM
C-58	0.9	0.3	SM
C-59	0.9	0.3	CL
C-60	1.5	0.4	SC SM
C-61	3.8	1.1	SC-SM

[illegible]ES:

- 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, HAMLIN CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 6-3

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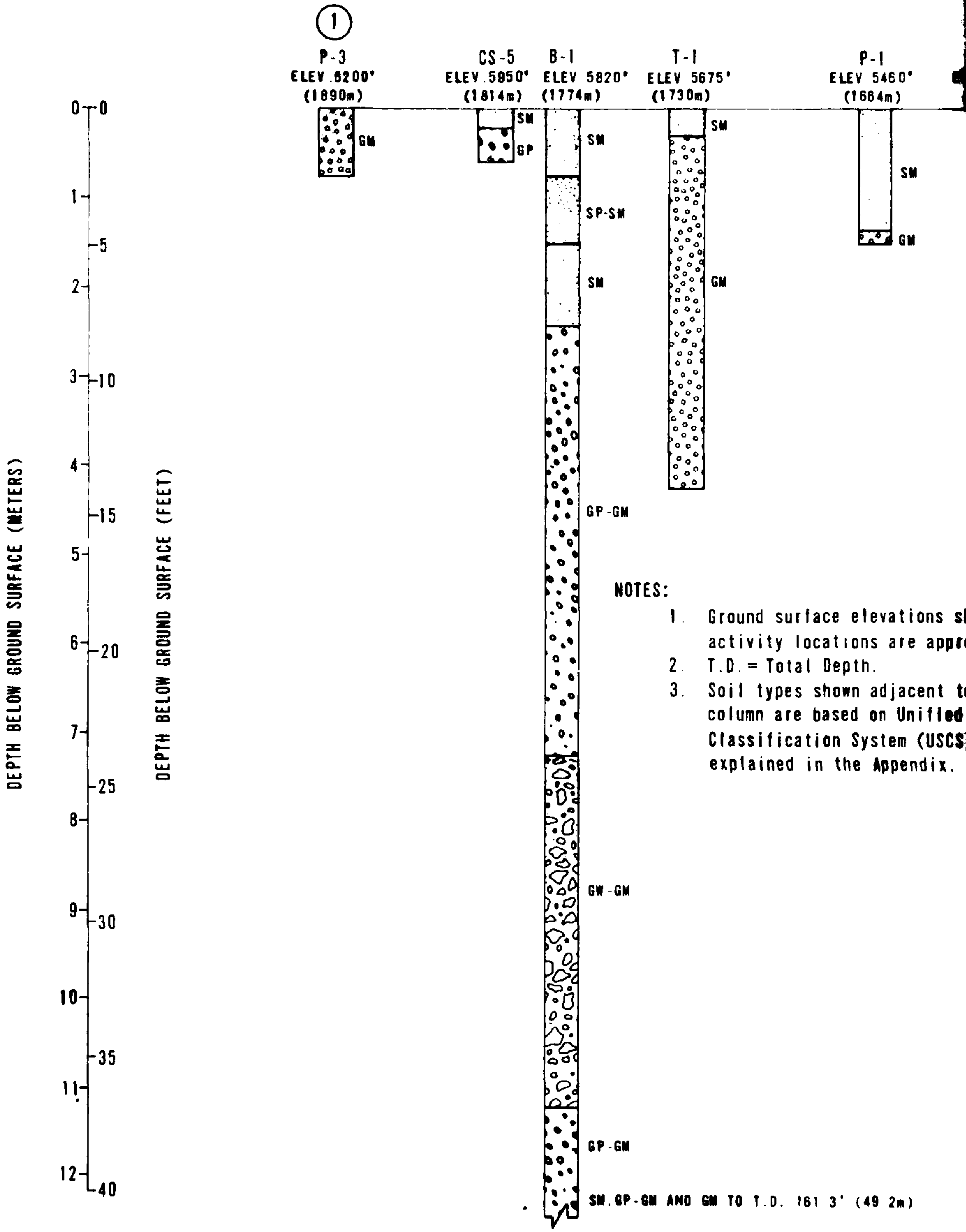
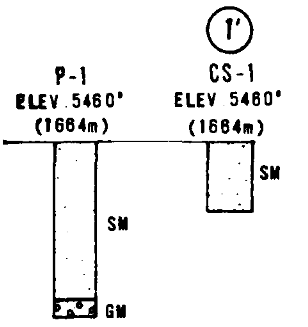


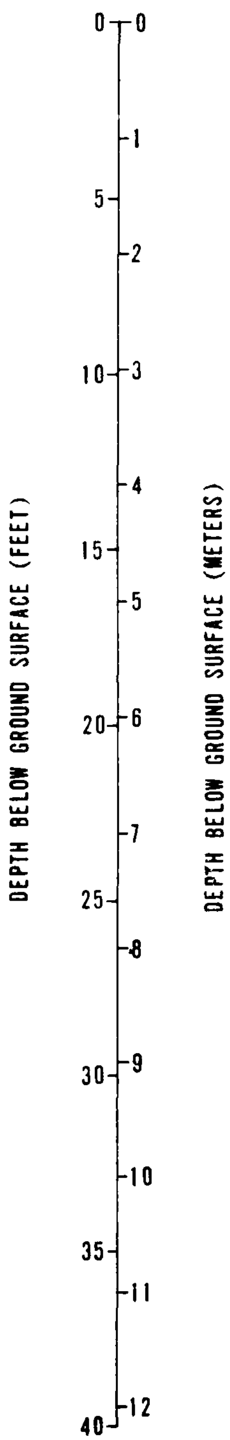
NOTES:

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

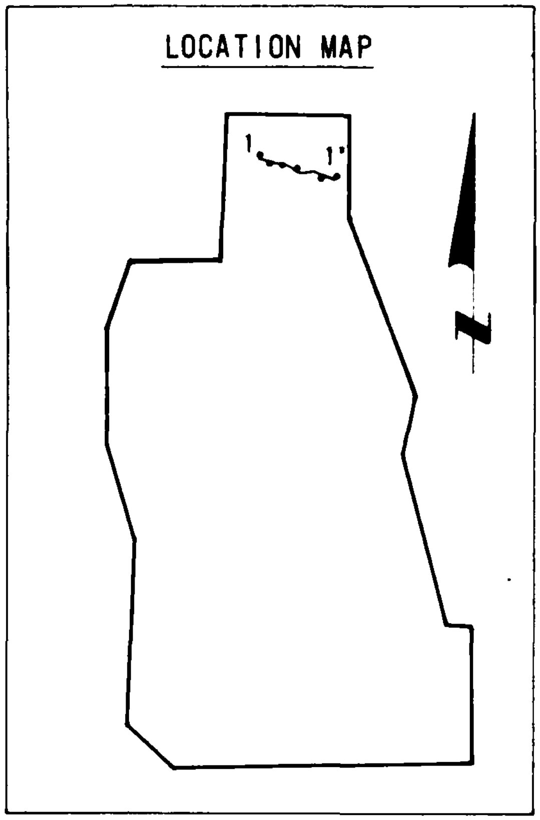


e elevations shown at
tions are approximate.
epth.
own adjacent to soil
sed on Unified Soil
n System (USCS) and are
the Appendix.

' (49.2m)



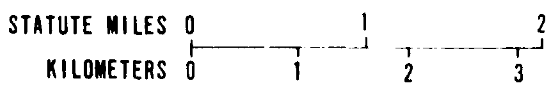
LOCATION MAP



EXPLANATION

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

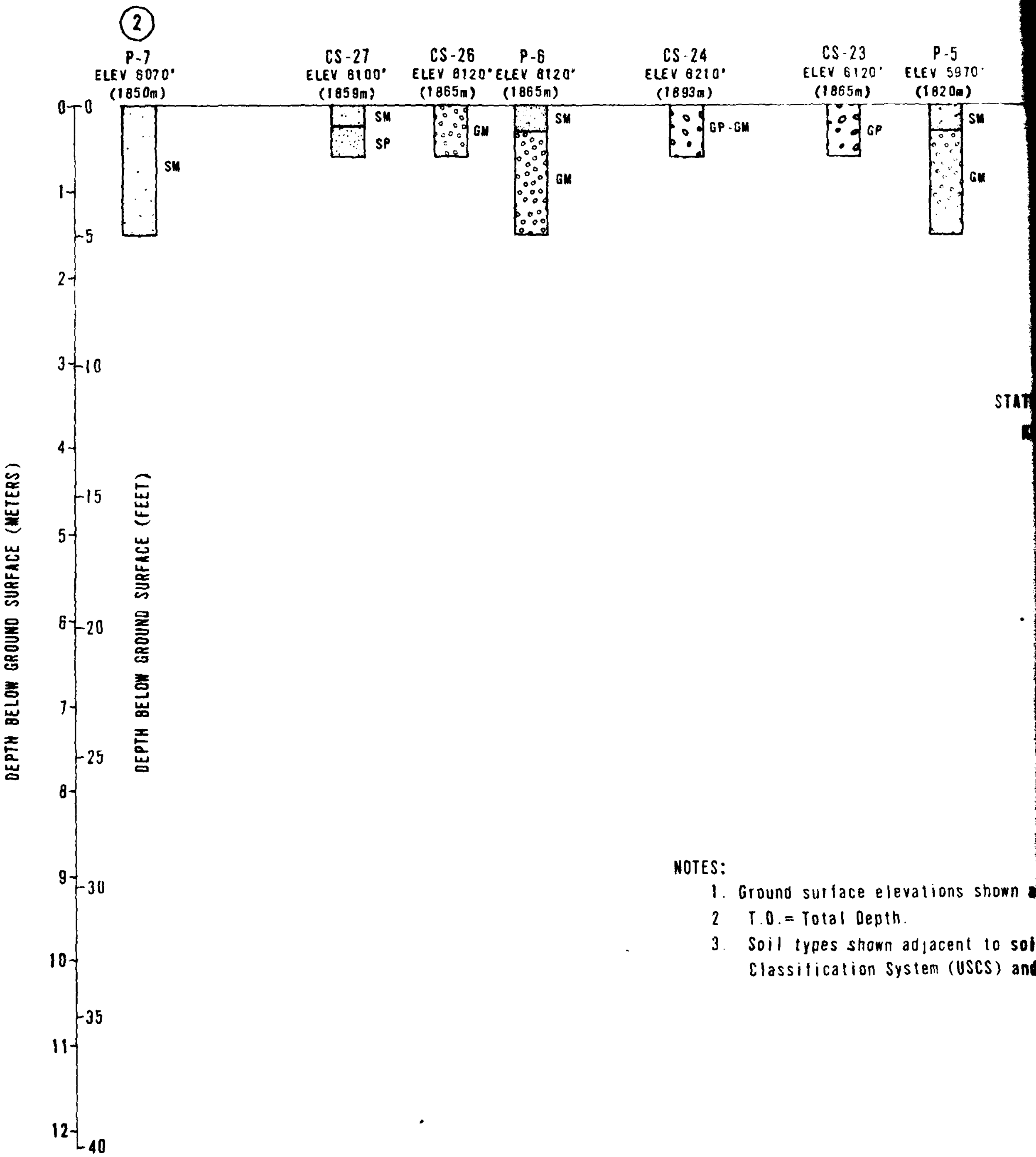
HORIZONTAL SCALE



SOIL PROFILE 1-1'
VERIFICATION SITE, HAMLIN COP, NEVADA

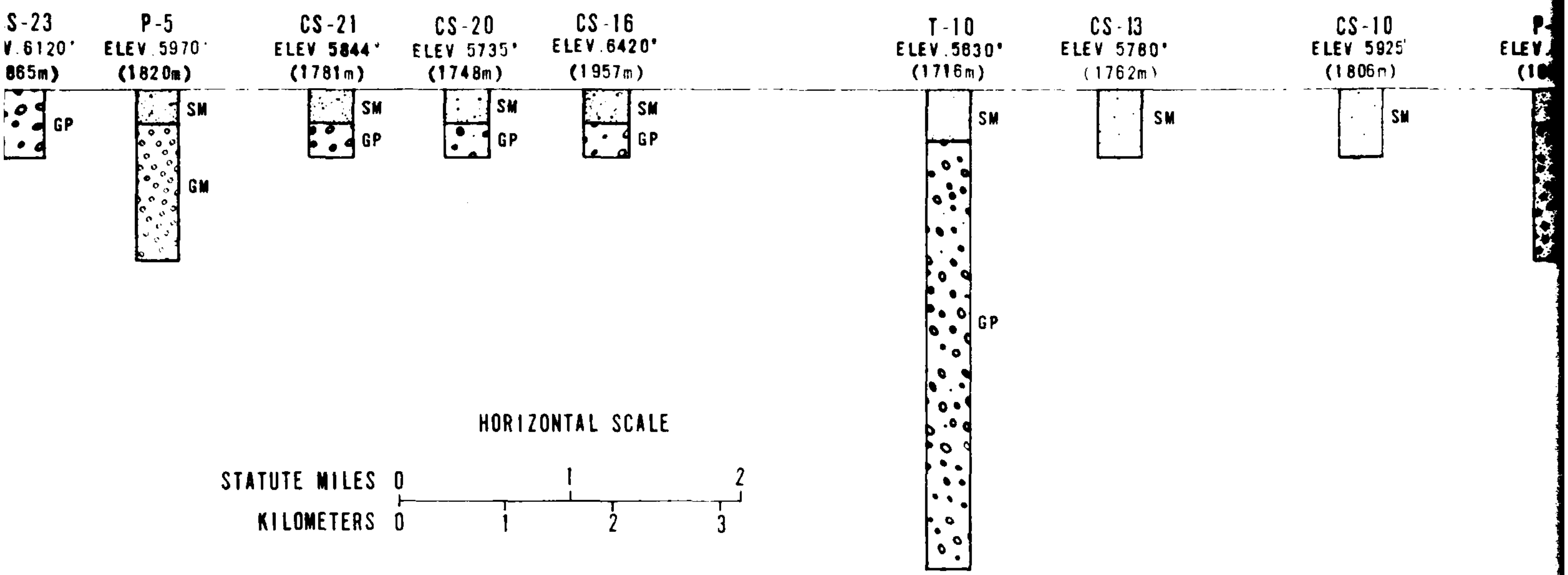
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE SAMSO	FIGURE 6-3

FUGRO NATIONAL, INC.



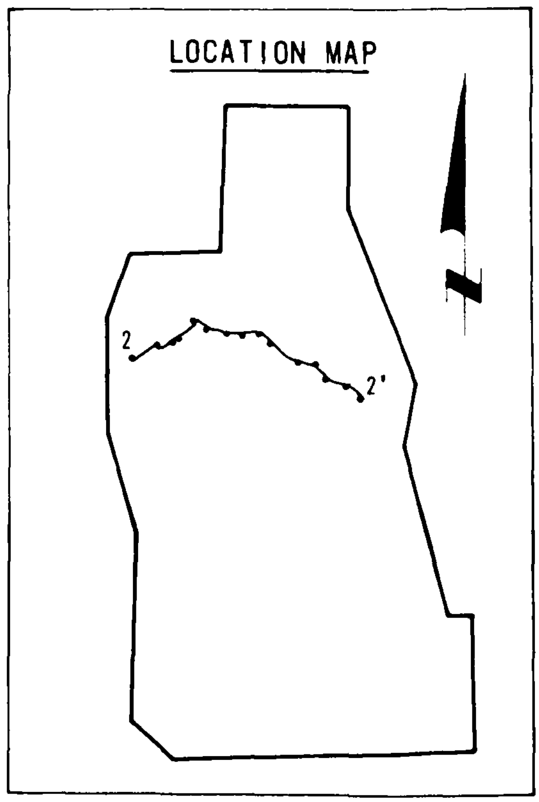
NOTES:

1. Ground surface elevations shown a
2. T.D.= Total Depth.
3. Soil types shown adjacent to soi
   Classification System (USCS) and

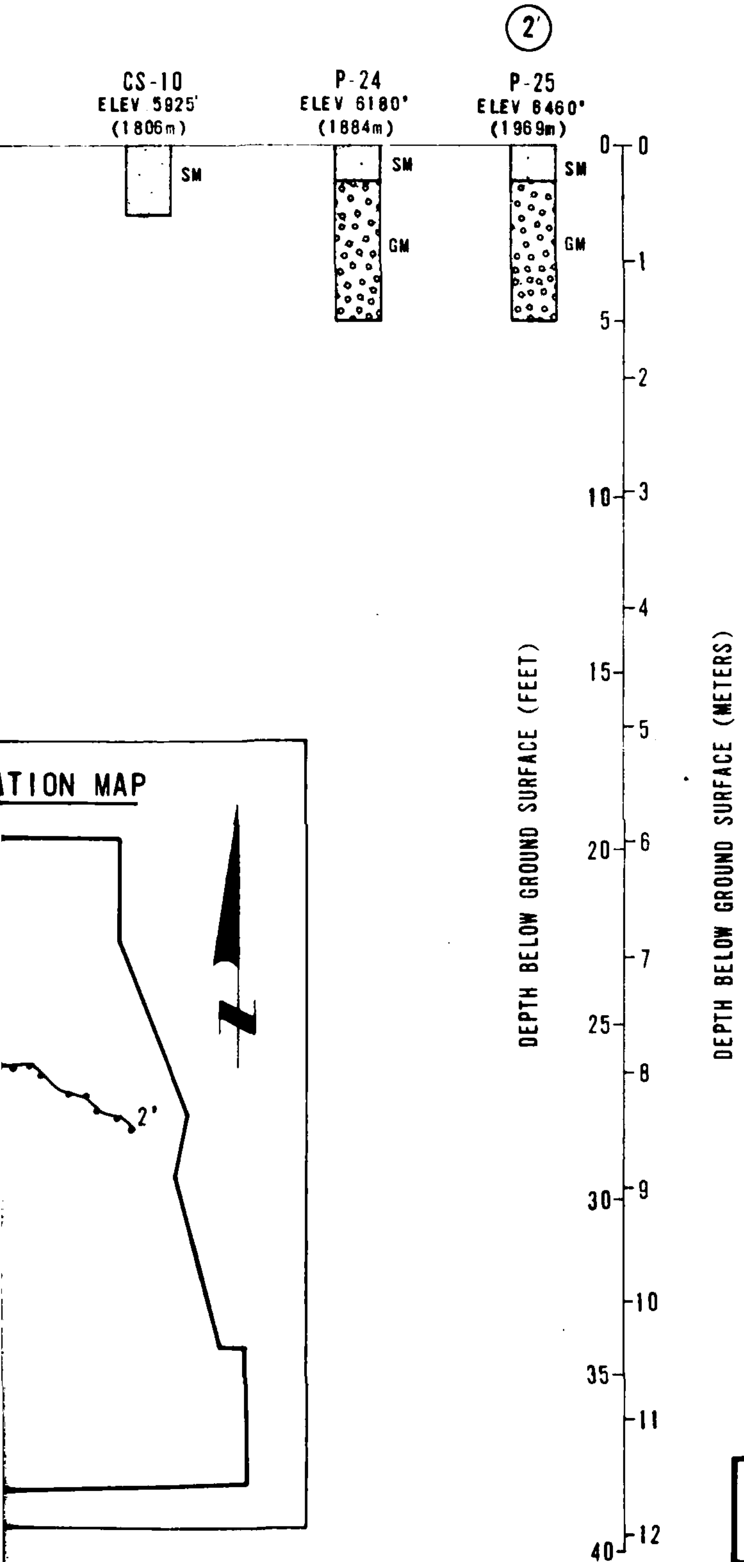


EXPLANATION

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



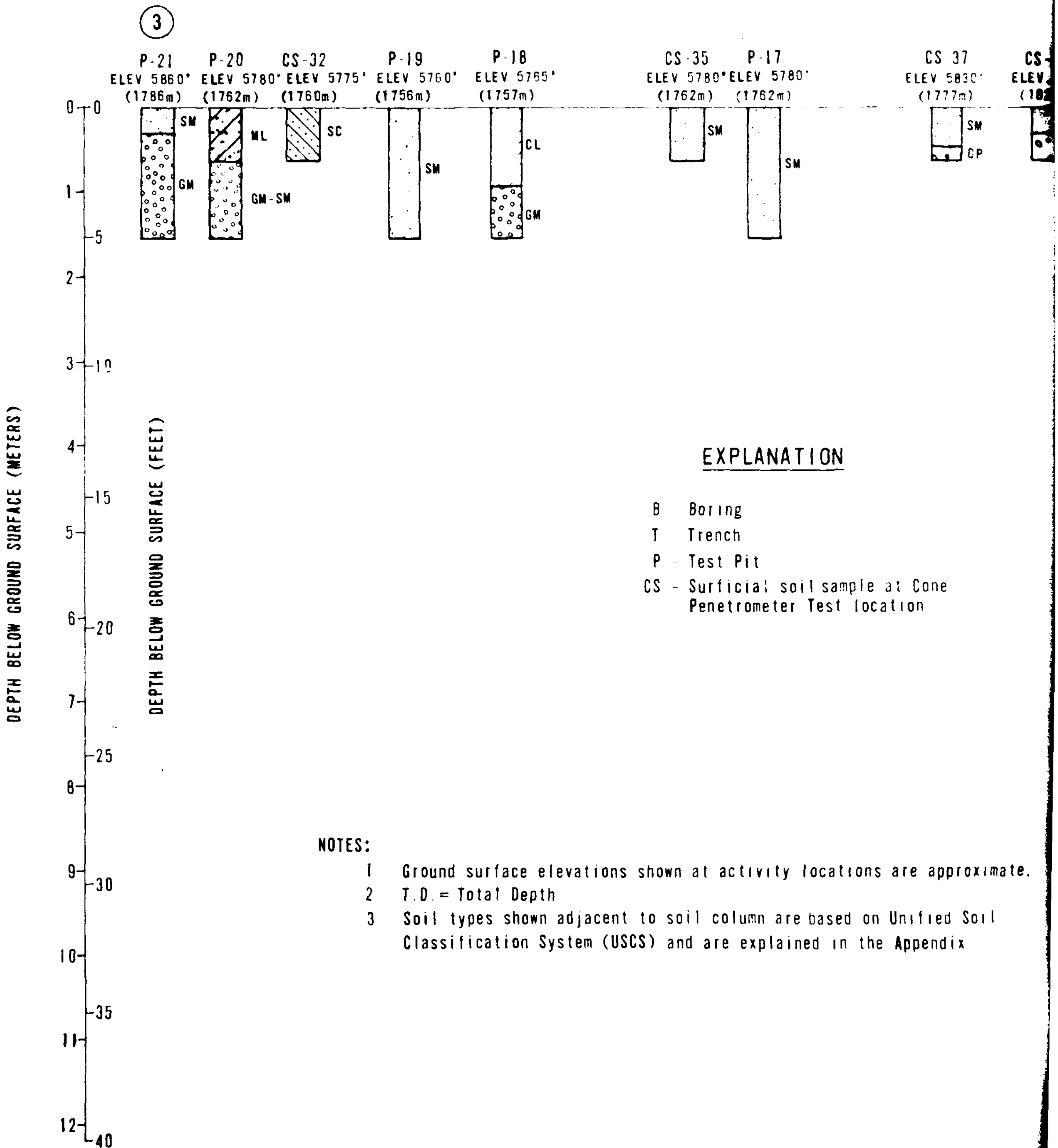
rface elevations shown at activity locations are approximate.
al Depth.
s shown adjacent to soil column are based on the Unified Soil
cation System (USCS) and are explained in the Appendix.



SOIL PROFILE 2-2'
VERIFICATION SITE, HAMLIN CDP, NEVADA

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE SAMSO	FIGURE 6-4

FUGRO NATIONAL, INC.



