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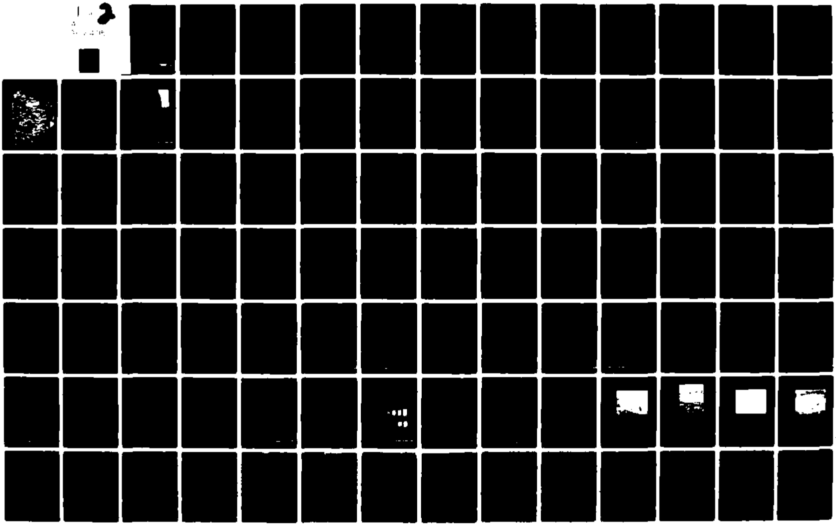

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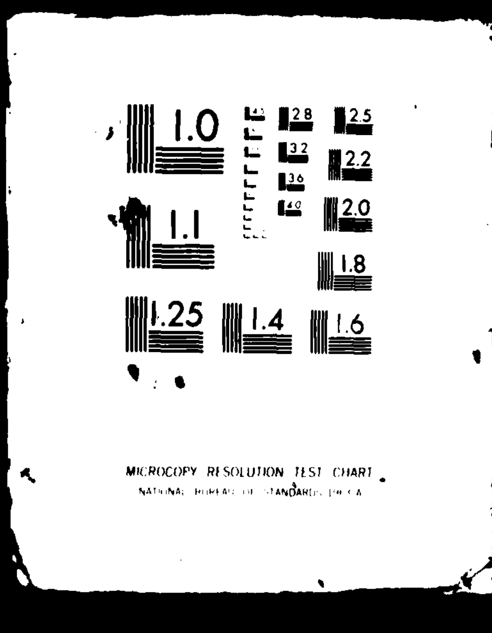

MX SITING INVESTIGATION
GEOTECHNICAL EVALUATION

AD A112405

AGGREGATE RESOURCES STUDY
HAMLIN VALLEY
NEVADA-UTAH

PREPARED FOR
BALLISTIC MISSILE OFFICE (BMO)
NORTON AIR FORCE BASE, CALIFORNIA

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This report contains the Valley-Specific Aggregate Resources Study evaluation for Hamlin Valley in Utah and Nevada. It is the fourth in a series of reports that contain valley-specific aggregate information on the location and suitability of basin-fill and rock sources for concrete and road-base construction materials. Field reconnaissance and limited laboratory testing, existing data from the Utah State Department of Highways, previous regional aggregate investigations, and ongoing Verification studies provide the basis for the findings presented.

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AGGREGATE RESOURCES STUDY

HAMLIN VALLEY

NEVADA-UTAH

Prepared for:

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

Prepared by:

Fugro National, Inc.
3777 Long Beach Boulevard
Long Beach, California 90807

6 June 1980

FOREWORD

This report was prepared for the Department of the Air Force Ballistic Missile Office (BMO) in compliance with Contract No. F04704-80-C-0006, CDRL Item No. 004A2. It presents the results of Valley-Specific aggregate resources investigation within and adjacent to selected lands in Utah and Nevada that are under consideration for siting the MX system.

This volume contains the results of the Aggregate Resources study in Hamlin Valley. It is the fourth of several Valley Specific Aggregate Resources investigations which will be prepared as separate volumes. Results of this report are presented as text, appendices, and two drawings.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont.)

FUGRO NATIONAL, INC.

TABLE OF CONTENTS (Cont.)

