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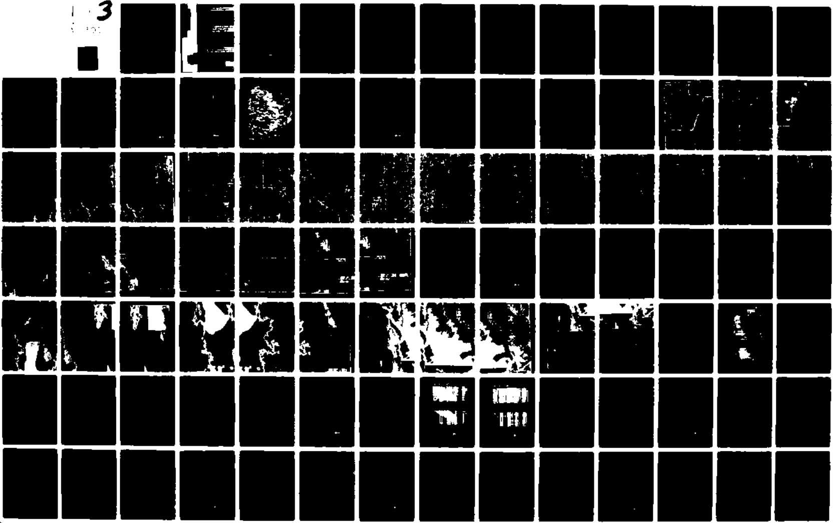

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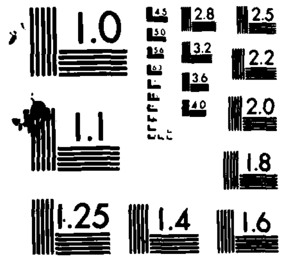

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This report presents results of geotechnical studies which were conducted in Lake Valley, Nevada. This volume is a synthesis of the data collected during the studies. Included are basic data consisting of boring and trench logs, seismic refraction surveys, sieve analyses, soils, electrical resistivity, depth to water, and depth to rocks.

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MX SITING INVESTIGATION
GEOTECHNICAL EVALUATION

VERIFICATION STUDY - LAKE VALLEY
NEVADA

VOLUME I - SYNTHESIS

Prepared for:

U.S. Department of the Air Force
Ballistic Missile Office (BMO)
Norton Air Force Base, California 92409

Prepared by:

Ertec Western, Inc.
3777 Long Beach Boulevard
Long Beach, California 90807

31 July 1981

Ertec

FOREWORD

This report was prepared for the U.S. Department of the Air Force, Ballistic Missile Office (BMO), in compliance with Contract No. F04704-80-C-0006, CDRL Item 004A6. It contains an evaluation of the suitability of Lake Valley, Nevada, for siting the MX Land Mobile Advanced ICBM system and presents the geological, geophysical, and soils engineering data upon which the evaluation is based. It is one of a series of reports covering the results of Verification studies in the Nevada-Utah region.

Verification studies, which were started in 1979, are the final phase of a site-selection process which was begun in 1977. The Verification objectives are to define sufficient area suitable for deployment of the MX system and to provide preliminary soils engineering data. Previous phases of the site-selection process were Screening, Characterization, and Ranking. In preparing this report, it has been assumed that the reader will be familiar with the previous studies.

Volume I of this report is a synthesis of the data obtained during the study. It contains discussions relative to the horizontal and vertical shelter basing modes. Volume II is a compilation of the data which may be used for independent interpretations or analyses.

VOLUME I

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LIST OF DRAWINGS

1.0 INTRODUCTION

1.1 PURPOSE AND BACKGROUND

This report presents the results of the geotechnical studies which were conducted in Lake Valley, Nevada, during the summer of 1980. The work was done as part of Ertec Western, Inc.'s (formerly Fugro National Inc.) Verification studies which have two major objectives:

1. Verify and refine boundaries of areas which are geotechnically suitable for the two proposed basing modes (horizontal and vertical shelter) for the MX missile system; and
2. Provide preliminary physical and engineering characteristics of the soils.

The report contains two volumes. This volume is a synthesis of the data collected during the studies. The data obtained as a result of the field and laboratory work are compiled by activity in Volume II.

The Verification program is the final phase of a site-selection process which started in 1977. The objective of the site-selection process is to identify and rank geotechnically suitable areas which are sufficiently large for deployment of the Missile-X (MX), an advanced intercontinental ballistic missile system. The phases are called Screening, Characterization, Ranking, and Verification. Screening used existing information from literature to identify areas which appeared to be suitable for deployment of MX based on geotechnical, cultural, and environmental criteria. Potentially usable regions were identified in seven western states. Both Characterization and Verification programs use field studies as well as published information. Following Screening and Characterization, the available geotechnical data were used to rank the seven regions. The ranking, based on relative construction costs, was made for various basing modes. Characterization studies emphasized collection of information to characterize geologic units with respect to construction of the MX basing options. Verification studies also obtain information on construction properties of the geologic units, but special emphasis is given to refining the boundaries of the geotechnically suitable areas. The boundaries were originally drawn during the Screening studies. The investigative techniques being employed during Verification studies are summarized in Table 1-1.

Figure 1-1 shows the site-selection schedule and identifies the technical report for each element in the process. Based on the results of Screening, Characterization, and Ranking, contiguous portions of Nevada and Utah were selected as a candidate siting region for the MX system, and Verification studies were started in 1978. The Verification program is continuing, and field work should be completed in 1982. The areas for which reports have been issued on the Verification studies are shown in Figure 1-2. The presently defined geotechnically suitable areas for the Nevada-Utah siting region are shown in Drawing 1-1. These areas will be adjusted as Verification studies are completed.

OBJECTIVES → **VERIFICATION OF SUITABLE AREA**

DATA FOR EVALUATIONS → **TERRAIN PARAMETERS** | **GEOLOGIC HAZARD**

FIELD TECHNIQUES AND APPLICATIONS →

Geologic mapping

- Identification and limits of areas with slopes greater than 5% and 10% grade

Geologic mapping

- Identification of faults and lineaments

LE AREA FOR MX DEPLOYMENT

CHAR

50'/150' DEPTH TO ROCK

Geologic mapping

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

Seismic refraction surveys

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

Borings

- Occurrence of rock

Existing data

- Published literature

50'/150' DEPTH TO GROUND WATER

Geologic mapping

- Obtain water depths from wells in study area
- Monitoring wells
- Occurrence of ground water

Electrical resistivity/ seismic refraction surveys

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

Existing data

- Published literature

EXTENT AND CHARACTERISTICS OF SOILS

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 and test pits

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

Cone penetrometer tests

- In situ soil strength

Laboratory tests

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

GEOPHYSI PROPERT

Seismic refraction

- Compressional wave
- Layering of soil

Electrical resis surveys

- Electrical conductivi
- Layering of soil

2

CTERISTICS OF BASIN FILL

PRELIMINARY GEOTECHNICAL CONSIDERATIONS AND RECOMMENDATIONS

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ROAD DESIGN DATA

Trenches and test pits

- Identification of soil types
- *In situ soil density and moisture*

Cone penetrometer tests

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

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
- *Presence of cobbles and boulders*

Laboratory tests

- Physical properties
- Engineering properties

Geologic mapping

- Distribution of geologic units

Seismic refraction surveys

- Excavatability

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FIELD TECHNIQUES VERIFICATION STUDIES

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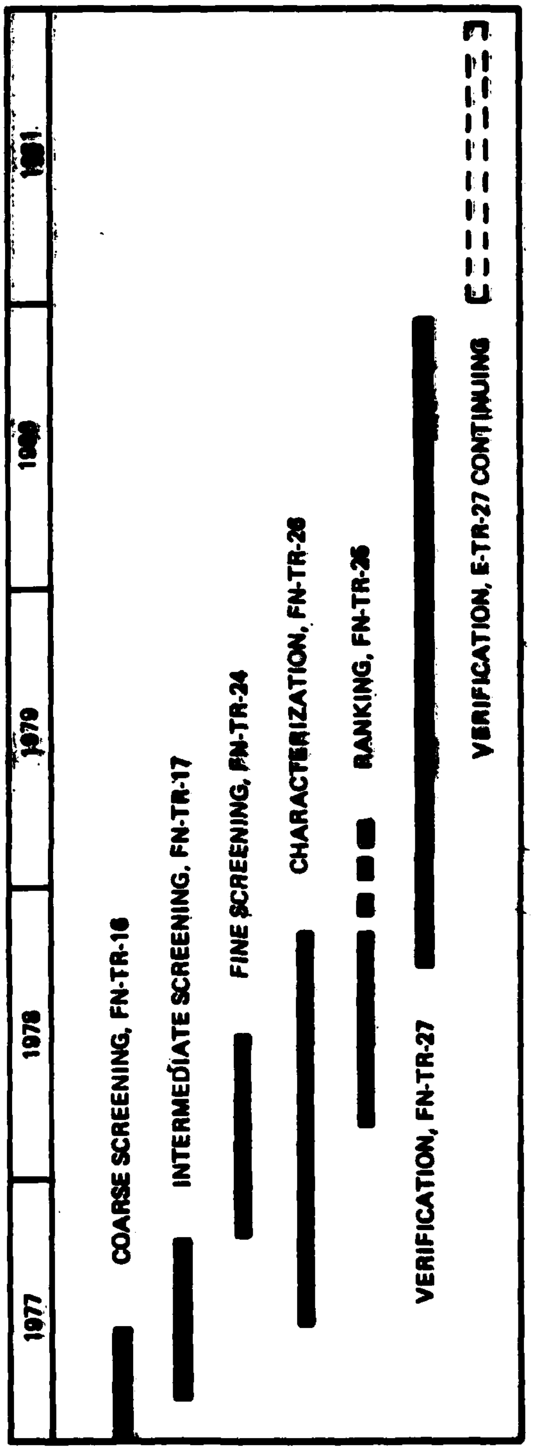

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SUMMARY OF SITE–
SELECTION SCHEDULE

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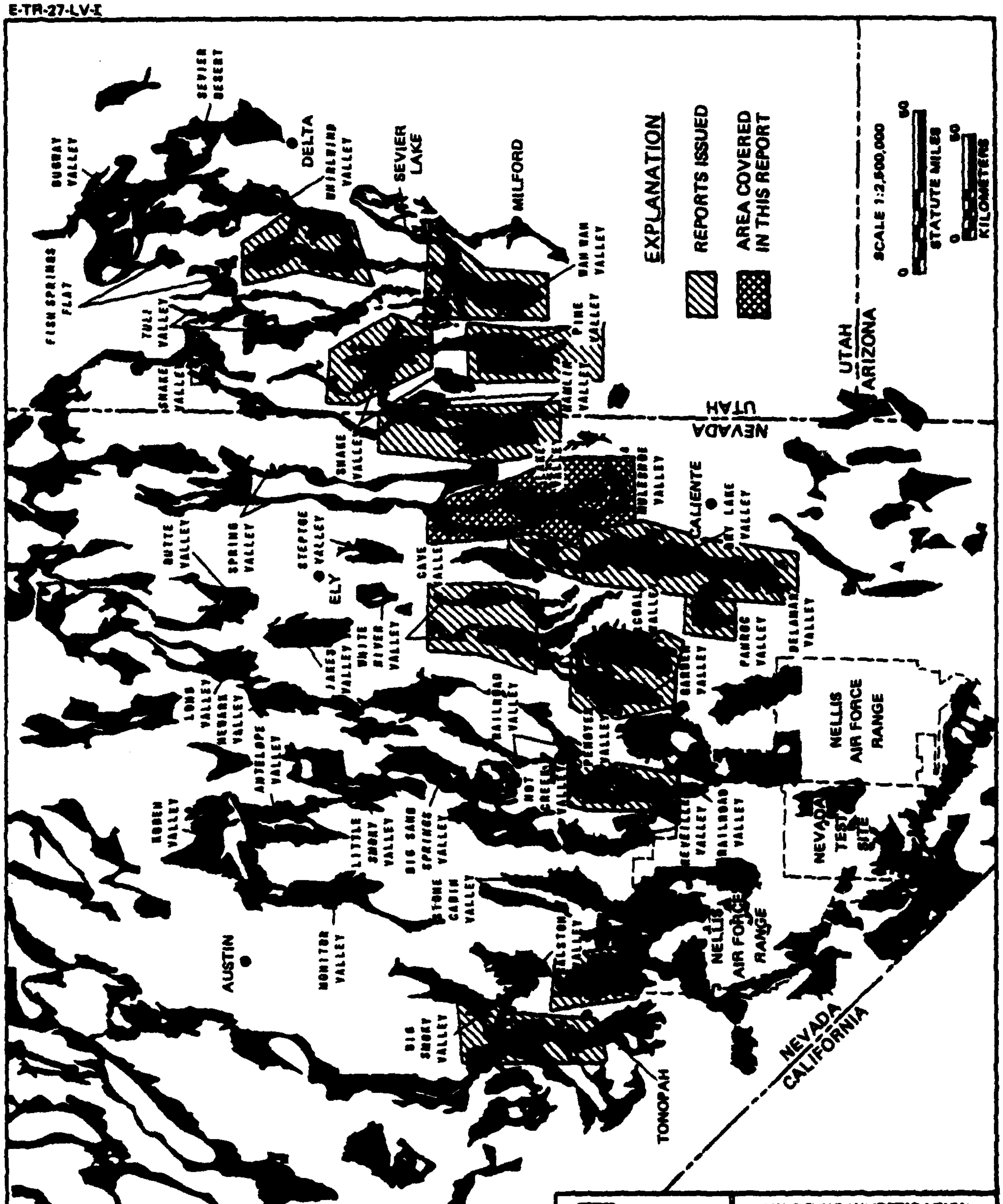
FIGURE 1-1



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AREAS COVERED BY VERIFICATION REPORTS NEVADA-UTAH

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FIGURE 1-3

1.2 SCOPE OF STUDY

The field work in Lake Valley was done in 1980. Table 1-2 lists the types and number of field activities that were performed in Lake Valley. The techniques of investigation are discussed in the Appendix.

Access to public lands in Lake Valley was arranged through the Ely, Nevada, district office of the Bureau of Land Management (BLM). At their request, all field activities were performed along existing roads or trails to minimize site disturbance. In some cases, this restriction prevents distributing activities in an optimum pattern for analysis of geotechnical conditions. Archaeological and environmental surveys were performed at each proposed activity location. Activity locations were moved from those few places where a potential environmental or archaeological disturbance was identified.

1.3 DISCUSSION OF ANALYSIS TECHNIQUES

1.3.1 Determination of Suitable Area

The number of field activities performed during this investigation established a relatively small data base for characterizing such a large area, especially in view of its complex geology and frequent soil variations. In some cases, the environmental restrictions limited the ability to achieve an optimum distribution of data points. Nevertheless, care has been taken to optimize the information that could be obtained within specified cost and time constraints of the project. The determination of suitable area is based on the exclusion criteria given in

GEOLOGY AND GEOPHYSICS–FIELD ACTIVITIES

TYPE OF ACTIVITY	NUMBER OF ACTIVITIES
Geologic mapping stations	123
Shallow refraction	22
Electrical Resistivity	20

ENGINEERING–FIELD ACTIVITIES

ACTIVITY	NO.	NOMINAL DEPTH FEET (METERS)
Borings	3	200 (61)
	4	160 (49)
Trenches	10	11-14 (3 - 4)
	4	3 - 7 (1 - 2)
Test pits	32	5 (2)
	8	3 - 4 (1)
Surficial samples	43	3 (1)
	8	1 - 2 (0.3 - 1)
CPT Soundings	102	1 - 114 (0.3 - 35)
Field CBR	2	3 - 4 (1)

ENGINEERING–LABORATORY TESTS

TYPE OF TEST	NUMBER OF TESTS
Moisture/density	130
Specific gravity	8
Sieve analysis	145
Hydrometer	2
Atterberg limits	49
Consolidation	3
Unconfined compression	4
Triaxial compression	3
Direct shear	9
Compaction	12
CBR	12
Chemical analysis	11

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SCOPE OF ACTIVITIES
LAKE VALLEY, NEVADA

31 JUL 81

TABLE 1-2

Appendix Section A2.0. The main attention was focused on the study of depth to rock, depth to water, terrain conditions, and near-surface soil characteristics. Maps showing the results of these studies are included in Section 3.0 and the suitable area map is included in Section 2.0.

a. Depth to Rock: For a Verification study, the depth to rock is estimated, and areas where the depths to rock are less than 50 and 150 feet (15 to 46 m) below the surface are outlined by contours (Drawing 3-3). These contours are interpreted from published well data, geologic literature, boring logs, and geophysical data. The interpretation considers the presence or absence of range-bounding faults, bedding plane attitudes, topographic slopes, evidence of erosional features such as pediments, and the presence or absence of young volcanic rocks.

b. Depth to Water: The depth-to-water map (Drawing 3-4) is based on data from wells listed in Table II- -1 (Volume II). Data compiled in Table II-3-1 came from: Ground-water monitoring wells constructed specifically for the Verification program; well logs on file with the State of Nevada Engineer's Office; and literature describing the valley hydrology. Whenever possible, the depth to water listed for a well represents the depth to the first, shallow, water-bearing zone, not the static water level. Static levels can be higher than first-encountered water depths since many valleys contain artesian aquifers for which the static water level is above the aquifer. The well data are plotted on a map and used to define the 50- and 150-foot (15- and 46-m) depth-to-water contours.

c. Terrain: The terrain map (Drawing 3-5) was compiled to show areas unsuitable for either vertical or horizontal shelters due to either high surface slopes or frequent deep drainage incisions (criteria are described in Appendix Table A2-1). The interpretation of terrain exclusions is based on a combination of field- and office-derived data. Field data include the visual information obtained by visiting the areas and making measurements of typical drainage incision depths. Visits frequently result in recognition of areas with locally steep slopes (for example, the sides of large and deeply incised drainages) that are not recognizable from data available in the office. Office-determined data consist of: 1) interpretation of 1:60,000 scale black and white and 1:25,000 scale color aerial photographs to determine terrain exclusions in areas lacking road access; and 2) topographic map analysis to define areas of greater than 10 percent slope.

d. Faults: The faults shown on the geologic map (Drawing 3-2) are primarily mapped by photogeologic interpretation (1:25,000 scale photos) and field reconnaissance. These faults are primarily Quaternary age but some late Tertiary faults may also be included. Generally, those within alluvial deposits are of Quaternary age. The faults shown within rocks in the mountain blocks or at the mountain-valley contact are of unknown age but are most certainly of late Tertiary and/or Quaternary age and have been active under the present tectonic regime. Published maps show numerous other faults within the rocks of the mountain blocks and some of these also may have been active under the present tectonic regime. Since they are not within the siting areas, they have not been studied. The published maps also show numerous inferred faults buried under the alluvium along the mountain-valley contacts. These faults are commonly verified by geophysical studies and may represent earthquake hazards. Since they have no surface expression, they cannot be verified by the reconnaissance methods employed in the fault studies.

1.3.2 Determination of Basin-Fill Characteristics

In addition to the primary objective of refining the boundaries of the suitable area, 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, will assist in planning future site-specific studies, and will be used by other MX participants.

The geologic map (Drawing 3-2) showing the distribution of surficial soils is based on the interpretation of aerial photographs, field mapping, and information from trenches, test pits, and surficial soil samples.

The investigations of engineering properties were designed primarily to obtain information needed for construction activities. For Verification studies, surficial soil conditions as related to road construction, a major cost item, received particular emphasis. Emphasis was placed also on soil conditions in the upper 20 feet (6 m) to supply information to the approximate depth of excavation for the horizontal shelter basing mode.

The results of laboratory tests run on samples from borings, trenches, and test pits and data from seismic refraction lines were used to estimate physical and engineering properties of the soils to a depth of 20 feet (6 m). The data are limited since only 14 trenches, 40 test pits, seven borings, and 22 seismic refraction lines were available. Four of the 14 trenches were less than 7 feet (2 m) deep because the backhoe capacity was exceeded when hard cementation and/or cobbles were encountered. There may be soil conditions in the upper 20 feet (6 m) that were not encountered by these 83 data points. The number of data points available for description of the surficial soils was increased to 236 by using 51 surface samples and 102 Cone Penetrometer Test (CPT) soundings.

The soil parameters between a depth of 20 and 160 feet (6 and 49 m) are based on data obtained from only seven borings. The spacing between borings ranged from 7 to 11 miles (11 to 18 km), therefore, the data presented may not be representative of the entire valley.

The length of the seismic refraction lines was chosen to investigate the velocity profile to a depth of at least 150 feet (46 m), which is the depth of interest for the vertical shelter basing mode.

Rose Creek
City
Imlay
PACIFIC
5000 ft
HUMBOLDT
VALLEY
Cr
Kyle Hot Sprs
BUENA VISTA
Flat
PLEASANT
VALLEY
JUMPER
Rock
VALLEY
Cr
34
35
Valley
BUFFALO
VALLEY
5000
Jersey Valley
REESE RIVER
Spring
34
35
38
39
29
28
27
26
25


117° 00'
116° 00'
North Battle Mountain
Battle Mountain
River
BOULDER VALLEY
Dunphy
Carlin Peaks
Marys Mtn
Marys Cr
Bobs Flat
Emigrant Pass
Carlin
Buckskin Mtn
Spring Canyon Mtn
7264
SOUTHERN PACIFIC
WESTERN PACIFIC
Palisade
Beowawe
Whirlwind Valley
Iron Blossom Mtn
5000
Hot Springs Point
CRESCENT
VALLEY
Thomas
Dry Hills
Trout
Gold Acres
Horse Cr
Pine
Pine Valley
Creek
Dry Cr
Black Mtn
Union Mtn
Garcia Flat
Mineral Hill
7000
Henderson
Robinson
Indian Cr
45
49
51
52
53
54
D E R
E U R E K A
LANDER
Hall
Grass
Denay Cr
Western Peak
KOBEH
VALLEY
Alkali Flat
VALLEY
DIAMOND
Roberts
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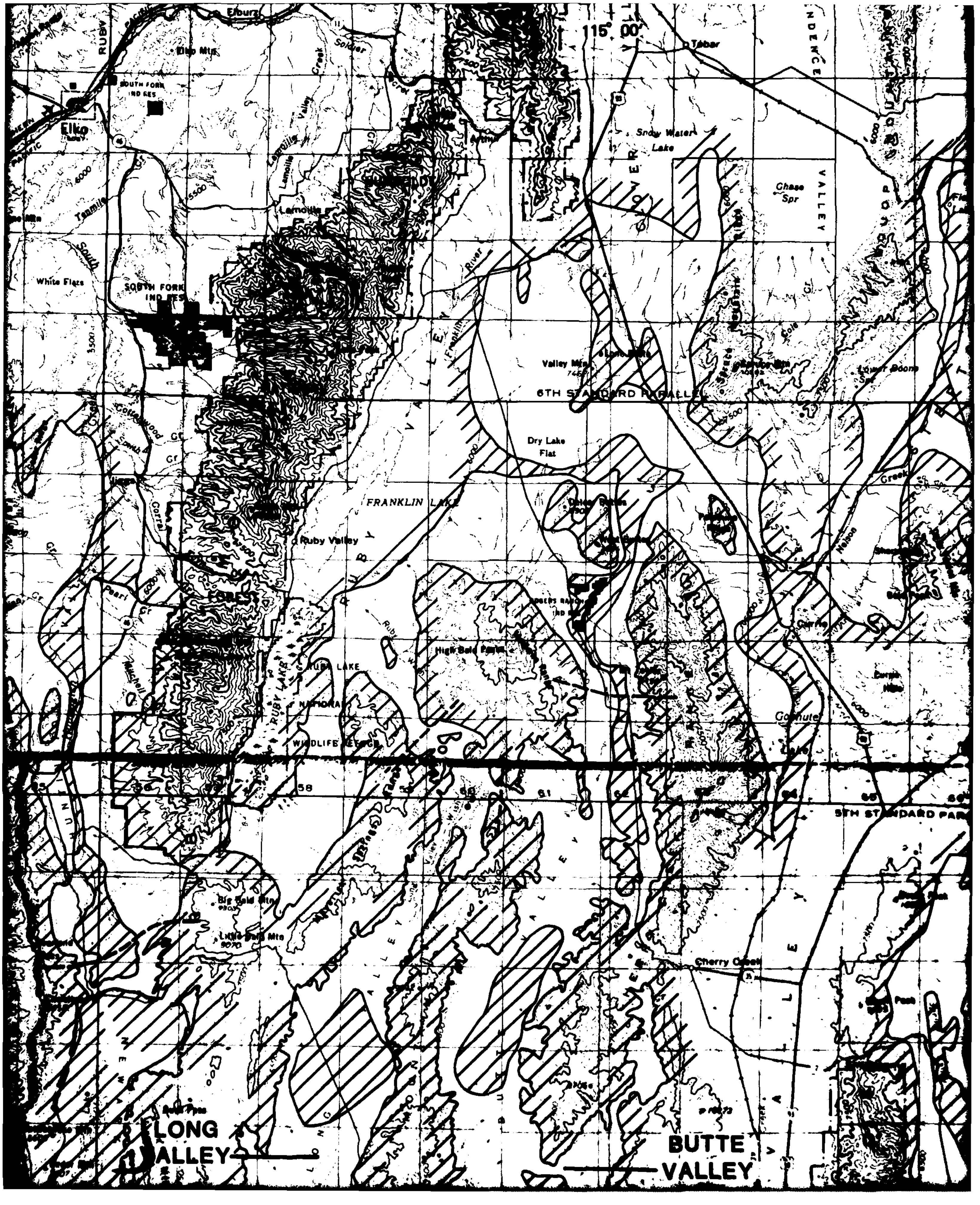

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Elburz
Tabor
Elko Mtn
SOUTH FORK IND RES
Elko
Snow Water Lake
Chase Spr
VALLEY
INDEPENDENCE
Lamoille
Tenmile
White Flats
South Fork
SOUTH FORK IND RES
Valley Mtn 7468
Lower Boone Spr
6TH STANDARD PARALLEL
Dry Lake Flat
FRANKLIN LAKE
Ruby Valley
Cottonwood Cr
Pearl Cr
Mitchell
High Bald Peak
RUBY LAKE
RUBY LAKE NATIONAL WILDLIFE REFUGE
Currie
Goshute
5TH STANDARD PARALLEL
Big Bald Mtn 9303
Little Bald Mtn 9070
Cherry Creek
LONG VALLEY
BUTTE VALLEY
RUBY VALLEY
Franklin River
Nelson
Cole
6000
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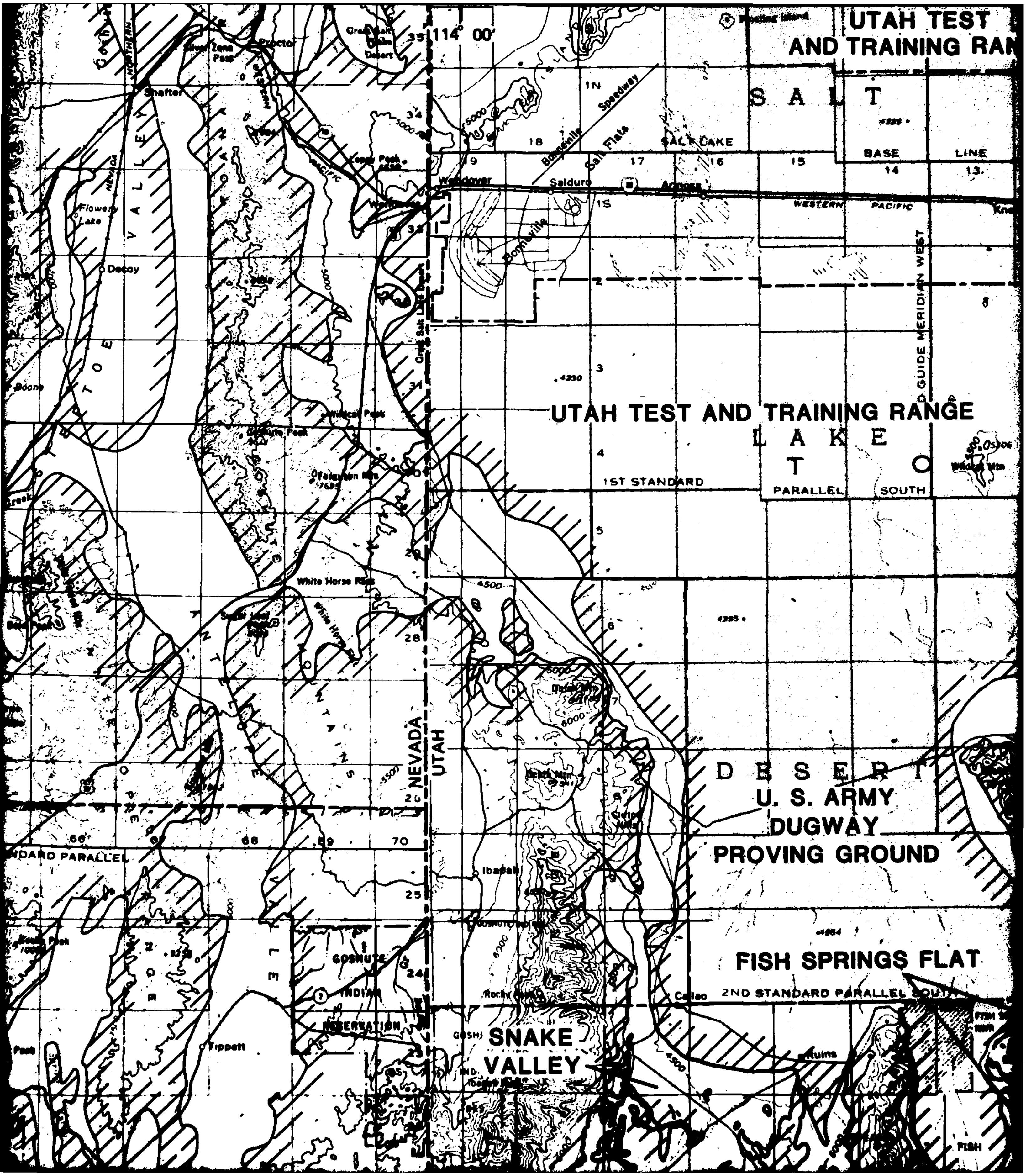

UTAH TEST AND TRAINING RANGE
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BASE LINE
SALT LAKE
Bonneville Salt Flats Speedway
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1S
Wendover
Salduro
Arinosa
WESTERN PACIFIC
114° 00'
Shafter
Proctor
Flowery Lake
Decoy
Boone
Bonneville
5000
Wildcat Peak
White Horse Pass
White Horse
4500
4330
4325
UTAH TEST AND TRAINING RANGE
LAKE
T O
1ST STANDARD
PARALLEL
SOUTH
GUIDE MERIDIAN WEST
Wildcat Mtn
NEVADA
UTAH
6000
D E S E R T
U. S. ARMY
DUGWAY
PROVING GROUND
Ibapah
FISH SPRINGS FLAT
2ND STANDARD PARALLEL SOUTH
Callao
Ruins
SNAKE
VALLEY
GOSHUTE
INDIAN
RESERVATION
Tippett
NDARD PARALLEL
66
67
68
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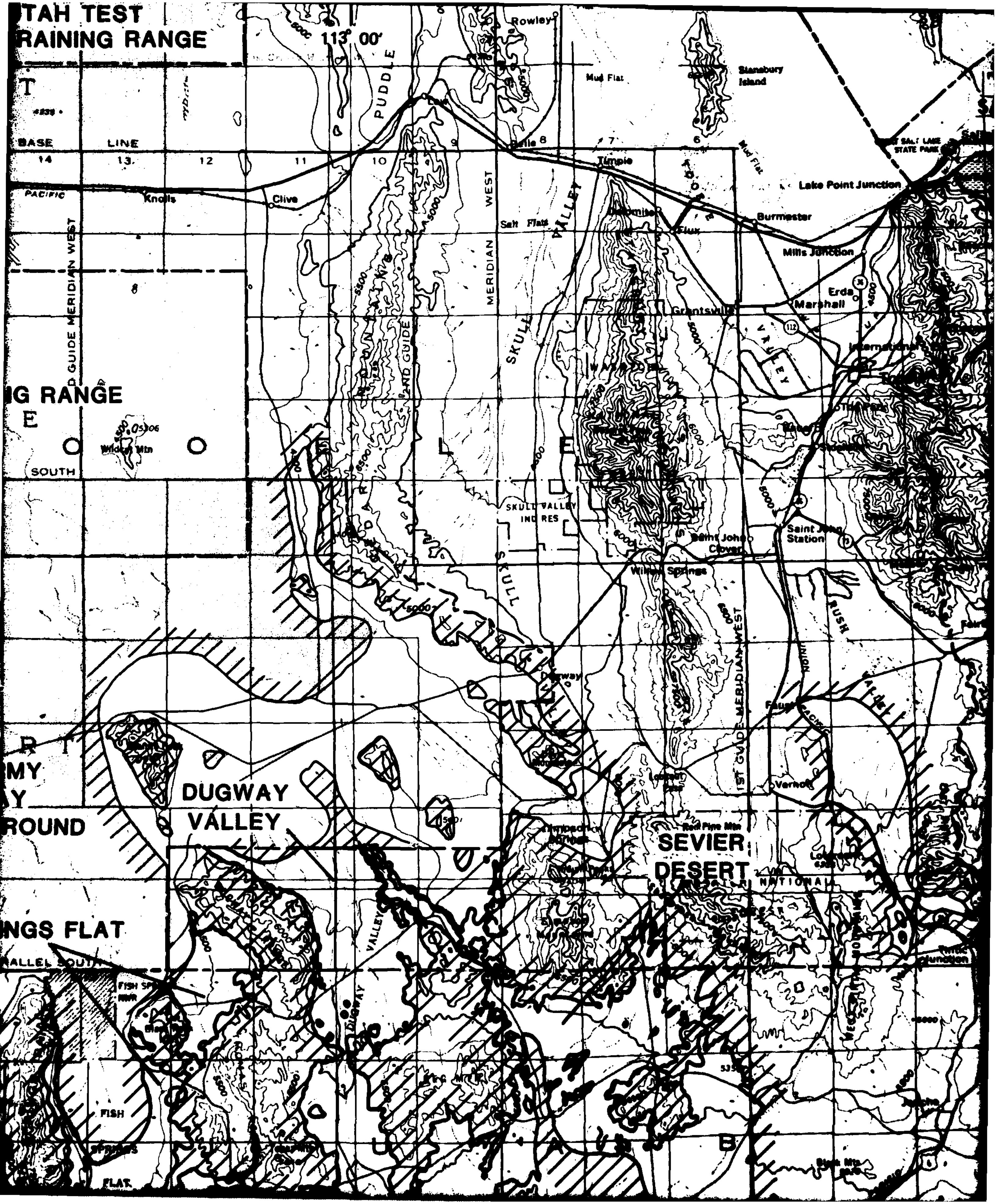
70
FISH


TAH TEST
RAINING RANGE
113° 00'
Rowley
Mud Flat
Stansbury Island
PUDDLE
BASE LINE
14
13
12
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8
7
6
PACIFIC
Knolls
Clive
Delle
Timpie
Mud Flat
Lake Point Junction
Burmester
Mills Junction
Salt Flats
Dolomite
Flux
Erda
Marshall
Grantsville
VALLEY
International
D GUIDE MERIDIAN WEST
MERIDIAN WEST
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Faust
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VALLEY
Red Pine Mtn
SEVIER
DESERT
NATIONAL
Simpson Springs
NGS FLAT
ALLEL SOUTH
FISH SPRINGS NWR
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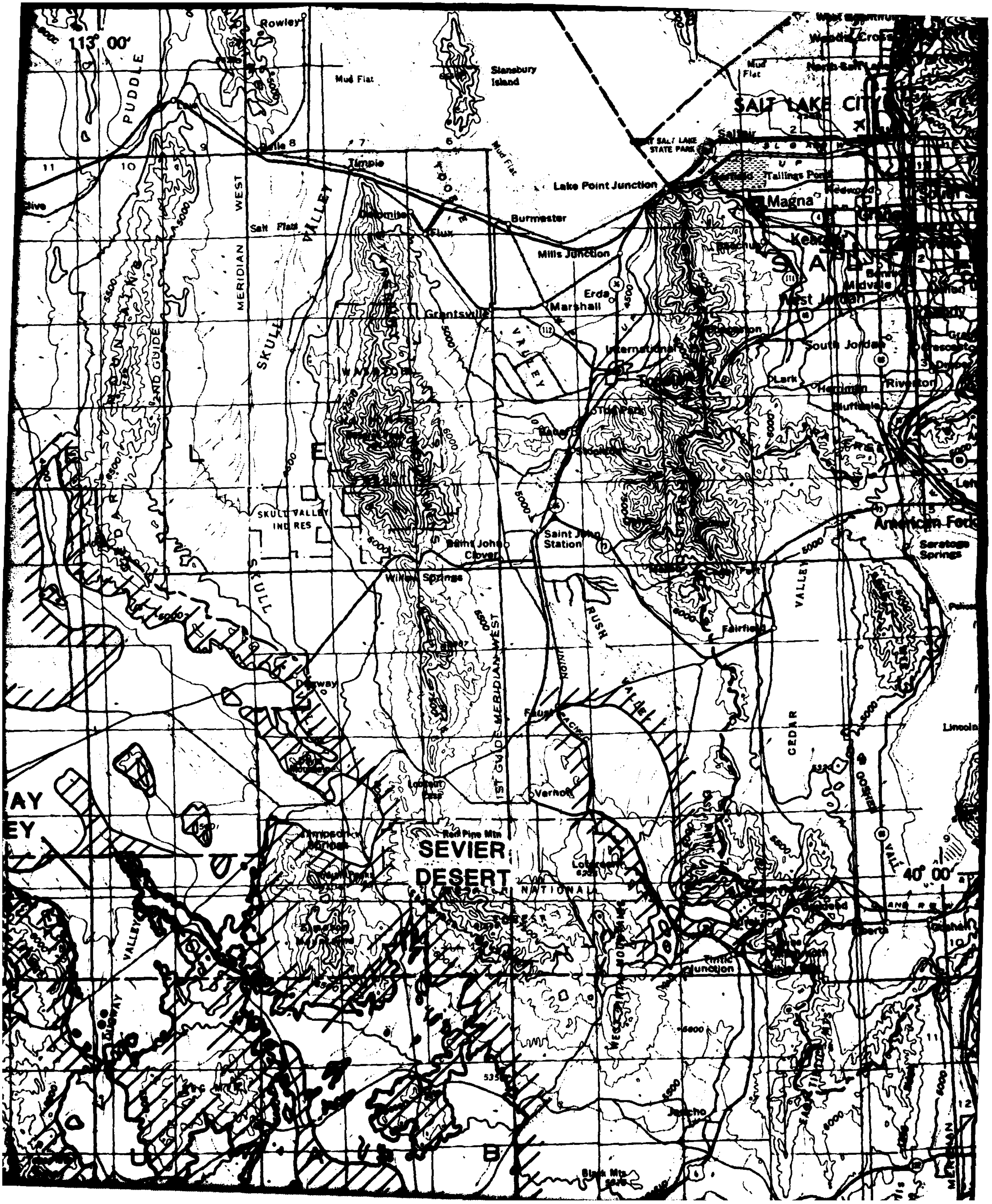
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WEST
MERIDIAN
SKULL
VALLEY
Timpie
Dolomite
Flux
Burmester
Mills Junction
Erda
Marshall
Grantsville
Kearns
West Jordan
Midvale
South Jordan
Lark
Herriman
Riverton
Tooele
Stockton
SKULL VALLEY IND RES
SKULL
Saint John Station
Saint John
Clover
Willow Springs
RUSH
VALLEY
Fairfield
CEDAR
VALLEY
American Fork
Saratoga Springs
Dugway
Faust
Lookout Pass
Vernon
1ST GUIDE MERIDIAN WEST
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Black Mtn
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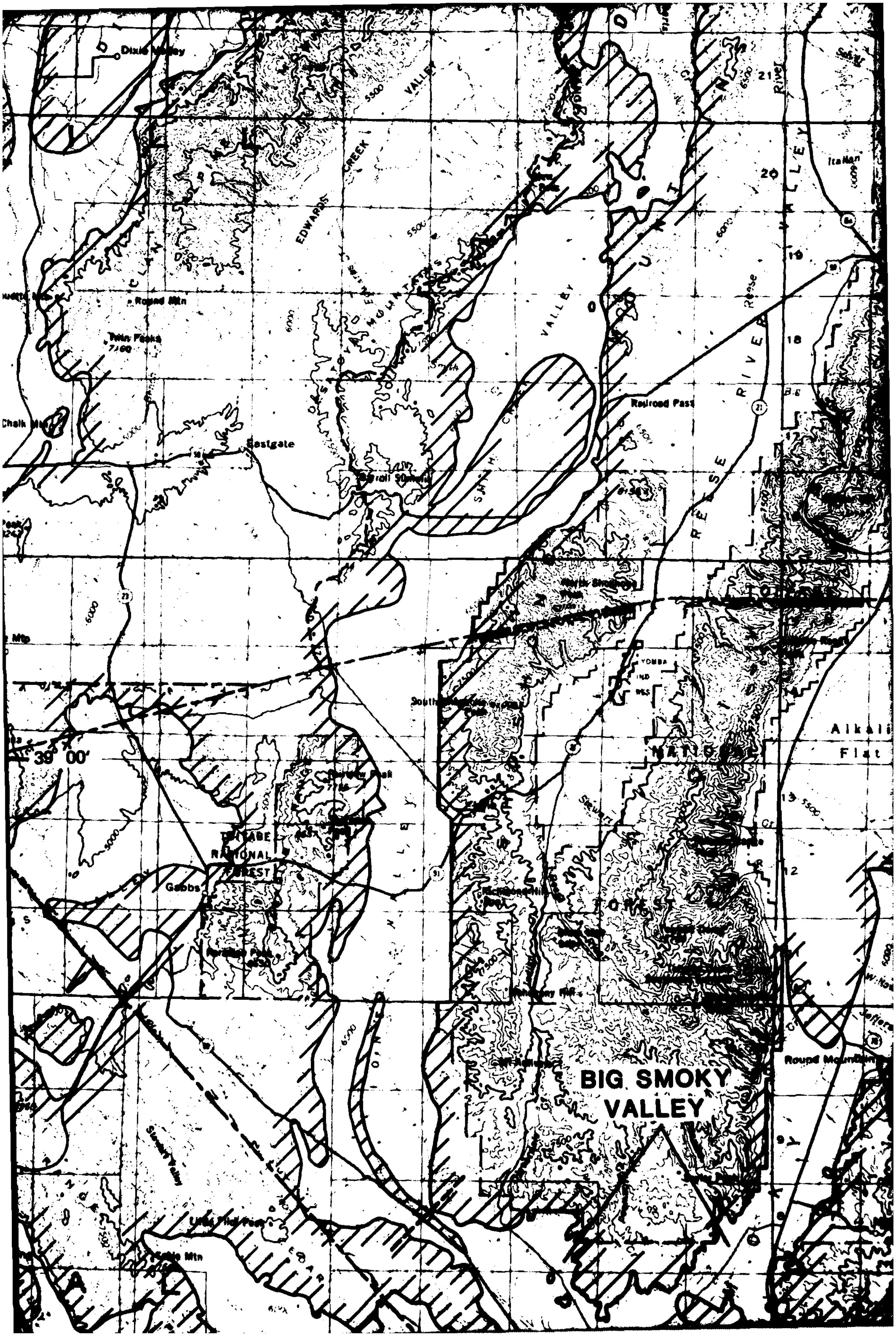

Dixie Valley
EDWARDS
CREEK
VALLEY
5500
6000
Round Mtn
Twin Peaks
7160
Chalk Mtn
Eastgate
Carroll Summit
VALLEY
Railroad Pass
Reese
RIVER
REESE
Italian
River
21
20
19
18
17
13
12
9
North Shoshone Peak
South Shoshone Peak
YOMBA
IND
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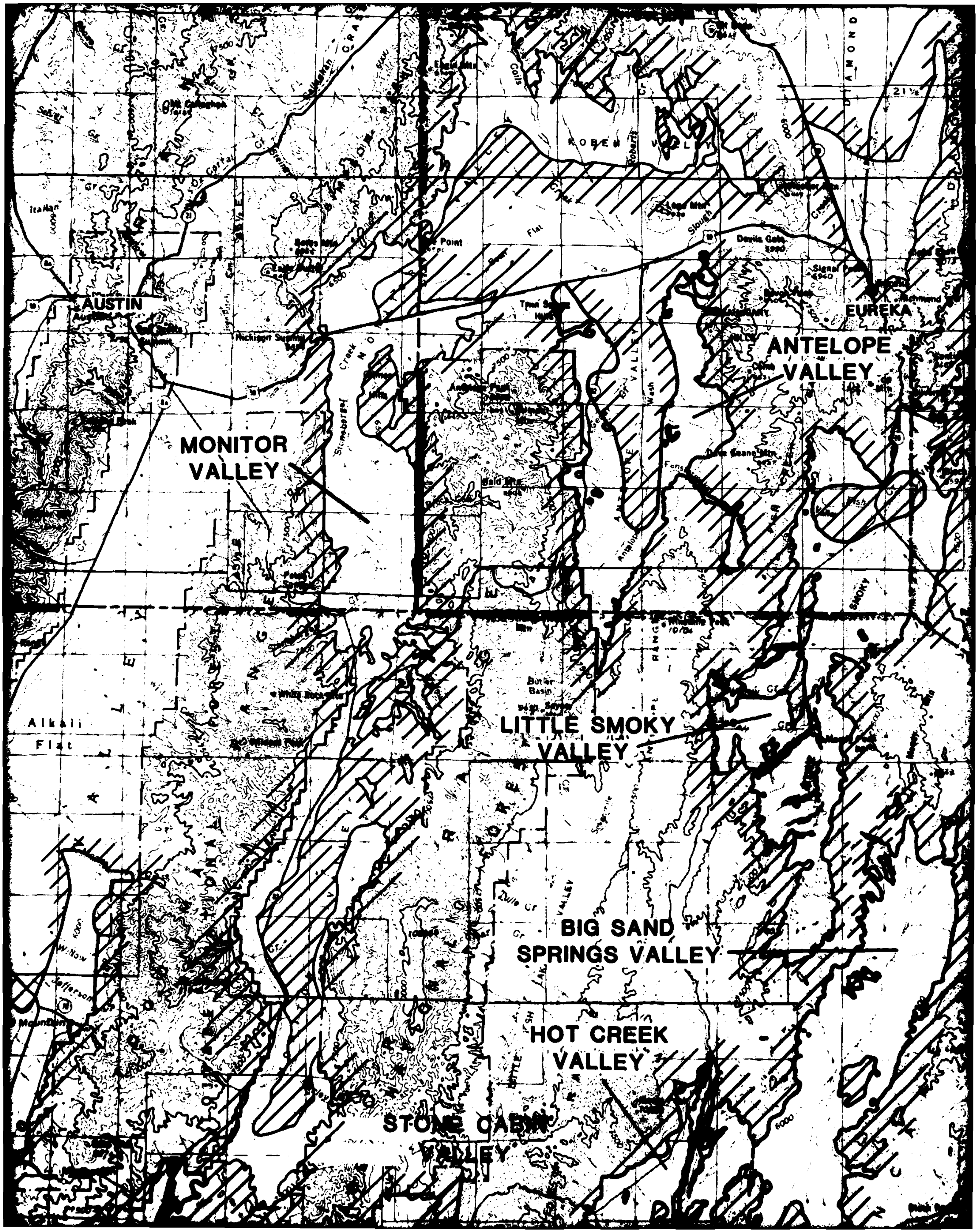
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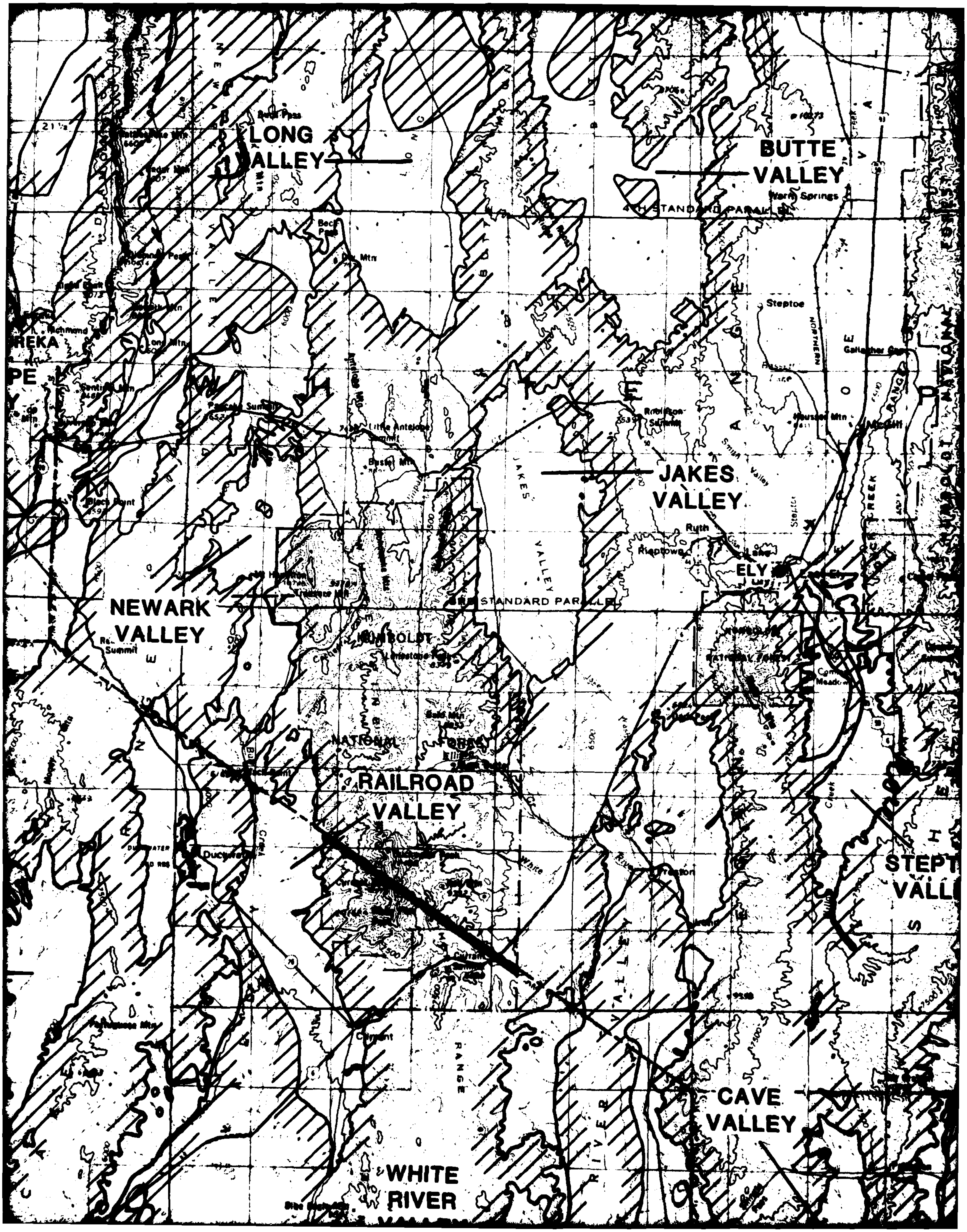
Alkali Flat
Butler Basin
Devils Gate
Hickison Summit
Italian
Stoneberger Creek
Dulle Cr
KOBEH VALLEY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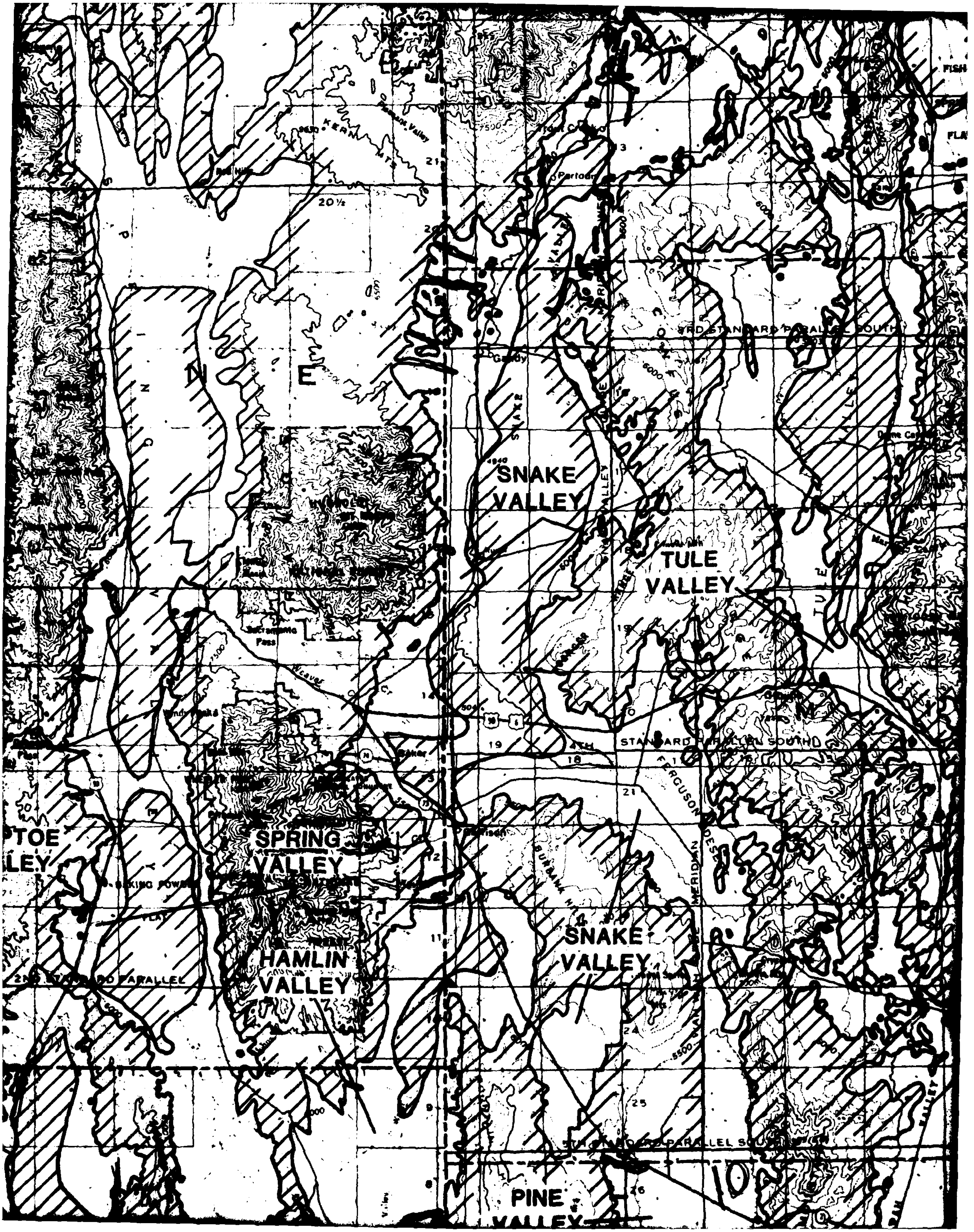
BUTTE VALLEY
Warm Springs
4TH STANDARD PARALLEL
Steptoe
Gallagher Gap
REKA
Richmond
Pancake Summit
Little Antelope Summit
Robinson Summit
McGill
JAKES VALLEY
JAKES VALLEY
Black Point
Ruth
Riepetown
ELY
NEWARK VALLEY
STANDARD PARALLEL
HUMBOLDT
NATIONAL FOREST
RAILROAD VALLEY
Duckwater
Preston
White
STEPT VALL
Currant
RANGE
CAVE VALLEY
WHITE RIVER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TULE VALLEY
SPRING VALLEY
HAMLIN VALLEY
SNAKE VALLEY
PINE VALLEY
TOE VALLEY
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KERN MTS
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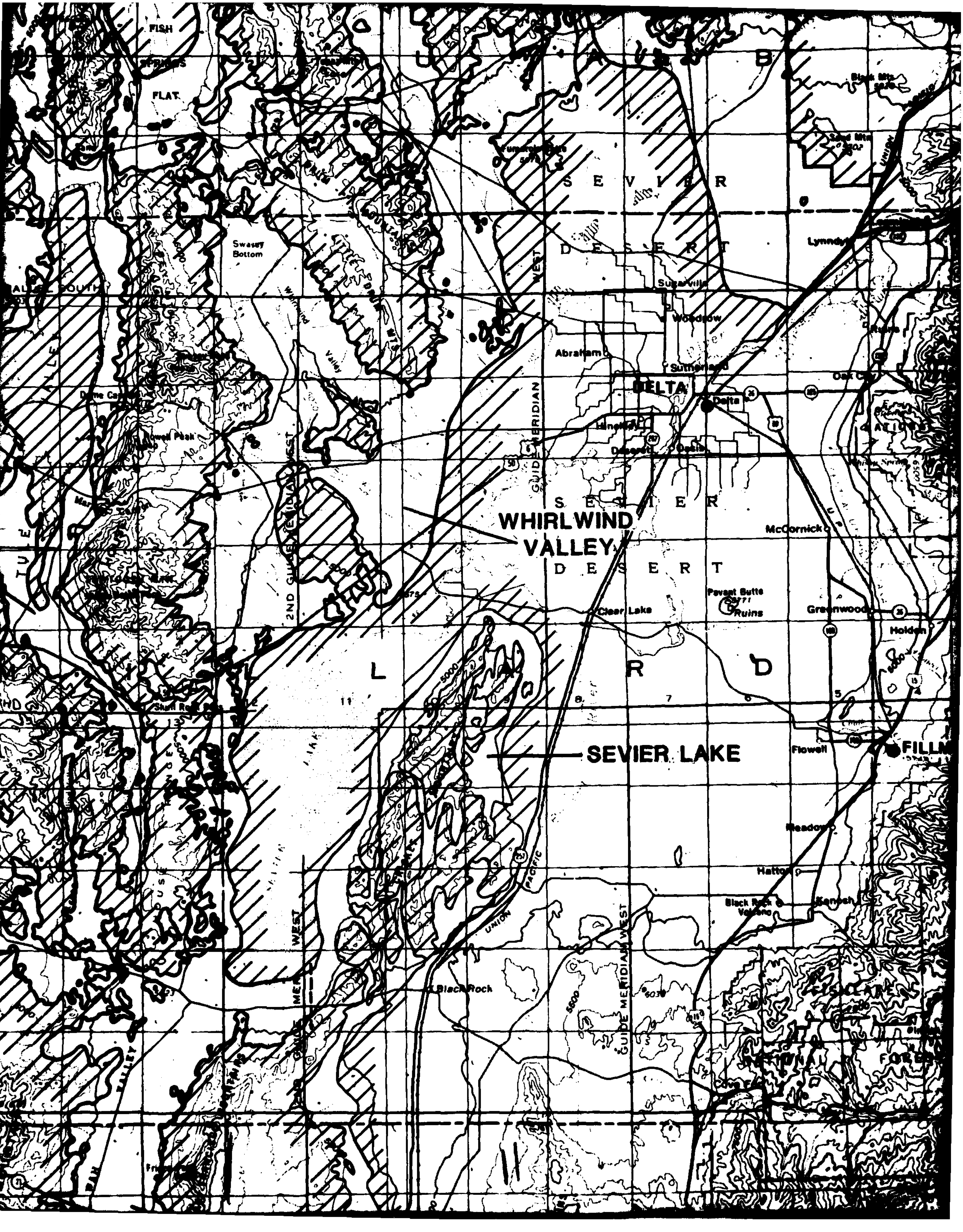
4TH STANDARD PARALLEL SOUTH
2ND STANDARD PARALLEL
STANDARD PARALLEL SOUTH
FERGUSON DESERT
MERIDIAN
Sacramento Pass
Baker
Gandy
Partoun
FISH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SEVIER DESERT
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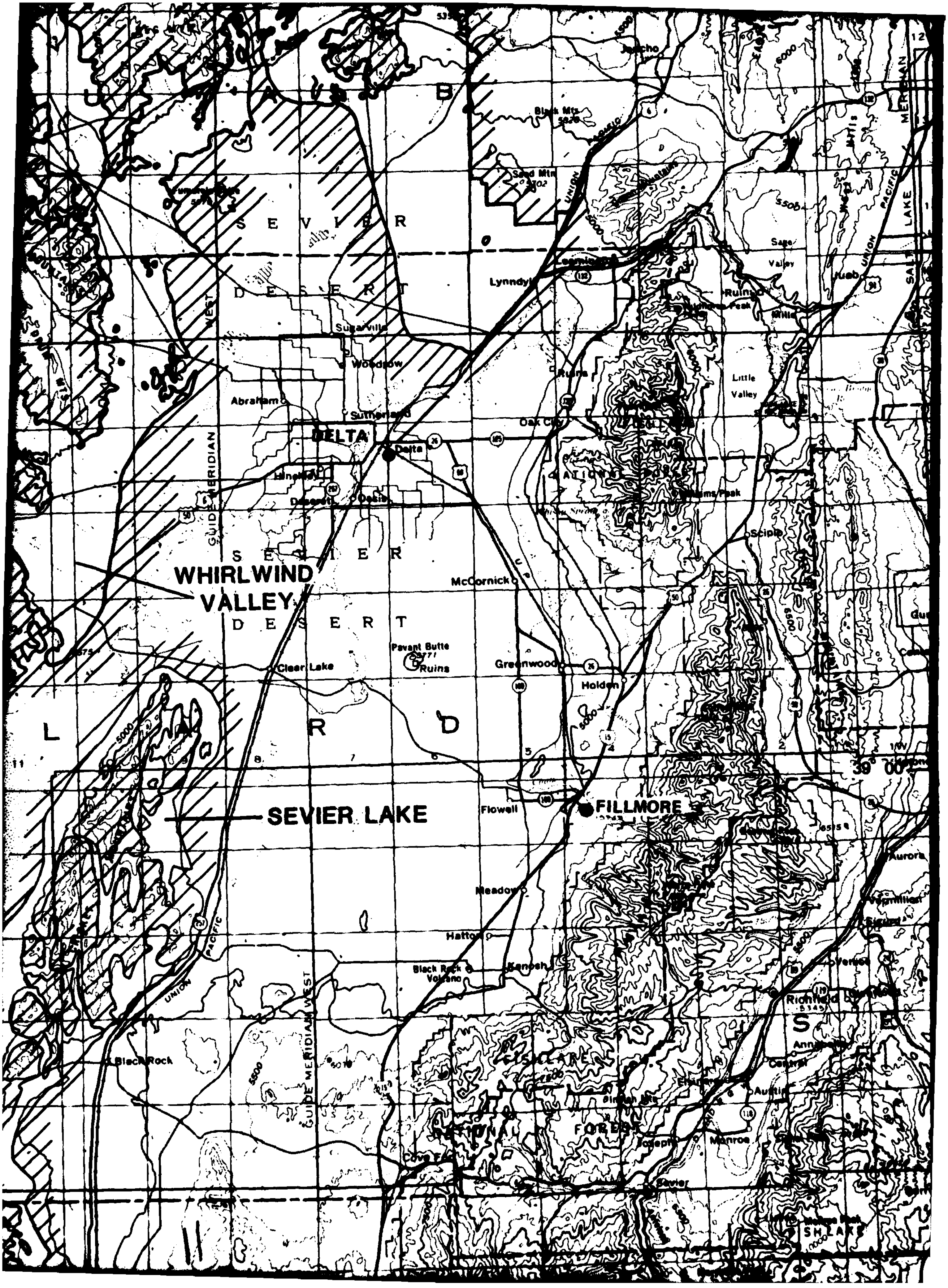
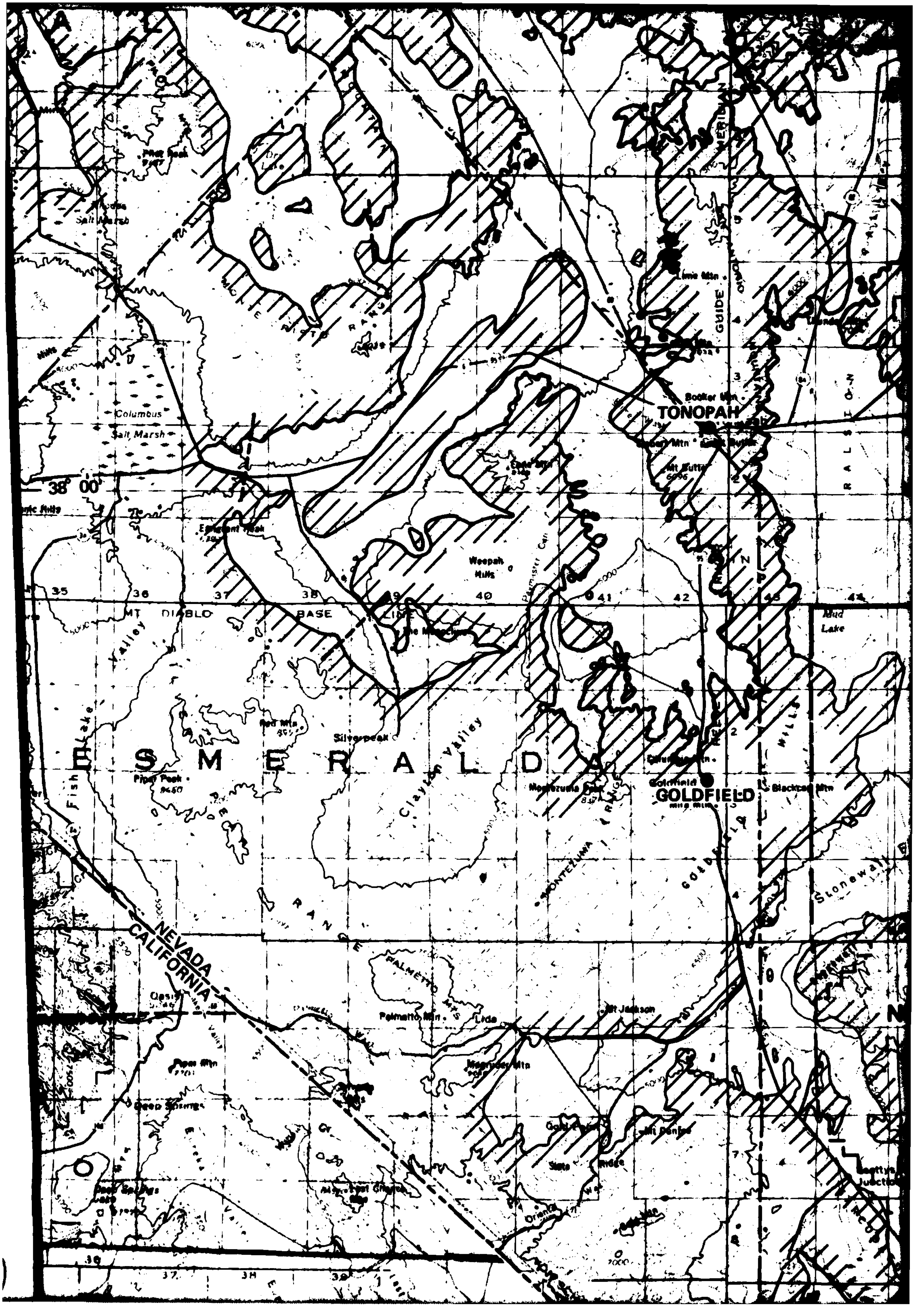
Sand Mtn
Fumarole Butte
Swasey Bottom
Lynndyl
Sugarville
Woodrow
Abraham
Sutherland
DELTA
Delta
Oak City
Hinckley
Deseret
Oasis
GUIDE MERIDIAN
2ND GUIDE MERIDIAN WEST
Dome Canyon
Howell Peak
WHIRLWIND VALLEY
McCornick
Pavant Butte
Ruins
Clear Lake
Greenwood
Holden
Skull Rock Pass
SEVIER LAKE
Flowell
FILLM
Meadow
Hatton
Black Rock Volcano
Kanosh
UNION PACIFIC
Black Rock
GUIDE MERIDIAN WEST
NATIONAL FOREST


WHIRLWIND VALLEY
SEVIER LAKE
SEVIER DESERT
SEVIER DESERT
DELTA
FILLMORE
Jericho
Black Mts
Sand Mtn
Lynndyl
Leamington
Sugarville
Woodrow
Abraham
Sutherland
Delta
Hinckley
Deseret
Oasis
Oak City
Little Valley
Sage Valley
Nephi
Mills
Ruins
McCornick
Pavant Butte
Ruins
Clear Lake
Greenwood
Holden
Scipio
Flowell
Meadow
Hatton
Kanosh
Black Rock Volcano
Black Rock
Richfield
Aurora
Vermillion
Sigurd
Venice
Annabella
Central
Austin
Elsinore
Joseph
Monroe
Sevier
Cove Fort
FISHLAKE
NATIONAL
FOREST
GUIDE MERIDIAN WEST
UNION PACIFIC
LARD
39° 00'

Pilot Peak
Rhodes
Salt Marsh
MONTE CRISTO RANGE
Columbus
Salt Marsh
38° 00'
Emigrant Peak
Lime Mtn
GUIDE MERIDIAN
Butler Mtn
TONOPAH
Mt Butler
6096
RALSTON
Weepah
Hills
35
36
37
38
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41
42
43
44
MT DIABLO BASE LINE
Mud
Lake
Fish Lake Valley
Red Mtn
Silverpeak
Clayton Valley
ESMERALDA
Piper Peak
8450
Montezuma Peak
Columbia Mtn
Goldfield
GOLDFIELD
Blackcap Mtn
MONTEZUMA RANGE
GOLDFIELD HILLS
Stonewall
NEVADA
CALIFORNIA
PALMETTO
Oasis
Palmetto Mtn
Lida
Mt Jackson
Magruder Mtn
Piper Mtn
Deep Springs
Gold Point
Mt Dunfee
Slate Ridge
Oriental
Beattys
Junction
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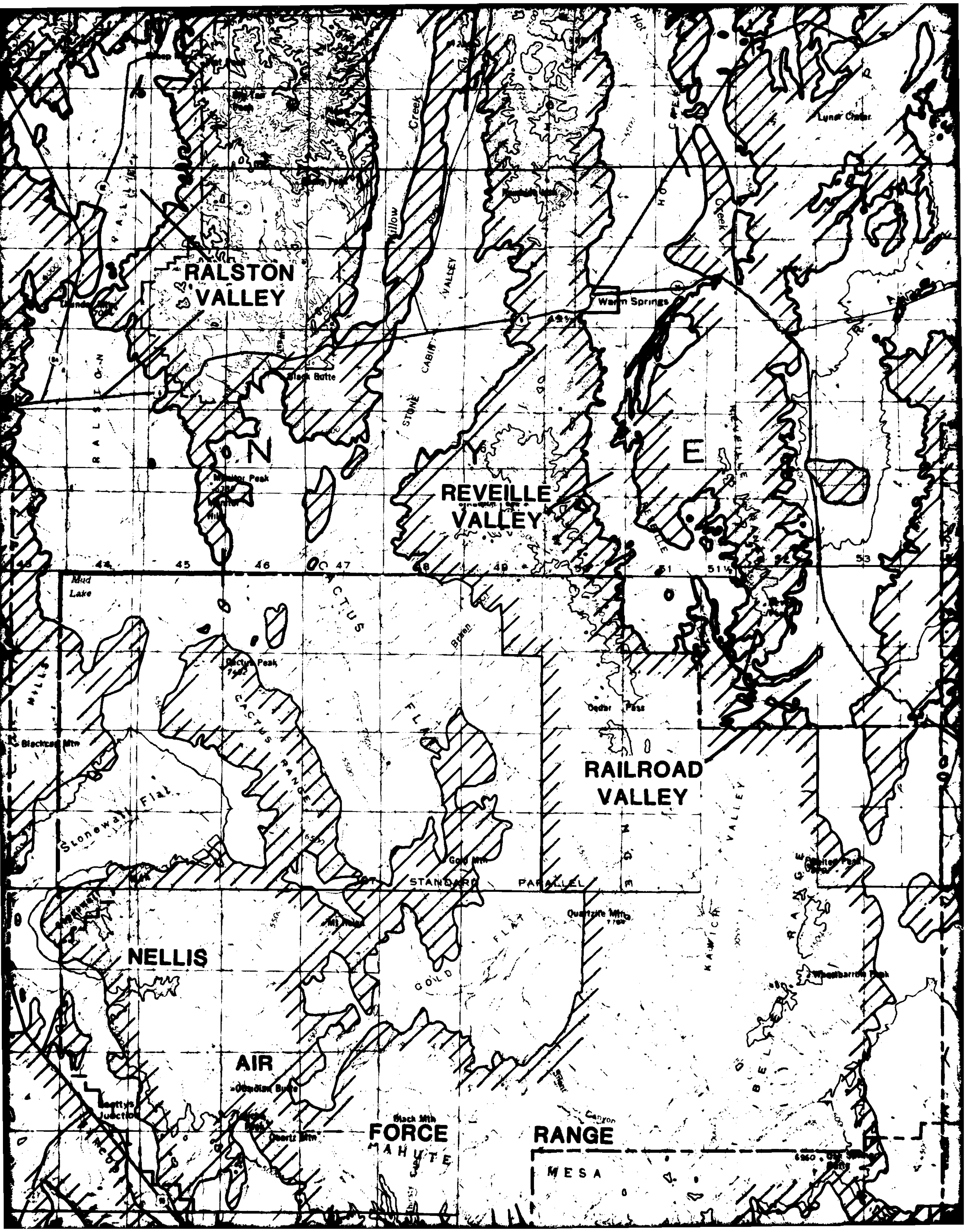
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Black Butte
Warm Springs
Willow Creek
STONE CABIN VALLEY
Hot Creek
Lunar Crater
N
Y
E
REVEILLE VALLEY
43
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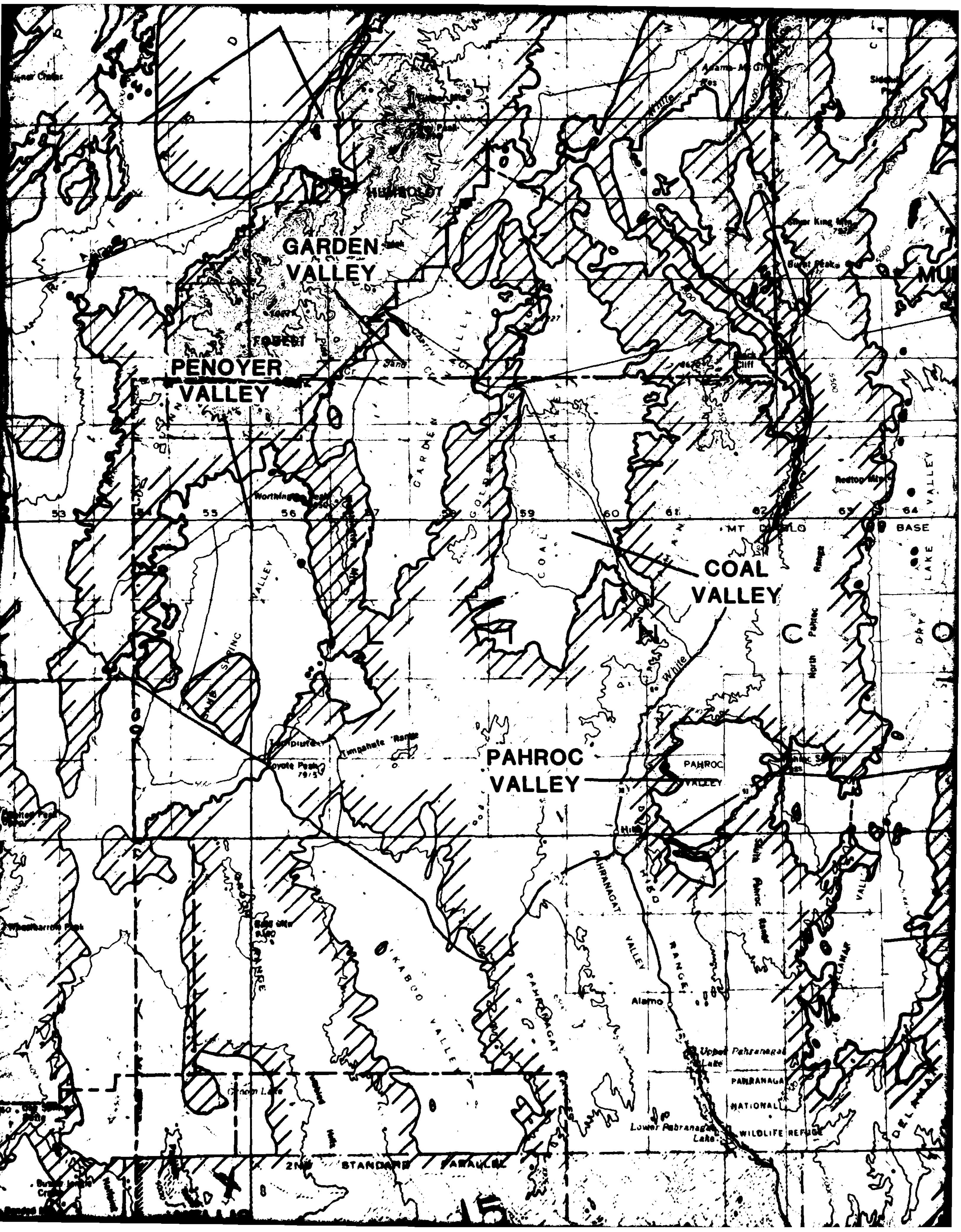
45
46
47
48
49
50
51
51½
52
53
Mud Lake
CACTUS FLAT
Cactus Peak
CACTUS RANGE
Blackcap Mtn
Stonewall Flat
Gold Mtn
STANDARD PARALLEL
Cedar Pass
RAILROAD VALLEY
Quartzite Mtn
KAWICH VALLEY
GOLD FLAT
Woodbarrow Peak
NELLIS
AIR
Obsidian Butte
Beattys Junction
Black Mtn
Quartz Mtn
FORCE
RANGE
MAHUTE
MESA
Canyon