EXPLANATION

B Boring

T - Trench

P - Test Pit

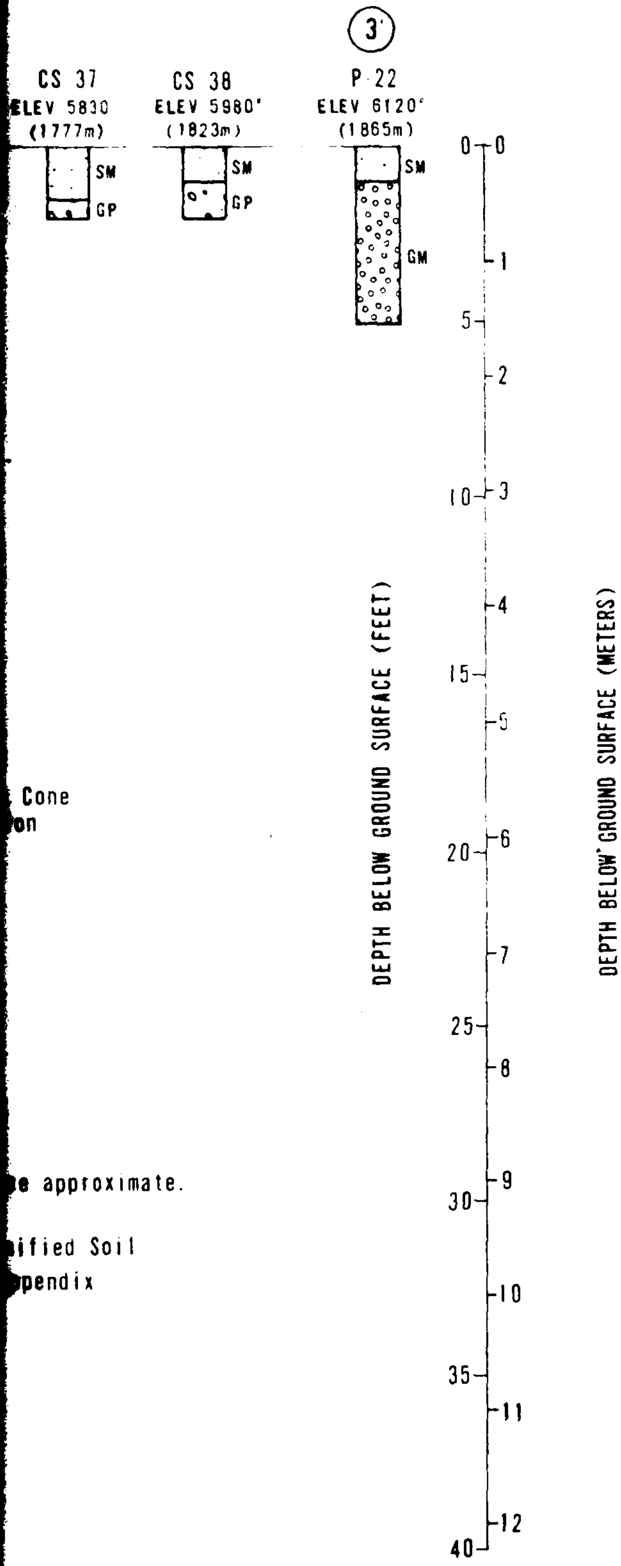
CS - Surficial soil sample at Cone Penetrometer Test location

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



Cone
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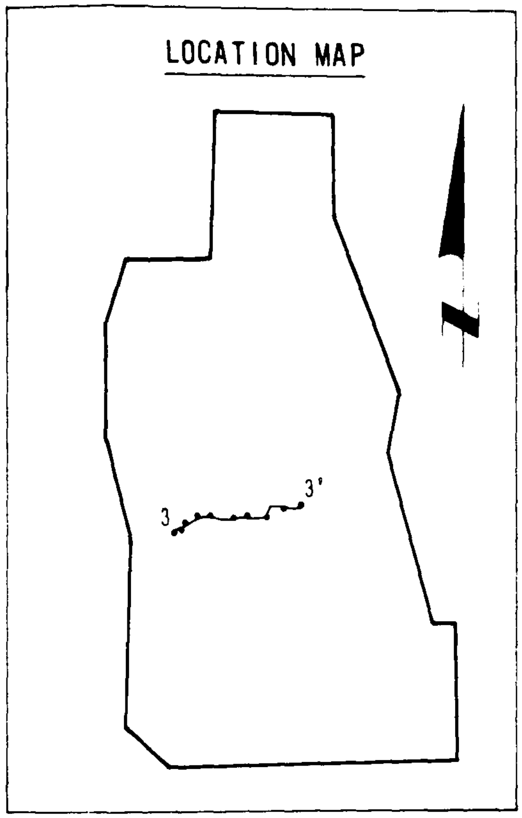
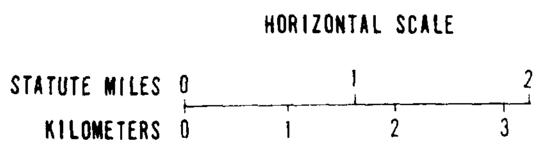
pendix





SOIL PROFILE 3-3'
VERIFICATION SITE, HAMLIN COP, NEVADA

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE SAMSO	FIGURE 6-5

FUGRO NATIONAL, INC.

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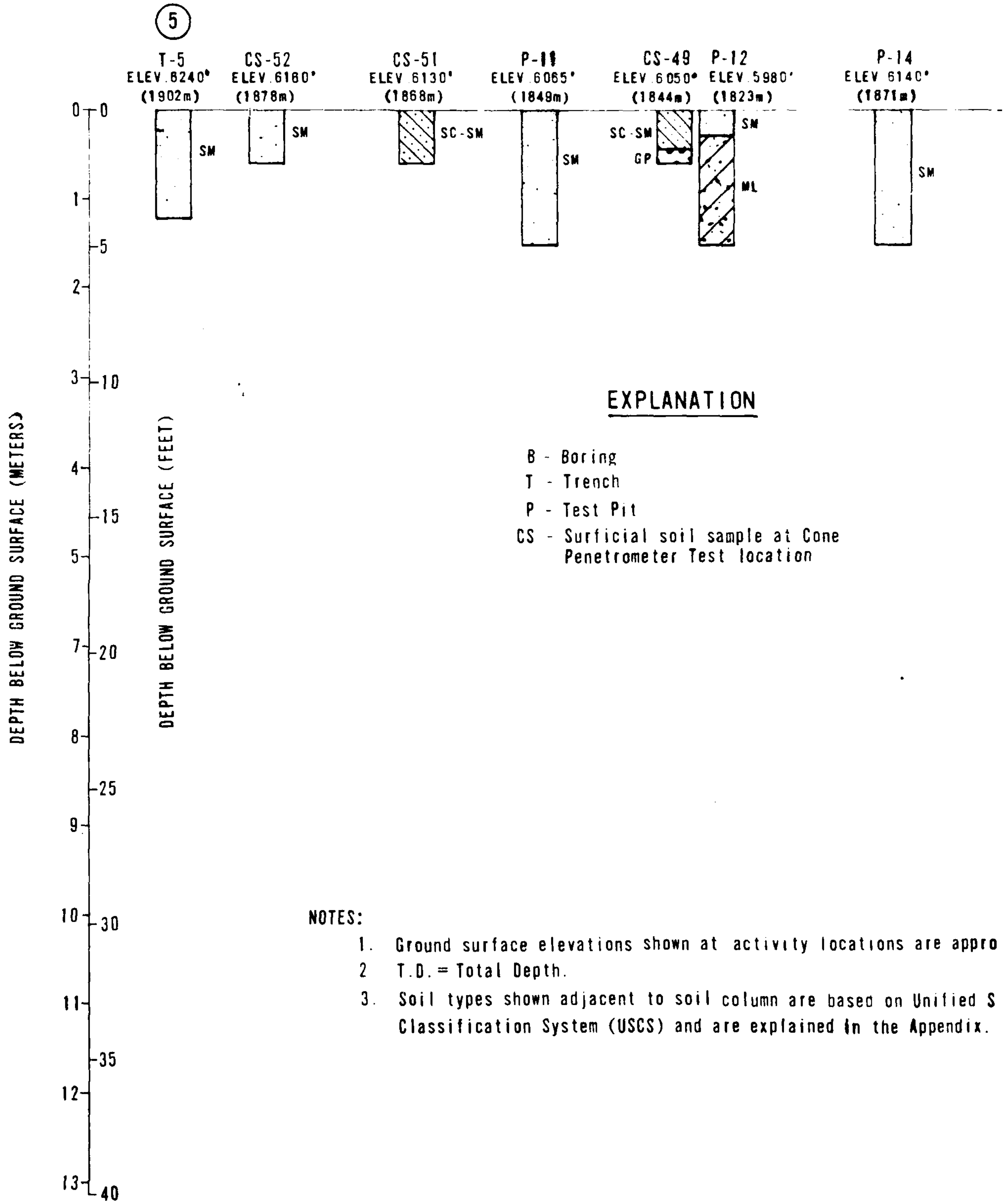
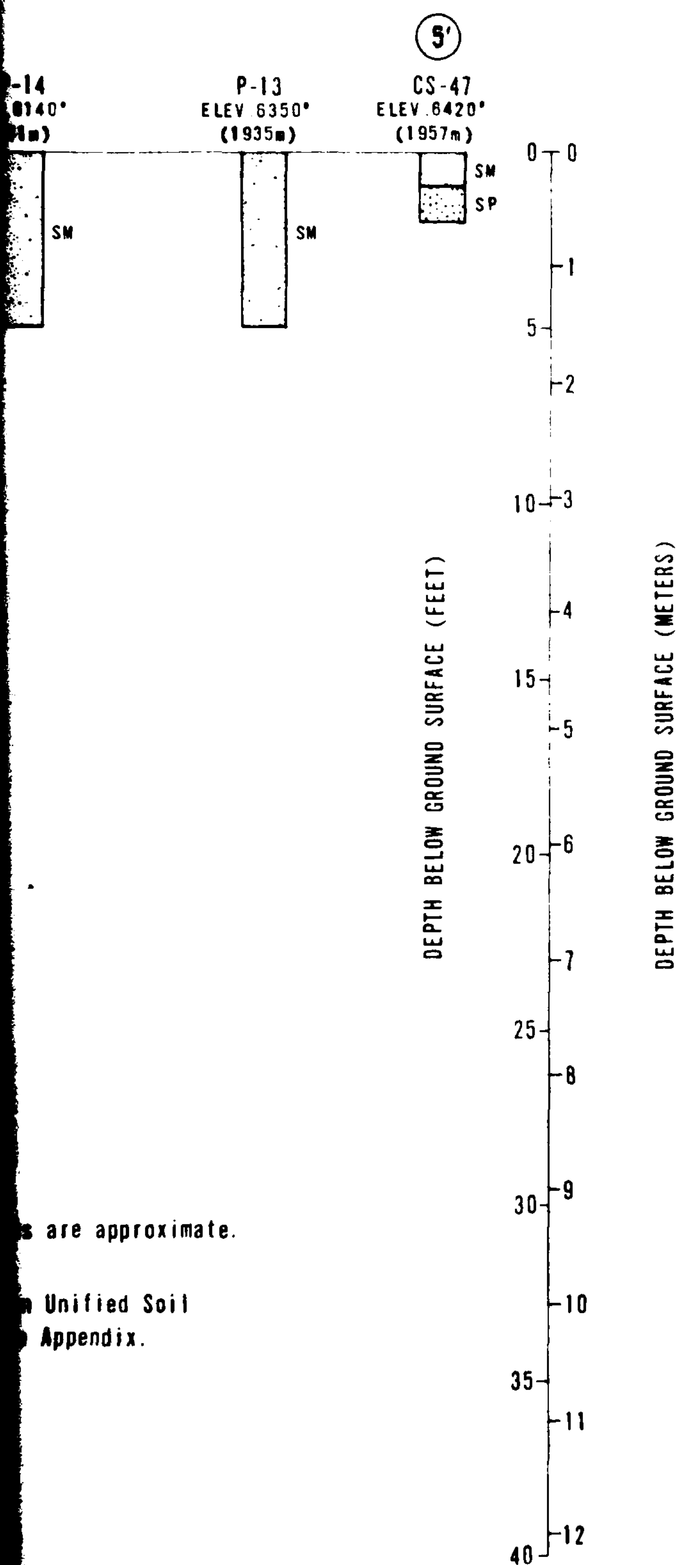


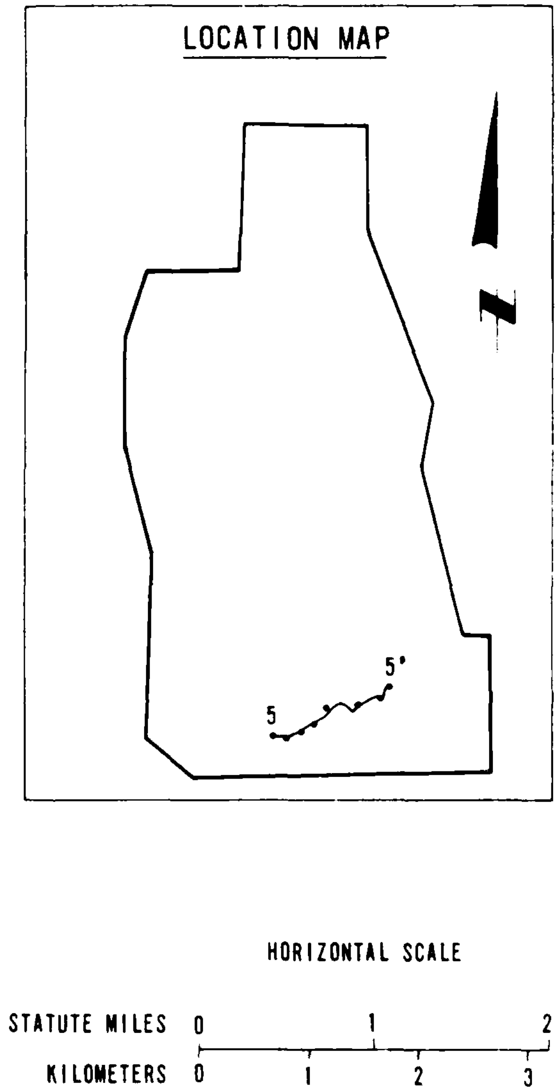
EXPLANATION

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 appro
2. T.D. = Total Depth.
3. Soil types shown adjacent to soil column are based on Unified S Classification System (USCS) and are explained in the Appendix.





s are approximate.

n Unified Soil
 Appendix.

SOIL PROFILE 5-5'
VERIFICATION SITE, HAMLIN COP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE
6-6

FUGRO NATIONAL, INC.

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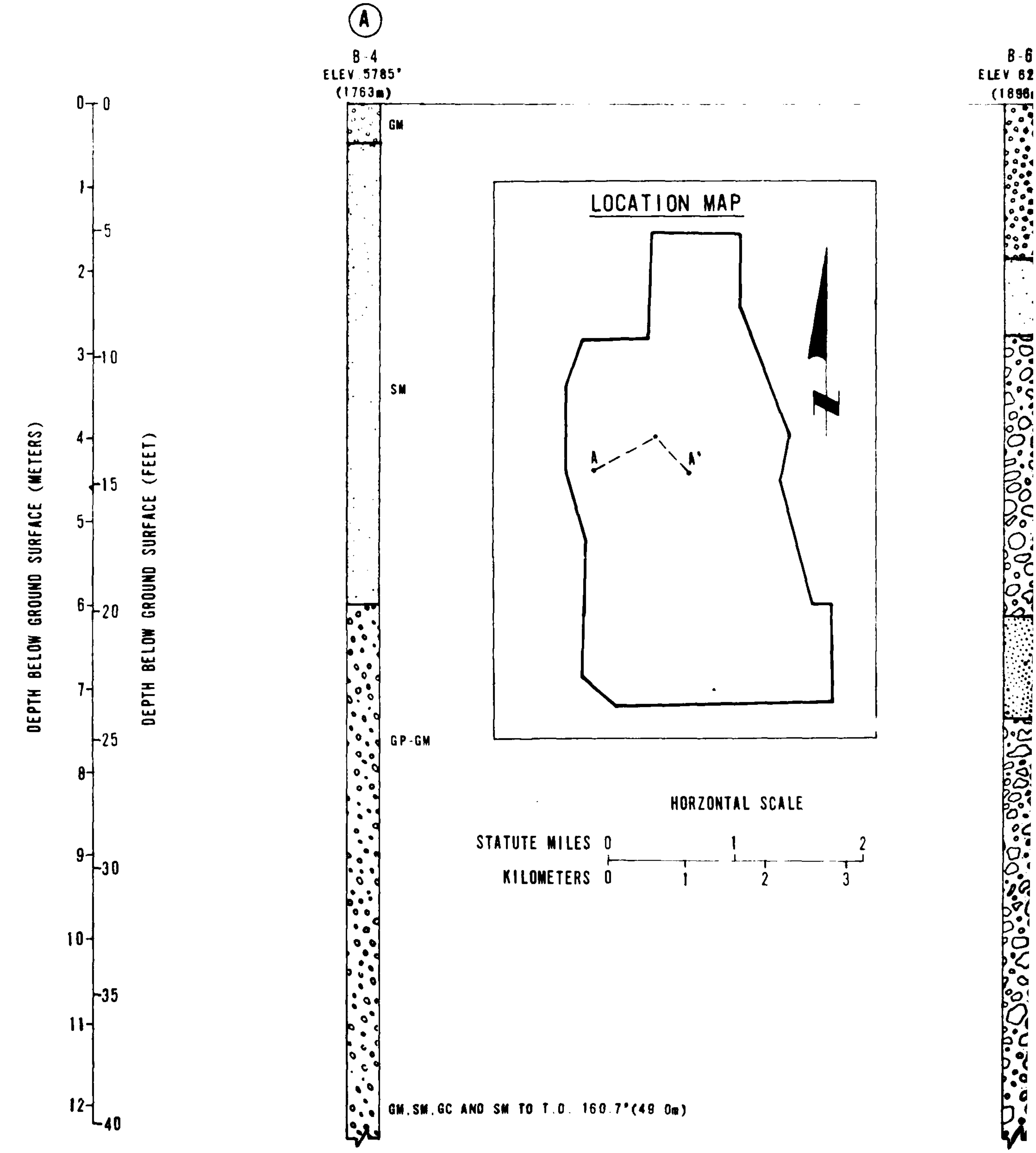
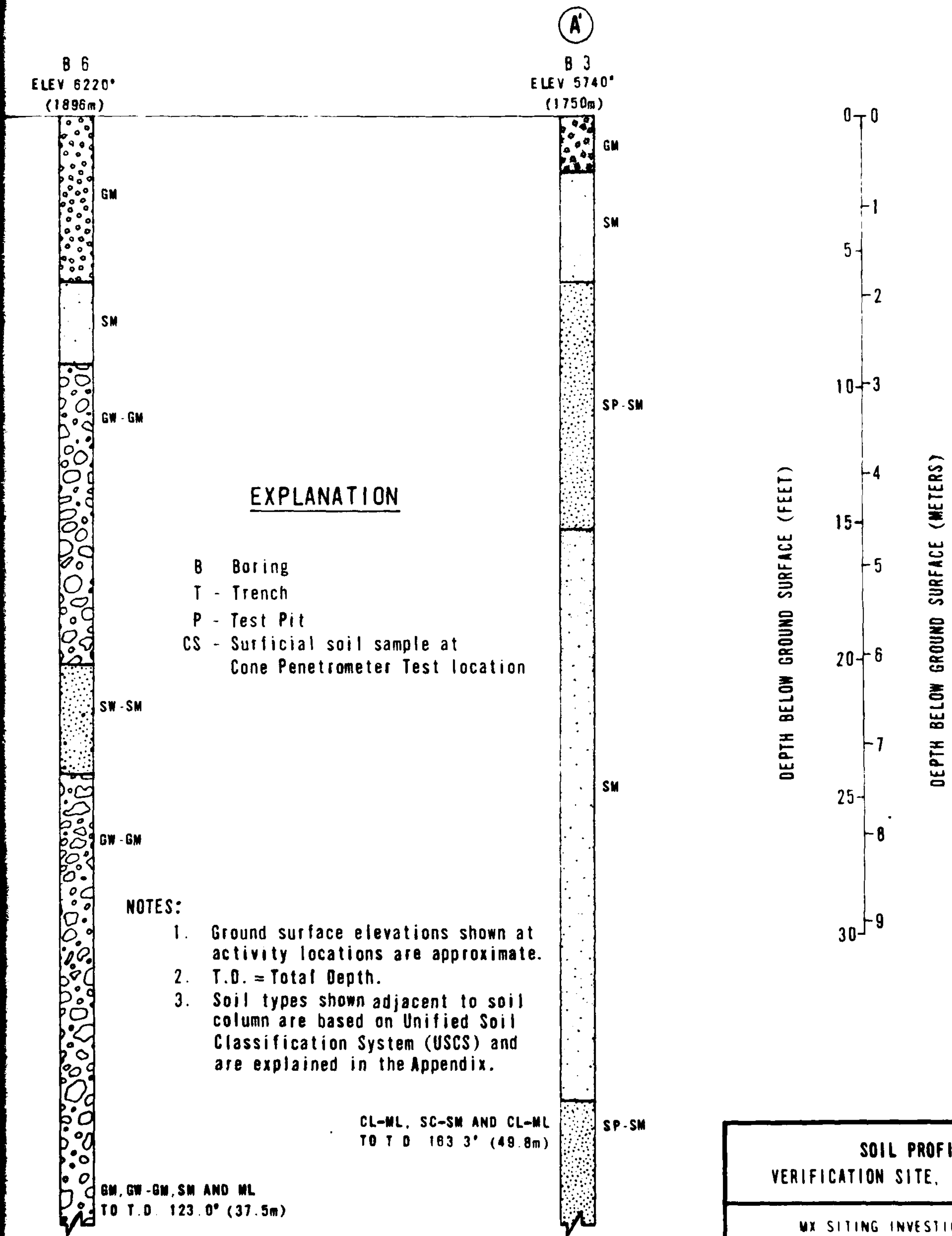

A
B-4
ELEV 5785'
(1763m)
B-6
ELEV 62
(1898
DEPTH BELOW GROUND SURFACE (METERS)
DEPTH BELOW GROUND SURFACE (FEET)
GM
SM
GP-GM
GM, SM, GC AND SM TO T.D. 160.7'(49 0m)
LOCATION MAP
A
A'
HORZONTAL SCALE
STATUTE MILES 0 1 2
KILOMETERS 0 1 2 3



EXPLANATION

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

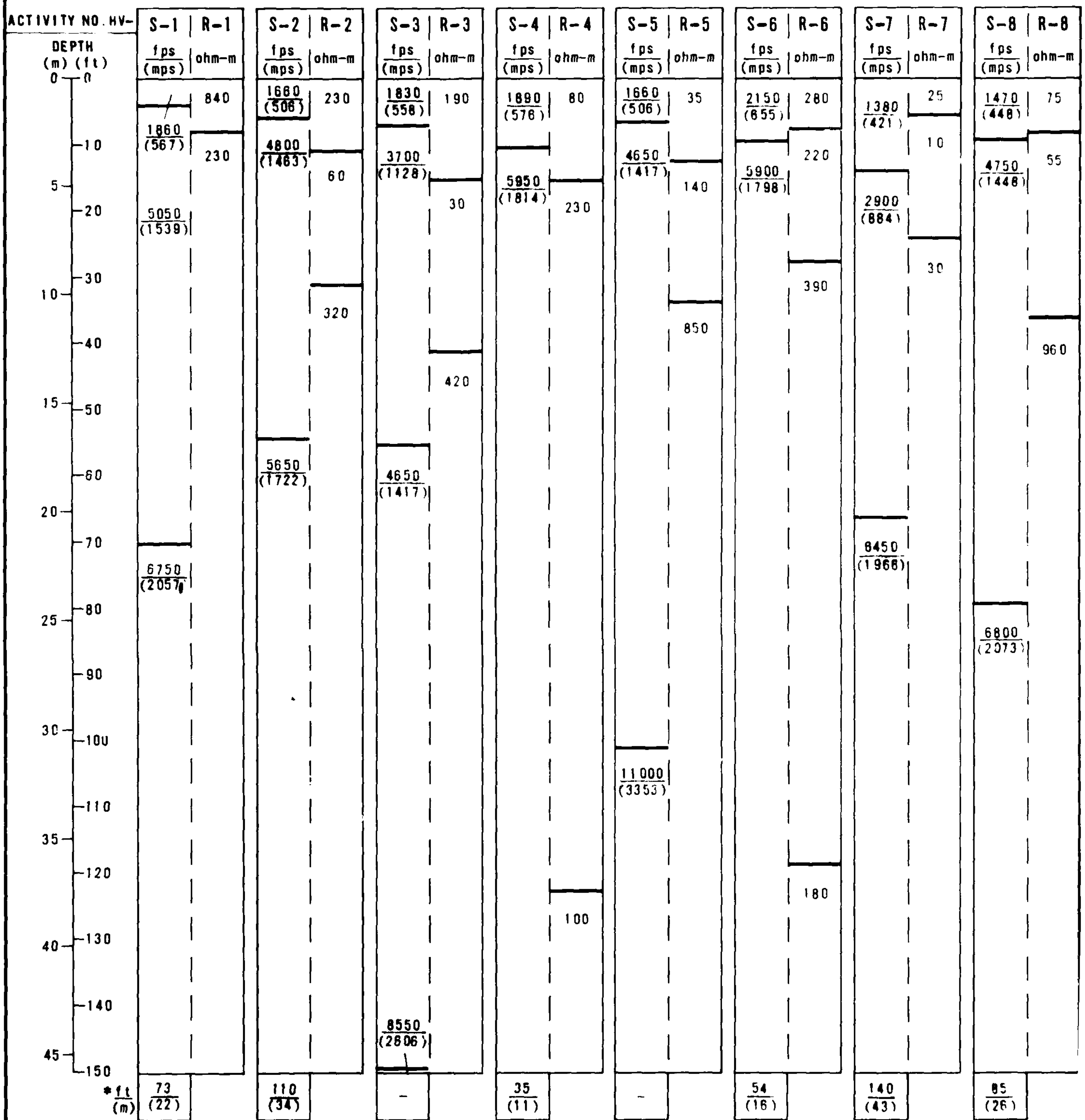
NOTES:

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.