Page

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF DRAWINGS

EXECUTIVE SUMMARY

This report contains the Valley-Specific Aggregate Resources Study (VSARS) evaluation for Hamlin Valley in Utah and Nevada. It is the fourth in a series of reports that contain valley-specific aggregate information on the location and suitability of basin-fill and rock sources for concrete and road-base construction materials. Field reconnaissance and limited laboratory testing, existing data from the Utah State Department of Highways, previous regional aggregate investigations, and on-going Verification studies provide the basis for the findings presented.

A classification system based on aggregate type and potential use was developed to rank the suitability of all basin-fill and rock aggregate sources. Four aggregate types have been designated; coarse, fine, and coarse and fine (multiple) aggregates derived from basin-fill sources and crushed rock aggregates derived from rock sources. Each aggregate type was then classified using the following definitions:

Class I — Potentially suitable concrete aggregate and road-base material source.

Class II — Possibly unsuitable concrete aggregate/potentially suitable road-base material source.

Class III — Unsuitable concrete aggregate or road-base material source.

Decisions on assigning a particular aggregate source to one of the three classes were determined from existing and Fugro National laboratory aggregate tests performed as part of this

study (abrasion resistance, soundness, and alkali reactivity), and to a lesser degree, field visual observations.

Emphasis in this study was placed on the identification of Class I basin-fill, coarse aggregate. These deposits are considered to be the primary sources of concrete and road-base construction materials. Results of the study are presented on a 1:125,000 scale aggregate resources map (Drawing 2) and are summarized as follows:

1. Coarse Aggregate - Major Class I coarse aggregate deposits are located in the Hamlin Valley study area in:

   a. Extensive alluvial fan (Aaf, Aafs, Aafg) and undifferentiated alluvial (Au) deposits adjacent to the southern Snake and northern Needle ranges and the Burbank Hills.

   b. Alluvial fan (Aaf) and undifferentiated alluvial deposits (Au) west of the Needle Range. Boundaries of these sources could not be delimited.

   Based on field observations, potentially suitable Class II coarse aggregate sources are widespread and extensive in the study area. Although boundaries of specific deposits could not be delineated, they are typically located within alluvial fans (Aaf, Aafs) flanking Class I and/or Class II rock sources.

2. Fine Aggregate - Many coarse aggregate basin-fill sources are also potential multiple sources (coarse and fine) that will supply varying quantities of fine aggregate either from the natural deposit or during processing. Specific alluvial

fan deposits were identified within an undifferentiated alluvial unit (Au) west of the Burbank Hills.

Potential Class II fine aggregate sources are widespread and extensive in the study area. Specific deposit boundaries could not be delineated but typically occur in alluvial fan (Aafs) and undifferentiated alluvial (Au) depositis basinward of most Class I and Class II rock exposures.

3. Crushed Rock - Abundant Class I crushed rock sources are present predominantly in the northern section of the study area.

   a. Guilmette Formation (Cau) - Northern Hamlin Valley study area (southern Snake and northern Needle ranges, and the Burbank Hills)

   b. Simonson and Sevy dolomites (Do) - West-central Hamlin Valley study area (Limestone Hills)

   c. Ely Limestone (Ls) - Northeastern Hamlin Valley study area (Burbank Hills and northern Needle Range)

   d. Tertiary Basalt (Vb) - Southeastern Hamlin Valley study area (southern Needle Range).

The useability of any of these rock units as sources of crushed rock aggregate depends on their location and accessibility within the study area and minability.

Additional aggregate testing and field investigations will be required to further refine the lateral and vertical extents of classification boundaries and define exact physical and chemical characteristics of a particular deposit or rock source within the valley.