GARDEN VALLEY
PENOYER VALLEY
COAL VALLEY
PAHROC VALLEY
FOREST
GARDEN
COAL
SPRING VALLEY
MT DIABLO
BASE
DRY LAKE VALLEY
North Pahroc Range
Worthington Peak
Timpahute Range
Coyote Peak 7975
Sugar King Mtn
Burnt Peaks
Black Cliff
Redtop Mtn
Adams-McGill Res
White
PAHROC VALLEY
Hiko
PAHRANAGAT VALLEY
HIKO RANGE
South Pahroc Range
Alamo
Upper Pahranagat Lake
Lower Pahranagat Lake
PAHRANAGAT NATIONAL WILDLIFE REFUGE
PAHRANAGAT
TIKABOO VALLEY
Wheelbarrow Peak
Groom Lake
2ND STANDARD PARALLEL
DELAMAR
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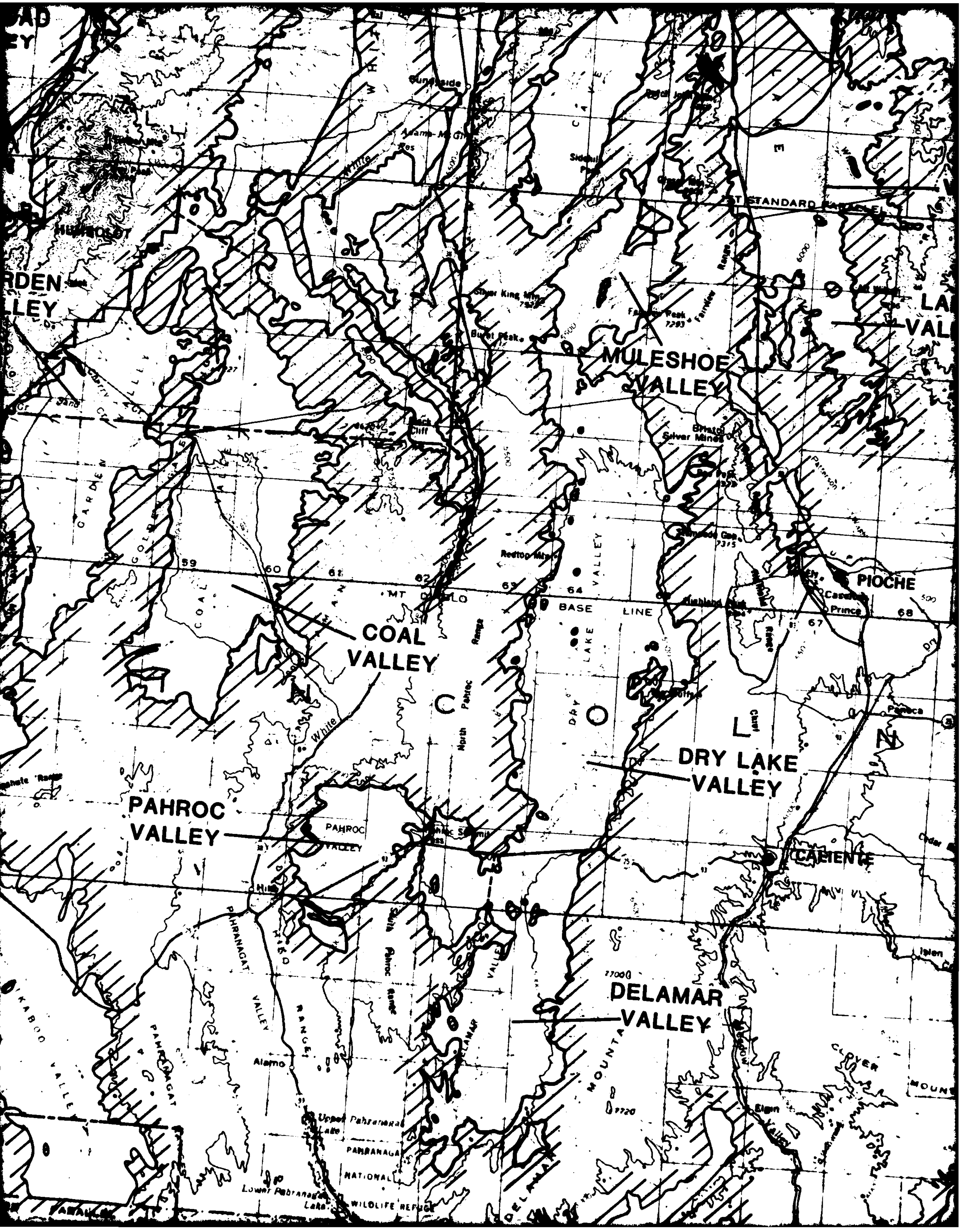
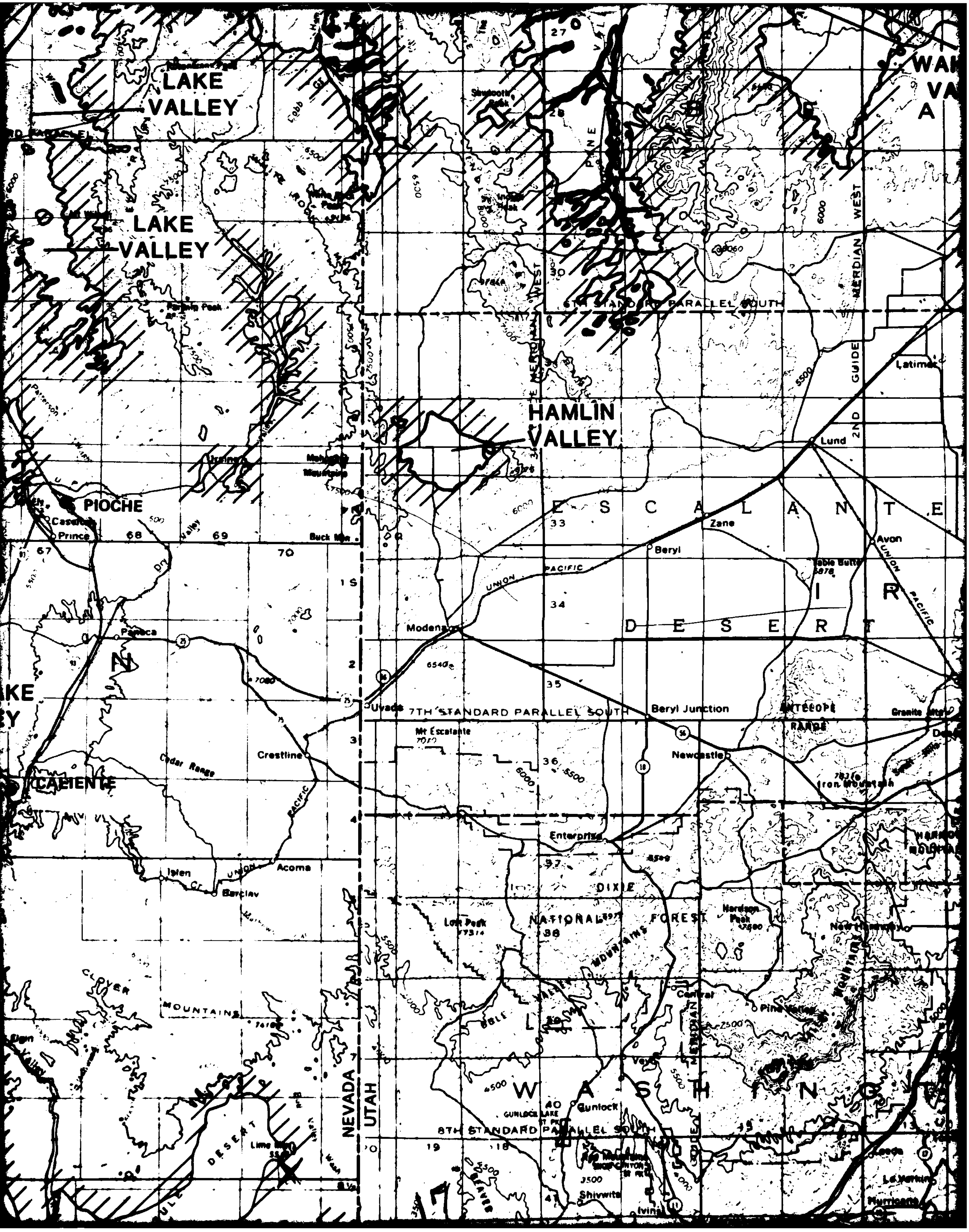

MULESHOE VALLEY
COAL VALLEY
DRY LAKE VALLEY
PAHROC VALLEY
DELAMAR VALLEY
RDEN VALLEY
LA VAL
HUMBOLDT
PIOCHE
CALIENTE
Sunnyside
Adams-McGill Res
White River
Silver King Mine 7527
Fairview Peak 7293
Burnt Peaks
Sidehill Pass
1ST STANDARD PARALLEL
Bristol Silver Mines
Black Cliff
Redtop Mine
MT DIABLO BASE LINE
59
60
61
62
63
64
67
68
Highland Peak
Caselton
Prince
Panaca
North Pahroc Range
South Pahroc Range
PAHROC VALLEY
White Summit Pass
Hiko
PAHRANAGAT VALLEY
PAHRANAGAT RANGE
Alamo
Upper Pahranagat Lake
Lower Pahranagat Lake
PAHRANAGAT NATIONAL WILDLIFE REFUGE
TIKABOO VALLEY
DELAMAR MOUNTAINS
DRY LAKE
GARDEN VALLEY
GOLDEN GATE RANGE
COAL VALLEY
CLOVER MOUNTAINS
Elgin
Islen
Meadow Valley
L I N C O L N


LAKE VALLEY
LAKE VALLEY
HAMLIN VALLEY
ESCALANTE DESERT
PIOCHE
Caselton
Prince
Panaca
CALIENTE
Crestline
Islen
Acoma
Barclay
Buck Mtn.
Dry Valley
Cedar Range
CLOVER MOUNTAINS
DESERT
Lime Mtn
Modena
Uvada
Mt Escalante 7012
Beryl
Zane
Lund
Latimer
Avon
Table Butte 5878
Beryl Junction
Newcastle
Enterprise
ANTELOPE RANGE
Granite Mtn
Iron Mountain
DIXIE NATIONAL FOREST
Lost Peak 7314
Harrison Peak 7600
Central
Pine Valley
Veyo
Gunlock
GUNLOCK LAKE
Shivwits
Ivins
Leeds
La Verkin
Hurricane
WASHINGTON
BULL VALLEY MOUNTAINS
Shoofly Peak
6TH STANDARD PARALLEL SOUTH
7TH STANDARD PARALLEL SOUTH
8TH STANDARD PARALLEL SOUTH
2ND GUIDE MERIDIAN WEST
UNION PACIFIC
NEVADA
UTAH
67
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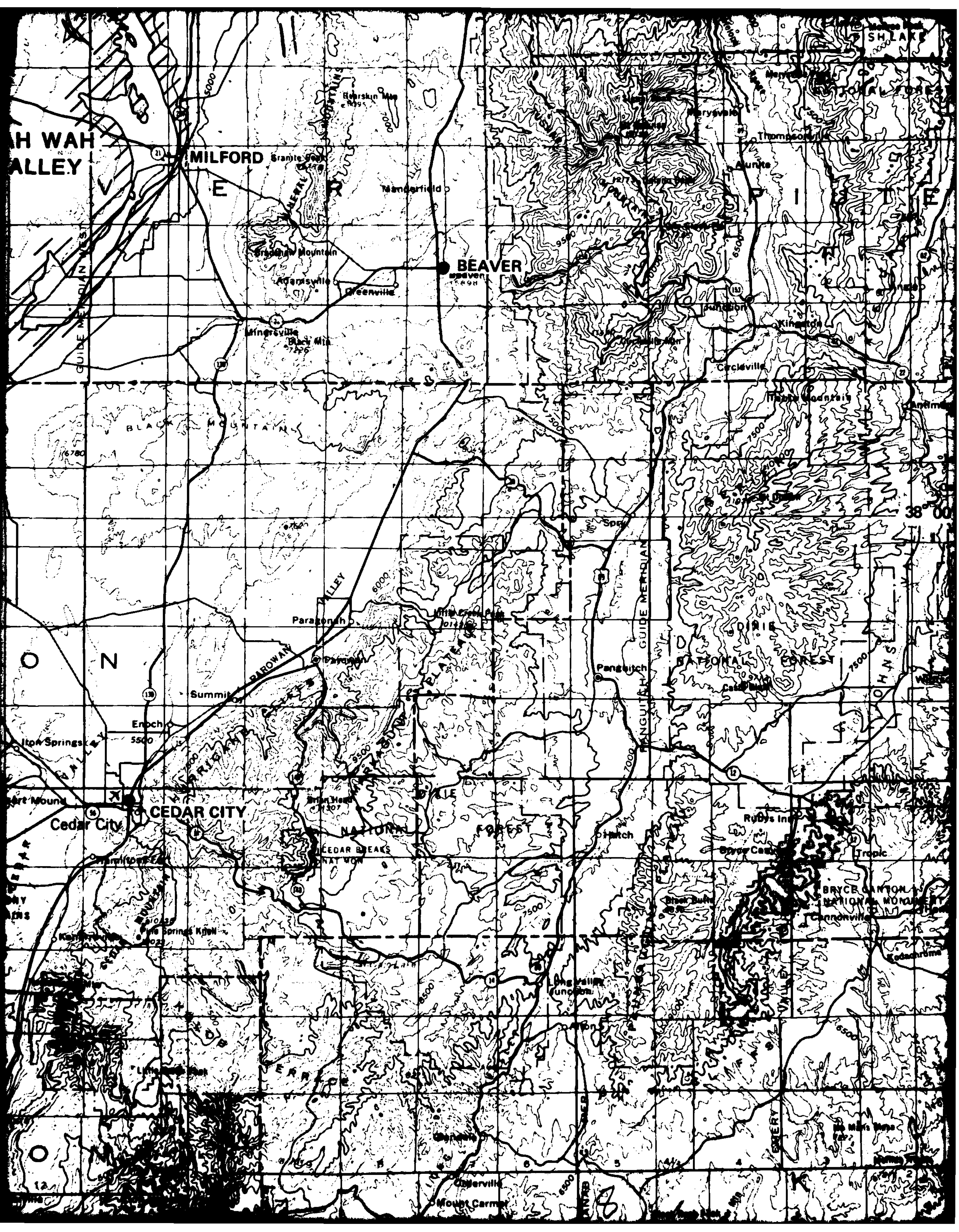
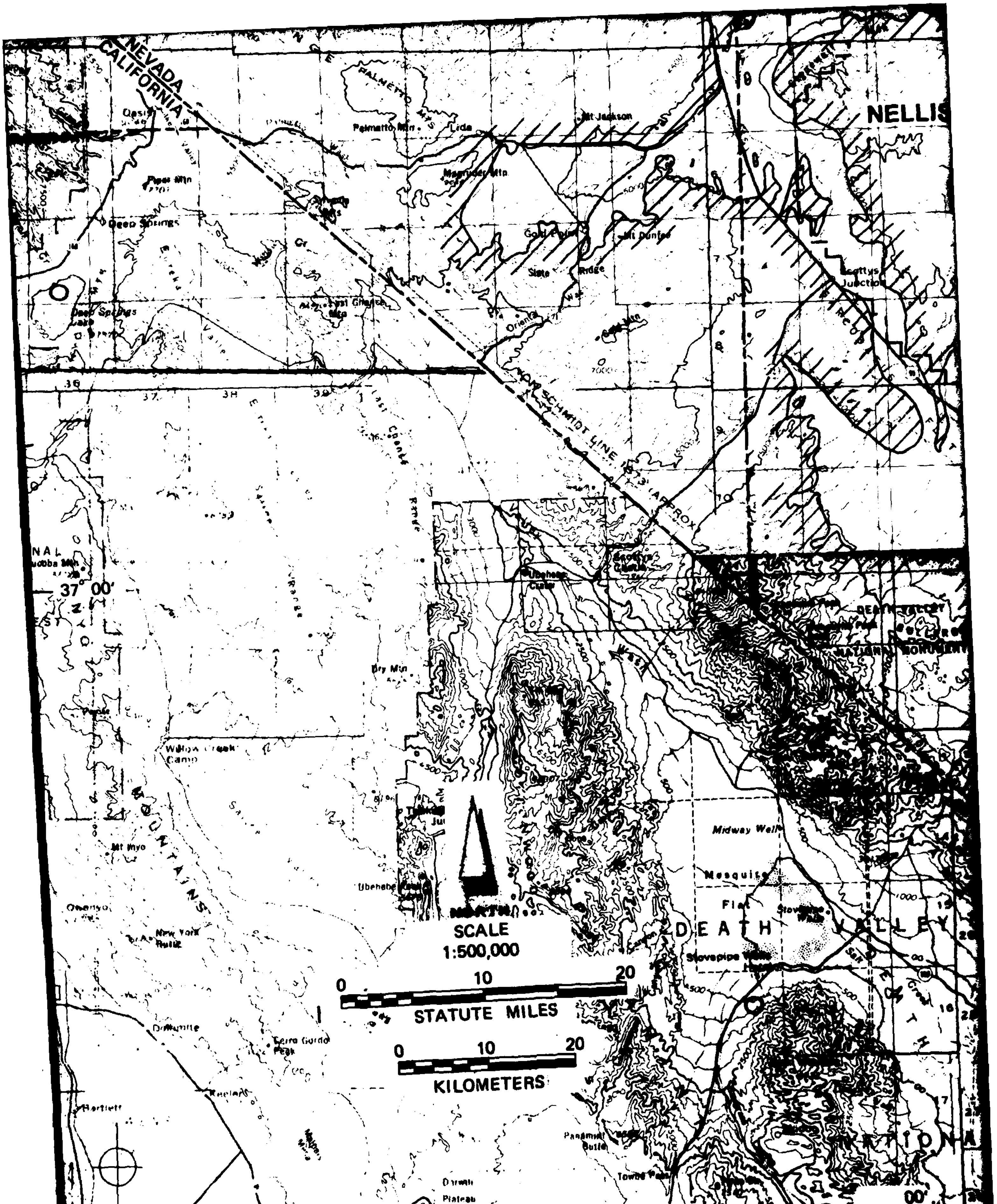
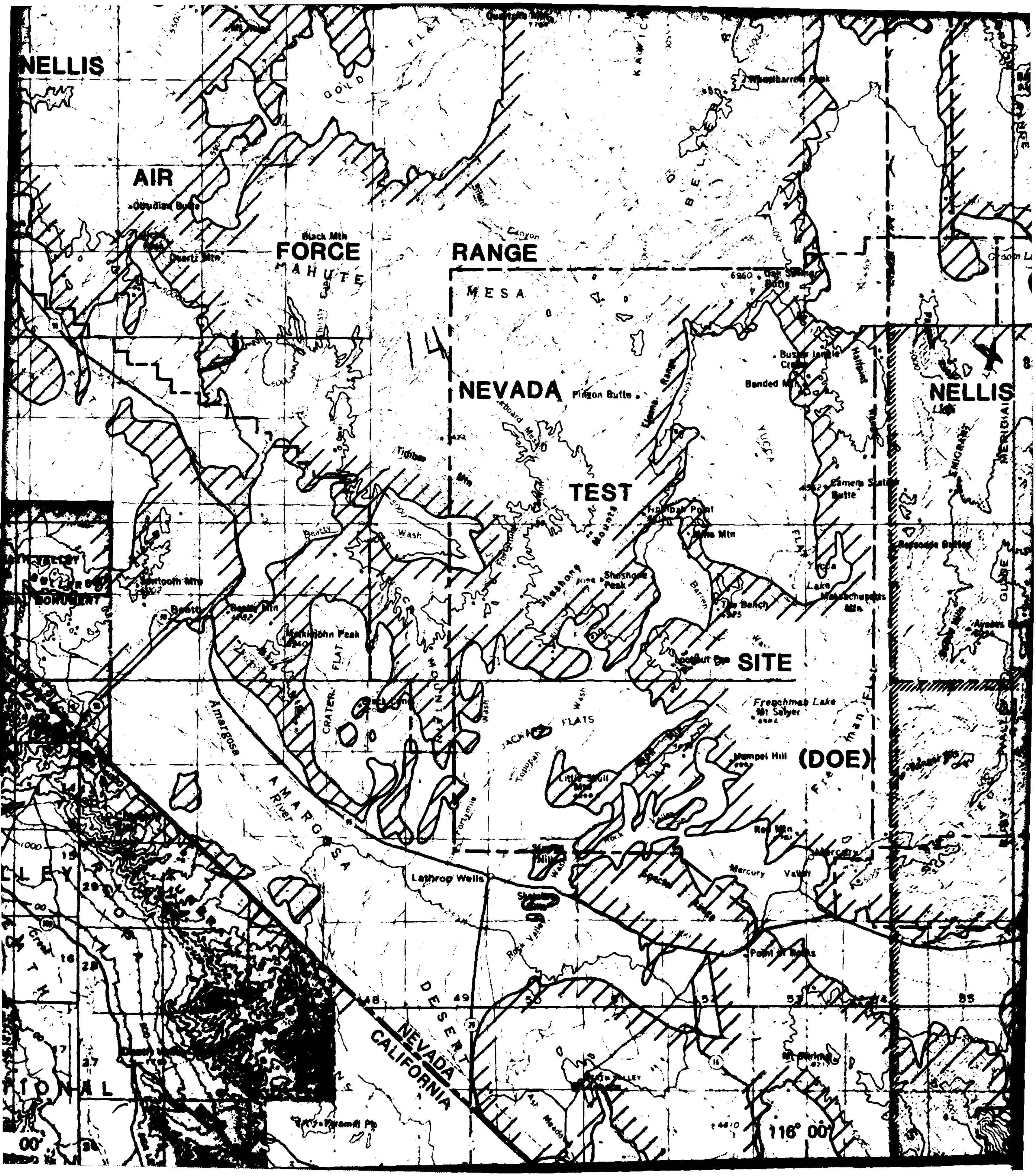
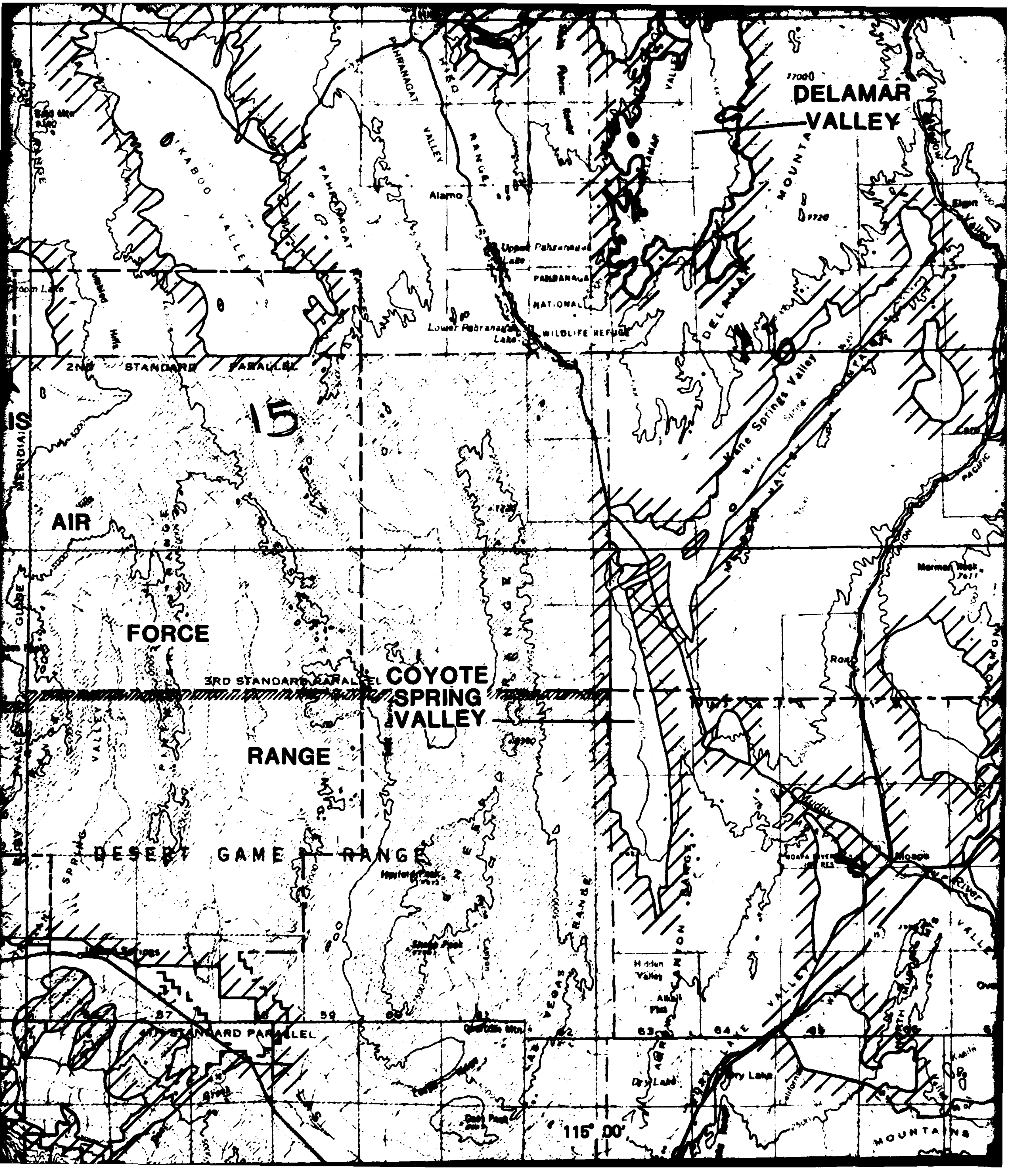
56
18
25
Patterson
Wah Wah Valley

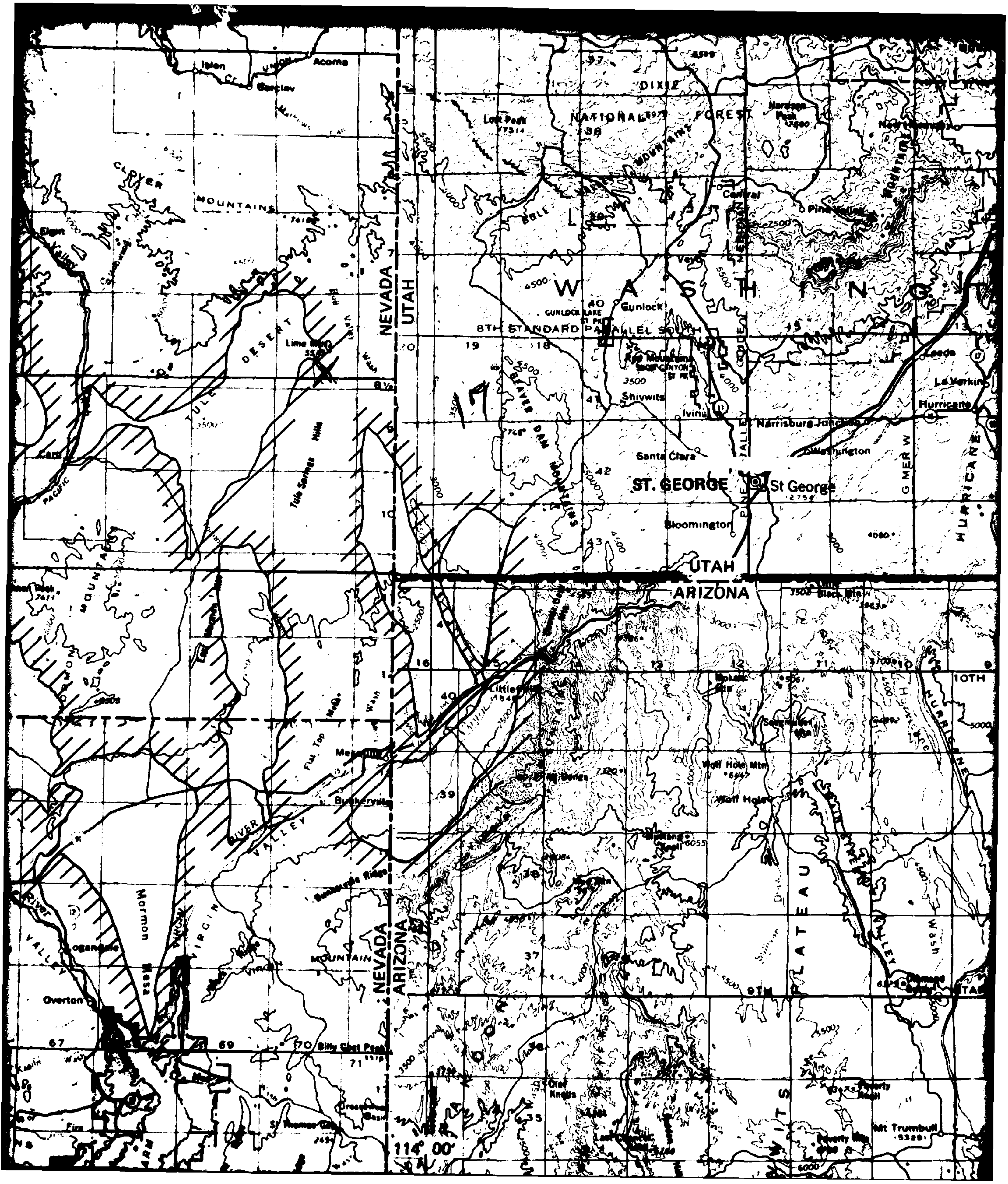


AH WAH
ALLEY
MILFORD
Granite Peak
Bearskin Mtn
Manderfield
MINERAL MOUNTAINS
BEAVER
Beaver
5898
Adamsville
Greenville
Minersville
Black Mtn
7226
Marysvale
Thompsonville
Alunite
Junction
Kingston
Circleville
BLACK MOUNTAIN
6780
Spry
Paragonah
Parowan
PAROWAN
Summit
Enoch
5500
Iron Springs
CEDAR CITY
Cedar City
Brian Head
CEDAR BREAKS
NAT MON
DIXIE
NATIONAL
FOREST
Panguitch
GUIDE MERIDIAN
38° 00'
Hatch
Rubys Inn
Bryce Canyon
Tropic
BRYCE CANYON
NATIONAL MONUMENT
Cannonville
Kodachrome
Long Valley
Junction
Alton
Glendale
Orderville
Mount Carmel
7500
6000
6500
9500

NEVADA
CALIFORNIA
NELLIS
Palmetto Mts
Palmetto Mtn
Lida
Mt Jackson
Magruder Mtn
Piper Mtn
Deep Springs
Deep Springs Lake
Gold Point
Mt Dunfee
Slate Ridge
Oriental
Gold Mtn
Scottys Junction
VON SCHMIDT LINE 1873 (APPROX)
Ubehebe Crater
Scottys Castle
DEATH VALLEY NATIONAL MONUMENT
37° 00'
Dry Mtn
Willow Creek Camp
INYO MOUNTAINS
Mt Inyo
New York Butte
Cerro Gordo Peak
Darwin Plateau
Panamint Springs
Panamint Butte
Towne Pass
Midway Well
Mesquite Flat
Stovepipe Wells
DEATH VALLEY
NORTH
SCALE
1:500,000
0 10 20
STATUTE MILES
0 10 20
KILOMETERS


NELLIS
AIR
FORCE
RANGE
NEVADA
TEST
SITE
(DOE)
NELLIS
GOLD FLAT
KAWICH
BELTED
Wheelbarrow Peak
Obsidian Butte
Black Mtn
Quartz Mtn
PAHUTE MESA
Canyon
Oak Spring Butte
Groom L
Busted Jungle Crest
Banded Mtn
Pinyon Butte
YUCCA
EMIGRANT
MERIDIAN
Timber Mtn
TEST
Camera Station Butte
Beatty Wash
Sawtooth Mtn
Beatty
Bare Mtn
Shoshone Mountain
Shoshone Peak
Mine Mtn
Yucca Lake
Massachusetts Mtn
The Bench
Meiklejohn Peak
Lookout Pk
CRATER FLAT
YUCCA MOUNTAIN
JACKASS FLATS
Frenchman Lake
Mt Salyer
Topopah Wash
Little Skull Mtn
Mampel Hill
Frenchman Flat
Amargosa River
AMARGOSA
Fortymile Wash
Red Mtn
Skull Mtn
Mercury
Mercury Valley
Lathrop Wells
Specter Range
Rock Valley
Point of Rocks
DESERT
NEVADA
CALIFORNIA
48
49
51
52
53
54
55
Mt Stirling
116° 00'
Pahrump Pk


DELAMAR VALLEY
PAHRANAGAT VALLEY
PAHRANAGAT RANGE
TIKABOO VALLEY
Alamo
Upper Pahranagat Lake
PAHRANAGAT NATIONAL WILDLIFE REFUGE
Lower Pahranagat Lake
DELAMAR
MOUNTAINS
2ND STANDARD PARALLEL
15
Kane Springs Valley
VALLEY
Elgin
PACIFIC
AIR
FORCE
RANGE
Mormon Peak 7411
3RD STANDARD PARALLEL
COYOTE SPRING VALLEY
SPRING VALLEY
DESERT GAME RANGE
Hayford Peak
Sheep Peak
LAS VEGAS RANGE
Muddy
Moapa
River
Hidden Valley
Alkali Flat
4TH STANDARD PARALLEL
57
58
59
60
62
63
64
65
Dry Lake
115° 00'
MOUNTAINS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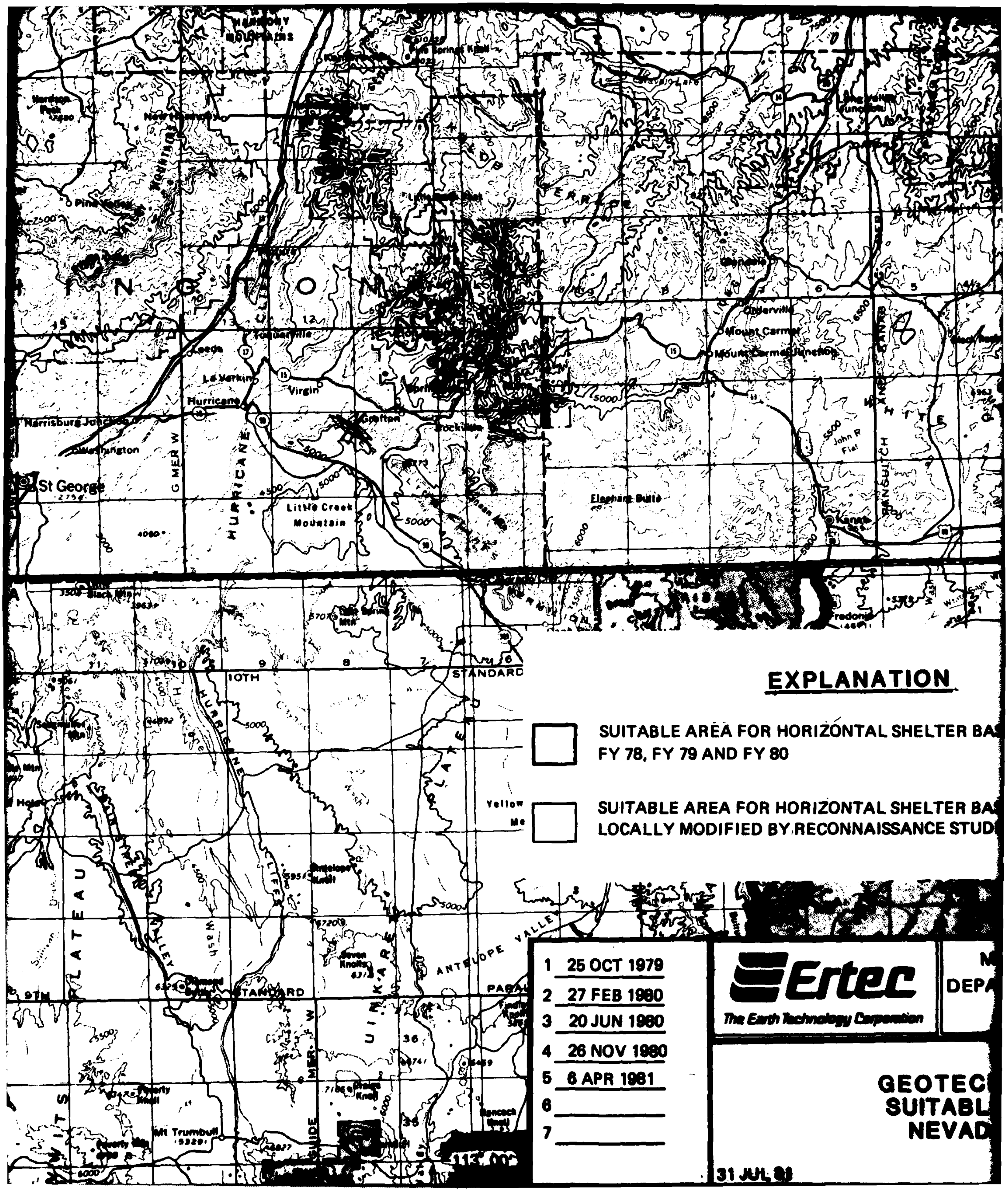
UTAH
ARIZONA
WASHINGTON
DIXIE NATIONAL FOREST
CLOVER MOUNTAINS
TULE DESERT
Tule Springs Hills
MORMON MOUNTAINS
Mormon Mesa
VIRGIN RIVER
VIRGIN VALLEY
VIRGIN MOUNTAINS
BEAVER DAM MOUNTAINS
PLATEAU
HURRICANE
8TH STANDARD PARALLEL SOUTH
9TH
10TH
Islen
Acoma
Barclay
Elgin
Caliente
Lime Mtn
Carp
Flat Top Mesa
Mesquite
Bunkerville
Bunkerville Ridge
Overton
Logandale
Bitty Goat Peak
St Thomas Gap
Lost Peak
Hardscrabble
Pine Valley
Central
Veyo
Gunlock
GUNLOCK LAKE
Shivwits
Ivins
Santa Clara
ST. GEORGE
St George
Bloomington
Washington
Harrisburg Junction
Leeds
La Verkin
Hurricane
Littlefield
Black Mtn
Wolf Hole Mtn
Wolf Hole
Mustang Knoll
Mt Trumbull
Poverty Knoll
Olaf Knolls
114° 00'



EXPLANATION

☐ SUITABLE AREA FOR HORIZONTAL SHELTER BAS
FY 78, FY 79 AND FY 80

☐ SUITABLE AREA FOR HORIZONTAL SHELTER BAS
LOCALLY MODIFIED BY RECONNAISSANCE STUD

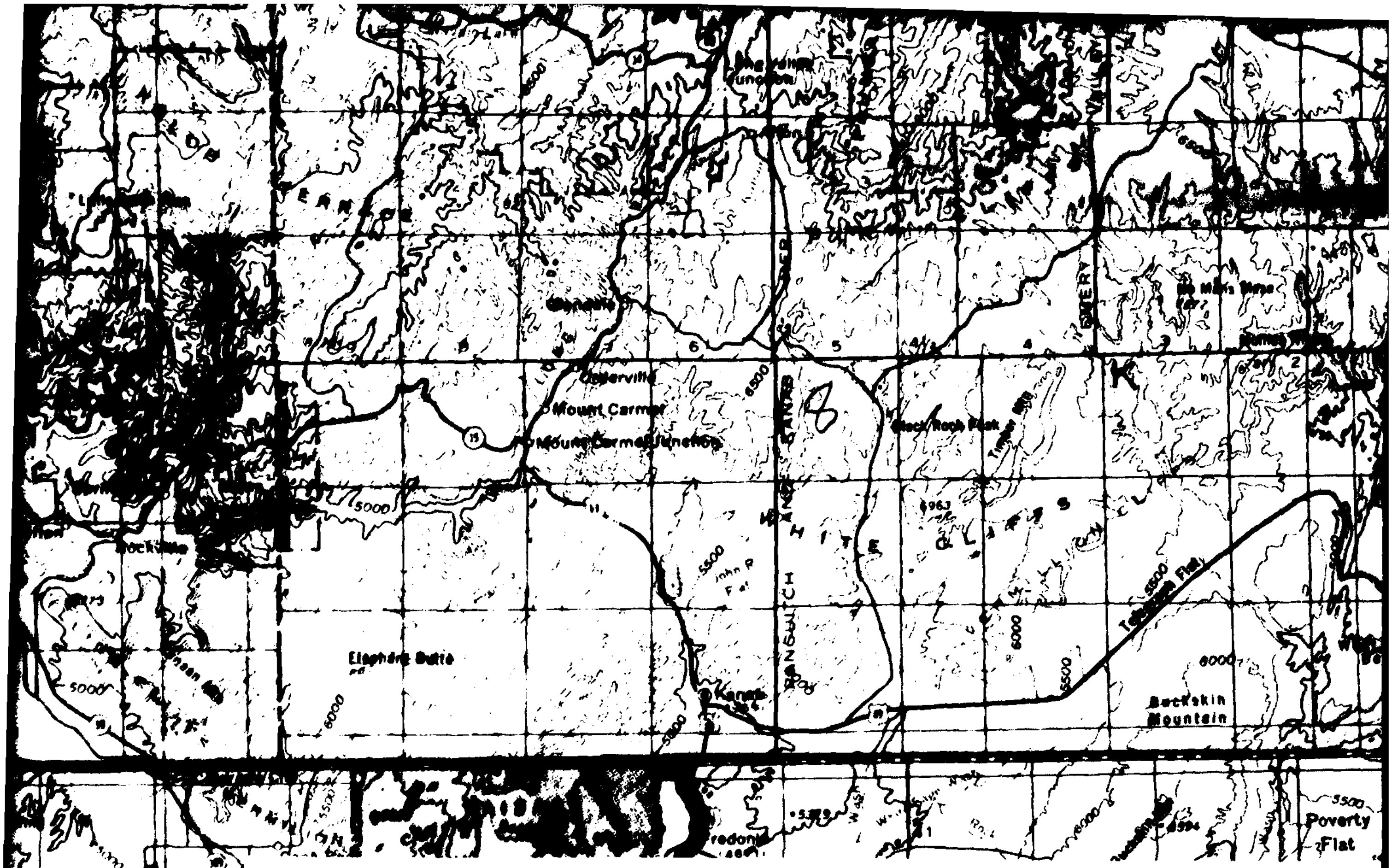
1 25 OCT 1979
2 27 FEB 1980
3 20 JUN 1980
4 26 NOV 1980
5 6 APR 1981
6 ____________
7 ____________

Ertec
The Earth Technology Corporation

M
DEPA

GEOTEC
SUITABL
NEVAD

31 JUL 81



EXPLANATION

☐ SUITABLE AREA FOR HORIZONTAL SHELTER BASED ON VERIFICATION STUDIES· FY 78, FY 79 AND FY 80

☐ SUITABLE AREA FOR HORIZONTAL SHELTER BASED ON SCREENING STUDIES. LOCALLY MODIFIED BY RECONNAISSANCE STUDIES

1 25 OCT 1979
2 27 FEB 1980
3 20 JUN 1980
4 26 NOV 1980
5 6 APR 1981
6 __________
7 __________

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The Earth Technology Corporation

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE
BMO/AFRCE-MX

GEOTECHNICALLY SUITABLE AREAS NEVADA-UTAH

31 JUL 81

DRAWING 1-1

2.0 RESULTS AND CONCLUSIONS

2.1 SUITABLE AREA

The results of the interpretation of area suitable for deployment in Lake Valley are listed in Table 2-1 and shown in map form in Drawing 2-1. The exclusion criteria used to make this interpretation are discussed in Appendix Section A2.0.

The total area of basin-fill materials in Lake Valley is 641 mi^2 (1660 km^2). Approximately 58 percent of this area is excluded for the horizontal shelter basing mode, leaving a suitable area of 267 mi^2 (691 km^2). For the vertical shelter basing mode, approximately 74 percent of the total area is excluded, leaving a suitable area of 167 mi^3 (433 km^2).

Detailed shelter layout studies indicate that, with 5200 feet (1585 m) between shelters in a two-thirds filled hexagonal layout, seven MX clusters can be placed in Lake Valley.

2.2 BASIN-FILL CHARACTERISTICS

This section contains brief descriptions of the soils in Lake Valley. More detailed information is presented in Sections 3.3 and 3.4.

2.2.1 Surficial Soils

Coarse-grained granular soils are the predominant surficial soils covering approximately 90 percent or more of the suitable area. They consist of sandy and/or silty gravels, and gravelly, silty and/or clayey sands. Generally sandy gravels and gravelly

VERIFICATION VALLEY	STATE	AREA MI ^{2} (KM^2) *		
		BEGINNING AREA	SUITABLE AREA	
			HORIZONTAL	VERTICAL
LAKE	NEVADA	641 (1660)	267 (691)	167 (433)

EXCLUSIONS	AREA MI ^{2} (KM^2)	PERCENT REDUCTION **
< 50 FEET (15M) TO ROCK	98 (253)	15
< 150 FEET (46M) TO ROCK	149 (386)	23
< 50 FEET (15M) TO WATER	127 (329)	20
150 FEET (46M) TO WATER	252 (650)	39
TERRAIN ***	171 (443)	27

* BEGINNING AREA COMPOSED OF BASIN-FILL MATERIALS EXCLUDING ALL ROCK OUTCROPS. ALL AREAS ARE ROUNDED OFF TO NEAREST SQUARE MILE INCREMENT. METRIC CONVERSIONS ARE ROUNDED OFF TO NEAREST SQUARE KILOMETER INCREMENT.

** PERCENT REDUCTIONS, BASED ON BEGINNING AREA, ARE ROUNDED OFF TO NEAREST WHOLE PERCENT. GROUND-WATER DATA FROM FUGRO NATIONAL, INC. (1979).

*** TERRAIN EXCLUSIONS BETWEEN THE 50 FT. ROCK EXCLUSIONARY CONTOUR AND THE VALLEY BASIN FILL/ROCK CONTACT HAVE NOT BEEN CALCULATED.

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MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE
BMO/AFRCE-MX

**ESTIMATED SUITABLE AREA
LAKE VALLEY, NEVADA**

31 JUL 81

TABLE 2-1

sands are predominant along the southeastern mountain fronts and in the northwestern portion of the valley.

In general, surficial soils grade to silty and/or clayey sands going downslope from the valley flanks toward the valley axis. The sands and gravels are generally poorly graded. They have variable degree of calcium-carbonate cementation. Cementation is most common in the southeastern portion of the valley.

Fine-grained soils cover no more than 10 percent of the geotechnically suitable area. They consist of sandy silts, silts, sandy clays, and clays. In the suitable area, the fine-grained soils are encountered sporadically in the central and southern portions of the valley. Their plasticity ranges from nonplastic to highly plastic.

2.2.2 Subsurface Soils

Soils in the subsurface are also predominantly coarse-grained consisting of sandy gravels, gravelly sands, sands, silty sands, and clayey sands. Gravels and gravelly sands commonly occur along mountain fronts and grade to finer soils toward the valley axis. The coarse-grained soils are generally dense to very dense below 2 to 3 feet (0.6 to 0.9 m). They are generally poorly graded throughout the valley. They contain coarse to fine sand and/or gravel, exhibit low compressibilities, and possess moderate to high shear strengths. Fine-grained soils (silts and clays) probably occur in less than 10 percent of the subsurface of the suitable area and are generally restricted to the central and southern portions of the valley. The fine-grained soils are nonplastic to highly plastic with low to moderate compressibilities and shear strengths. Variable calcium-carbonate cementation exists in all the subsurface soils.

2.3 CONSTRUCTION CONSIDERATIONS

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

2.3.1 Grading

Mean surficial slopes in the suitable area are approximately three percent. Surface gradients are between five and nine percent in about 10 percent of the suitable area. Therefore, preconstruction grading will be minimal for most of the valley. More extensive grading will be necessary along the western valley margin where surface slopes generally range from five to nine percent.

The maximum grade at any shelter location in the layout planned for the valley would be between five and nine percent. For approximately 90 percent of the shelters, the grade would be less than five percent.

2.3.2 Roads

The predominant, coarse-grained, surficial soils will generally provide good subgrade support for roads where they are in a dense state. However, most of these soils exhibit low strength to an average depth of 2.2 feet (0.7 m). The subgrade supporting properties of these low-strength, coarse-grained soils are inadequate but they can be improved by mechanical compaction. Compaction to an average depth of 2.5 feet (0.8 m) appears to be necessary in a majority of the suitable area. Compaction to greater depth may be required in approximately 10 to 20 percent of the granular soil area. Based on results of laboratory California Bearing Ratio (CBR) tests, the in-situ granular soils, when compacted, will provide good to very good subgrade support for roads.

Based on limited testing, the fine-grained surficial soils exhibit low strength in the suitable area to an average depth of 1.4 feet (0.4 m). Supporting qualities of these soils in their natural state are inadequate for direct support of the base or subbase course of the road system. Results of laboratory CBR tests indicate that mechanical compaction will not adequately strengthen these fine-grained soils for direct support of the base course, but a select granular subbase layer over the compacted fine-grained surficial soils will give the required support.

Aggregates suitable for use as a road base-course material are present in Lake Valley and are described in detail in the Valley Specific Aggregate Resources Study report (Ertec Western, 1981b). These studies indicate that potentially suitable, road, base-course, aggregate sources are available in sufficient quantity to meet construction requirements of the MX system in Lake Valley.

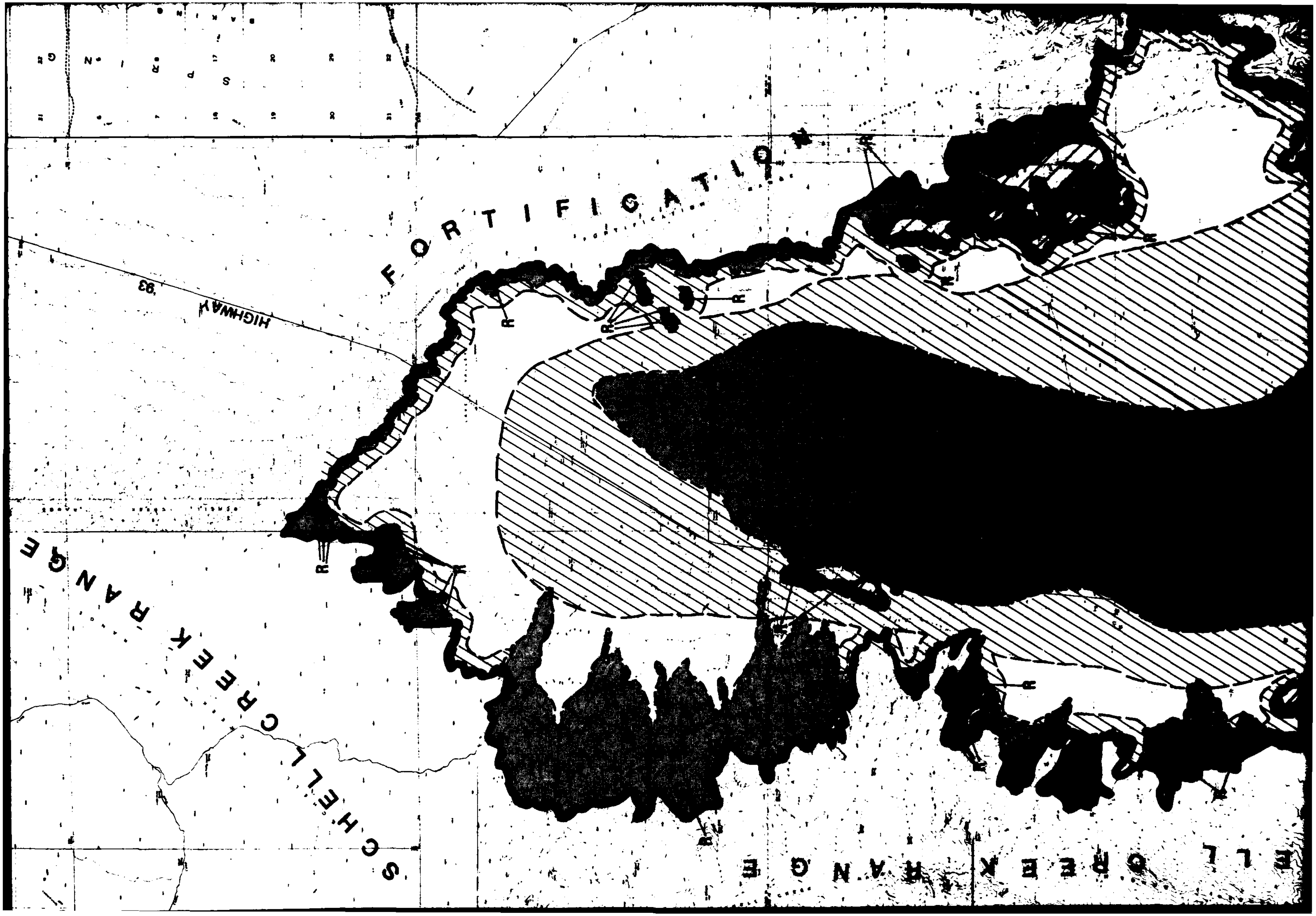
Drainage incision depths are generally less than 6 feet (1.8 m) within 90 percent of the suitable area. Therefore, the overall cost of drainage structures for roads will be low. The depths of incisions of the major drainages range from 10 to 41 feet (3.0 to 12.5 m).

2.3.3 Excavatability and Stability

The soils in the construction zone are generally dense to very dense and possess various degrees of calcium-carbonate cementation. Fine-grained soils occur in less than 10 percent of the subsurface.

Horizontal Shelter: Excavation for the horizontal shelter can be done using conventional equipment such as scrapers, backhoes, and bulldozers. Excavation will be easy to moderately difficult in approximately 55 to 65 percent of the suitable area; however, excavation will be difficult in the remaining area due to cobbles, boulders, and strong calcium-carbonate cementation in the subsurface. Difficult excavation is generally limited to the areas adjacent to the mountain fronts in the southern portion of the valley. The soils investigation indicates that excavations for construction of shelters should be cut back to slopes ranging from 1/2:1 to 1 1/2:1 (horizontal:vertical) for stability. Variations in density and shear strength which depend on soil composition and the degree of cementation cause the wide variation in slope angle. Because of low-strength surficial soil, the slope of the top 2 to 3 feet (0.6 to 0.9 m) in all excavations will generally have to be cut flatter.

Vertical Shelter: Relatively low compressional wave velocities in the upper 120 feet (36 m) indicate that large diameter auger drills could be used for vertical shelter excavation. Most excavations will be in granular soils with only intermittent cemented or cohesive soil intervals. Therefore, the vertical walls of these excavations in some cases will probably require the use of slurry or other stabilizing techniques.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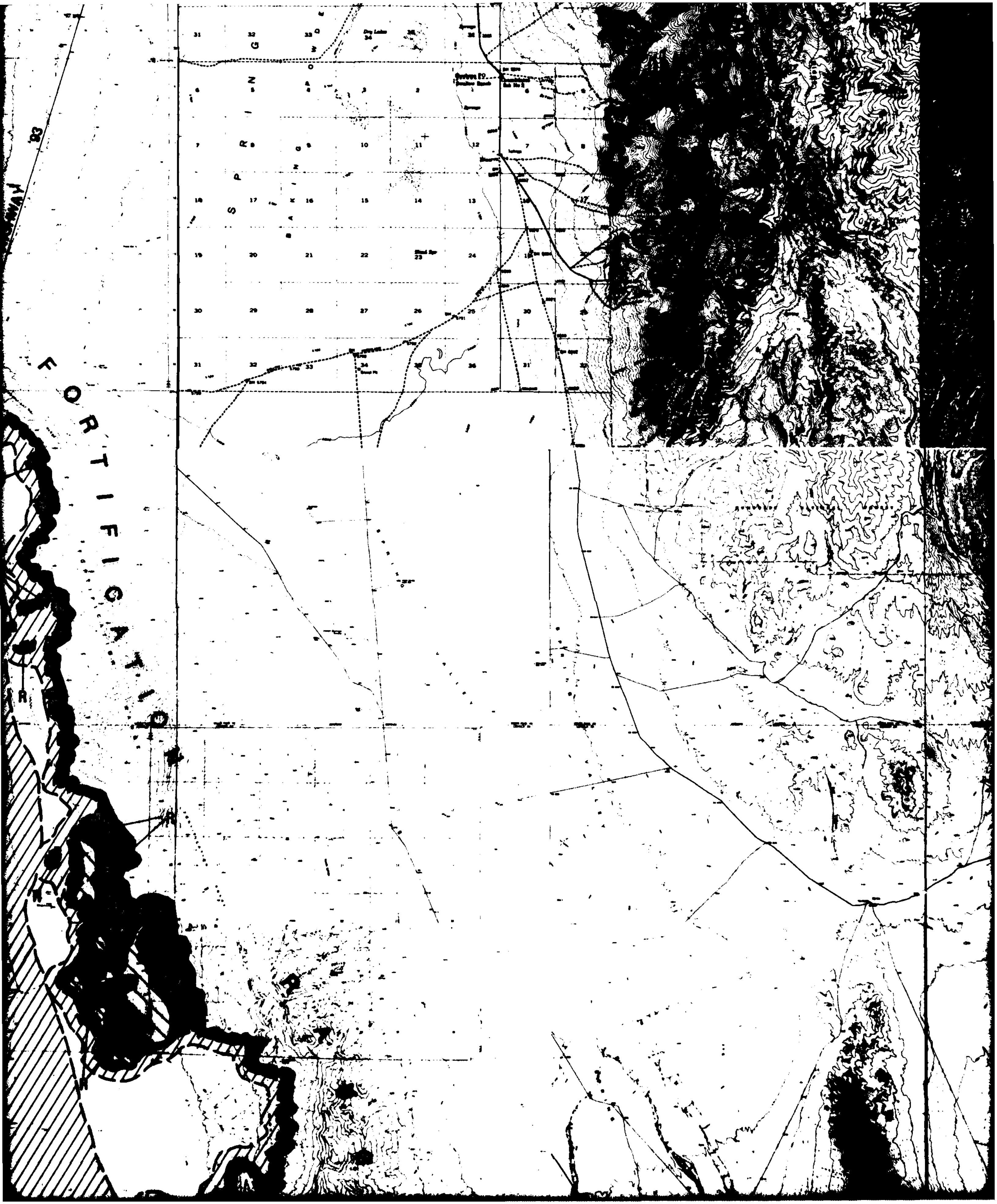
93
FORTIFICATION
SPRING
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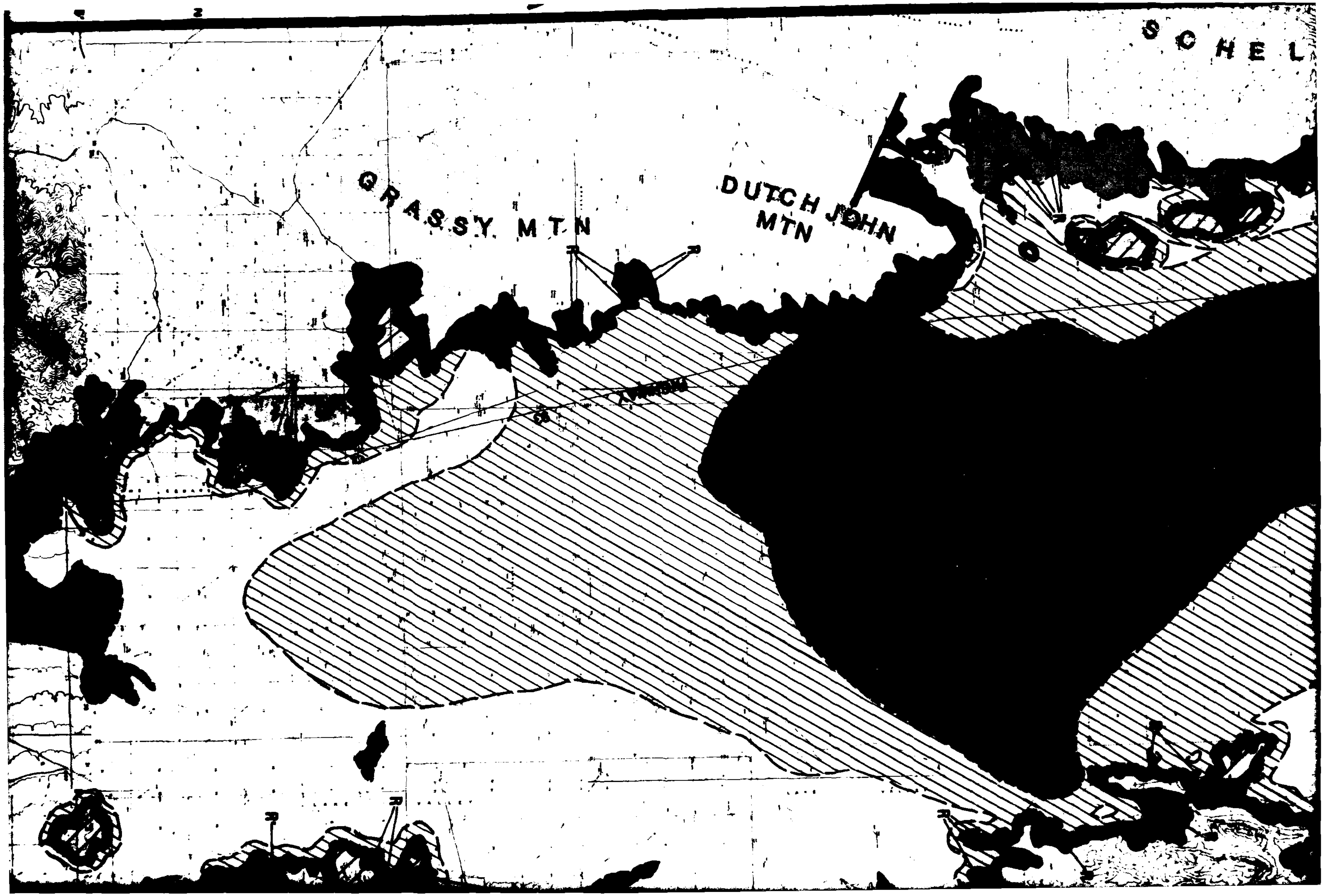
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DUTCH JOHN MTN
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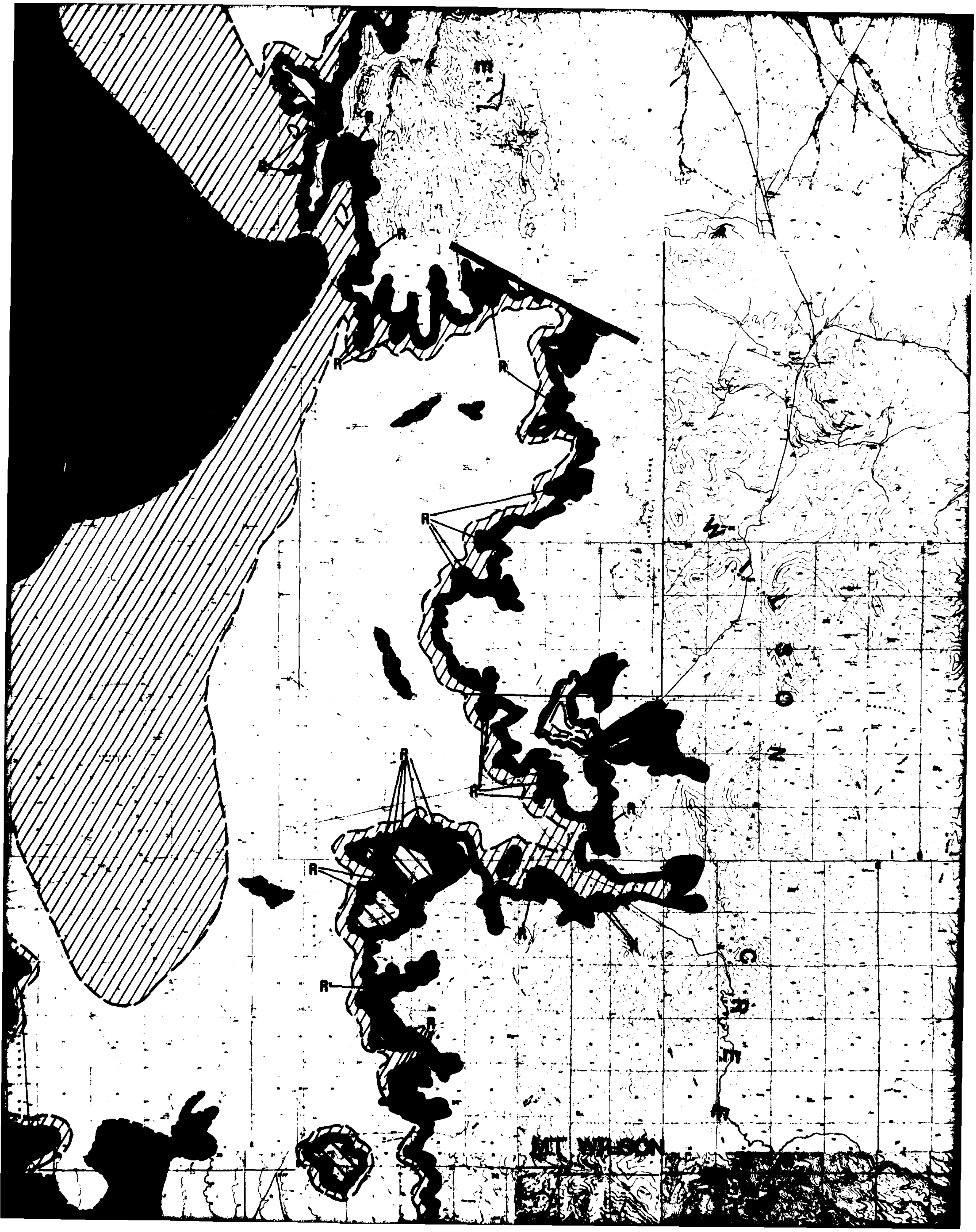
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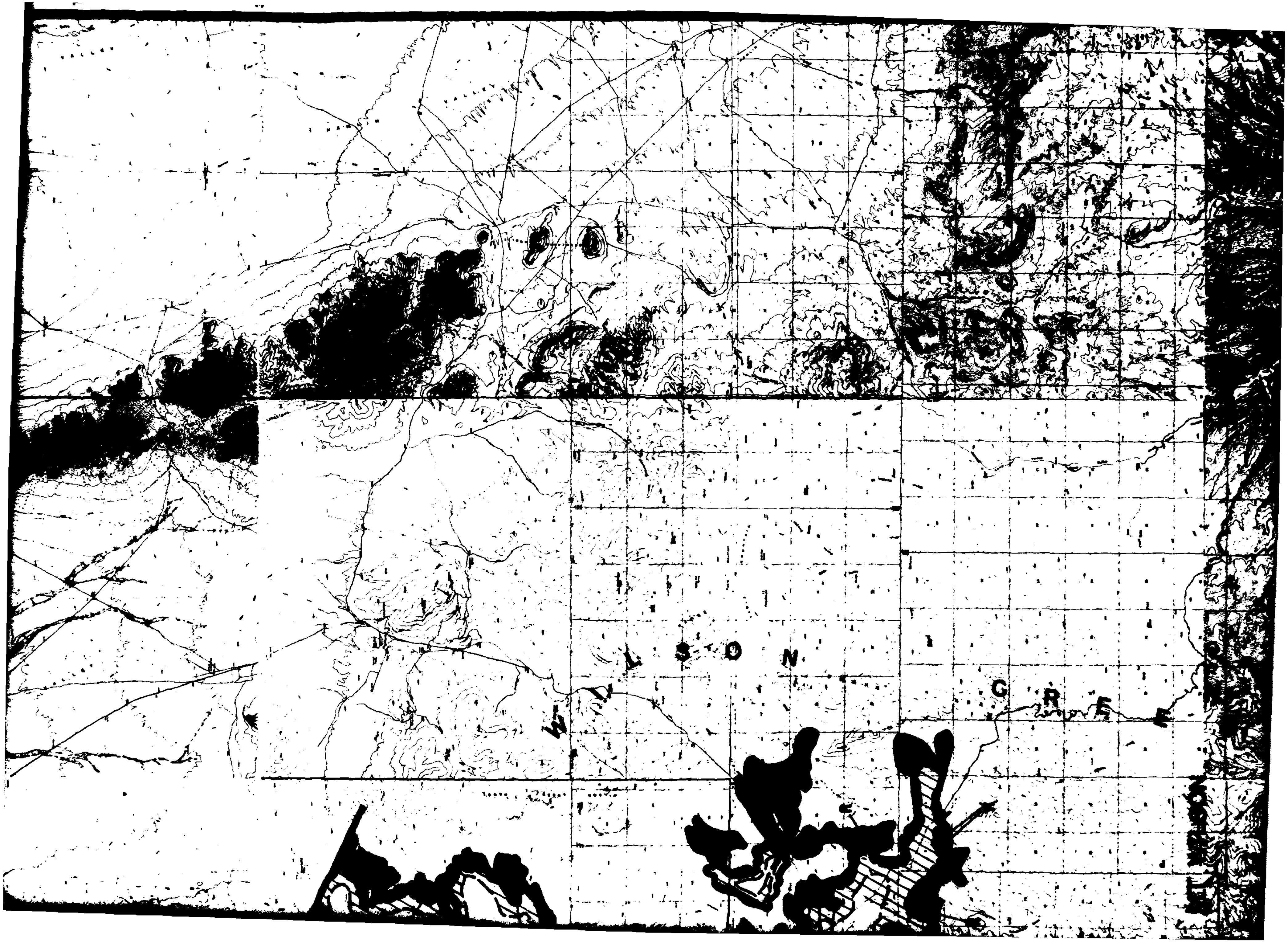
WILSON
CREEK
MT. WILSON


WILSON CREEK
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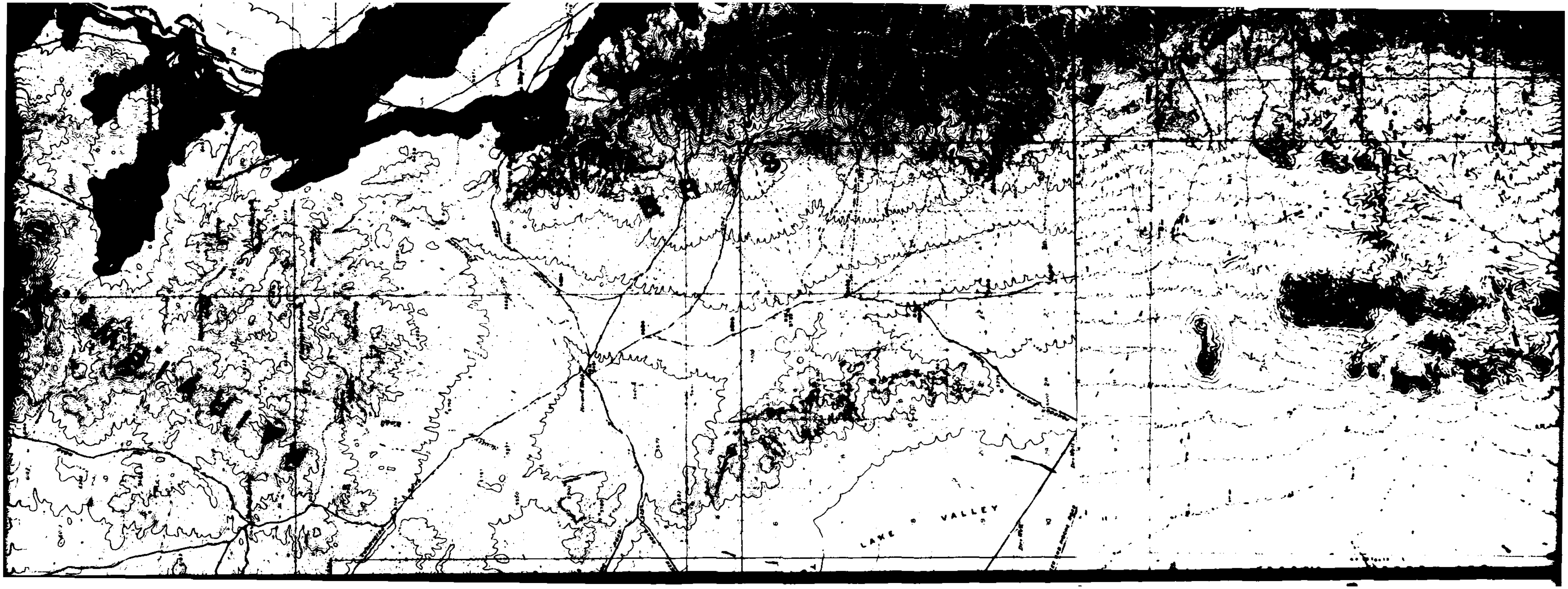

LAKE VALLEY


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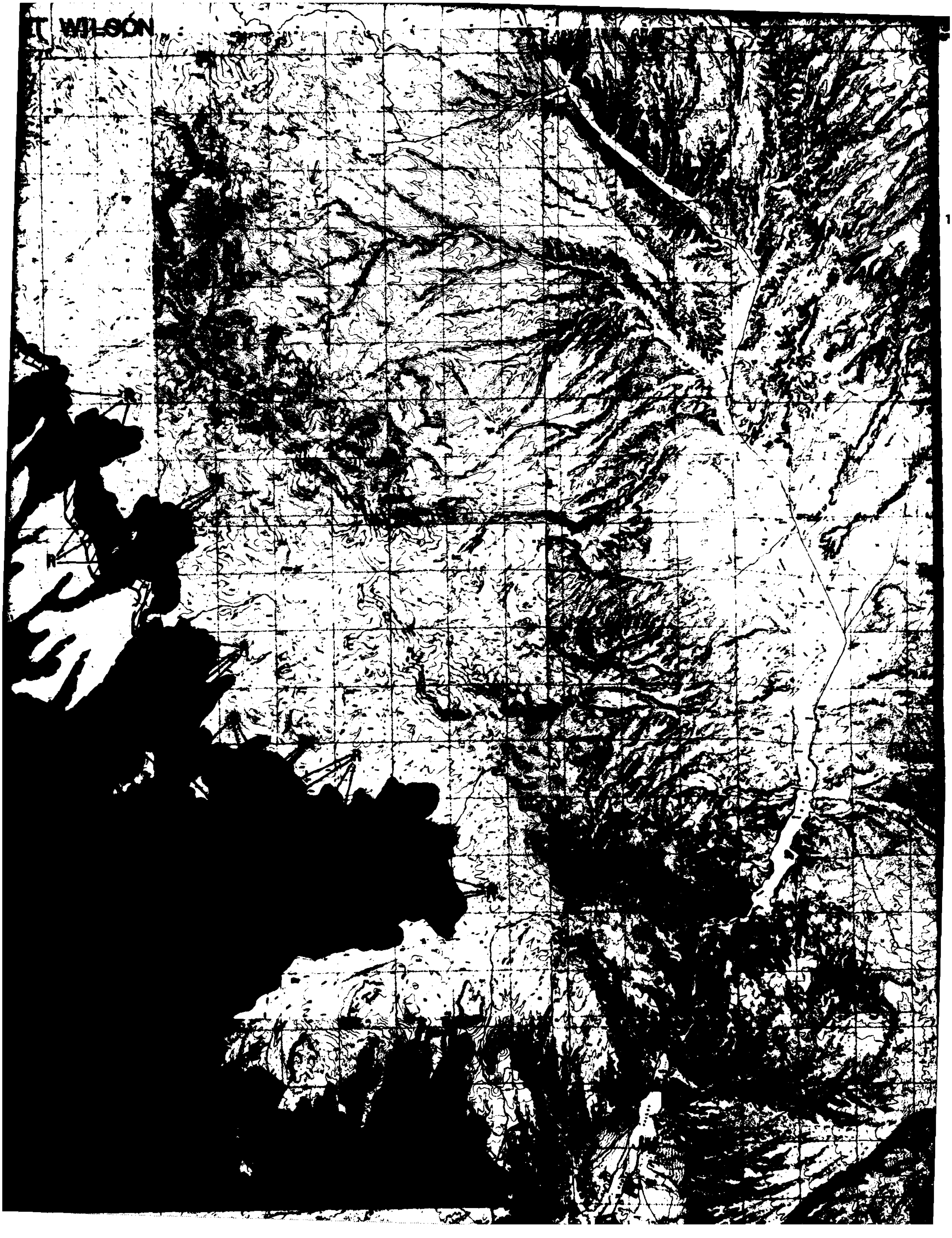
T WILSON
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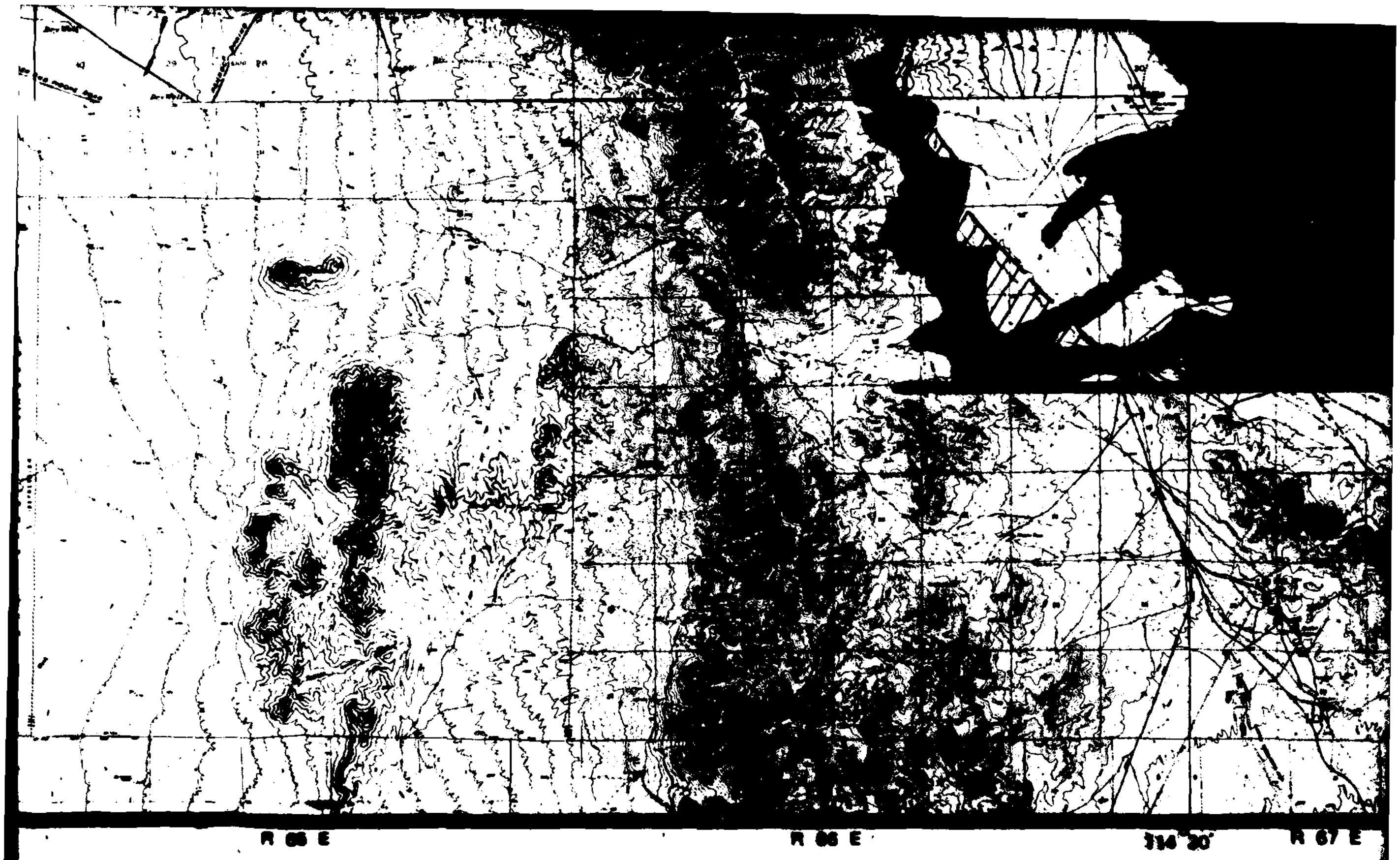

○	Area suitable for horizontal and v than 150 feet (46m).
▨	Area suitable for horizontal shelter than 50 feet (15m) and less than 1
●	Area unsuitable for both horizont of depth to rock and water, topog
▨	Areas of isolated exposed rock.
R	Areas of isolated exposed rock to
—	Contact between rock and basin
—	Valley borders.