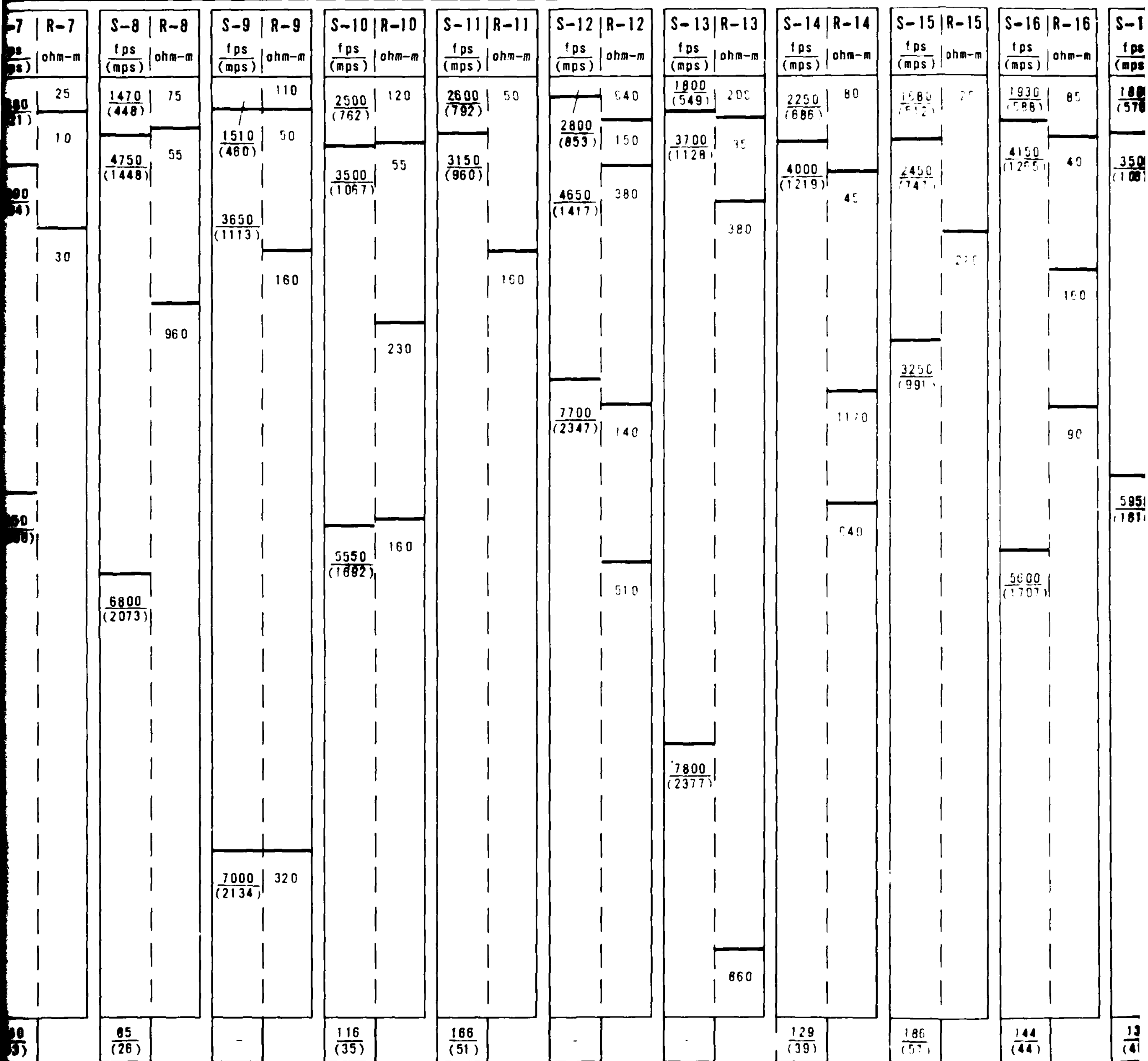
SOIL PROFILE A-A' VERIFICATION SITE, HAMLIN CDP, NEVADA	
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE SAMSO	FIGURE 6-7

FUGRO NATIONAL, INC.

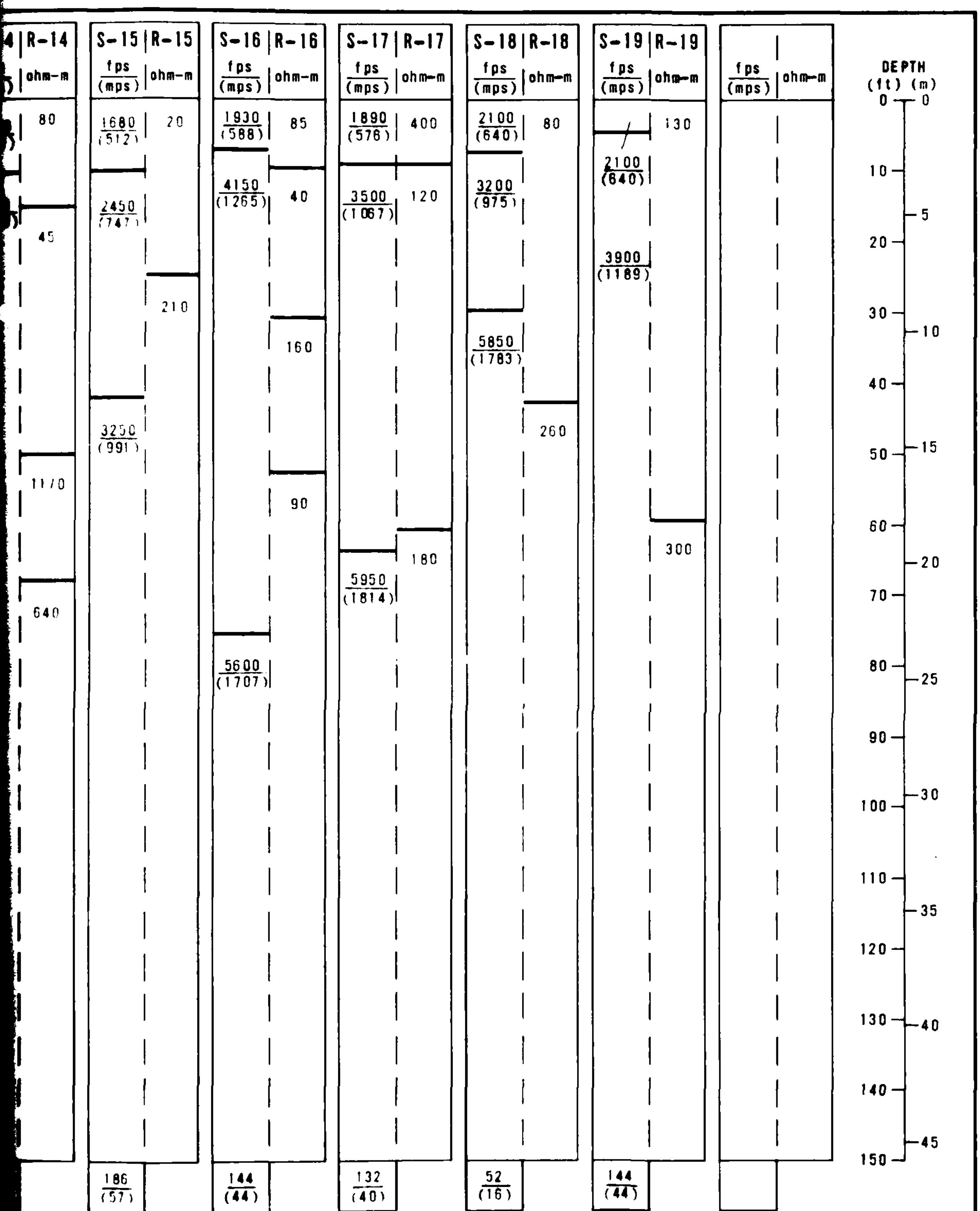
1 2



* 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 then 7000 fps (2134 mps).



R-7
ohm-m
25
10
30
S-8 | R-8
fps (mps) | ohm-m
1470 (448)
4750 (1448)
6800 (2073)
75
55
960
85 (26)
S-9 | R-9
fps (mps) | ohm-m
1510 (460)
3650 (1113)
7000 (2134)
110
50
160
320
S-10 | R-10
fps (mps) | ohm-m
2500 (762)
3500 (1067)
5550 (1692)
120
55
230
160
116 (35)
S-11 | R-11
fps (mps) | ohm-m
2600 (792)
3150 (960)
50
160
166 (51)
S-12 | R-12
fps (mps) | ohm-m
2800 (853)
4650 (1417)
7700 (2347)
150
380
140
510
S-13 | R-13
fps (mps) | ohm-m
1800 (549)
3700 (1128)
7800 (2377)
380
860
S-14 | R-14
fps (mps) | ohm-m
2250 (686)
4000 (1219)
80
45
129 (39)
S-15 | R-15
fps (mps) | ohm-m
3250 (991)
S-16 | R-16
fps (mps) | ohm-m
1930 (588)
4150
5600 (1707)
40
160
90
144 (44)



SEISMIC REFRACTION AND ELECTRICAL RESISTIVITY VERIFICATION SITE, HAMLIN CDP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 6-4

FUGRO NATIONAL, INC.

AFV-18

soils, as determined from field and laboratory test results, are summarized in Table 6-5. Range of gradation of these soils is shown in Figure 6-8.

Below 10 feet (3 m), coarse-grained soils are generally dense to very dense and exhibit moderate to high shear strengths. They are poorly to well graded and contain fine to coarse sands and gravels. The degree of calcium carbonate cementation varies from none to strong, depending on age of the deposit. The wide range of seismic wave velocities in coarse-grained soils is apparently due to variation in density, composition, and cementation. Fine-grained soils (silts and clays) are of slight to medium plasticity and stiff consistency. They exhibit moderate compressibility and moderate to high shear strength. Seismic wave velocities in the fine-grained soils are substantially lower than determined for coarse-grained soils.

The electrical resistivity profiles typically show a relatively shallow zone of decreased resistivity between layers of higher resistivity. The lower resistivity layer may indicate a zone where salts have been concentrated through leaching and evaporation. Electrical conductivity of the soils in the upper 50 feet (15 m) ranges from 0.0026 to 0.0450 mhos per meter and averages 0.0090 mhos per meter. At six of the 19 locations tested, the measured conductivities were less than the minimum value of 0.004 mhos per meter specified in the Fine Screening criteria. Chemical test results indicate that potential for sulfate attack of soils on concrete may be "considerable."

DEPTH RANGE	2' - 20' (0.6 - 6.0m)		
SOIL DESCRIPTION	Coarse-grained soils		Fine-g
	Sandy Gravels, Gravelly Sands, and Silty Sands		Sandy Silts
USCS SYMBOLS	GP, GW, GM, SP, SM		ML, CL
ESTIMATED EXTENT IN SUBSURFACE %	80-90		10-20
PHYSICAL PROPERTIES			
DRY DENSITY pcf (kg/m³)	95.0-143.5 (1522-2299)	[20]	79.2-101.0 (1269-1618)
MOISTURE CONTENT %	1.2-21.7	[20]	10.6-36.4
DEGREE OF CEMENTATION	none to strong		none to mode
COBBLES 3-12 inches (8-30 cm) %	0-10		0
GRAVEL %	16-59	[13]	0-6
SAND %	35-68	[13]	19-44
SILT AND CLAY %	5-34	[13]	50-81
LIQUID LIMIT	NDA		34-42
PLASTICITY INDEX	NDA		9-19
COMPRESSIONAL WAVE VELOCITY fps (mps)	1380-5950 (421-1814)	[19]	2450-3200 (747-975)
SHEAR STRENGTH DATA			
UNCONFINED COMPRESSION S_u - ksf (kN/m²)	0.42 (20)	[1]	NDA
TRIAXIAL COMPRESSION c - ksf (kN/m²), $\phi°$	NDA		c = 0, ϕ = 40°
DIRECT SHEAR c - ksf (kN/m²), $\phi°$	NDA		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 6 borings, 11 trenches, and 28 test pits, and results of 21 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 21 seismic refraction surveys.

- [ ] -
- NDA - No

6.0m)	20' - 160' (6.0 - 49.0m)				
Fine-grained soils		Coarse-grained soils		Fine-grained soils	
Sandy Silts and Sandy Clays		Sandy Gravels, Gravelly Sands, Silty Sands, and Clayey Sands		Sandy Silts and Sandy Clays	
ML, CL		GP, GW, GM, GC, SP, SW, SM, SC		ML, CL	
10-20		80-90		10-20	
79.2-101.0 (1269-1618)	[5]	86.4-140.7 (1384-2254)	[49]	91.5-112.6 (1466-1804)	[8]
10.6-36.4	[5]	4.7-35.0	[52]	14.3-28.2	[8]
none to moderate		none to strong		none to weak	
0		0-10		0	
0-6	[3]	0-63	[29]	0-4	[3]
19-44	[3]	20-81	[29]	17-42	[3]
50-81	[3]	6-49	[29]	58-83	[3]
34-42	[2]	31-48	[5]	NDA	
9-19	[2]	8-19	[5]	NDA	
2450-3200 (747-975)	[2]	3500-5950 (1067-1814)	[18]	2450-3250 (747-991)	[3]
NDA		NDA		NDA	
c=0, $\phi = 40$	[3]	NDA		c=0.3, $\phi = 19$ (14)	[3]
NDA		c=0, $\phi = 39$	[3]	NDA	

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

CHARACTERISTICS OF SUBSURFACE SOILS
VERIFICATION SITE, HAMLIN COP, NEVADA

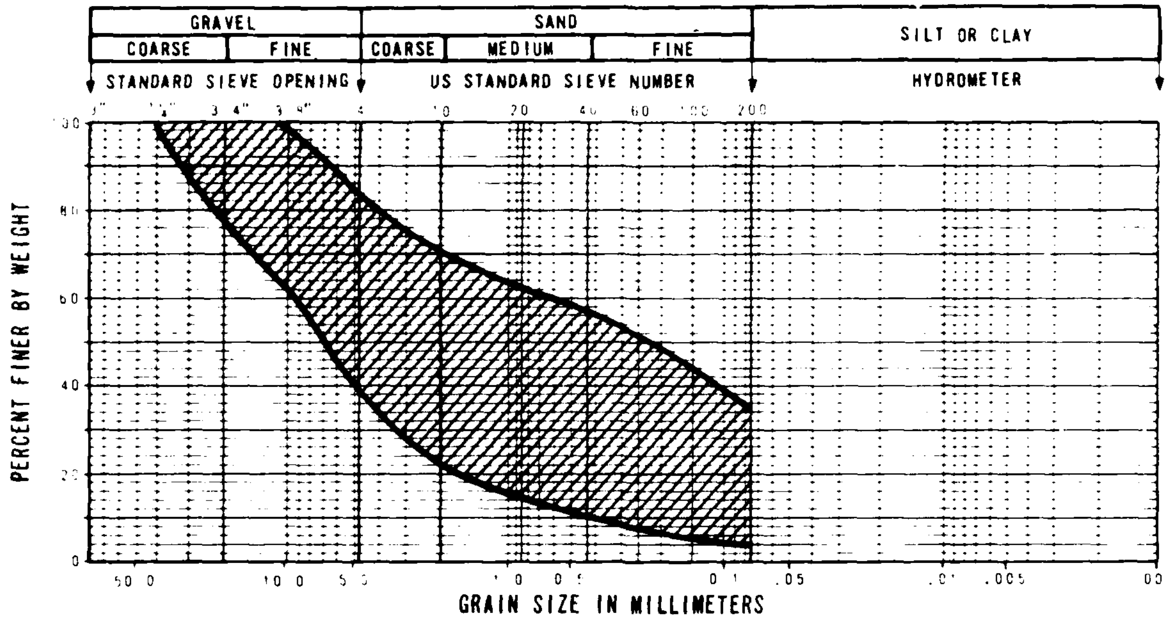
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 6-5

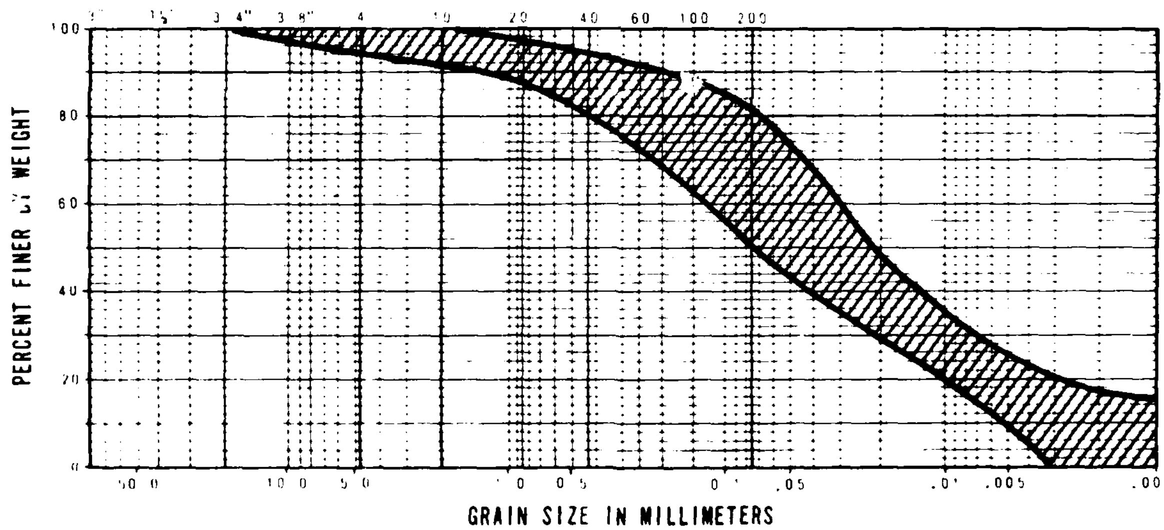
FUGRO NATIONAL, INC.

AFV-20

, 2



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



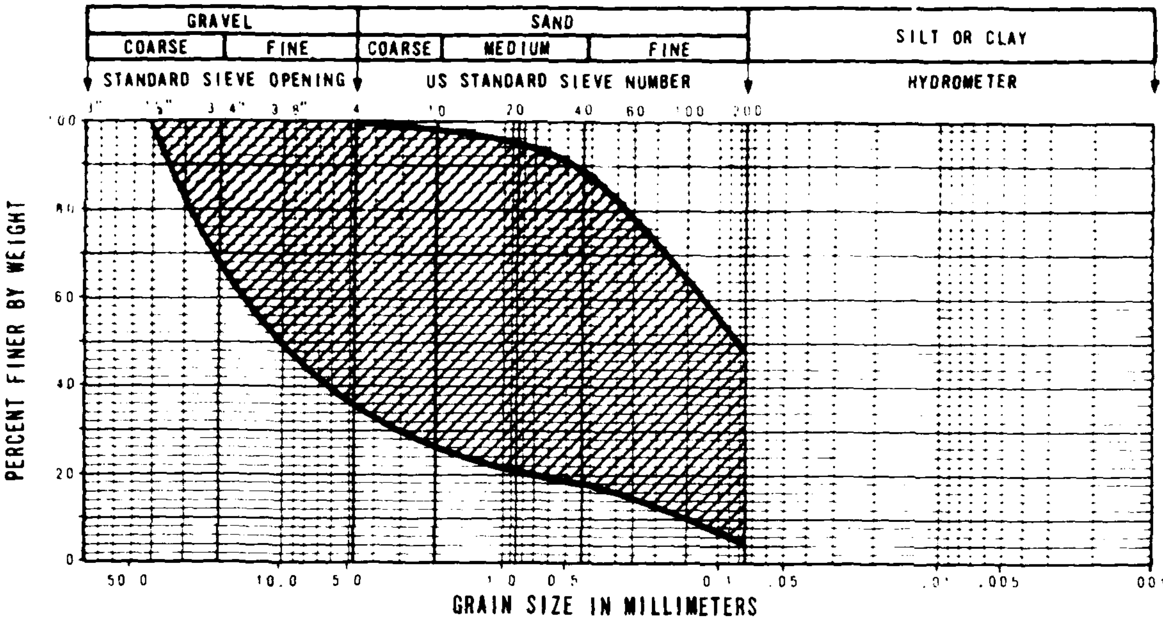
SOIL DESCRIPTION: Fine-grained soils from 2 to 20 feet (0.6 to 6m)

RANGE OF GRADATION OF SUBSURFACE SOILS
VERIFICATION SITE, HAMLIN COP, NEVADA

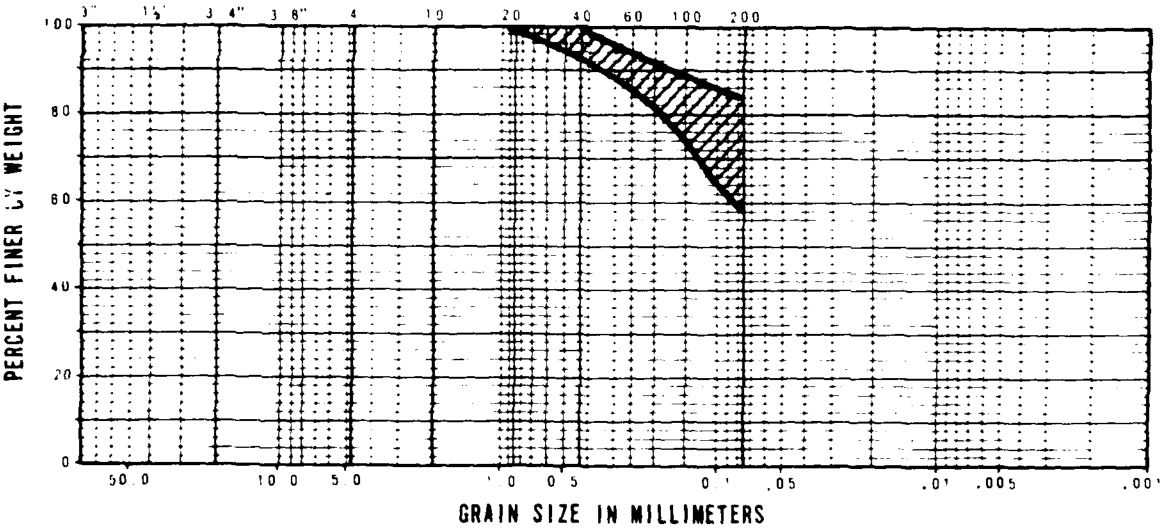
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 6-8
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, HAMLIN COP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 6-8

FUGRO NATIONAL, INC.