1.0 INTRODUCTION

1.1 STUDY AREA

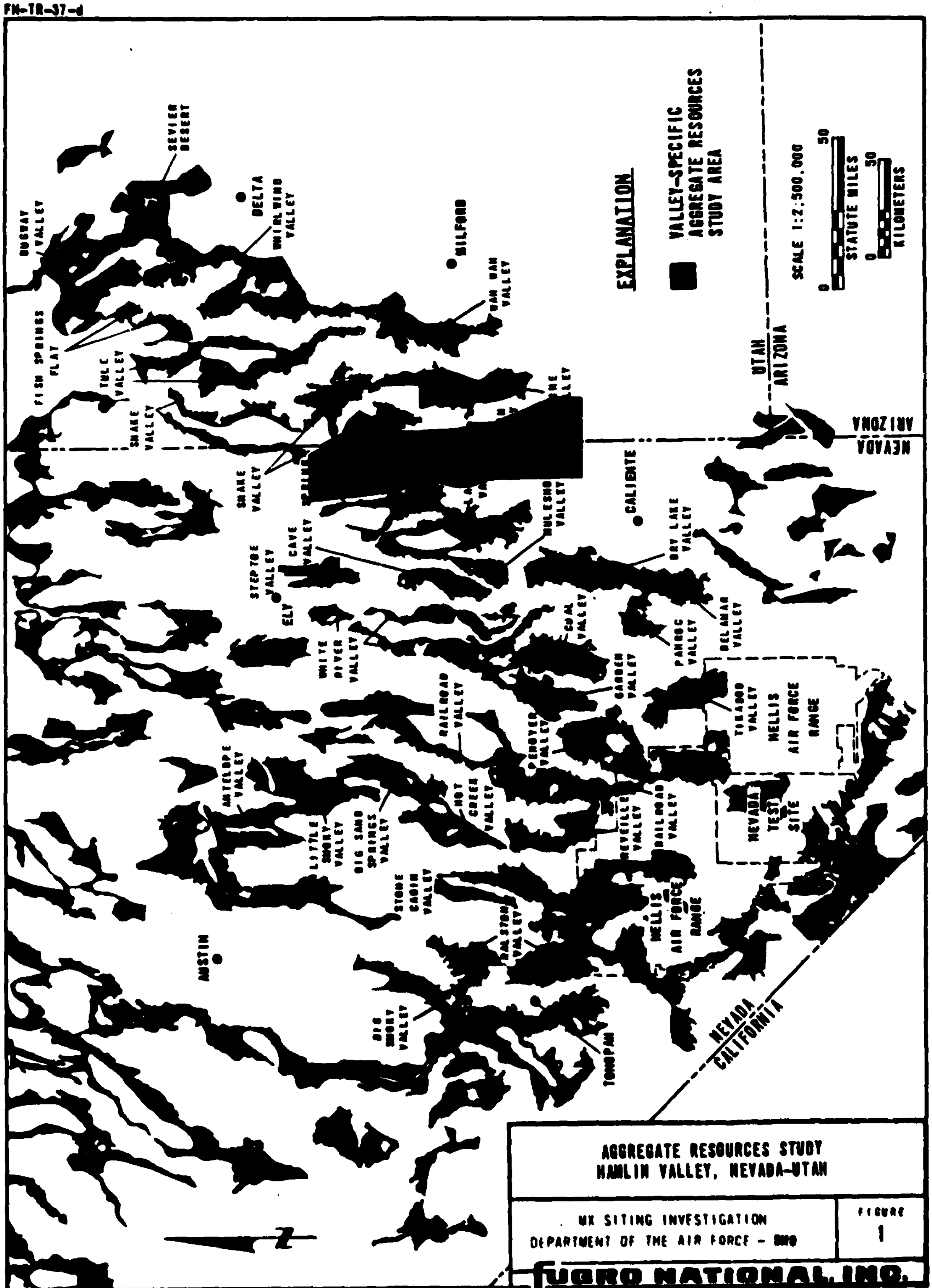
This report presents the results of the Valley-Specific Aggregate Resources Study completed for Hamlin Valley (Figure 1). Located in portions of White Pine and Lincoln counties in eastern Nevada, and Millard, Beaver, and Iron counties in western Utah, this north-south elongate area is comprised of an alluvial basin flanked primarily by sedimentary and igneous rock mountain ranges. Spring and Lake valleys border the site on the west and Snake and Pine Valleys form the eastern boundary.

U.S. 6 (50) and Utah State Highway 21 (Nevada State Highway 73) provides access across the northern study area. A network of unpaved roads and four-wheel-drive trails crisscross the site (Drawing 1) and provide access to most of the valley.

The study area is mainly comprised of desert rangeland managed by the Bureau of Land Management and contains part of the Humboldt National Forest on its northwest side. The towns of Baker, Nevada, and Garrison, Utah, lie in the extreme northern section of the study areas.