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SUITABLE AREA
FOR HORIZONTAL AND VERTICAL SHELTERS
LAKE VALLEY, NEVADA

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R 68 E R 69 E

EXPLANATION

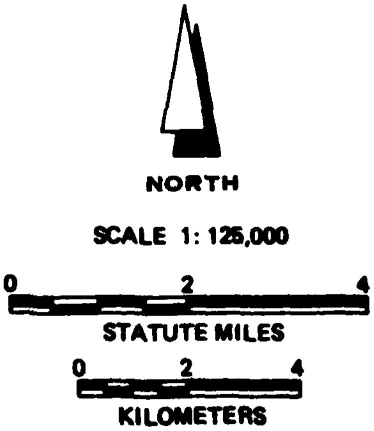
vertical shelter basing modes. Depth to rock and water greater

but, not suitable for vertical shelter. Depth to rock greater
150 feet (46m).

ntal and vertical shelter basing modes as determined from application
pography/terrain and cultural exclusions.

too small for shading.

fill.



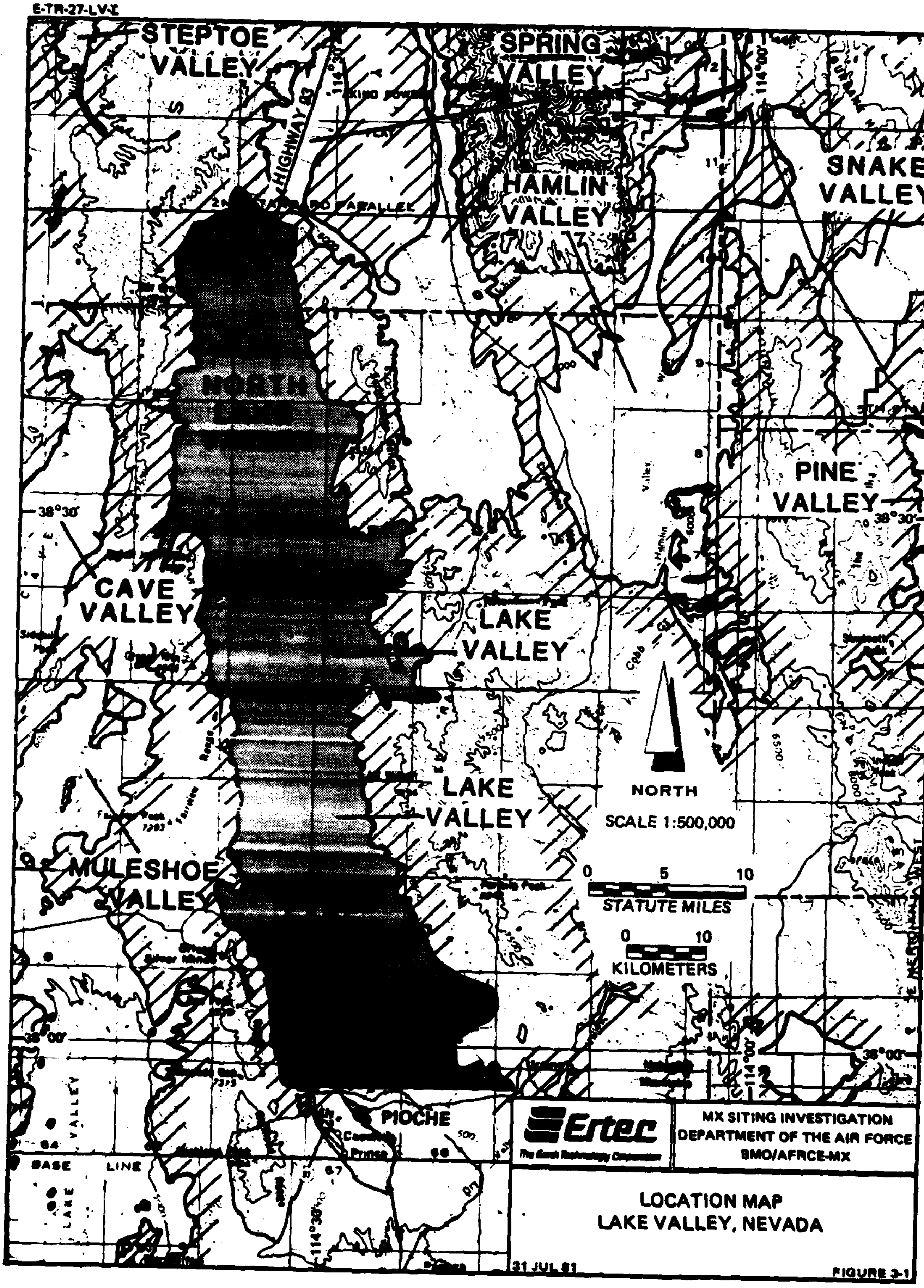
3.0 GEOTECHNICAL SUMMARY

3.1 GEOGRAPHIC SETTING

Lake Valley is a north-south trending valley in southeastern Nevada about 60 miles (97 km) southeast of Ely (Figure 1-2). It is between Cave and Muleshoe valleys on the west and Hamlin Valley on the east immediately north of Pioche (Figure 3-1). Lake Valley is bordered on the west by the southern Schell Creek Range, Dutch John and Grassy mountains, and the Fairview and Bristol ranges (Drawing 3-1). The Pioche Hills form the southwestern border of the valley. The Wilson Creek Range forms the southeastern and eastern boundaries, and the Fortification Range forms the northeastern and northern boundaries of the valley.

A low topographic divide extends across the valley from the central Fairview Range on the west to the Wilson Creek Range on the east (near Mt. Wilson, about N latitude 38°15'), thereby dividing the valley into a closed topographic basin on the north and Patterson Wash on the south. For the purpose of this report, the two areas will be referred to as North Lake Valley and South Lake Valley, respectively.

Highway 93 extends north-south along the entire western side of the valley (Figure 3-1) and, together with a network of well used and graded dirt roads, provides access throughout the valley. Lake Valley is connected by narrow mountain passes with Muleshoe Valley on the southwest and Spring Valley on the northeast. The valley is primarily undeveloped desert rangeland and has three major ranches; Geyser Ranch in the extreme northern



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LOCATION MAP
LAKE VALLEY, NEVADA

31 JUL 81

FIGURE 3-1

portion of the valley and Mt. Wilson Ranch and Lake Valley Acres in the central portion of the valley.

3.2 GEOLOGIC SETTING

3.2.1 Rock Type

Lake Valley is an elongate, north-trending alluvial basin bordered by mountains made up of sedimentary, metasedimentary, and volcanic rocks. The southern Schell Creek Range (Drawing 3-2) is composed primarily of Paleozoic limestone, dolomite, quartzite and shale with minor intrusions of Tertiary quartz diorite and rhyolite. The Dutch John and Grassy mountains are composed of Paleozoic limestone, siltstone, and shale. The Fairview Range is largely low, volcanic hills (Oligocene andesite and dacite with isolated outcrops of faulted, Paleozoic clastic and carbonate rocks). The Bristol Range and Pioche Hills are composed of Paleozoic quartzite, limestone, and shale. The Wilson Creek and Fortification ranges are chiefly composed of Tertiary andesite, rhyolite, and tuff, with portions of the Fortification Range also underlain by Paleozoic quartzite and limestone.

3.2.2 Structure

The geologic structure of Lake Valley is typical of the Great Basin tectonic province in that it is a result of late Tertiary and Quaternary block faulting due to tensional stresses directed in an east-west or northwest-southeast direction. In general, the fault blocks in the Great Basin are tilted horst and graben structures with the valleys occupying the down-tilted or downdropped blocks and the mountains representing the upturned or uplifted blocks. The major faults bounding these blocks generally trend to the north and are usually near the margins of the valleys.

Geomorphology and surface geology suggest that North Lake Valley is a horst-graben complex with the Schell Creek Range being tilted down to the east. Gravity data (Ertec, 1981a) support this interpretation.

A major range-bounding normal fault is present along the western margin of Lake Valley near the base of the Schell Creek Range (Tschanz, 1970), Dutch John Mountain, and Grassy Mountain (Drawing 3-2). A zone of north-trending surface faults and lineaments are present within the valley-fill approximately 3.5 miles (5.6 km) east of the Schell Creek Range. This zone is approximately 18 miles (28.8 km) long and comprises discontinuous, subparallel breaks and lineaments that may represent another younger, major fault. There is no surficial evidence of a major fault with Quaternary movement along the eastern margin of Lake Valley. A group of northeast oriented lineaments approximately 5 miles (8 km) wide and 9 miles (14.5 km) long is located in the east-central portion of North Lake Valley.

Faults with evidence of Quaternary movement within South Lake Valley are short and have random orientations. The outcrop pattern of the Pliocene-age Panaca Formation in the central portion of South Lake Valley indicates the valley floor has undergone uplift during the Quaternary period, but the lack of major range-bounding faults suggests that this uplift is not localized along any fault zones.

3.2.3 Surficial Geologic Units

Geologic data stops and engineering field activities (Drawing 3-1) were used to verify the interpretations of surficial geologic units made from aerial photographs (1:25,000 scale). The predominant surficial geologic unit in North Lake Valley contains Pleistocene pluvial lake deposits which range from silts and clays near the axis of the valley to sands and gravels near the old lake margins. In South Lake Valley, the predominant surficial geologic unit is made up of intermediate-age alluvial fan deposits (A5i) which range from silty to gravelly sands. These intermediate-age fans are extensively incised by the active tributary system of Patterson Wash.

Surficial geologic units mapped in Lake Valley (Drawing 3-2) consist of the following:

- Intermediate-age Alluvial Fan Deposits (A5i) - These Pleistocene fan deposits are the most widespread geologic unit and occupy approximately 60 to 70 percent of the total valley area. The majority of these fans are composed of gravelly to silty sands. The fans occur along the base of the mountains and extend toward the center of the valley. Cementation in the fan deposits varies from absent to strong but is generally weak. Caliche development varies from none to Stage IV (predominantly Stage II). Fans composed of sandy gravel occupy an area of approximately 20 mi^2 (52 km^2) at the extreme northern end of Lake Valley. Cementation in these latter fans varies from moderate to strong; caliche development varies from Stage II to Stage IV.

- Young-age Alluvial Fan Deposits (A5y) - These Holocene sediments occupy five to eight percent of the total valley area. In North Lake Valley, these units occur as outwash fans around the margin of the old pluvial lake. The majority of these fans consist of silty sands to sandy silts. Cementation is absent to weak; caliche development varies from none to Stage II. A young-age alluvial fan deposit of silty gravel occurs at the northern end of the pluvial lake adjacent to an A5i gravel fan. The A5y gravel fan exhibits no cemented layers but does have a well-developed Stage I caliche. In south Lake Valley, the A5y fans are generally associated with the fluvial (A1) deposits and occur along the central axis of the valley. These fans are composed primarily of silty sand with absent to weak cementation. Caliche development ranges from none to Stage II (predominantly none).

o Old Fluvial Deposit (A2) - This Quaternary unit covers only 2 mi^2 (5 km^2) and is in the southeastern portion of North Lake Valley. This unit is a remnant of the pluvial period and represents a drainage channel which at one time flowed northwest. The deposits within this abandoned channel are silty sand. There is no cementation in the unit, but it does exhibit a Stage II caliche development.

o Young Fluvial and Associated Floodplain Deposits (A1) - These Holocene Epoch deposits cover two to three percent of the total valley area. The majority of these deposits occur in South Lake Valley along the central axis of Patterson Wash and its extensive tributary system. In North Lake Valley, only a few minor fluvial systems exist which drain the higher topographic areas. The fluvial deposits within Lake Valley vary from sandy silts and clays to silty sands. These deposits exhibit no cementation nor caliche development.

o Lacustrine Deposits (A4, A4o) - A4 represents Holocene playas and A4o designates Tertiary-Quaternary lacustrine sediments. These deposits occur exclusively in North Lake Valley and cover approximately 20 percent (128 mi^2 [332 km^2]) of the total valley area. The largest A4 deposit covers approximately 3 mi^2 (8 km^2) and is an active playa composed of silts and clays. The A4o deposits are the remnants of a Holocene-age pluvial lake referred to in the literature as Carpenter Lake. The interior portion of the lakebed is composed of playa-type silts and clays with no cementation or caliche development. The grain size of these deposits increase to silty or gravelly sands at the outer margins of this extinct lake with no cementation or caliche development. The margin of this ancient lakebed contains abundant shoreline features which indicate a maximum elevation for the lake of 5985 feet (1825 m). These shoreline features include sandy gravel and gravelly to silty sand bars. Cementation in these features is absent to weak; caliche development varies from none to Stage II.

o Tertiary Young Sediments (Tys) - In South Lake Valley, deep erosion along Patterson Wash has exposed Tertiary lacustrine deposits of the Panaca Formation. In general, these deposits are covered by a veneer of alluvial fan and stream deposits, but scattered outcrops do appear on the surface (Drawing 3-2). These near horizontal, lakebed deposits are well stratified tuffaceous siltstone, sandstone, and mudstone, but they should pose no engineering or construction problems since drilling and cone penetrometer tests indicate that they are rippable.

- Eolian Deposits (A3s, A3d) - These Holocene-age deposits consist of windblown sand deposited in sheets (designated "s") and dunes (designated "d"). These units cover less than two percent of the valley and are within the margin of the pluvial lake. The sheet and dune deposits are composed of clean sand with no gravel, cementation, or caliche development.

3.3 SURFACE SOILS

Surficial soils of Lake Valley are predominantly coarse-grained. They range from gravels with trace to some fines to sands with little to some fines. Fine-grained soils (silts and clays) cover a limited area, being confined generally to an older lacustrine deposit in the northern portion of the valley and along a major drainage channel in the south. Soils from the predominant surficial geologic units (those estimated to cover at least five percent of the total area) can be combined into three categories based on their physical and engineering characteristics.

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

3.3.1 Characteristics

A summary of the characteristics of surficial soils, based on field and laboratory test results, is presented in Table 3-1. In addition to the physical properties, the table includes road design data, consisting of laboratory compaction and CBR test

SOIL DESCRIPTION		Sandy Gravels, Silty Gravels and Gravelly Sands		Silty Sands
USCS SYMBOLS		GW, GP, GM, SP, SM		SM, SC
PREDOMINANT SURFICIAL GEOLOGIC UNITS		A5is		A4os, A5is
ESTIMATED AREAL EXTENT	%	20 - 30		55 - 65
PHYSICAL PROPERTIES				
COBBLES 3 – 12 inches (8 – 30 cm)	%	5 - 10		0 - 10
GRAVEL	%	19 - 82	[16]	0 - 28
SAND	%	13 - 69	[16]	36 - 78
SILT AND CLAY	%	5 - 28	[16]	18 - 50
LIQUID LIMIT		NDA		26 - 67
PLASTICITY INDEX		NDA		NP - 33
ROAD DESIGN DATA				
MAXIMUM DRY DENSITY	pcf (kg/m³)	108.5 (1738)	[1]	117.0 - 12 (1874 - 19
OPTIMUM MOISTURE CONTENT	%	17.0	[1]	11.0 - 13.
CBR AT 90% RELATIVE COMPACTION	%	16	[1]	8 - 19
SUITABILITY AS ROAD SUBGRADE (1)		good to very good		fair to go
SUITABILITY AS ROAD SUBBASE OR BASE (1)		fair to good		poor to f
THICKNESS OF LOW STRENGTH SURFICIAL SOIL (2)	RANGE ft (m)	0.4 - 2.7 (0.1 - 0.8)	[31]	0.4 - 11. (0.1 - 3.4
	AVERAGE ft (m)	0.9 (0.3)	[31]	2.6 (0.8)

(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 3-2 for details.

NOTES:

Silty Sands and Clayey Sands	Sandy Silts, Silts, Sandy Clays and Clays	
SM, SC	ML, CL, CH	
A4os, A5is	A4of, A5is	
55 - 65	10 - 20	
0 - 10	0	
0 - 28 [36]	0 - 16 [14]	
36 - 78 [36]	1 - 46 [14]	
18 - 50 [36]	53 - 99 [14]	
26 - 67 [10]	27 - 67 [12]	
NP - 33 [13]	NP - 42 [13]	
117.0 - 121.0 (1874 - 1938) [6]	106.0 - 120.4 (1698 - 1929) [4]	
11.0 - 13.0 [6]	12.4 - 20.3 [4]	
8 - 19 [6]	3 - 6 [4]	
fair to good	poor	
poor to fair	not suitable	
0.4 - 11.2 (0.1 - 3.4) [47]	0.1 - 26.7 (0.0 - 8.1) [22]	
2.6 (0.8) [47]	5.3 (1.6) [22]	

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

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CHARACTERISTICS OF SURFICIAL SOILS
LAKE VALLEY, NEVADA

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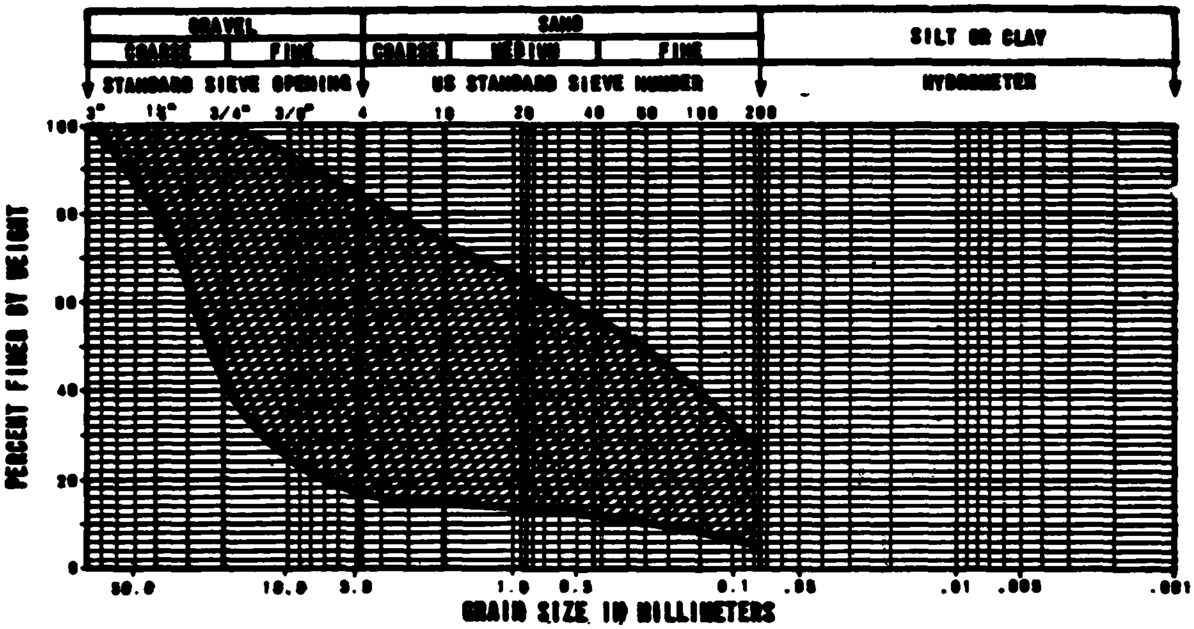
2

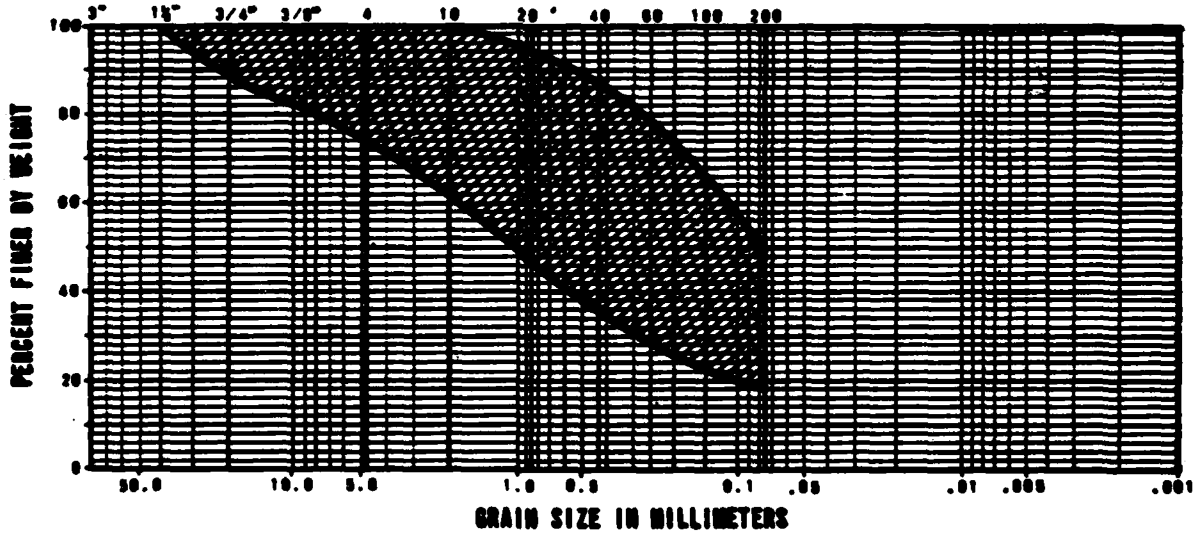
results, thickness of low-strength surficial soils, and a qualitative assessment of their suitability for road use. Gradation ranges for the three categories of surficial soils are shown in Figure 3-2. The surficial soils in the top 2 feet (0.6 m) have sporadic, weak to strong calcium-carbonate cementation.

Approximately 20 to 30 percent of the total area is covered by sandy gravels and gravelly sands. Gravelly soils commonly occur in the intermediate-age fans in the western portion of the valley and along the southeastern mountain fronts. In general, gravel content increases toward the mountain fronts. Gravelly sands and sandy gravels have a wide range of particle sizes, but most are poorly graded. Cobbles and boulders to 12 inches (30 cm) and larger in diameter are encountered occasionally at or near the ground surface in these gravelly deposits. They occur more often in the northwestern portion of the valley.

Silty sands and clayey sands are the predominant surficial soils, covering approximately 55 to 65 percent of the total area. They are widely distributed, being the major component in all areas except in the old and intermediate-age alluvial fans near mountain fronts. The sands are coarse to fine and are poorly graded. They contain little to some amounts of fines and their plasticity ranges from nonplastic to highly plastic. The fines content is highest along the central axis and decreases toward the valley margin. Gravel content increases toward the mountain fronts.



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



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

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**RANGE OF GRADATION OF
SURFICIAL SOILS
LAKE VALLEY, NEVADA**
PAGE 1 OF 2

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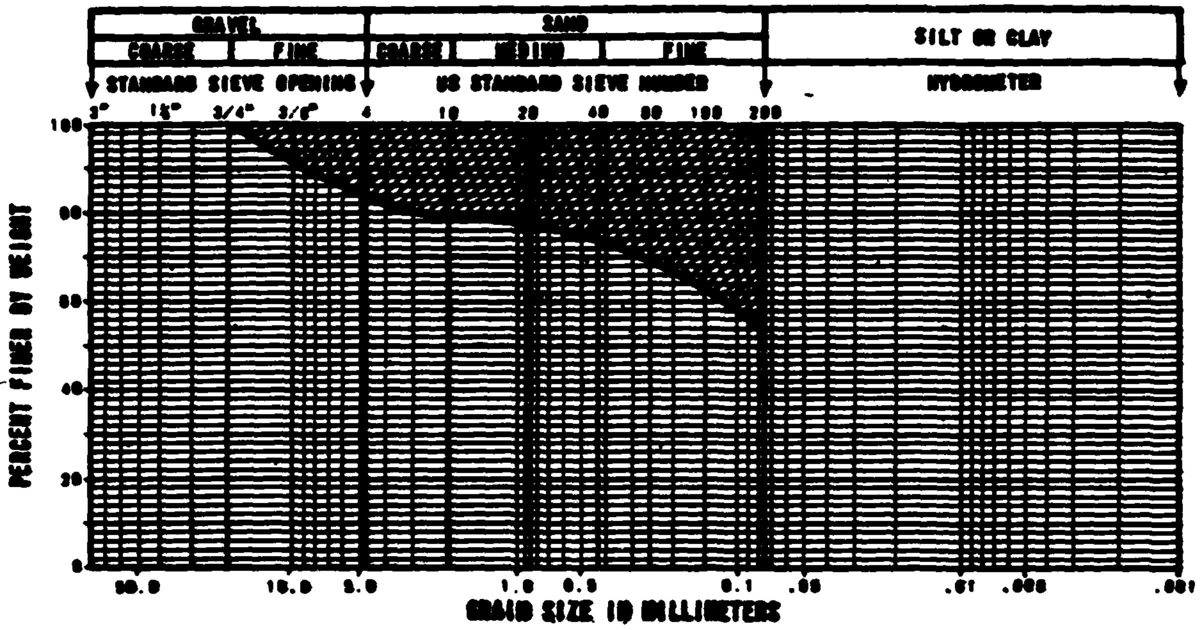
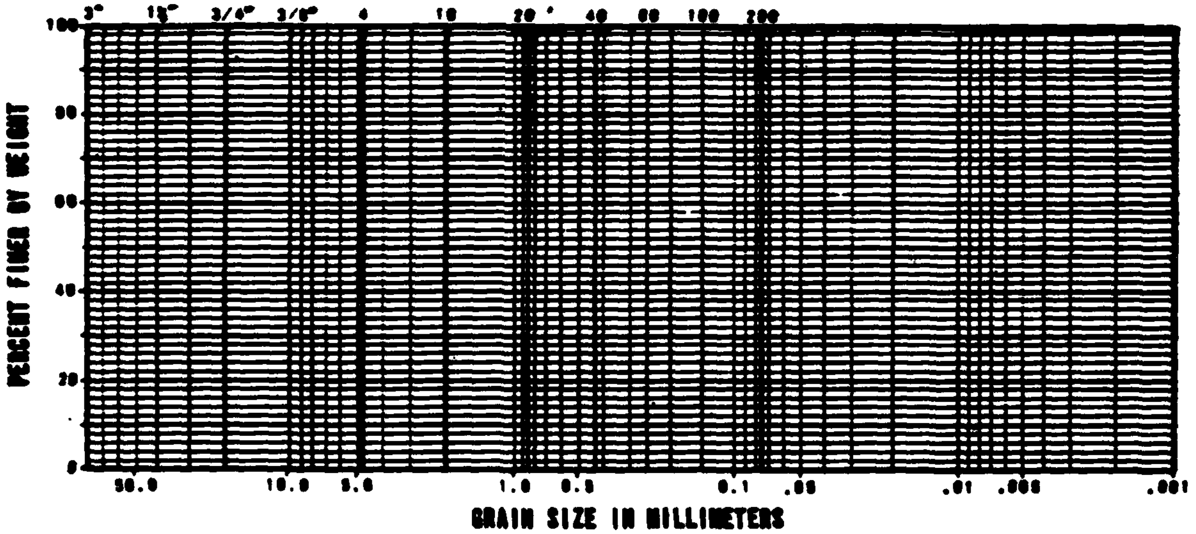
FIGURE 3-8



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



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RANGE OF GRADATION OF
SURFICIAL SOILS
LAKE VALLEY, NEVADA
PAGE 2 OF 2

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FIGURE 3-8

Silts and clays cover 10 to 20 percent of the total valley area. They consist of sandy silts, silts, sandy clays, and clays, and occur predominantly in older lacustrine deposits in North Lake Valley and along a major drainage channel in South Lake Valley. These soils contain traces to some amounts of sand. Their plasticity ranges from nonplastic to highly plastic.

3.3.2 Low-Strength Surficial Soil

Based on the CPT results and soil classifications, the thickness of low-strength surficial soil at each CPT location was estimated and is presented in Table 3-2.

Summaries of the range and mean thickness of the low-strength surficial soil for the three soil categories are included in Table 3-1. Sandy gravels and gravelly sands exhibit low strength to depths ranging from 0.4 to 2.7 feet (0.1 to 0.8 m), with an average of 0.9 feet (0.3 m). Silty and clayey sands exhibit low strengths to depths ranging from 0.4 to 11.2 feet (0.1 to 3.4 m), with an average of 2.6 feet (0.8 m). The range of depths of low-strength, granular soils is due to variations in the in-situ density and calcium-carbonate cementation. Silts and clays exhibit low strength to depths ranging from zero to greater than 33.0 feet (0.0 to 10.1 m), with an average of 5.3 feet (1.6 m) in the total area. The deep, low-strength, fine-grained soils are concentrated mainly in North Lake Valley. The variation in the extent of low-strength, fine-grained soils is due to changes in the in-situ density, the amount of fine sand present, and calcium-carbonate cementation.

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	0.8	0.2	SM
C-3	1.2	0.4	SM
C-4	0.6	0.2	SM
C-5	0.7	0.2	SM
C-6	0.8	0.2	SP-SM
C-7	1.0	0.3	SM
C-8	0.7	0.2	SM
C-9	1.9	0.6	SM
C-10	10.0	3.0	ML
C-11	0.8	0.2	SM
C-12	1.6	0.5	ML
C-13	1.0	0.3	GM
C-14	1.0	0.3	GM
C-15	0.4	0.1	SM
• C-16	1.0	0.3	GC
• C-17	2.0	0.6	GM
C-18	0.3	0.1	ML
• C-19	0.7	0.2	CL
C-20	7.6	2.3	CL
C-21	10.4	3.2	ML
C-22	1.0	0.3	SM
C-23	1.1	0.3	SM
C-24	1.0	0.3	SM
• C-25	1.2	0.4	SM
C-26	0.7	0.2	SM
C-27	0.9	0.3	SM
• C-28	1.2	0.4	SM

CONE PENETROMETER TEST NUMBER(1)	THICKNESS OF LOW STRE SURFICIAL SOIL,(2	
	FEET	METER
C-29	0.9	0.3
C-30	0.7	0.2
• C-31	0.8	0.2
C-32	0.8	0.2
C-33	0.7	0.2
C-34	0.6	0.2
C-35	1.8	0.6
• C-36	7.0	2.1
• C-37	4.0	1.2
C-38	0.9	0.3
• C-39	0.4	0.1
• C-40	11.2	3.4
C-41	1.7	0.5
• C-42	1.7	0.5
C-43	3.4	1.0
• C-44	1.0	0.3
• C-45	1.4	0.4
• C-46	0.6	0.2
C-47	1.0	0.3
• C-48	1.0	0.3
• C-49	1.2	0.4
C-50	9.3	2.8
C-51	12.3	3.7
• C-52	1.4	0.4
C-53	2.0	0.6
C-54	0.8	0.2
C-55	0.9	0.3
• C-56	3.8	1.2

(1) For Cone Penetrometer Test locations see Drawing 3-1 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 so

• SM/ML –

• NDA – No

• • - In ma

THICKNESS OF LOW STRENGTH SURFICIAL SOIL,(2) FEET	THICKNESS OF LOW STRENGTH SURFICIAL SOIL,(2) METERS	SOIL TYPE (3)
0.9	0.3	GP-GM
0.7	0.2	SM
0.8	0.2	SC
0.8	0.2	SM
0.7	0.2	SM
0.6	0.2	SM
1.8	0.6	SM
7.0	2.1	SM
4.0	1.2	SM
0.9	0.3	SM
0.4	0.1	SC
11.2	3.4	SM
1.7	0.5	SC
1.7	0.5	CL
3.4	1.0	SM
1.0	0.3	SC
1.4	0.4	SM
0.6	0.2	GM
1.0	0.3	SM
1.0	0.3	SM
1.2	0.4	SC
9.3	2.8	CL
12.3	3.7	CL/SC
1.4	0.4	SC
2.0	0.6	SC
0.8	0.2	CL
0.9	0.3	CL
3.8	1.2	SM

CONE PENETROMETER TEST NUMBER(1)	THICKNESS OF LOW STRENGTH SURFICIAL SOIL,(2) FEET	THICKNESS OF LOW STRENGTH SURFICIAL SOIL,(2) METERS	SOIL TYPE (3)
• C-57	8.2	2.5	SC/ML
• C-58	0.7	0.2	SM
• C-59	0.8	0.2	SM
C-60	0.8	0.2	SC
• C-61	0.9	0.3	SM
• C-62	2.0	0.6	SC
• C-63	1.0	0.3	SM
• C-64	0.8	0.2	SC
C-65	0.7	0.2	SM
• C-66	0.8	0.2	SM
• C-67	0.9	0.3	SM
• C-68	0.5	0.2	SM
• C-69	0.6	0.2	SC
• C-70	1.3	0.4	CL
• C-71	0.9	0.3	SM
• C-72	0.7	0.2	SM
C-73	9.4	2.9	SM/CL
C-74	0.9	0.3	CL
C-75	8.5	2.6	CH
C-76	> 33.0	> 10.1	CL
C-77	26.7	8.1	CL
• C-78	1.8	0.6	CL
C-79	5.1	1.6	CL-ML
C-80	2.0	0.6	SC/SM
C-81	1.0	0.3	SC
C-82	1.0	0.3	SM
C-83	1.0	0.3	SM
C-84	0.4	0.1	GW-GM

NOTES:

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

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THICKNESS OF LOW STRENGTH
SURFICIAL SOILS
LAKE VALLEY, NEVADA
PAGE 1 OF 2

31 JUL 81

TABLE 3-

2

CONE PENETROMETER TEST NUMBER(1)	THICKNESS OF LOW STRENGTH SURFICIAL SOIL,(2)		SOIL TYPE (3)
	FEET	METERS	
C-85	9.5	2.9	CH
C-86	>33.0	>10.1	CL
C-87	8.0	2.4	SM
C-88	11.0	3.4	SM
•C-89	1.0	0.3	SM
•C-90	1.3	0.4	SM
C-91	9.5	2.9	SM
C-92	0.9	0.3	SM
C-93	3.9	1.2	CL
C-94	0.5	0.2	CL
C-95	4.7	1.4	SM
C-96	5.7	1.7	SM
C-97	1.0	0.3	ML
C-98	3.8	1.2	ML
C-99	2.8	0.9	SM
C-100	0.7	0.2	GP-GM
•C-101	2.7	0.8	GM
C-102	0.9	0.3	SM

CONE PENETROMETER TEST NUMBER(1)	THICKNESS OF LOW SURFICIAL S
	FEET

(1) For Cone Penetrometer Test locations see Drawing 3-1 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: • Fo
st
of

• SM

•

•

THICKNESS OF LOW STRENGTH SURFICIAL SOIL,(2)		SOIL TYPE (3)
FEET	METERS	

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

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

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THICKNESS OF LOW STRENGTH
SURFICIAL SOILS
LAKE VALLEY, NEVADA
PAGE 2 OF 2

31 JUL 81

TABLE 3-2

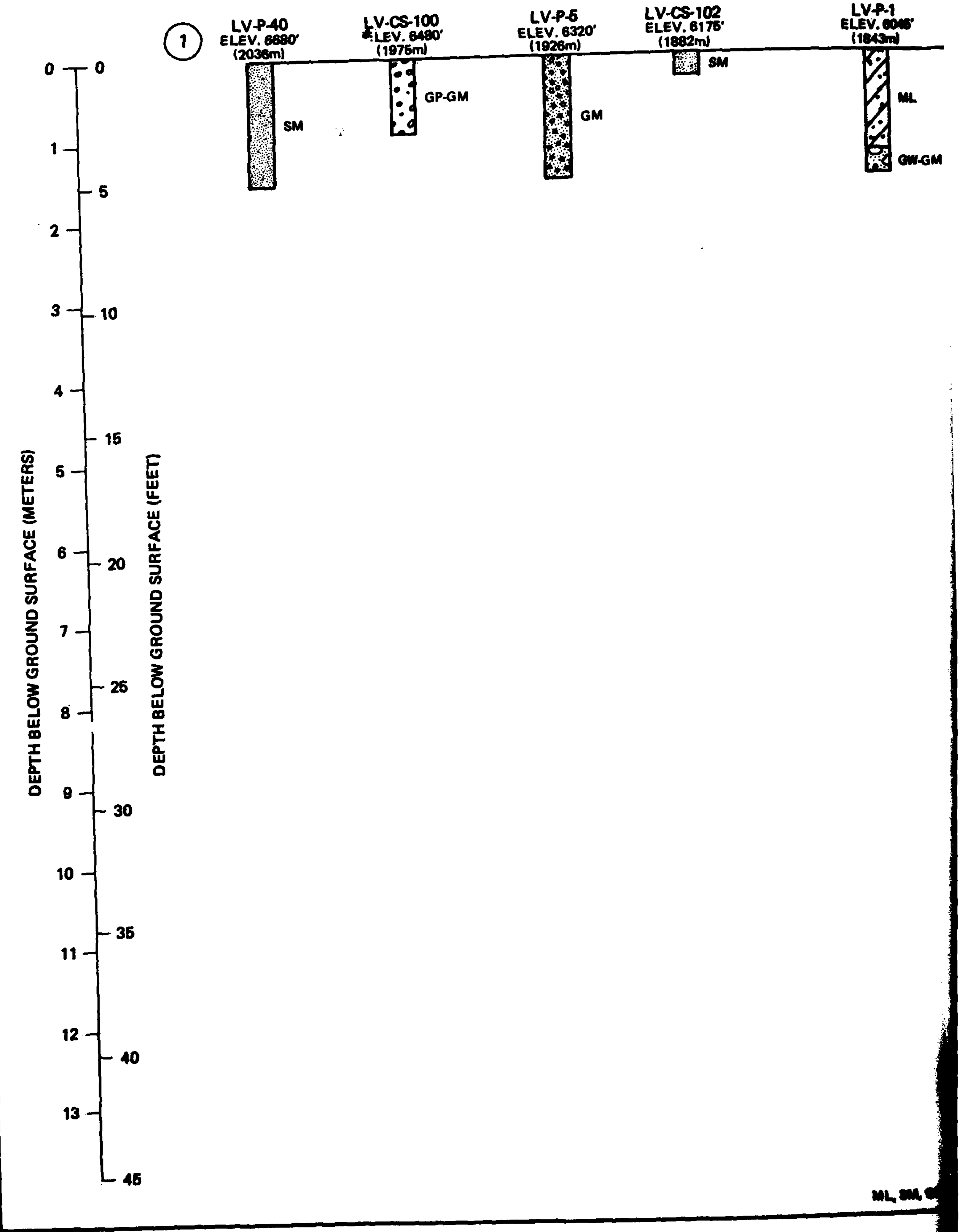
2

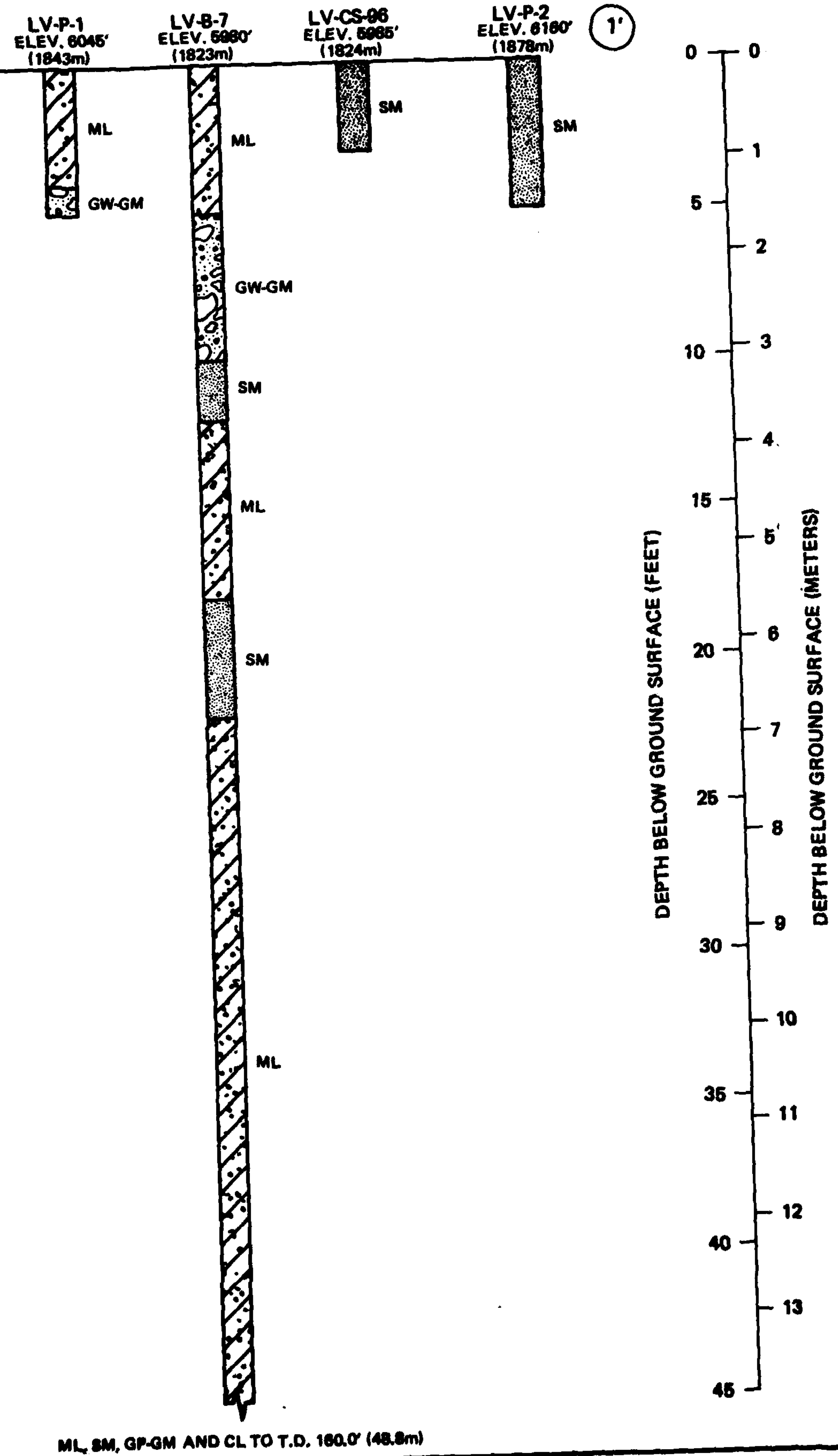
3.4 SUBSURFACE SOILS

Subsurface soils are predominantly coarse-grained (granular) and are estimated to compose 80 to 90 percent of the total area. These soils consist of sandy gravels, gravelly sands, sands, silty sands, and clayey sands. Fine-grained soils are mainly encountered in the lacustrine deposit in the northern portion of the valley. They are also interbedded in the older lacustrine deposit and along a major drainage in the southern portion of the valley. The fine-grained soils consist of sandy silts, clayey silts, silts, sandy clays, and clays with plasticity ranging from nonplastic to highly plastic. Fine-grained soils are estimated to compose 10 to 20 percent of the subsurface deposits within the total area boundaries.

The composition of subsurface soils with depth, as determined from borings, trenches, and test pits, is illustrated in the soil profiles presented in Figures 3-3 through 3-9. Results of seismic and electrical surveys are summarized in Table 3-3. The characteristics of subsurface soils, determined from field and laboratory tests, are presented in Table 3-4. Ranges of gradation of the subsurface soils are shown in Figure 3-10.

Coarse-grained subsurface soils are poorly to well graded, contain coarse to fine sands and gravels, and are dense to very dense below 2 to 3 feet (0.6 to 0.9 m). Variable cementation occurs intermittently, but well-developed, continuous cementation was not encountered. These soils exhibit low compressibilities and moderate to high shear strengths.

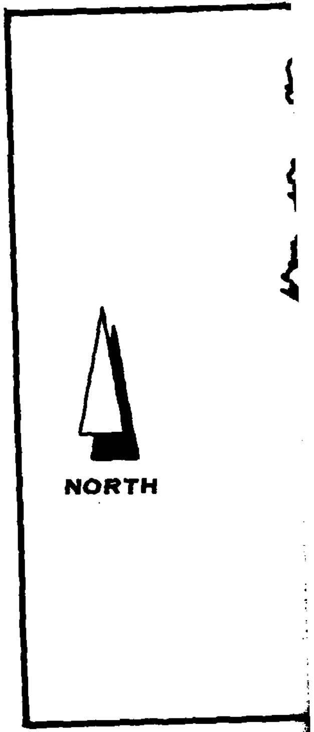

①
LV-P-40
ELEV. 6680'
(2036m)
SM
LV-CS-100
ELEV. 6480'
(1975m)
GP-GM
LV-P-5
ELEV. 6320'
(1926m)
GM
LV-CS-102
ELEV. 6175'
(1882m)
SM
LV-P-1
ELEV. 6045'
(1843m)
ML
GW-GM
DEPTH BELOW GROUND SURFACE (METERS)
DEPTH BELOW GROUND SURFACE (FEET)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
0
5
10
15
20
25
30
35
40
45
ML, SM, G



1

2

LO



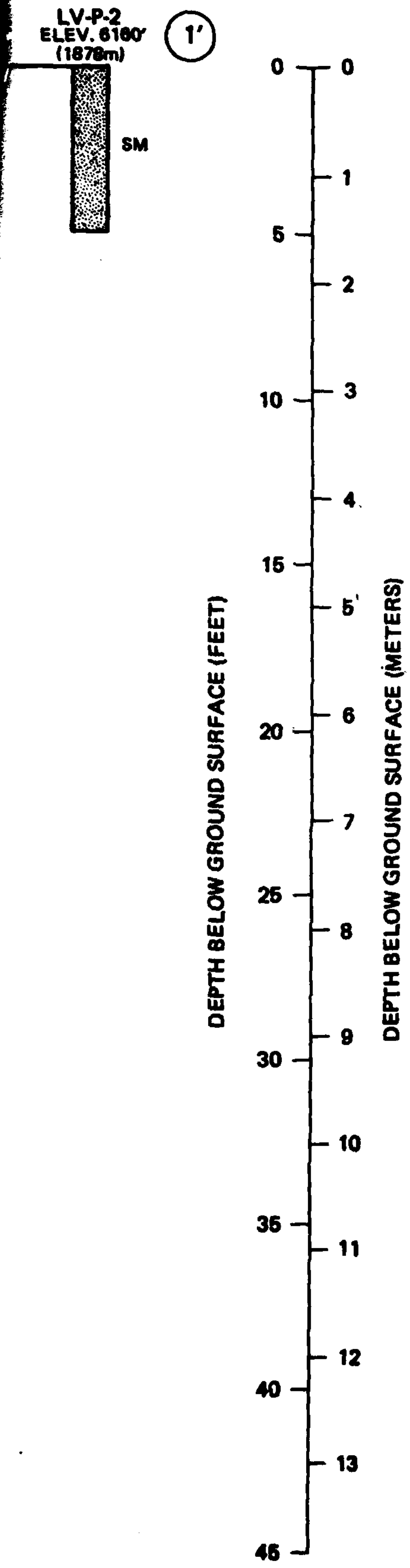
B - Boring
T - Trench
P - Test Pit
CS - Surficial soil sample a

NOTES:

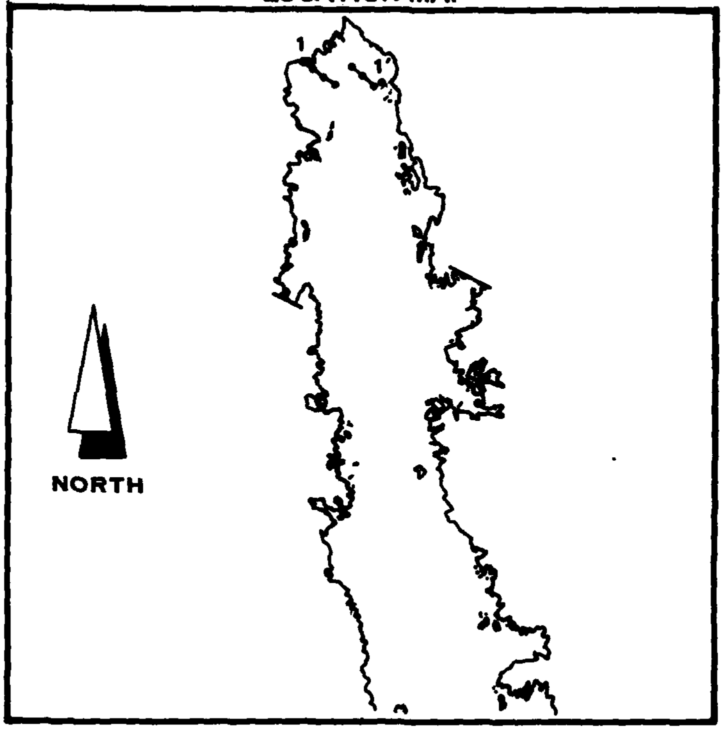
1. Ground surface elevati
2. T. D. - Total Depth.
3. Soil types shown adjac
   Classification System (

STATUTE MILES

KILOMETERS



LOCATION MAP



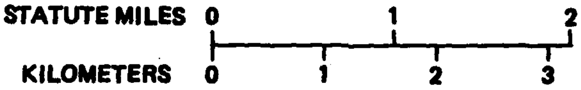
EXPLANATION

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

HORIZONTAL SCALE



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BMO/AFRCE-MX

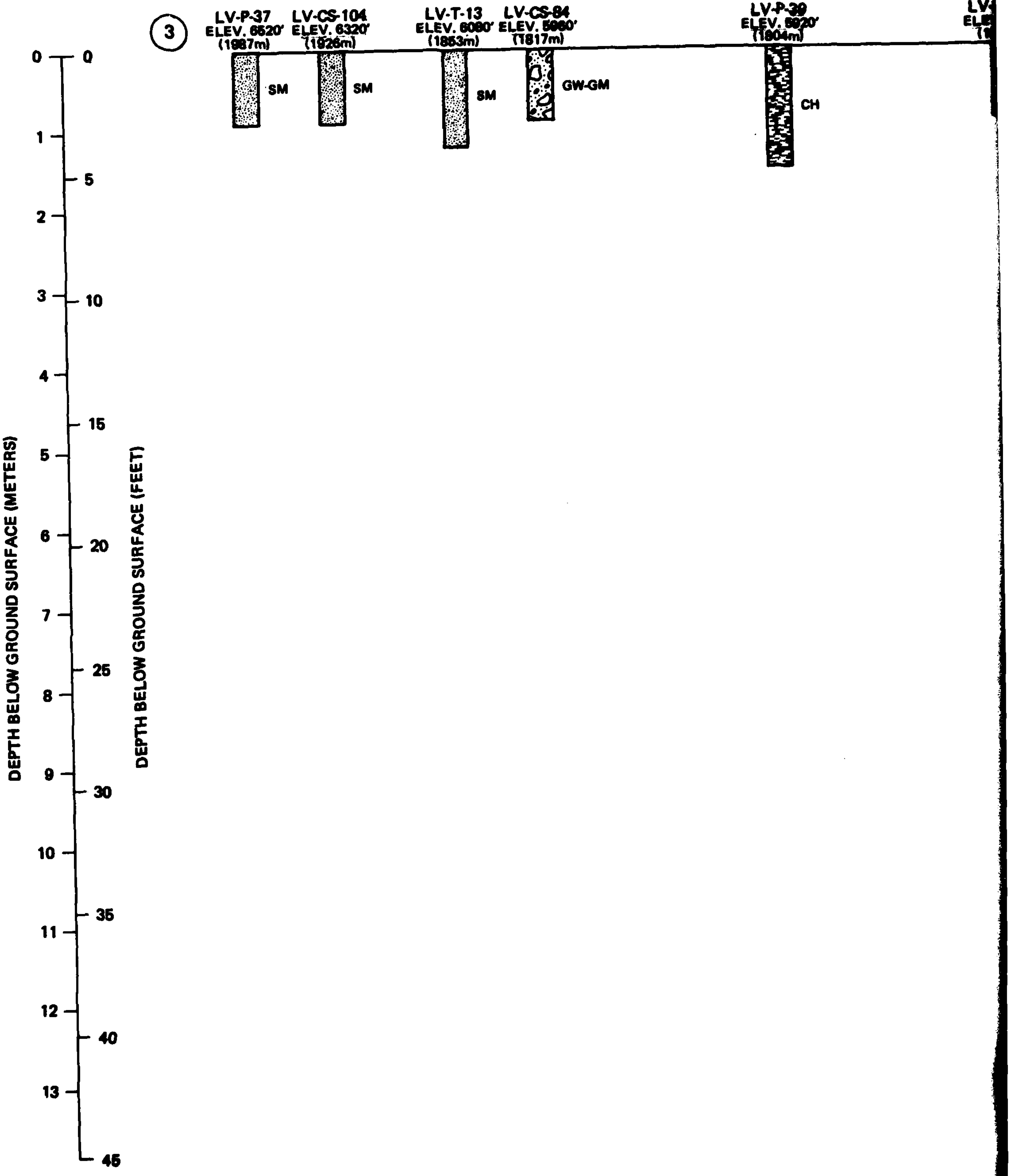
SOIL PROFILE 1 –1'
LAKE VALLEY, NEVADA

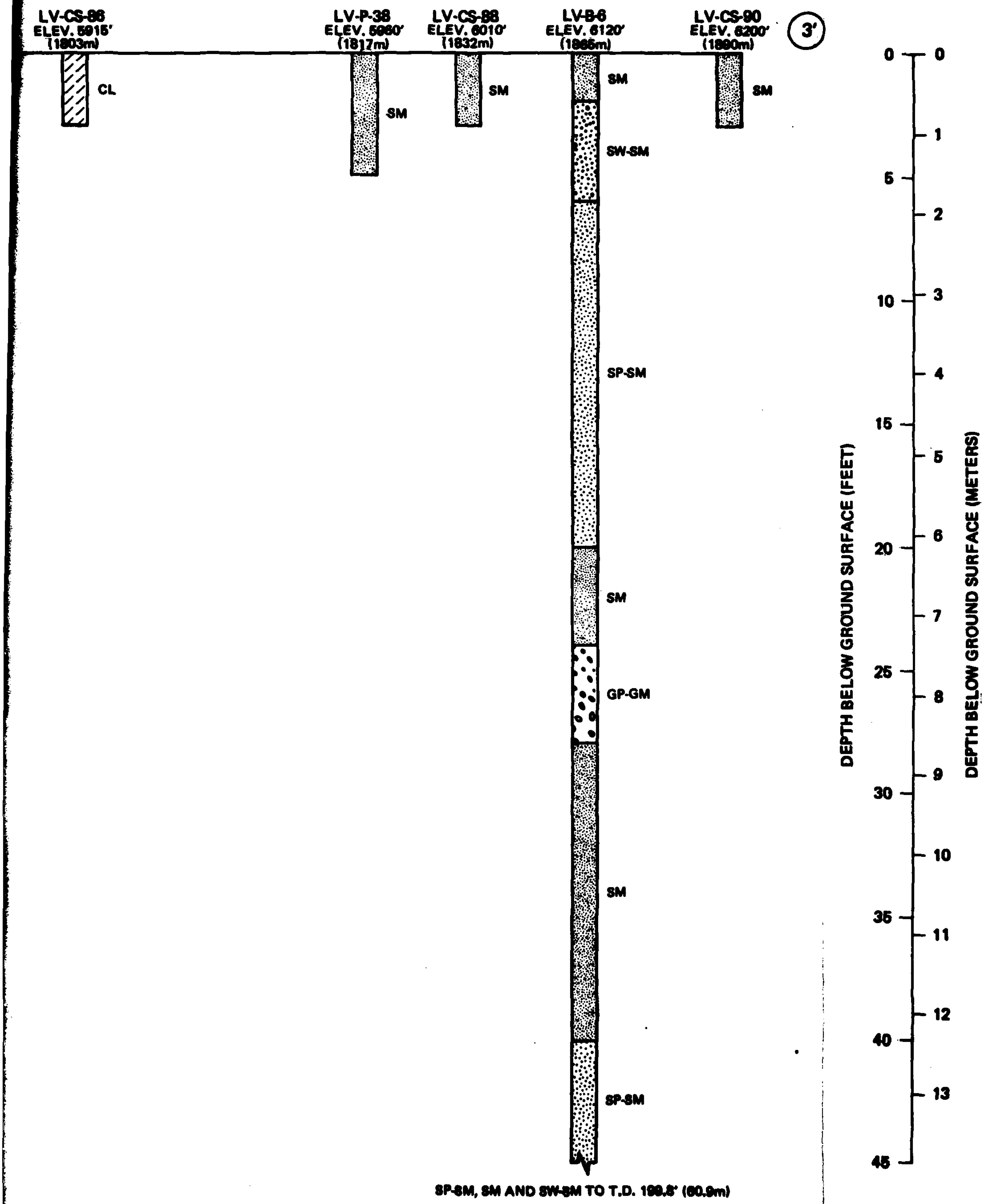
31 JUL 81

FIGURE 3-3

2

3


③
LV-P-37
ELEV. 6520'
(1987m)
SM
LV-CS-104
ELEV. 6320'
(1926m)
SM
LV-T-13
ELEV. 6080'
(1853m)
SM
LV-CS-84
ELEV. 5960'
(1817m)
GW-GM
LV-P-39
ELEV. 5920'
(1804m)
CH
LV
ELE
DEPTH BELOW GROUND SURFACE (METERS)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
DEPTH BELOW GROUND SURFACE (FEET)
0
5
10
15
20
25
30
35
40
45



SP-SM, SM AND SW-SM TO T.D. 199.8' (60.9m)

B - Borin
T - Tren
P - Test
CS - Sur

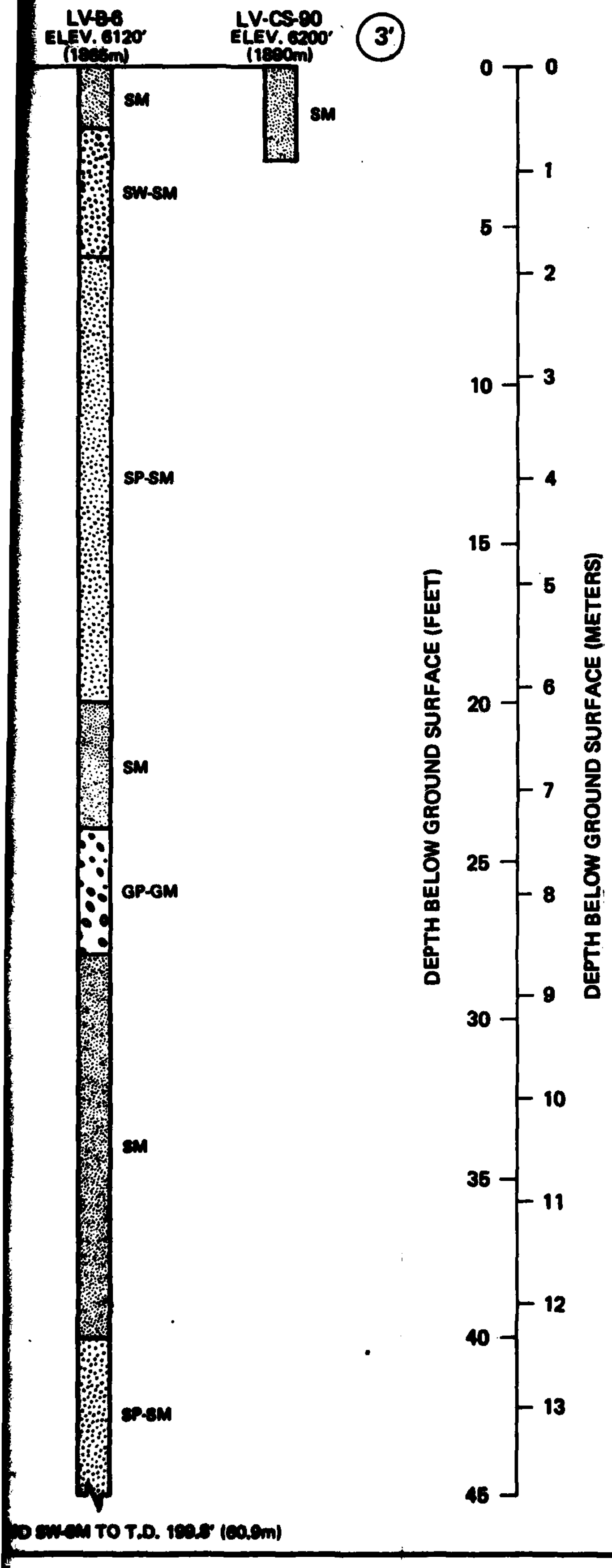
NOTES:

1. Grou
2. T.D.
3. Soil
Clas

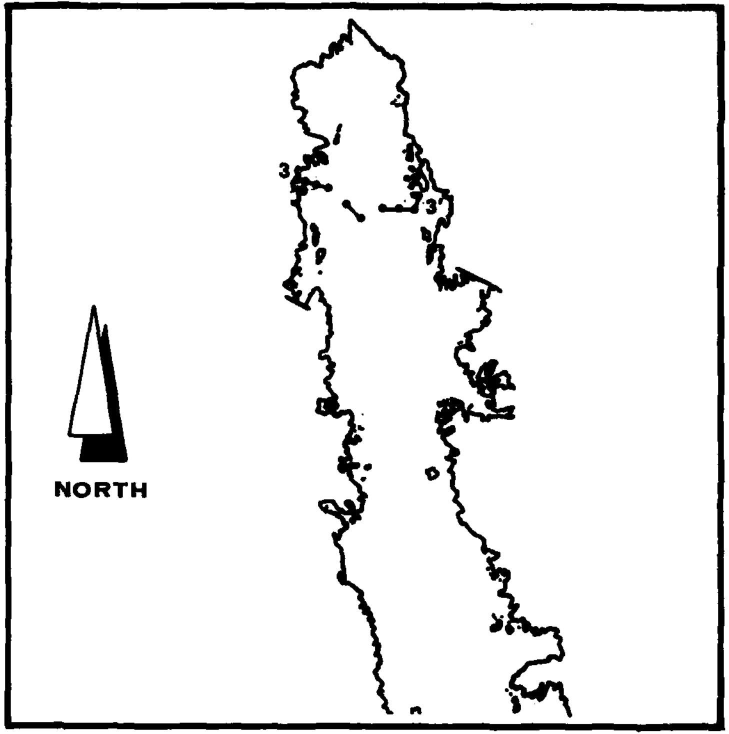
STAT

KIL

2



LOCATION MAP



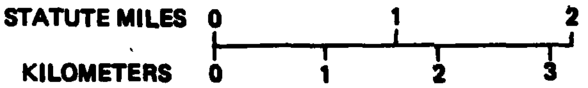
EXPLANATION

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

HORIZONTAL SCALE



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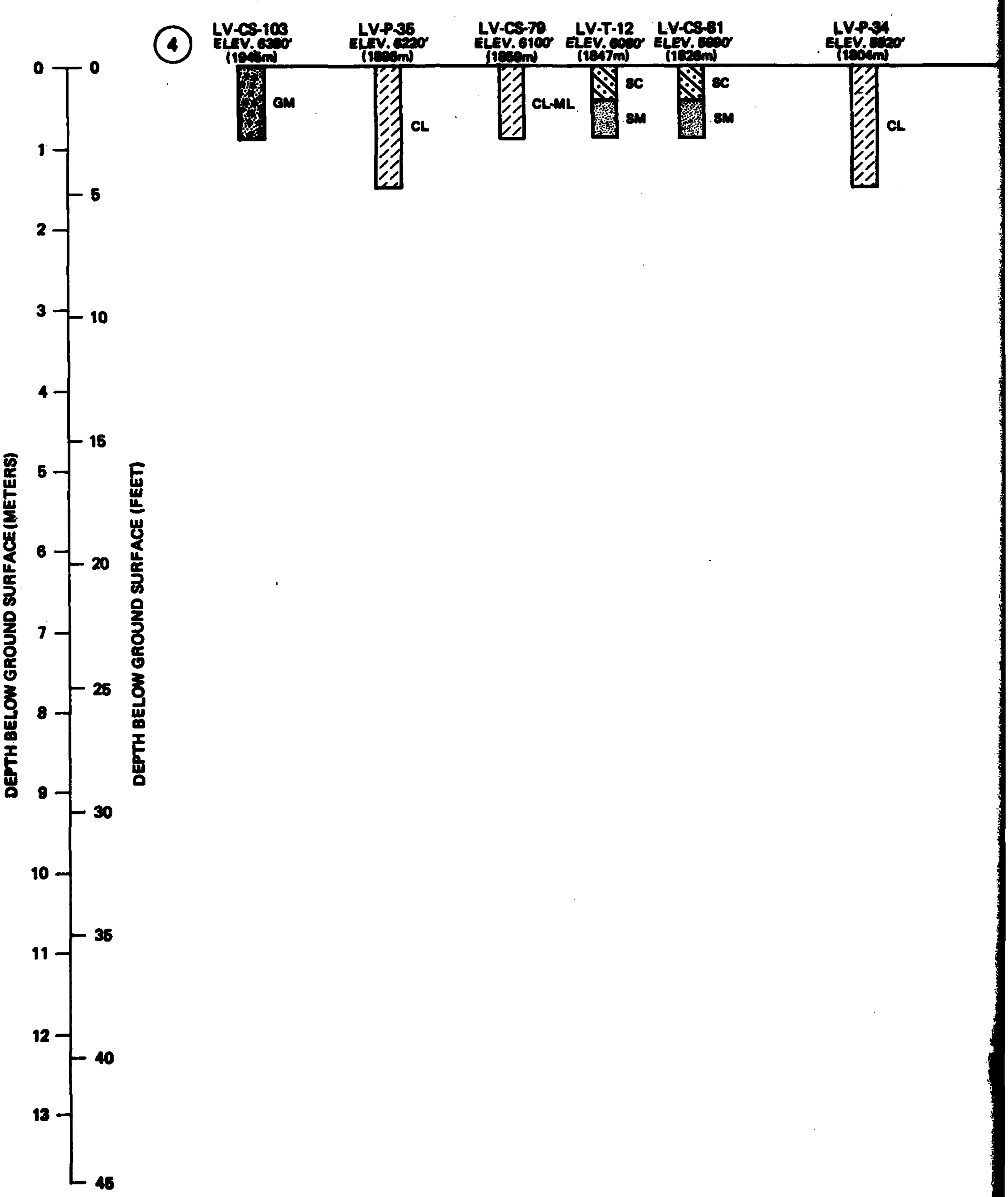
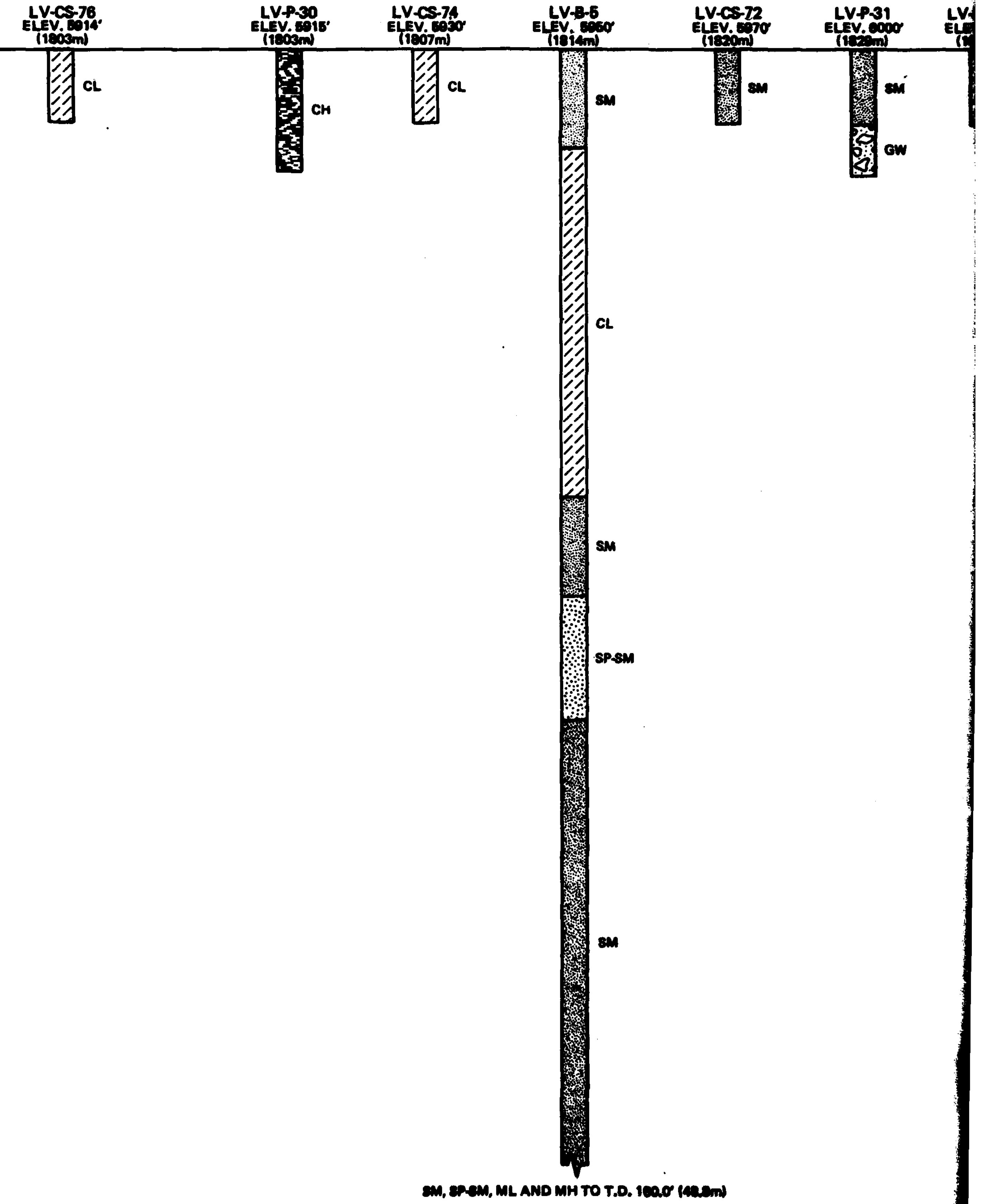
SOIL PROFILE 3 – 3'
LAKE VALLEY, NEVADA