6.6 TERRAIN

The Hamlin Site occupies a topographically open basin which is drained by Hamlin Wash. Surface elevations along the drainage range from a high in the south of 6100 feet (1859 m) to a low in the northwest of 5400 feet (1646 m), defining a regional gradient of 19 feet per mile (4 m per km) to the north. Characteristics of the terrain are most heavily influenced by the morphologic expression of the surficial geologic units. Categories of terrain are differentiated in Drawing 6-3.

Depths of incision are greatest in the A5o and A5i fans that flank the mountain fronts. Drainage depths along the north and central valley flanks average 6 feet (2 m; category II) and corresponding slopes average 4 percent. Depth of incision increases significantly in the southern part of the site. Comparable slopes of 4 percent exhibit an average depth of incision of over 13 feet (4 m; category III). Fan segments reflecting unsuitable (category VII) terrain are restricted to peripheral areas along the Needle and Snake ranges and to the south-central part of the site.

The flat central part of the site is dominated by younger alluvial fan and terrace deposits. Slopes generally average 1 percent and drainage depths are 2 feet (0.6 m) or less (category I).

6.7 DEPTH TO ROCK

The approximate configuration of the 50-foot (15-m) and 150-foot (46-m) depth to rock contours are shown in Drawing 6-4. This estimation is based on limited published well data, engineering and geophysical data obtained for this report, and consideration of the lithology and structure of rock bounding the valley. As shown, approximately 12 percent of the site is interpreted to be underlain by rock less than 50 feet (15 m) in depth with less than 5 percent interpreted to be underlain by rock at a depth between 50 feet and 150 (46 m) feet.

Depth to rock contours are interpreted as closely paralleling the steep, cliff-forming sedimentary rocks bounding the north and central portions of the site. Data to provide control of the contours are sparse. At seismic line S-5, located a few hundred feet from a limestone outcrop in the Snake Range, a seismic velocity of 11,000 fps (3353 mps) was calculated at a depth of 100 feet (30 m), supporting a steeply dipping range front. In the southwest corner of the site, volcanic hills of low relief are suspected of having associated shallow subsurface components. Depth to rock contours were situated further from rock outcrops to avoid these high risk areas.

On seismic lines S-9, S-12, and S-13, respective velocities of 7000, 7700, and 7800 fps (2134, 2347, 2377 mps) were obtained. A boring to 150 feet is also associated with each of these localities and in each case, a partially cemented fanglomerate was encountered at a depth corresponding to the high velocity layer. On Drawing 6-4, these locations were not considered as rock exclusions.

6.8 DEPTH TO WATER

The interpretation of the 50-foot (15-m) and 150-foot (46-m) depth to water contours is based primarily upon existing evaluations made by the U.S. Geologic Survey (Hood and Rush, 1966), supplemented with boring and resistivity data obtained during the Verification program (Drawing 6-5). As interpreted, the area with ground water at less than 50 feet comprises approximately 12 to 15 percent of the site area and an additional 15 to 18 percent lies between 50 feet and 150 feet in depth.

The site is a partially drained, ground-water basin (Eakin, Price and Harrill, 1976) which is hydrologically continuous with Snake Valley to the north. Water table depths range from less than 10 feet (3 m) in the northern end of the site to greater than 150 feet in the southern end.

Resistivity data indicate the possibility of perched water in the northeast corner of the site at depths of 8 feet (2.5 m) and 10 feet at stations R-1 and R-2, respectively. Boring data, however, do not confirm this interpretation. If perched water is present in this area, the quantity is very low.

6.9 RESULTS AND CONCLUSIONS

6.9.1 Suitable Area

Resulting suitable area, as defined by FY 79 Verification Studies in the Hamlin Site, is shown in Drawing 6-6. The site contains approximately 245 mi^2 (635 km^2) of usable area for a hybrid trench basing mode and 150 mi^2 (390 km^2) for a vertical shelter basing mode concept. These figures are smaller than those presented during Intermediate/Fine Screening studies and represent a general refinement of area based on:

1. New terrain exclusions, particularly in the southern portion of the site, that were not discernible at a scale used for Screening studies;
2. Small reductions in area around the margins of the site due to shallow rock identified during field verification; and
3. Significantly larger depth to water exclusions based on data obtained after the Intermediate Screening studies.

6.9.2 Construction Considerations

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

6.9.2.1 Grading

The surficial slopes in the Hamlin Site range from 0 to 8 percent with an average of 3 percent. Therefore, preconstruction grading for roads and trenches will be minimal.

6.9.2.2 Roads

The surficial granular soils of low strength will require mechanical compaction to an average depth of 1.3 feet (0.4 m) to improve their subgrade supporting properties. Laboratory California Bearing Ratio (CBR) test results indicate that the compacted granular soils will provide good to very good subgrade support. Compaction of the fine-grained surficial soils may not provide adequate subgrade support. Therefore, these soils should be covered with a select granular subbase layer over the compacted subgrade. As an alternative, these soils could be partially or totally removed, depending on 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 will be suitable as road subbase and base course material when less than 25 percent fines (passing a No. 200 sieve) are present. These soils are present in surface and subsurface areas; however, their areal extent is unknown.

The average depth of drainage incisions in the suitable area is 8 feet (2.4 m) and exceeds 12 feet (3.6 m) over approximately 20 percent of the area. Big Spring Wash in the northwestern portion of the site has an incision depth of 75 feet (23 m); however, drainage incision depths in the rest of the suitable area range from less than 1 foot to 33 feet (0.3 to 10 m). Overall, the cost of drainage structures will probably be moderate to high.

6.9.2.3 Excavatability and Stability

The soils in the construction zone are generally medium dense to very dense. Calcium carbonate cementation is moderately well developed in the upper 10 feet (3 m) but is variable with depth. Fine-grained soils are expected to compose less than 20 percent of the soils within the construction zone.

Hybrid Trench: The 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 trench excavations will generally have to be sloped back for stability. Below this zone, vertical trench walls will be temporarily stable in approximately 70 percent of the area. Sloping or trench shoring will probably be required in the remaining area.

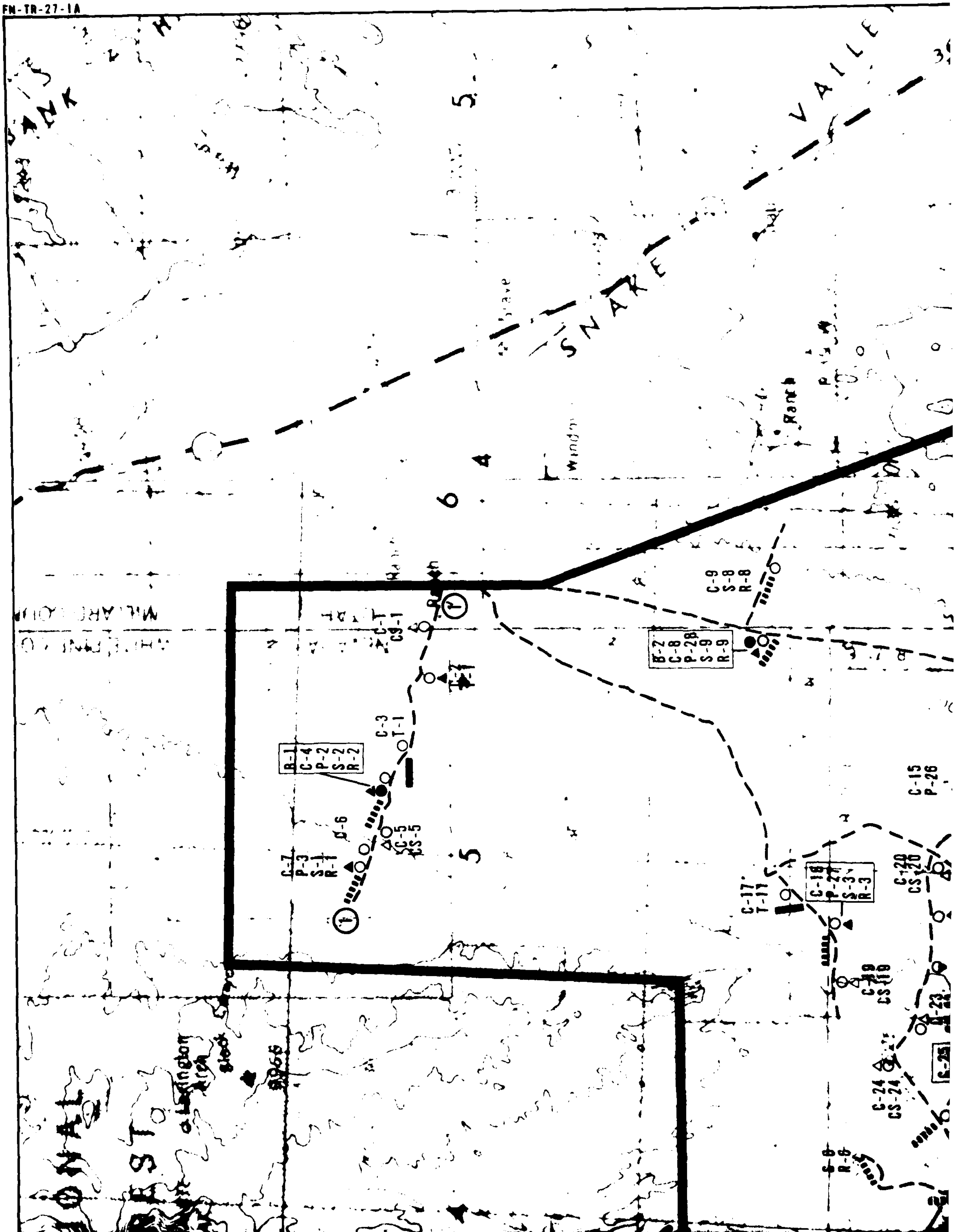
Vertical Shelter: Within the depth of vertical shelter construction, compressional wave velocities indicate easy to moderately difficult excavation conditions over most of the site. Large diameter auger drills could be used for excavation of vertical shelters. Excavations to 120 feet (37 m) will probably not remain stable without the use of slurry or other stabilizing techniques.

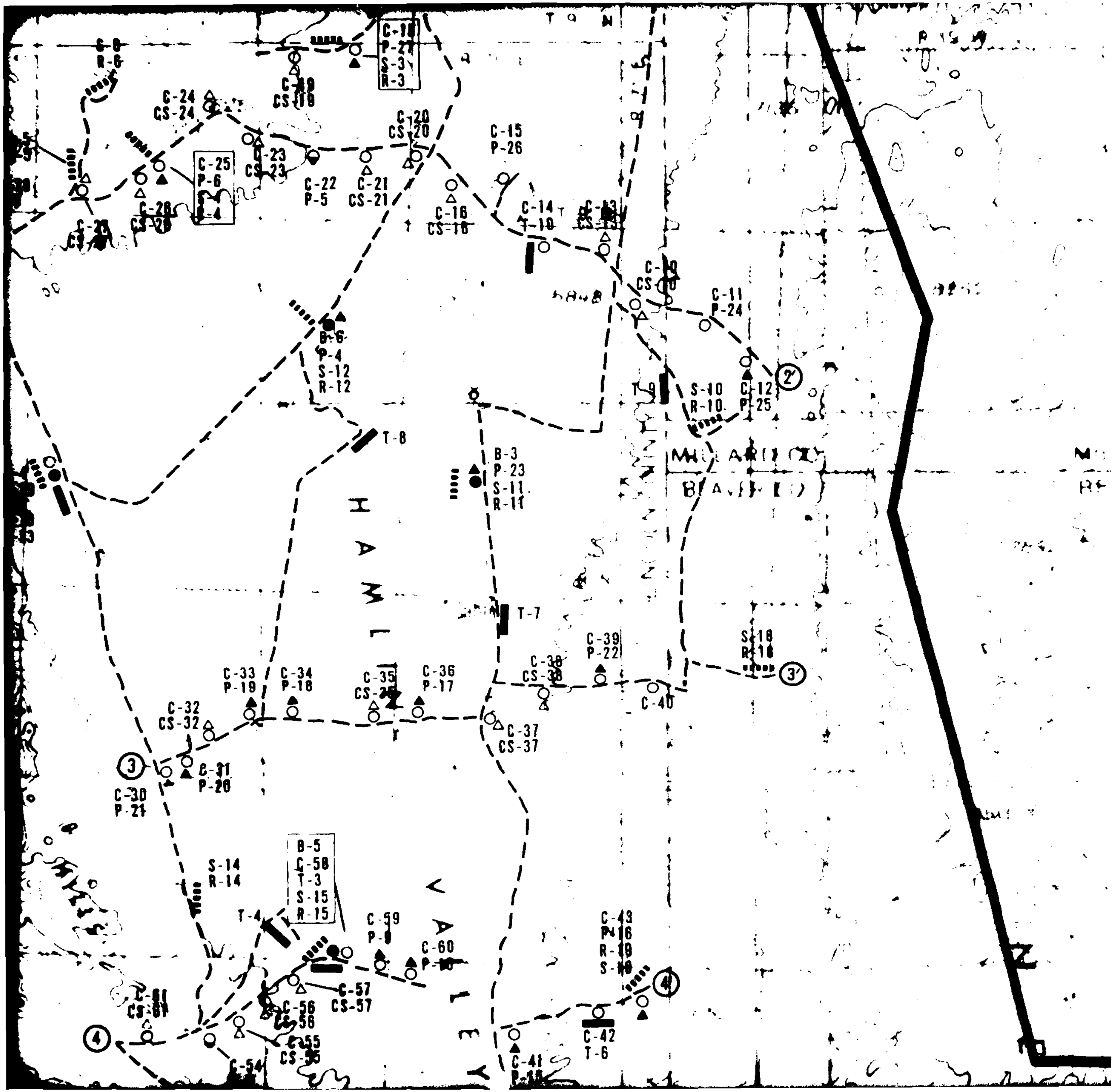
The following geotechnical conditions have been identified as requiring additional information.

6.10 RECOMMENDATIONS FOR FUTURE STUDIES

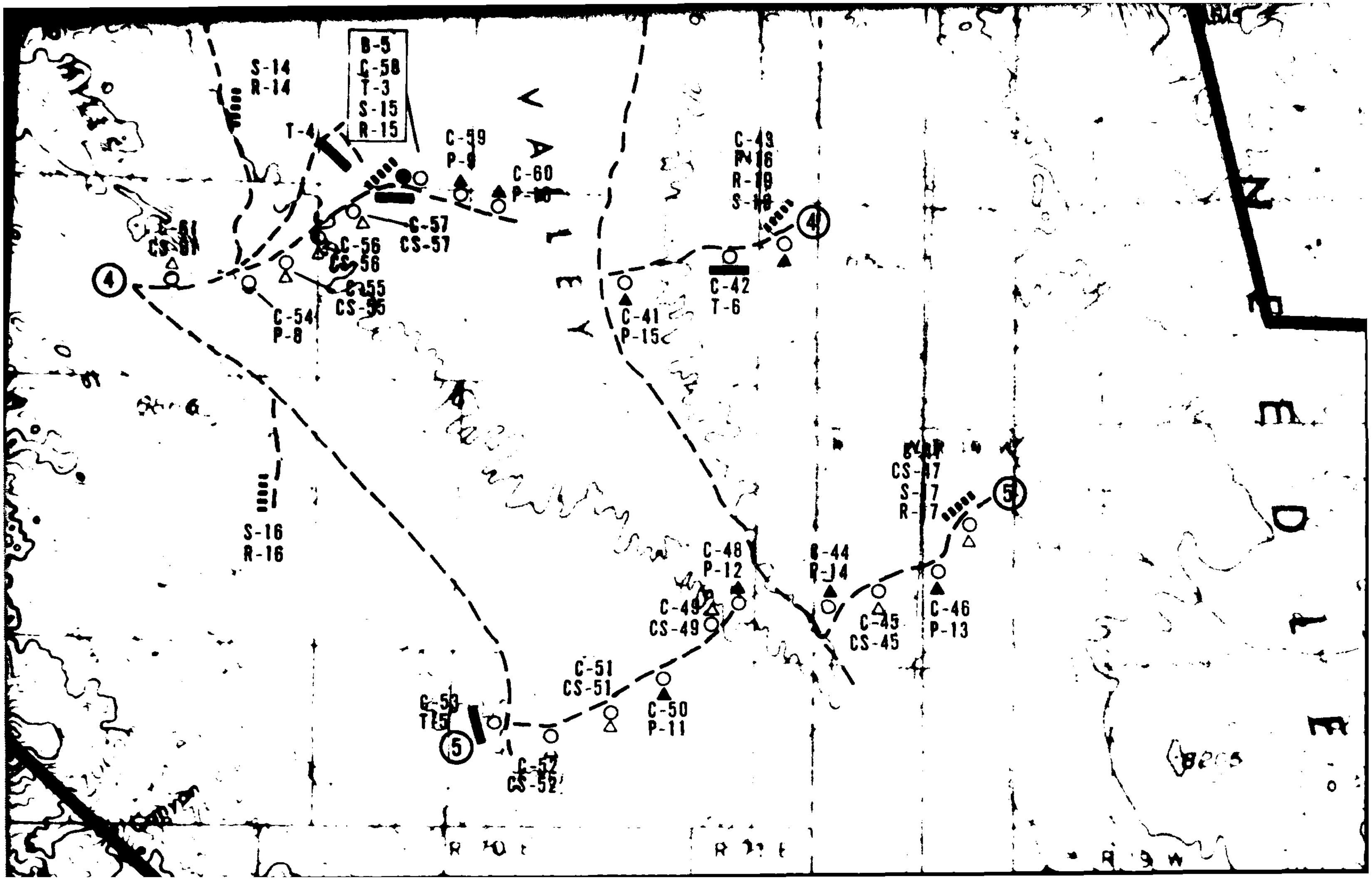
1. The 150-foot (46-m) to ground-water contour is very approximate near the Limestone Hills in the western portion of the site. Additional ground-water observation wells are recommended to determine the depth to and extent of ground water in this area.

2. A full verification field investigation is recommended in a large parcel immediately north and east of the site. Part of this area has been redefined as suitable on the basis of better ground-water information since the Intermediate Screening report and has not been field-verified.


SNAKE VALLEY
B-1
C-4
P-2
S-2
R-2
C-3
T-1
C-9
S-8
R-8
B-2
C-8
P-28
S-9
R-9
C-15
P-26
C-17
T-17
C-18
P-27
S-3
R-3
C-20
CS-20
C-7
P-3
S-1
R-1
C-5
CS-5
C-24
CS-24



HAMLIN VALLEY
C-18
P-27
S-3
R-3
C-24
CS-24
C-25
P-6
C-23
CS-23
C-22
P-5
C-21
CS-21
C-20
CS-20
C-15
P-26
C-16
CS-16
C-14
T-10
C-11
P-24
C-12
P-25
S-10
R-10
B-6
P-4
S-12
R-12
T-8
B-3
P-23
S-11
R-11
T-7
C-39
P-22
C-40
S-18
R-18
C-33
P-19
C-34
P-18
C-36
P-17
C-37
CS-37
C-32
CS-32
C-30
P-21
S-14
R-14
B-5
C-58
T-3
S-15
R-15
T-4
C-59
C-60
C-43
C-42
T-6
C-57
CS-57
C-56
CS-56
C-55
C-54
C-41

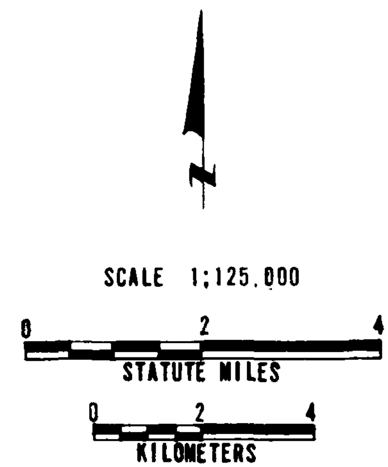


S-14
R-14
B-5
C-58
T-3
S-15
R-15
T-4
C-59
C-60
VALLEY
C-57
CS-57
C-56
CS-56
C-55
C-54
P-8
C-41
C-42
T-6
C-43
S-16
R-16
C-48
P-12
C-49
CS-49
C-51
CS-51
C-50
P-11
C-53
C-52
CS-52
C-45
CS-45
C-46
P-13
CS-47
EDLE
R 10
R 9 W

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



2 JUL 79

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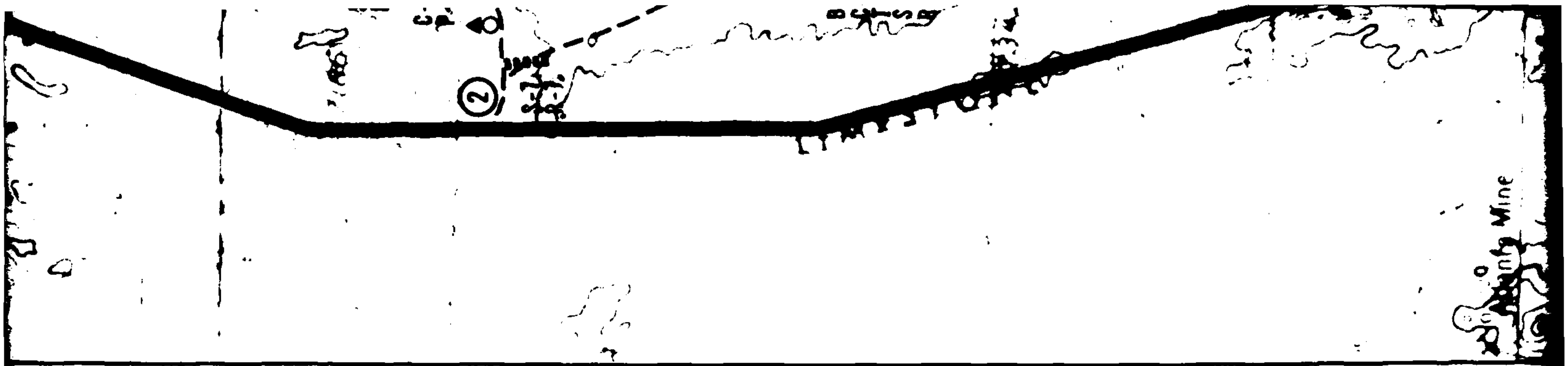