1.2 BACKGROUND

The MX aggregate program began in 1977 with the investigation of Department of Defense (DOD) and Bureau of Land Management (BLM) lands in California, Nevada, Arizona, New Mexico, and Texas (FN-TR-20D). Refinement of the MX siting area added portions of Utah and Nevada that were not studied in the initial Aggregate



AGGREGATE RESOURCES STUDY
HAMLIN VALLEY, NEVADA-UTAH

MX SITING INVESTIGATION
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FIGURE 1

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Resources Evaluation Investigation (AREI). This additional area (Figure 2), defined as the Utah Aggregate Resources Study area (UARSA) was evaluated in Fall 1979 and a second general aggregate resources report (FN-TR-34) was submitted on 3 March 1980. Both general aggregate investigations were designed to provide regional information on the general location, quality, and quantity of aggregates that could be used in the construction of the MX system.

Subsequent to the general studies, Valley-Specific Aggregate Resources Studies (VSARS) were developed in FY 79 to provide more detailed information on potential aggregate sources in specified valley areas.

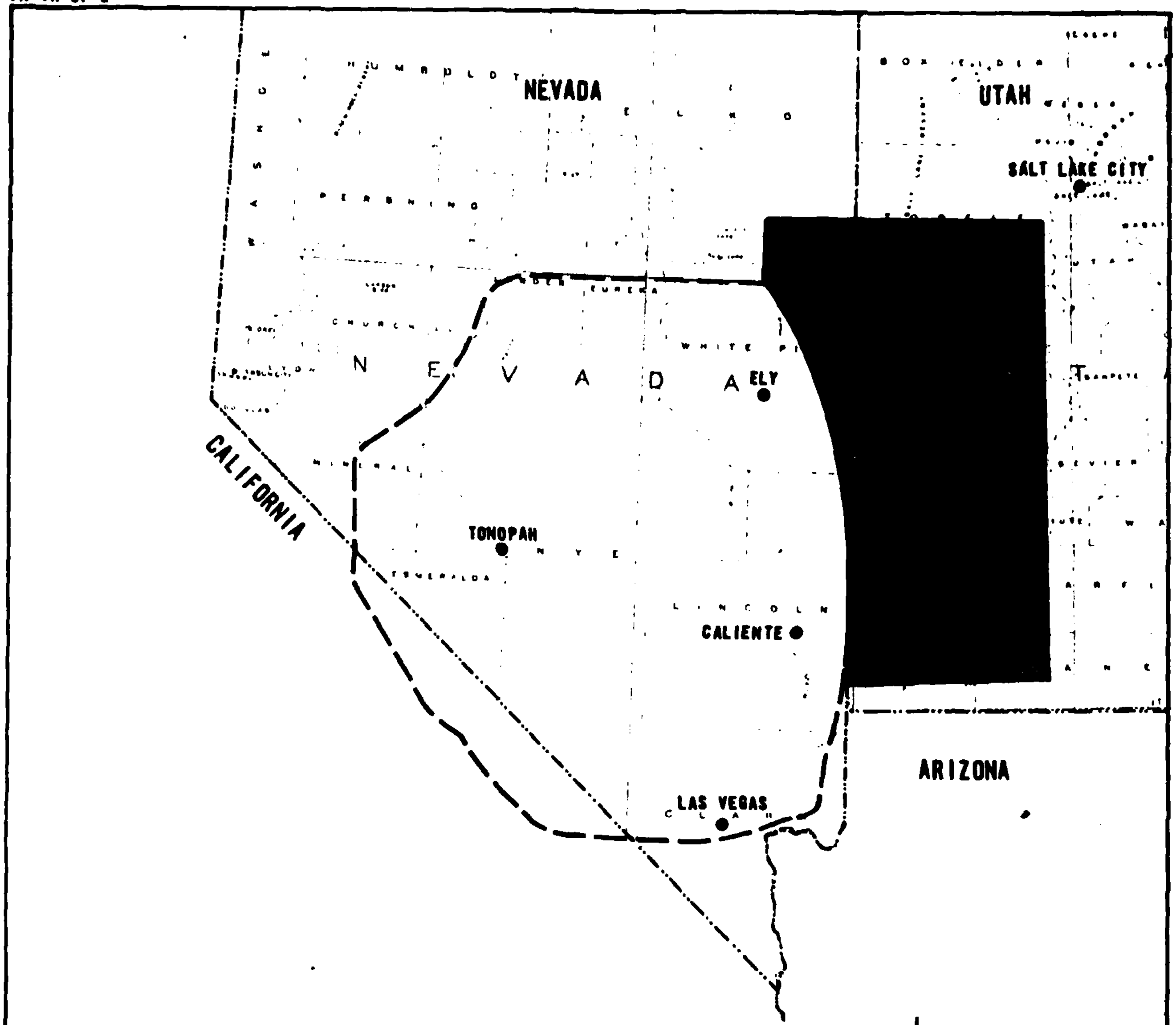
1.3 OBJECTIVES

The primary objective of the VSARS program is to classify on a valley basis, basin-fill deposits and rock for suitability as concrete and road base construction materials. The Valley-Specific Aggregate Resources Study format is designed to select and present the locations of the most acceptable aggregate sources for preliminary construction planning and follow-on, detailed aggregate investigations.

1.4 SCOPE

The scope of this investigation required office and field studies and included the following:

(1) Collection of available existing data on the quality and quantity of potential concrete aggregate and road base material sources. American Society of Testing and Materials (ASTM) standards and Standard Specifications



EXPLANATION

— — NEVADA-CALIFORNIA AGGREGATE RESOURCES EVALUATION INVESTIGATION FY 78 (FN-TR-20D)

■ UTAH AGGREGATE RESOURCES STUDY, FY 79 (FN-TR-34)

SCALE 1: 5,000,000

0 50 100
STATUTE MILES

0 50 100
KILOMETERS

UTAH-NEVADA REGIONAL AGGREGATE STUDIES	
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - BMO	FIGURE 2
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6 JUN 80

for Public Works Construction (SSPWC) were used to evaluate quality.

(2) Aerial and ground reconnaissance of all identified potential aggregate sources in the valley area, with more detailed investigation and sample collection of likely basin-fill (coarse and fine aggregates) and rock (crushed rock aggregates) construction material sources.