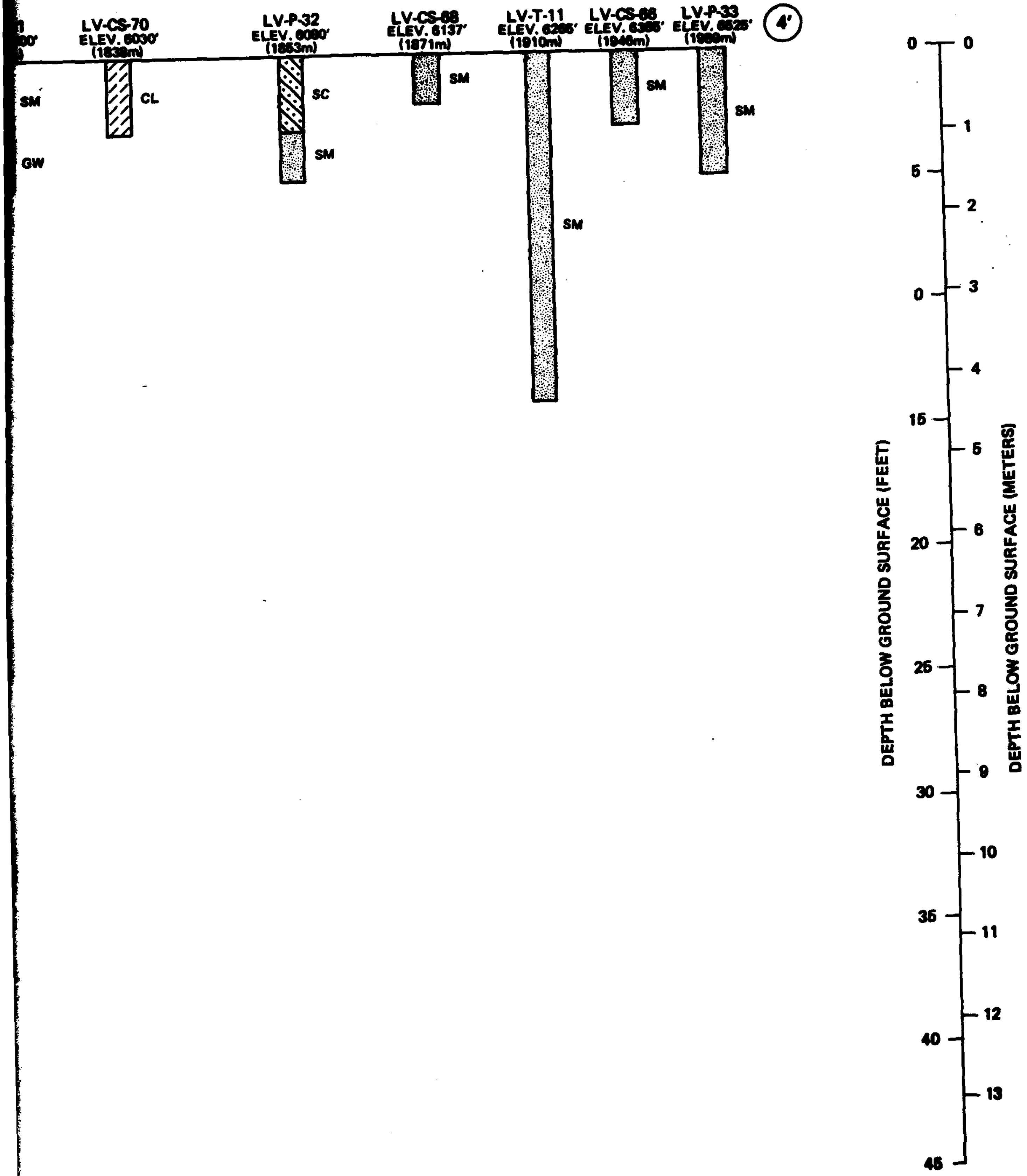
31 JUL 81

FIGURE 3-4


④
LV-CS-103
ELEV. 6380'
(1945m)
GM
LV-P-35
ELEV. 6220'
(1896m)
CL
LV-CS-79
ELEV. 6100'
(1859m)
CL-ML
LV-T-12
ELEV. 6060'
(1847m)
SC
SM
LV-CS-81
ELEV. 5990'
(1826m)
SC
SM
LV-P-34
ELEV. 5920'
(1804m)
CL
DEPTH BELOW GROUND SURFACE (METERS)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
DEPTH BELOW GROUND SURFACE (FEET)
0
5
10
15
20
25
30
35
40
45

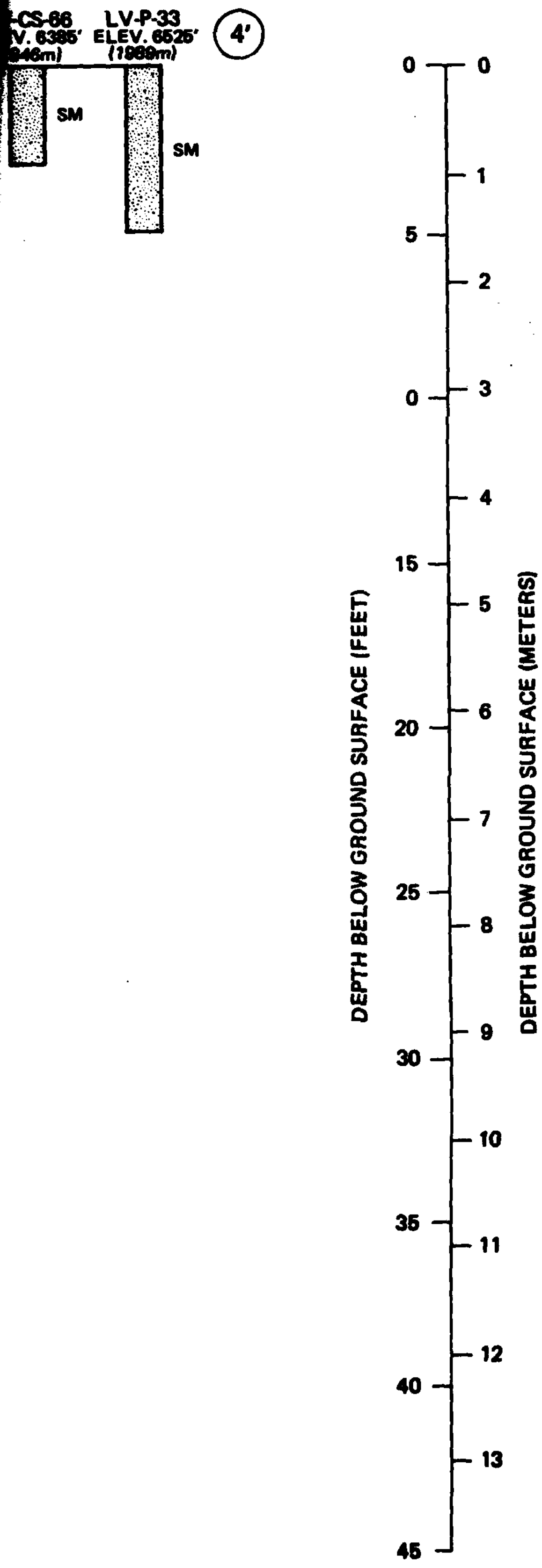

LV-CS-76
ELEV. 5914'
(1803m)
CL
LV-P-30
ELEV. 5915'
(1803m)
CH
LV-CS-74
ELEV. 5930'
(1807m)
CL
LV-B-5
ELEV. 5950'
(1814m)
SM
CL
SM
SP-SM
SM
SM, SP-SM, ML AND MH TO T.D. 160.0' (48.8m)
LV-CS-72
ELEV. 5970'
(1820m)
SM
LV-P-31
ELEV. 6000'
(1829m)
SM
GW
LV
ELE
(1

2

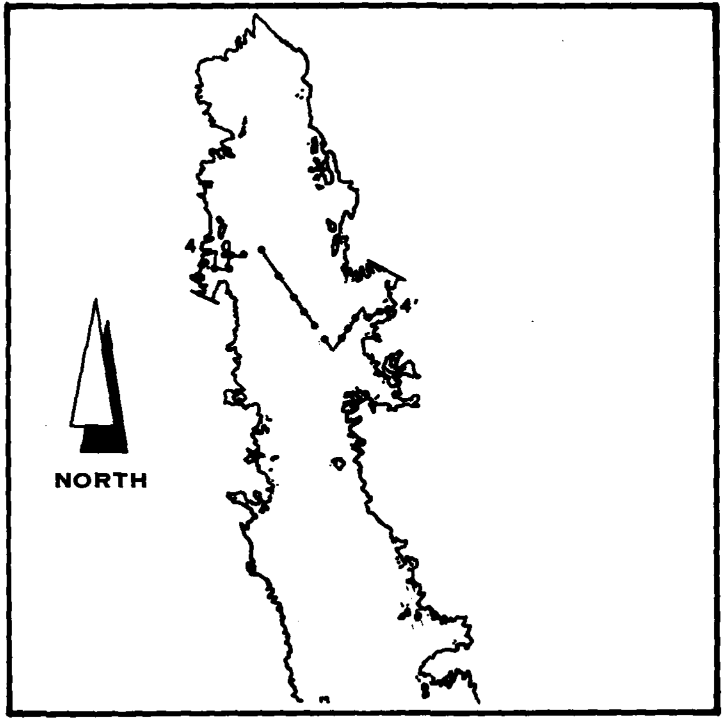


00'
SM
GW
LV-CS-70
ELEV. 6030'
(1838m)
CL
LV-P-32
ELEV. 6080'
(1853m)
SC
SM
LV-CS-68
ELEV. 6137'
(1871m)
SM
LV-T-11
ELEV. 6266'
(1910m)
SM
LV-CS-66
ELEV. 6385'
(1946m)
SM
LV-P-33
ELEV. 6525'
(1989m)
SM
4'
0
5
0
15
20
25
30
35
40
45
0
1
2
3
4
5
6
7
8
9
10
11
12
13
DEPTH BELOW GROUND SURFACE (FEET)
DEPTH BELOW GROUND SURFACE (METERS)

3



LOCATION MAP



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

HORIZONTAL SCALE

STATUTE MILES 0 1 2
KILOMETERS 0 1 2 3

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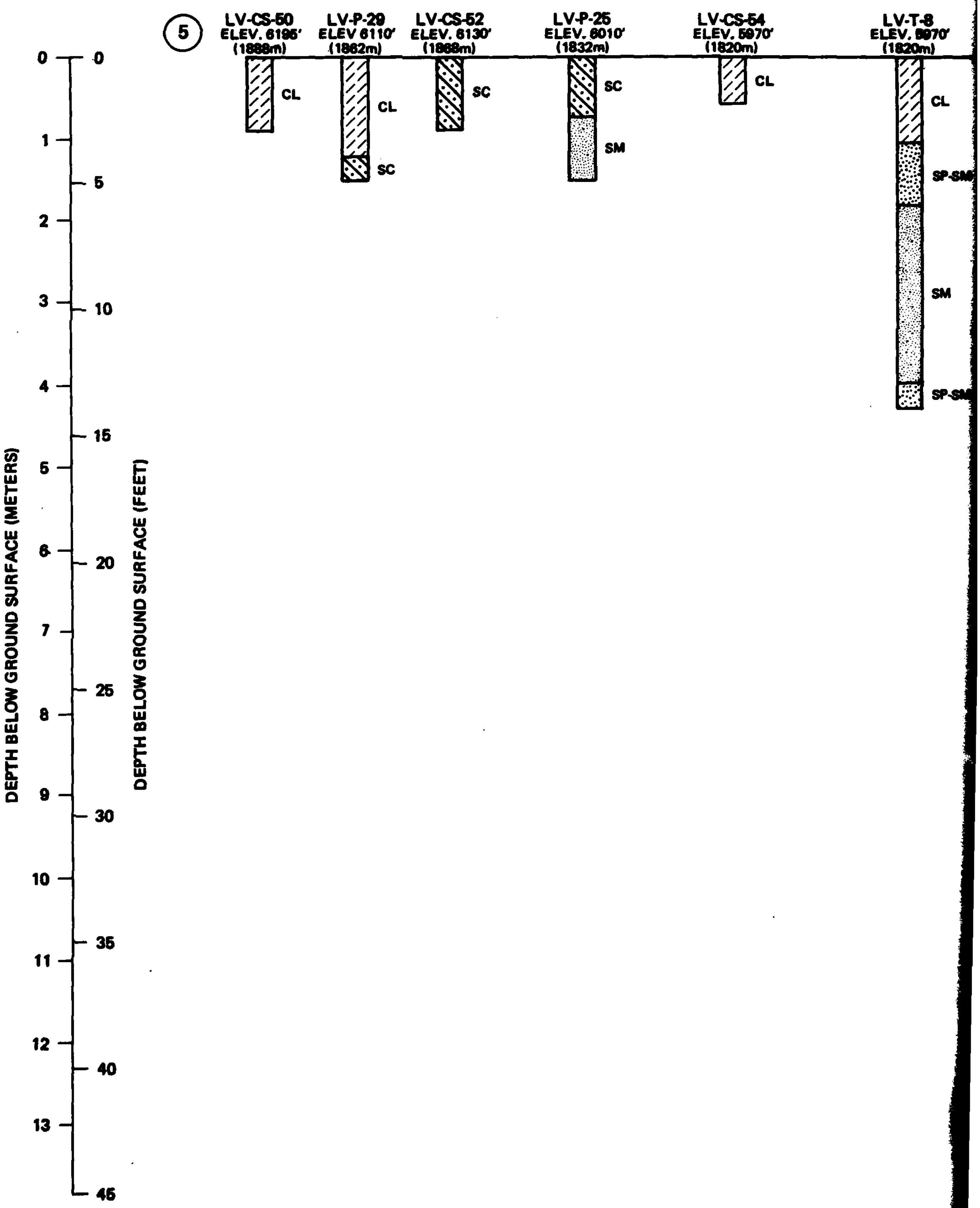
BMO/AFRCE-MX

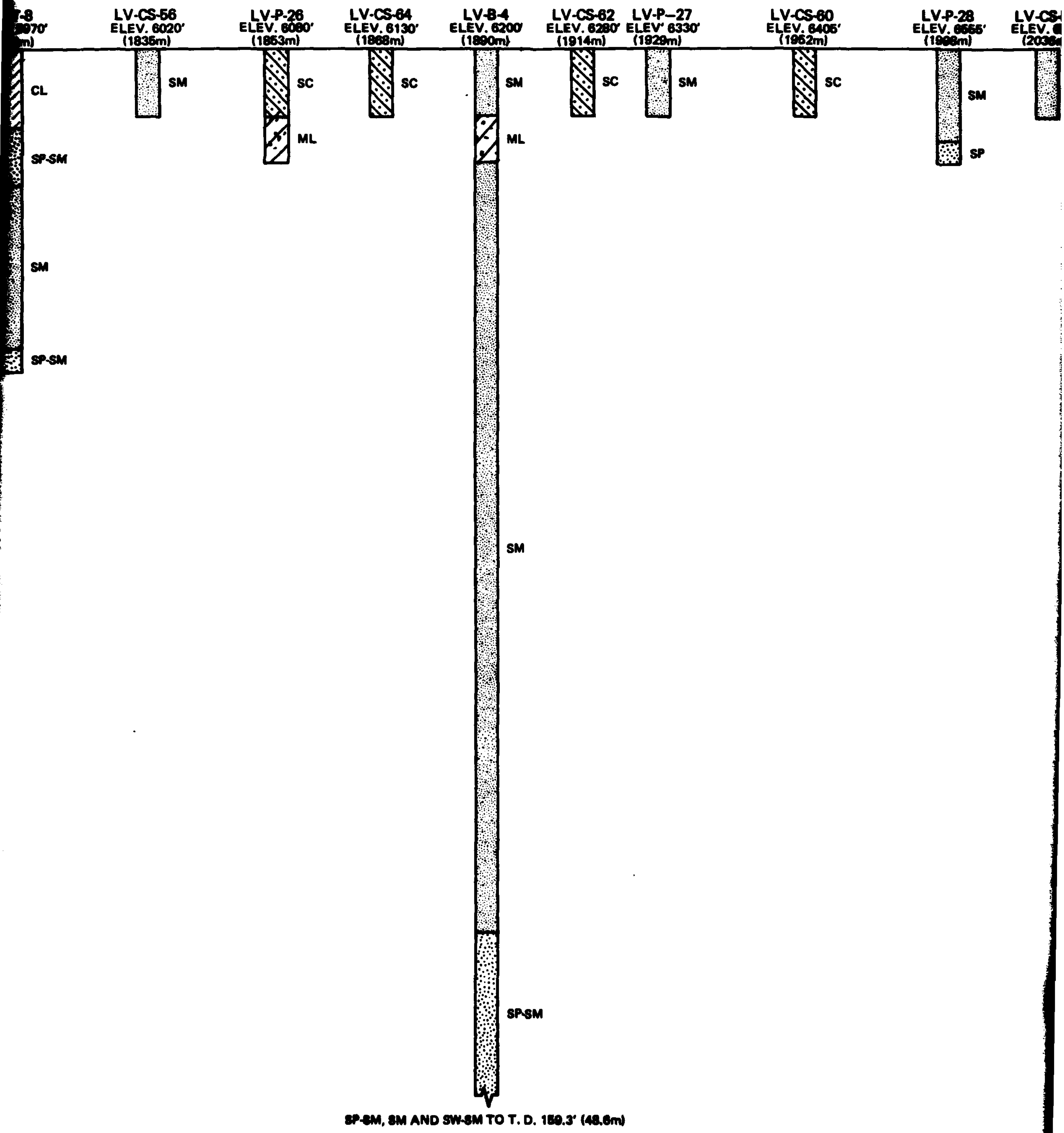
SOIL PROFILE 4 –4'
LAKE VALLEY, NEVADA

31 JUL 81

FIGURE 3-6

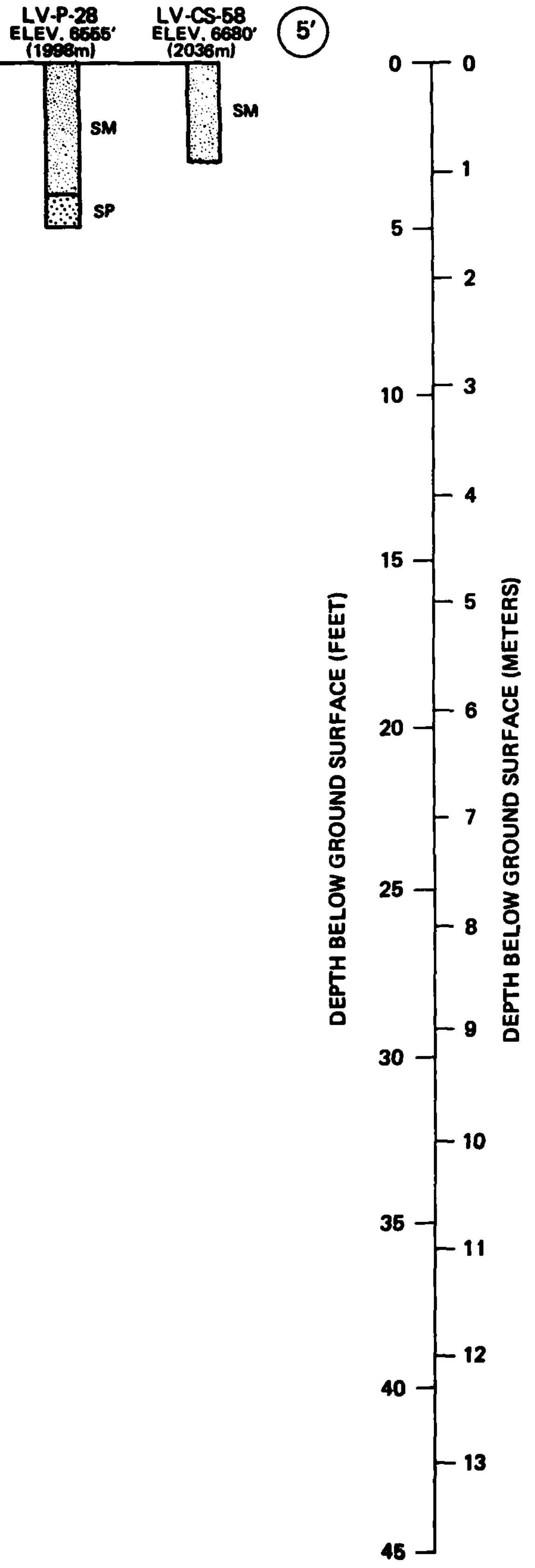
3


⑤
LV-CS-50
ELEV. 6195'
(1888m)
LV-P-29
ELEV 6110'
(1862m)
LV-CS-52
ELEV. 6130'
(1868m)
LV-P-25
ELEV. 6010'
(1832m)
LV-CS-54
ELEV. 5970'
(1820m)
LV-T-8
ELEV. 5970'
(1820m)
CL
CL
SC
SC
SC
SM
CL
CL
SP-SM
SM
SP-SM
DEPTH BELOW GROUND SURFACE (METERS)
DEPTH BELOW GROUND SURFACE (FEET)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
0
5
10
15
20
25
30
35
40
45

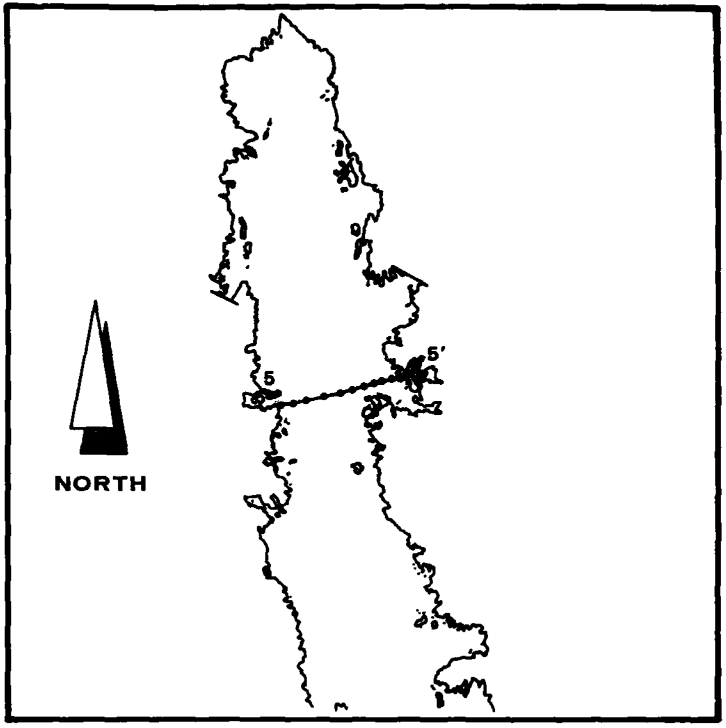


-8
970'
m)
CL
SP-SM
SM
SP-SM
LV-CS-56
ELEV. 6020'
(1835m)
SM
LV-P-26
ELEV. 6080'
(1853m)
SC
ML
LV-CS-64
ELEV. 6130'
(1868m)
SC
LV-B-4
ELEV. 6200'
(1890m)
SM
ML
SM
SP-SM
LV-CS-62
ELEV. 6280'
(1914m)
SC
LV-P-27
ELEV' 6330'
(1929m)
SM
LV-CS-60
ELEV. 6405'
(1952m)
SC
LV-P-28
ELEV. 6555'
(1998m)
SM
SP
LV-CS-
ELEV.
(2036
SP-SM, SM AND SW-SM TO T. D. 159.3' (48.6m)

2



LOCATION MAP



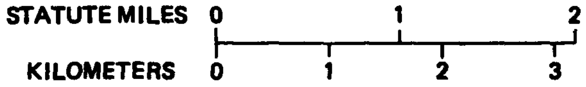
EXPLANATION

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

HORIZONTAL SCALE



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BMO/AFRCE-MX

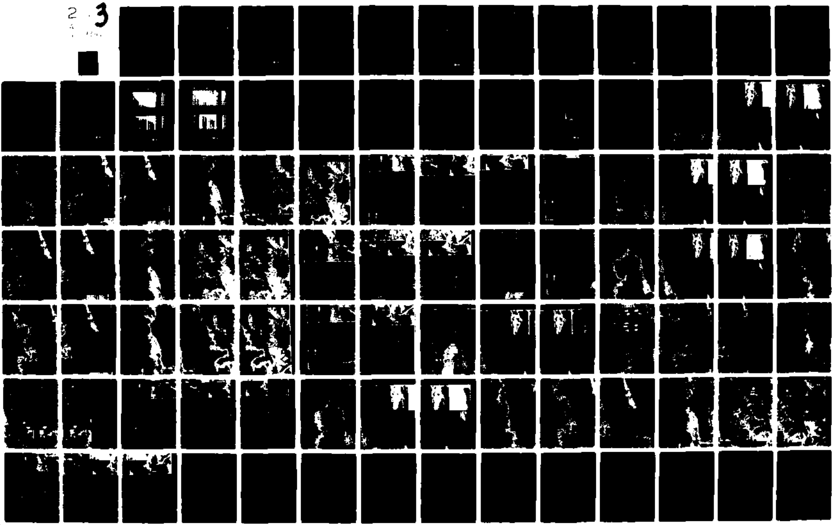
SOIL PROFILE 5 – 5'
LAKE VALLEY, NEVADA

31 JUL 81

FIGURE 3-6

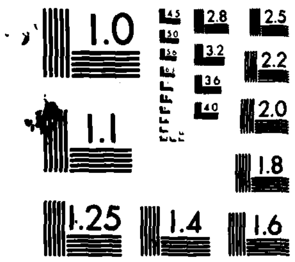
AD-A113 001 ERTEC WESTERN INC LONG BEACH CA F/G 13/2
MX SITING INVESTIGATION. GEOTECHNICAL EVALUATION. VERIFICATION --ETC(U)
JUL 81 F04704-80-C-0006
UNCLASSIFIED E-TR-27-LV-1 NL

2 3

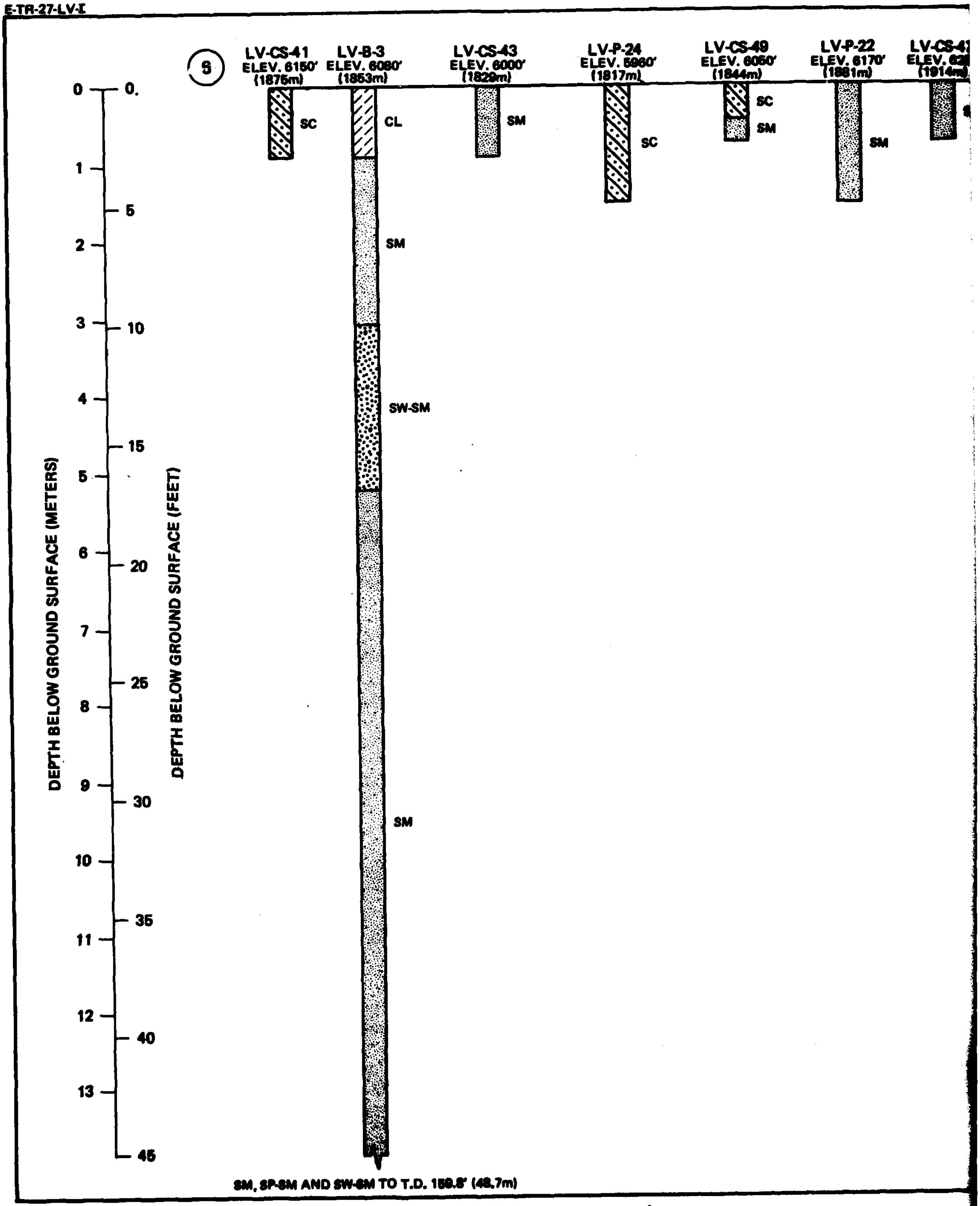


2 OF 3

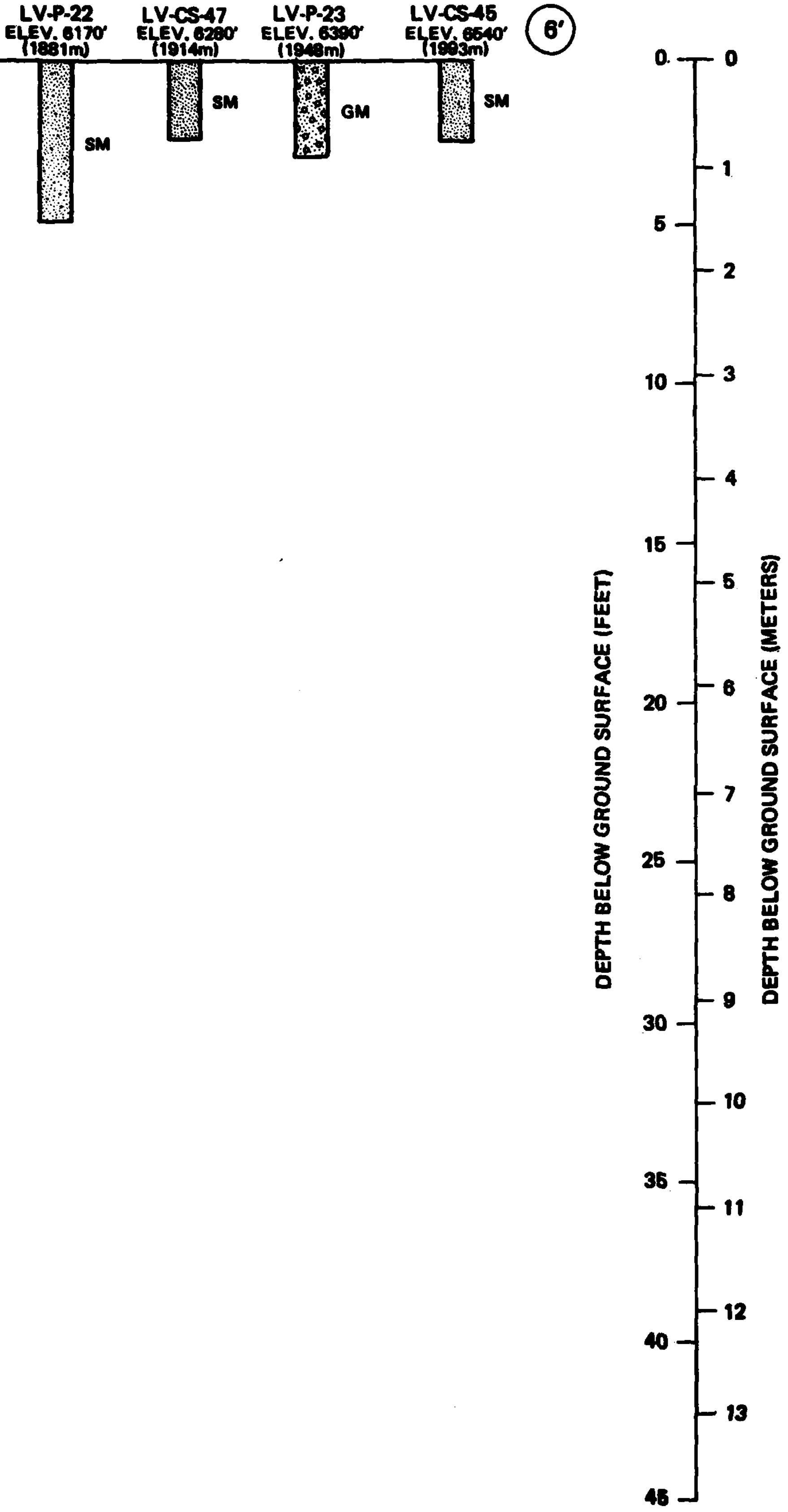
AD-
A113001



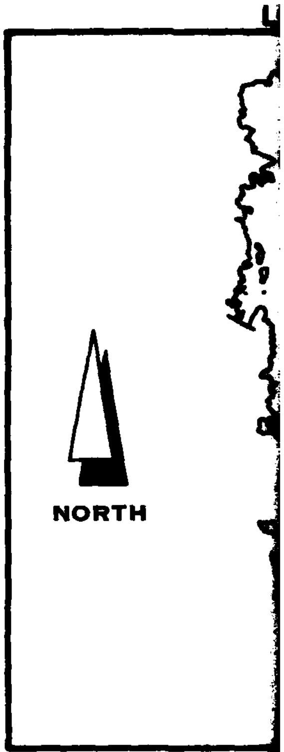
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A



SM, SP-SM AND SW-SM TO T.D. 159.8' (48.7m)



L



B - Boring
T - Trench
P - Test Pit
CS - Surficial soil sample

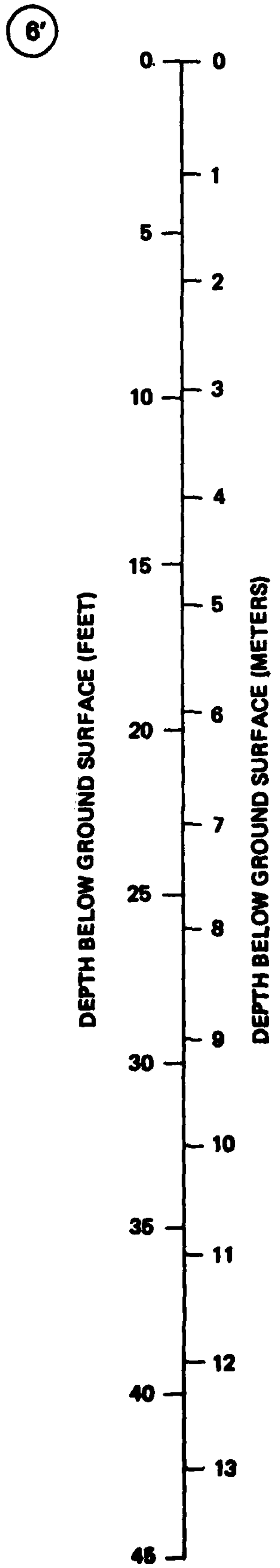
NOTES:

1. Ground surface eleva
2. T. D. - Total Depth.
3. Soil types shown adj
   Classification System

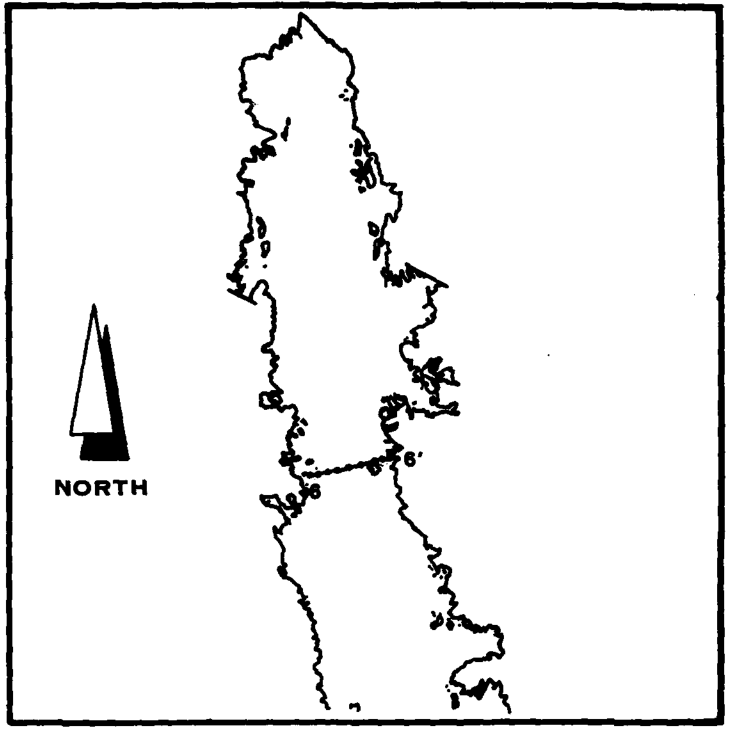
STATUTE MILES

KILOMETERS

2



LOCATION MAP



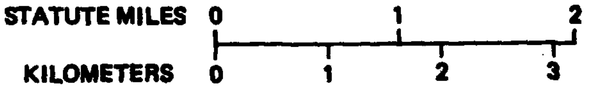
EXPLANATION

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

HORIZONTAL SCALE



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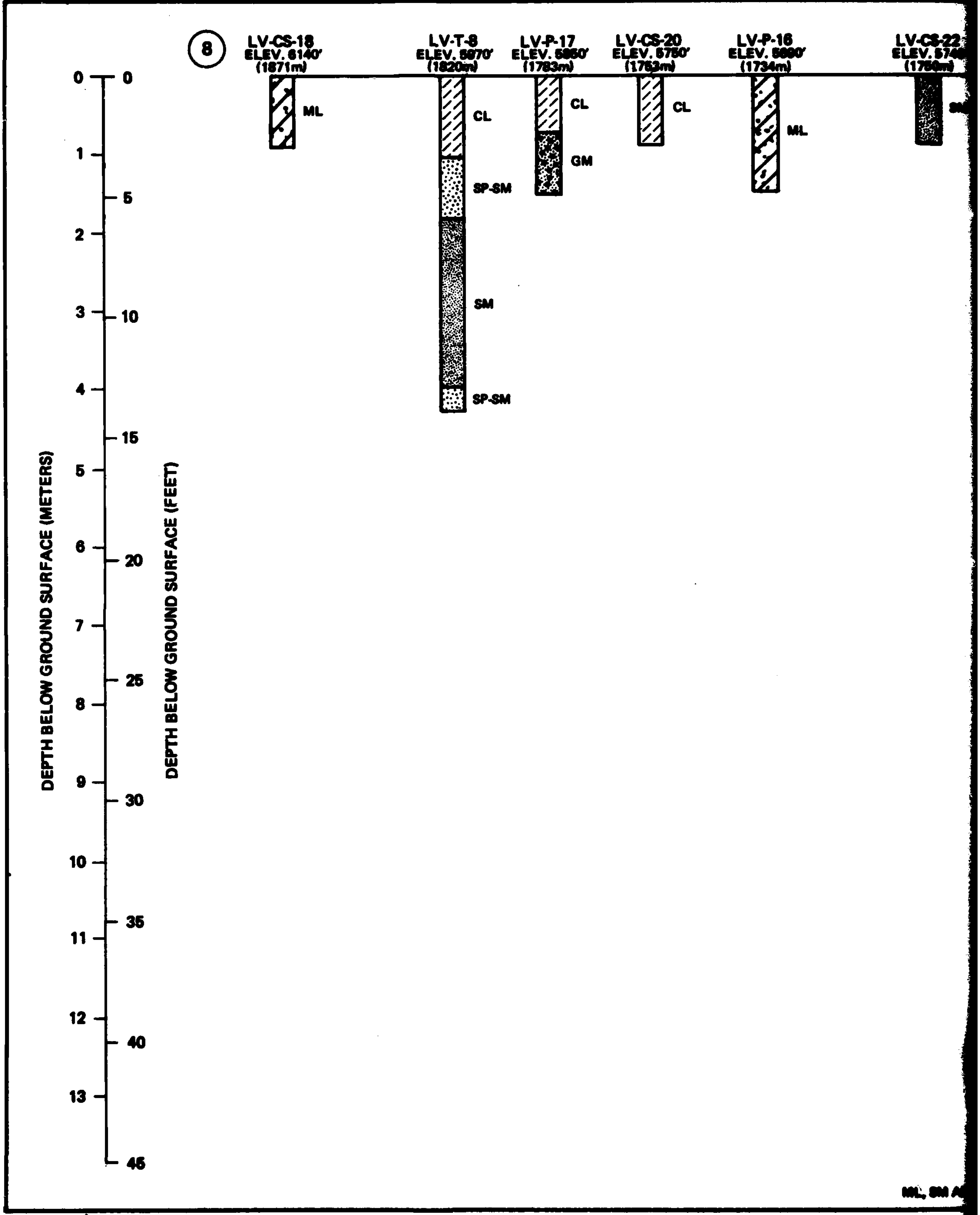
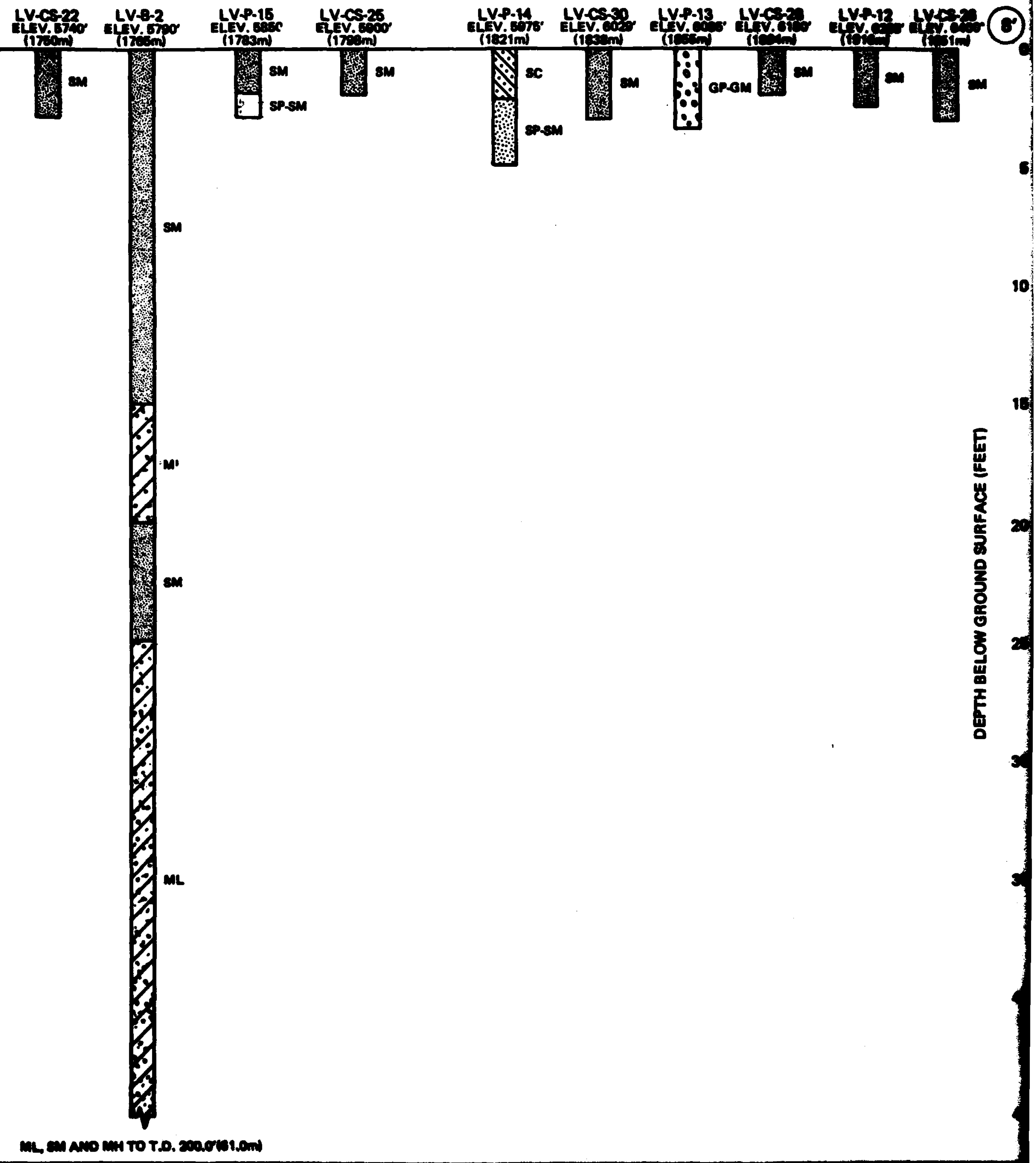
SOIL PROFILE 6 – 6'
LAKE VALLEY, NEVADA

31 JUL 81

FIGURE 3-7

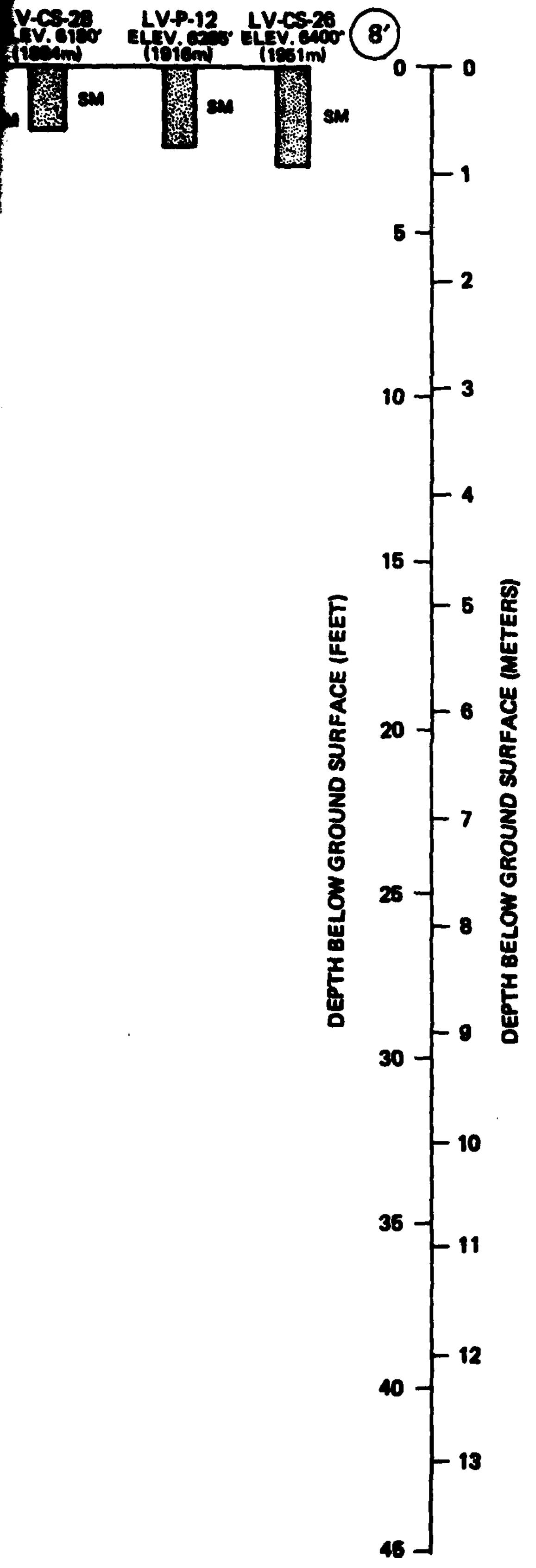
2


8
LV-CS-18
ELEV. 6140'
(1871m)
LV-T-8
ELEV. 5970'
(1820m)
LV-P-17
ELEV. 5850'
(1783m)
LV-CS-20
ELEV. 5750'
(1753m)
LV-P-16
ELEV. 5690'
(1734m)
LV-CS-22
ELEV. 574
(1750m)
ML
CL
SP-SM
SM
SP-SM
CL
GM
CL
ML
0
1
2
3
4
5
6
7
8
9
10
11
12
13
0
5
10
15
20
25
30
35
40
45
DEPTH BELOW GROUND SURFACE (METERS)
DEPTH BELOW GROUND SURFACE (FEET)
ML, SM A

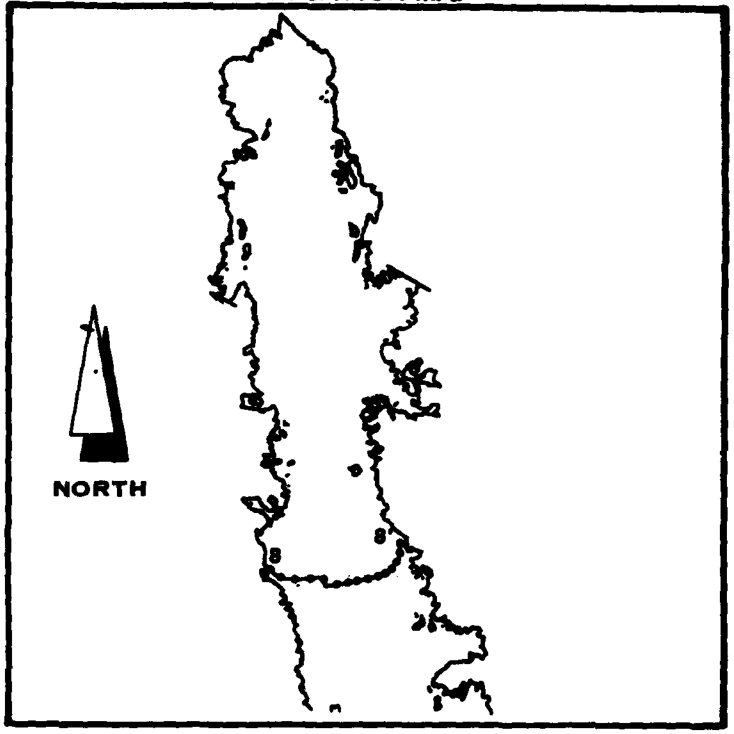


ML, SM AND MH TO T.D. 200.0'(61.0m)

2



LOCATION MAP



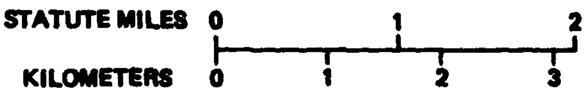
EXPLANATION

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

HORIZONTAL SCALE



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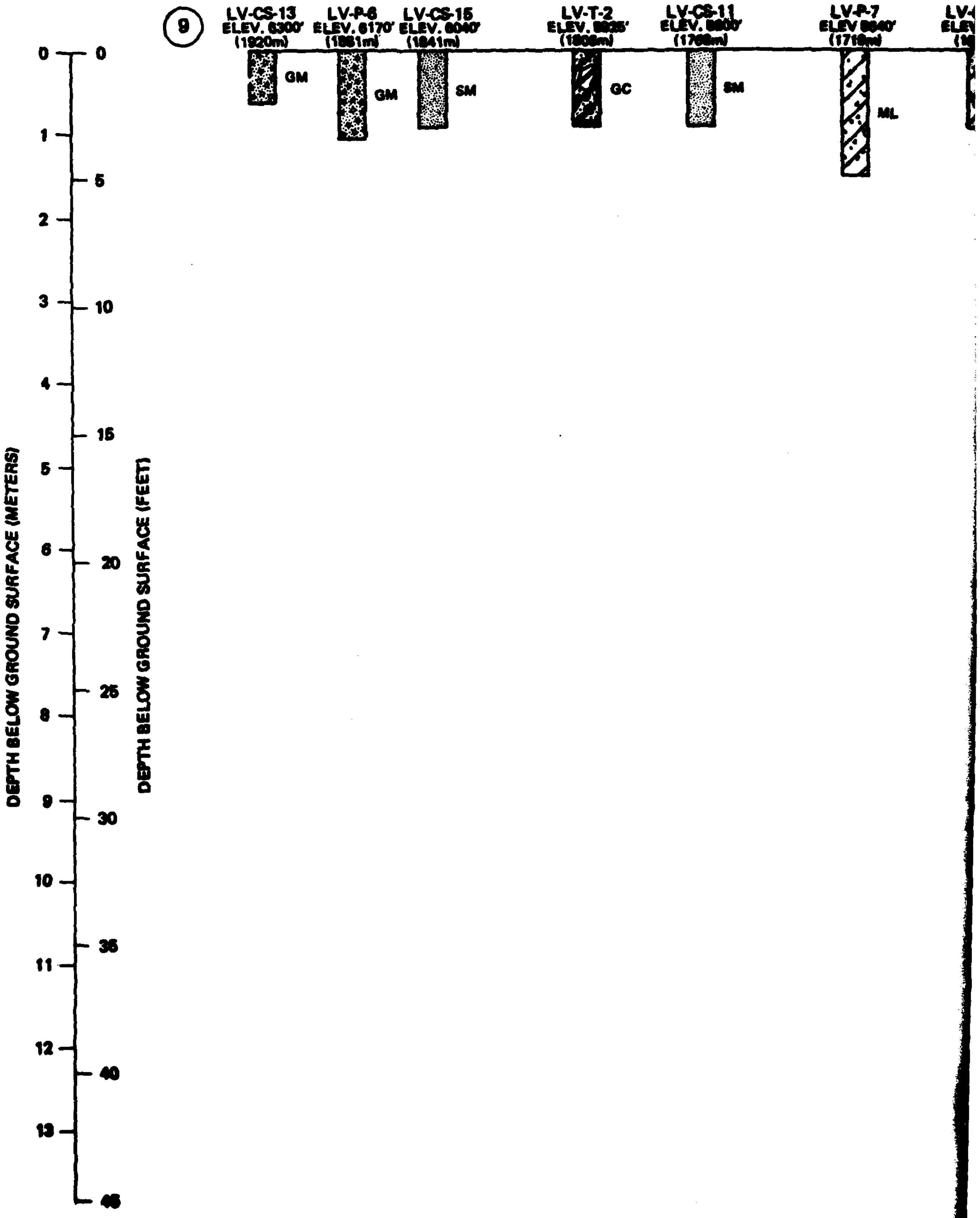
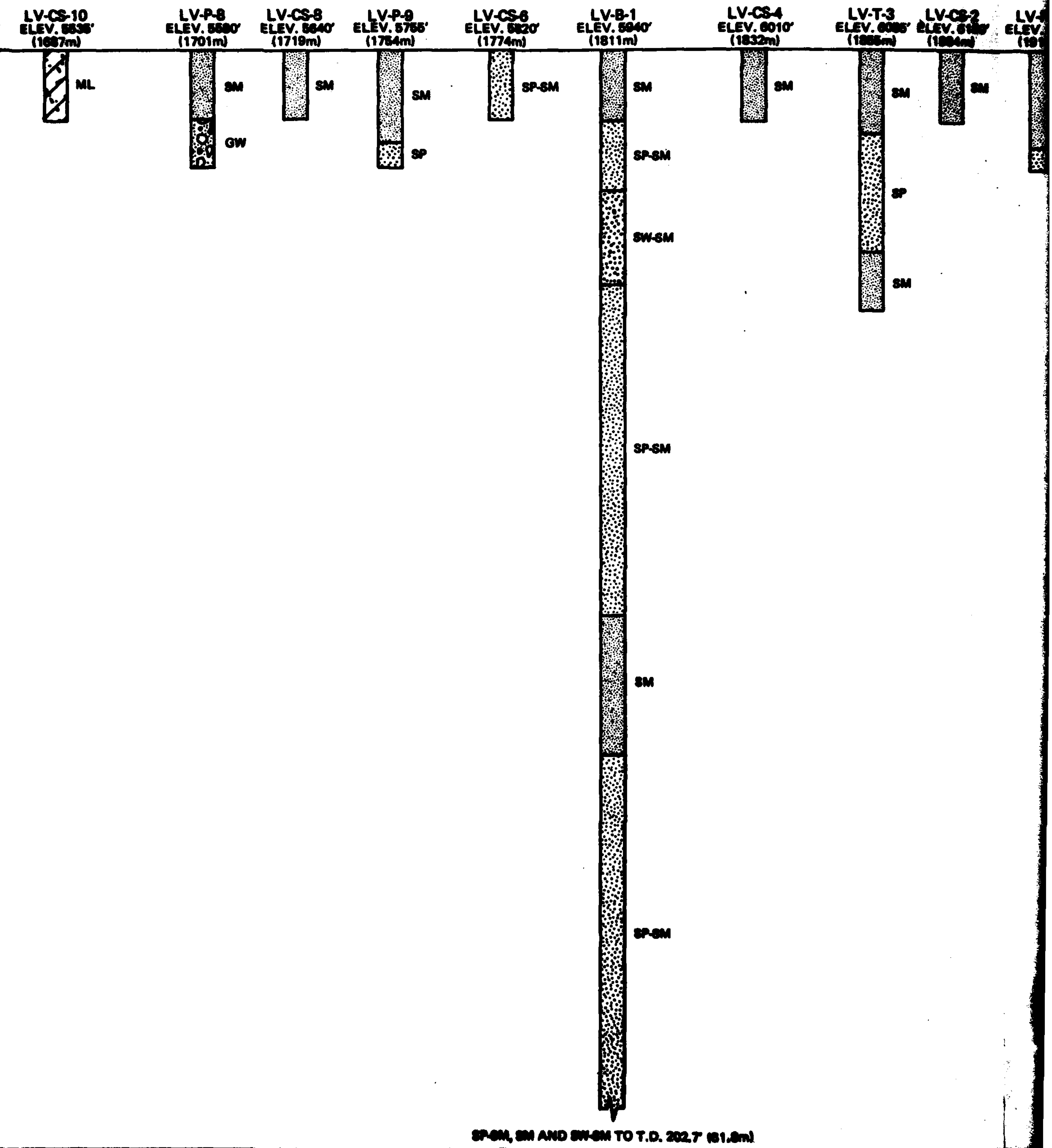
SOIL PROFILE 8 – 8'
LAKE VALLEY, NEVADA

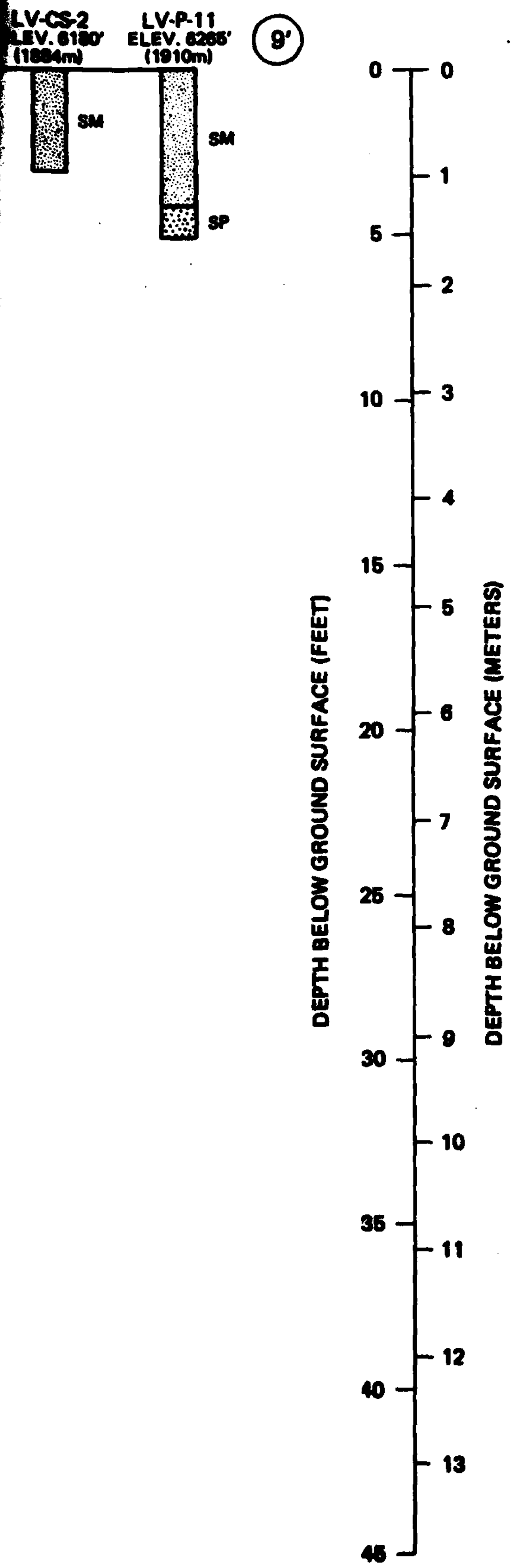
31 JUL 81

FIGURE 3-8

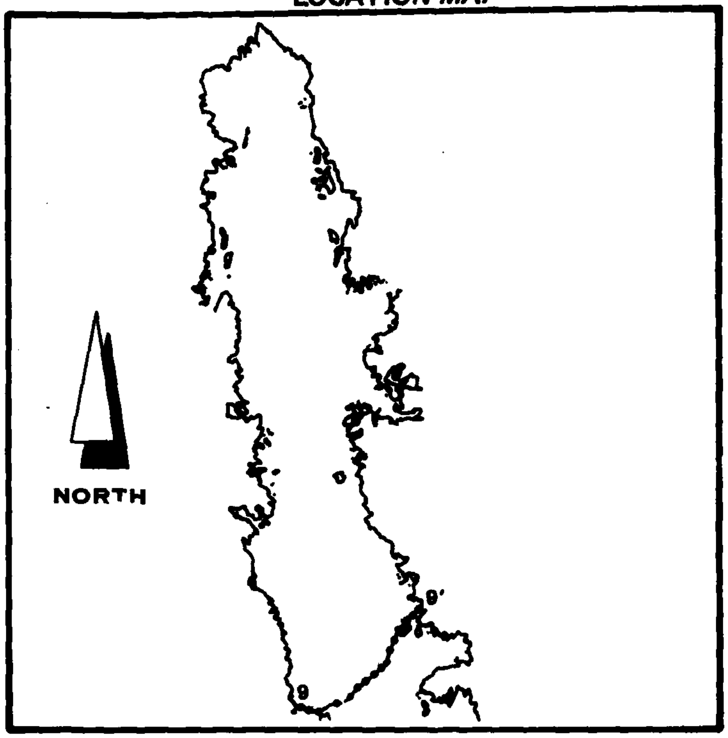

9
LV-CS-13
ELEV. 6300'
(1920m)
LV-P-6
ELEV. 6170'
(1881m)
LV-CS-15
ELEV. 6040'
(1841m)
LV-T-2
ELEV. 5925'
(1806m)
LV-CS-11
ELEV. 5800'
(1768m)
LV-P-7
ELEV 5640'
(1719m)
GM
GM
SM
GC
SM
ML
DEPTH BELOW GROUND SURFACE (METERS)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
DEPTH BELOW GROUND SURFACE (FEET)
0
5
10
15
20
25
30
35
40
45


LV-CS-10
ELEV. 5535'
(1687m)
ML
LV-P-8
ELEV. 5580'
(1701m)
SM
GW
LV-CS-8
ELEV. 5640'
(1719m)
SM
LV-P-9
ELEV. 5755'
(1754m)
SM
SP
LV-CS-6
ELEV. 5820'
(1774m)
SP-SM
LV-B-1
ELEV. 5940'
(1811m)
SM
SP-SM
SW-SM
SP-SM
SM
SP-SM
SP-SM, SM AND SW-SM TO T.D. 202.7' (61.8m)
LV-CS-4
ELEV. 6010'
(1832m)
SM
LV-T-3
ELEV. 6085'
(1855m)
SM
SP
SM
LV-CS-2
ELEV. 61[illegible]'
(1864m)
SM
LV-
ELEV.
(19

2



LOCATION MAP



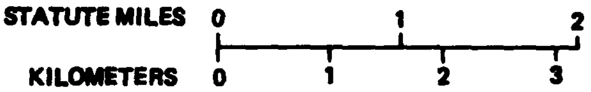
EXPLANATION

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

HORIZONTAL SCALE



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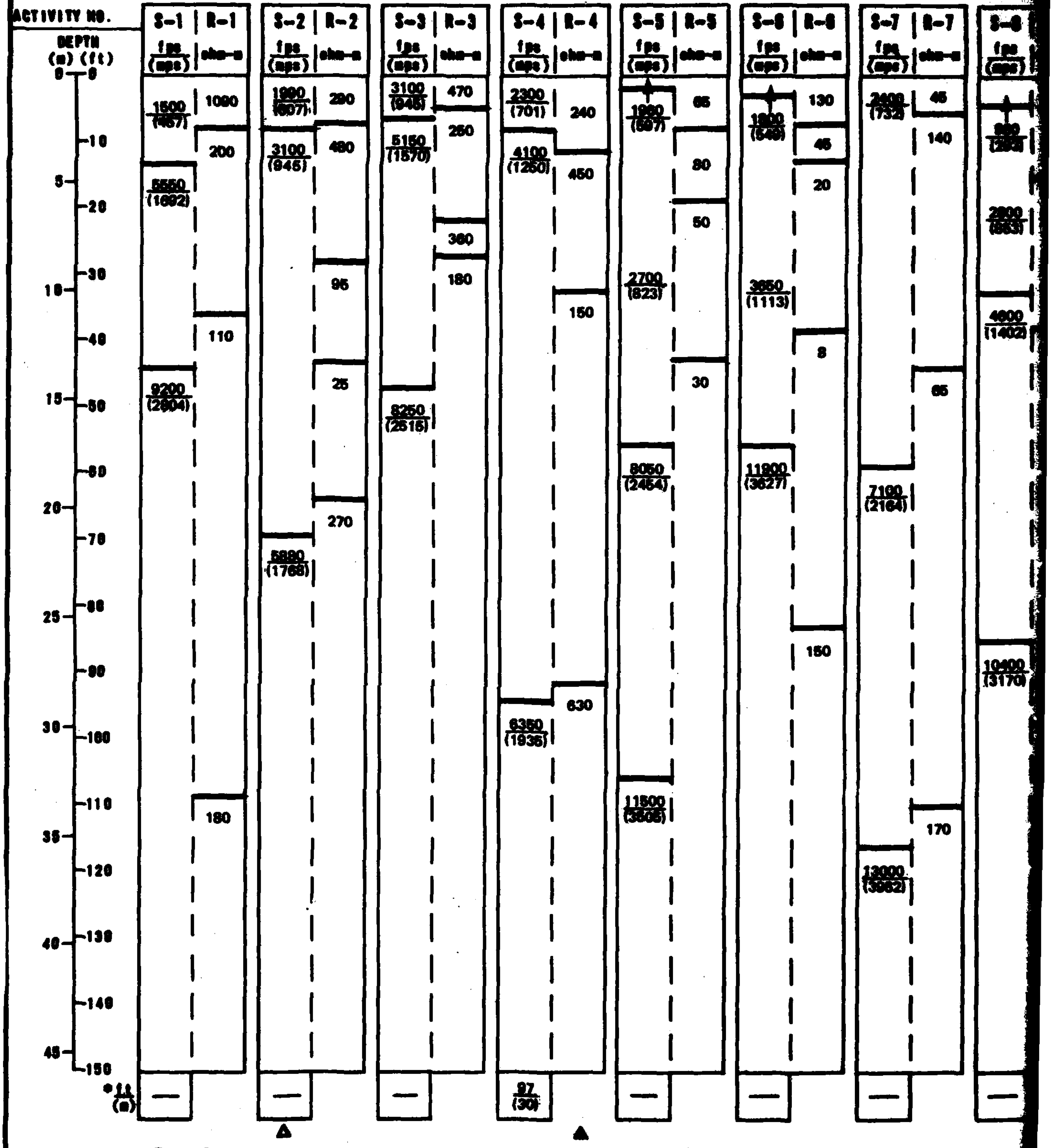
SOIL PROFILE 9 – 9'
LAKE VALLEY, NEVADA

31 JUL 81

FIGURE 3-9

3



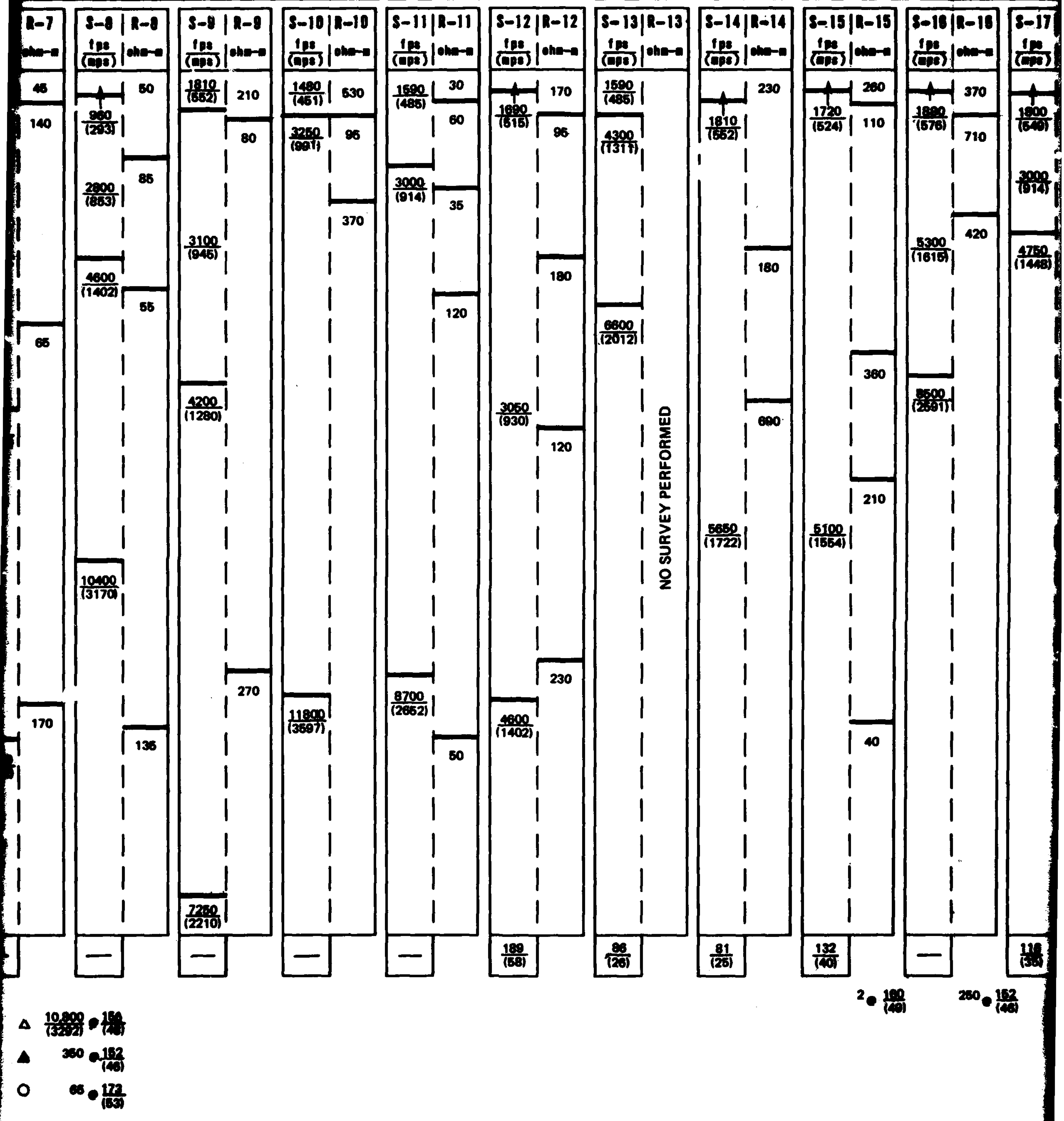
Deeper Results
Velocity/Resistivity @ Depth

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

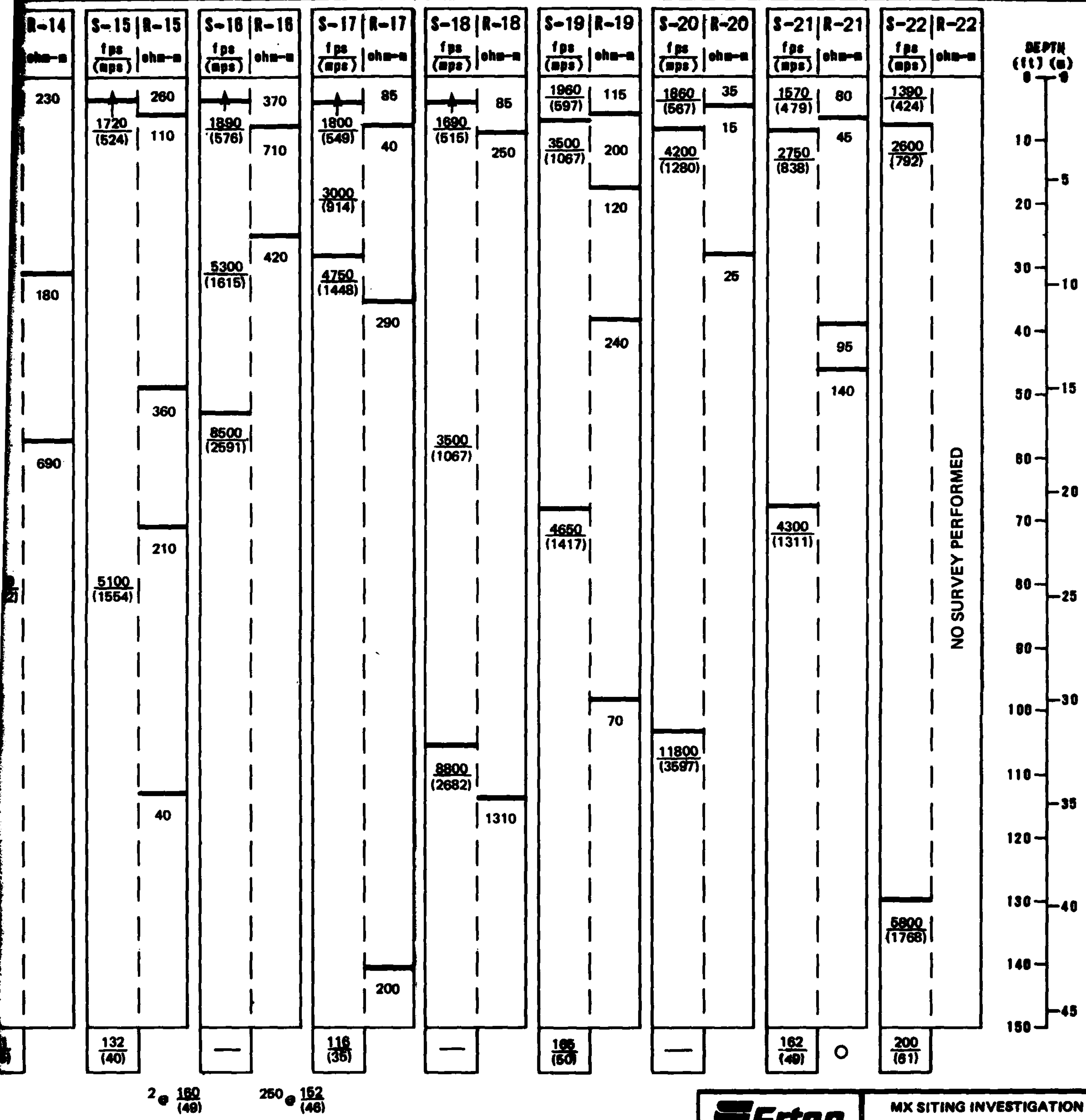
△ 10,[illegible] ([illegible]) @

▲ 360 @

○ 65 @


R-7
ohm-m
45
140
65
170
S-8
fps
(mps)
960
(293)
2800
(853)
4600
(1402)
10400
(3170)
—
R-8
ohm-m
50
85
55
136
S-9
fps
(mps)
1810
(552)
3100
(945)
4200
(1280)
7250
(2210)
—
R-9
ohm-m
210
80
270
S-10
fps
(mps)
1480
(451)
3250
(991)
11800
(3597)
—
R-10
ohm-m
530
95
370
S-11
fps
(mps)
1590
(485)
3000
(914)
8700
(2652)
—
R-11
ohm-m
30
60
35
120
50
S-12
fps
(mps)
1690
(515)
3050
(930)
4600
(1402)
189
(58)
R-12
ohm-m
170
95
180
120
230
S-13
fps
(mps)
1590
(485)
4300
(1311)
6600
(2012)
86
(26)
R-13
ohm-m
NO SURVEY PERFORMED
S-14
fps
(mps)
1810
(552)
5650
(1722)
81
(25)
R-14
ohm-m
230
180
690
S-15
fps
(mps)
1720
(524)
5100
(1554)
132
(40)
R-15
ohm-m
260
110
360
210
40
2 ● 160/(49)
S-16
fps
(mps)
1890
(576)
5300
(1615)
8500
(2591)
—
R-16
ohm-m
370
710
420
250 ● 152/(46)
S-17
fps
(mps)
1800
(549)
3000
(914)
4750
(1448)
116
(35)
△ 10,800/(3292) ● 150/(46)
▲ 360 ● 152/(46)
○ 65 ● 173/(53)

2



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SEISMIC REFRACTION AND ELECTRICAL RESISTIVITY RESULTS LAKE VALLEY, NEVADA

30 JUL 81

TABLE 3-3

DEPTH RANGE	2' – 20' (0.6 – 6.0m)	
SOIL DESCRIPTION	Coarse-grained soils	Fine-grai
	Sandy Gravels, Gravelly Sands, Sands, Silty Sands and Clayey Sands	Sandy Silts, Silts, S Clays
USCS SYMBOLS	GW, GM, SW, SP, SM, SC	ML, CL, CH
ESTIMATED EXTENT IN SUBSURFACE %	85 - 95	5 - 15
PHYSICAL PROPERTIES		
DRY DENSITY pcf (kg/m^3)	78.3 - 130.7 (1254 - 2094) [18]	67.6 - 112.4 (1083 - 1801)
MOISTURE CONTENT %	4.1 - 25.2 [18]	8.3 - 29.9
DEGREE OF CEMENTATION	*weak to moderate*	*moderate*
COBBLES 3 – 12 inches (8 – 30 cm) %	0 - 5	0
GRAVEL %	0 - 70 [29]	0 - 15
SAND %	28 - 97 [29]	1 - 46
SILT AND CLAY %	1 - 49 [29]	51 - 99
LIQUID LIMIT	27 [1]	27 - 65
PLASTICITY INDEX	NP - 10 [3]	NP - 48
COMPRESSIONAL WAVE VELOCITY fps (mps)	1400 - 5650 (427 - 1722) [42]	960 - 1810 (293 - 552)
SHEAR STRENGTH DATA		
UNCONFINED COMPRESSION S_u – ksf (kN/m^2)	NDA	NDA
TRIAXIAL COMPRESSION c – ksf (kN/m^2), ϕ°	NDA	NDA
DIRECT SHEAR c – ksf (kN/m^2), ϕ°	c = 0.0 - 1.2 (0 - 57) ϕ = 38 - > 45° [3]	c = 0.4 (19) ϕ

NOTES:

- Characteristics of soils between 2 and 20 feet (0.6 and 6.0 meters) are based on results of tests on samples from 7 borings, 7 trenches, 10 test pits, 2 field CBR locations and results of 22 seismic refraction surveys.
- Characteristics of soils below 20 feet (6.0 meters) are based on results of tests on samples from 7 borings and results of 22 seismic refraction surveys.