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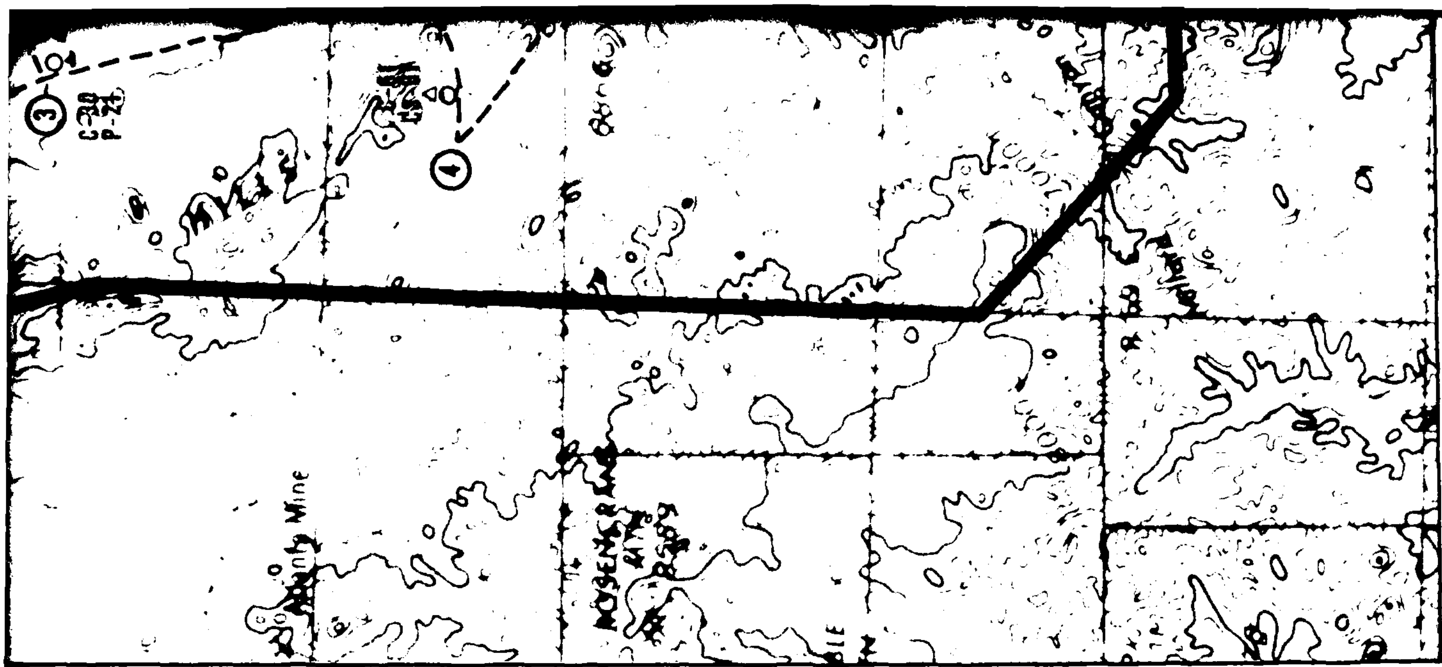

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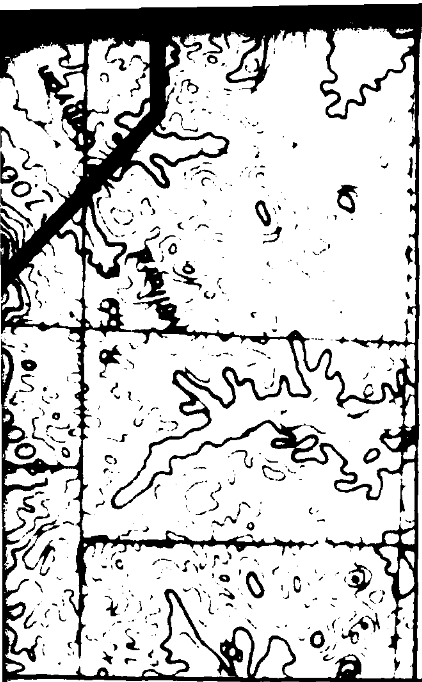


NOTES

ACTIVITY LOCATIONS
VERIFICATION SITE HAMLIN CDP, NEVADA

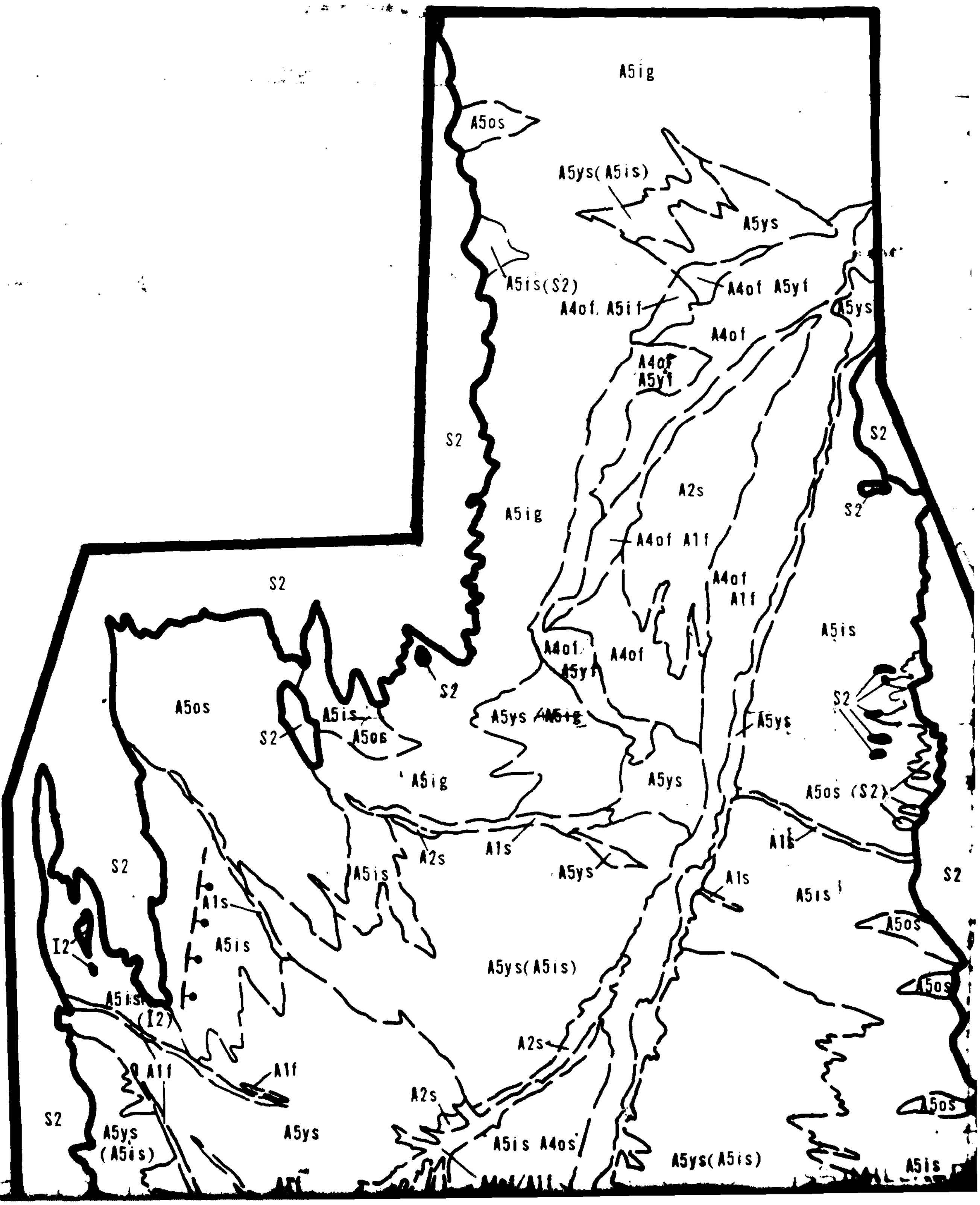
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

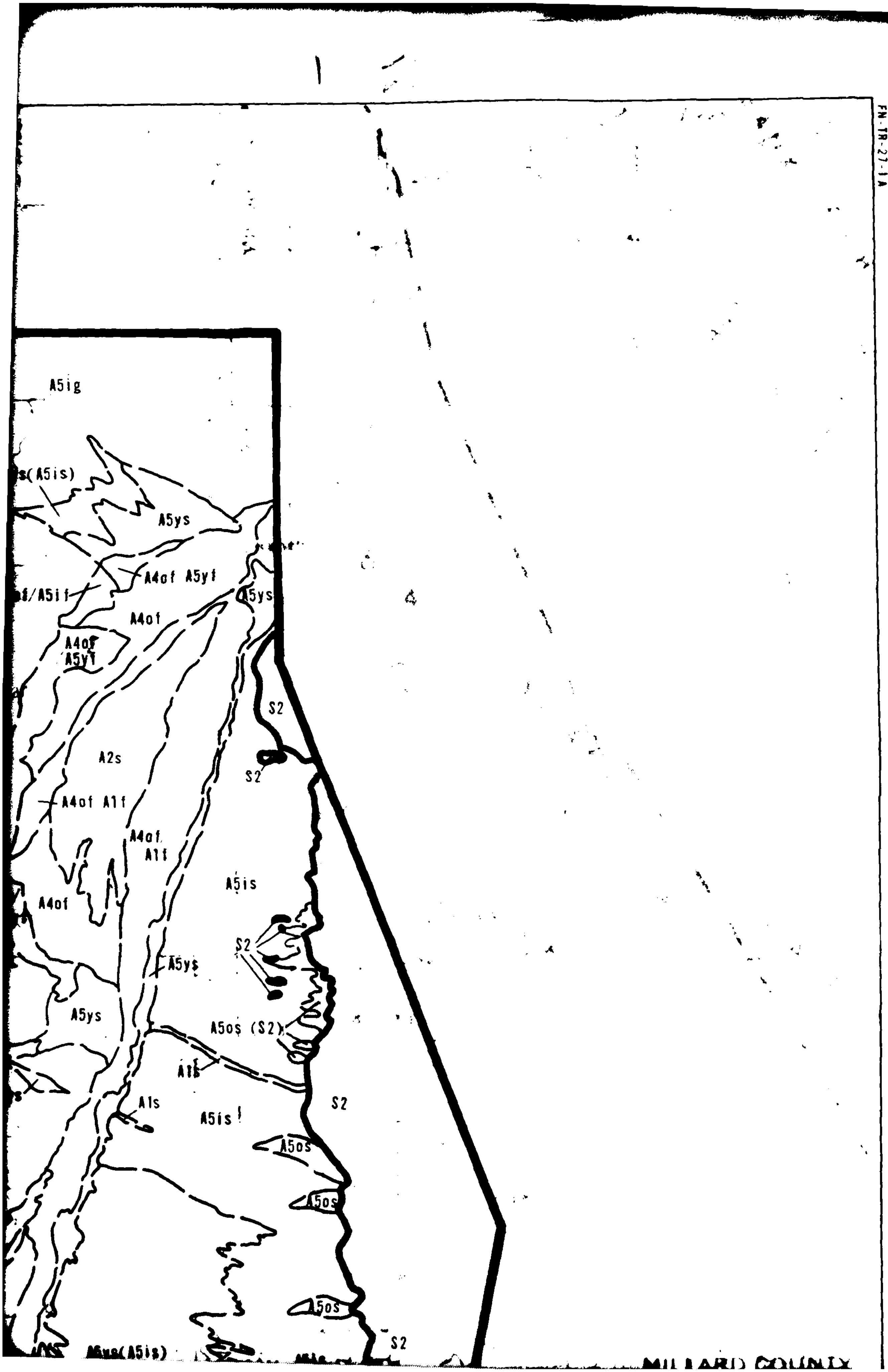
DRAWING 6-1

FUGRO NATIONAL, INC.

2 JUL 79

NATIONAL




A5ig
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A4of A5yf
/A5if
A5ys
A4of
A4of
A5yf
S2
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A4of
A1f
A5is
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S2
A5ys
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A5os (S2)
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S2
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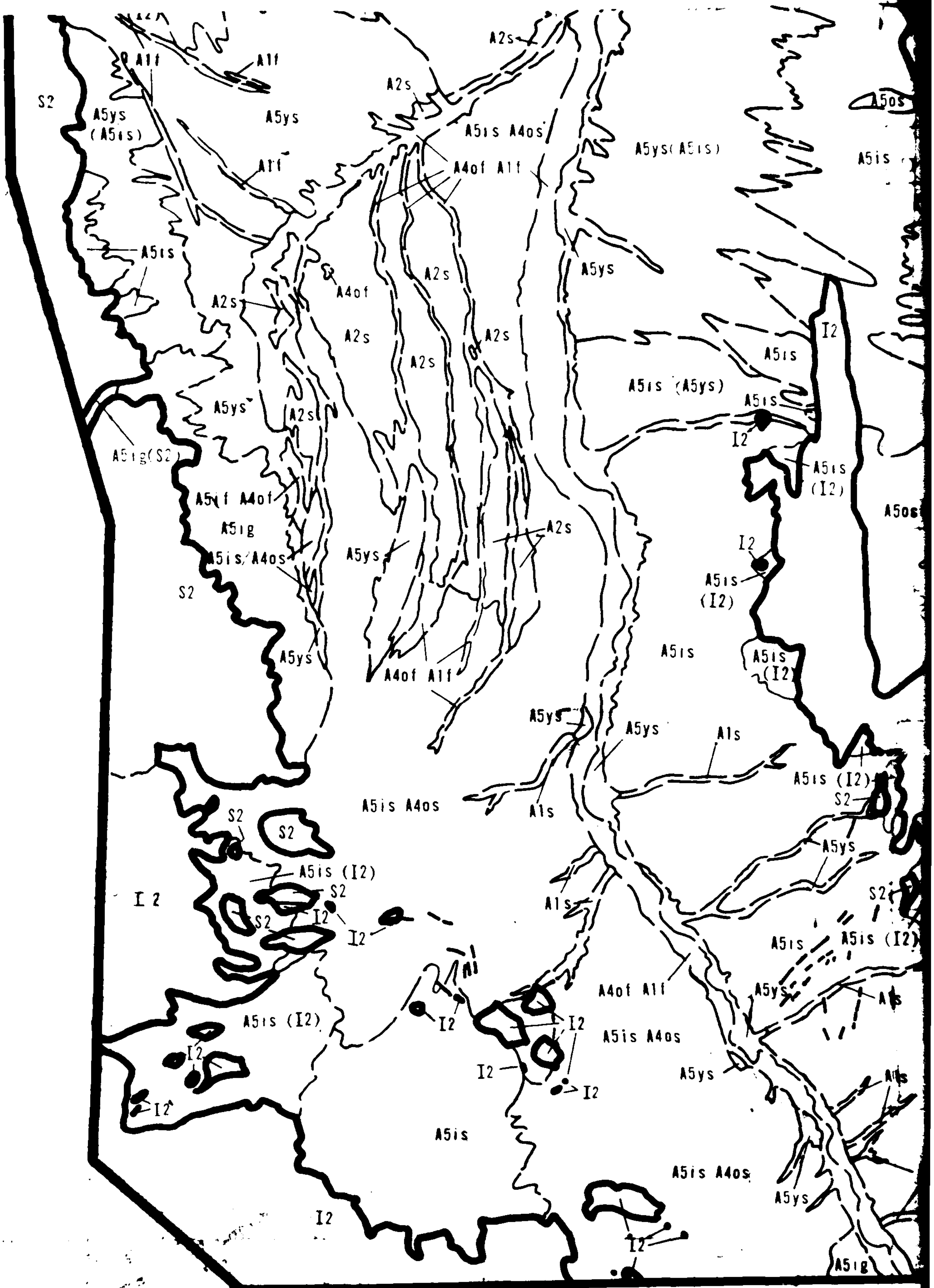
4
MILLARD COUNTY



A1f
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A4of
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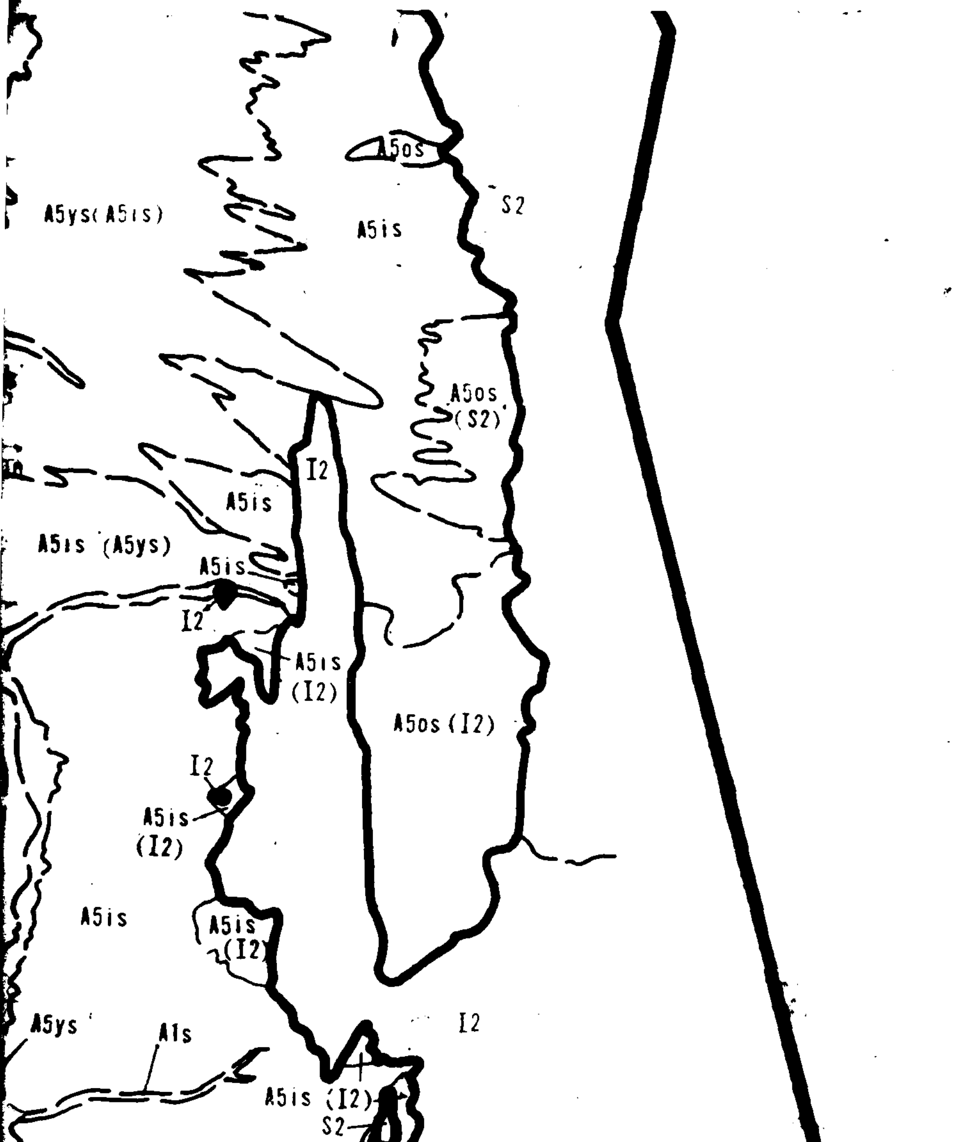

A5os
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A1s
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A5is (I2)
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A5ys
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A5is (I2)
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A1f
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EXPLANATION

SURFICIAL BASIN-FILL DEPOSITS

A1f / A1s	Younger Fluvial Deposits - Modern stream channel and flood-pl[...] sandy silt (ML) and A1s, silty sand (SM)
A2s	Older Fluvial Deposits - Older stream channel and flood-plain [...] composed of silty sand (SM).
A4of / A4os	Older Lacustrine Deposits - Older bed lake deposits of: A4of, [...] clayey silt (CL, ML) and A4os, silty sand (SM).
A5ys	Younger Alluvial Fan Deposits - Active younger alluvial fan de[...] and gravelly sand (SM).
A5is / A5ig	Intermediate Alluvial Fan Deposits - Inactive, intermediate-ag[...] A5is, weakly cemented silty sand and gravelly sand (SM) and [...] silty gravel (GM).
A5os	Older Alluvial Fan Deposits - Older, highly eroded alluvial fa[...] cemented silty sand and gravelly sand (SM).

ROCK UNITS

Igneous (I)

I1	Quartz monzonite and granodiorite
I2	Rhyolite, quartz latite, dacite and andesite
I3	Airfall tuff; tuff breccia; and andesite, trachyte, and lat[...]

Sedimentary (S)

S1	Sandstone and orthoquartzite
S2	Limestone and dolomite, locally cherty, with thin interbeds [...]
S3	Shale with interbedded limestone

A5ys A5is Combination of geologic unit symbols indicates a mixture of [...] or rock units inseparable at map scale

A5is (S2) 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 surf[...] ball on downthrown side.

DEPART[...] VER[...]

EXPLANATION

RFICIAL BASIN-FILL DEPOSITS

s - Modern stream channel and flood-plain deposits of A1f,
s, silty sand (SM)

- Older stream channel and flood-plain deposits in terraces
(SM).

ts - Older bed lake deposits of: A4of, sandy clay and
d A4os, silty sand (SM).

osits - Active younger alluvial fan deposits of silty sand

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

its - Older, highly eroded alluvial fan deposits of moderately
gravelly sand (SM).

ROCK UNITS

nodiorite

dacite and andesite

a; and andesite, trachyte, and latite ignimbrite.

zite

locally cherty, with thin interbeds of sandstone

imestone

nit symbols indicates a mixture of either surficial basin-fill
le at map scale

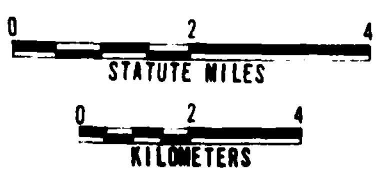
es surface unit at shallow depth.

SYMBOLS

basin fill.

basin-fill or rock units.

SCALE 1:125,000



...of geologic unit symbols indicates a mixture of eith...
or rock units inseparable at map scale

A5is (S2) 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 basi...
ball on downthrown side.

NOTES: 1. Surficial basin-fill units pertain only to the upper several feet of soil. ...
surficial deposits and scale of map presentation, unit descriptions refer t...
soil types. Varying amounts of other soil types can be expected within eac...

2. The distribution of geologic data stations is presented in Volume IV. Draw...
all station data and generalized description of all geologic units is inclu...
Section 1.0

3. Geology in areas of exposed rock from Hintze (1963), Hose and Blake (1976)...
Pampeyan (1970).

SURFICIAL GEOLOGIC UNITS
VERIFICATION SITE, HAMLIN CDP NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

DRAWING
6-2

FUGRO NATIONAL, INC.

gic unit symbols indicates a mixture of either surficial basin-fill
arable at map scale

erlies surface unit at shallow depth.

SCALE 1:125,000

0 2 4
STATUTE MILES

0 2 4
KILOMETERS

SYMBOLS

and basin fill.