(3) Laboratory testing to supplement available existing data and to provide detailed information to assist in determining the suitability of specific basin-fill or rock deposits as construction material sources within the valley area.

(4) Development and application of an aggregate classification system (Section 2.5) that emphasizes aggregate type (coarse, fine, or crushed rock) and potential construction use (concrete and/or road base).

2.0 STUDY APPROACH

2.1 EXISTING DATA

Collection of existing test data from available sources was an important factor in the VSARS program. The principal source of existing data directly pertaining to aggregate construction materials was the Utah State Department of Highways (Appendix A). The majority of this information is related to the use of aggregate material for asphaltic concrete, base coarse in road construction, or ballast material. However, many of the suitability tests for these types of construction materials are similar to those for concrete and were applicable to this investigation (Appendix A).

2.2 SUPPLEMENTAL FUGRO NATIONAL DATA

Supplemental Fugro National data were obtained from: (1) field data and supplementary test data collected during the general aggregate resources studies (FN-TR-20D, FN-TR-34), (2) Hamlin Valley Verification study (FN-TR-27-IA), and (3) the current Valley-Specific Aggregate Resources Study (Appendix A).

The primary objective of the initial, general aggregate study was a regional evaluation and ranking of all potential aggregate sources. Five data points from the general aggregate studies were located within the Valley-Specific study area (Drawing 1) and consequently supplied specific aggregate information. These five stops contained one 150-pound sample collected for limited laboratory testing (Appendix A).

Verification geologic Maps were an initial source of information on the type and extent of basin-fill units within specific valley areas. While the Verification studies are not specifically designed to generate aggregate information, the data collected are applicable to the aggregate evaluation.

The VSARS program required aerial and ground reconnaissance of the study area to collect additional information to verify conditions determined during the data review. Included in the 28 field station data stops was the collection of 20 samples for additional laboratory testing. Potential coarse and fine aggregate basin-fill samples were collected by channel sampling stream cuts or man-made exposures. Potential crushed rock aggregate samples were obtained from exposures of fresh or slightly weathered material whenever possible. The weight of the samples collected ranged between 100 and 150 pounds. Hand samples, which generally did not exceed 5 pounds in weight, were collected for office analyses.