- [ ] - Number of
- NDA - No data a
- * - High angle d

.6 - 6.0m)	20' - 160' (6.0 - 49.0m)	
Fine-grained soils	Coarse-grained soils	Fine-grained soils
Sandy Silts, Silts, Sandy Clays and Clays	Sandy Gravels, Gravelly Sands, Sands and Silty Sands	Sandy Silts, Clayey Silts, Sandy Clays and Clays
ML, CL, CH	GP-GM, SW, SP, SM	ML, CL, MH
5 - 15	80 - 90	10 - 20
67.6 - 112.4 (1083 - 1801) [5]	71.1 - 132.5 (1139 - 2123) [74]	65.3 - 97.2 (1046 - 1557) [27]
8.3 - 29.9 [5]	4.7 - 43.0 [74]	13.9 - 49.2 [27]
moderate	weak to strong	weak to strong
0	0 - 5	0
0 - 15 [9]	0 - 64 [31]	0 - 5 [10]
1 - 46 [9]	30 - 94 [31]	8 - 41 [10]
51 - 99 [9]	5 - 50 [31]	59 - 92 [10]
27 - 65 [6]	70 [1]	33 - 66 [5]
NP - 48 [7]	NP - 12 [4]	NP - 32 [9]
960 - 1810 (293 - 552) [2]	2400 - 6600 (732 - 2012) [32]	NDA
NDA	NDA	0.8 - 2.2 (38 - 105) [4]
NDA	c = 2.5 (120) $\phi = 30$ [1]	c = 1.1 - 3.0 (53 - 144) $\phi = 27 - 29$ [2]
c = 0.4 (19) $\phi = 41$ [1]	c = 0.0 - 2.0 (0 - 96) $\phi = 31 -> 45°$ [4]	NDA

- [ ] - Number of tests performed.
- NDA - No data available (insufficient data or tests not performed)
- ° - High angle due to large gravel and/or cementation.

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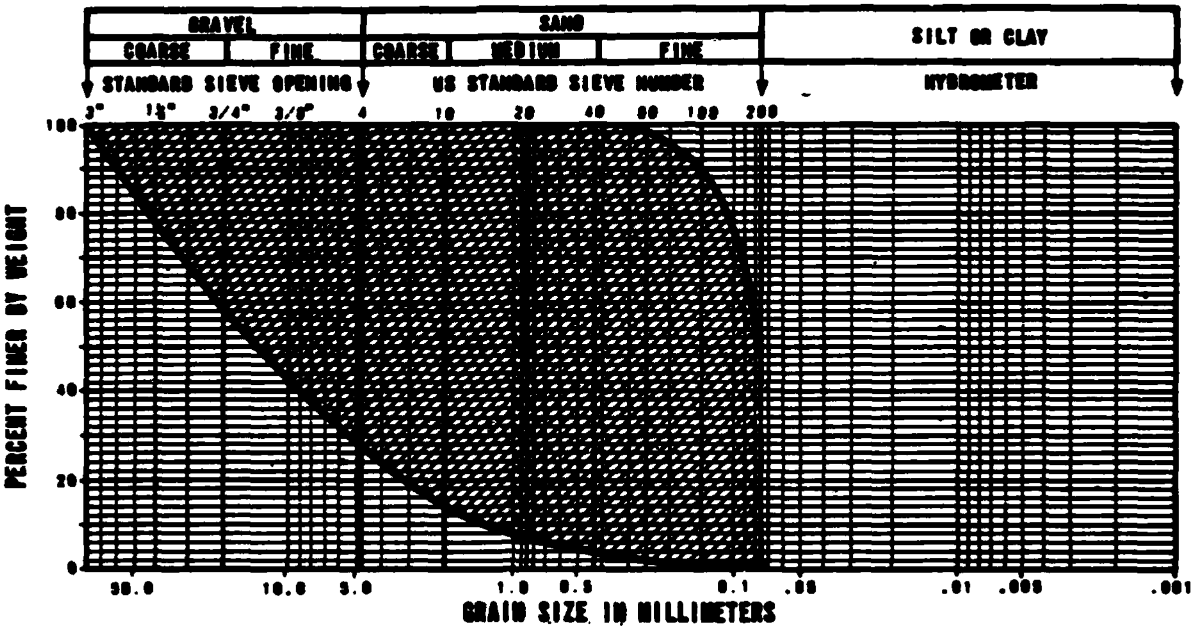
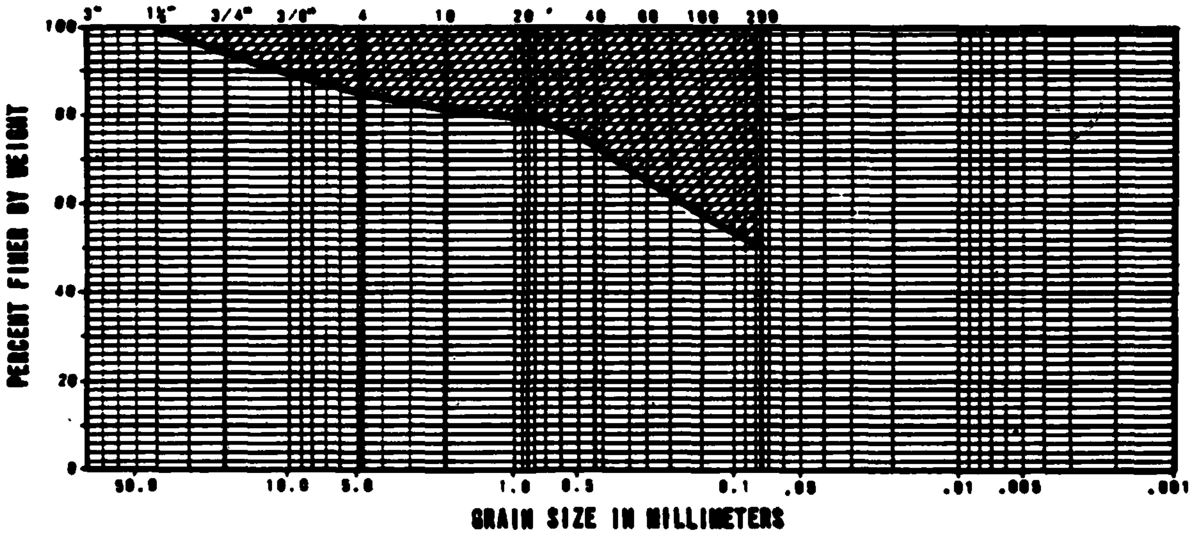
CHARACTERISTICS OF SUBSURFACE SOILS
LAKE VALLEY, NEVADA

31 JUL 81
TABLE 3-

2



SOIL DESCRIPTION: Coarse - Grained Soils
from 2 to 20 feet (0.6 to 6.0m)



SOIL DESCRIPTION: Fine - Grained Soils
from 2 to 20 feet (0.6 to 6.0m)

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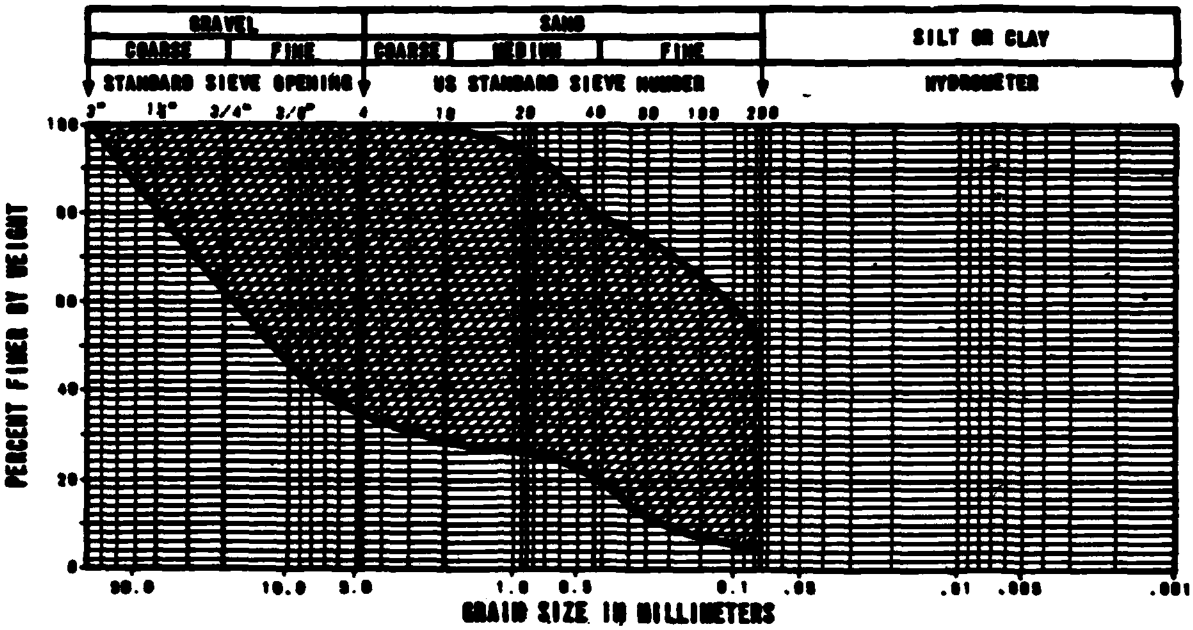
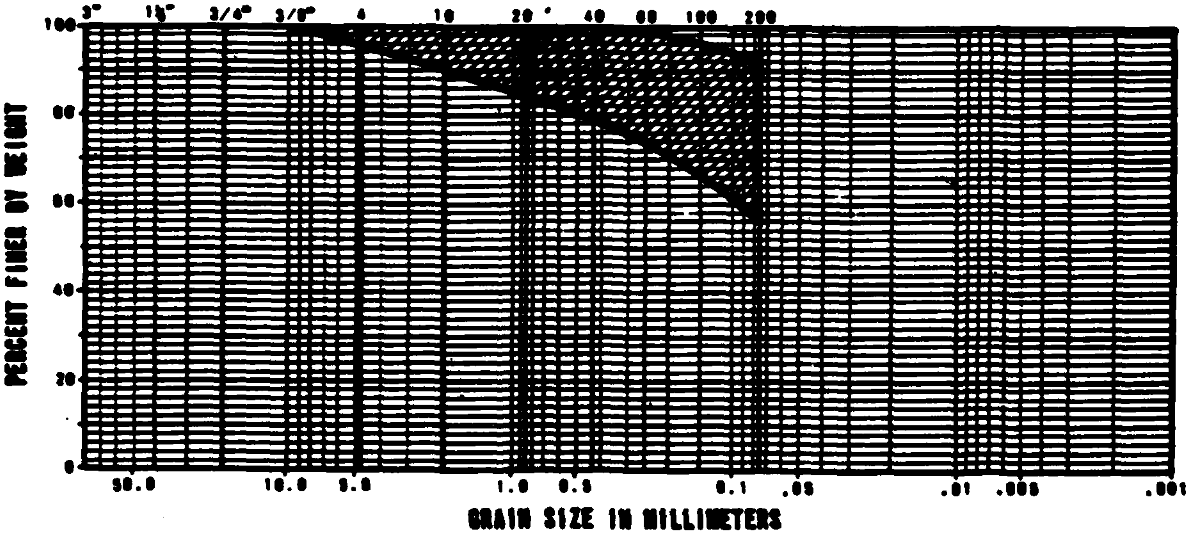
RANGE OF GRADATION OF
SUBSURFACE SOILS
LAKE VALLEY, NEVADA
PAGE 1 OF 2

31 JUL 81

FIGURE 3-10



SOIL DESCRIPTION: Coarse - Grained Soils
from 20 to 160 feet (6.0 to 49.0 m)



SOIL DESCRIPTION: Fine - Grained Soils
from 20 to 160 feet (6.0 to 49.0m)

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RANGE OF GRADATION OF
SUBSURFACE SOILS
LAKE VALLEY, NEVADA
PAGE 2 OF 2

31 JUL 81

FIGURE 3-19

Fine-grained soils (silts and clays) range in consistency from soft to very stiff and exhibit low to moderate compressibilities and shear strengths. Calcium-carbonate cementation varies from weak to strong, depending on the age of the deposit.

The soils in the construction zone (120 feet [37 m]) have a wide range of seismic compressional wave velocities (960 to 6600 fps [293 to 2012 mps]), depending on their composition, consistency, cementation, and moisture content. Seismic compressional wave velocities were measured in only the coarse-grained soils. Generally, velocities in fine-grained soils are found to be substantially lower than those in coarse-grained soils. Compressional wave velocities for deeper materials are also listed in Table 3-3.

Electrical conductivity measured for the soils in the upper 50 feet (15 m) ranged from 0.0015 to 0.0478 mhos per meter (average 0.0109 mhos per meter). At six of the 20 measurement locations, the measured conductivities were less than the minimum value of 0.004 mhos per meter specified in the Fine Screening criteria.

Results of chemical tests done on 11 samples obtained from Lake Valley indicate that the potential for sulfate attack for soils on concrete will be "negligible" to "mild."

3.5 DEPTH TO ROCK

Drawing 3-3 shows the approximate boundaries of the areas in which the depth to rock is less than 50 and 150 feet (15 and 46 m), respectively, in Lake Valley. This interpretation is on limited point data from borings, seismic refraction surveys, site-specific published data, and depths inferred from geologic and geomorphic relationships. Approximately 15 percent of the basin-fill material in the valley is interpreted to be underlain by rock at depths of less than 50 feet (15 m). An additional eight percent of the valley is interpreted to contain shallow rock between depths of 50 and 150 feet (15 and 46 m).

The bedrock/basin-fill contact is highly irregular within Lake Valley. In North Lake Valley, on the west flank of the Fortification Range, volcanic rocks protrude through the overlying intermediate-age fans, and the area adjacent to the mountain front has been interpreted to be underlain by shallow rock. Reentrant canyons throughout the valley are also interpreted to contain shallow rock beneath the alluvial fan and active wash deposits. Numerous outcrops of bedrock are found up to 2 miles (3.2 km) into the valley from the rock/basin-fill contact. Based on these outcrops, the area where rock is interpreted to exist at depths of less than 50 feet (15 m) forms a strip varying from one-tenth (.16 km) to 2 miles (3.2 km) in width along the entire valley margin and around isolated outcrops of bedrock.

3.6 DEPTH TO WATER

Drawing 3-4 shows the location of all 96 data points used to define ground-water conditions in Lake Valley. The sources of these data in addition to Ertec activities are: Rush and Eakin (1963); Rush (1964); and the Nevada State Engineer's Office

(1959-1967). Information pertaining to the wells is listed in Table II-3-1 (Volume II).

Approximately 20 percent of the valley basin is interpreted to contain shallow water at depths less than 50 feet (15 m). An additional 19 percent of the valley is interpreted to contain water between depths of 50 and 150 feet (15 and 46 m).

North Lake Valley is interpreted to be a closed basin system which prevents movement of shallow ground water (<200 feet [318 m]) out of this part of the valley. In South Lake Valley, shallow ground water occurs along the central axis of the valley, i.e., along Patterson Wash and its tributary system. Both the ground water and surface water flow south out of the valley.

3.7 TERRAIN

3.7.1 Terrain Exclusions

Terrain conditions are shown in Drawing 3-5. Areas designated as terrain exclusions are considered to be unsuitable based on a combination of field-derived and office-derived data which were evaluated under the criteria in Appendix Table A2-1. Field-derived exclusions include: 1) areas having very steep slopes, such as the sides of major drainages; and 2) areas in which incisions deeper than 10 feet (3 m) are spaced closer than 1000 feet (305 m) apart. Office-derived exclusions consist primarily of areas identified on topographic maps as having slopes greater than 10 percent. In some instances, where road access is inadequate for field inspection, office analysis of aerial photographs was used to define and exclude areas of rugged or adverse terrain. However, preference was given to determining these exclusions in the field. Even though areas where slopes exceed five percent are considered to be suitable, they are shown in Drawing 3-5 because they require special consideration in planning construction and operations.

Approximately 27 percent or 171 mi^2 (443 km^2) of the total area within Lake Valley is excluded due to adverse terrain. Fifty-five to 60 percent of this excluded area (approximately 102 mi^2 [264 km^2]) is based on the field-derived, drainage-depth-spacing exclusions (two or more drainages deeper than 10 feet per linear 1000 feet). Approximately 60 percent of this field-derived exclusion is located in South Lake Valley. In general, it outlines the deeply incised tributary system of Patterson Wash. The remainder of the terrain-exclusion areas (approximately 69 mi^2 [179 km^2]) consists of topographic slopes exceeding 10 percent. These slopes are generally located near the bedrock/basin-fill contact. This criterion typically excludes small reentrant canyons around the valley. In South Lake Valley, the majority of the exclusions for terrain are located along the steep walls of the numerous drainages.

3.7.2 Incision Depths and Number of Drainages Per Mile

Data on incision depths and number of drainages encountered per mile were analyzed for Lake Valley. Information on incision depths was obtained from field observations with the number of drainages per mile determined from both field observations and interpretations of aerial photographs.

The results shown in Table 3-5 are average values of the two drainage characteristics (depth and number per mile). They are listed for each prevalent surficial unit with further breakdowns providing data on 1) characteristics of the geologic unit on each side of the valley axial drainage and 2) characteristics of the unit where its surface slopes are between five and 10 percent versus areas where its slopes are less than five percent.

The small areal extent of some of the surficial units resulted in only limited data which were insufficient for analysis (Table 3-5). The available data show that A5i alluvial fans within Lake Valley have slightly deeper incisions than the majority of the other surficial units and also have a greater average number of drainages per mile, especially on the western side of the valley. Incision depths vary within the different surficial geologic units depending on grain size and degree of slope.

The only other unit that presents any potential for concern with regard to drainages is the fluvial deposits (A1) that occur in South Lake Valley. Drainages in this unit occur much less frequently than drainages in the A5i units but are usually much deeper.

SURFICIAL GEOLOGIC UNIT	AVERAGE NUMBER OF DRAINAGES PER MILE			
	WESTERN SIDE OF VALLEY		EASTERN SIDE OF VALLEY	
	SURFACE SLOPE, %		SURFACE SLOPE, %	
	0-5	5-10	0-5	5-10
A1s	1.3 (.72)	—	1.2 (0.6)	—
A2s	—	—	1.0	—
A4of	1.6 (1.4)	—	1.4 (1.2)	—
A4os	1.8 (1.3)	—	1.2 (0.8)	—
A5ig	6.2 (3.6)	3.2 (2.3)	—	—
A5is	7.2 (3.7)	8.9 (3.4)	5.3 (2.8)	2.6 (2.2)
A5yf	2.3 (1.6)	—	1.7 (1.1)	—
A5ys	1.2 (0.8)	—	1.7 (1.2)	—

NOTE: DRAINAGES WERE COUNTED ALONG A ONE-MILE LINE PERPENDICULAR TO THE DRAINAGE DIRECTION.

SURFICIAL GEOLOGIC UNIT	AVERAGE DEPTH OF INCISIONS			
	WESTERN SIDE OF VALLEY		EASTERN SIDE OF VALLEY	
	SURFACE SLOPE, %		SURFACE SLOPE, %	
	0-5	5-10	0-5	5-10
A1f	8.0 ft* 2.4 m	—	4.0 ft* 1.2 m	—
A1s	12.0 ft* 3.6 m	—	—	—
A4of	2.0 ft* 0.6 m	—	3.0 ft* 1.0 m	—
A4os	[illegible]	—	[illegible]	—
A4og	[illegible] (1.2 m)	—	—	—
A5is	5.4 ft ([illegible] ft) 1.6 m (1.0 m)	[illegible] ft ([illegible] ft) 2.0 m (1.2 m)	[illegible] ft (4.2 ft) (1.[illegible] m) (1.3 m)	[illegible] ft ([illegible] ft) 2.3 m (1.7 m)
A5ig	[illegible] ft (2.7 ft) [illegible] m ([illegible] m)	[illegible] ft ([illegible] ft) [illegible] m (2.7 m)	—	—
A5yf	—	—	1.5 ft* 0.5 m	—
A5ys	3.8 ft (1.1 ft) 1.2 m (0.3 m)	5.5 ft* 1.7 m	—	—

*	LIMITED DATA (6<n<10) VALUE IS MEDIAN, NO STANDARD DEVIATION
—	NO DATA OR INSUFFICIENT DATA(n<6)
( )	STANDARD DEVIATION
A5i	INTERMEDIATE-AGE ALLUVIAL FANS
A5y	YOUNG-AGE ALLUVIAL FANS
A4o	OLDER LACUSTRINE DEPOSITS
A4	ACTIVE PLAYAS
g	GRAVELS
s	SANDS
f	FINES; CLAYS, SILTS

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MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE
BMO/AFRCE-MX

DRAINAGES PER MILE AND DEPTHS OF INCISIONS IN PREVALENT SURFICIAL GEOLOGIC UNITS LAKE VALLEY, NEVADA

31 JUL 81

TABLE 3-[illegible]

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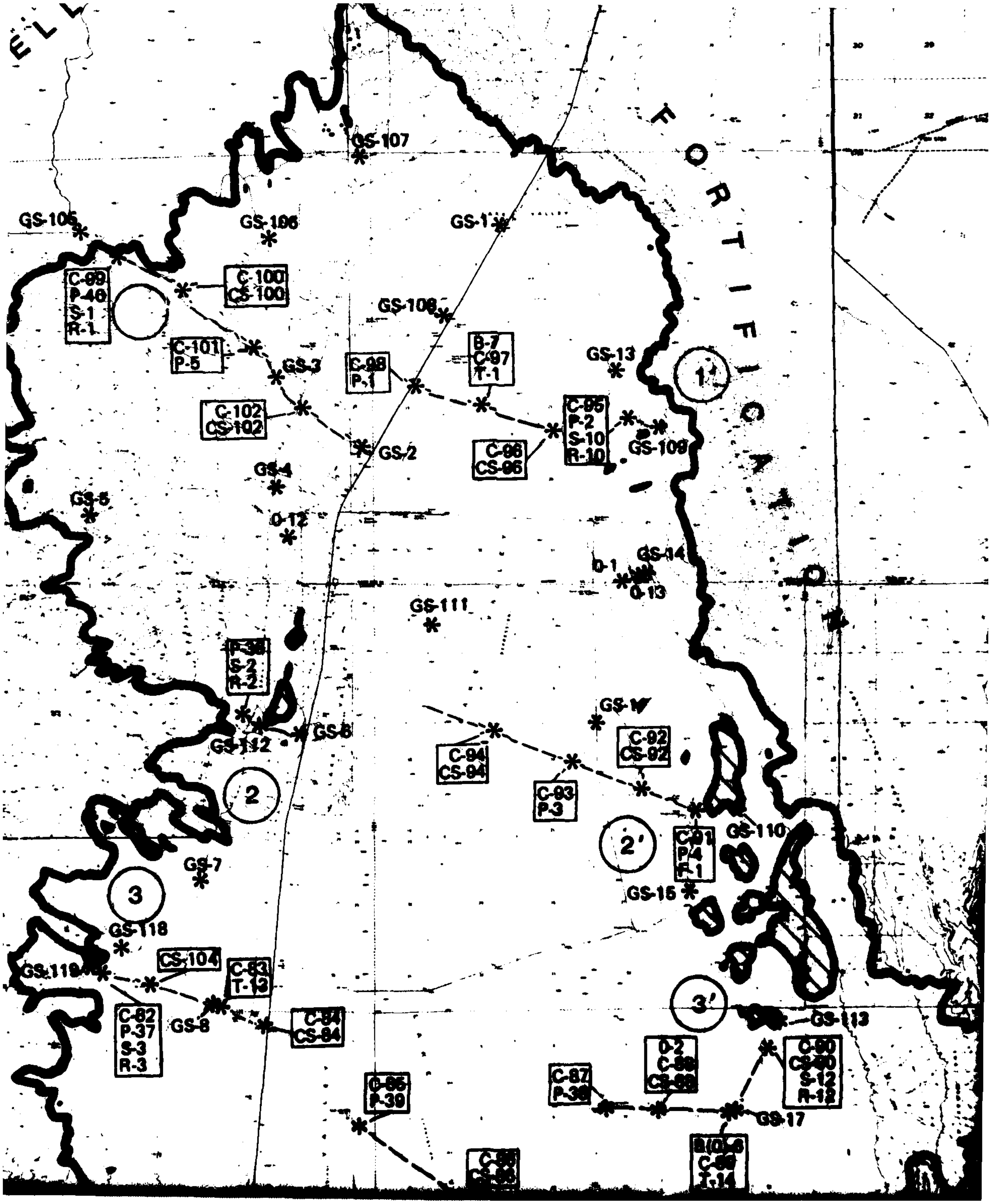
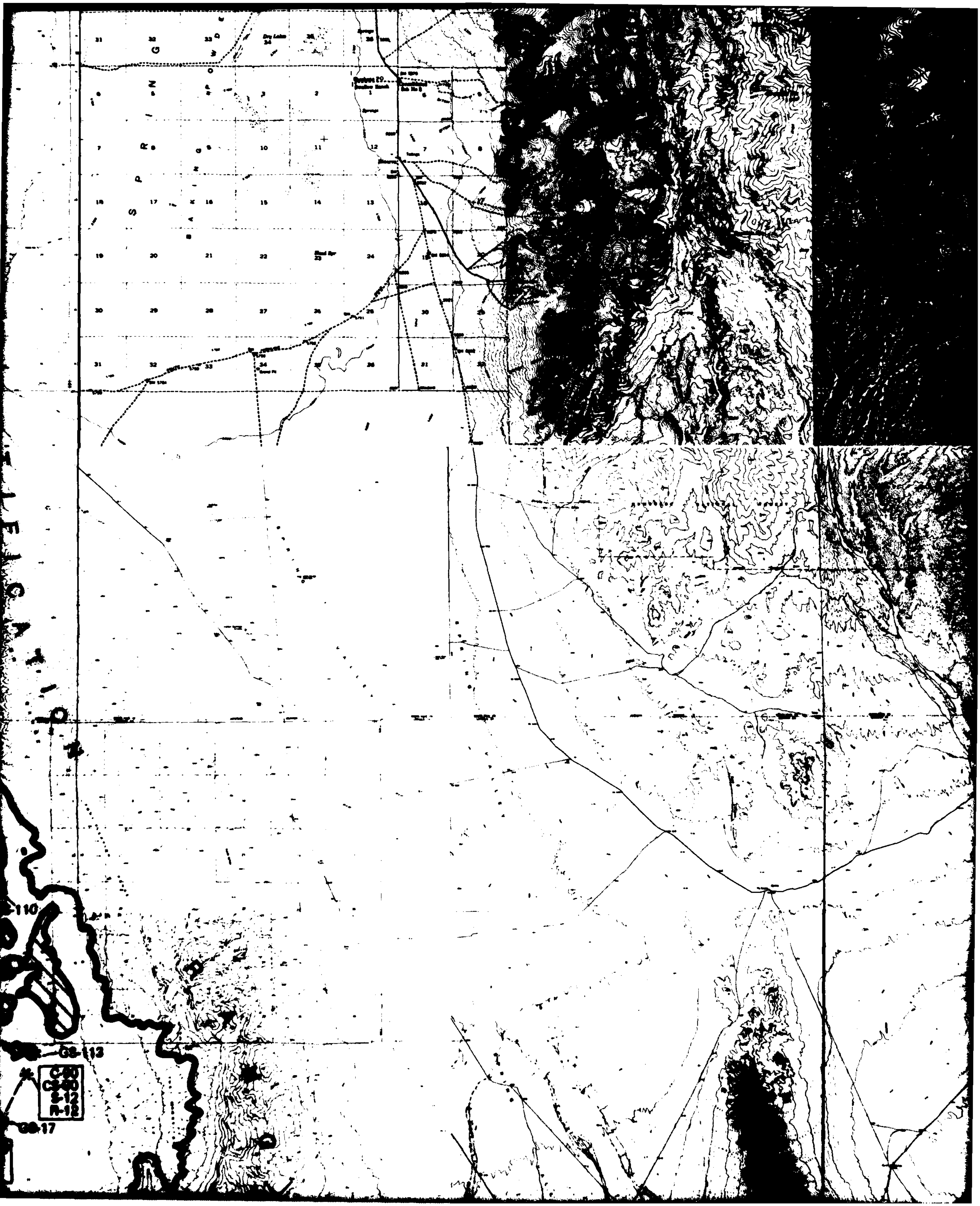

ELL
FORTIFICATION
GS-107
GS-105
GS-106
GS-1
C-99
P-46
S-1
R-1
C-100
CS-100
GS-108
C-101
P-5
GS-3
C-98
P-1
B-7
C-97
T-1
GS-13
1'
C-102
CS-102
C-95
P-2
S-10
R-10
GS-109
GS-2
C-96
CS-96
GS-4
GS-5
0-12
0-1
GS-14
0-13
GS-111
P-38
S-2
R-2
GS-6
GS-112
GS-17
C-92
CS-92
C-94
CS-94
C-93
P-3
2
2'
C-91
P-4
F-1
GS-110
GS-7
3
GS-15
GS-118
CS-104
C-83
T-13
GS-119
3'
GS-113
C-82
P-37
S-3
R-3
GS-8
C-84
CS-84
0-2
C-88
CS-88
C-90
CS-90
S-12
R-12
C-87
P-36
C-85
P-39
GS-17
C-86
CS-86
B(0)-6
C-89
T-14



S P R I N G
Dry Lake
110
GS-113
C-60
CS-60
S-12
R-12
GS-17

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18
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25
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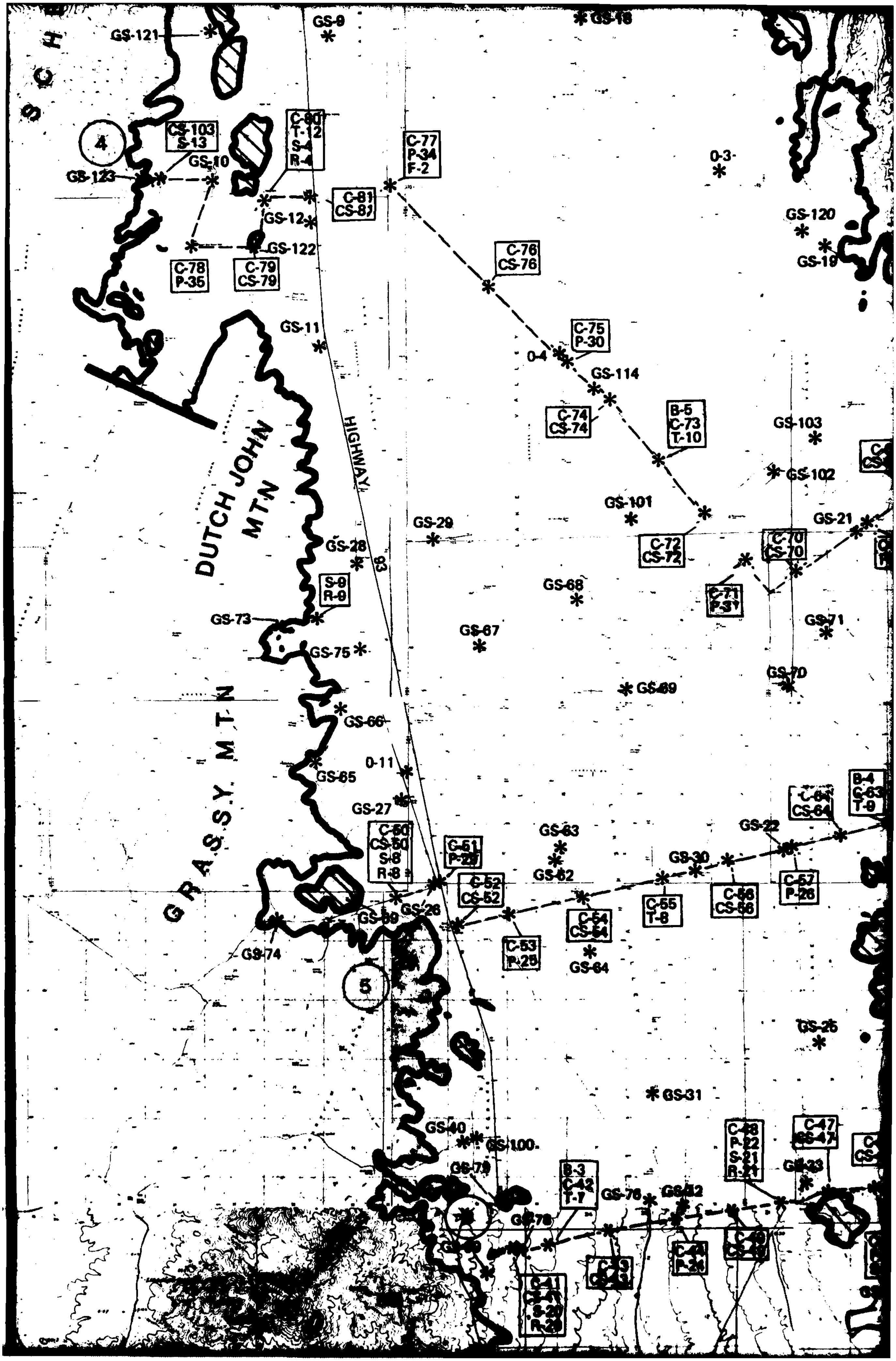
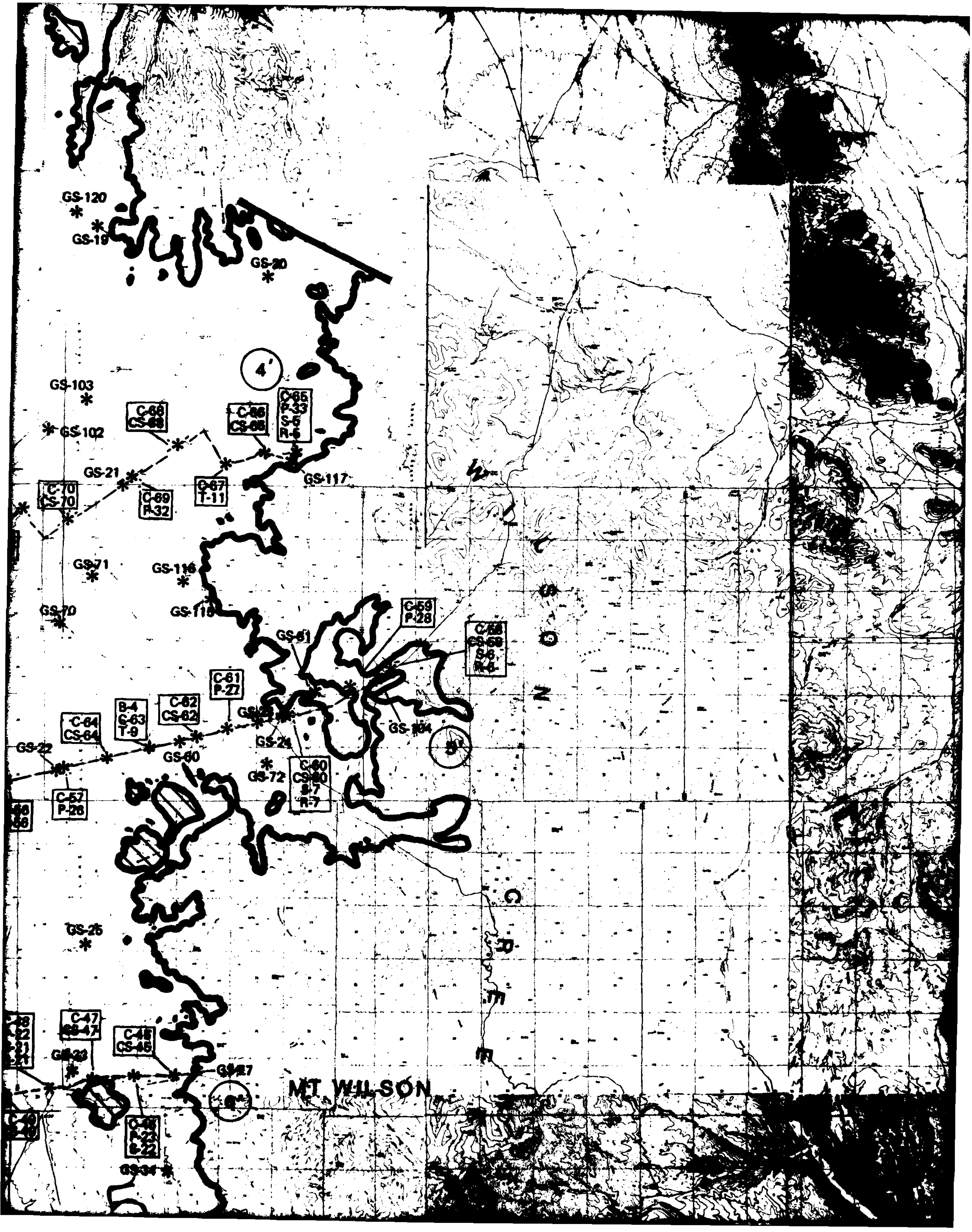
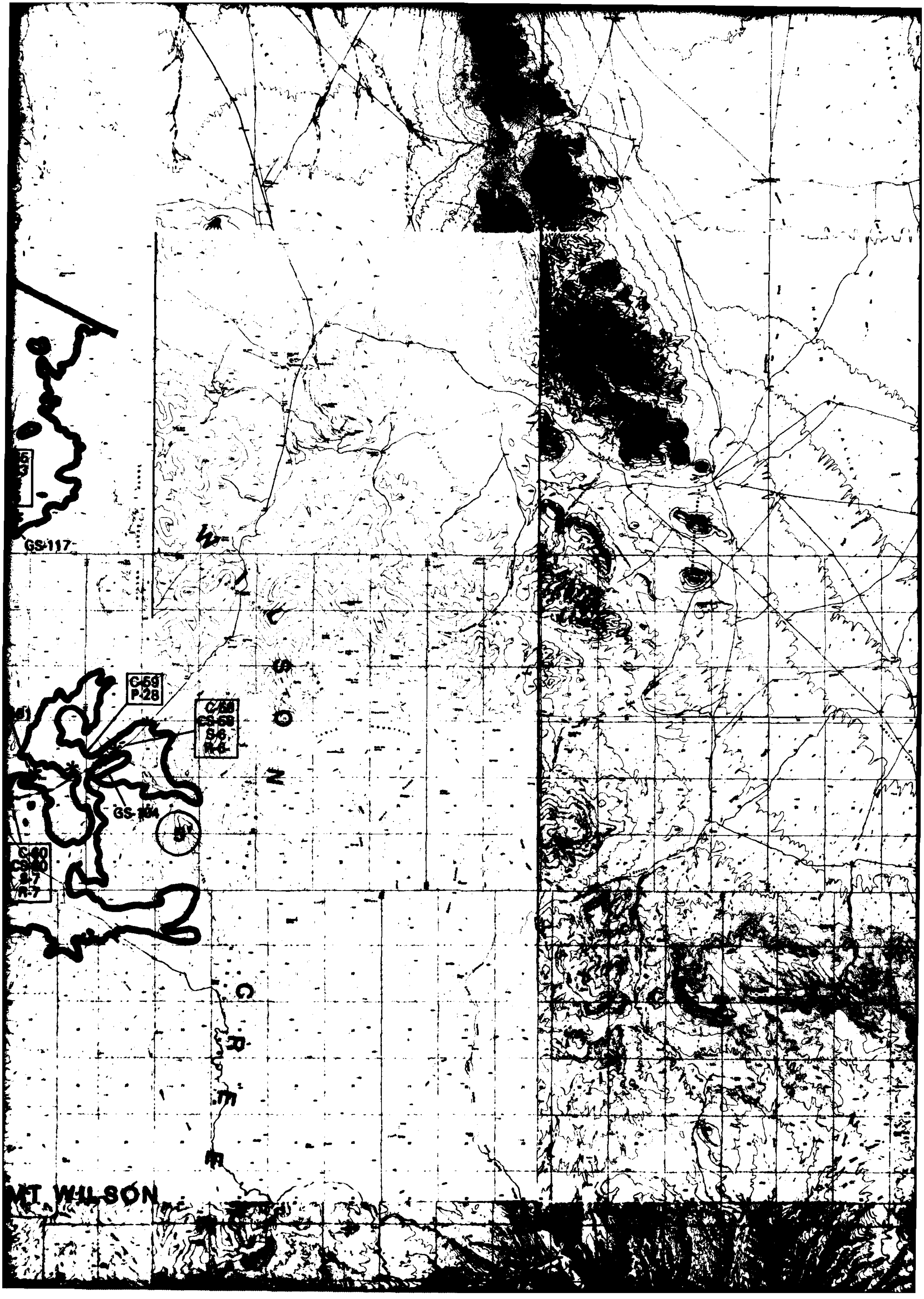
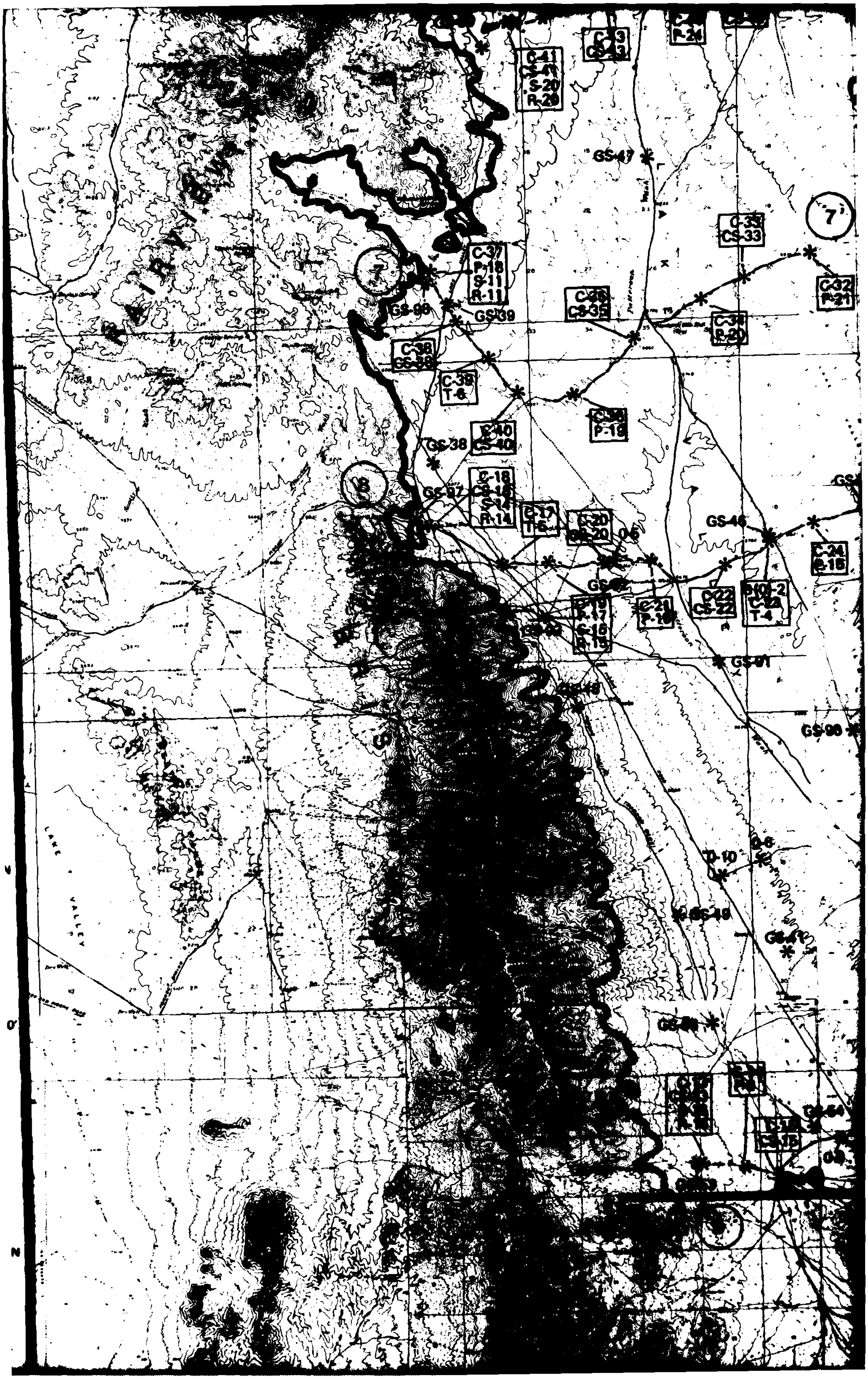
29
36
31
32

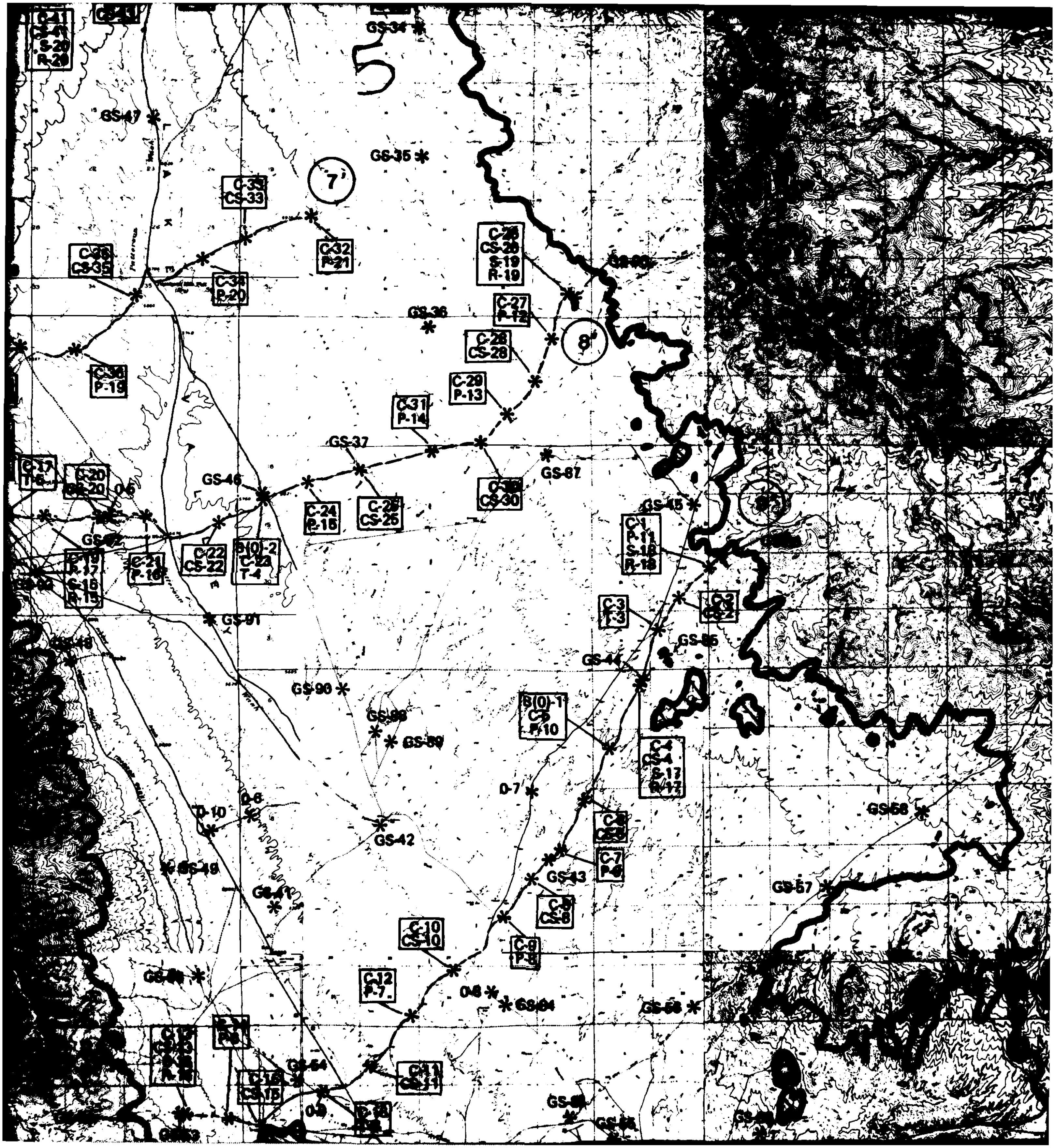

S C H
GS-121
GS-9
GS-16
4
CS-103
S-13
C-80
T-12
S-4
R-4
C-77
P-34
F-2
GS-123
GS-10
0-3
C-81
CS-81
GS-12
GS-120
GS-122
GS-19
C-78
P-35
C-79
CS-79
C-76
CS-76
GS-11
C-75
P-30
0-4
GS-114
C-74
CS-74
B-5
C-73
T-10
GS-103
DUTCH JOHN
MTN
HIGHWAY
93
GS-102
GS-101
GS-29
GS-21
C-72
CS-72
C-70
CS-70
GS-28
GS-68
S-9
R-9
C-71
P-31
GS-71
GS-73
GS-67
GS-75
GS-70
GS-69
GS-66
GRASSY MTN
0-11
GS-65
B-4
C-63
T-9
C-64
CS-64
GS-27
GS-63
GS-22
C-50
CS-50
S-8
R-8
C-51
P-27
GS-30
GS-62
C-52
CS-52
C-57
P-28
C-55
T-8
C-56
CS-56
GS-59
GS-26
C-54
CS-54
GS-74
C-53
P-25
GS-64
5
GS-25
GS-31
GS-40
GS-100
C-48
P-22
S-21
R-21
C-47
CS-47
GS-79
B-3
C-42
T-7
GS-33
GS-76
GS-32
GS-78
C-46
CS-46
C-43
CS-43
C-44
P-26
C-41
CS-41
S-20
R-20



GS-120
GS-19
GS-20
4'
GS-103
GS-102
C-68
CS-68
C-66
CS-66
C-65
P-33
S-5
R-6
GS-117
GS-21
C-70
CS-70
C-69
P-32
C-67
T-11
GS-71
GS-116
GS-70
GS-115
GS-61
C-59
P-28
C-58
CS-58
S-6
R-6
C-61
P-27
B-4
C-63
T-9
C-62
CS-62
C-64
CS-64
GS-23
GS-104
GS-24
5'
GS-22
GS-60
GS-72
C-60
CS-60
S-7
R-7
C-57
P-26
GS-25
C-47
CS-47
C-45
CS-45
GS-27
MT WILSON
C-46
P-23
S-22
GS-34


GS-117
WILSON
C-59
P-28
C-58
CS-58
S-6
R-6
GS-104
C-60
CS-60
S-7
R-7
CREEK
MT. WILSON


C-43
GS-43
P-21
C-41
CS-41
S-20
R-29
GS-47
7
C-33
CS-33
C-37
P-18
S-11
R-11
7
C-32
P-21
C-36
CS-35
GS-98
GS-39
C-34
P-20
C-38
CS-38
C-39
T-6
C-35
P-19
C-40
CS-40
GS-38
8
C-18
CS-18
S-14
R-14
GS-97
C-17
T-5
C-20
CS-20
O-5
GS-46
C-24
P-15
C-19
P-17
C-16
R-15
C-21
P-16
C-22
CS-22
BIO-2
C-23
T-4
GS-91
GS-48
GS-90
LAKE VALLEY
D-10
O-6
GS-49
CS-15
O-8



C-21
CS-41
S-20
R-20
GS-34
GS-47
GS-35
7
C-33
CS-33
C-32
P-21
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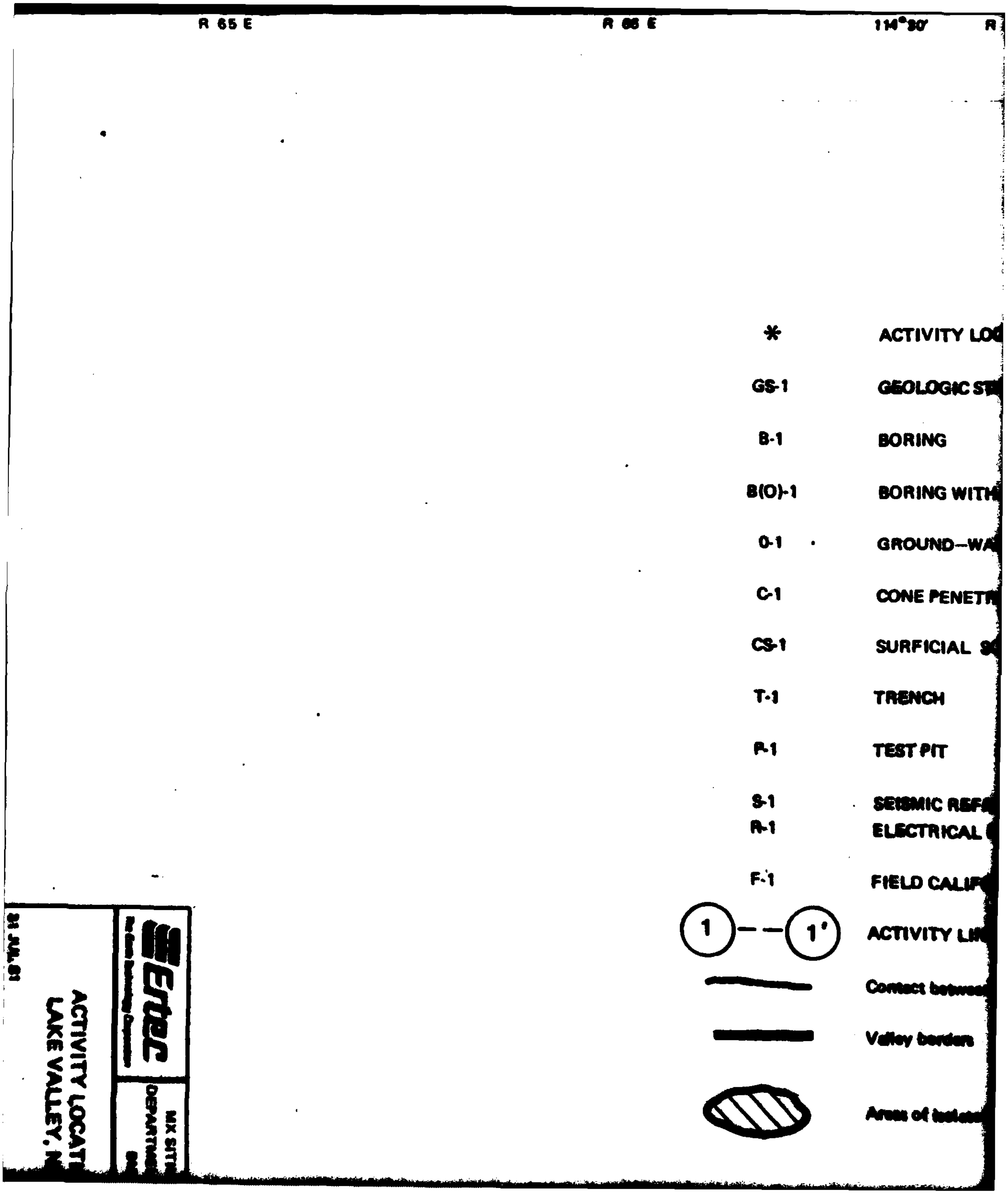
CS-26
S-19
R-19
C-35
CS-35
C-34
P-20
C-27
P-12
GS-36
C-28
CS-28
8
C-36
P-19
C-29
P-13
C-31
P-14
GS-37
GS-87
C-17
T-6
C-20
CS-20
0-5
GS-46
C-24
P-15
C-25
CS-25
C-30
CS-30
GS-45
C-1
P-11
S-18
R-18
GS-92
C-19
P-17
S-16
R-15
C-21
P-16
C-22
CS-22
B(0)-2
C-23
T-4
C-2
CS-2
C-3
P-3
GS-91
GS-48
GS-85
GS-44
GS-90
B(0)-1
C-5
P-10
GS-88
GS-89
C-4
CS-4
S-17
R-17
0-7
GS-58
0-10
0-6
GS-42
C-6
CS-6
C-7
P-6
GS-49
GS-43
GS-41
C-8
CS-8
GS-57
C-10
CS-10
C-9
P-8
C-12
P-7
0-8
GS-64
GS-56
GS-54
C-11
CS-11
C-16
CS-15
0-9
GS-53

5

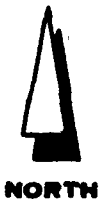

T WILSON
8
GS-87
GS-45
C-1
P-11
S-18
R-18
C-3
P-3
C-2
GS-2
GS-86
GS-44
10
C-4
GS-4
P-17
R-17
C-7
GS-43
GS-58
GS-57


R 65 E
R 66 E
114°30'
R
*
ACTIVITY LO
GS-1
GEOLOGIC ST
B-1
BORING
B(O)-1
BORING WITH
O-1
GROUND–WA
C-1
CONE PENETR
CS-1
SURFICIAL S
T-1
TRENCH
P-1
TEST PIT
S-1
SEISMIC REF
R-1
ELECTRICAL
F-1
FIELD CALIF
1
1'
ACTIVITY LI
Contact betwee
Valley borders
Areas of isolat
Ertec
MX SIT
DEPARTM
ACTIVITY LOCAT
LAKE VALLEY, N
31 JUL 81

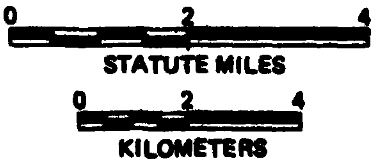
114°30' R 67 E R 68 E R 69 E

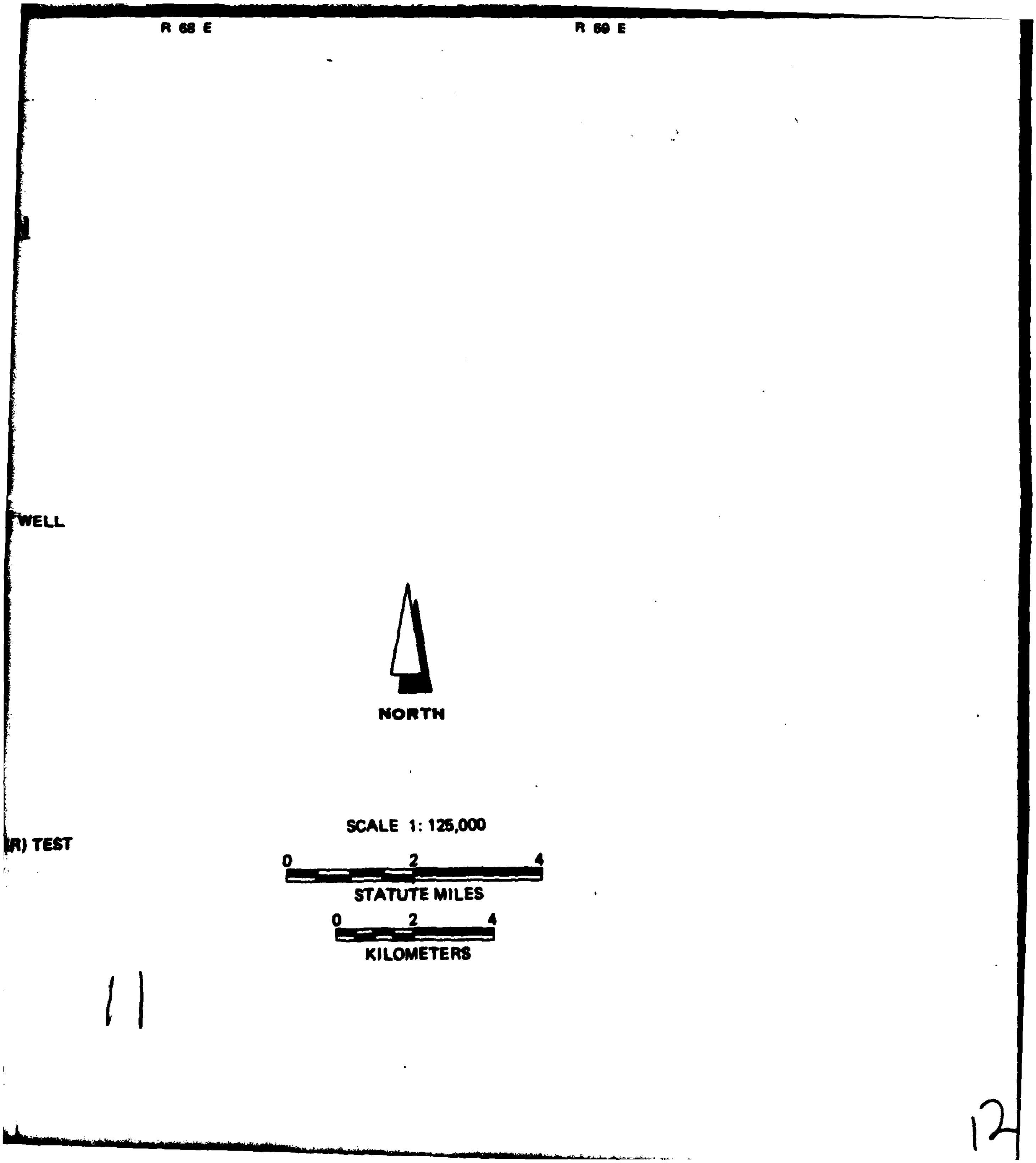
EXPLANATION

*	ACTIVITY LOCATION
GS-1	GEOLOGIC STATION
B-1	BORING
B(O)-1	BORING WITH OBSERVATION WELL
O-1	GROUND—WATER LEVEL MEASUREMENT WELL
C-1	CONE PENETROMETER TEST (CPT)
CS-1	SURFICIAL SOIL SAMPLE
T-1	TRENCH
P-1	TEST PIT
S-1	SEISMIC REFRACTION LINE
R-1	ELECTRICAL RESISTIVITY SOUNDING
F-1	FIELD CALIFORNIA BEARING RATIO (CBR) TEST
①--(1')	ACTIVITY LINE
—	Contact between rock and basin-fill
—	Valley borders



SCALE 1: 125,000




R 68 E
R 69 E
WELL
R) TEST
NORTH
SCALE 1: 125,000
0
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4
STATUTE MILES
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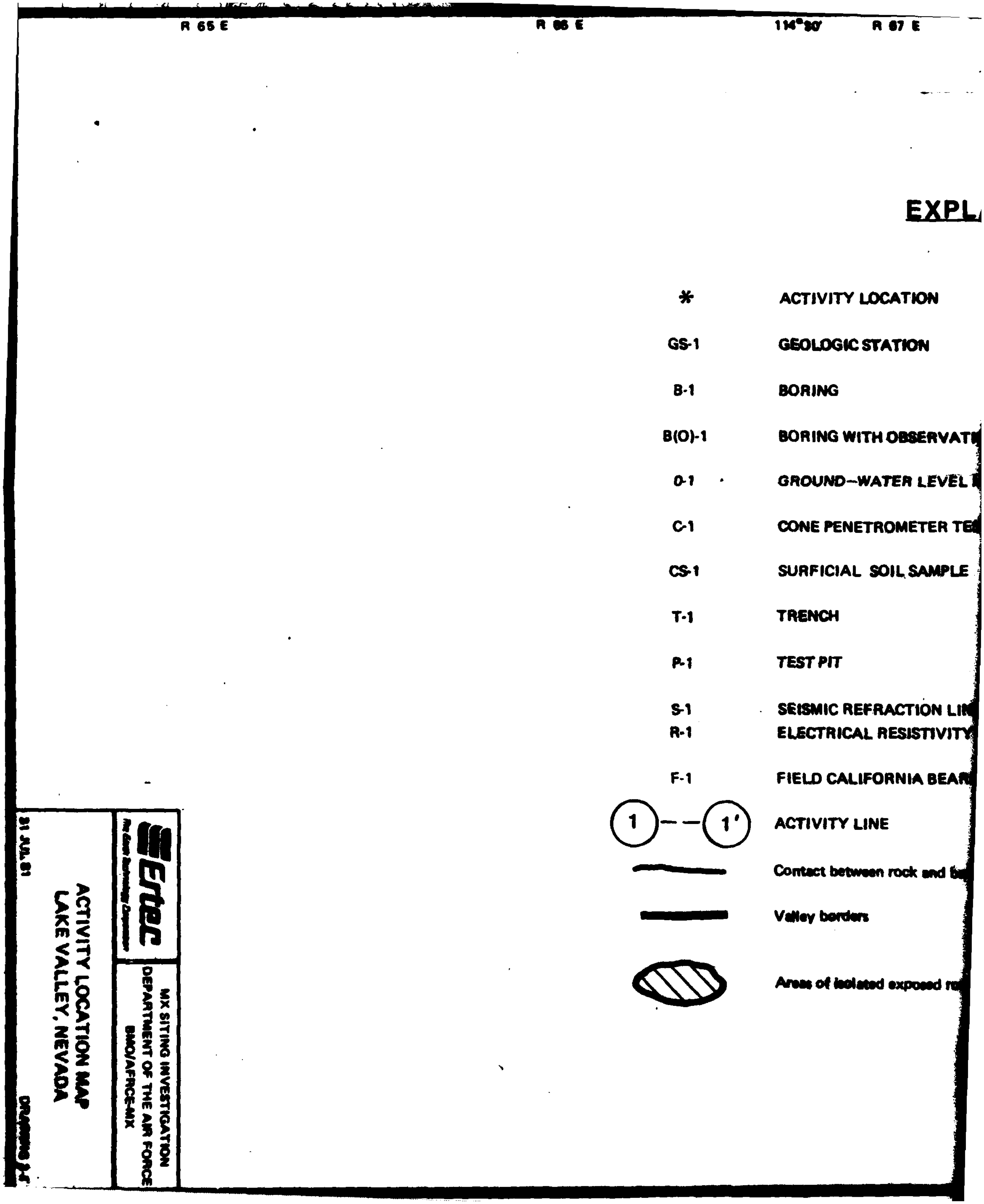
2
4
KILOMETERS

11

12



EXPL

*	ACTIVITY LOCATION
GS-1	GEOLOGIC STATION
B-1	BORING
B(O)-1	BORING WITH OBSERVAT
O-1	GROUND-WATER LEVEL
C-1	CONE PENETROMETER TE
CS-1	SURFICIAL SOIL SAMPLE
T-1	TRENCH
P-1	TEST PIT
S-1	SEISMIC REFRACTION LI
R-1	ELECTRICAL RESISTIVITY
F-1	FIELD CALIFORNIA BEAR
① - - ①'	ACTIVITY LINE
―	Contact between rock and b
━	Valley borders
▨	Areas of isolated exposed r