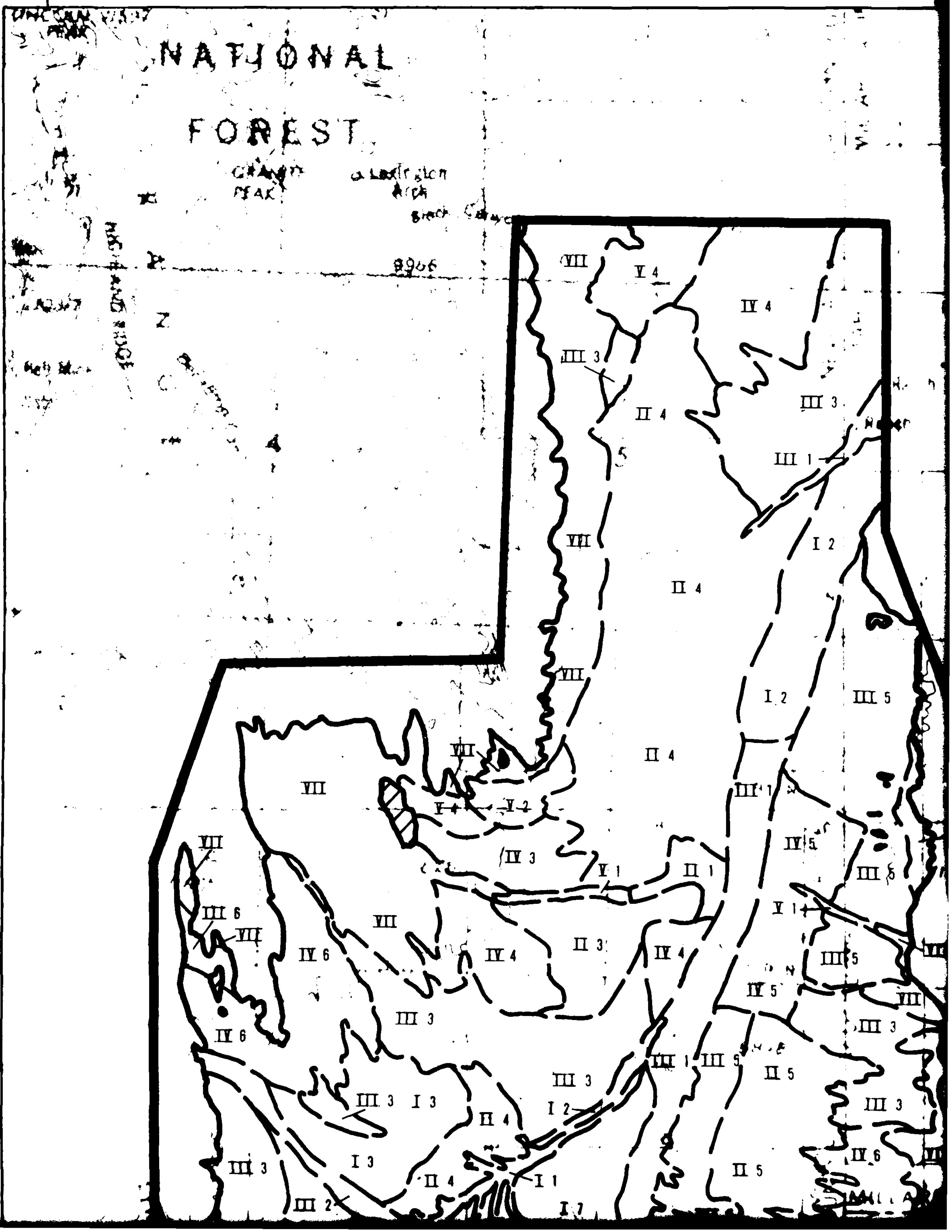
icial basin-fill or rock units.

ace rupture of faults offsetting surficial basin-fill deposits,
side.

its pertain only to the upper several feet of soil. Due to variability of
scale of map presentation, unit descriptions refer to the predominant
ounts of other soil types can be expected within each geologic unit

logic data stations is presented in Volume IV, Drawing 1. A tabulation of
eralized description of all geologic units is included in Volume IV.

osed rock from Hintze (1963), Hose and Blake (1976), and Tschanz and


NATIONAL
FOREST
8906
VII
V 4
IV 4
III 3
II 4
III 3
III 1
VII
I 2
II 4
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II 4
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VII
V 2
III 1
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IV 3
V 1
II 1
III 5
VII
III 6
VII
V 1
VII
IV 6
IV 4
II 3
IV 4
III 5
IV 5
VII
III 3
III 3
IV 6
III 1
III 5
II 5
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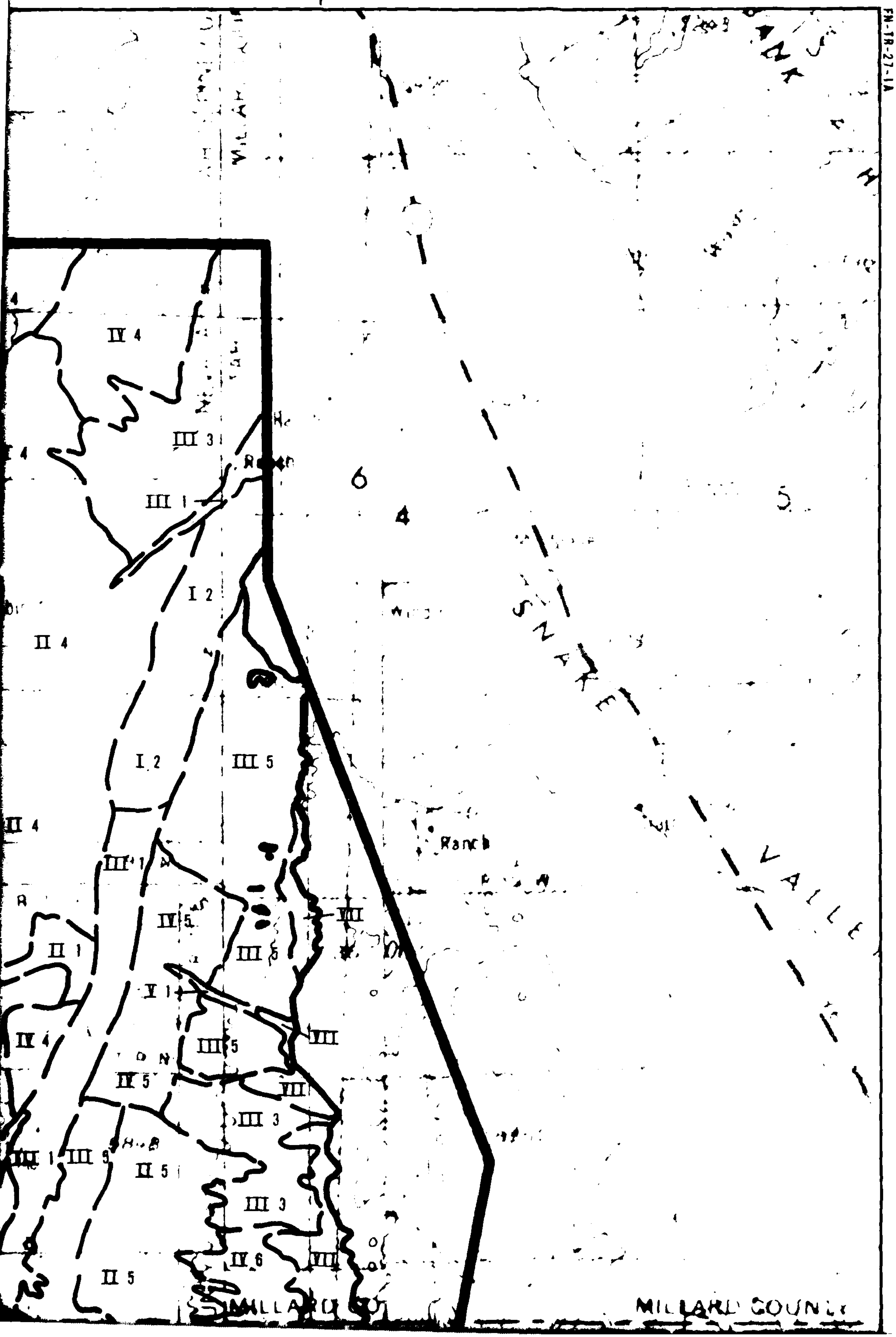
II 4
I 1
IV 6
II 5
III 2
I 7

1 2


FN-TR-27-IA
SNAKE VALLEY
MILLARD COUNTY
MILLARD CO
Ranch
IV 4
III 3
III 1
I 2
II 4
III 5
II 4
III 1
IV 5
II 1
III 5
V 1
IV 4
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IV 6
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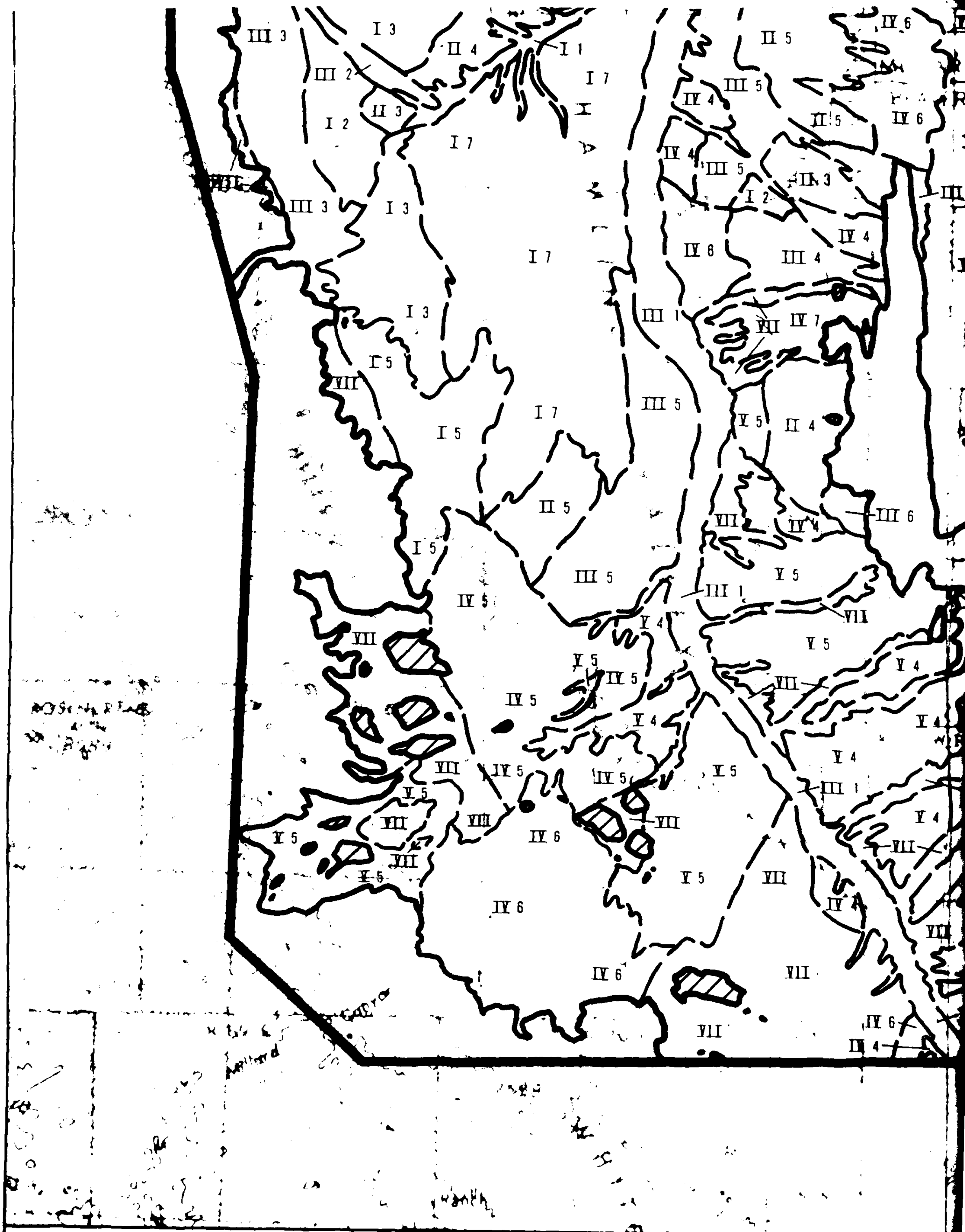
5


III 3
I 3
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I 2
I 7
IV 6
IV 4
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VII
IV 7
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VII
III 5
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V 5
II 4
I 5
II 5
III 6
VII
IV 4
I 5
III 5
V 5
III 1
IV 5
V 4
VII
V 5
VII
V 5
IV 5
IV 5
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VII
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IV 5
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III 1
V 5
VII
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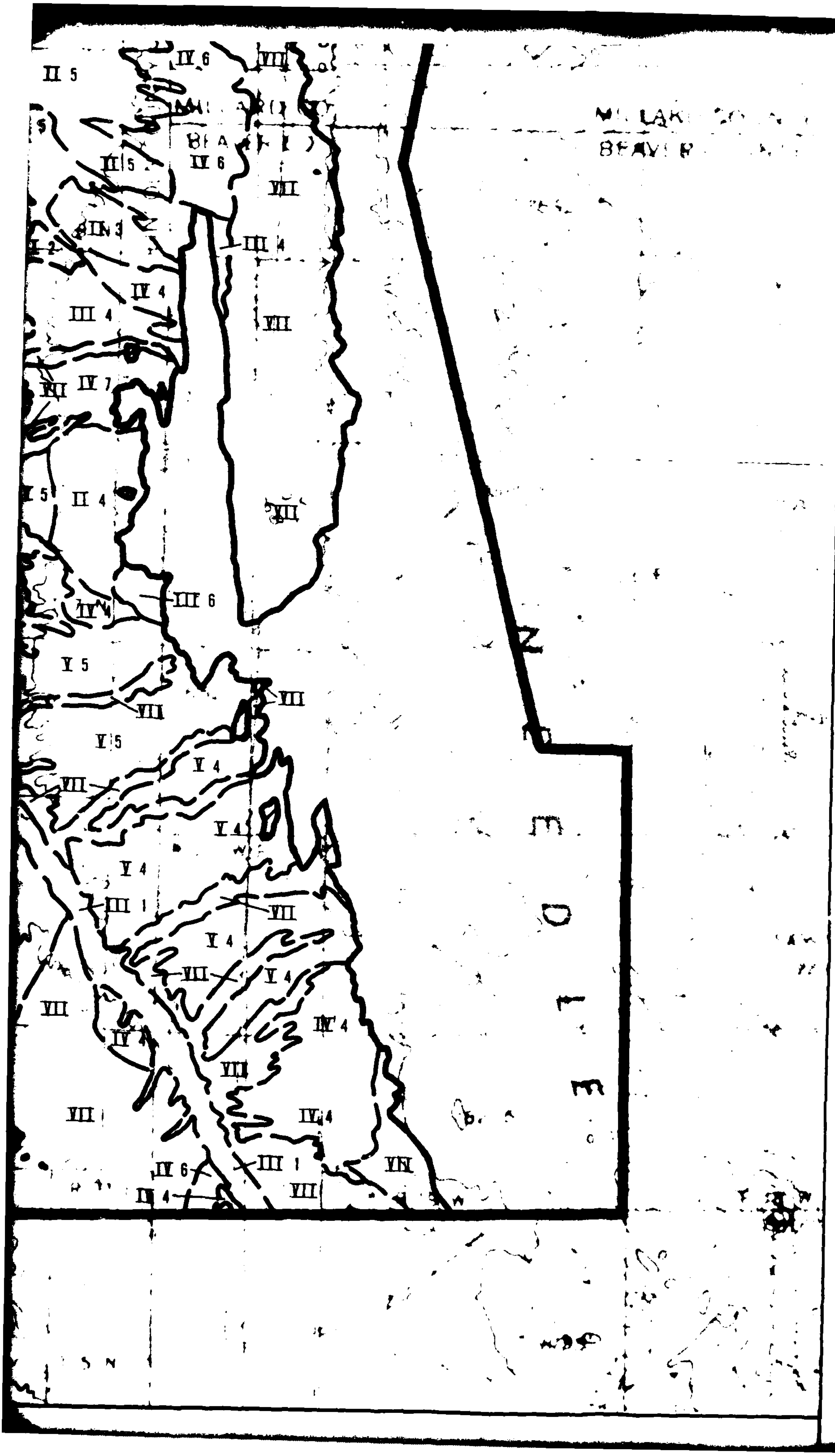
II 5
IV 6
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VII
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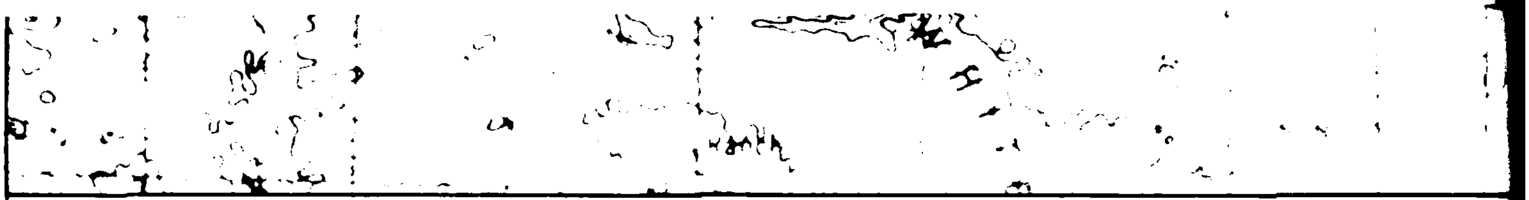
IV 4
IV 6
III 1
VII

4



EXPLANATION

Terrain Category (see table belo[w] ------ III 3 ------ Drainage spacing, i.e. the maximum num[ber] of drainages of the corresponding cat[egory] 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 HAMLIN COP NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

DRAWING 6-3

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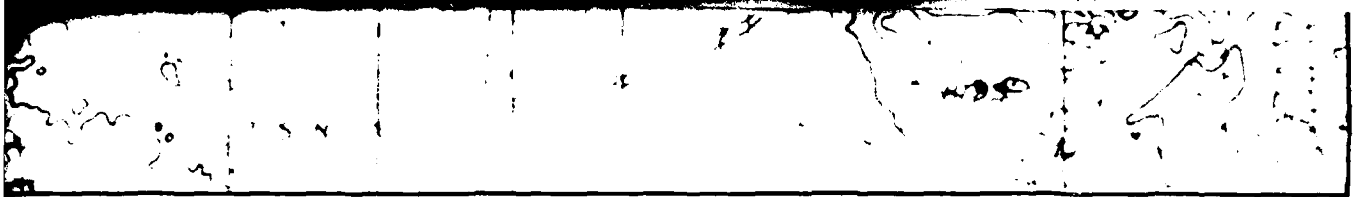


NATION

— 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
Appendix A2.0. Exclusion Criteria)

es

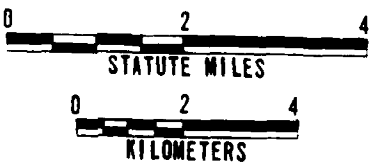
ill

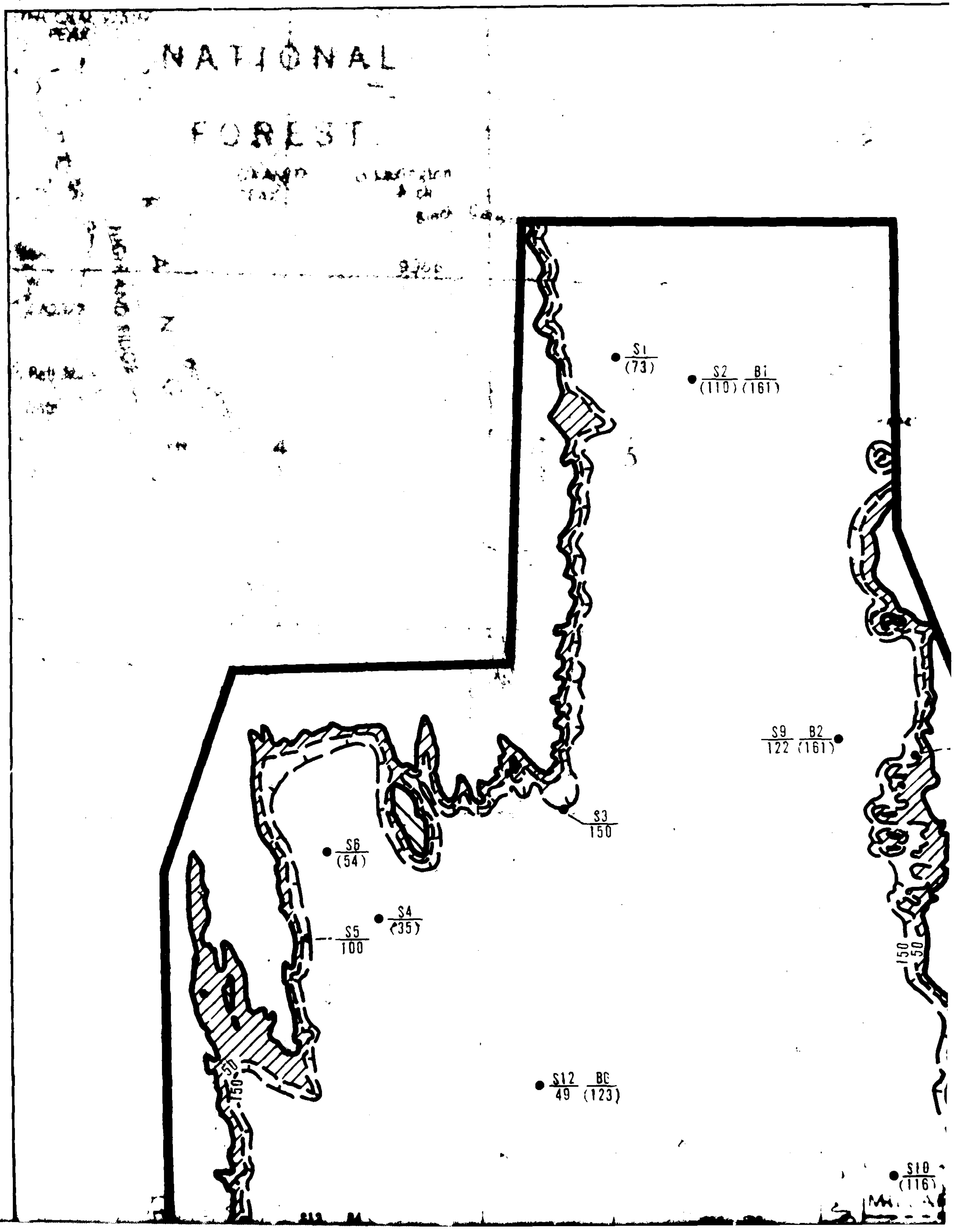
ted exposed rock.

map are from: (1) field observations,
maps, and (3) 1:60,000 and 1:25,000
of presentation and variability of
generalized.