Identification of basin-fill materials in all field studies followed ASTM D2488-69 Description of Soils (Visual-Manual Procedure), and the Unified Soil Classification System (Appendix C). Rock identifications followed procedures described in the Quarterly of the Colorado School of Mines (1955) and Standard Investigative Nomenclature of Constituents of Natural Mineral Aggregates (ASTM C294-69).

2.3 DATA ANALYSIS

Geologic and engineering criteria were used in the evaluation of potential aggregate sources within the study area. This was supplemented by laboratory analysis of selected samples during the Valley-Specific aggregate testing program (Table 1). Coarse aggregate is defined as plus 0.185 inch (4.699 mm) fine gravel to boulders basin-fill material. Fine aggregate is defined as minus 0.375 inch (9.52 mm) coarse to fine sand basin-fill material. While all laboratory tests supplied definitive information, the soundness, abrasion, and alkali reactivity results were considered the most critical in determining the use and acceptablity of a potential aggregate source.

2.4 PRESENTATION OF RESULTS

Results of the study are presented in text, tables, two 1:125,000 scale maps, and appendices. Drawing 1 presents the location of the 40 existing test data and supplemental Fugro data sites within the study area. Drawing 2 presents the location of all VSARS laboratory sample sites and all potential basin-fill and rock aggregate sources within the valley area. In addition, these potential aggregate sources are classified according to proposed aggregate use and type (Section 2.5).

Geologic unit symbols utilized in Drawing 2 relate to standard geological nomenclature whenever possible. Undifferentiated basin-fill and rock units were established primarily to accomodate accuracy of data and map scale and may contain deposits which could supply significant quantities of high quality

ASTM TEST	SAMPLE TYPE AND NUMBER OF TESTS		
	COARSE	FINE	ROCK
ASTM C-88; SOUNDNESS BY USE OF MAGNESIUM SULFATE	9	8	8
ASTM C-131; RESISTANCE TO ABRASION BY USE OF THE LOS ANGELES MACHINE	9		8
ASTM C-136; SIEVE ANALYSIS	12	12	
ASTM C-289; POTENTIAL REACTIVITY OF AGGREGATES (CHEMICAL METHOD)	0	0	3
ASTM C-127 AND C-128; SPECIFIC GRAVITY AND ABSORPTION	7	1	3

AGGREGATE TESTS
HAMLIN VALLEY
AGGREGATE RESOURCES STUDY, NEVADA

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TABLE 1

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materials. A conversion table to relate these geologic symbols to the geologic unit nomenclature used in Fugro National Verification studies is contained in Appendix E.

All contacts which represent distinct boundaries between geologic units are shown as solid lines in Drawing 2. The contacts are dashed where the depicted data were extrapolated beyond the limits of the source data or where accuracy of the data may be questionable. Local small deposits of one geologic unit may be found in close association with a larger deposit of a different geologic unit. Due to the reconnaissance level of the field investigation or map scale limitations, these smaller deposts could not be depicted on the aggregate resources map and have been combined with the more prevalent material. Similarly, potential aggregate source classifications are preliminary and may contain lesser amount of material of another use or type. Therefore, all classification lines are dashed and delimit the best aggregate evaluations possible at this level of investigation. In cases of highly variable rock or basin-fill units and limited aggregate tests, boundaries could not be drawn and information is presented as point data on Drawing 2.

Appendices contain tables summarizing the basic data collected during Fugro National's supplemental field investigations, the results of Fugro National's supplemental testing programs, and existing test data gathered from various outside sources (Appendix A). Also included in appendices are an explanation of caliche development (Appendix B), the Unified Soil Classification

System (Appendix C), photographs of typical aggregate sources within the Hamlin Valley Specific area (Appendix D, and a geologic unit cross reference table (Appendix E).

2.5 PRELIMINARY CLASSIFICATION OF POTENTIAL AGGREGATE SOURCES

A system was developed to preliminarily classify all potential aggregate sources in the study area. This classification is designed to present the best potential sources of coarse, fine, coarse and fine (multiple source), and crushed rock aggregate types within a Valley-Specific area (Drawing 2) based on potential aggregate use (Table 2). Concrete aggregate parameters are the principal consideration in this report as materials suitable for use as concrete aggregate and generally acceptable for use as road-base material. Therefore, the three classifications described below are based primarily on results of the abrasion, soundness, and alkali reactivity tests.