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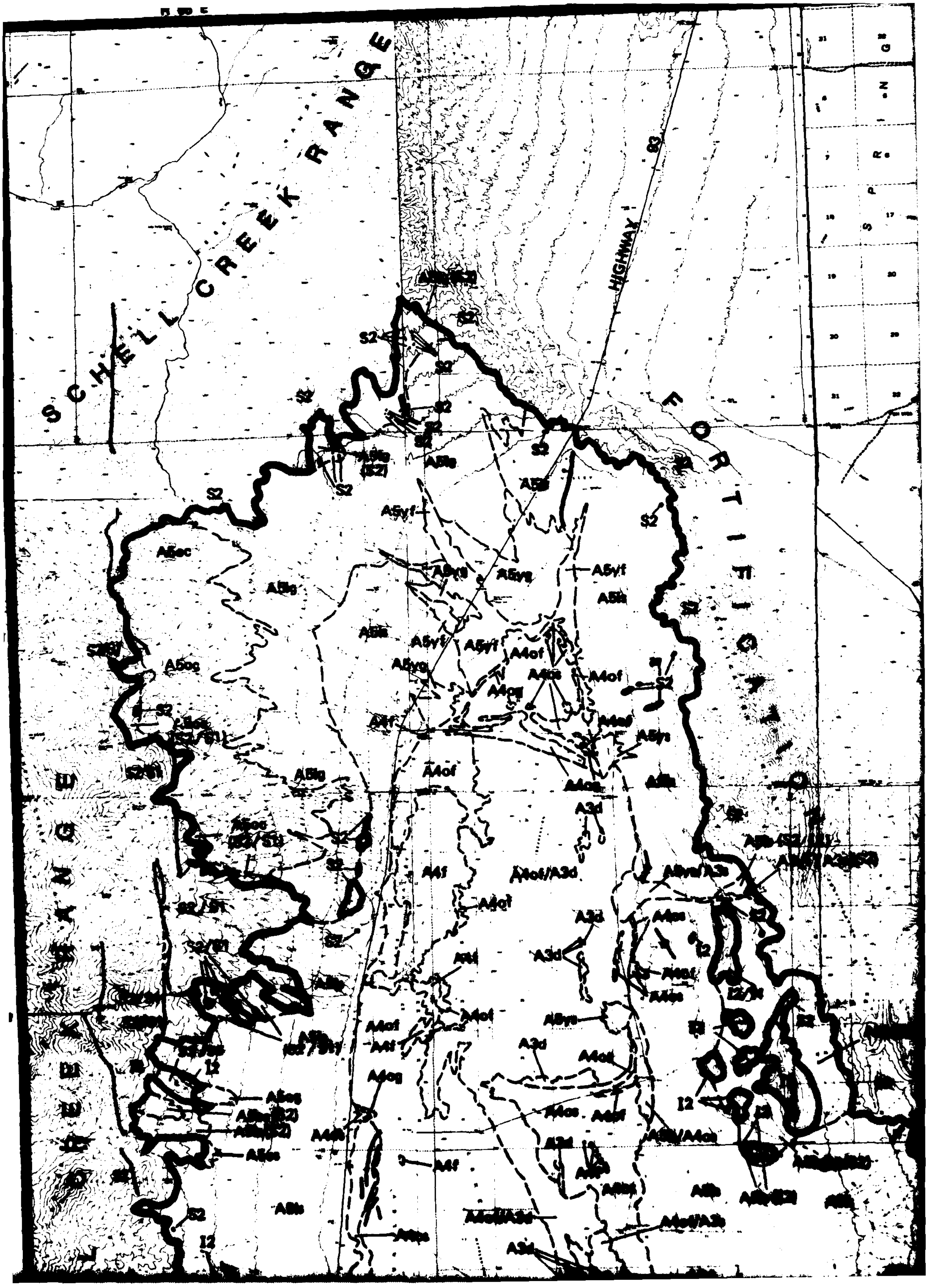
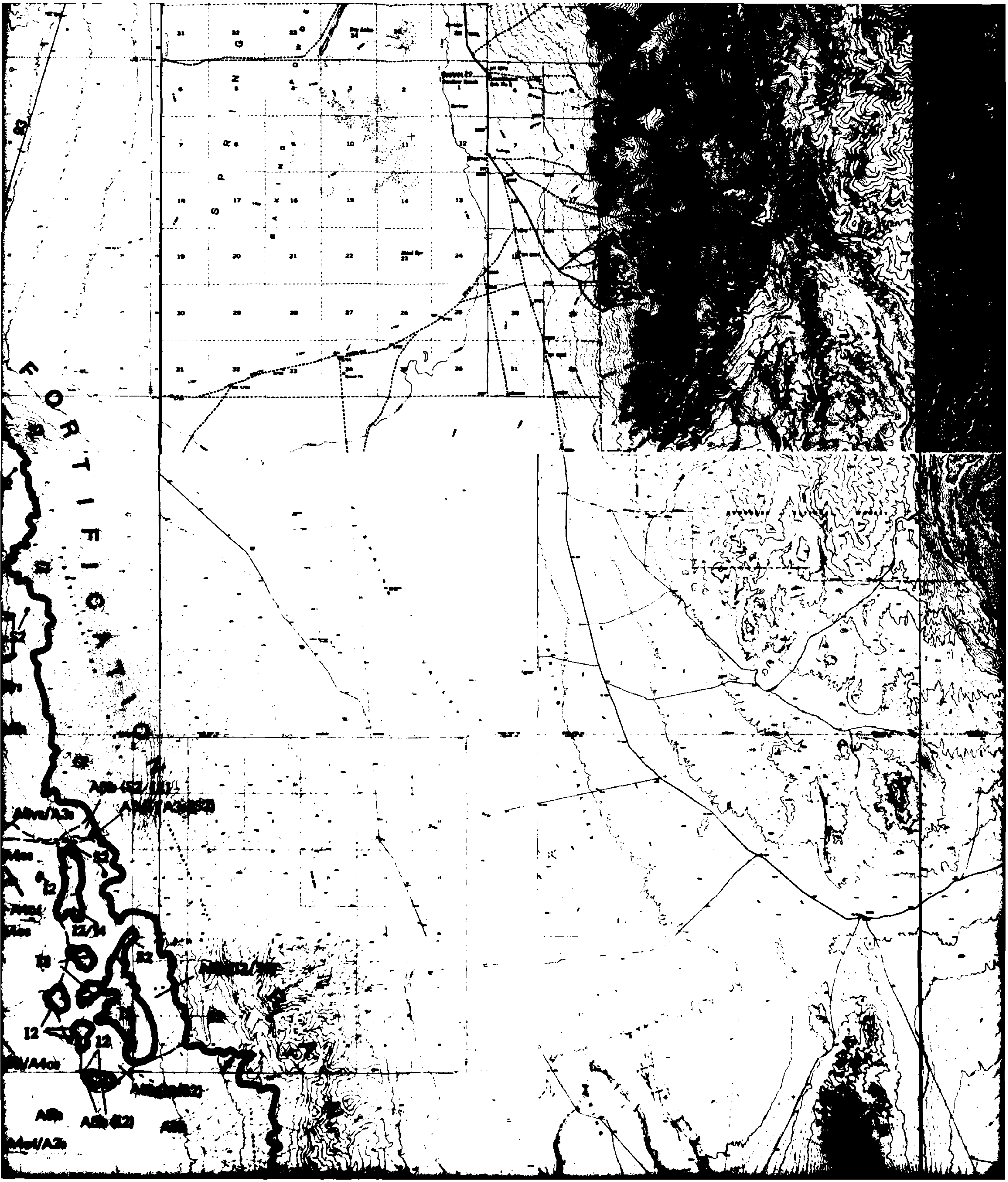
ACTIVITY LOCATION MAP
LAKE VALLEY, NEVADA

31 JUL 81

DRAWING 1-


SCHELL CREEK RANGE
FORTIFICATION RANGE
HIGHWAY 93
S2
S2/S1
A5yf
A5ys
A5yg
A5ec
A5lg
A5og
A4of
A4os
A4og
A4f
A3d
A4of/A3d
A4of/A3b
A5ys/A3s
(S2)
(S2/S1)
I2
I2/I1

93
S P R I N G
V A L L E Y
F O R T I F I C A T I O N
31
32
33
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32
33
34
35
36
31
S2
I2
I2/I4
I2
I2
I2
A3a
Mol/A2a


35
2
1
6
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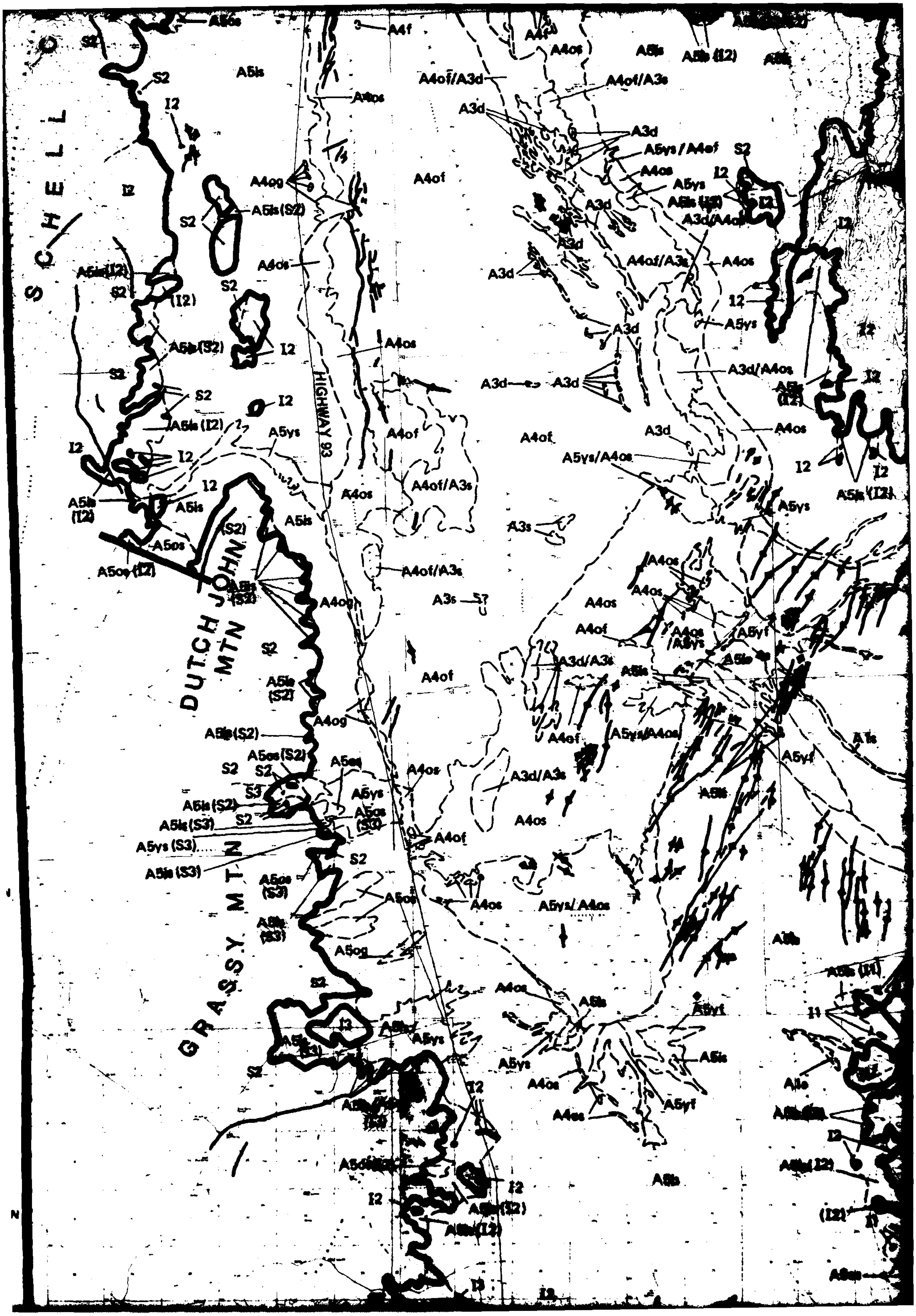
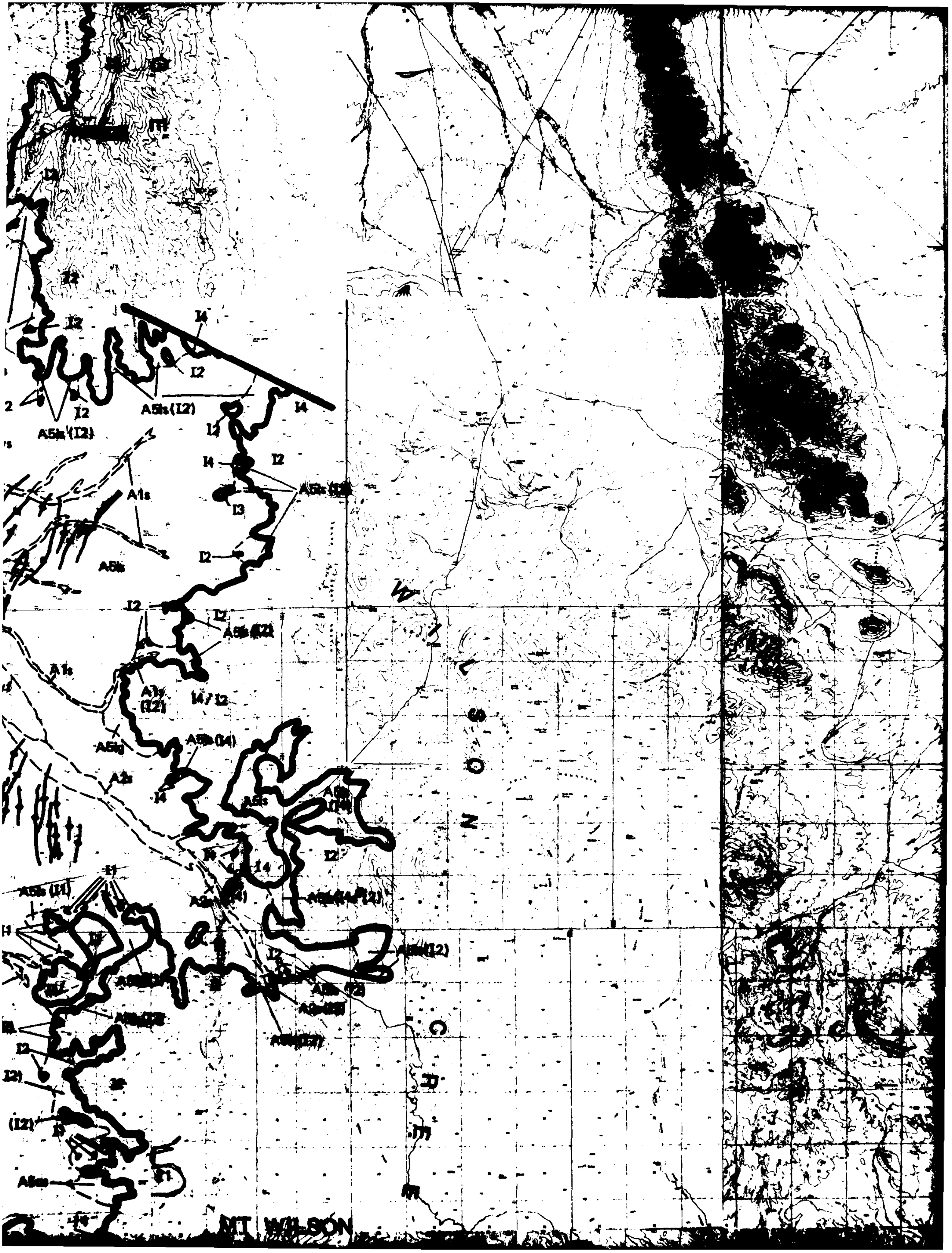
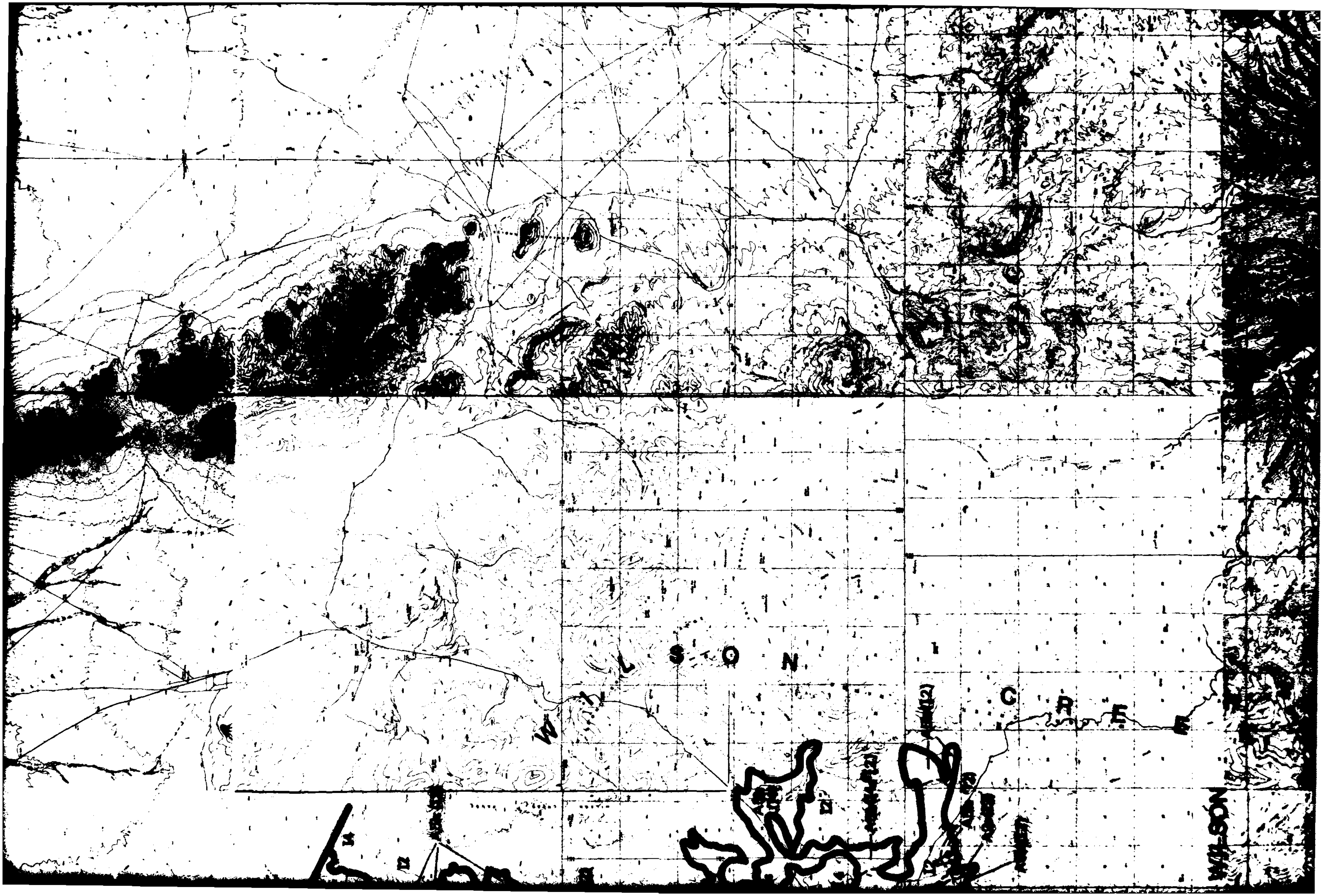

SCHELL
DUTCH JOHN MTN
GRASSY MTN
HIGHWAY 93
A4f
A4os
A5is
A5is (I2)
A4of/A3d
A4of/A3s
A3d
A5ys/A4of
S2
I2
A4og
A5is(S2)
A4of
A5ys
A3d/A4os
A5is(I2)
(I2)
A4os
A5ys
A3d/A4os
A5is (I2)
A5ys/A4os
A5os
A5os (I2)
(S2)
A3s
A4of/A3s
A4og
A5yf
A3d/A3s
A5ys/A4os
A1s
A5os (S2)
S3
A5is (S3)
A5ys (S3)
A5os (S3)
A5og
I1
A1is
I3



I2
A5ls (I2)
I4
I2
A5ls (I2)
I3
A1s
A5ls
A5ls (I2)
I4 / I2
A1s
A1s (I2)
A5ls (I4)
A5ls
A2s
I4
I1
A5ls (I1)
A5ls (I4)
MT WILSON


WILSON CREE
14
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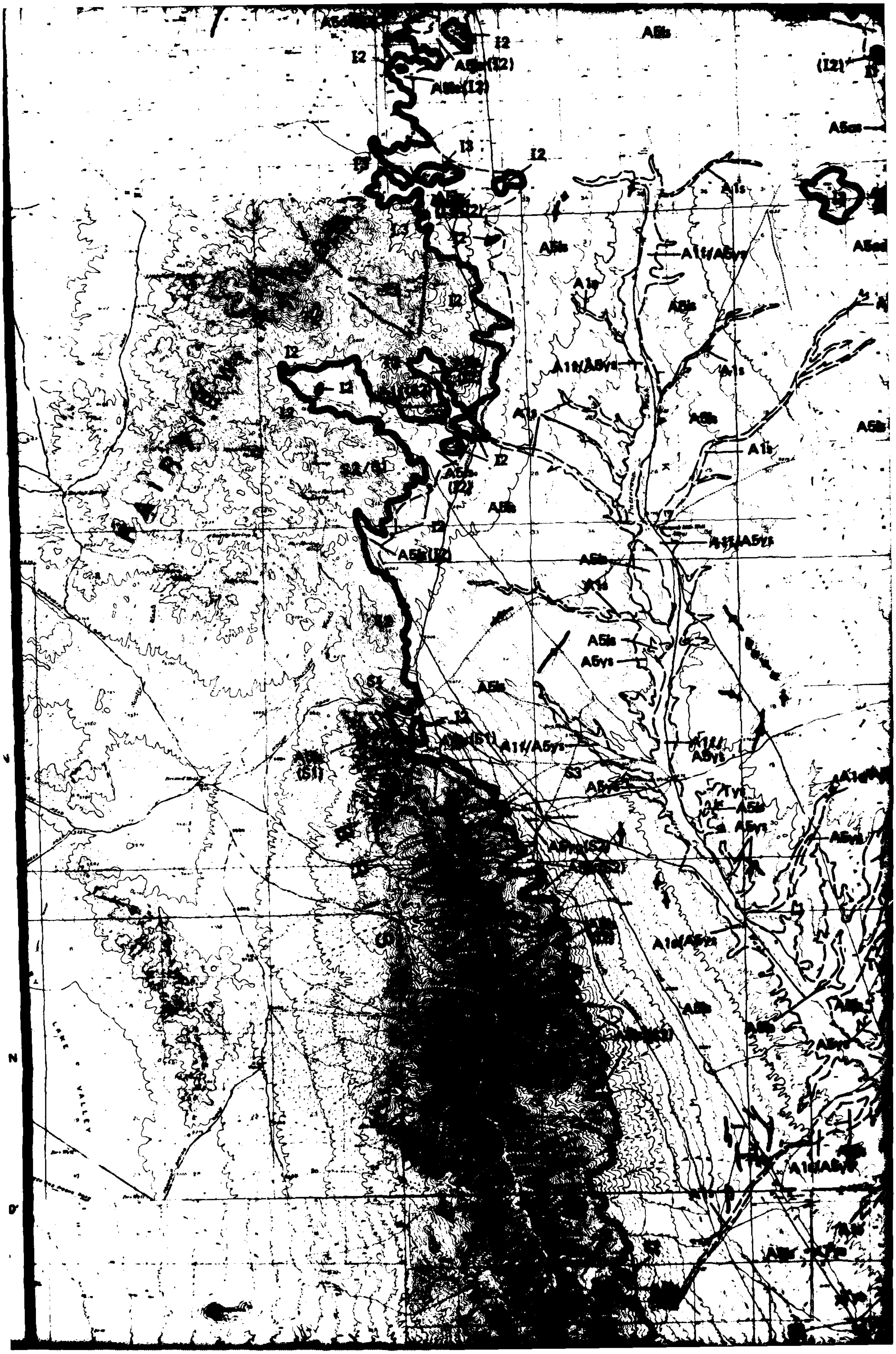
12
(12)
WILSON


A5ls
I2
I2
A5ls(I2)
A5ls(I2)
(I2)
A5ss
I3
I2
I3
A1s
A5sd
I3
I2
A5ls
A1f/A5ys
I2
A5ls
I2
A1f/A5ys
A1s
I2
A5ls
A1s
I2
S2/S1
A5ls
(I2)
A5ls
A1f/A5ys
I2
A5ls(I2)
A5ls
A1s
A5ls
A5ys
A5ls
S1
I2
A5ls(S1)
A1f/A5ys
A1f/A5ys
A5ls
(S1)
S3
A5ys
Tys
A5ls
A5ys
A1d/A5ys
A5ys
A1d/A5ys
A5ls
A5ys
A1d/A5ys
LAKE VALLEY
V
N
D'


MT WILSON
I1
A5os
I1
A5os
A1s
A5is (I2)
I1
A5is (I1)
A5is
I2
A5is (I2)
A5is (I2)
I2
A1s/A5ys
A5ys
A1s/A5ys
A1s
A1s
A5ys
A5ys
A1s/A5ys
A1s
I2
I2
Tys
A5ys
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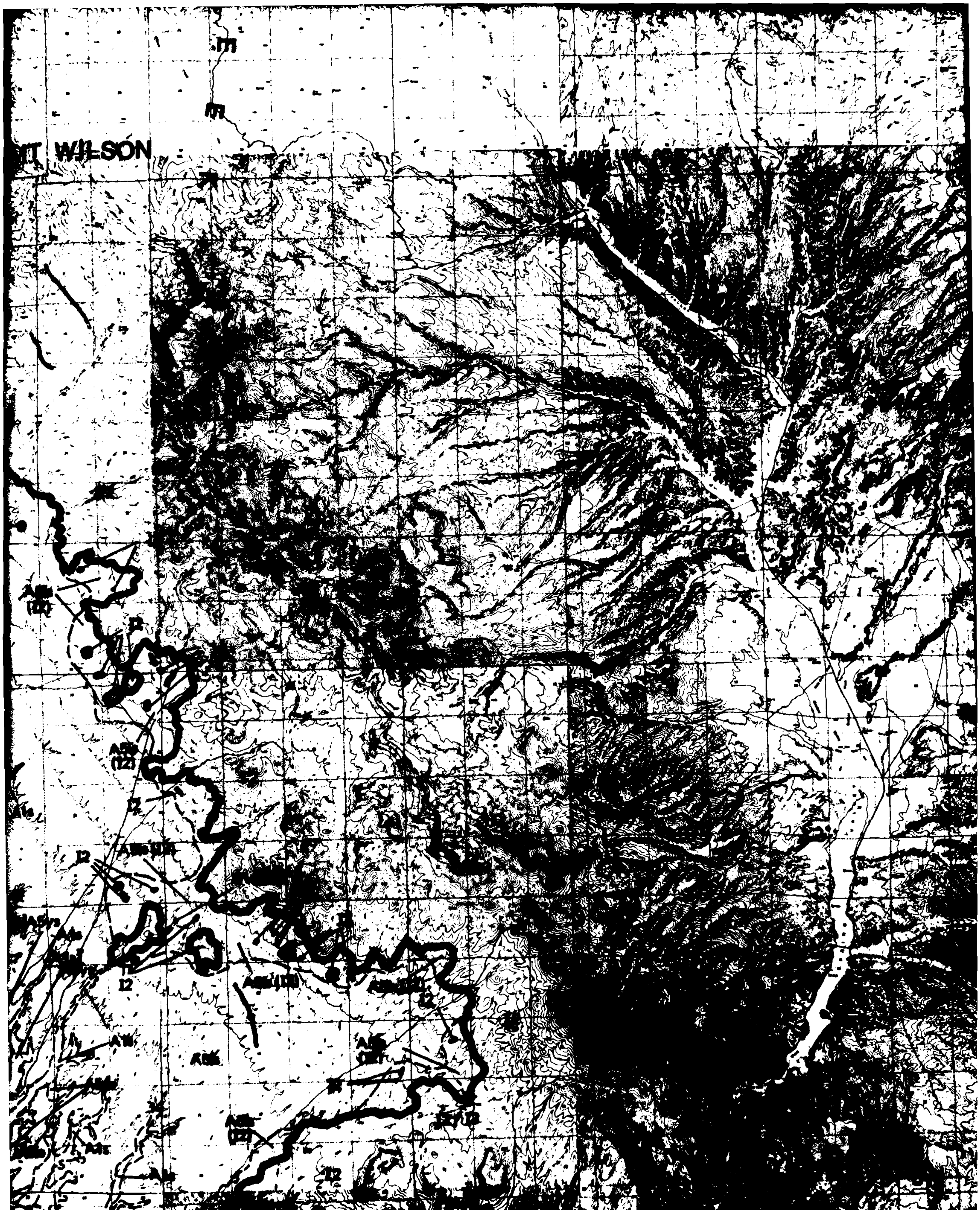
A5ys
A1s
A5ys
Tys
A1s
A5is (I2)


MT WILSON
(12)
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(12)
12
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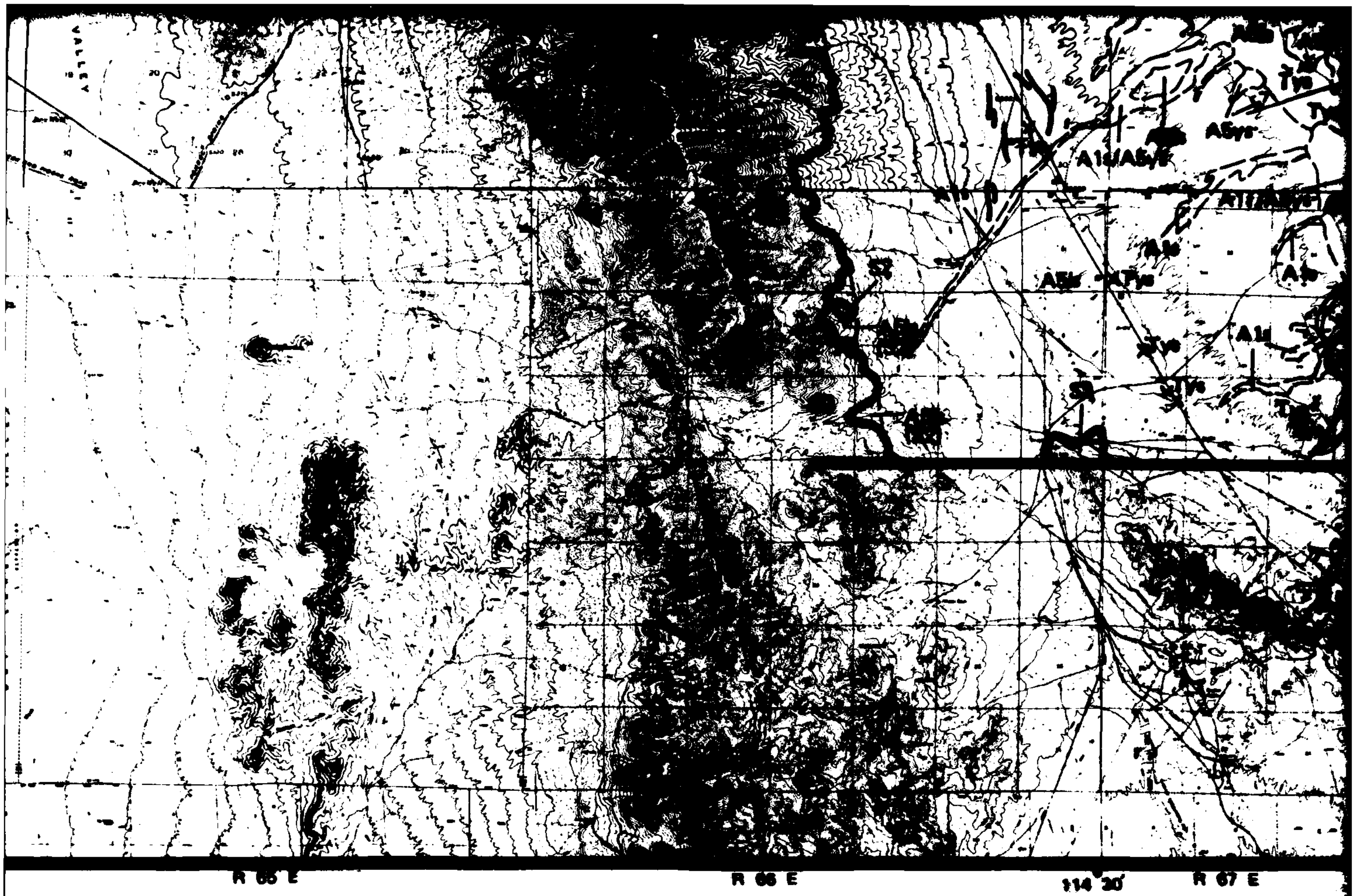
12
(12)
12
12

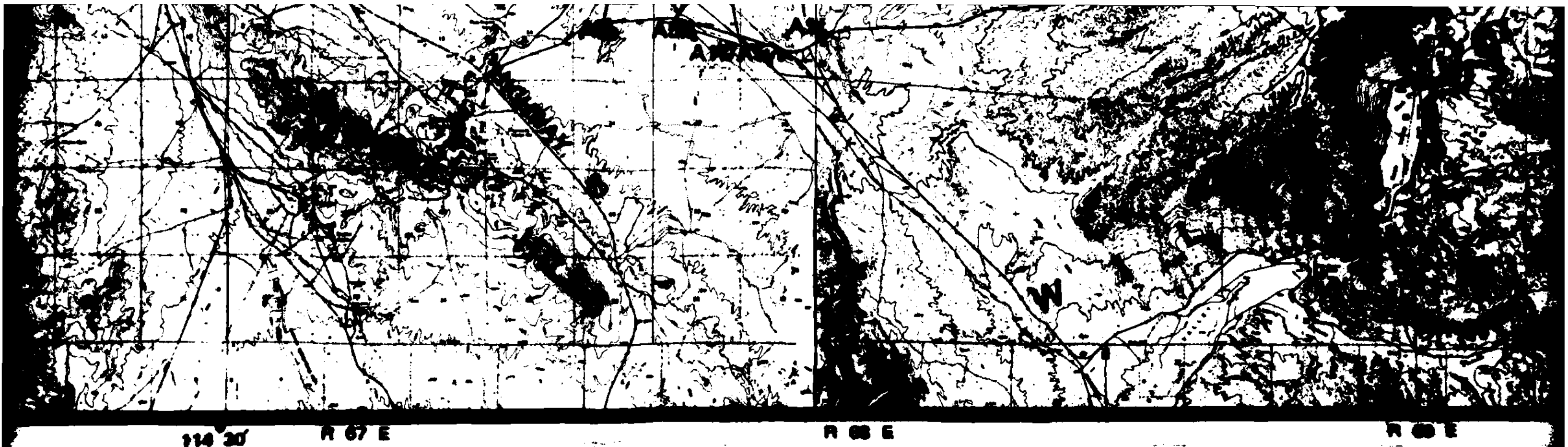


EXP

SURFICIAL

A1f A1s	Young fluvial deposits in modern A1s – silty sand.
A2s	Old fluvial deposits in remnant stream
A3s A3d	Eolian deposits of wind blown sand.
A4f	Young lacustrine active playa
A4of A4os A4og	Old lacustrine sediments deposited A4os – silty to gravelly sand on [illegible] only on map [illegible] of lake
A5yf A5ys A5yg	[illegible] A5ys – silty and gravelly sand.

10



EXPLANATION

SURFICIAL BASIN–FILL DEPOSITS

Young fluvial deposits in modern stream channels and flood plains. A1f – sandy silts and clays; A1s – silty sand.

Old fluvial deposits in remnant stream channels. A2s – silty sand.

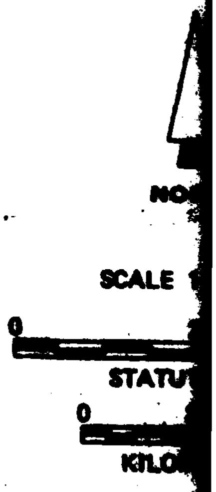
Eolian deposits of wind blown sand. A3s – sheet sands; A3d – dune sands.

Young lacustrine active playa deposits. A4f – silts and clays.

Old lacustrine sediments deposited during past pluvial periods. A4of – silts and clays; A4os – silty to gravelly sands on margins of lake deposits [illegible] as bars; A4og – sandy gravel deposits only on map margins of lake deposits as bars.

Young-age alluvial fan deposits undergoing active dep[illegible] A5yf – sandy silts and clays; A5ys – silty and gravelly sands; A5yg – silty gravel[illegible]

Intermediate-age alluvial fan deposits undergoing [illegible] erosion with no deposition. A5is – gravelly and silty sands; A5ig – silty gravel[illegible]



R 68 E R 69 E

TION

FILL DEPOSITS

nd flood plains. A1f – sandy silts and clays;

A2s – silty sand.

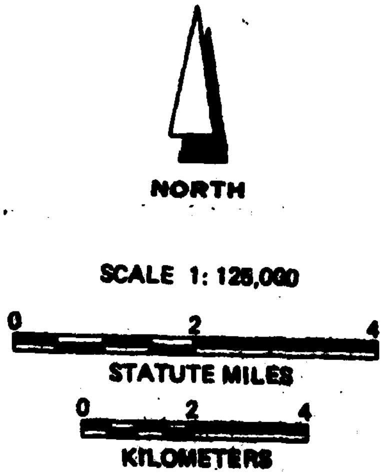
nt sands; A3d – dune sands.

lidated dunes.

[illegible] A4cf – silts and clays;
deposits such as bars; A4cg – sandy gravel
[illegible]

[illegible] A1hd – sandy silts and clays;
[illegible]

[illegible] erosion with no deposition.



A5li A5lq	Intermediate-age alluvial fan deposits undergoing [illegible] erosion with no deposition. A5li – gravelly and silty sands; A5lq – silty [illegible]
A5es A5eg A5ec	Old-age alluvial fan deposits having deep [illegible] eroded [illegible]. A5es – gravelly to silty sands; A5eg – sandy gravel; A5ec – [illegible] caliche
Tys	Tertiary young sediments of the Tertiary Panaca Formation containing well stratified siltstones, sandstones, and conglomerates (indicated on map by [illegible]
A5lk/A5ys	Combination of geologic unit symbols indicates a mixture of surficial basin-fill deposits inseparable at map scale.
A5es(I2)	Parenthetic unit underlies surface at shallow depth.

ROCK UNITS

Igneous (I)

I1	Igneous intrusive rock consisting of coarse grained pink granite.
I2	Undifferentiated volcanic rocks consisting of rhyolite, latite, dacite and andesite.
I3	Undifferentiated volcanic rocks consisting of mafic material - basalt.
I4	Undifferentiated volcanic rocks consisting of welded tufts, ash flows, ignimbrites and pyroclastics.

Sedimentary (S)

S1	Sandstone.
S2	Limestones and dolomites.
S3	Claystones and siltstones.
S5	Conglomerates and fanglomerates.

SYMBOLS

———	Contact between rock and basin-fill.
— — —	Contact between surficial basin-fill or rock units.
—┬— · ·	Fault, trace of surface rupture, ball on downthrown side, dashed where approximately located in bedrock, dotted where inferred in alluvium.
—◆—	Tectonic lineament, probably a fault, generally expressed as a linear vegetational growth on aerial photographs.
▬▬▬	Valley borders.

NOTES:

1. [illegible]
2. [illegible]
3. [illegible]

A5es	
Tys	Tertiary young [illegible] [illegible], and [illegible]
A5la/A5ys	Combination of surficial unit sy Inseparable at map scale.
A5es(I2)	Parenthetic unit underlies surface

ROCK U

Igneous (I)

I1	Igneous intrusive rock consisting
I2	Undifferentiated volcanic rocks o
I3	Undifferentiated volcanic rocks o
I4	Undifferentiated volcanic rocks o

Sedimentary (S)

S1	Sandstones.
S2	Limestones and dolomites.
S3	Claystones and siltstones.
S5	Conglomerates and fanglomerates

SYMB

———	Contact between rock and bas
— — —	Contact between surficial basin
—⊥— · ·	Fault, trace of surface rupture, bedrock, dotted where inferred
——◆——	Tectonic lineament, probably photographs.
▬▬▬	Valley borders.

NOTES:

1. [illegible]
2. [illegible]
3. [illegible]

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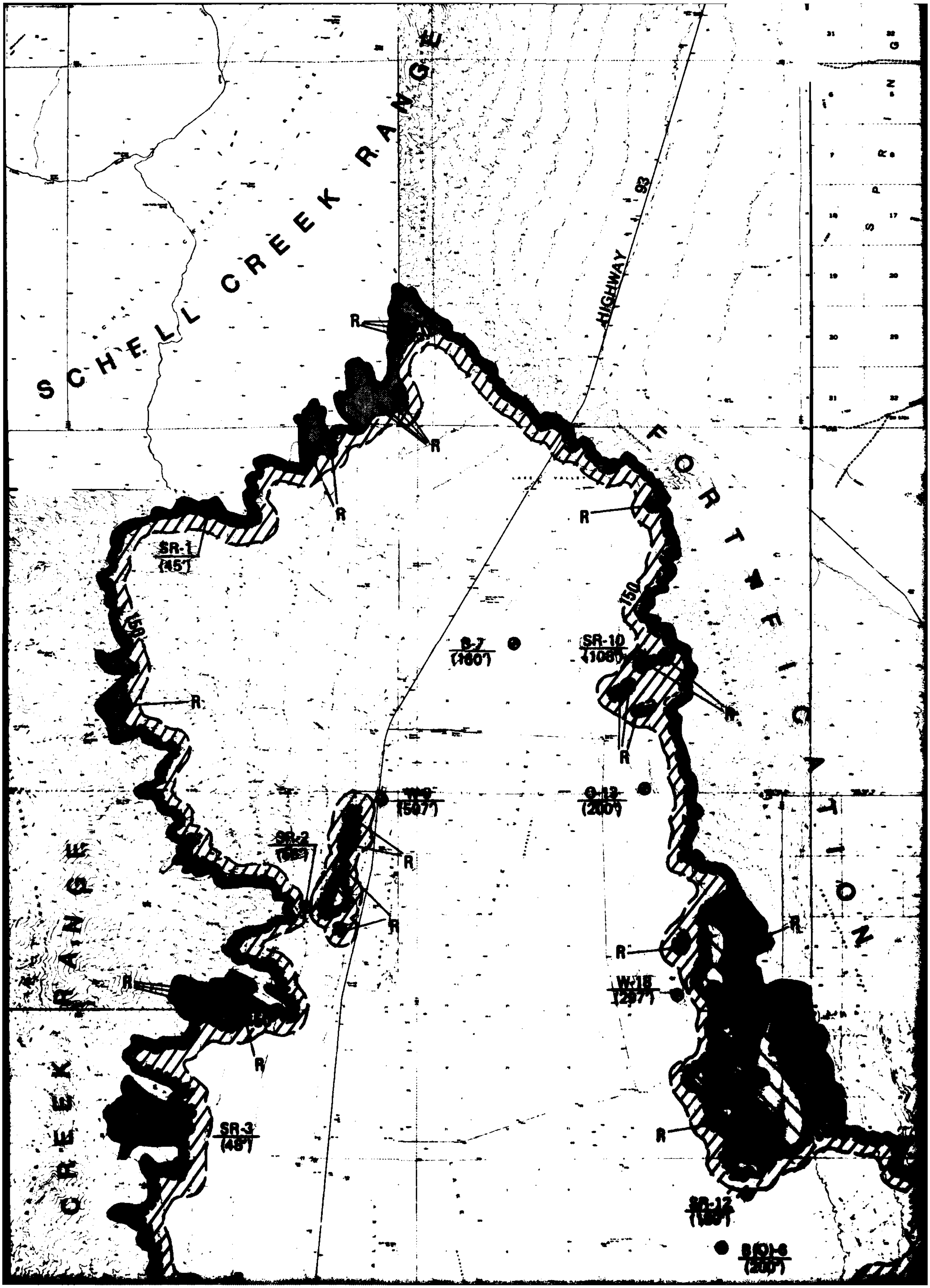
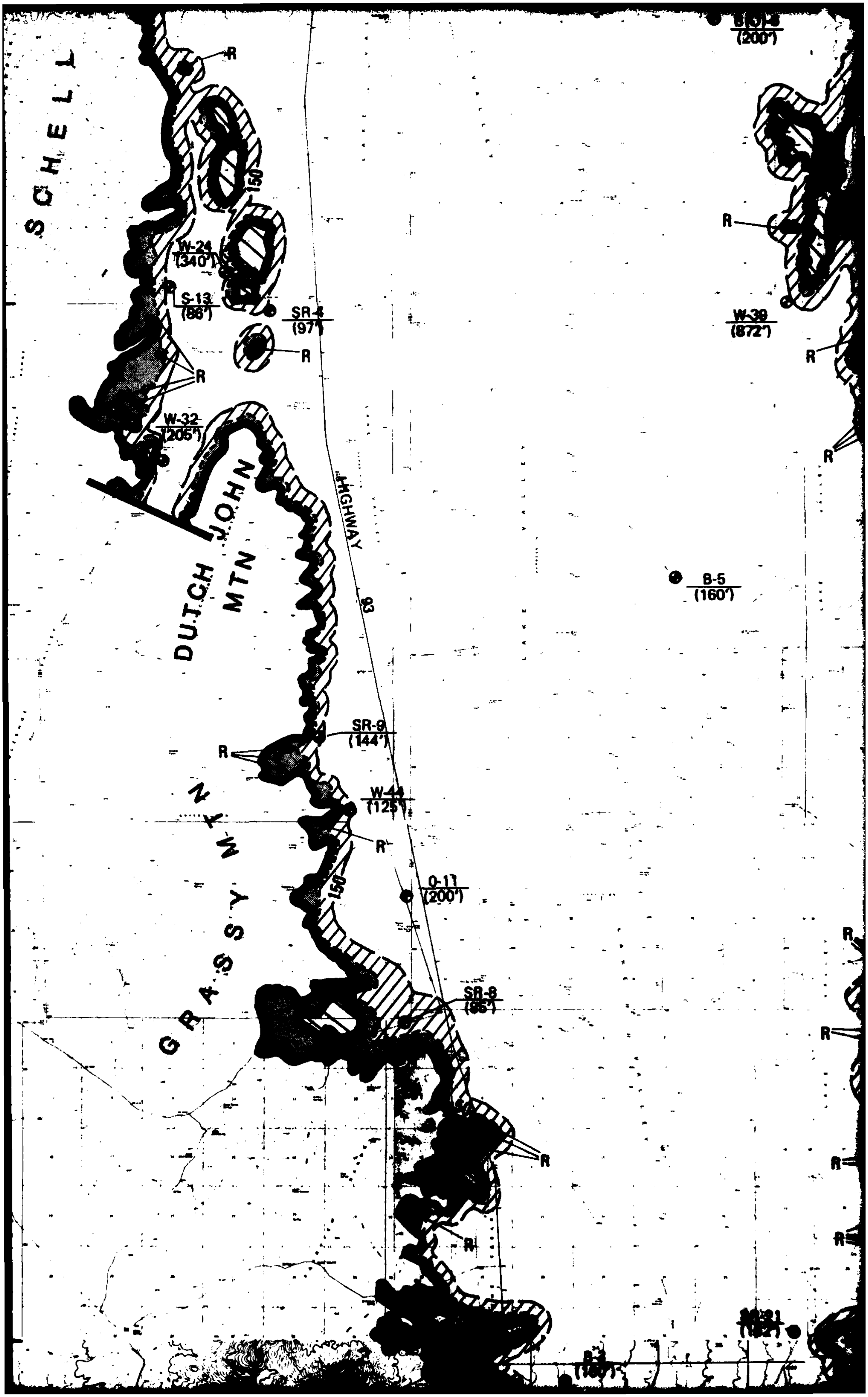
SURFICIAL GEOLOGICAL UNITS
LAKE VALLEY, NEVADA

14


SCHELL CREEK RANGE
HIGHWAY 93
FORTIFICATION
R
R
R
SR-1
(45')
150
R
B-7
(160')
SR-10
(108')
150
R
R
W-9
(507')
G-13
(200')
SR-2
(65')
R
R
CREEK RANGE
R
R
150
R
R
W-15
(297')
R
SR-3
(48')
SR-12
(150')
B(O)-6
(200')

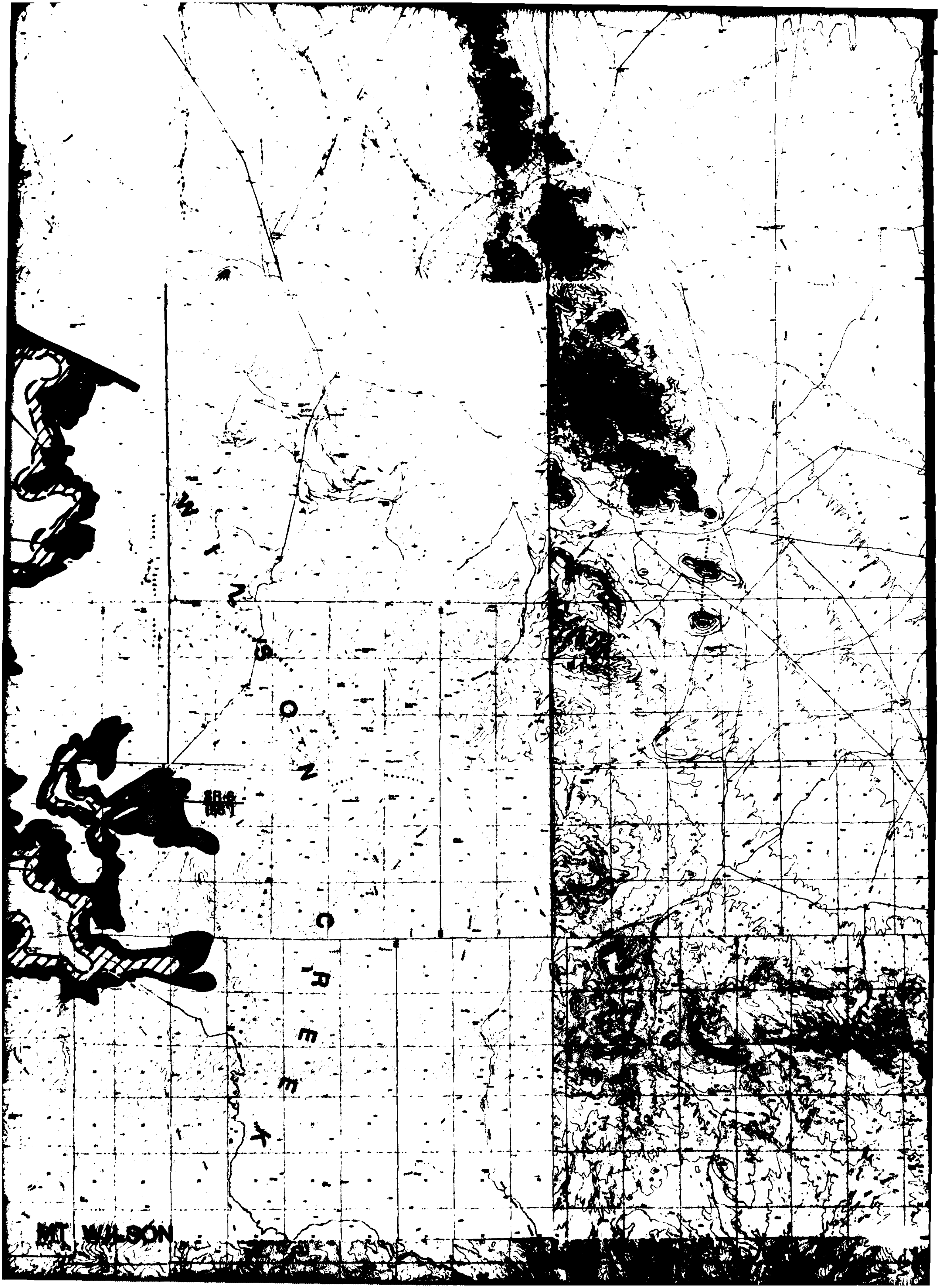

WAY 93
FORTIFICATION
SPRING
150
10
R
R
R
R
R
W-15
(125')
SR-12
(180')
31
32
33
34
35
36
6
5
4
3
2
1
7
8
9
10
11
12
18
17
16
15
14
13
19
20
21
22
23
24
30
29
28
27
26
25
31
32
33
34
35
36

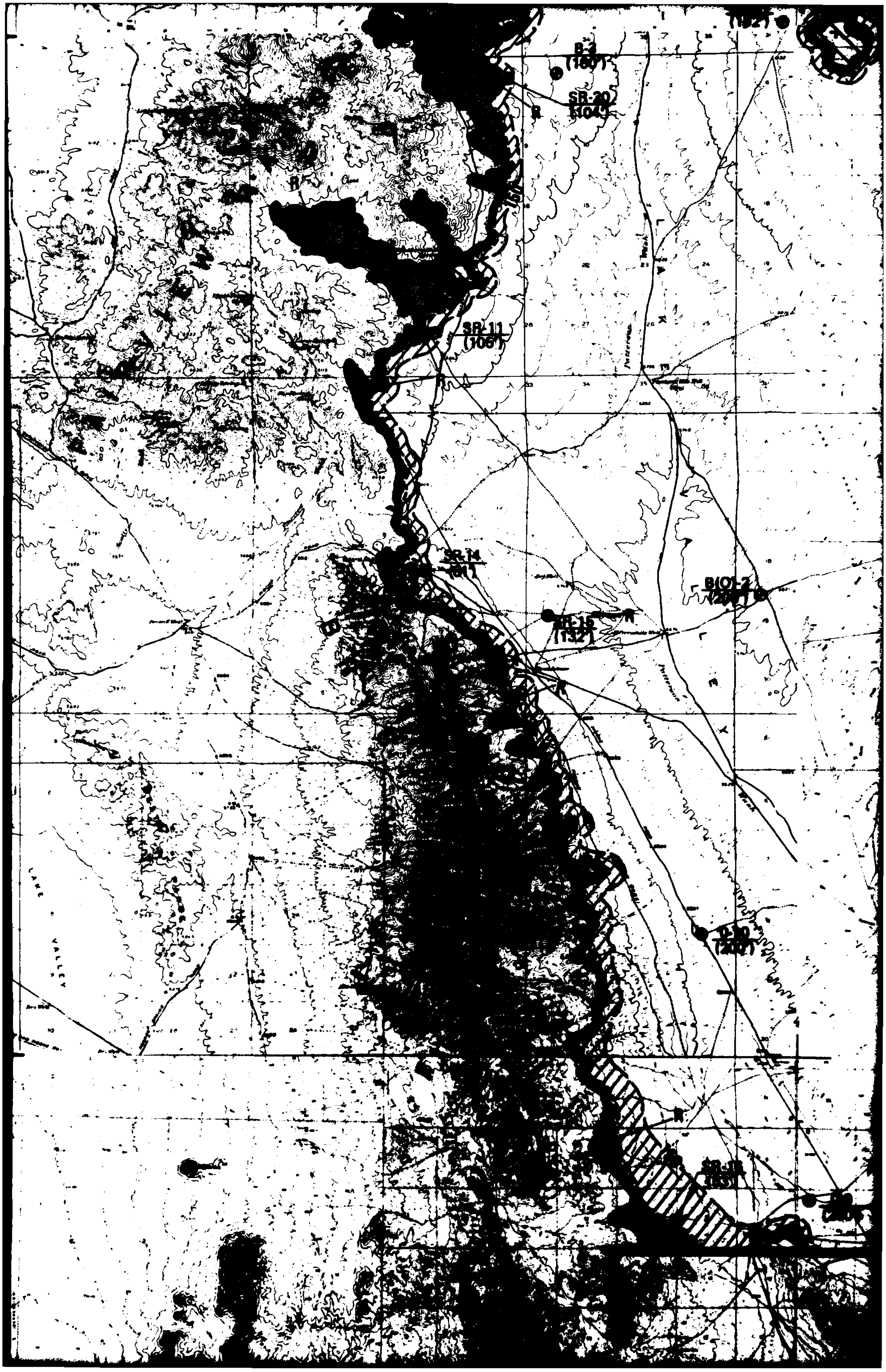

Spring
36
2
1
6
5
Spring
11
12
7
8
14
13
17
18
Blind Spr
23
24
19
26
25
30
29
35
36
31
32

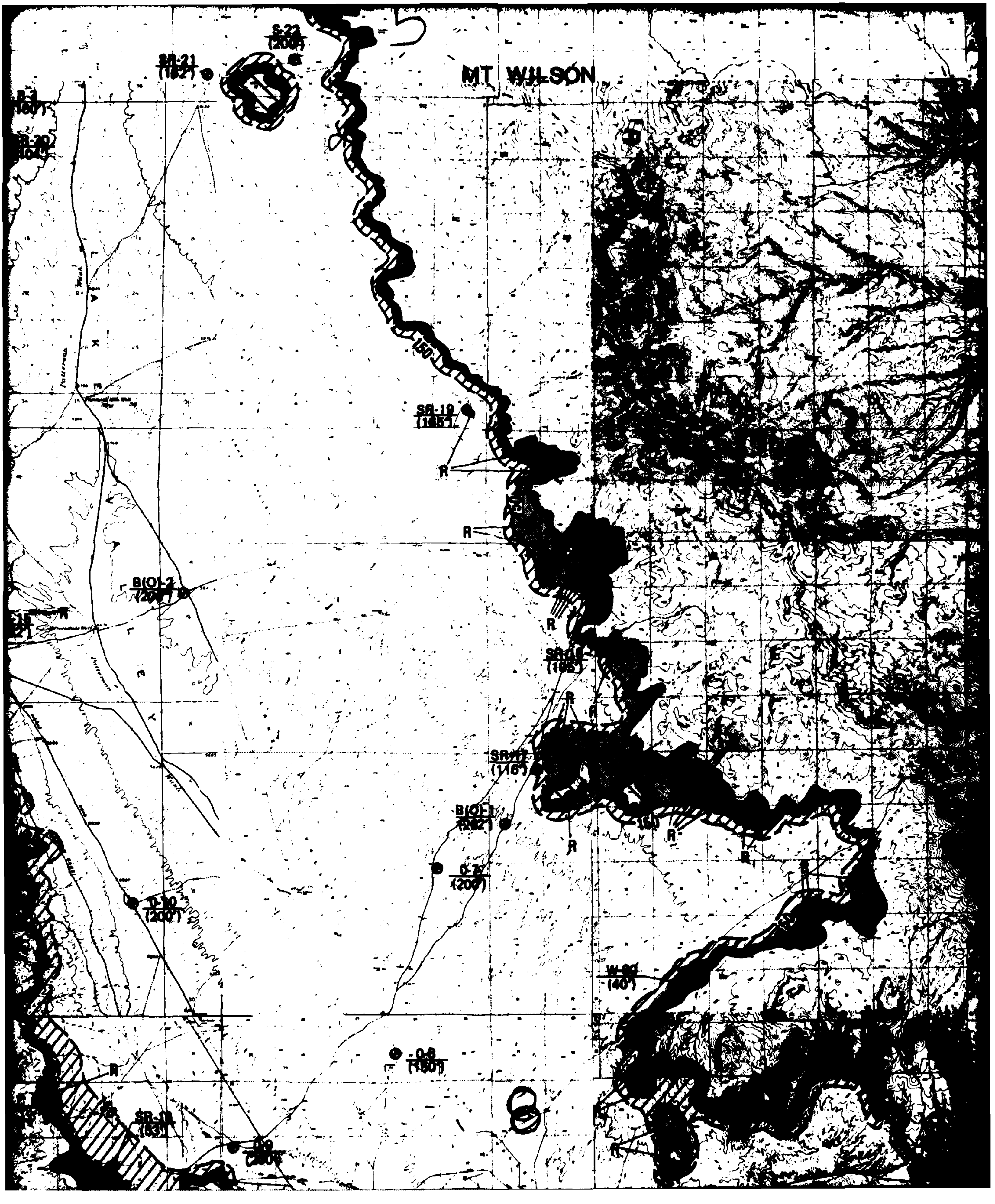

SCHELL
DUTCH JOHN MTN
GRASSY MTN
HIGHWAY 93
150
R
W-24
(340')
S-13
(86')
SR-4
(97')
W-32
(205')
SR-9
(144')
W-44
(125')
O-11
(200')
SR-8
(95')
B-5
(160')
W-39
(872')
(200')
(162')
(160')


SR-12
(180')
B(O)-6
(200')
N
R
R
W-39
(872')
R
150
R
R
B-5
(160')
R
SR-5
(56')
R
150
W
I
L
S
O
N
R
SR-6
(66')
SR-7
(60')
B-3
(150')
R
R
R
C
R
E
E
K
R
R
S-22
(200')

5


WILSON CREEK
MT WILSON


(152')
B-3
(160')
SR-20
(104')
SR-11
(105')
SR-14
(61')
SR-15
(132')
B(O)-2
D-30
(200')
LAKE
VALLEY


S-22
(200')
SR-21
(152')
MT WILSON
R-3
(160')
SR-20
(104')
150
SR-19
(165')
R
R
B(O)-2
(200')
R
R
SR-18
(105')
R
R
SR-17
(116')
B(O)-1
(262')
150
R
R
R
O-7
(200')
O-10
(200')
150
W-90
(40')
O-8
(160')
R
SR-16
(83')
O-9
(200')
R


MT WILSON
R
R
R
(116')
150
R
R
R
(200')
(40')

R 65 E R 66 E 114°30' R 67 E

EXPLA

▩ 50' Contour indicates rock at a depth of approx
rock less than 50 feet (15m).

▨ 150' Contour indicates rock at a depth of approx
rock between 50 feet (15m) and 150 feet (4

━ Contact between rock and basin-fill.

▬ Valley borders.

▨ Areas of isolated exposed rock.

R Areas of isolated exposed rock too small fo

● SR-7 / 150' Data Source – Seismic refraction line (S), a
sounding (SR), boring (B), boring with [illegible]
or published water well (W).

Depth to rock or, when in parentheses, [illegible]

NOTE: [illegible]

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DEPTH TO ROCK
LAKE VALLEY, NEVADA

31 JUL 81

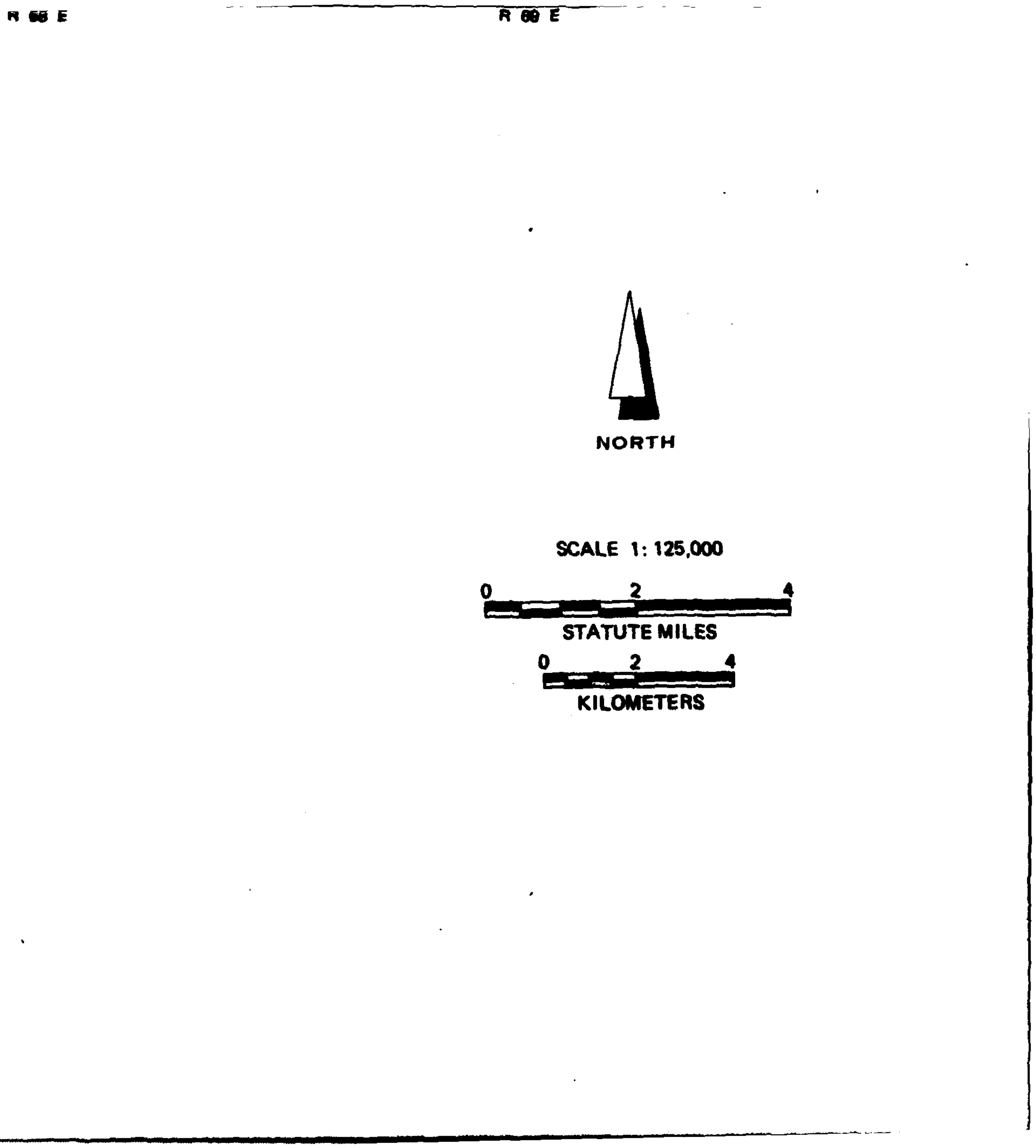
TION

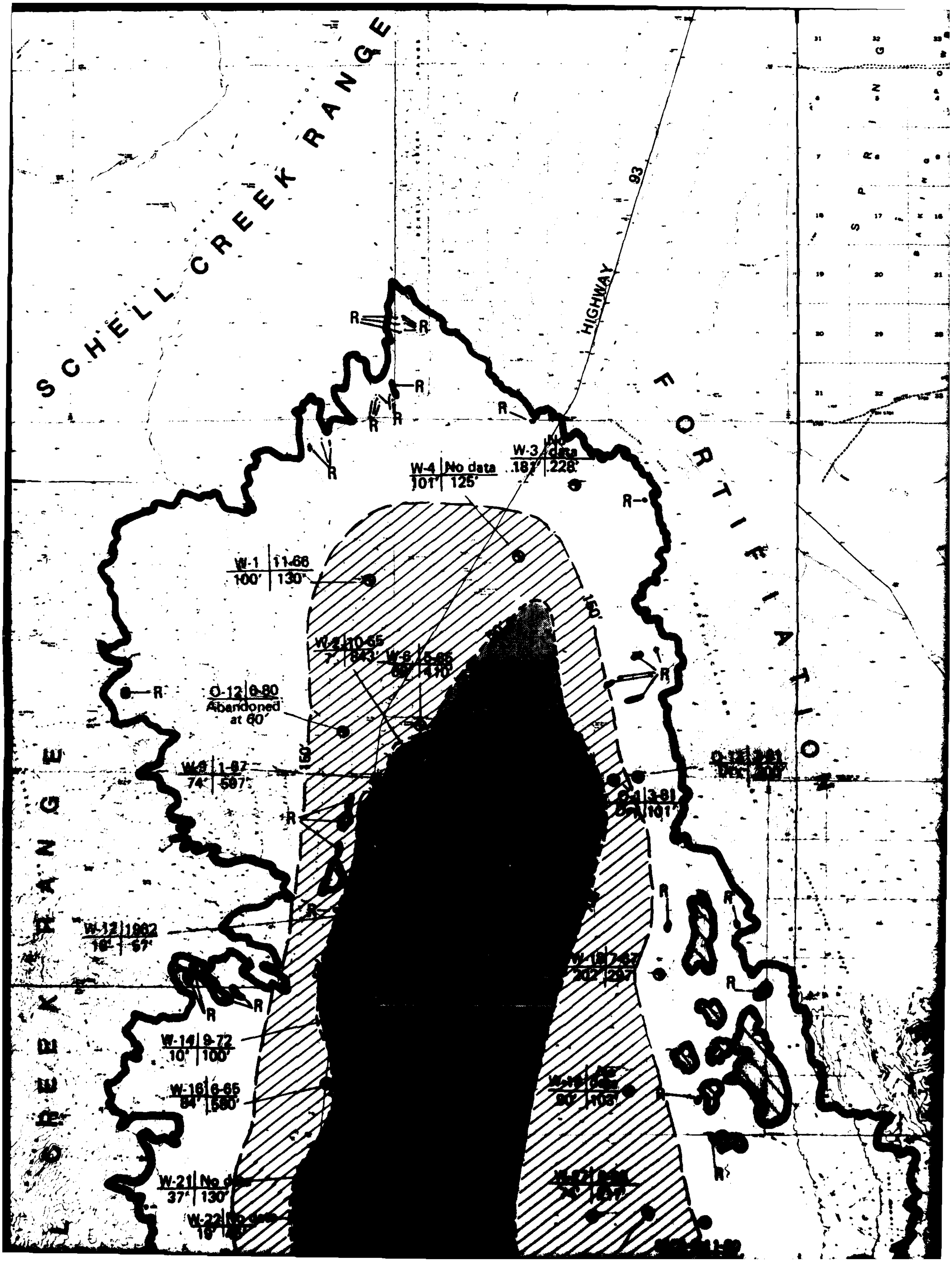
0 feet (15m) — shading indicates

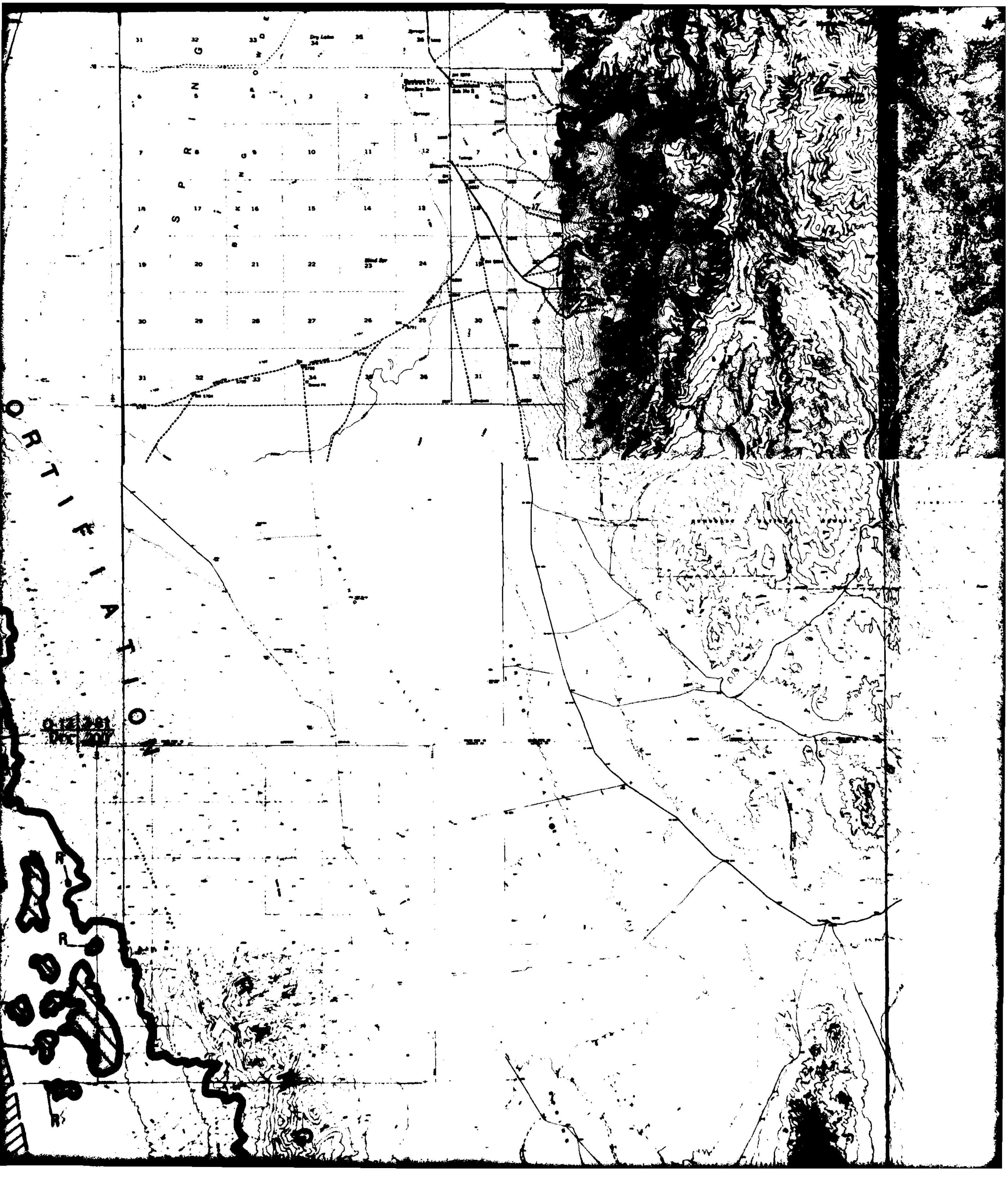
150 feet (46m) — shading indicates

ection line and electrical resistivity
ell (B(O)), observation well (O),

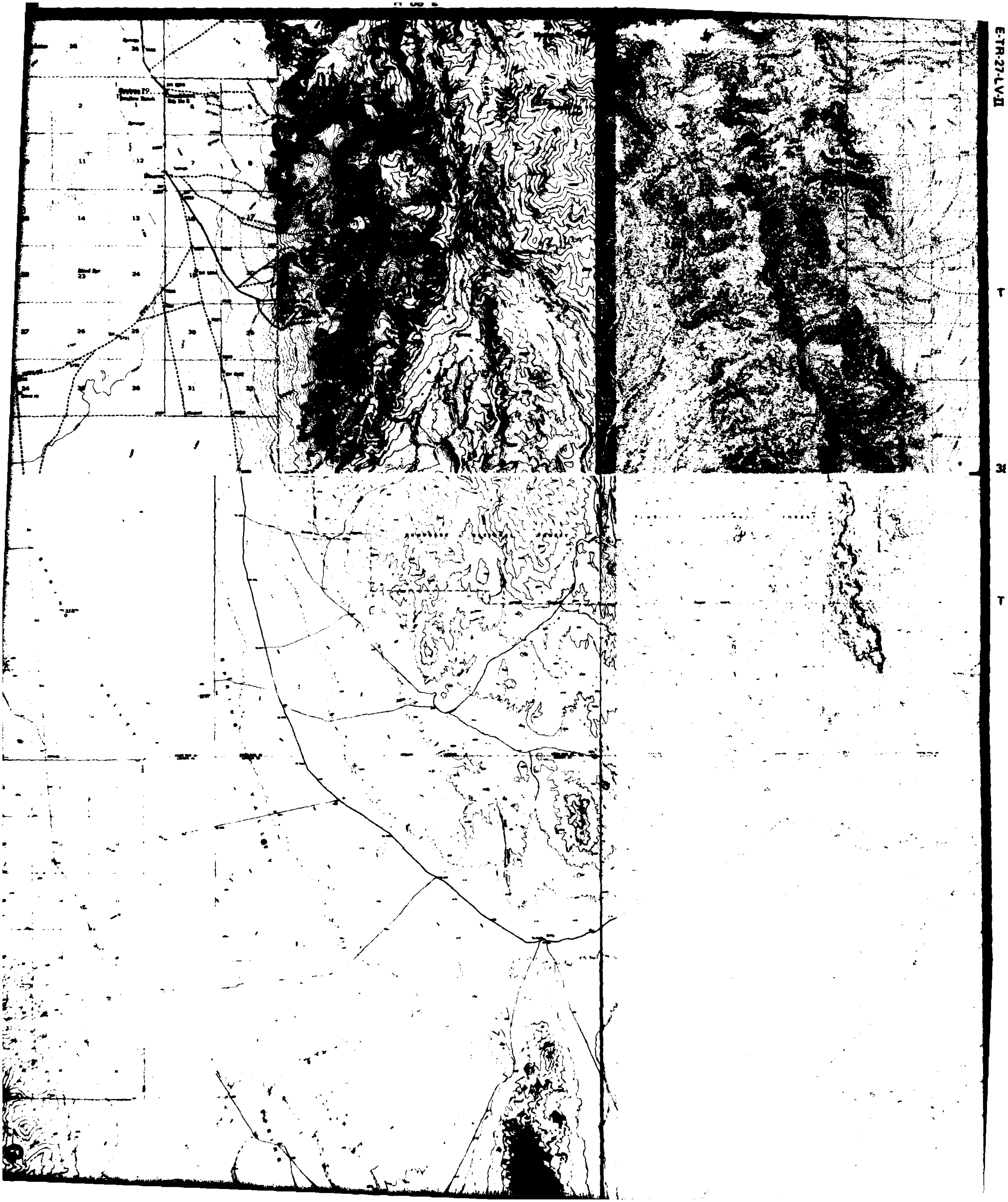
which rock not encountered.