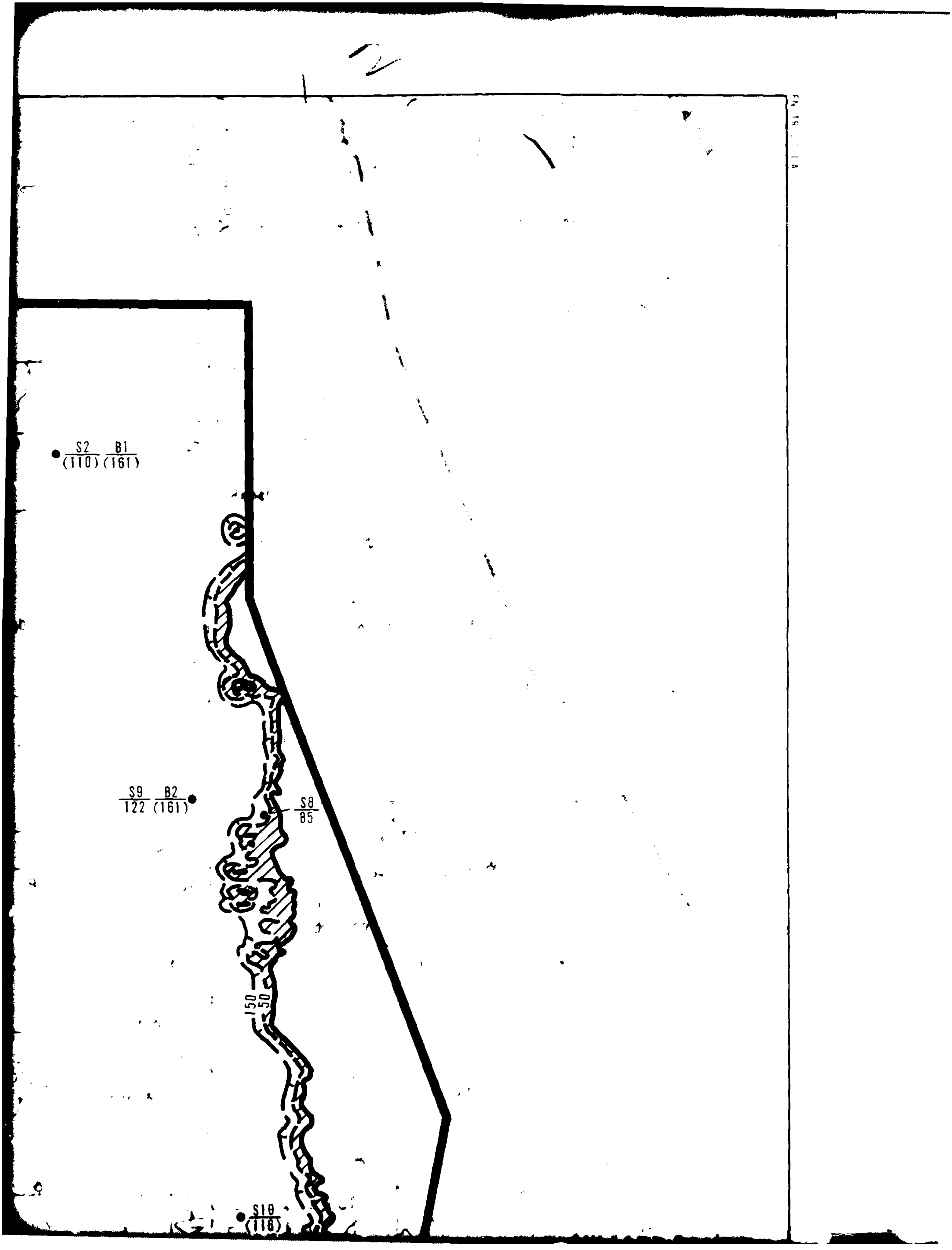
6

SCALE 1:125,000





NATIONAL
FOREST
S1
(73)
S2
(110)
B1
(161)
S9
122
B2
(161)
S3
150
S6
(54)
S4
(35)
S5
100
S12
49
BC
(123)
S10
(116)
50
150


S2
(110)
B1
(161)
S9
122
B2
(161)
S8
85
150
50
S10
(116)

AD-A113 322 FUGRO NATIONAL INC LONG BEACH CA F/G 13/2
MX SITING INVESTIGATION GEOTECHNICAL EVALUATION. VOLUME IA. NEV--ETC(U)
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UNCLASSIFIED FN-TR-27-1A NL

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4 OF 4

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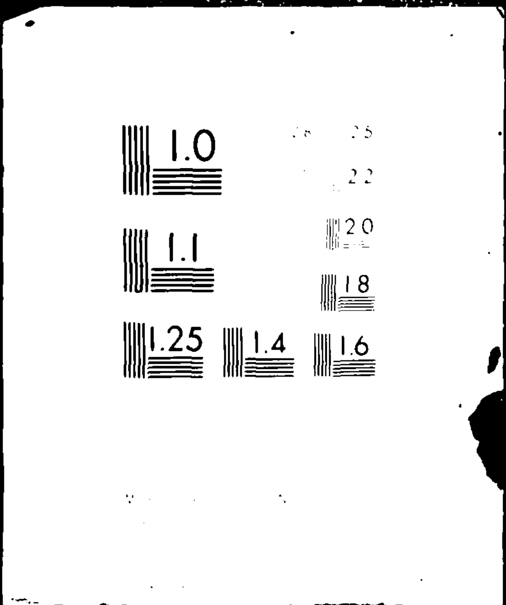
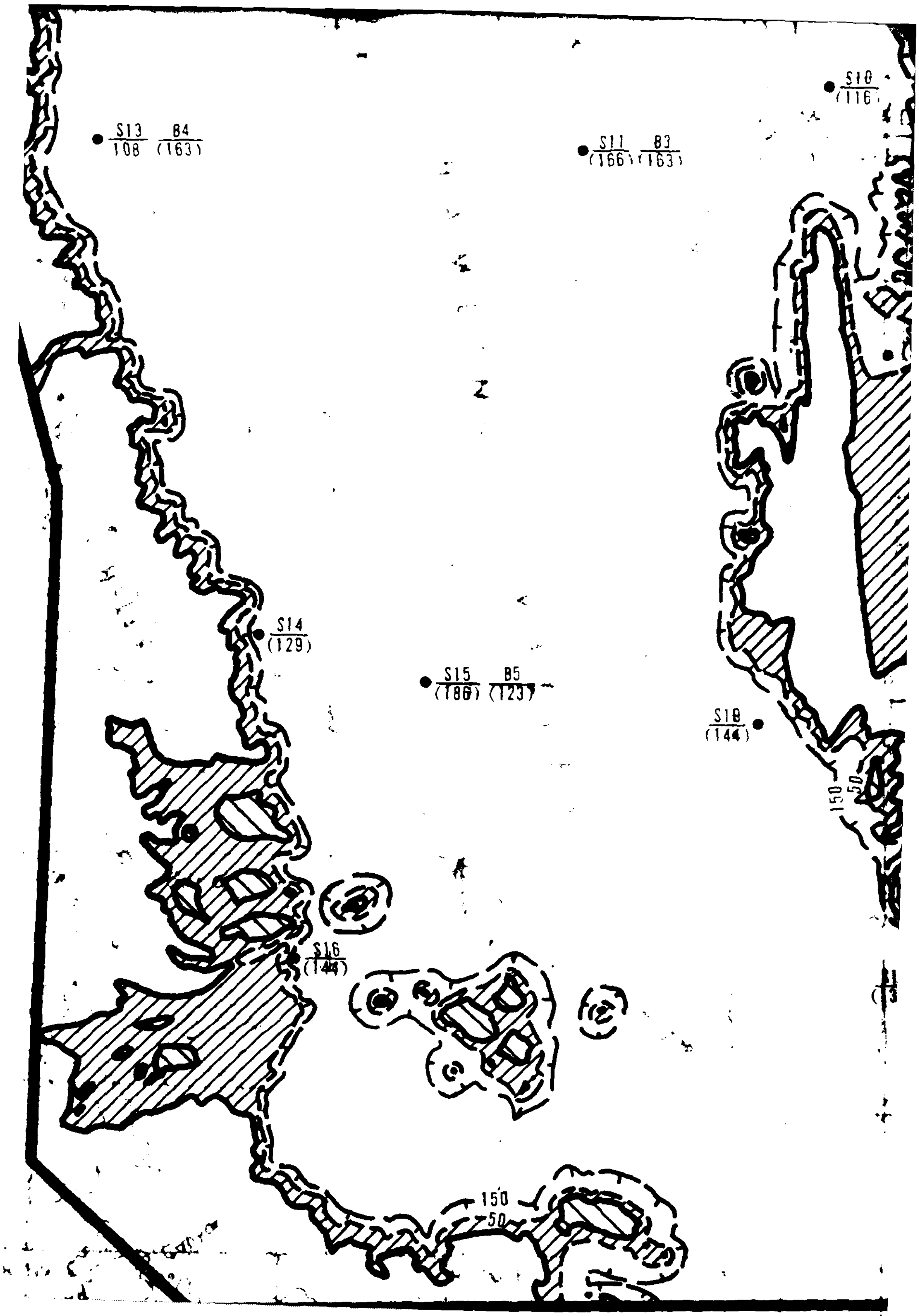
113322





S13 / 108
84 / (163)
S11 / (166)
83 / (163)
S10 / (116)
S14 / (129)
S15 / (188)
85 / (123)
S18 / (144)
S16 / (144)
150
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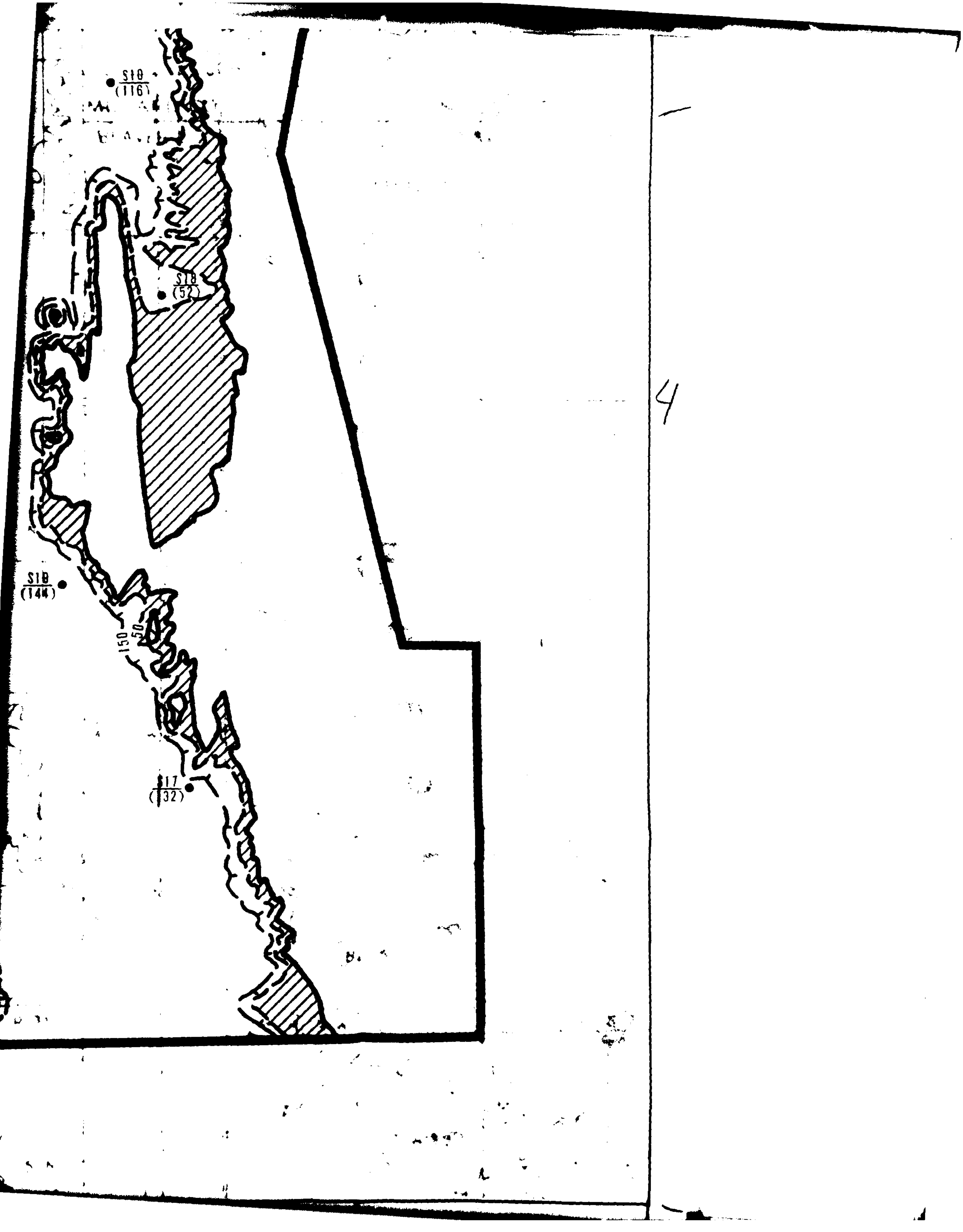
150
50


S18
(116)
S18
(52)
S18
(144)
150
50
S17
(132)
4

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 indicates 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, HAMLIN COP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

DRAWING
6-4

FUGRO NATIONAL, INC.

5

depth of approximately
dicates rock less

depth of approximately
indicates rock less

in-fill.

isolated exposed rock

(S) seismic refraction
stivity sounding (R).

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n in parentheses, depth
occur (feet).

geologic interpretations
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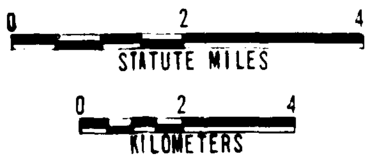
SCALE 1:125,000



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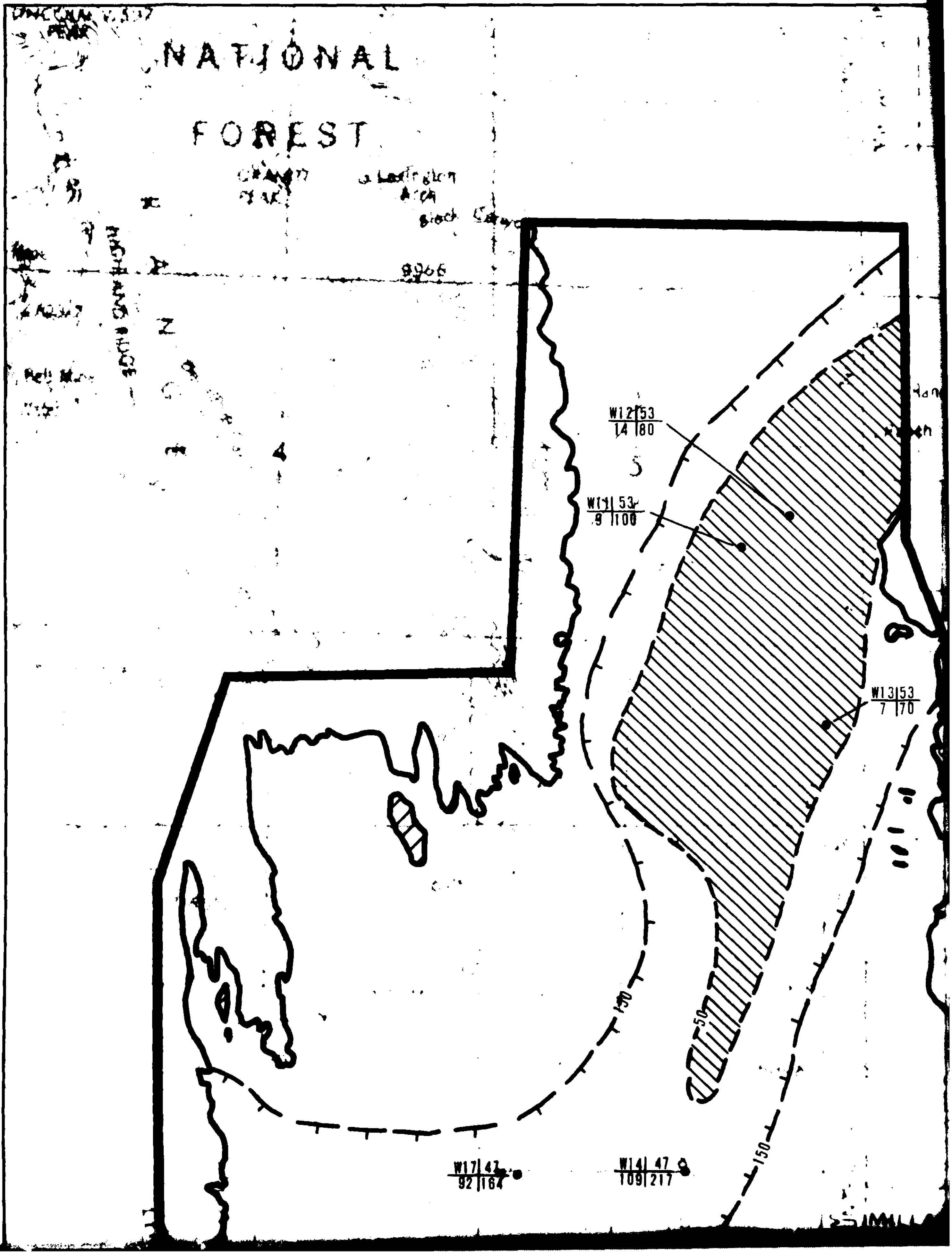
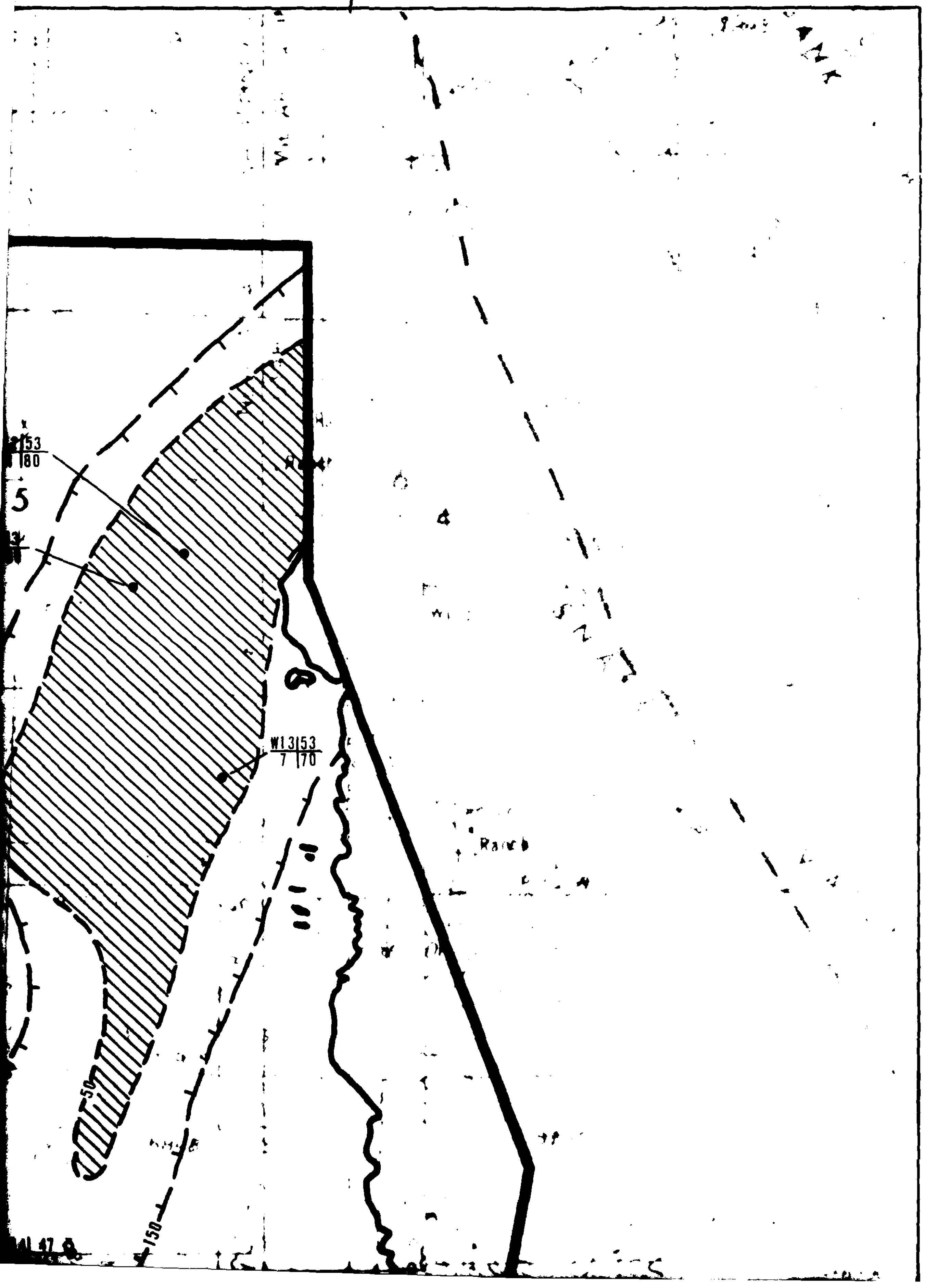
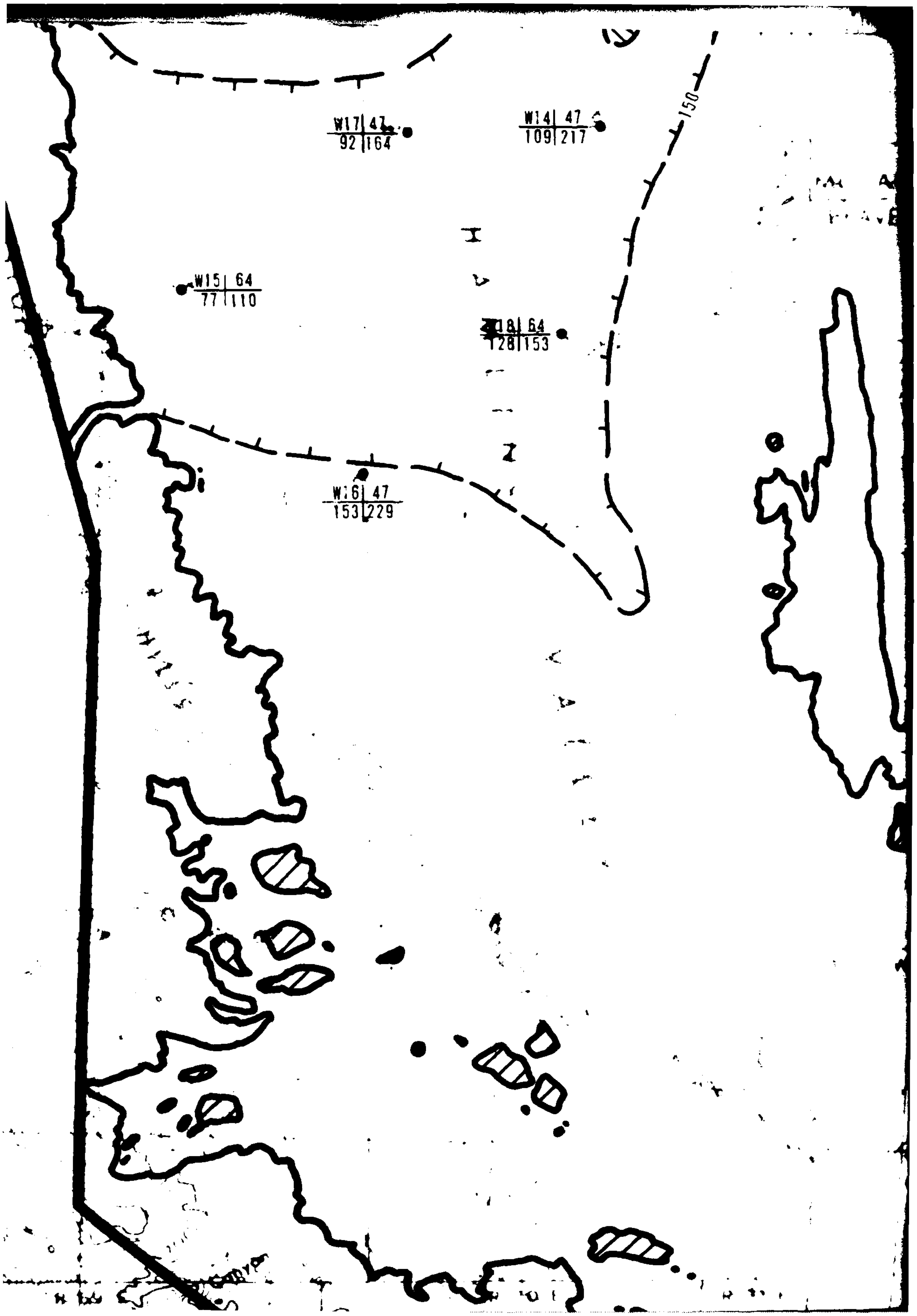
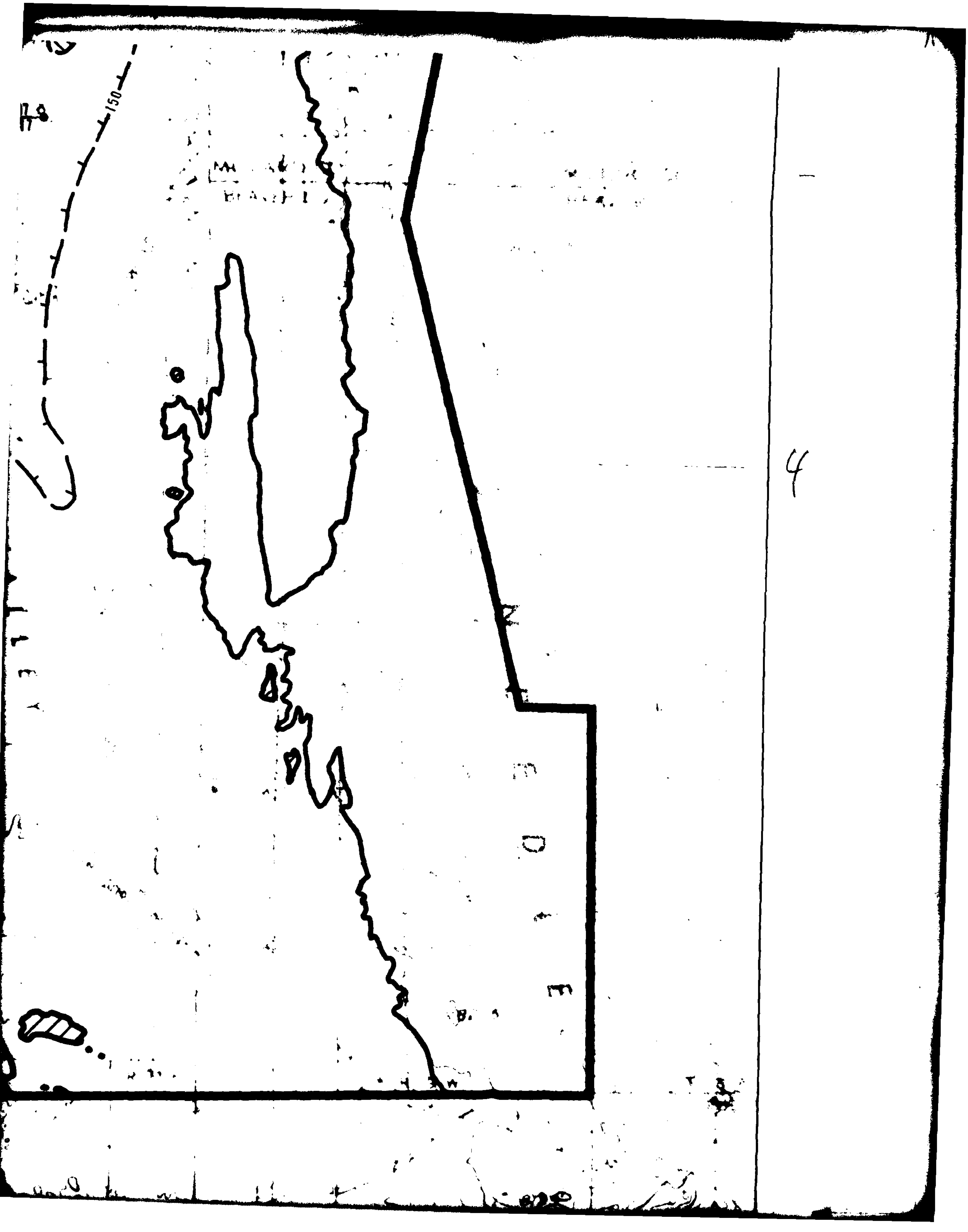