Class I — Potentially suitable concrete aggregate and road-base material sources. Coarse and crushed rock aggregates which either passed abrasion, soundness, and alkali reactivity tests or passed abrasion and soundness tests and were not tested for alkali reactivity; fine aggregates which either passed soundness and alkali reactivity tests or passed soundness tests and were not tested for alkali reactivity.

Class II — Possibly unsuitable concrete aggregate/potentially suitable road-base material source. Coarse, fine, and crushed rock aggregates which either failed the soundness and/or alkali reactivity tests or were classified only by field visual observations or other test data.

Class III — Unsuitable concrete aggregate or road-base material. Coarse and crushed rock aggregates which failed abrasion test and were excluded from further testing fine and rarely, coarse aggregates composed of significant amounts of clay- and silt-sized particles.

AGGREGATE CHARACTERISTIC[1]			AGGREGATE USE CLASSIFICATION		
			CLASS I	CLASS II	CLASS III
ABRASION RESISTANCE, PERCENT WEAR[2]			< 50	< 50	> 50
SOUNDNESS, PERCENT LOSS[3]	COARSE AGGREGATE	Na SO_4	< 12	> 12	> 12
		Mg SO_4	< 18	> 18	> 18
	FINE AGGREGATE	Na SO_4	< 10	> 10	> 10
		Mg SO_4	< 15	> 15	> 15
POTENTIAL ALKALI REACTIVITY[4]			INNOCUOUS TO POTENTIALLY DELETERIOUS	DELETERIOUS	DELETERIOUS

1. AGGREGATE CHARACTERISTIC BASED ON STANDARD TEST RESULTS
2. ASTM C131 (500 REVOLUTIONS)
3. ASTM C88 (5 CYCLES)
4. ASTM C289

PRELIMINARY AGGREGATE CLASSIFICATION SYSTEM VALLEY-SPECIFIC AGGREGATE RESOURCES STUDY	
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - BMO	TABLE 2

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Sources not specifically identified as Class I, II, or III from the three critical test results or clay- and silt-sized particle content, are designated as Class II sources. All classifications are preliminary with additional field reconnaissances, testing, and case history studies needed to confirm adequacy, delimit areal boundaries, and define exact physical and chemical characteristics.

The following publications/sources were used in defining the three use classifications:

(1) ASTM C33-74A Standard Specifications for concrete Aggregate,

(2) SSPWC Part II Construction Sections 200-1.1, 1.4, 1.5, and 1.7,

(3) Literature applicable to concrete aggregates,

(4) Industrial producers of concrete aggregates, and

(5) Consultants in the field of concrete aggregates.

3.0 GEOLOGIC SETTING

3.1 PHYSIOGRAPHY

The study area lies entirely within the Basin and Range physiographic province. Primary physiographic features are controlled by block faulting which has produced the uplifted mountains and down-dropped alluvial basins characteristic of this region. Mountain ranges and the valley basin generally trend north-south. Elevations within the valley range from about 5200 feet (1585 m) at the northern end of the study area to about 6600 feet (2012 m) near the southern terminus. Eight mountain ranges bound the valley basin on all but the northern end, which is open to Snake Valley. These ranges include the Limestone Hills, the southern Snake Range and the Manogant, White Rock, Needle, and Wilson Creek mountains on the western side and the Burbank Hills and Needle Range on the eastern side of the study area (Drawing 2). Topographic relief between mountain ridges and basins is greatest along the northwestern valley margin, averaging about 3000 feet (914 m). Drainage is open in the main valley with surface water flowing north into Snake Valley along Hamlin Valley Wash.

3.2 LOCATION AND DESCRIPTION OF GEOLOGIC UNITS

Rocks representing the Paleozoic, Mesozoic, and Cenozoic eras are located within and adjacent to the Valley-Specific area (Drawing 2). These rocks are of various igneous (intrusive and extrusive) metamorphic, and sedimentary lithologies.