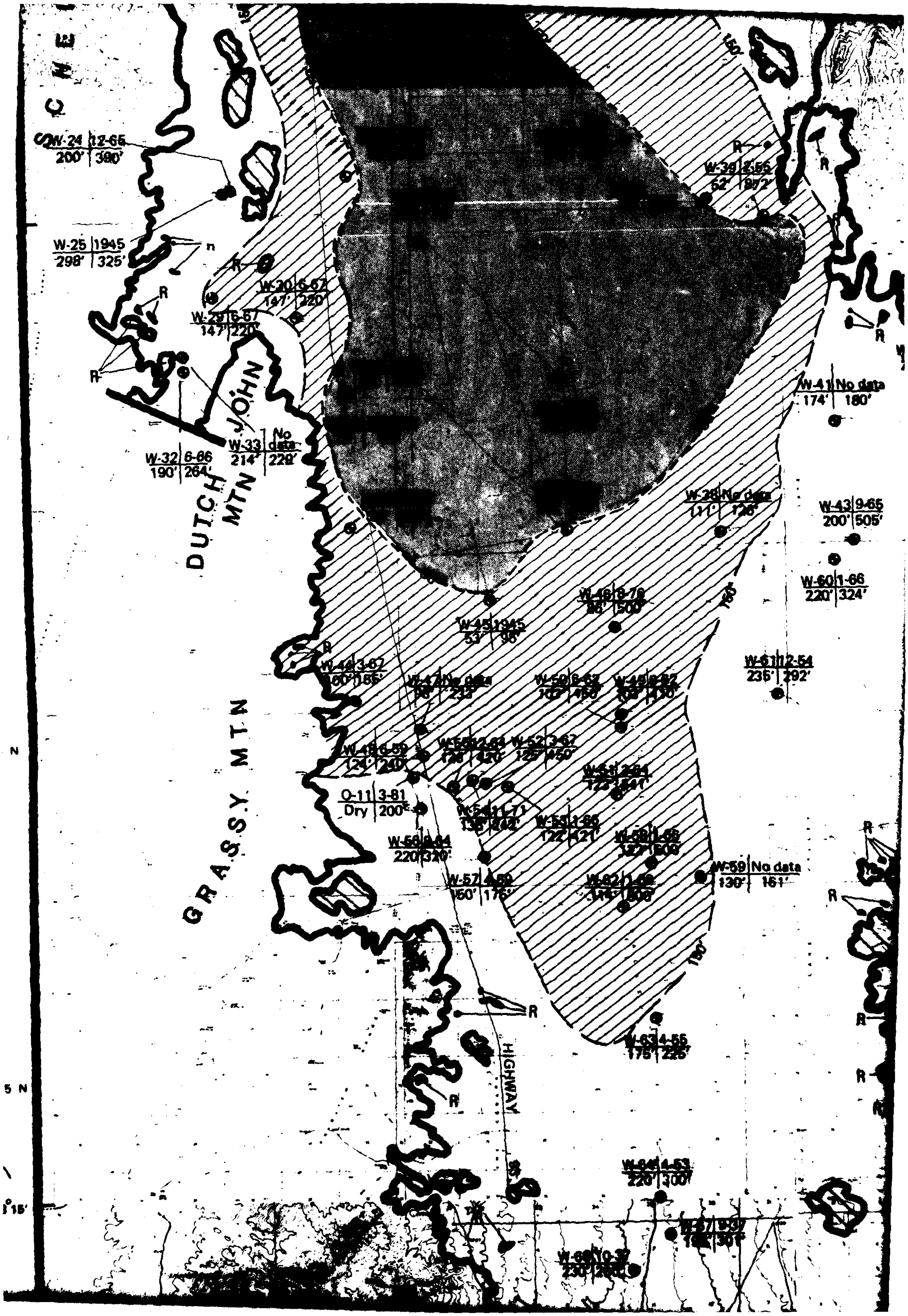


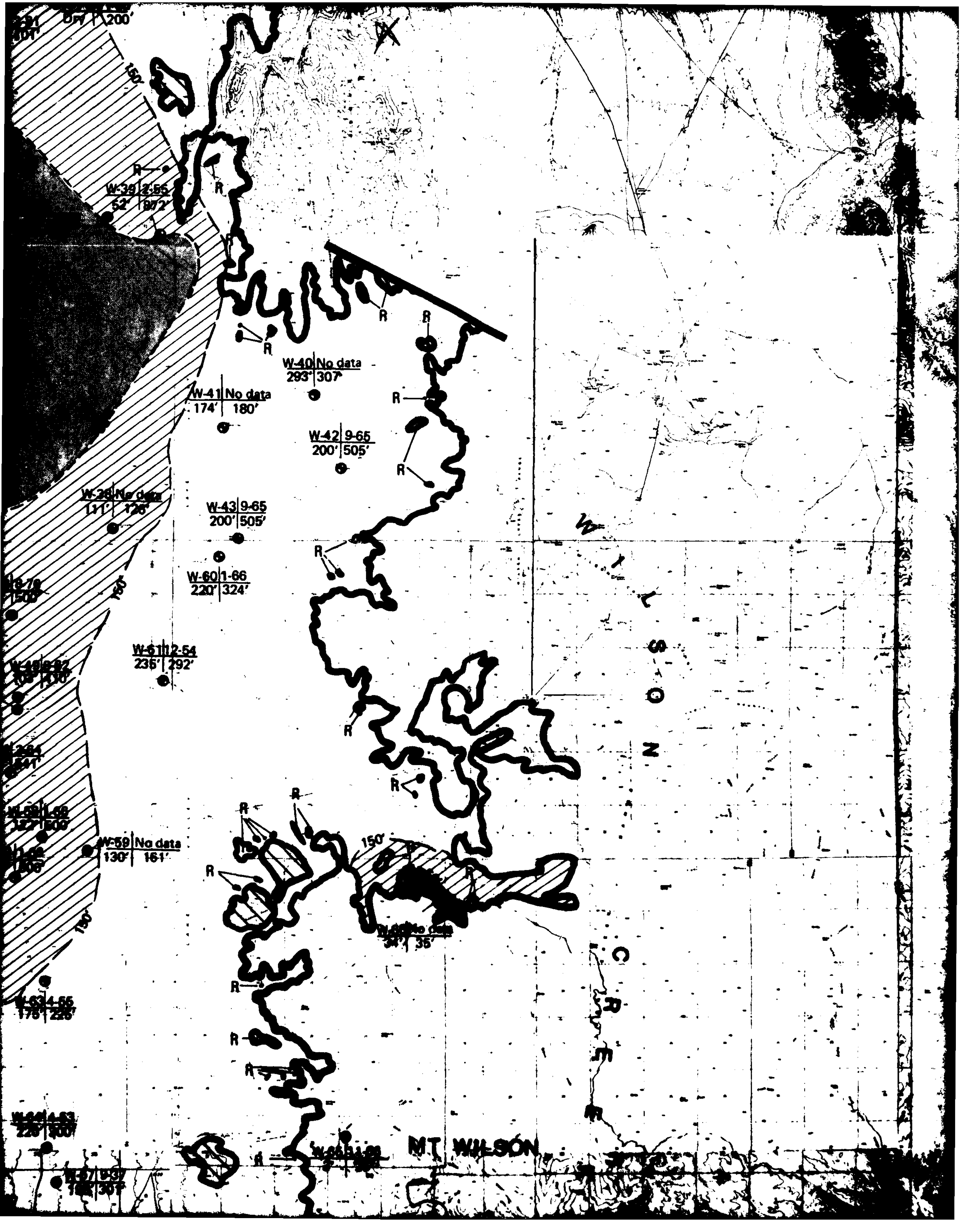

SCHELL CREEK RANGE
FORTIFICATION
HIGHWAY
93
W-4 | No data
101' | 125'
W-3 | No data
181' | 228'
W-1 | 11-66
100' | 130'
150'
W-2 | 10-65
7' | 843'
W-6 | 5-65
68' | 470'
O-12 | 6-80
Abandoned at 60'
W-9 | 1-67
74' | 597'
O-1 | 3-81
101'
W-12 | 1962
16' | 57'
W-18 | 7-67
202' | 297'
W-14 | 9-72
10' | 100'
W-16 | 6-65
84' | 580'
103'
W-21 | No d
37' | 130'
W-22
19'
R

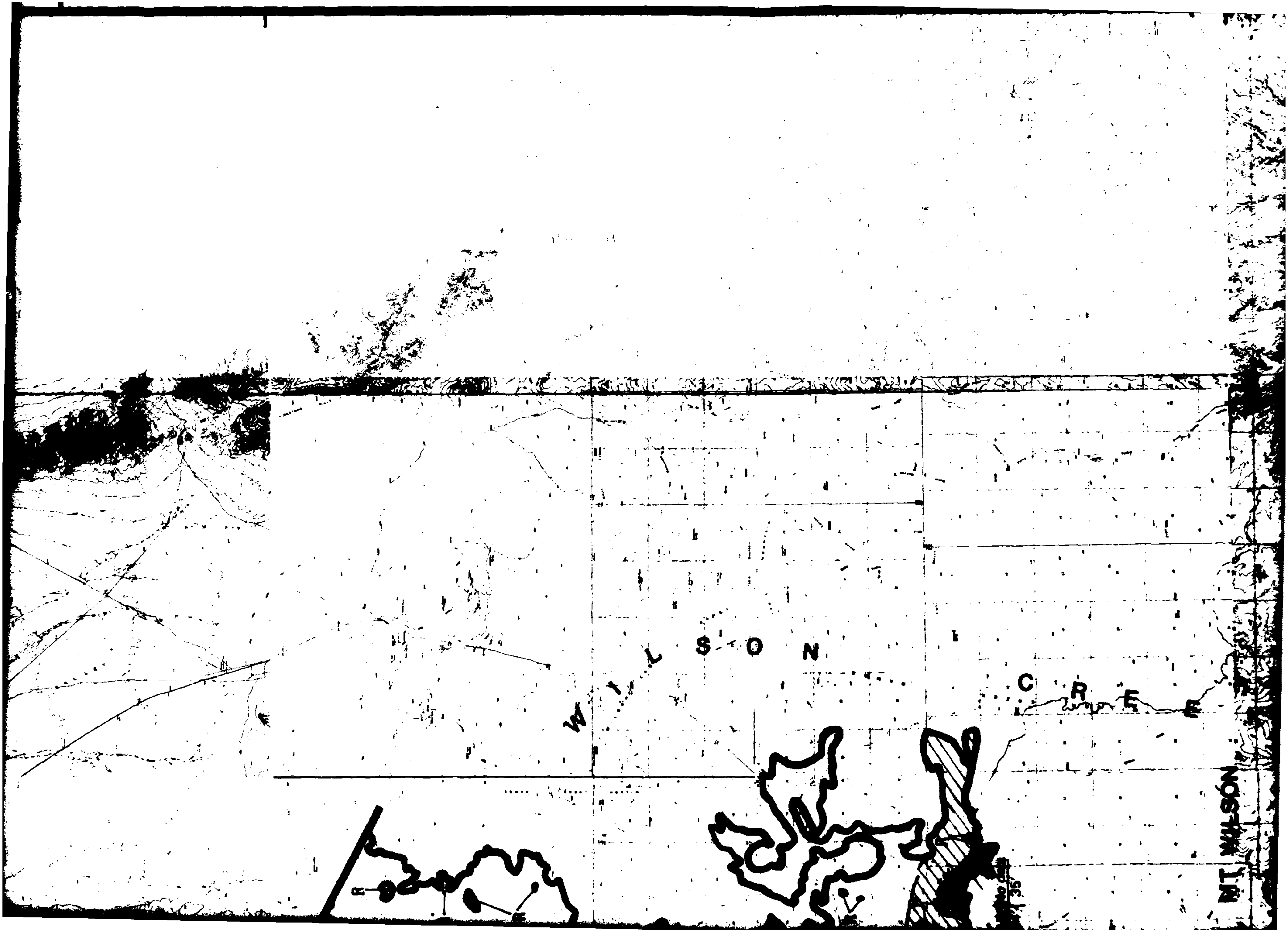


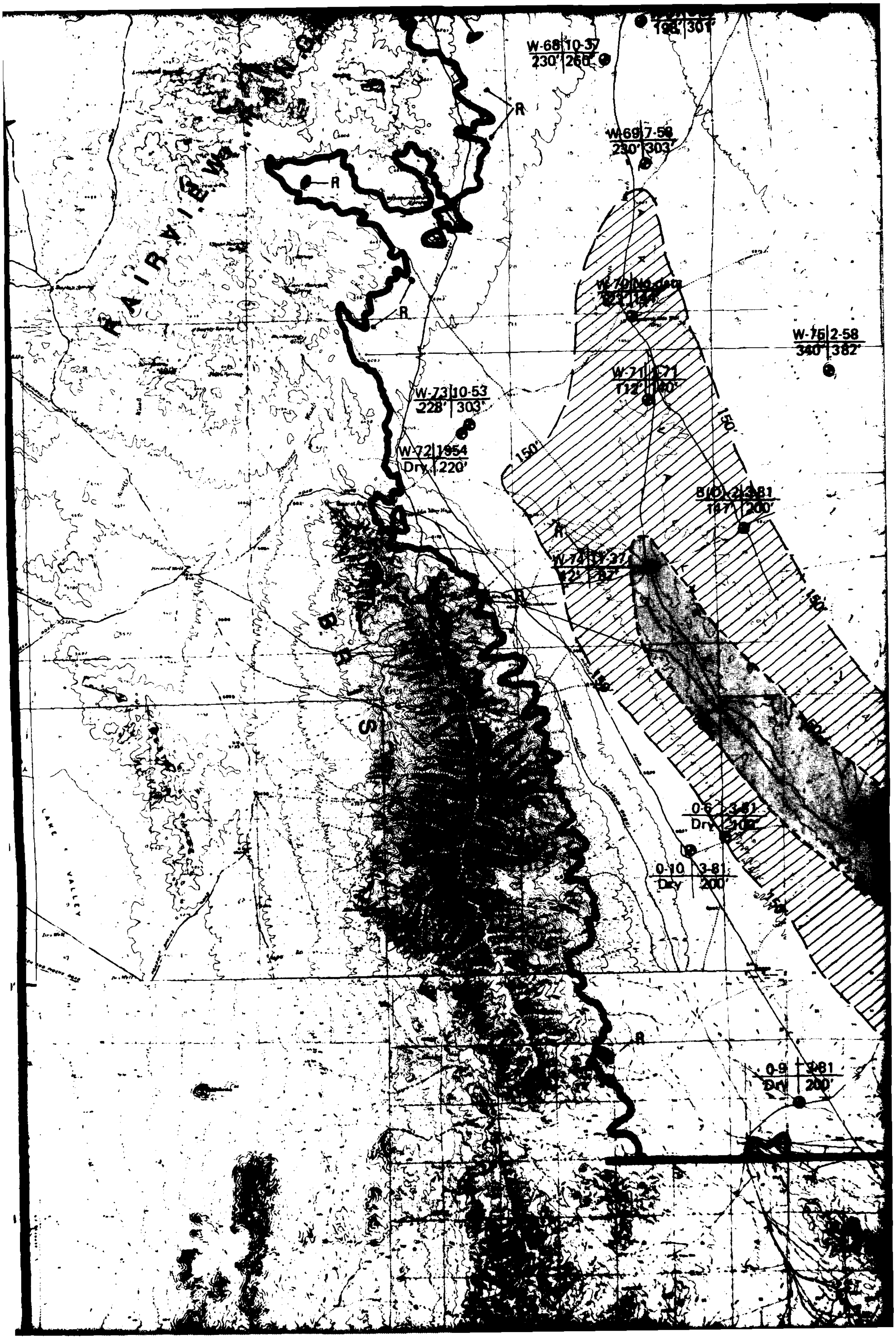
31
32
33
Dry Lake 34
35
36
6
5
4
3
2
1
6
5
7
8
9
10
11
12
7
8
18
17
16
15
14
13
19
20
21
22
Blind Spr 23
24
30
29
28
27
26
25
30
31
32
33
34
35
36
31
SPRING
ORTIFICATION
D-12 2-81
DK 20T
R
R
R

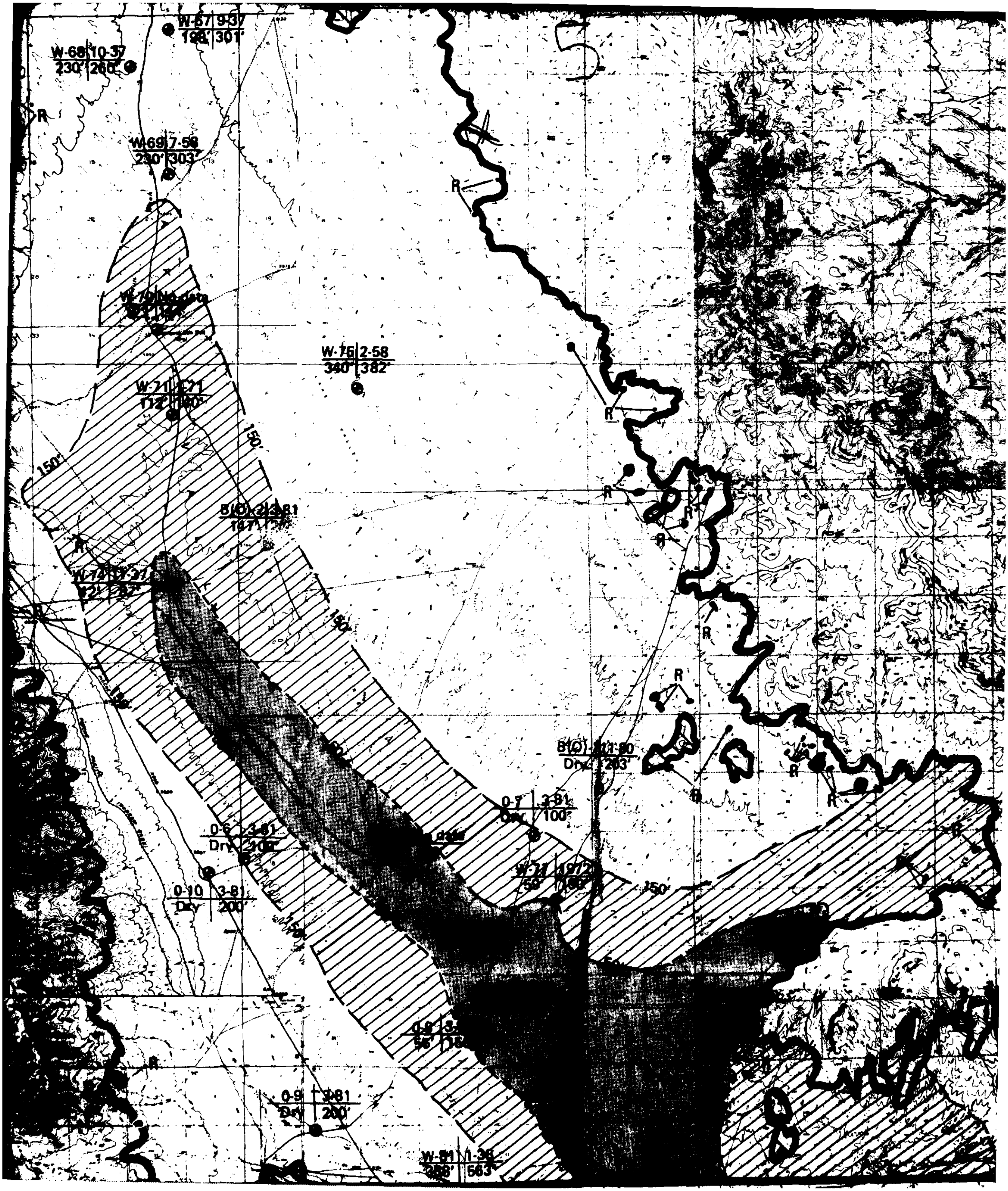


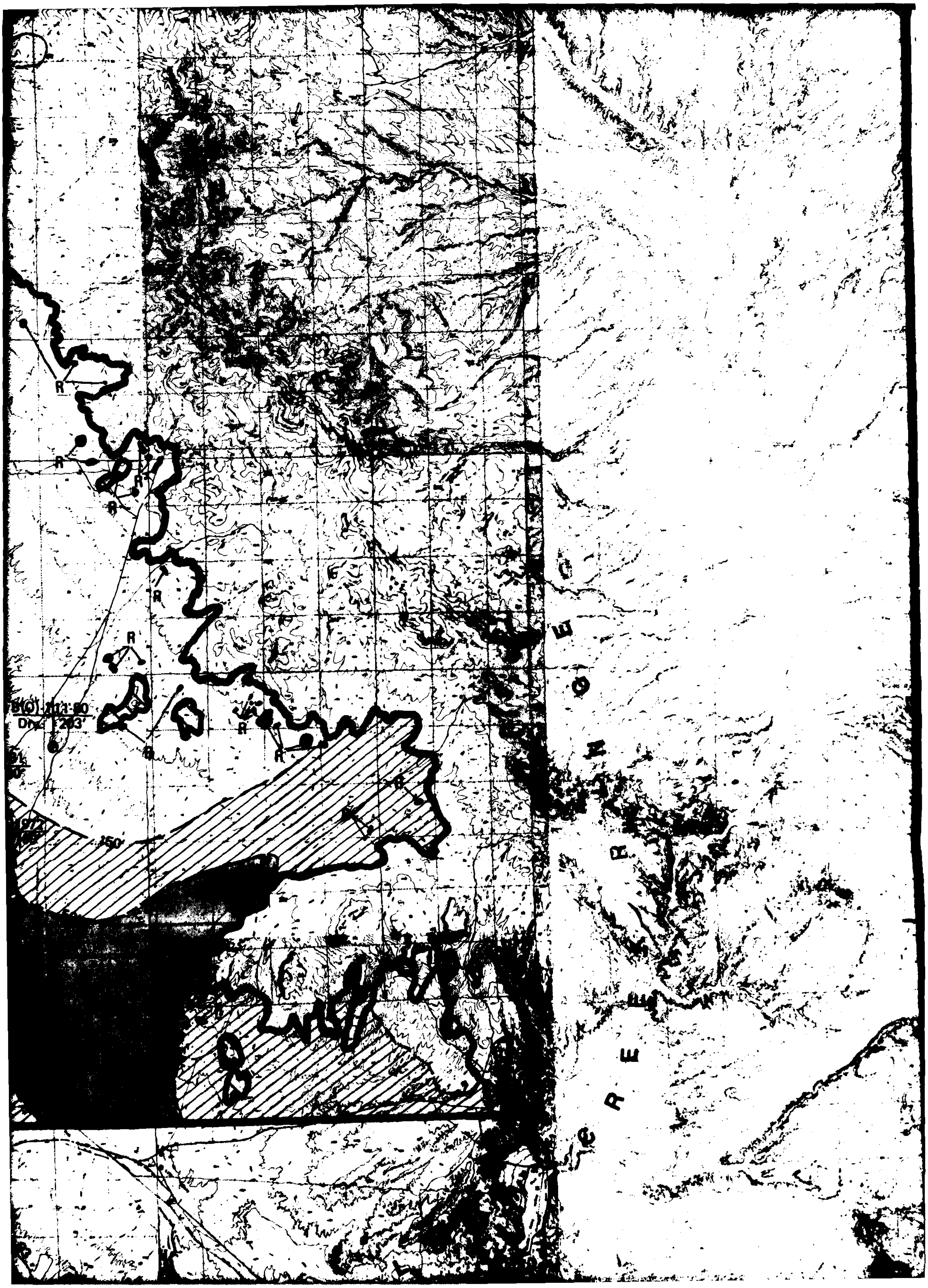

C N E
W-24 12-65 200' 390'
W-25 1945 298' 325'
n
R
W-30 6-67 147' 220'
W-29 6-67 147' 220'
DUTCH JOHN MTN
W-33 No data 214' 229'
W-32 6-66 190' 264'
150
W-39 2-55 52' 872'
W-41 No data 174' 180'
W-38 No data 111' 126'
W-43 9-65 200' 505'
W-60 1-66 220' 324'
W-46 8-76 96' 500'
W-45 1945 53' 96'
W-61 12-54 236' 292'
W-44 3-67 160' 165'
W-47 No data 96' 233'
W-50 6-62 107' 450'
W-49 6-62 103' 430'
GRASSY MTN
N
W-48 6-59 124' 240'
W-55 12-63 126' 420'
W-52 3-67 125' 450'
W-51 2-64 123' 641'
O-11 3-81 Dry 200'
W-54 11-71 138' 242'
W-53 1-66 122' 421'
W-58 1-66 127' 500'
W-56 9-64 220' 320'
W-59 No data 130' 161'
W-57 4-59 150' 175'
W-62 1-66 115' 500'
HIGHWAY
W-63 4-55 175' 225'
5 N
W-64 4-53 220' 300'
W-67 9-37 186' 301'
W-68 10-37 230' 260'
15'


200'
150'
R
W-39 2-55
52' 872'
R
R
R
R
W-40 No data
293' 307'
W-41 No data
174' 180'
R
W-42 9-65
200' 505'
R
W-38 No data
111' 126'
W-43 9-65
200' 505'
R
W-60 1-66
220' 324'
150'
8-78
500'
W-61 12-54
236' 292'
R
W-48
R
R
R
R
W-59 No data
130' 161'
150'
R
No data
34' 35'
150'
W-63 4-55
175' 225'
R
R
R
W I L S O N
C R E E K
MT WILSON
W-67 9-37
301'


WILSON
CREE
R
R
35′
MT WILSON


198' | 301'
W-68 | 10-37
230' | 268'
R
R
W-69 | 7-58
230' | 303'
AIRVIEW
R
W-70 | No data
123' | 144'
W-76 | 2-58
340' | 382'
W-71 | 1-71
112' | 140'
W-73 | 10-53
228' | 303'
150
150'
W-72 | 1954
Dry | 220'
B(O)-2 | 3-81
147' | 200'
R
W-74 | 11-37
12' | 87'
R
BRAS
150'
150'
0-6 | 3-81
Dry | 102'
LAKE VALLEY
0-10 | 3-81
Dry | 200'
R
0-9 | 3-81
Dry | 200'


5
W-67 9-37
198' 301'
W-68 10-37
230' 266'
R
W-69 7-58
230' 303'
W-70 No data
W-75 2-58
340' 382'
W-71 7-71
112' 140'
150'
150'
B(O)-2 3-81
147'
R
W-74 11-37
150
150
R
R
R
R
R
R
R
0-6 3-81
Dry 102'
0-10 3-81
Dry 200'
B(O) 11-80
Dry 203'
0-7 3-81
Dry 100'
W-77 1972
59' 156'
150'
0-8
56'
R
0-9 3-81
Dry 200'
W-81 1-38
368' 563'



R
R
R
R
R
R
R
R
B(O)-211-80
Dry 1203'
150

R 65 E R 66 E 114°30' R 67 E

EXPLANATIO

50'	Contour indicates water at a depth of approximately 50 fee water less than 50 feet (15m).
150' ▨	Contour indicates water at a depth of approximately 150 f water between 50 feet (15m) and 150 feet (46m).
	Absence of contours indicates water occures at depths of g borings, and assorted wells indicate depths to ground wate remainder of Lake Valley (see Volume I, Section 3.0).
▬	Contact between rock and basin-fill.
▬	Valley borders.
▨	Areas of isolated exposed rock.
R	Areas of isolated exposed rock too small for shading.
● W-1 | 5-80 340' | 394'	Data Source - Published water well (W), or observation w with observation well (B(O)), see Volume II, Table II-3-1 Depth to water (feet).

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DEPTH TO WATER
LAKE VALLEY, NEVADA

31 JUL 81

DRAWING 3-4

114°30′ R 67 E R 68 E R 69 E

EXPLANATION

water at a depth of approximately 50 feet (15m) - shading indicates feet (15m).

water at a depth of approximately 150 feet (46m) - shading indicates feet (15m) and 150 feet (46m).

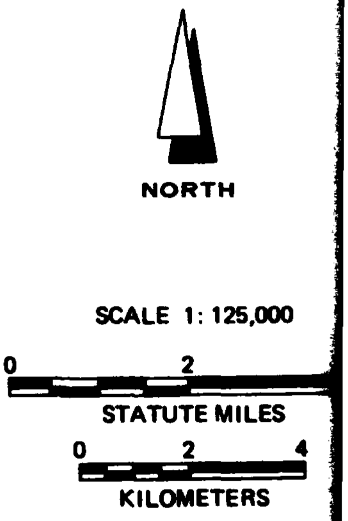
urs indicates water occures at depths of greater than 150 feet. Ertec Western, Inc. ted wells indicate depths to ground water generally in excess of 200 feet throughout Valley (see Volume I, Section 3.0).

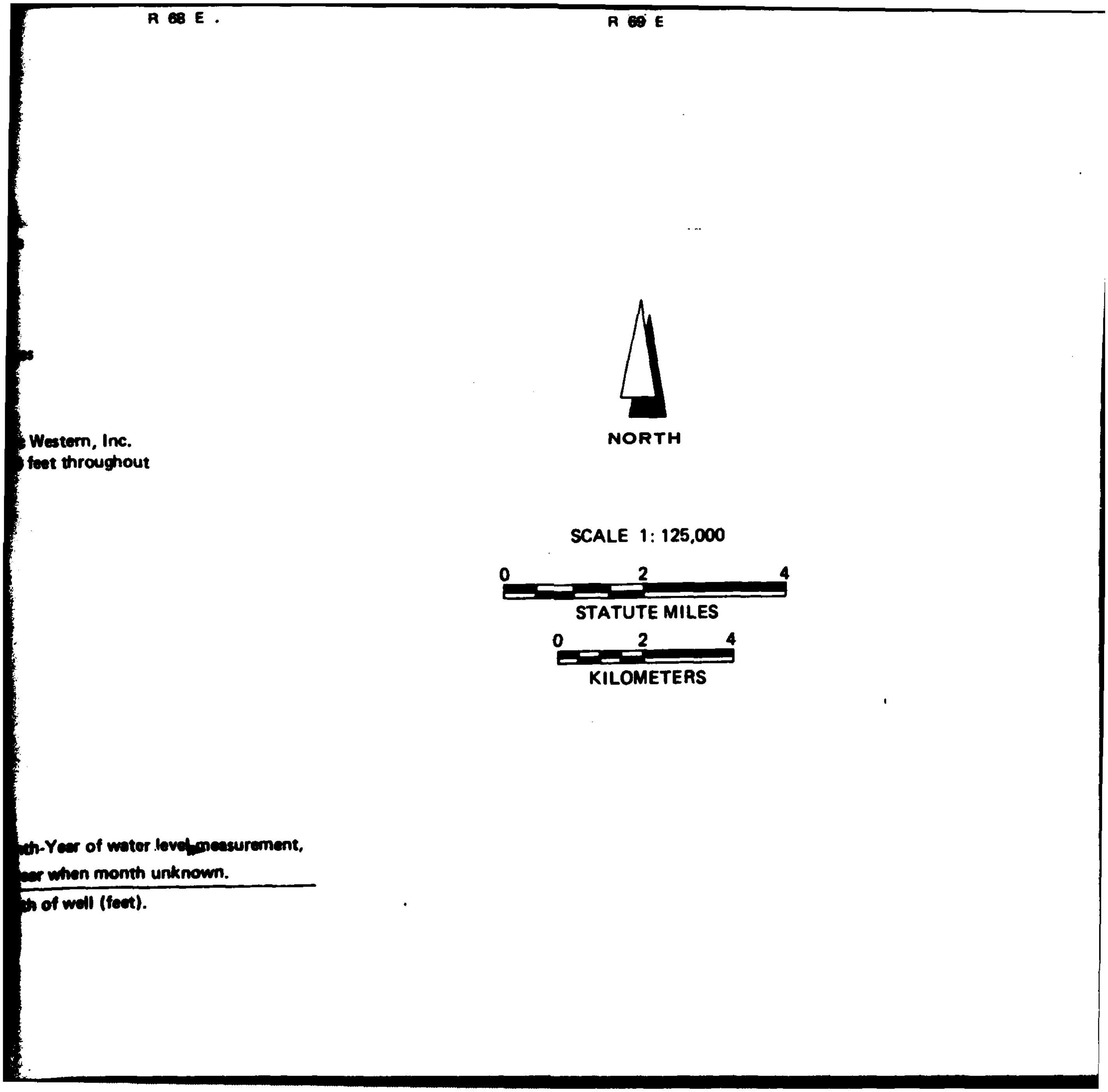
rock and basin-fill.

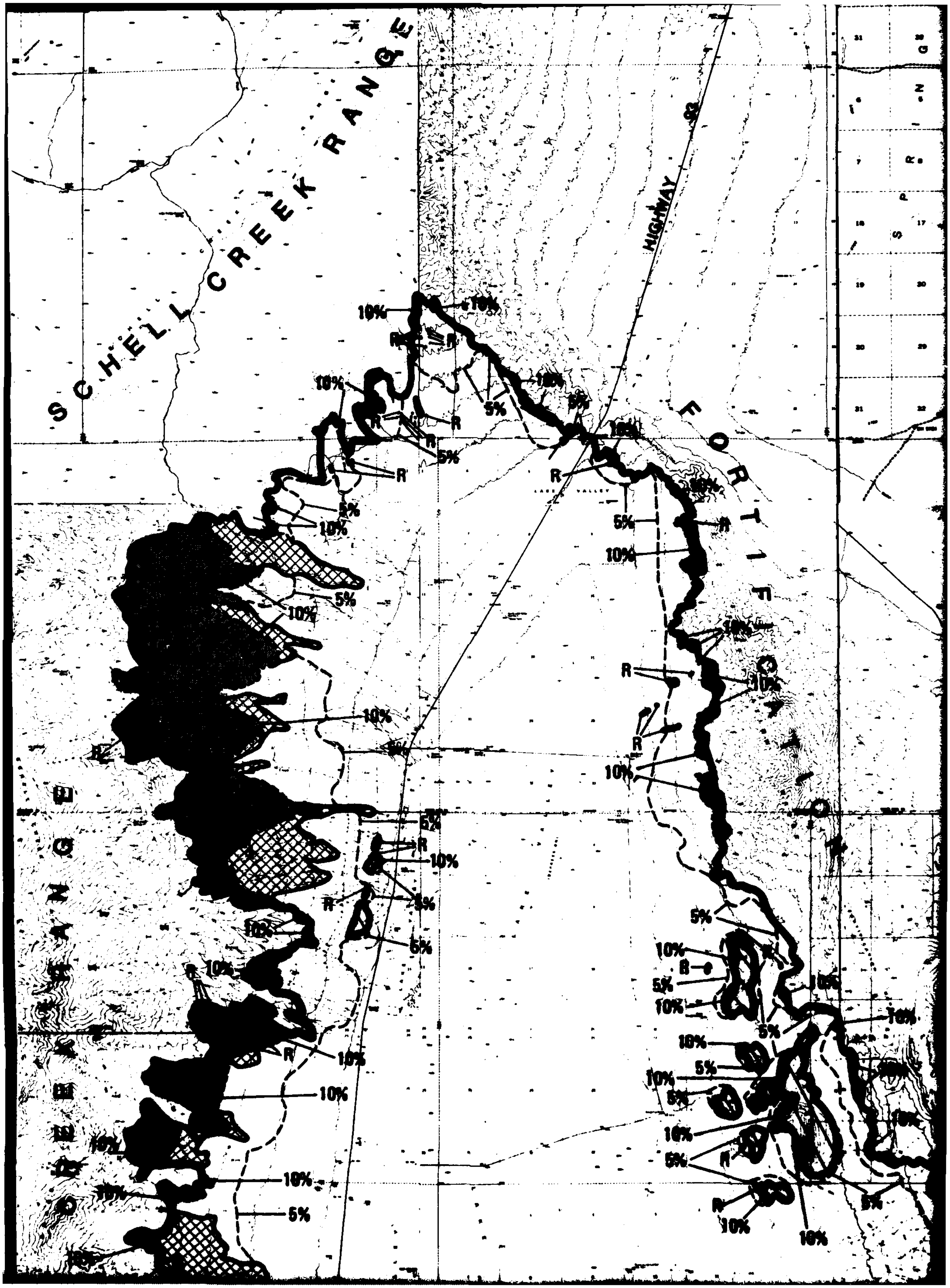
xposed rock.

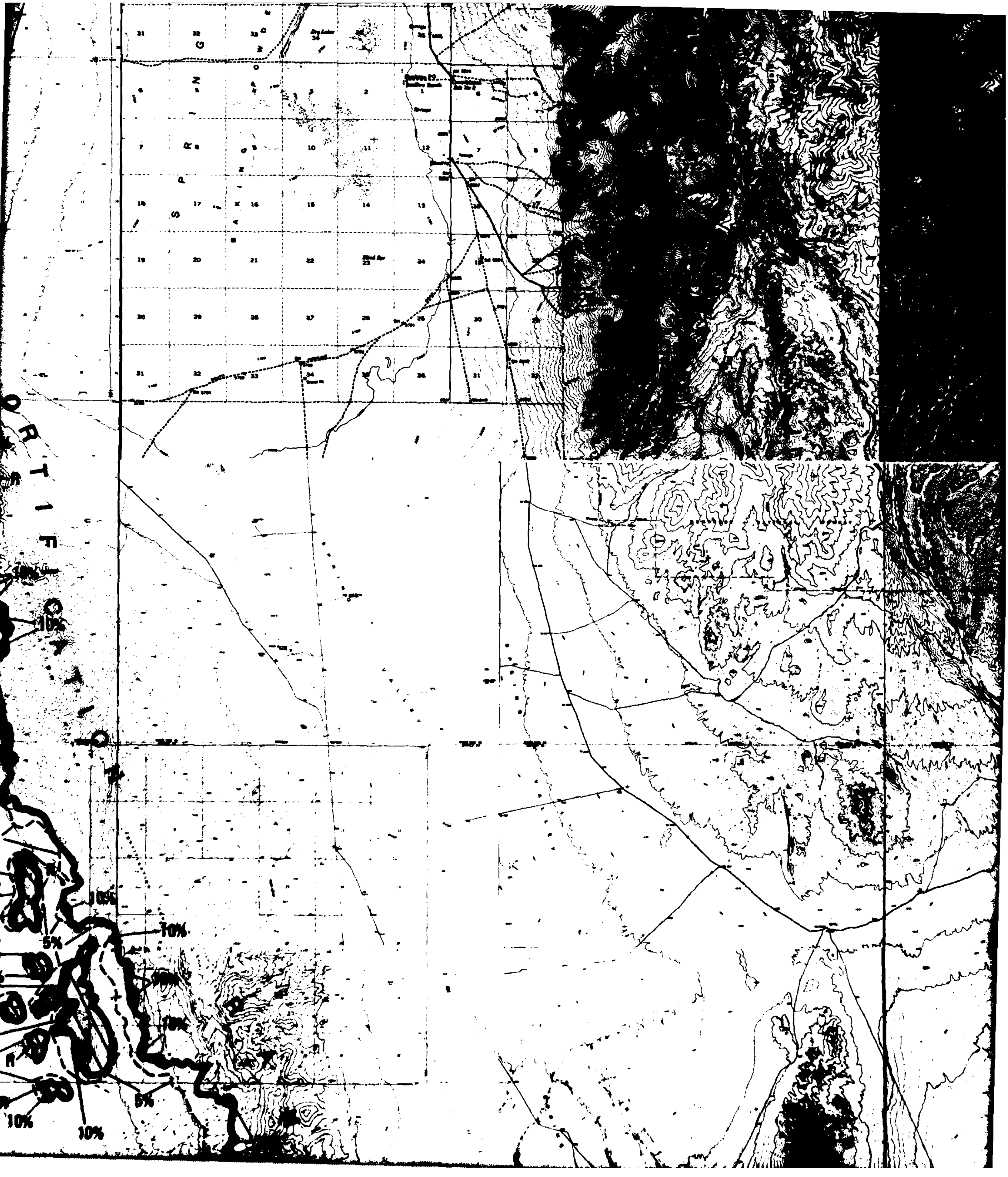
exposed rock too small for shading.

lished water well (W), or observation well (O), or boring well (B(O)), see Volume II, Table II-3-1.	Month-Year of water level measurement, or year when month unknown.
et).	Depth of well (feet).

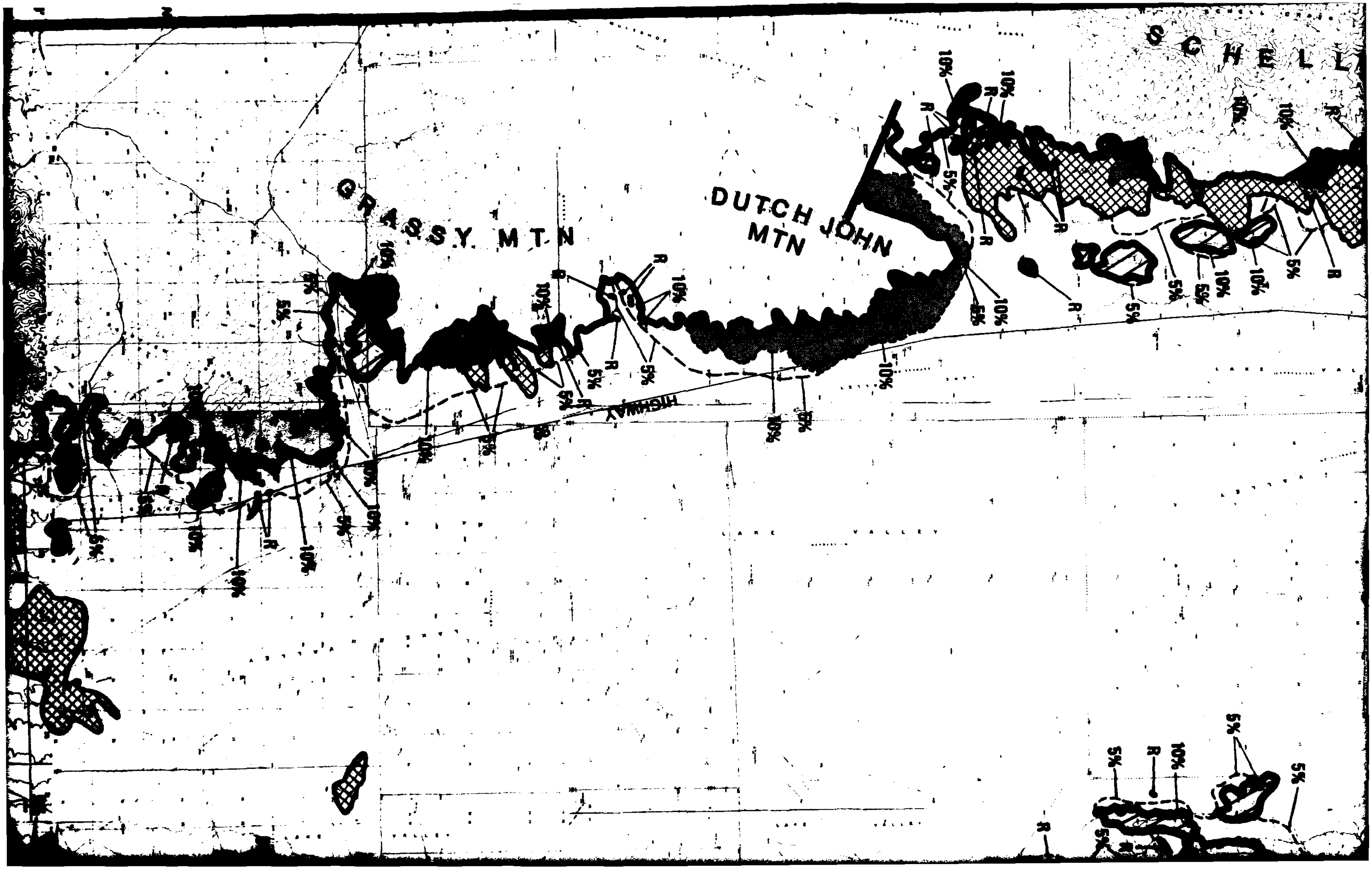



R 68 E
R 69 E
NORTH
SCALE 1: 125,000
0
2
4
STATUTE MILES
0
2
4
KILOMETERS
Western, Inc.
feet throughout
th-Year of water level measurement,
ear when month unknown.
th of well (feet).

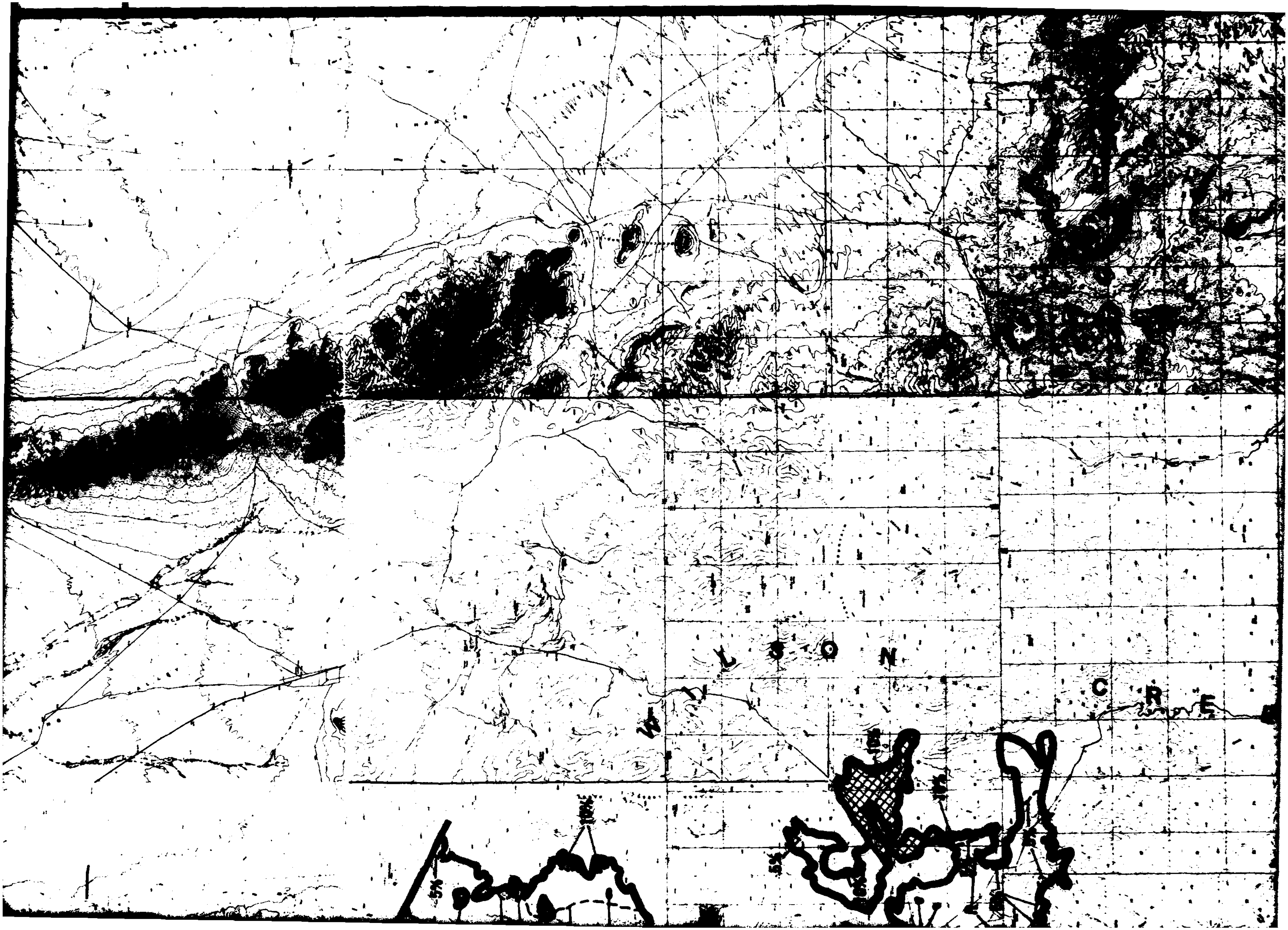

SCHELL CREEK RANGE
FORTIFICATION
HIGHWAY 93
10%
5%
R

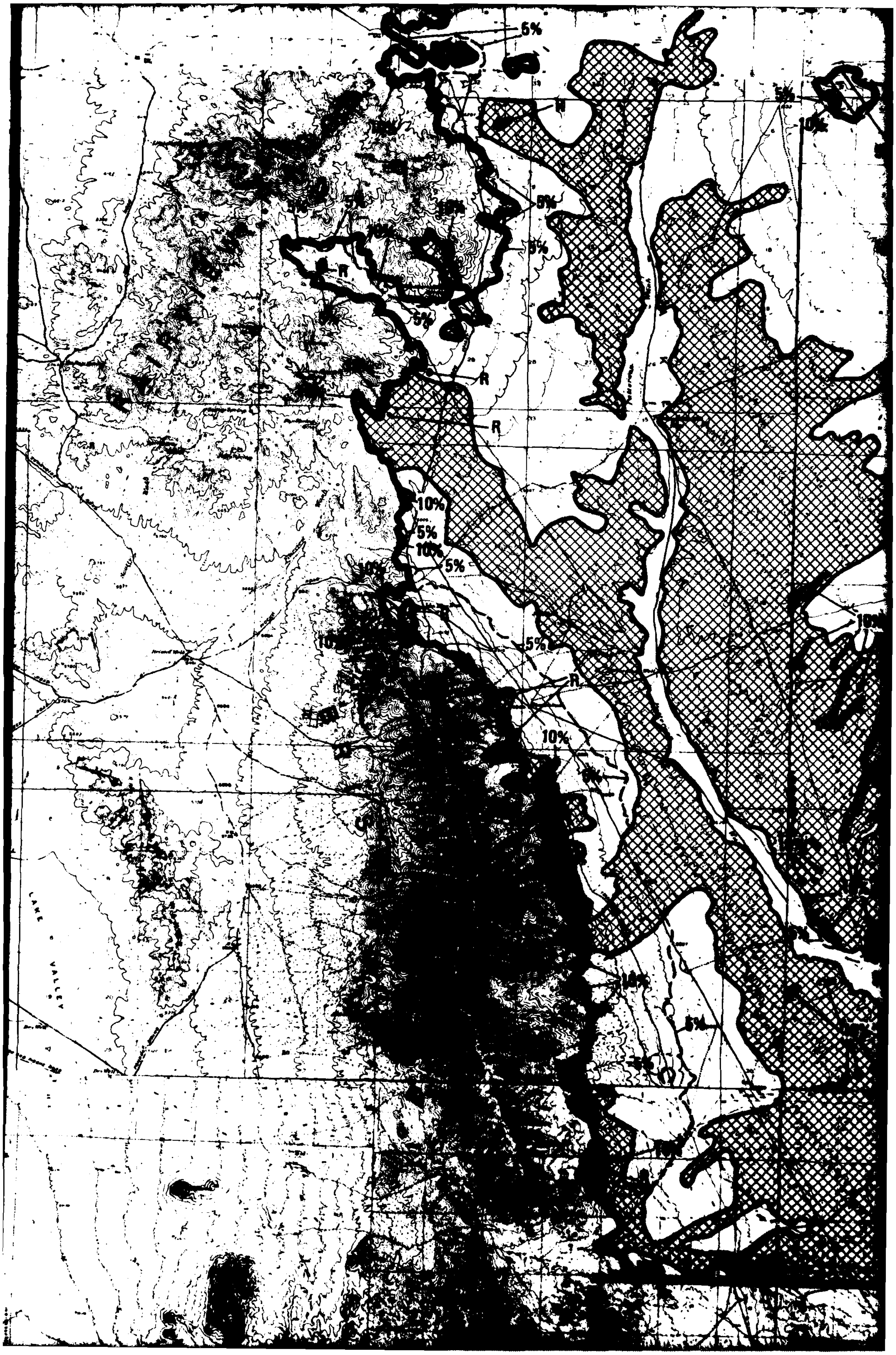

10%
10%
10%
5%
10%
10%
10%
5%
10%
10%

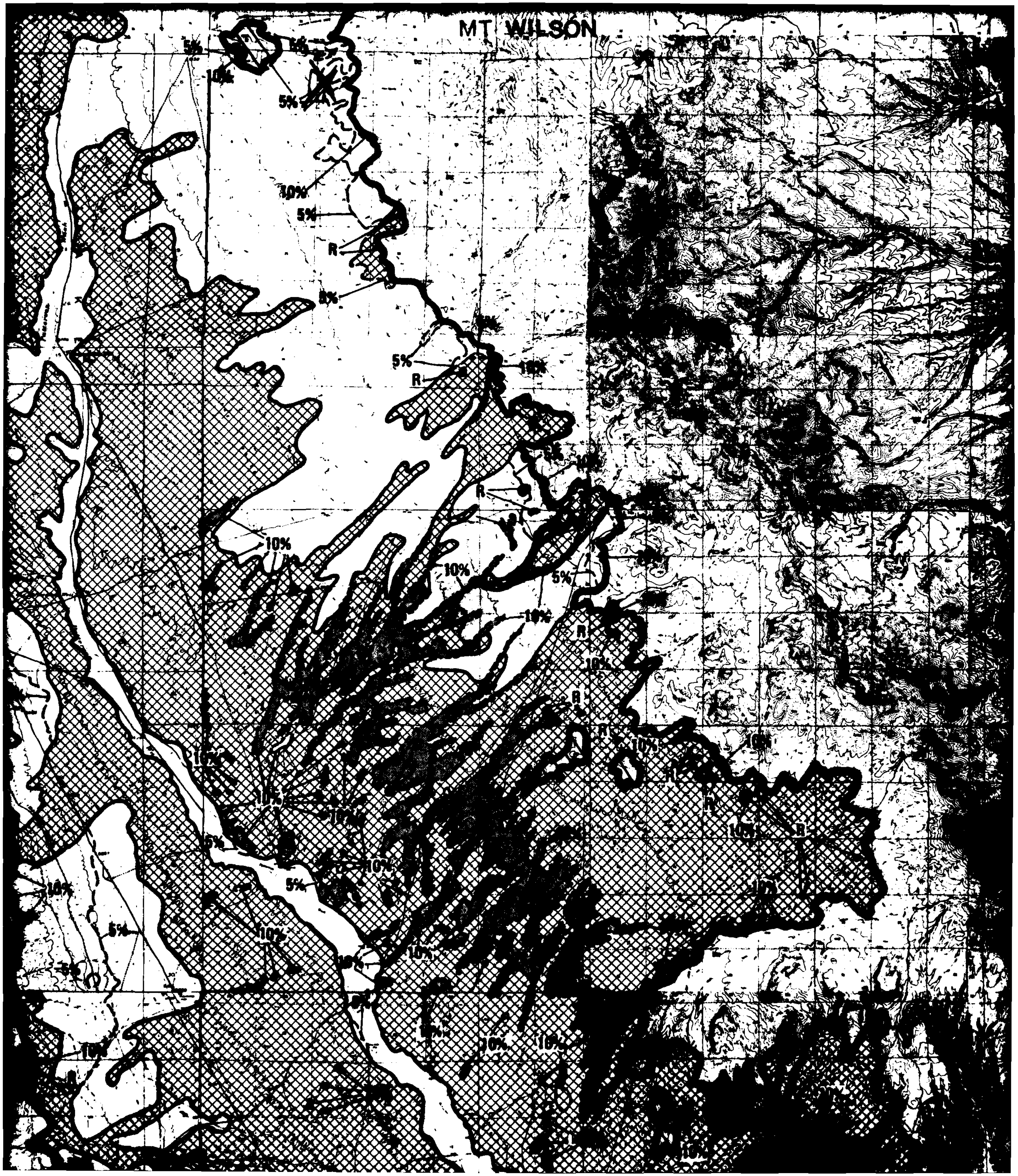

T
T


S C H E L L
DUTCH JOHN
MTN
GRASSY MTN
HIGHWAY
L A K E V A L L E Y
R
10%
5%


5%
10%
R
5
MT. WILSON


WILSON
CRE
5%
10%
5%
10%
10%
10%
5%


5%
R
10%
5%
5%
10%
R
5%
R
R
10%
5%
10%
5%
10%
10%
5%
R
10%
5%
10%
10%
5%
5%
10%
LAKE VALLEY


MT WILSON
5%
10%
5%
5%
10%
5%
R
5%
5%
R
10%
R
10%
10%
10%
5%
10%
R
10%
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5%
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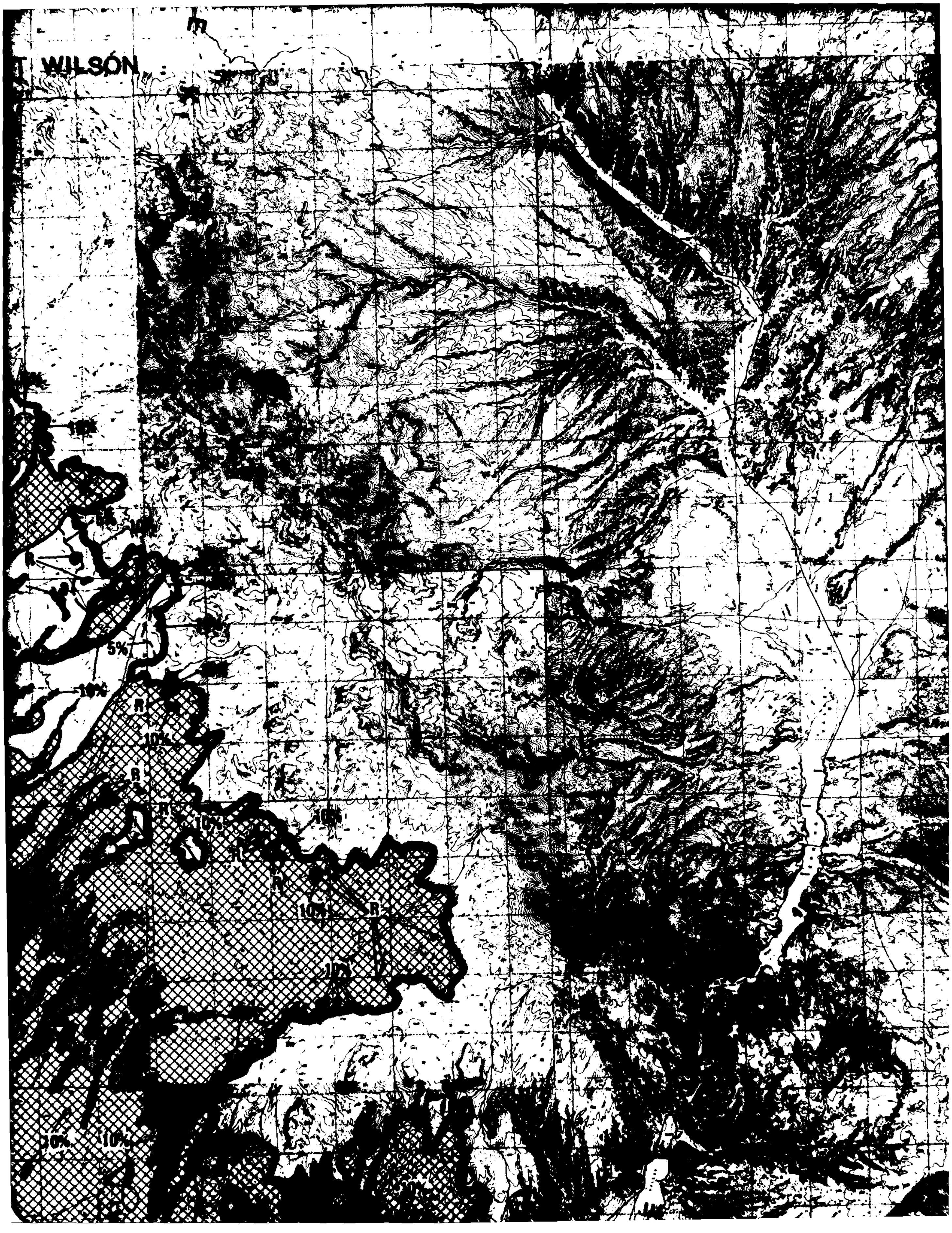
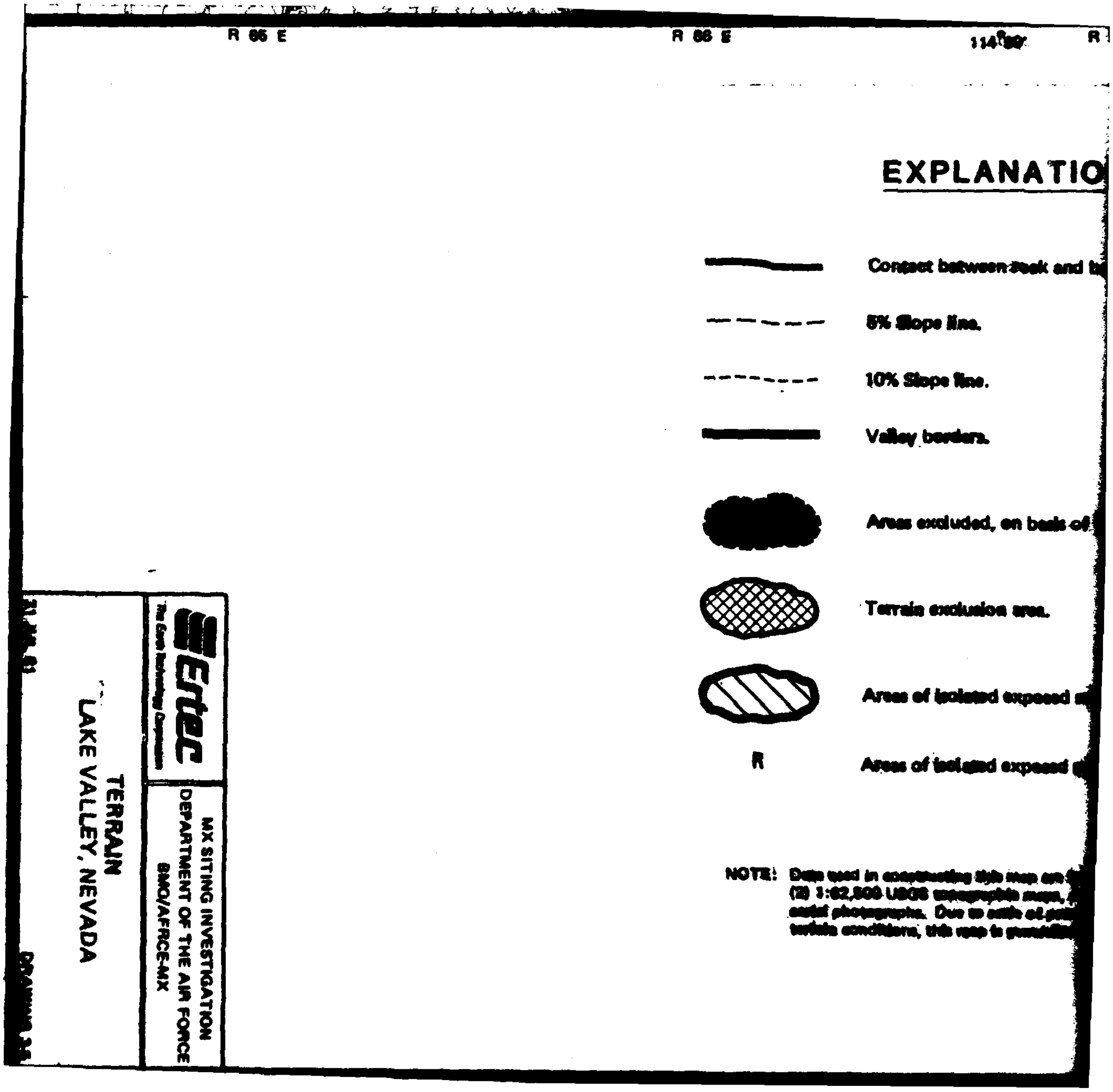
10%
10%
10%
10%



T WILSON
10%
5%
10%
R
10%
R
R
10%
R
10%
R
10%
R
10%
10%
10%
10%



EXPLANATIO

▬	Contact between rock and
- - -	5% Slope line.
- - -	10% Slope line.
▬	Valley borders.
●	Areas excluded, on basis of
▩	Terrain exclusion area.
▨	Areas of isolated exposed
R	Areas of isolated exposed

NOTE: Data used in constructing this map are
(2) 1:62,500 USGS topographic maps,
aerial photographs. Due to scale of
terrain conditions, this map is

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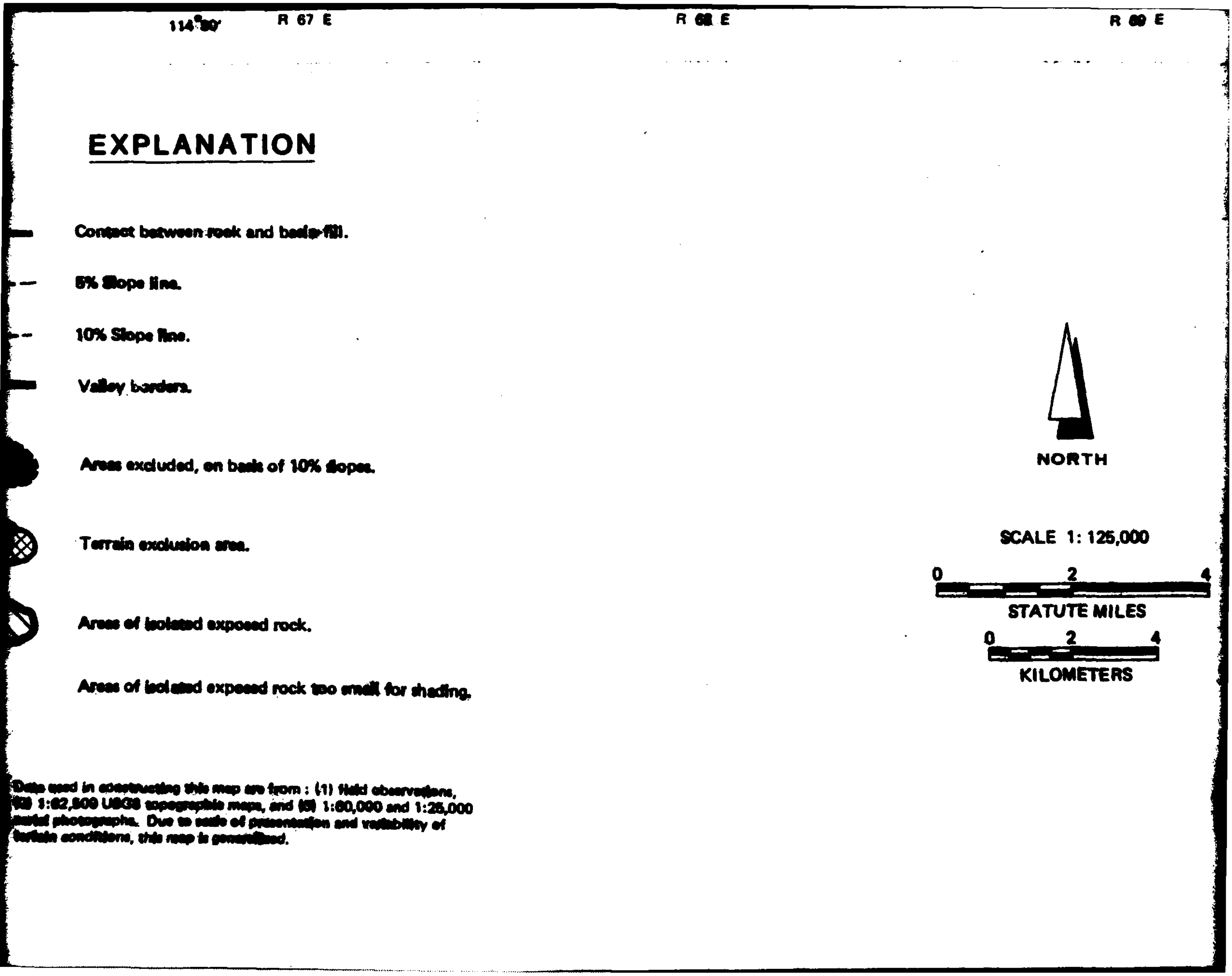
TERRAIN
LAKE VALLEY, NEVADA

31 JUL 81
DRAWING 3-5



EXPLANATION

Contact between rock and basin-fill.

5% Slope line.

10% Slope line.

Valley borders.

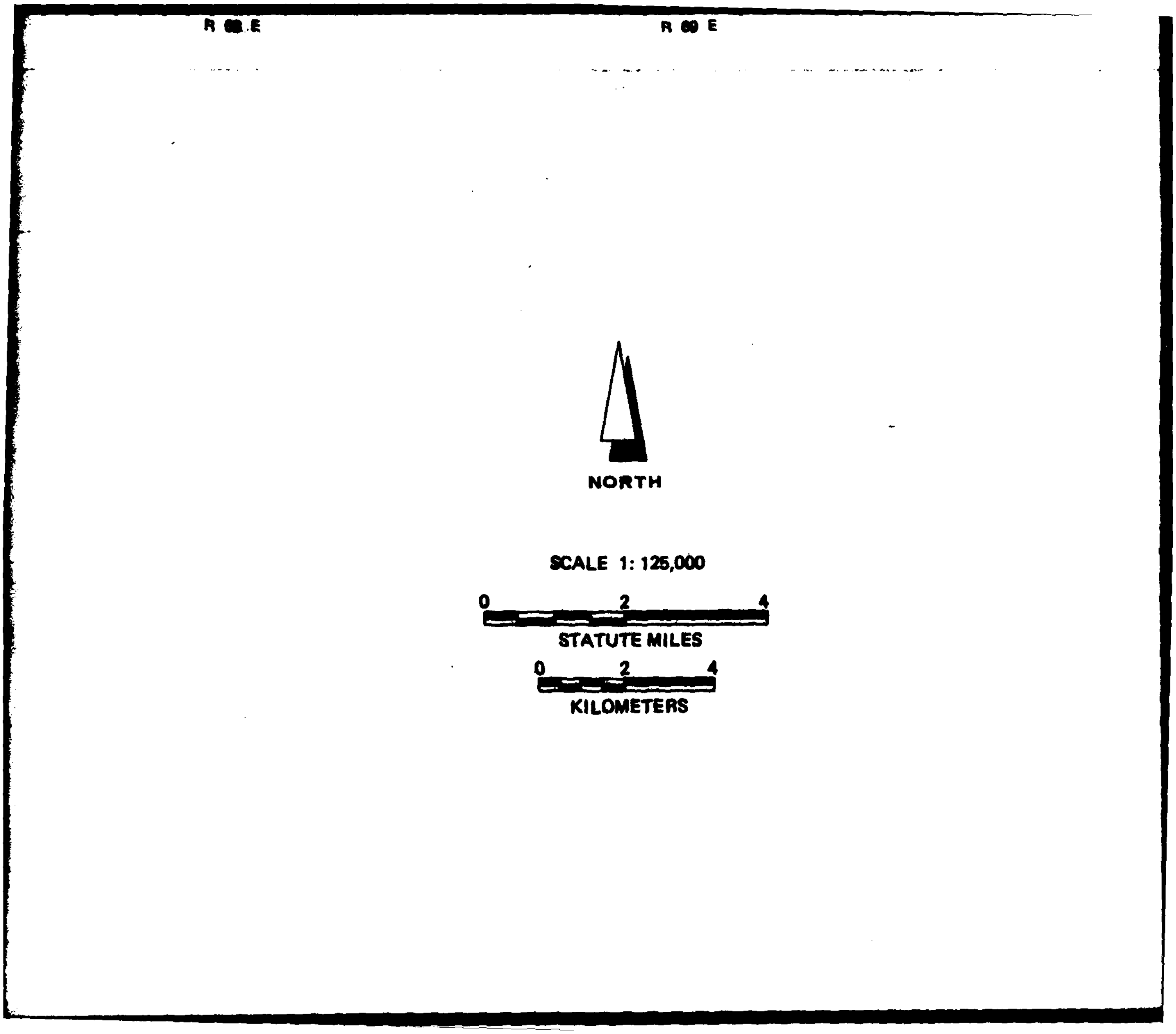
Areas excluded, on basis of 10% slopes.

Terrain exclusion area.

Areas of isolated exposed rock.

Areas of isolated exposed rock too small for shading.

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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A1.0 GLOSSARY OF TERMS

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

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

ALLUVIAL FAN - A body of stream deposits whose surface approximates a segment of a cone that radiates downslope from the point where the stream leaves a mountainous area and experiences a marked change in gradient resulting in deposition of alluvium.

ALLUVIUM - A general term for a more-or-less stratified deposit of gravel, sand, silt, clay, or other debris, moved by streams from higher to lower ground.

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

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

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

Liquid limit (LL) - The water content corresponding to the arbitrary limit between the liquid and plastic states of consistency of a soil (ASTM D 423-66).

Plastic limit (PL) - The water content corresponding to an arbitrary limit between the plastic and the semisolid states of consistency of a soil (ASTM D 424-59).

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

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

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

BEDROCK - A general term for the rock, usually solid, that underlies soil or other unconsolidated, surficial material. The term is also used here to include the rock composing the local mountain ranges.

BORING - A hole drilled in the ground for the purpose of subsurface exploration.

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

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

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

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

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

CALICHE - In general, secondary calcium carbonate cementation of unconsolidated materials occurring in arid and semiarid areas.

CALIFORNIA BEARING RATIO (CBR) - The ratio (in percent) of the resistance to penetration developed by a subgrade soil to that developed by a specimen of standard crushed rock base material (ASTM D 1883-73). During the CBR test, the load is applied on the circular penetration piston (3 in^2 base area [19 cm^2]) which is penetrated into the the soil sample at a constant penetration rate of 0.05 inch/minute (1.2 mm/min). The bearing ratio reported for the soil is normally the one at 0.1 inch (2.5 mm) penetration.

CLAST - An individual constituent, grain, or fragment of a sediment or rock, produced by the mechanical weathering (disintegration) of a larger rock mass.

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

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

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

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

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

COBBLE - A rock fragment, larger than a pebble and smaller than a boulder, having a diameter between 3 and 10 inches (64 and 256 mm), being somewhat rounded or otherwise modified by abrasion in the course of transport.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

ELECTRICAL RESISTIVITY - Property of a material which resists flow of electrical current.

EOLIAN - A term applied to materials which are deposited by wind.

EPHEMERAL (stream) - A stream or reach of a stream that flows briefly only in direct response to precipitation in the immediate locality, and whose channel is at all times above the water table.

EXTERNAL DRAINAGE - Stream drainage system whose down-gradient flow is unrestricted by any topographic impediments.

EXTRUSIVE ROCK - Igneous rock that has been ejected onto the earth's surface (e.g., lava, basalt, rhyolite, andesite, detrital material, volcanic tuff, pumice).

FAULT - A plane or zone of fracture along which there has been displacement.

FAULT BLOCK MOUNTAINS - Mountains that are formed by normal faulting in which the surface crust is divided into partially to entirely fault-bounded blocks of different elevations.

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

FINER-GRAINED - A term applied to alluvial fan deposits which are composed predominantly of material less than 3 inches (76 mm).

FLUVIAL DEPOSITS - Material produced by river action; generally loose, moderately well-graded sands and gravel.

FORMATION - A mappable assemblage of rocks characterized by some degree of homogeneity or distinctiveness.

FUGRO DRIVE SAMPLE - A 2.50-inch-(6.4-cm) diameter soil sample obtained from a drill hole with a Fugro drive sampler. The Fugro drive sampler is a ring-lined barrel sampler containing 12 one-inch-(2.54-cm) long brass sample rings. The sampler is advanced into the soil using a drop hammer.

GEOMORPHOLOGY - The study, classification, description, nature, origin, and development of present landforms and their relationships to underlying structures and of the history of geologic changes as recorded by these surface features.

GEOPHONE - The instrument used to transform seismic energy into electrical voltage; a seismometer, jug, or pickup.

GRABEN - An elongated crustal block that has been downthrown along faults relative to the rocks on either side.

GRAIN-SIZE ANALYSIS (GRADATION) - A type of test to determine the distribution of soil particle sizes in a given soil sample. The distribution of particle sizes larger than 0.074 mm (retained on the No. 200 sieve) is determined by sieving, while the distribution of particle sizes smaller than 0.074 mm is determined by a sedimentation process using a hydrometer.

GRANULAR - See Coarse-Grained.

GRAVEL - Particles of rock that pass a 3-inch (76.2 mm) sieve and are retained on a No. 4 (4.75 mm sieve).

GRAVITY - The force of attraction between bodies because of their mass. Usually measured as the acceleration of gravity.

GYPSIFEROUS - Containing gypsum, a mineral consisting mostly of calcium sulfate.

HORST - An elongated crustal block that has been uplifted along faults relative to the rocks on either side.

INTERIOR DRAINAGE - Stream drainage system that flows into a closed topographic low (basin).

INTRUSIVE (rock) - A rock formed by the process of emplacement of magma (liquid rock) in preexisting rock, (e.g., granite, granodiorite, quartz monzonite).

LACUSTRINE DEPOSITS - Materials deposited in a lake environment.

LINE - A linear array of observation points, such as a seismic line.