NATIONAL
FOREST
8966
Z
4
5
W12 53
14 80
W11 53
9 100
W13 53
7 70
150
50
W17 47
92 164
W14 47
109 217
150

2




W17 | 47
92 | 164
W14 | 47
109 | 217
150
W15 | 64
77 | 110
W18 | 64
128 | 153
W16 | 47
153 | 229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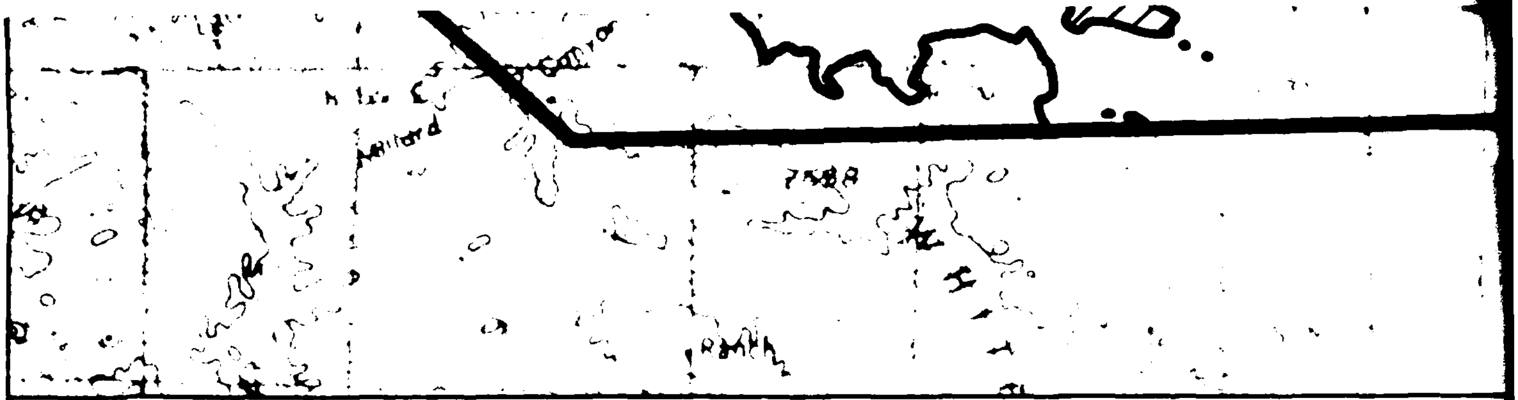


EXPLANATION

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.

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 IV Section 2.0.	Year of water level measurement
Depth to water (feet)	Depth of well (feet)

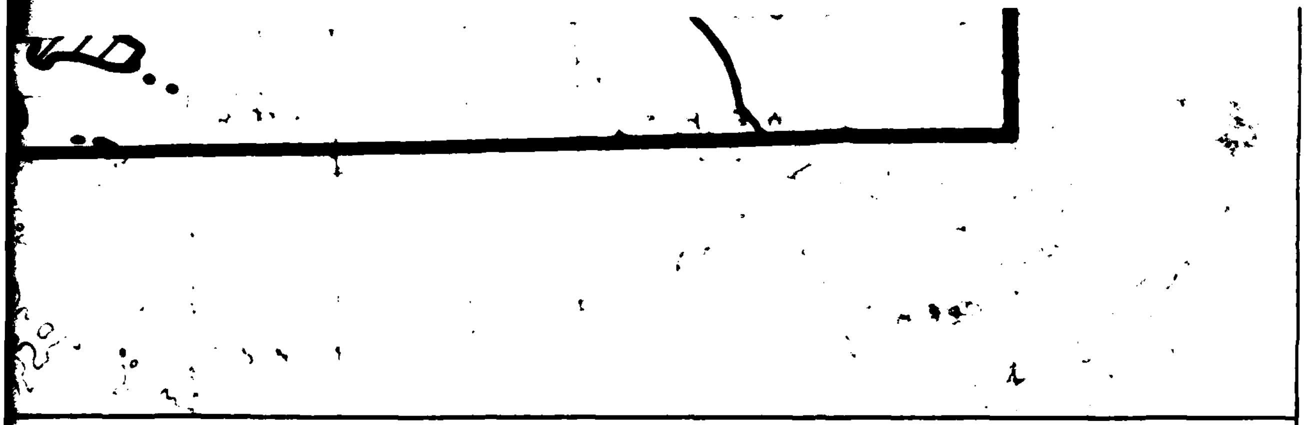
NOTE: The contours are based entirely on the data points shown on the map. Extensive interpretation has been used and it can be expected that contour locations will change as additional data are obtained

DEPTH TO WATER
VERIFICATION SITE HAMLIN CDP NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

DRAWING 6-5

FUGRO NATIONAL, INC.



a depth of approximately
s less than 50 feet (15m)

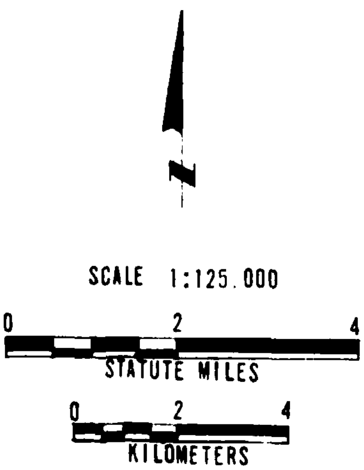
a depth of approximately
ates less than 150 feet

ll.

d exposed rock

ismic esistivity see Volume IV	Year of water level measurement
	Depth of well (feet)

on the data points shown on the map
een used and it can be expected that
as additional data are obtained



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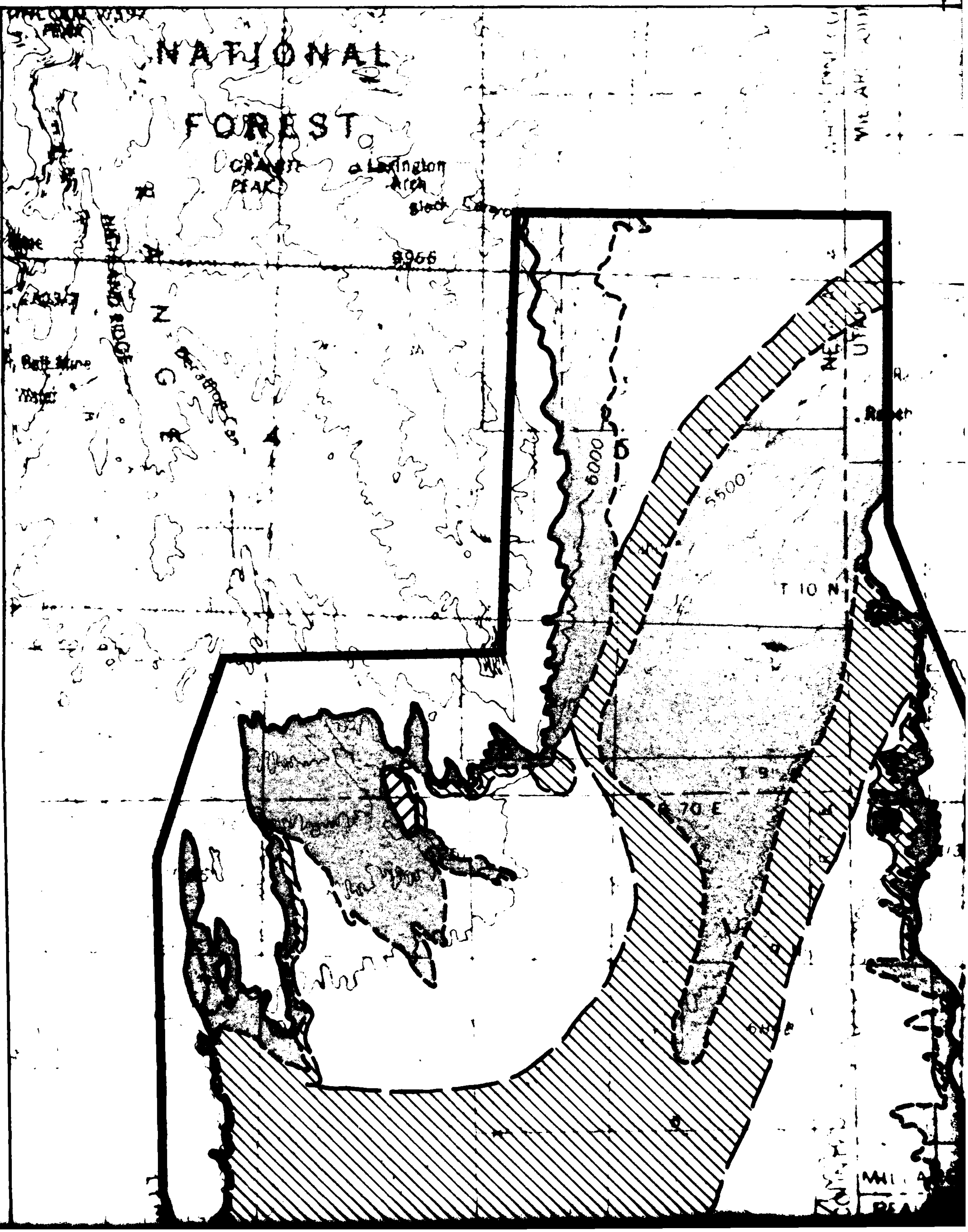
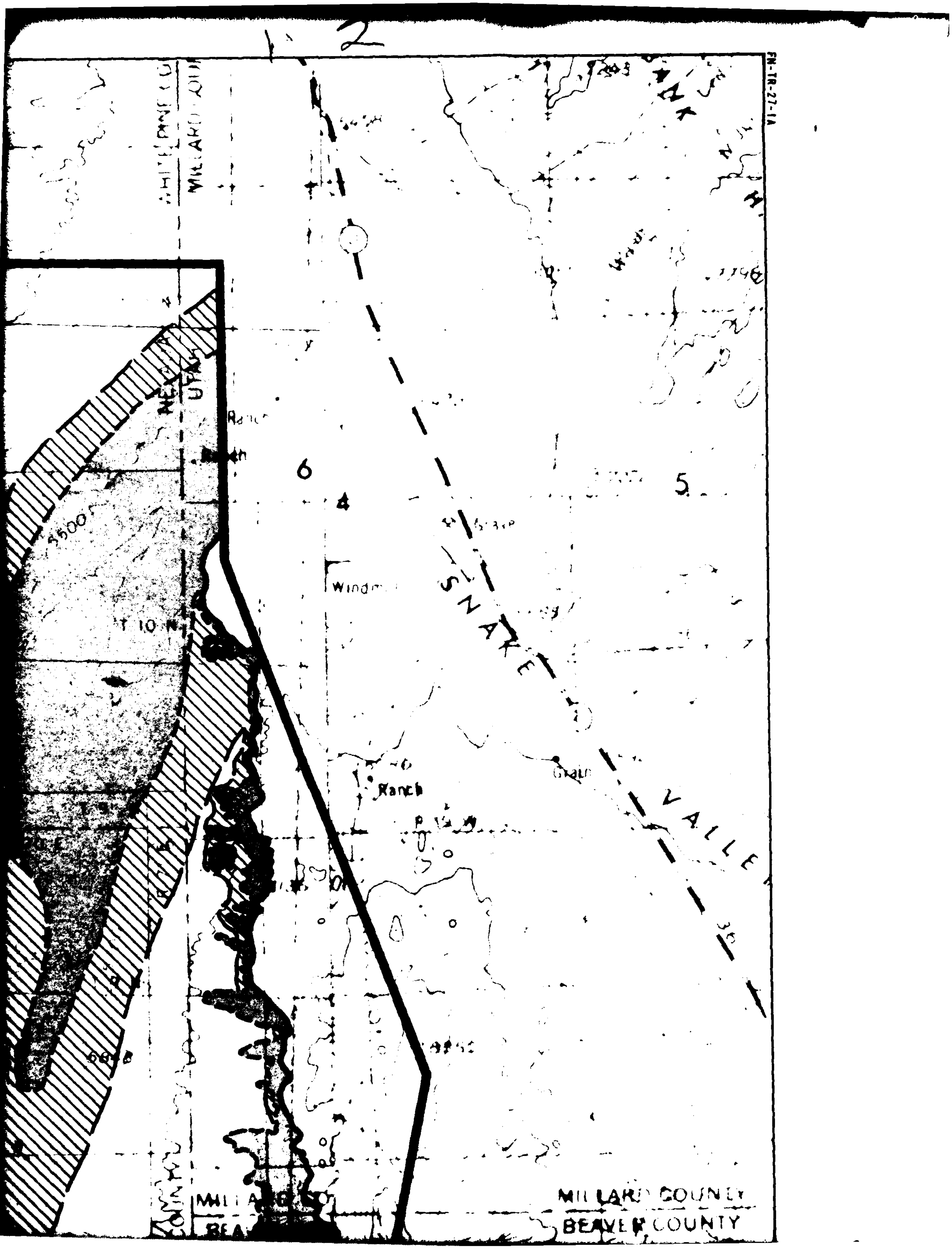
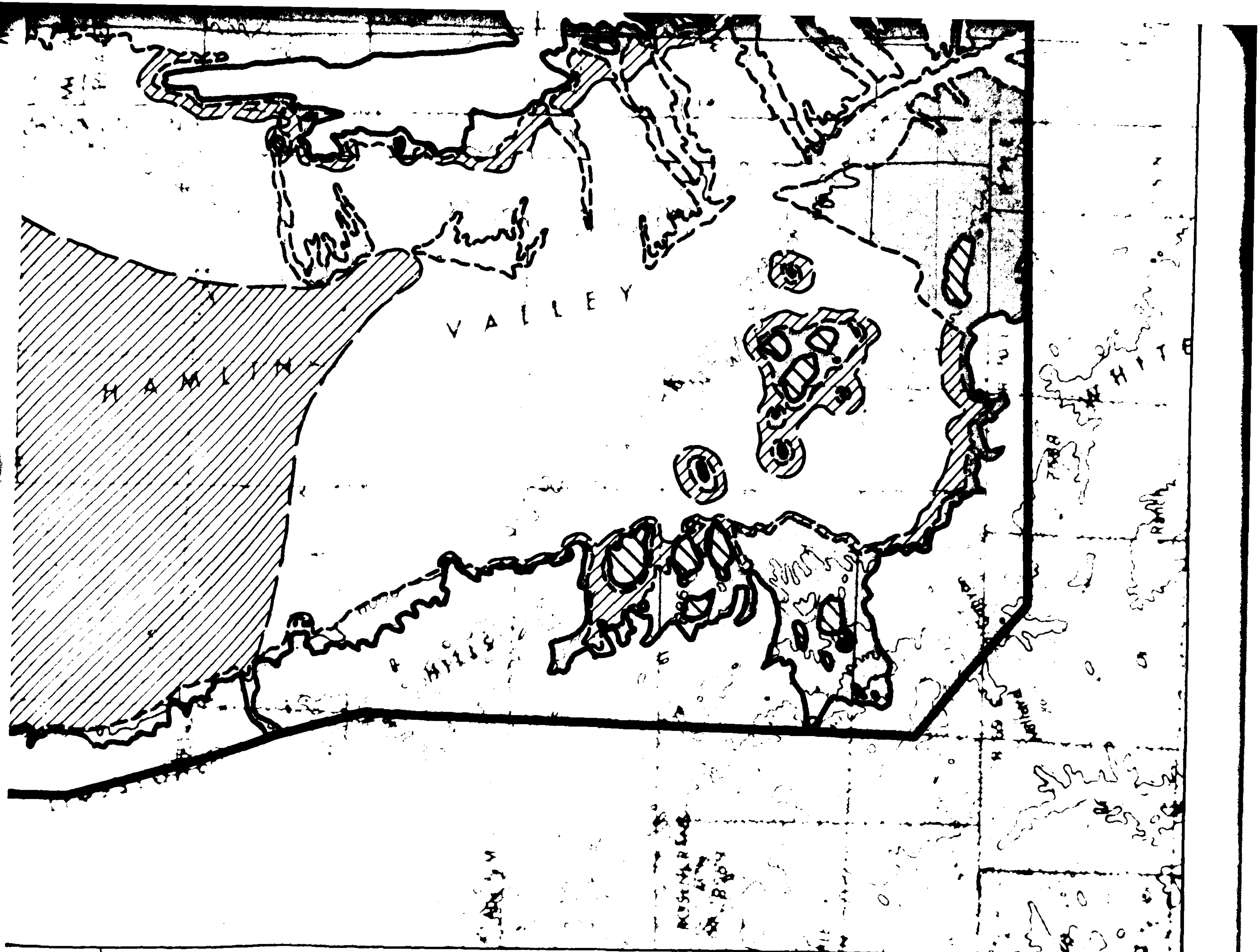
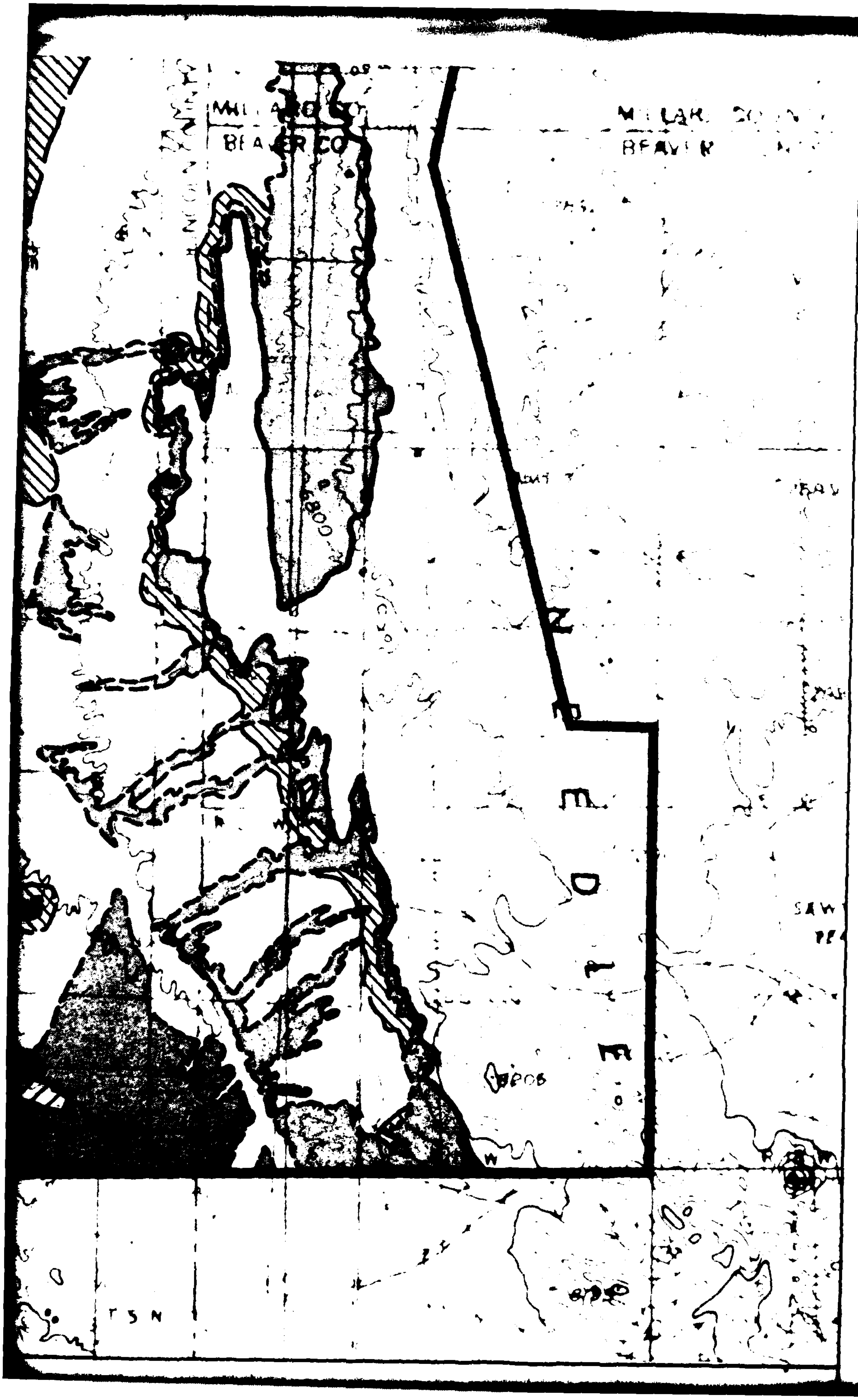



FN-TR-27-IIA
SNAKE VALLEY
6
5
Ranch
Windm
NEVADA
UTAH
T 10 N
MILLARD COUNTY
BEAVER COUNTY


HAMLIN
VALLEY
HILLS
WHITE



4

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.

Shading indicates areas of isolated 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, HAMLIN COP, NEVADA

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

DRAWING
6-6

FUGRO NATIONAL, INC.

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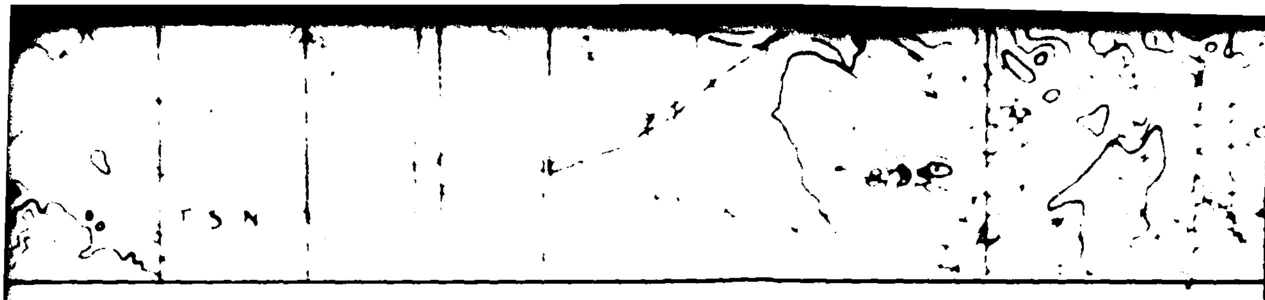

d vertical shelter
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150 feet (46m).

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STATUTE MILES

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