LINEAMENT - A linear topographic feature of regional extent that is thought to reflect crustal structure.

LIQUID LIMIT - See ATTERBERG LIMITS.

LOW STRENGTH SURFICIAL SOIL - Soil which will perform poorly as a road subgrade at its present consistency when used directly beneath a road section.

MOISTURE CONTENT - The ratio, expressed as a percentage, of the weight of water contained in a soil sample to the oven-dried weight of the sample.

N VALUE - Penetration resistance, described as the number of blows required to drive the standard split-spoon sampler for the second and third 6 inches (0.15 m) with a 140-pound (63.5-kg) hammer falling 30 inches (0.76 m) (ASTM D 1586-67).

OPTIMUM MOISTURE CONTENT - Moisture content at which a soil can be compacted to a maximum dry unit weight by a given compactive effort.

P-WAVE - See Compressional Wave.

PATINA (Desert Varnish) - A dark coating or thin outer layer produced on the surface of a rock or other material by weathering.

PAVEMENT/DESERT PAVEMENT - When loose material containing pebble-sized or larger rocks is exposed to rainfall and wind action, the finer dust and sand are blown or washed away and the pebbles gradually accumulate on the surface, forming a mosaic which protects the underlying finer material from wind attack. Pavement can also develop in finer-grained materials. In this case, the armored surface is formed by dissolution and cementation of the grains involved.

PERCHED GROUND WATER - Unconfined ground water separated from an underlying main body of ground water by an unsaturated zone.

PERMEABILITY - The property of soil and/or rock material which permits liquid to pass through.

pH - An index of the acidity or alkalinity of a soil in terms of the logarithm of the reciprocal of the hydrogen ion concentration.

PHI (0) - Angle of internal friction.

PIEZOMETRIC SURFACE - An imaginary surface representing the static head of ground water and defined by the level to which water will rise in a well.

PITCHER TUBE SAMPLE - An undisturbed, 2.87-inch- (73-mm) diameter soil sample obtained from a drill hole with a Pitcher tube sampler. The primary components of this sampler are an outer rotating core barrel with a bit and an inner stationary, spring-loaded, thin-wall sampling tube which leads or trails the outer barrel drilling bit depending upon the hardness of the material being penetrated.

PLASTIC LIMIT - See ATTERBERG LIMITS.

PLASTICITY INDEX - See ATTERBERG LIMITS.

PLAYA/PLAYA DEPOSITS - A term used in the southwest U.S. for a dried-up, flat-floored area composed of thin, evenly stratified sheets of clay, silt, or fine sand, and representing the lowest part of a shallow, completely closed or undrained, desert lake basin in which water accumulates and is quickly evaporated, usually leaving deposits of soluble salts.

POORLY GRADED - A descriptive term applied to a coarse-grained soil if it consists predominantly of one particle size (uniformly graded) or has a wide range of sizes with some intermediate sizes obviously missing (gap-graded).

RANGE-BOUNDING FAULT - Usually a normal fault in which one side has moved up relative to the other and which separates the mountain front from the valley.

RELATIVE AGE - The relationship in age (oldest to youngest) between geologic units without specific regard to number of years.

RESISTIVITY (True, Intrinsic) - The property of a material which resists the flow of electric current. The ratio of electric-field intensity to current density.

ROCK UNITS - Distinct rock masses with different characteristics (e.g., igneous, metamorphic, sedimentary).

ROTARY WASH DRILLING - A boring technique in which advancement of the hole through overburden is accomplished by rotation of a heavy string of rods while continuous downward pressure is maintained through the rods on a bit at the bottom of the hole. Water or drilling mud is forced down the rods to the bit, and the return flow brings the cuttings to the surface.

S-WAVE - See Shear Wave.

SAND - Soil passing through No. 4 (4.75 mm) sieve and retained on No. 200 (0.075 mm) sieve.

SAND DUNE - A low ridge or hill consisting of loose sand deposited by the wind, found in various desert and coastal regions and generally where there is abundant surface sand.

SEISMIC - Having to do with elastic waves. Energy may be transmitted through the body of an elastic solid as P-waves (compressional waves) or S-waves (shear waves).

SEISMIC LINE - A linear array of travel time observation points (geophones). In this study, each line contains 24 geophone positions.

SEISMIC REFRACTION DATA: - Data derived from a type of seismic shooting based on the measurement of seismic energy as a function of time after the shot and of distance from the shot, by determining the arrival times of seismic waves which have traveled nearly parallel to the bedding in high-velocity layers in order to map the depth to such layers.

SEISMOGRAM - A seismic record.

SEISMOMETER - See Geophone.

SHEAR STRENGTH - The maximum resistance of a soil to shearing (tangential) stresses.

SHEAR WAVE - A body wave in which the particle motion is perpendicular to the direction of propagation. Also called <u>S-Wave</u> or <u>transverse wave</u>.

SHEET FLOW - A process in which stormborne water spreads as a thin, continuous veneer (sheet) over a large area.

SHEET SAND - A blanket deposit of sand which accumulates in shallow depressions or against rock outcrops, but does not have characteristic dune form.

SHOT - Any source of seismic energy; e.g., the detonation of an explosive.

SHOT POINT - The location of any source of seismic energy; e.g., the location where an explosive charge is detonated in one hole or in a pattern of holes to generate seismic energy. Abbreviated SP.

SILT - Fine-grained soil passing the No. 200 sieve (0.074 mm) that is nonplastic or very slightly plastic and that exhibits little or no strength when air-dried.

SILT SIZE - That portion of the soil finer than 0.02 mm and coarser than 0.002 mm.

SITE - Location of some specific activity or reference point.

SPECIFIC GRAVITY - The ratio of the weight in air of a given volume of soil solids at a stated temperature to the weight in air of an equal volume of distilled water at a stated temperature.

SPLIT-SPOON SAMPLE - A disturbed sample obtained with a split-spoon sampler with an outside diameter of 2.0 inches (5.1 cm). The sample consists of a split barrel which is driven into the soil using a drop hammer.

SPREAD - The layout of geophone groups from which data from a single shot are recorded simultaneously. Spreads containing 24 geophones have been used in Fugro's seismic refraction surveys.

STREAM CHANNEL DEPOSITS - See Fluvial Deposits.

STREAM TERRACE DEPOSITS - Stream channel deposits no longer part of an active stream system, generally loose, moderately well graded sand and gravel.

SULFATE ATTACK - The process during which sulfates, salts of sulfuric acid, contained in ground water cause dissolution and damage to concrete.

SURFICIAL DEPOSIT - Unconsolidated residual colluvialand alluvial deposits occurring on or near the earth's surface.

TEST PIT - An excavation made to depths of about 5 feet (1.5 m) by a backhoe. A test pit permits visual examination of undisturbed material in place.

TRENCH - An excavation by a backhoe to depths of about 15 feet (4.5 m). A trench permits visual examination of soil in place and evaluaton of excavation wall stability.

TRIAXIAL COMPRESSION TEST - A type of test to measure the shear strength of an undisturbed soil sample (ASTM D 2850-70). To conduct the test, a cylindrical specimen of soil is surrounded by a fluid in a pressure chamber and subjected to an isotropic pressure. An additional compressive load is then applied, directed along the axis of the specimen called the axial load.

Consolidated-drained (CD) Test - A triaxial compression test in which the soil was first consolidated under an all-around confining stress (test chamber pressure) and was then compressed (and hence sheared) by increasing the vertical stress. Drained indicates that excess pore water pressures generated by strains are permitted to dissipate by the free movement of pore water during consolidation and compression.

Consolidated-undrained (CU) Test - A triaxial compression test in which essentially complete consolidation under the confining (chamber) pressure is followed by a shear at constant water content.

UNCONFINED COMPRESSION - A type of test to measure the compressive strength of an undisturbed sample (ASTM D 2166-66). Unconfined compressive strength is defined as the load per unit area at which an unconfined prismatic or cylindrical specimen of soil will fail in a simple compression test.

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) - A system which determines soil classification for engineering purposes on the basis of grain-size distribution and Atterberg limits.

VALLEY FILL - See Basin-Fill Material/Basin-Fill Deposits.

VELOCITY - Refers to the propagation rate of a seismic wave without implying any direction. Velocity is a property of the medium and not a vector quantity when used in this sense.

VELOCITY LAYER - A layer of rock or soil with a homogeneous seismic velocity.

VELOCITY PROFILE - A cross section showing the distribution of material seismic velocities as a function of depth.

WASH SAMPLE - A sample obtained by screening the returned drilling fluid during rotary wash drilling.

WATER TABLE - The upper surface of an unconfined body of water at which the pressure is equal to the atmospheric pressure.

WELL-GRADED - A soil is identified as well-graded if it has a wide range in grain size and substantial amounts of most intermediate sizes.

Definitions were derived from the following references:

American Society for Testing and Materials, 1976, Annual book of ASTM standards, Part 19: Philadelphia, American Society for Testing and Materials, p. 484.

Fairbridge, Rhodes W., ed., 1968, The enclyclopedia of geomorphology: Stroudsburg, Pennsylvania: Dowden, Hutchinson, and Ross, Inc., p. 1295.

Gary, M., McAfee, R., Jr., Wolf, C. L., eds., 1972, Glossary of geology: Washington, D.C., American Geological Institute, p. 805.

Merriam, G., and Merriam, C., 1977, Webster's new collegiate dictionary: Springfield, Massachusetts, G. and C. Merriam Co., p. 1536.

Sheriff, R. E., 1973, Encyclopedic dictionary of exploration geophysics: Tulsa, Oklahoma: Society of Exploration Geophysicists, p. 266.

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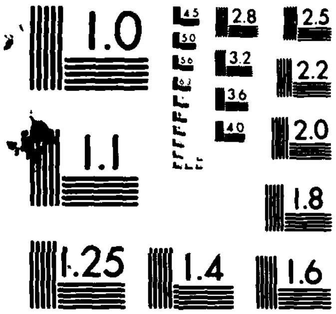

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

A2.0 EXCLUSION CRITERIA

The exclusion criteria used during the Verification Studies are based on both geotechnical and cultural considerations. Land excluded for geotechnical reasons includes areas of shallow rock, shallow water, and adverse terrain. Cultural exclusions include areas near towns, lands already withdrawn from public use, and regions with potentially high economic value. The exclusion criteria are defined in Table A2-1.

CRITERIA		DEFINITION AND COMMENTS
SURFACE ROCK AND ROCK OCCURRING WITHIN 50 FEET (15m) AND 150 FEET (46m) OF THE GROUND SURFACE		Rock is defined as any earth material which is not rippable by conventional excavation methods. Where available, seismic P-wave velocities were evaluated in the determination of rock conditions.
SURFACE WATER AND GROUND WATER OCCURRING WITHIN 50 FEET (15m) AND 150 FEET (46m) OF THE GROUND SURFACE		Surface water includes all significant lakes, reservoirs, swamps, and major perennial streams. Water which would be encountered in a 50-foot and 150-foot excavation was considered in the application of this criterion. Depths to ground water resulting from deeper confined aquifers were not considered.
TERRAIN	Percent Grade	Areas having surface gradients exceeding 10 percent or a preponderance of slopes exceeding 10 percent as determined from maps at scales of 1 :125 000, 1 :62 500, and 1 :24 000 and by field observation.
	Drainage	Areas averaging two or more 10-foot deep drainages per 1000 feet (measured parallel to contours, as determined from maps at scales of 1 :24,000 or in the field).
CULTURAL	Quantity/Distance:	Eighteen nautical mile exclusion arcs from cities having populations (1970) of 25,000 or more. Three nautical mile exclusion arcs from cities having populations (1970) of between 5,000 and 25,000.
	Land Use:	All significant federal and state forests, parks, monuments, and recreational areas. All significant federal and wildlife refuges, grasslands, ranges, preserves and management areas. Indian reservations.

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EXCLUSION CRITERIA
VERIFICATION STUDIES, NEVADA–UTAH

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TABLE A3-1

A3.0 ENGINEERING GEOLOGIC PROCEDURES

The principal objectives of the field geology investigation were to:

1. Delineate surficial extent of soil types and geologic units;
2. Assess terrain conditions; and
3. Make observations helpful in defining depth to rock and water.

Aerial photographs (1:60,000 scale black and white; 1:25,000 scale color) served as the base on which all mapping was done. Field activities were directed toward checking the photogeologic mapping.

Field checking consisted chiefly of collecting data about surficial soils at selected locations in order to refine contacts and define engineering characterisitics of photogeologic units. At each location, observations of grain-size distribution, color, clast lithology, surface soil development, and a variety of engineering parameters were recorded (see Volume II, Geotechnical Data). Observations were made in existing excavations (borrow pits, road cuts, stream cuts) or in hand-dug test pits. Extrapolation of this data, to determine surficial extent, was accomplished by geologic reconnaissance over existing roads.

Of the parameters listed, grain size is the most important for engineering purposes and, for this reason, is included in the geologic unit designation. However, grain size is not readily mapped on aerial photos, and much of the field work involved determination of the extent of surficial deposits of a particular grain-size category (gravel, sand, or fine-grained).

Terrain data were also taken at geologic field stations. Drainage width and depth were estimated and predominant surface slope was measured. Slopes were measured over a distance of 100 to 150 feet (31 to 46 m) with an Abney hand level. For additional data, depths of major drainages encountered during geologic reconnaissance between stations were recorded on the aerial photographs.

To help refine depth to rock interpretations, observations were concentrated along the basin margin to identify areas of shallow rock. Observations regarding depth to water were restricted to measurements in existing wells and identification of areas with water at the surface.

A4.0 GEOPHYSICAL PROCEDURES

A4.1 SEISMIC REFRACTION SURVEYS

A4.1.1 Instruments

Field explorations were performed with a 24-channel SIE Model RS-44 seismic refraction system which consisted of 24 amplifiers coupled with a dry-write, galvanometer-type recording oscillograph. Seismic energy was detected by Mark Products Model L-10 geophones with natural frequency of 4.5 Hz. Geophones were fitted with short spikes to provide good coupling with the ground. Cables with two takeout intervals were used to transmit the detected seismic signal from the geophones to the amplifiers. Time of shot was transmitted from shotpoint to recording system via an FM radio link.

The degree of gain was set on the amplifiers by the instrument operators and was limited by the background noise at the time of the shot. The amplifiers are capable of maximum gain of 1.1 million. The oscillograph placed timing lines on the seismograms at 0.01-second intervals. The timing lines form the basis for measuring the time required for the energy to travel from the shot to each geophone.

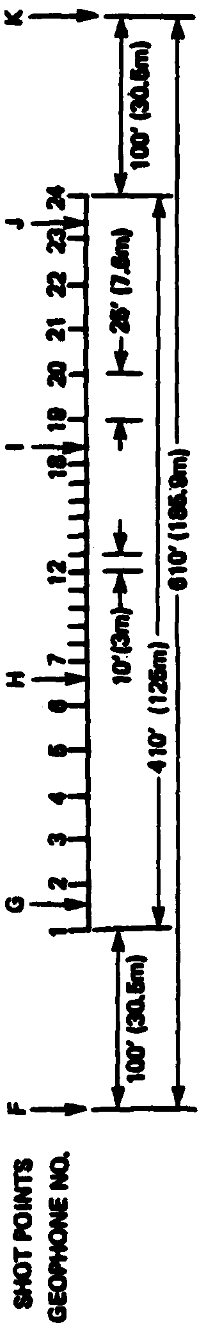
A4.1.2 Field Procedures

Each seismic refraction line consisted of a single spread of 24 geophones with a distance of 410 feet (125 m) between end points (Figure A4-1). Geophone spacing provided six intervals of 25 feet (7.6 m) at both ends of the line and 11 central intervals of 10 feet (3 m). Six shots were made per spread at locations 65 feet (20 m), 190 (58 m) and 305 feet (93 m) left and right of the spread center. The recording system was located between geophones 12 and 13.

The explosive used was "Kinestik" which was transported to the site as two nonexplosive components, a powder and a liquid. The components were mixed in the field to make an explosive compound. Charges ranged in size from one-third to five pounds and were buried from 1 to 5 feet (0.3 to 1.5 m) deep. Charges were detonated using Reynold's exploding bridge wire (EBW) detonators instead of conventional electric blasting caps. Use of EBWs provides maximum safety against accidental detonation and extremely accurate "time breaks" (instant of detonation). Relative elevations of geophones and shotpoints were obtained by level or transit where lines had more than 2 or 3 feet (0.6 to 0.9 m) of relief.

A4.1.3 Data Reduction

The travel times for compressional waves from the shots to the geophones were obtained from the seismograms by visual inspection. These times were plotted at their respective horizontal



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SEISMIC REFRACTION LINE
LAYOUT
VERIFICATION STUDIES, NEVADA—UTAH

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FIGURE A4-1

distances and best fit lines were drawn through the points to obtain apparent velocities for materials below the seismic line.

A combination of delay time and ray tracing methods was used in a computer program to obtain depth to refracting horizons from the time-distance information.

A4.2 ELECTRICAL RESISTIVITY SURVEYS

A4.2.1 Instruments

Electrical resistivity measurements were made with a Bison Instrument model 2350B resistivity meter which provides current to the earth through two electrodes and measures the potential (voltage) drop across two other electrodes.

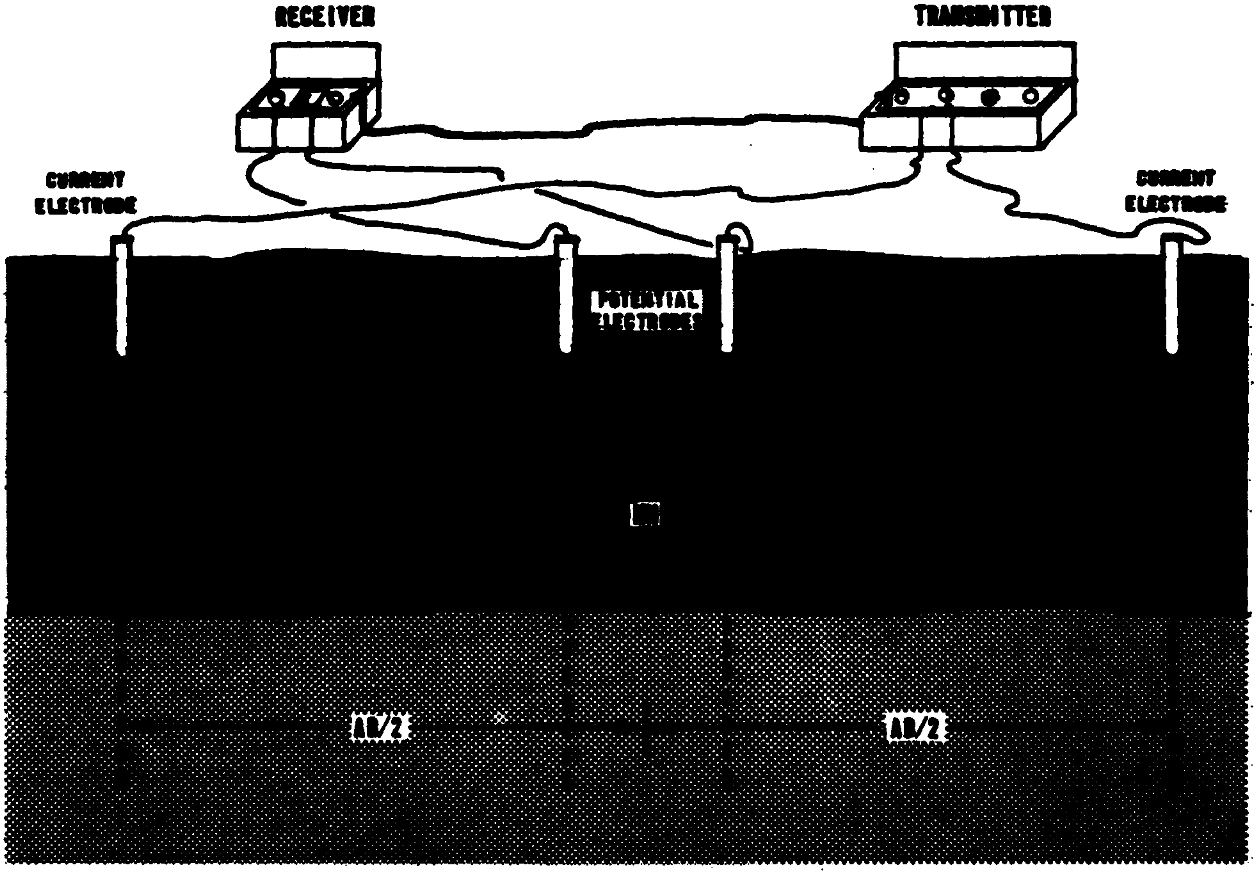
A4.2.2 Field Procedures

Electrical resistivity soundings were made using the Schlumberger electrode arrangement. Soundings are made by successive resistivity measurements which obtain information from deeper and deeper materials. The depth of penetration of the electrical current is increased by increasing the distance between the current electrodes. The arrangement of electrodes in the Schlumberger method is shown in Figure A4-2. The four electrodes are in a line with the two current electrodes on the ends. The distance between the current electrodes (AB) is always five or more times greater than the distance between the potential electrodes (MN).

The initial readings are made with MN equal to 5 feet (1.5 m) and AB equal to 30 feet (9 m). Successive readings were made with AB at 40, 50, 60, 80, 100, 120, 160, 200, 300, 400, 500, and 600 feet (12, 15, 18, 24, 30, 37, 49, 61, 91, 122, 152, and 183 m). MN spacing is sometimes increased one or two times as AB is expanded. This increase is required when the signal drops to a level below the meter's sensitivity. The potential drop is greater between more widely spaced electrodes (MN), so increasing MN increases the signal. When it becomes necessary to increase MN, the spacing of AB is reduced to the spacing of the previous reading. MN is then increased and a measurement is made. This provides two resistivity measurements at the same AB spacing but with different MN spacings.

A4.2.3 Data Reduction

Each apparent resistivity value is plotted versus one-half the current electrode spacing (AB/2) used to obtain it. Log-log graph paper is used to form the coordinates for the graph. A smooth curve is drawn through the points. This sounding curve forms the basis for interpreting the resistivity layering at the sounding location.



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SCHLUMBERGER ARRAY ELECTRICAL RESISTIVITY SOUNDING

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FIGURE A4-2

A computer program that does iterative "curve-matching" is used to develop a layer model that has a theoretical resistivity curve that is similar to the field curve. An electronic digitizer is used to digitize the field curve for computer program input.

A5.0 ENGINEERING PROCEDURES

Soil engineering activities consisted of the following:

1. Field activities:
    - o Borings
    - o Trenches
    - o Test Pits
    - o Surficial Samples
    - o Cone Penetrometer Tests
    - o Field CBR Tests
2. Office activities:
    - o Laboratory Tests
    - o Data Analyses and Interpretations

The procedures used in the various activities are described in the following sections.

A5.1 BORINGS

A5.1.1 Drilling Techniques

The borings were drilled at designated locations using rotary techniques. A truck-mounted Failing 1500 drill rig with hydraulic pulldown was used. The borings were nominally 4 7/8 inches (124 mm) in diameter. A bentonite-water slurry was used to return soil cuttings to the surface. A tricone drill bit was used for coarse-grained soils and a drag bit for drilling in fine-grained soils. Depths drilled ranged from 160 to 200 feet (49 to 61 m), unless bedrock was encountered at lesser depth.

A5.1.2 Method of Sampling

A5.1.2.1 Sampling Intervals

Soil samples were obtained at the following nominal depths as well as at depths of change in soil type:

0' to 10' (0.0 to 3.0 m) - Pitcher or drive-samples at 3' intervals
10' to 30' (3.0 to 9.1 m) - Pitcher or drive-samples at 5' intervals
30' to 120' (9.1 to 36.6 m) - Pitcher or drive-samples at 10' intervals
120' to 200' (36.6 to 61.0 m) - Pitcher or drive-samples at 20' intervals

A5.1.2.2 Sampling Techniques

a. Ertec Drive Samples: Ertec drive samplers were used to obtain relatively undisturbed soil samples. The Ertec drive sampler is a ring-lined barrel sampler with an outside diameter of 3.0 inches (76.2 mm) and inside diameter of 2.50 inches (65.5 mm). It contains 12 individual 1-inch- (25.4-mm) long rings and is attached to a 12-inch- (30-cm) long waste barrel.

The sampler was advanced using a downhole hammer weighing 300 pounds (136 kg) with a drop of 24 inches (61.0 cm).

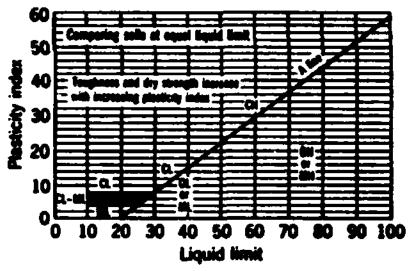
The number of blows required to advance the sampler for a 6-inch (15-cm) interval were recorded. Samples obtained were retained in the rings, placed in plastic bags with manually twisted top ends and sealed in plastic sample containers. Each sample was identified with a label indicating job number, boring number, sample number, depth range, Unified Soil Classification Symbol (USCS), (Table A5-1) and date. Ring samples were placed in foam-lined steel boxes.

b. Pitcher Samples: The Pitcher sampler was used to obtain undisturbed soil samples. The primary components of this sampler are an outer rotating core barrel with a bit and an inner, stationary, spring-loaded, thin-wall sampling tube which leads or trails the outer barrel drilling bit, depending on the hardness of the material penetrated. The average inside diameter of the sampling tubes used was 2.87 inches (73 mm). Before placing the Pitcher tube in the outer barrel, the tube was inspected for sharpness and protrusions.

The Pitcher sampler was then lowered to the bottom of the boring and the thin-walled sampling tube advanced into the soil ahead of the rotating cutting bit by the weight of the drill rods and hydraulic pulldown. The thin-walled sampling tube was retracted into the core barrel and the sampler was brought to the surface. After removal of the sampling tube from the core barrel, the length of the recovered soil sample was measured and recorded. Before preparing and sealing the tube, the drilling fluid in the Pitcher tube was removed. Cap plugs were taped in place on the top and bottom of the Pitcher tube and sealed with wax. When Pitcher samples could not be retrieved without disturbance, they were clearly marked as "disturbed." Each sealed Pitcher tube was labeled as explained under "Ertec Drive Samples" and then placed vertically in foam-lined wooden boxes.

c. Bulk Samples: Bulk samples from rotary drilling were obtained by screening the returning drilling fluid to obtain wash samples. Recovered samples were placed in plastic bags and labeled as explained previously.

d. Split-Spoon Samples: Split-spoon samplers were used to obtain disturbed, but representative, soil samples continuously in the top 10.5 feet (3.2m). Soil samples were classified and disposed of in the field. The split spoon sampler consists of a barrel shoe, a split barrel or tube, a solid sleeve, and a sampler head. The inside diameter of the sampler shoe is 1.375 inches (35 mm) and the length is about 18 inches (45.7 cm). Sampling with the split barrel sampler is accomplished by driving the sampler into the ground with a 140-pound (63.6-kg) hammer dropped 30 inches (76 cm). The number of blows required to drive the sampler the last 12 inches (30.4 cm) was recorded as the Standard Penetration Resistance (N value).

Field Identification Procedures (Excluding particles larger than 3 in. and basing fractions on estimated weights)						Group Symbols[a]	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria		
Coarse-grained soils More than half of material is *larger* than No. 200 sieve size[b] (The No. 200 sieve size is about the smallest particle visible to naked eye)	Gravels More than half of coarse fraction is larger than No. 4 sieve size (For visual classification, the ¼ in. size may be used as equivalent to the No. 4 sieve size)	Clean gravels (little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes			*GW*	Well graded gravels, gravel-sand mixtures, little or no fines	Give typical name; indicate approximate percentages of sand and gravel; maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbols in parentheses For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics Example: *Silty sand*, gravelly; about 20% hard, angular gravel particles ½-in. maximum size; rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; (*SM*)	Use grain size curve in identifying the fractions as given under field identification Determine percentages of gravel and sand from grain size curve Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse grained soils are classified as follows: Less than 5% GW, GP, SW, SP More than 12% GM, GC, SM, SC 5% to 12% Borderline cases requiring use of dual symbols	$C_U = \frac{D_{60}}{D_{10}}$ Greater than 4 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			Predominantly one size or a range of sizes with some intermediate sizes missing			*GP*	Poorly graded gravels, gravel-sand mixtures, little or no fines			Not meeting all gradation requirements for *GW*	
		Gravels with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures see *ML* below)			*GM*	Silty gravels, poorly graded gravel-sand-silt mixtures			Atterberg limits below "A" line, or *PI* less than 4	Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)			*GC*	Clayey gravels, poorly graded gravel-sand-clay mixtures			Atterberg limits above "A" line, with *PI* greater than 7	
	Sands More than half of coarse fraction is smaller than No. 4 sieve size	Clean sands (little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes			*SW*	Well graded sands, gravelly sands, little or no fines			$C_U = \frac{D_{60}}{D_{10}}$ Greater than 6 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			Predominantly one size or a range of sizes with some intermediate sizes missing			*SP*	Poorly graded sands, gravelly sands, little or no fines			Not meeting all gradation requirements for *SW*	
		Sands with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures, see *ML* below)			*SM*	Silty sands, poorly graded sand-silt mixtures			Atterberg limits below "A" line or *PI* less than 5	Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)			*SC*	Clayey sands, poorly graded sand-clay mixtures			Atterberg limits below "A" line with *PI* greater than 7	
Fine-grained soils More than half of material is *smaller* than No. 200 sieve size	Identification Procedures on Fraction Smaller than No. 40 Sieve Size										
			Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)						
	Silts and clays liquid limit less than 50		None to slight	Quick to slow	None	*ML*	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions Example: *Clayey silt*, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (*ML*)	 Plasticity chart for laboratory classification of fine grained soils		
			Medium to high	None to very slow	Medium	*CL*	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays				
			Slight to medium	Slow	Slight	*OL*	Organic silts and organic silt-clays of low plasticity				
	Silts and clays liquid limit greater than 50		Slight to medium	Slow to none	Slight to medium	*MH*	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts				
			High to very high	None	High	*CH*	Inorganic clays of high plasticity, fat clays				
			Medium to high	None to very slow	Slight to medium	*OH*	Organic clays of medium to high plasticity				
Highly Organic Soils			Readily identified by colour, odour, spongy feel and frequently by fibrous texture			*Pt*	Peat and other highly organic soils				

From Wagner, 1957.

[a] *Boundary classifications*. Soils possessing characteristics of two groups are designated by combinations of group symbols. For example *GW–GC*, well graded gravel-sand mixture with clay binder.

[b] All sieve sizes on this chart are U.S. standard.

Field Identification Procedure for Fine Grained Soils or Fractions

These procedures are to be performed on the minus No. 40 sieve size particles, approximately $\frac{1}{64}$ in. For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests.

Dilatancy (Reaction to shaking):

After removing particles larger than No. 40 sieve size, prepare a pat of moist soil with a volume of about one-half cubic inch. Add enough water if necessary to make the soil soft but not sticky.

Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.

Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

Dry Strength (Crushing characteristics):

After removing particles larger than No. 40 sieve size, mould a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun or air drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.

High dry strength is characteristic for clays of the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour.

Toughness (Consistency near plastic limit):

After removing particles larger than the No. 40 sieve size, a specimen of soil about one-half inch cube in size, is moulded to the consistency of putty. If too dry, water must be added and if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about one-eight inch in diameter. The thread is then folded and re-rolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.

After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.

The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line.

Highly organic clays have a very weak and spongy feel at the plastic limit.

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UNIFIED SOIL CLASSIFICATION SYSTEM

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TABLE A8-1

e. Rock Samples: Rock cores are obtained with a sampler which consists of a core barrel with a diamond cutting bit at its lower end. The bit cuts an annular hole in the rock mass, thereby creating a cylinder or core of rock which is recovered in the core barrel. Rock cores were obtained using rotary drilling methods and NX double-tube core barrels (core size 2.125 inches; 54 mm). When rock was encountered in a boring, approximately 15 feet (4.5 m) of core was obtained before abandoning the hole. The rock cores were removed from the core barrel, examined by a geologist, and placed in core boxes. The core boxes were labeled as explained above in "Ertec Drive Samples."

A5.1.3 Logging

All soils were classified in the field by the procedures outlined in Section A5.5, "Field Visual Soil Classification," of this Appendix. Rock encountered in the borings was described according to classifications given in Travis (1955) and Folk (1974). The following general information was entered on the boring logs at the time of drilling: boring number; project name, number, and location; name of drilling company and driller; name of logger and date logged; and method of drilling and sampling, drill bit type and size, driving weight and average drop as applicable. As drilling progressed, the soil samples recovered were visually classified as outlined in Section A5.5, "Field Visual Soil Classification," and the description was entered on the logs. Section A5.5 also discusses other pertinent data and observations which were entered on the boring logs during drilling.

A5.1.4 Sample Storage and Transportation

Samples were handled with care, drive sample containers being placed in foam-lined steel boxes, while Pitcher samples were transported in foam-lined wooden boxes. Particular care was exercised by drivers while traversing rough terrain to avoid disturbing the samples. Whenever ambient air temperatures fell below 32°F, samples were stored in heated rooms during the field work and transported to Ertec Western's Long Beach laboratory in heated cabins in back of pickup trucks.

A5.1.5 Ground-Water Observation Wells

When ground water was encountered during drilling or where a boring was located in an area estimated to have ground water within 150 feet (46 m) of the ground surface, the completed boring was cased with 2-inch-diameter (51-mm) polyvinyl-chloride (PVC) pipe to 160 feet (49 m). This PVC pipe was slotted in the bottom 20 feet (6 m). After installation of the pipe, the well was flushed until the water was clear. After equilibrium was reached, the water level was measured and recorded periodically.

A5.2 TRENCHES, TEST PITS, AND SURFICIAL SAMPLES

A5.2.1 Excavation Equipment

The trenches, test pits, and surficial samples were excavated using a rubber tire-mounted Case 580C backhoe with a maximum depth capability of 14 feet (4.3 m).

A5.2.2 Method of Excavation

Unless caving occurred during the process of excavation, the trench width was nominally 2 feet (0.6 m). Trench depths were typically 10 to 14 feet (3.0 to 4.3 m) and length 14 feet (4.3 m). Test pits were nominally 2 feet (0.6 m) wide, 5 feet (1.5 m) deep, and ranged from 5 to 10 feet (1.5 to 3.0 m) in length. Surficial sample excavations were typically 2 feet (0.6 m) wide, 2 to 3 feet (0.6 to 1.0 m) deep, and about 3 to 5 feet (0.9 to 1.5 m) long. The trench and test pit walls were vertical. However, where surface materials were unstable, the trench walls were sloped back to a safe angle to prevent sloughing during the completion of excavation and logging. The excavated material was deposited on one side at least 4 feet (1.2 m) from the edge of the trenches in order to minimize stress loads at the edges. The excavations were backfilled with the excavated material and the ground surface was restored to a condition as conformable with the surrounding terrain as practical.

A5.2.3 Sampling

The following sampling procedures were generally followed for all trenches, test pits, and surficial samples.

- Representative bulk soil samples (large or small) were obtained in the top 2 feet (0.6 m). If the soil type changed in the top 2 feet, bulk samples of both the soil types were obtained. In addition, bulk samples of all soil types encountered at different depths in the excavation were obtained. For each soil type in the top 2 to 3 feet (0.6 to 0.9 m), two large bulk samples (weighing about 50 pounds [22.7 kg] each) were taken. Bulk samples from other depths were limited to one bag. When soils from two locations were similar, only a small bag sample weighing about 2 pounds (0.9 kg) was taken from the second location.

- All large bulk samples were placed first in plastic bags and then in cloth bags. The small bulk samples were placed in small plastic bags. All sample bags of soil were tied tightly at the top to prevent spillage and tagged with the following information: project number; trench, test pit, or surficial sample number; bulk sample number; depth range in feet; Unified Soil Classification symbol; and date. The samples were transported to the field office for storage and then to Ertec Western's Long Beach office in pickup trucks.

A5.2.4 Logging

The procedures for field visual classification of soil and rock encountered from the trenches, test pits, and surficial samples were basically the same as the procedures for logging of borings (Section A5.1.3). For excavations shallower than 4 feet (1.2 m) technicians entered the excavations and logged them. Logging of the excavations deeper than 4 feet (1.2 m) was accomplished from the surface and by observing the backhoe bucket contents. All trench walls were photographed prior to backfilling.

Each field trench, test pit, and surficial sample log included trench, test pit, or surficial sample number; project name, number and location; name of excavator; type of excavation equipment; name of logger; and date logged. As excavations proceeded, the soil types encountered were visually classified and described as outlined in Section A5.5, "Field Visual Soil Classification." Section A5.5 also discusses other pertinent data and observations made which were entered on the logs during excavation.

A5.3 CONE PENETROMETER TESTS

A5.3.1 Equipment

The equipment consisted of a truck-mounted [17.5 tons (15,877 kg) gross weight] electronic cone penetrometer equipped with a 15-ton (13,608 kg) friction cone (cone end resistance capacity of 15 tons (13,608 kg) and 4-1/2-ton (4082 kg) limit on the friction sleeve). All operating controls, recorder, cables, and ancillary equipment were housed in the specially designed vehicle which was completely self-contained. The penetrometer, the key element of the system, contained the necessary load cells and cable connections. One end of the unit was threaded to receive the first sounding rod. When carrying out the tests, hollow rods with an outside diameter of 1.42 inches (3.6 cm) and a length of 3.3 feet (1.0 m) were used to push down the cone. The hydraulic thrust system was mounted over the center of gravity of the truck, permitting use of the full 17.5-ton (15,877 kg) truck weight as load reaction.

The cone had an apex angle of 60° and a base area of 2.3 in^2 (15 cm^2). The resistance to penetration was measured by a built-in load cell in the tip and was relayed to the surface recorder via cables in the sounding rods. The friction sleeve, having an area of 31.8 in^2 (205 cm^2), was fitted above the cone base. The local friction was measured by load cells mounted in the friction sleeve and recorded in the same manner as the end resistance. The end resistance and friction resistance were recorded on a strip chart.

A5.3.2 Test Method

Tests were performed in accordance with ASTM D3441-75T, "Tentative Method for Deep, Quasi-Static, Cone and Friction-Cone Penetration Tests of Soil." Basically, the test was conducted by positioning the electronic cone penetrometer truck over the designated area for testing, setting the outriggers on the ground surface, checking the level of the rig, then pushing the cone into the ground at a rate of 0.79 in/s (2 cm/s) until refusal (defined as the capacity of the cone, friction sleeve, or hydraulics system) or the desired depth of penetration was reached. As a general rule, the depth of penetration did not exceed 33 feet (10 m). If refusal was reached within the top 2 or 3 feet, the test was performed again a few feet away from the first location. Details of the test such as refusal reached, depth, cone used, etc., were entered on a log sheet.

A minimum of three cone penetrometer tests were performed at all field California Bearing Ratio (CBR) test locations.

A5.4 FIELD CALIFORNIA BEARING RATIO (CBR) TESTS

A5.4.1 Equipment

The equipment used to conduct the field CBR tests was as described in the U.S. Army Corps of Engineers' Technical Manual 5-30. Other equipment for conducting a field density test by the sand cone method (ASTM D 1556-64, Test for Density of Soil in Place by the Sand-Cone Method) and the "Speedy Moisture Meter" for field determination of soil moisture content were also included. A backhoe and shovels were used to excavate the CBR test pits.

A5.4.2 Test Method

Field CBR tests were generally performed at four depths at each designated location. The procedures for conducting the CBR tests were as described in the U.S. Army Corps of Engineers' Technical Manual (TM) 5-30, pp. 2-86 to 2-96. Tests were performed in test pits at depths ranging from 1 to 4 feet (0.3 to 1.2 m) below ground surface. Testing was not attempted where numerous cobbles or heavily cemented soils were encountered. Three CBR tests were performed at each depth and the results recorded. Generally, a field density test (ASTM D 1556-64, Test for Density of Soil in Place by the Sand-Cone Method) and moisture content determination (by Speedy Moisture Meter Method) were performed at the CBR test depths.

A5.4.3 Sampling

At each CBR test location, large bulk samples of soils at test depths were obtained. See Section A5.2.3, "Sampling," for trenches, test pits, and surficial samples for details.

A5.4.4 Logging

Field CBR test results, field density test results, and moisture content determinations were recorded at the time of each test. All soil samples were classified and logged in accordance with the procedures outlined in Section A5.5, "Field Visual Soil Classification."

A5.5 FIELD VISUAL SOIL CLASSIFICATION

A5.5.1 General

All field logging of soils was performed in accordance with the procedures outlined in this section. Soil samples were visually classified in the field in general accordance with the procedures of ASTM D 2488-69, Description of Soils (Visual-Manual Procedure). The ASTM procedure is based on the Unified Soil Classification System (see Table A5-1). It describes several visual and/or manual methods which can be used in the field to estimate the USCS soil group for each sample. The following section details several of the guidelines used in the field for describing soils, drilling and excavating conditions, and unusual conditions encountered.

A5.5.2 Soil Description

Soil descriptions entered on the logs of borings, trenches, test pits, and surficial samples generally included those listed below.

Coarse-Grained Soils	Fine-Grained Soils
USCS Name and Symbol	USCS Name and Symbol
Color	Color
Range in Particle Size	Consistency
Gradation (well, poorly)	Moisture Content
Density	Plasticity
Moisture Content	Reaction to HCl
Particle Shape	
Reaction to HCl	

Some additional descriptions or information recorded for both coarse- and fine-grained soils included: degree of cementation, secondary material, cobbles and boulders, and depth of change in soil type.

Definitions of some of the terms and criteria used to describe soils and conditions encountered during the investigations follow.

a. USCS Name and Symbol: Derived from Table A5-1, the Unified Soil Classification System. The soils were first designated as coarse- or fine-grained.

Coarse-grained soils are those in which more than half (by weight) of the particles are visible to the naked eye. In making this estimate, particles coarser than 3 in. (76 mm) in diameter were excluded. Fine-grained soils are those in which more than half (by weight) of the particles are so fine that they cannot be seen by the naked eye. The distinction between coarse- and fine-grained can also be made by sieve analysis with the No. 200 sieve (.074 mm) size particle considered to be the smallest size visible to the naked eye. In some instances, the field technicians describing the soils used a No. 200 sieve to estimate the amount of fine-grained particles. The coarse-grained soils are further divided into sands and gravels by estimating the percentage of the coarse fraction larger than the number 4 sieve (about 1/4 inch or 5 mm). Each coarse-grained soil is then qualified as silty, clayey, poorly graded, or well graded as discussed under plasticity and gradation.

Fine-grained soils were identified in the field as clays or silts with appropriate adjectives (clayey silt, silty clay, etc.) based on the results of dry strength, dilatancy, and plastic thread tests (see ASTM D 2488-69 for details of these tests).

Dual USCS symbols and adjectives were used to describe soils exhibiting characteristics of more than one USCS group.

b. <u>Color</u>: Color descriptions were recorded using the following terms with abbreviations in parentheses.

White (w)
Yellow (y)
Orange (o)
Red (r)
Brown (br)
Green (gn)
Blue (bl)
Gray (gr)
Black (blk)

Color combinations as well as modifiers such as light (lt) and dark (dk) were used.

c. <u>Range in Particle Size</u>: For coarse-grained soils (sands and gravels), the size range of the particles visible to the naked eye was estimated as fine, medium, coarse, or a combined range (fine to medium).

d. <u>Gradation</u>: Well graded indicates a coarse-grained soil which has a wide range in grain size and substantial amounts of most intermediate particle sizes. A coarse-grained soil was identified as poorly graded if it consisted predominantly of one size (uniformly graded) or had a wide range of sizes with some intermediate sizes obviously missing (gap-graded).

e. <u>Density or Consistency</u>: The density or consistency of the in-place soil was estimated based on the number of blows required to advance the Fugro drive or split-spoon sampler, the drilling rate and/or hydraulic pulldown needed to drill, ease (or difficulty) of excavation of trench or test pit, or trench or test pit wall stability. For fine-grained soils, the field guides to shear strength presented below were also used to estimate consistency.

- Coarse-grained soils - GW, GP, GM, GC, SW, SP, SM, SC (gravels and sands)

Consistency	N-Value (ASTM D 1586-67), Blows/Foot
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	>50

- Fine-grained Soils - ML, MH, CL, CH (Silts and Clays)

	Shear Strength		
Consistency	(ksf)	(kN/m^2)	Field Guide
Very Soft	<0.25	<12	Sample with height equal to twice the diameter, sags under own weight
Soft	0.25-0.50	12.0-24.0	Can be squeezed between thumb and forefinger
Firm	0.50-1.00	24.0-48.0	Can be molded easily with fingers
Stiff	1.00-2.00	48.0-96.0	Can be imprinted with slight pressure from fingers
Very Stiff	2.00-4.00	96.0-192.0	Can be imprinted with considerable pressure from fingers
Hard	>4.00	>192.0	Cannot be imprinted by fingers

f. Moisture Content: The following guidelines were used in the field for describing the moisture in the soil samples:
Dry : No feel of moisture
Slightly Moist: Much less than normal moisture
Moist : Normal moisture for soil
Very Moist : Much greater than normal moisture
Wet : At or near saturation

g. Particle Shape: Coarse-grained soils

Angular : Particles have sharp edges and relatively plane sides with unpolished surfaces

Subangular: Particles are similar to angular but have somewhat rounded edges

Subrounded: Particles exhibit nearly plane sides but have well-rounded corners and edges

Rounded : Particles have smoothly curved sides and no edges

h. Reaction to HCl: As an aid for identifying cementation, some soil samples were tested in the field for their reaction to dilute hydrochloric acid. The intensity of the HCl reaction was described as none, weak, or strong.

i. Degree of Cementation: Based on the intensity of the HCl reaction and observation, the degree of cementation of a soil layer was described as weak to strong. Also, the following stages of development of caliche (cemented) profile were indicated where applicable.

Stage	Gravelly Soils	Nongravelly Soils
I	Thin, discontinuous pebble coatings	Few filaments or faint coatings
II	Continuous pebble coatings, some interpebble fillings	Few to abundant nodules, flakes, filaments
III	Many interpebble fillings	Many nodules and internodular fillings
IV	Laminar horizon overlying plugged horizon	Increasing carbonate impregnation

j. Secondary Material: Example - Sand with trace to some silt

Trace	5-12%	(by dry weight)
Little	13-20%	(by dry weight)
Some	>20%	(by dry weight)

k. Cobbles and Boulders: A cobble is a rock fragment, usually rounded or subrounded, with an average diameter between 3 and 12 inches (76 and 305 mm). A boulder is a rock fragment, usually rounded by weathering or abrasion, with an average diameter of 12 inches (305 mm) or more. The presence of cobbles and/or boulders was identified by noting the sudden change in drilling difficulty or cuttings in borings or by visual observation in excavations. An estimate of the size, range, and percentage of cobbles and/or boulders in the strata was recorded on the logs.

l. Depth of Change in Soil Type: During drilling of borings, the depths of changes in soil type were determined by observing samples, drilling rates, changes in color or consistency of drilling fluid, and relating these to depth marks on the drilling rods. In excavations, strata thicknesses were measured with a tape. All soil type interfaces were recorded on the logs by a horizontal line at the approximate depth mark.

In addition to the observations recorded relating to soil descriptions, remarks concerning drilling difficulty, loss of drilling fluid in the boring, water levels encountered, trench wall stability, ease of excavation, and other unusual conditions were recorded on the logs.

A5.6 LABORATORY TESTS

Laboratory tests were performed on selected representative undisturbed and bulk samples. All laboratory tests (except chemical tests) were performed in Fugro National's Long Beach laboratory. The chemical tests were conducted by Pomeroy, Johnson, and Bailey Laboratories of Pasadena, California. All tests were performed in general accordance with the American Society for Testing and Materials (ASTM) procedures. The types of tests performed and their ASTM designations are summarized as follows.

Type of Test	ASTM Designation
Unit Weight	D 2937-71
Moisture Content	D 2216-71
Particle-Size Analysis	D 422-63
Liquid Limit	D 423-66
Plastic Limit	D 424-59
Triaxial Compression	D 2850-70
Unconfined Compression	D 2166-66
Direct Shear	D 3080-72
Consolidation	D 2435-70
Compaction	D 1557-70
California Bearing Ratio (CBR)	D 1883-73
Specific Gravity	D 854-58
Water Soluble Sodium	D 1428-64
Water Soluble Chloride	D 512-67
Water Soluble Sulfate	D 516-68
Water Soluble Calcium	D 511-72
Calcium Carbonate	D 1126-67
Test for Alkalinity (pH)	D 1067-70

A5.7 DATA ANALYSIS AND INTERPRETATION

A5.7.1 Preparation of Final Logs and Laboratory and Field Test Summary Sheets

The field logs of all borings, trenches, test pits, and surficial sample excavations were prepared by systematically combining the information given on the field logs with the laboratory test results. The resultant logs include generally the following information: description of soil types encountered; sample types and depth intervals, lithology (graphic soil column); estimates of soil density or consistency; depth locations of changes in soil types; remarks concerning trench wall stability; drilling difficulty, cementation, and cobbles and boulders encountered; and the total depth of exploration. Laboratory test results presented in the logs include dry density and moisture content; percent of gravel, sand, and fines; and liquid limit and plasticity index. Also, miscellaneous information such as surface elevation, surficial geologic unit, date of activity, equipment used, and dimensions of the activity are shown on the log.

Field CBR test summary sheets were prepared and include the following information for each test site: depth of test; USCS soil type; grain-size distribution and plasticity (from lab testing); in-situ dry unit weight and moisture content (from lab testing); average field CBR values; and remarks concerning cementation and induration.

Laboratory data were summarized in tables. All samples which were tested in the laboratory were listed. Results of sieve analyses, hydrometer, Atterberg limits, in-situ dry strength and moisture content tests, and calculated degree of saturation and void ratio were entered on the tables. Test summary sheets for triaxial compression, unconfined compression, direct shear, consolidation, chemical, CBR, and compaction tests were prepared separately.

The Cone Penetrometer Test results consist of continuous plots of cone resistance, friction sleeve resistance, and friction ratio versus depth from ground surface. Beside the plot, a soil column with USCS soil types encountered at the test location is shown. Other information presented on the log includes surface elevation and surficial geologic unit.

Volume II titled "Geotechnical Data" presents the following basic engineering data.

Boring Logs	Section II - 6.0
Trench and Test Pit Logs	Section II - 7.0
Surficial Sample Logs	Section II - 8.0
Laboratory Test Results	Section II - 9.0
Field CBR Results	Section II - 10.0
Cone Penetrometer Test Results	Section II - 11.0

A5.7.2 Soil Characteristics

A5.7.2.1 General

The soil characteristics are discussed in two parts, surface soils and subsurface soils. The following three tables were prepared and are presented in Sections 3.3 and 3.4 of the report.

1. Characteristics of Surficial Soils;
2. Thickness of Low Strength Surficial Soils; and
3. Characteristics of Subsurface Soils.

The following sections, A5.7.2.2 and A5.7.2.3, explain the data analyses and interpretation used in preparing the above tables.

A5.7.2.2 Surface Soils

In order to define the characteristics of the surficial soils, data from trenches, test pits, borings, surficial soil samples, cone penetrometer tests, field CBR tests and surficial geologic maps were reviewed in conjunction with the laboratory test results. The soils were then grouped into three categories of soils with similar general characteristics. These categories, their descriptions, and associated characteristics were tabulated. This table (Characteristics of Surficial Soils, Table 3-1) includes soil descriptions by the Unified Soil Classification System, predominant surficial geologic units, the estimated areal extent (percent) of each category, important physical properties summarized from laboratory test results, and certain road design related data.

The important physical properties summarized include the estimated cobbles content, grain-size analyses, and Atterberg limits. Ranges for these properties were determined from the field logs and laboratory test results. These ranges are useful for categorizing soils, evaluating construction techniques, and providing data for preliminary engineering evaluations and for use by other MX participants.

Road design data presented in Table 3-1 were developed from field and laboratory tests and consist of three distinct groups:

1. Laboratory test results;
2. Suitability of soils for road use; and
3. Low strength surficial soil.

These road design related data were considered important because roads (interconnecting and secondary) constitute a major portion of the geotechnically related costs. The following paragraphs briefly discuss the development of road design data.

a. Laboratory Test Results: These include ranges of maximum dry density, optimum moisture content (ASTM D 1557-70) and CBR (ASTM D 1883-73) at 90 percent relative compaction for each soil category. The maximum dry density and optimum moisture content are important quality control parameters during roadway construction. California Bearing Ratio is the ratio of the resistance to penetration developed by a subgrade soil to that developed by a specimen of standard crushed-rock base material and is the basis for many empirical road design methods used in this country.

b. Suitability of Soils for Road Use: Included in this group is suitability of soils for use as road subgrade, subbase, or base. Parameters used to make these qualitative assessments were characteristics related to CBR, frost susceptibility, drainage, and volume change potential. The following guidelines were used in estimating the suitability of soils for road use.

1. Suitability as a road subgrade.

Very Good - soils which can be compacted with little effort to high CBR values (CBR >30), exhibit low frost susceptibility, fair to good drainage, and low volume change potential.

Good - soils which can be compacted with some effort to moderate CBR values (CBR 15-30), exhibit moderate frost susceptibility, fair drainage, and medium volume change potential.

Fair - soils which can be compacted with considerable effort to moderate CBR values (CBR 15-30), exhibit moderate to high frost susceptibility, fair to poor drainage, and medium volume change potential.

Poor - soils which require considerable effort for compaction to even low CBR values (CBR <15), exhibit high frost susceptibility, poor drainage, or high volume change potential. These soils should generally be removed and replaced with better quality material.

2. Suitability as road subbase or base.

Good - soils which exhibit negligible frost susceptibility, good drainage, and negligible volume change potential.

Fair - soils which require some treatment or processing to upgrade for use.

Poor - soils which would require relatively extensive processing or soil stabilization to upgrade for use.

Not Suitable - soils which cannot be modified to give adequate roadway support.

The parameters used in the aforementioned suitability ratings are discussed in the following paragraphs.

i. <u>CBR Characteristics</u>: California Bearing Ratio, which is commonly used for road design, is dependent on soil type. During previous verification studies, a limited number of CBR tests were performed on several soil types which were representative of the surficial soils in the various Verification Sites. Based on these test results, a relationship between CBR and percent fines (percent passing through No. 200 sieve) was established and is shown in Figure A5-1. Envelopes for clays and granular soils with plastic fines and silts and granular soils with nonplastic fines are shown in the figure. This plot was used to estimate the range of laboratory CBR values for the various surficial soil categories.

ii. <u>Other Characteristics</u>: These characteristics pertain to frost susceptibility, drainage, and volume change potential. They were estimated based on the physical properties of the soils, results of consolidation tests (for volume change potential), published literature, and our experience. Following are the definitions of these characteristics.

1. Frost susceptibility is defined as potential for detrimental ice segregation upon freezing or loss of strength upon thawing.

Low - negligible to little potential
Moderate - some potential
High - considerable potential

2. Drainage characteristics pertain to internal movement of water through soil.

Good - materials which drain rapidly and do not tend to plug with fines

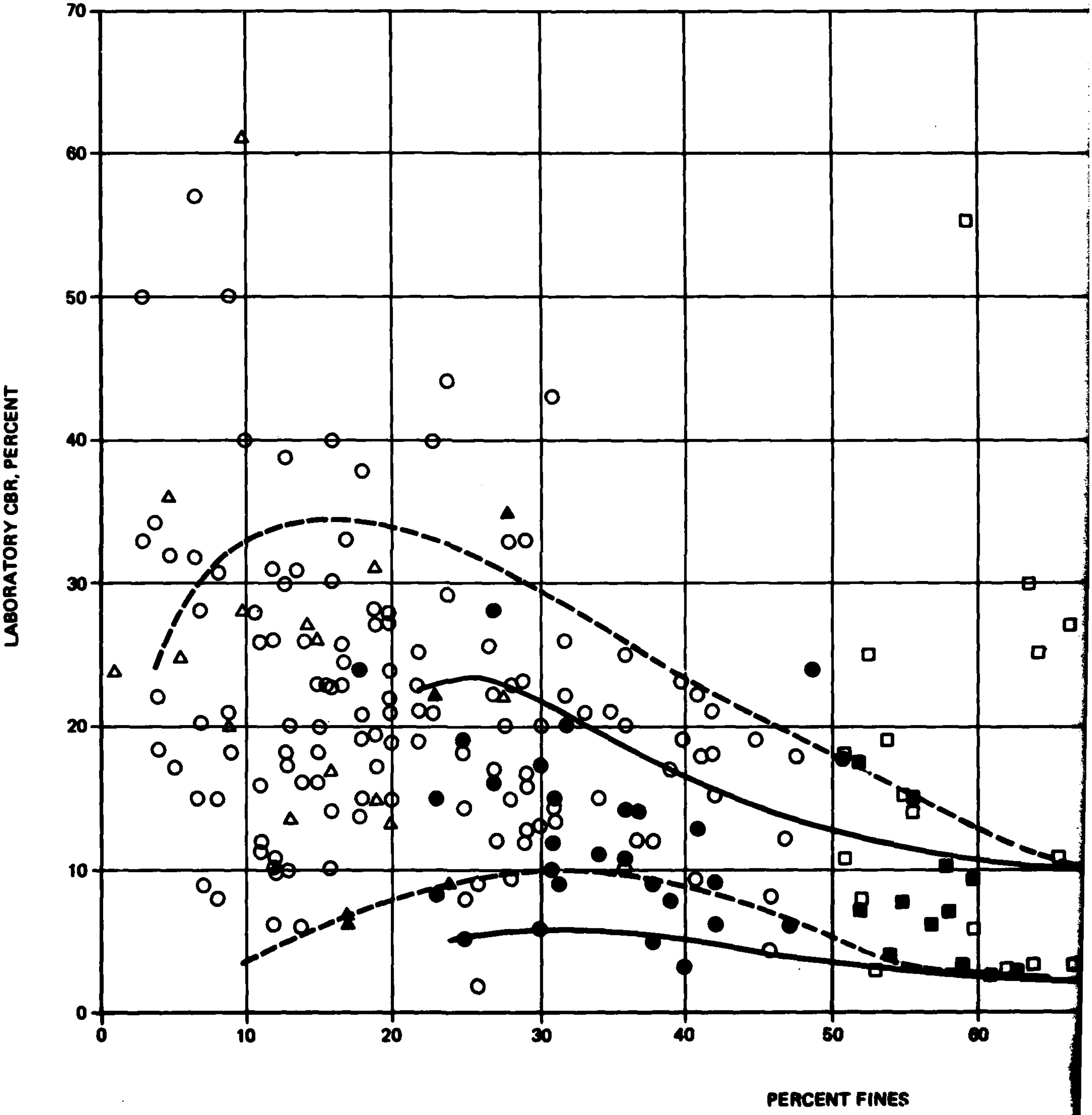
Fair - natural internal drainage is fairly rapid but there is some tendency for plugging of voids with fines

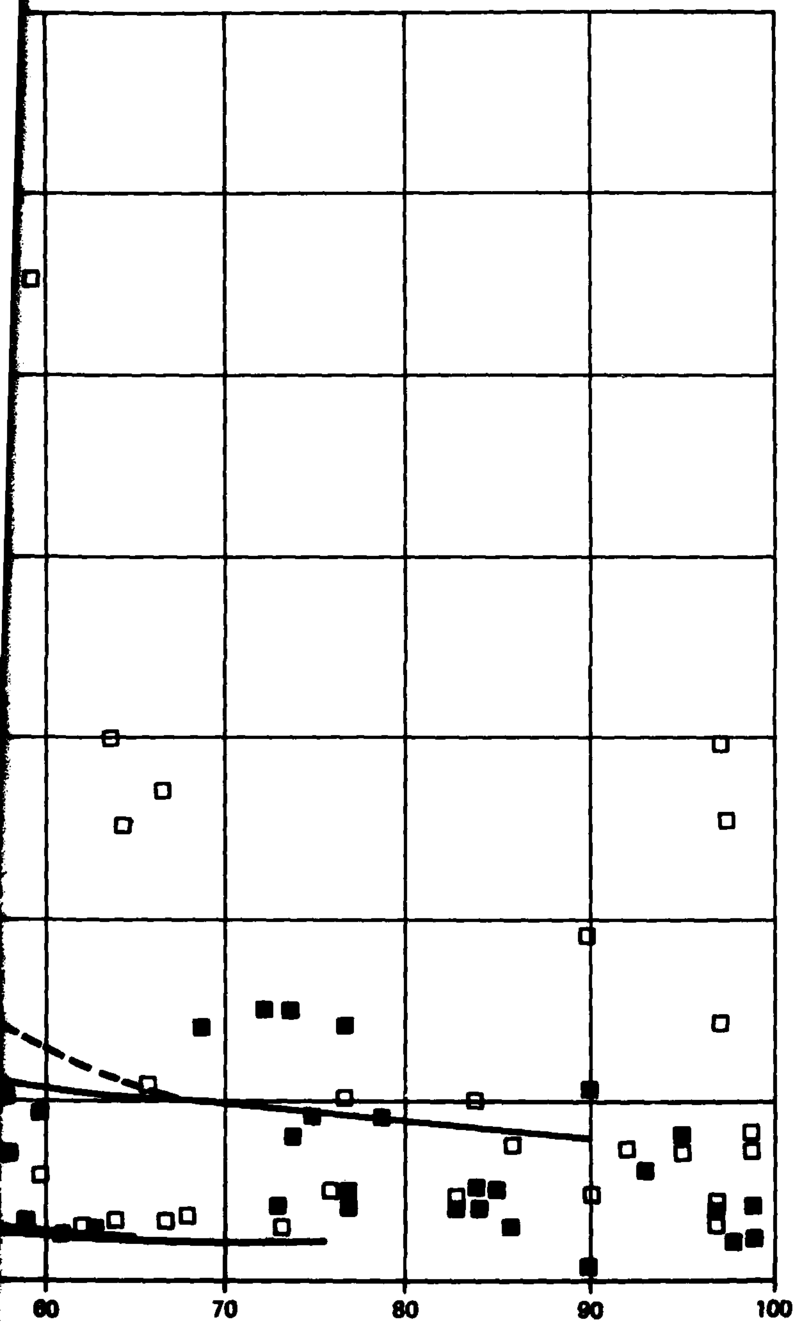
Poor - internal drainage is somewhat slow and plugging with fines can often occur

Practically Impervious - materials which exhibit almost no natural internal drainage

3. Volume change potential corresponds to soil swelling or shrinkage due to change in moisture content.

Low - 0 to 2 percent volume change
Medium - 2 to 4 percent volume change
High - > 4 percent volume change


LABORATORY CBR, PERCENT
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
PERCENT FINES



EXPLANATION

- △ Gravels with nonplastic fines (GM, GW, GP, GP-GM, GW-GM)
- ▲ Gravels with plastic fines (GC, GC-GM)
- ○ Sands with nonplastic fines (SP, SW, SM, SP-SM, SW-SM)
- ● Sands with plastic fines (SC, SC-SM)
- □ Silts (ML)
- ■ Clays (CL, CH, CL-ML)
- – – – – – Envelope for silts and granular soils with nonplastic fines
- ——— Envelope for clays and granular soils with plastic fines

NOTES:

1. Fines correspond to soil passing through No. 200 (0.074mm opening) sieve.
2. California Bearing Ratio at 90% relative compaction.
3. Soil types (GM, SC) are based on Unified Soil Classification System.

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PLOT OF LABORATORY CBR VERSUS PERCENT FINES VERIFICATION VALLEYS, NEVADA–UTAH

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FIGURE A8-1

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c. Low Strength Surficial Soil: Included in this group is extent of low strength surficial soil. The roads for the MX system will be built on existing ground surface with minimum cut and fill. Therefore, the costs of roads depend on the consistency (or strength) of the surficial soil. In order to evaluate the strength of the surficial soils, cone penetrometer test results were used.

Low strength surficial soil is defined as soil which will perform poorly (failure of subgrade) as a road subgrade at its present consistency when used directly beneath a road section. In order to define "low strength" using CPT results, the following four approaches were pursued. These approaches are subjective and qualitative and are based on our experience as well as published literature.

i. Field visual observations: During logging of the borings, the excavation of trenches, test pits, and obtaining surficial soil samples, consistency or compactness of the surficial soils was described qualitatively. A detailed comparison of the CPT results (cone end resistance) and the consistency of the soils was done for different soil types. Using engineering judgement, an upper limit cone resistance was established which encompassed a majority of the soils likely to perform poorly as road subgrades.

ii. Standard Penetration Test (SPT): SPT is very widely used and accepted in geotechnical engineering practice in this country. A study of available literature revealed that the ratio of cone resistance (q_c, tsf) to Standard Penetration Resistance (N, blows per foot) has a certain range for different soil types. In 1979 Verification studies, limited field SPTs were performed in Reveille-Railroad and Big Smoky sites. Ratios of q_c/N were computed for these tests and were found to be comparable to those reported in literature for similar soil types. Using the relationships applicable to the soils present in the Verification sites, an upper limit of cone resistance, equivalent to midrange of "medium dense" category, (SPT N-value = 10 to 30 blows per foot) was established for defining the "low strength" surficial soils.

iii. In-Situ Dry Density: A comparison was made between in-situ dry densities determined from Fugro Drive and Pitcher samples obtained from soil borings and CPT results at the same locations and depths. From this comparison, it was observed that identifiable trends do exist between cone resistance values and soil densities. In this case also, an upper limit of cone resistance equivalent to midrange of "medium dense" category (relative compaction), was established for defining the "low strength" of surficial soils.

iv. Field CBR Tests: During Verification studies, field CBR tests were performed in Reveille Railroad, Pine, Wah Wah, Steptoe, Lake, Spring, Stone Cabin, Hot Creek, and Big Smoky valleys. The procedures for conducting the CBR tests were as described in the U.S. Army Corps of Engineers' Technical Manual (TM) 5-30, pp. 2-86 to 2-96. The test results were compared to Cone Penetrometer Tests performed at the same location. A plot of average field CBR and average cone resistance was prepared and is presented in Figure A5-2. The plot shows the results of the tests in sands only, since tests in gravel and fine-grained soils were very few. Although there is considerable scatter, the majority of the data points fall in a band which is shown in Figure A5-2. From this plot, a range of CPT resistance corresponding to low field CBR values (indicating low strength surficial soils) was established.

As a result of the preceding four approaches, the following criteria for defining low strength surficial soil were established:

q_c <120 tsf (117 kg/cm^2) for coarse-grained soils
q_c < 80 tsf (78 kg/cm^2) for fine-grained soils

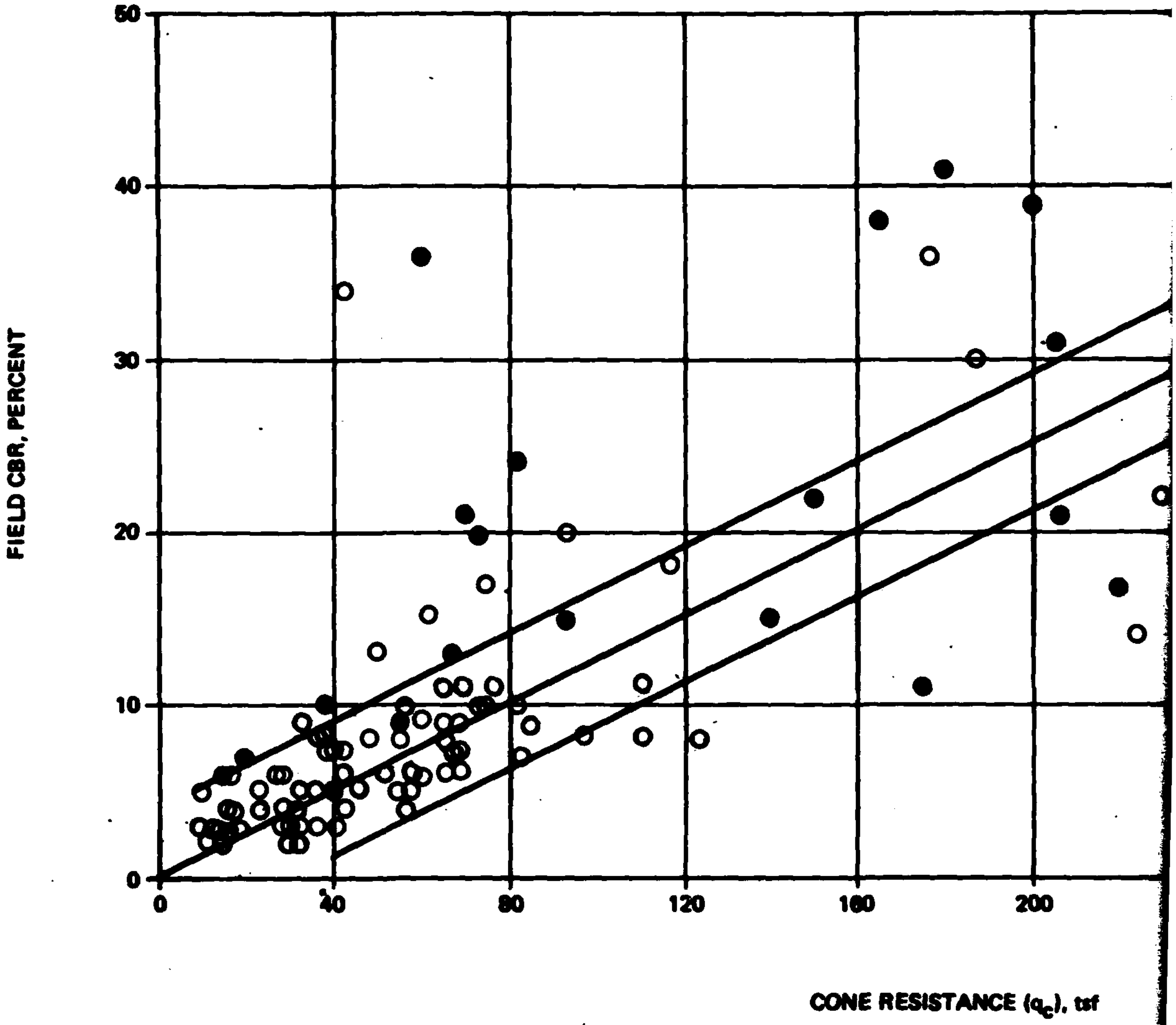
These criteria are preliminary at this stage and may be revised as more data become available from future verification studies. The criteria were used to determine the extent of low strength surficial soil at each CPT location. The results are tabulated in Table 3-2, "Thickness of Low Strength Surficial Soil."

A5.7.2.3 Subsurface Soils

Characteristics of the subsurface soils were developed using data from seismic refraction surveys, borings, trenches, test pits, and laboratory tests.

The soils were divided into coarse-grained and fine-grained soils in two ranges of depth, 0 to 20 feet and 20 to 160 feet (0 to 6 m and 6 to 49 m). Physical and engineering properties of the soils were then tabulated as "Characteristics of Subsurface Soils" (Table 3-4) based on laboratory test results on representative samples. The table includes soil descriptions, Unified Soil Classification System symbols, the estimated subsurface extent of each soil group, comments on the degree of cementation, estimated cobbles content, and ranges of values from the following laboratory and field tests: dry density, moisture content, grain-size distribution, liquid limit, plasticity index, compressional wave velocity, unconfined compression, triaxial compression, and direct shear.

The excavatability and stability of excavation walls of a horizontal or a vertical shelter were evaluated from the



EXPLANATION

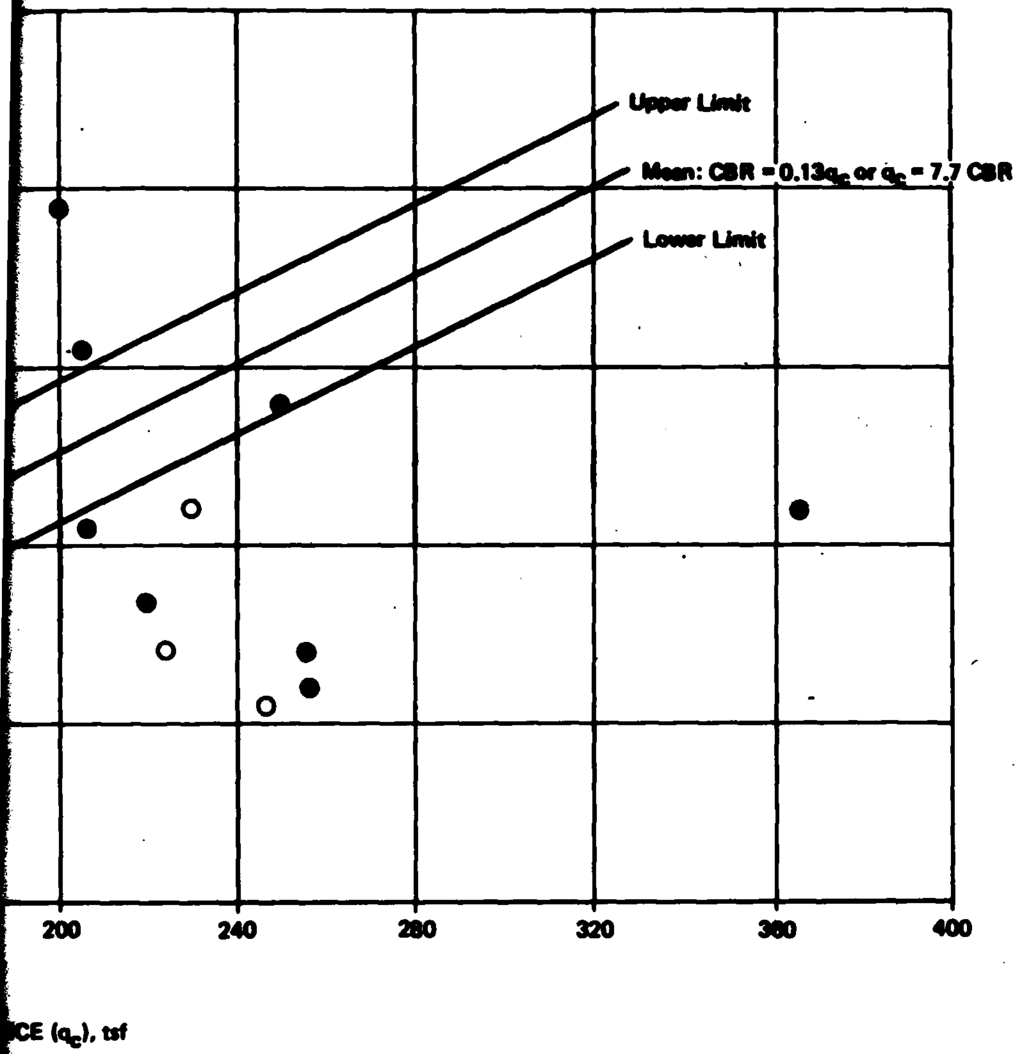
○ Tests in soils without cementation.

● Tests in soils with cementation.

NOTES: 1. Data are for coarse-grained soils tested in Reveille, Railroad, Pine, Wah Wah, Steptoe, Lake, Spring, Stone Cabin, Hot Creek, and Big Smoky valleys.

2. Band between the upper and lower limits includes 74% of all the data points.

3. Depth of CBR tests is from one to four feet.



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RELATIONSHIP BETWEEN FIELD CBR AND CPT CONE RESISTANCE VERIFICATION VALLEYS, NEVADA–UTAH

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FIGURE A5-2

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subsurface data using seismic velocities, soil types, shear strength, presence of cobbles and boulders, and cementation. Problems encountered during trench and test pit excavations and drilling of borings were also considered in the evaluation.