Paleozoic sedimentary rocks consist predominantly of thin- to very thick-bedded quartzites, limestones, and dolomites with interbedded sandstone, shale, and siltstone. They occur extensively in the northern portion of the area within the southern Snake Range, northern Needle Range, and Limestone and Burbank hills and as scattered outcrops elsewhere. Intruding Paleozoic rocks at the northern end of Hamlin Valley are Mesozoic granitic intrusives exposed primarily within the southern Snake Range.

Cenozoic rocks where present, unconformably overlie older rocks. They consist of Tertiary granitic intrusives and volcanic rocks (older rocks are possibly late Mesozoic in age) composed of welded and nonwelded tuffs as well as scattered lava flows of basaltic to rhyolitic composition.

Quaternary alluvial deposits lie unconformably above all older units and consist primarily of Late Pliocene to recent alluvial fan, older lacustrine, and stream channel and terrace deposits. These units reach a combined thickness of many hundreds to thousands of feet. Alluvial fan deposits are the most extensive of the exposed Quaternary sediments, forming a nearly continuous apron flanking the mountain fronts.

These geologic units have been grouped into eight rock and three basin-fill geologic units for use in discussing potential aggregate sources. The grouping of these units is based on similarities in physical and chemical characteristics and map scale limitations. The resulting units allow for simplicity of discussion and presentation without altering the conclusions of the study.

3.2.1 Rock Units

Geologic rock units were grouped into the following eight categories (Drawing 2): quartzite (Qtz), limestone (Ls), dolomite (Do), carbonate rocks undifferentiated (Cau), sedimentary rocks undifferentiated (Su), granitic rocks (Gr), basalt (Vb), and volcanic rocks undifferentiated (Vu).

3.2.1.1 Quartzite - Qtz

The Cambrian Prospect Mountain Quartzite crops out extensively in the southern Snake Range. This formation consists of reddish brown to white, thinly to massively bedded, fine grained quartzite with interbeds of less resistant quartzite, micaceous shale, pebble conglomerate, and arkosic sandstone. Diabase dikes and sills of basaltic appearance locally intrude the formations.

Eureka Quartzite crops out in a small unit in the west-central portion of the study area at the southern end of the Limestone Hills (Drawing 2). It is thin, generally less than 500 feet (150 m) thick, and because of its close association with dolomitic rocks (Do) is often mapped with this rock unit. The formation is white or light gray in appearance, vitreous, sugary, fine- to medium-grained, massive orthoquartzite. Sandstone and dolomitic sandstone is exposed at the top and bottom of the formation.

3.2.1.2 Limestone - Ls

Limestone is a carbonate rock which is hard, durable, medium bedded to massive and a major cliff former within the study area. Principal limestone formations are all Paleozoic in age and include the Riepe Springs, Ely, Notch Peak, Marjum and Joanna limestones and the Lower Pogonip Group. The limestones are typically medium to dark gray, fine to medium grained, fossiliferous, and sparsely cherty with well developed bedding and jointing. This unit is mapped chiefly in the southern Snake Range, Burbank Hills, northern Needle Range, and in scattered localities in the southern Needle Range (Drawing 2).

3.2.1.3 Dolomite - Do

Dolomite is a high magnesium carbonate rock that is characteristically hard, dark to medium gray in appearance, medium grained, sparsely to moderately cherty with well developed bedding and jointing. Principal formations that compose the bulk of this unit are the Simonson, Sevy, Fish Haven and Laketown dolomites. These formations crop out primarily in the southernmost section of the Snake Range and the Limestone Hills (Drawing 2).

3.2.1.4 Carbonate Rocks Undifferentiated - Cau

Materials classified as undifferentiated carbonate rocks include thick, complex sequences of limestone and dolomite with thin interbeds of sandstone, siltstone, and shale. Individual units are not delineated separately due to map scale limitations and the highly interbedded nature of these units. Principal formations in this unit include lower Paleozoic limestone and dolomite including the Devonian Guilmette Formation. These cliff-forming rocks are chiefly limestone and are typically light to dark gray in appearance, thin bedded to massive, hard, cherty, fossiliferous, and durable. This unit is primarily exposed in the Burbank Hills, the Northern Needle Range, and the southern Snake Range (Drawing 2).

3.2.1.5 Sedimentary Rocks Undifferentiated - Su

Geologic formations mapped as undifferentiated sedimentary rocks include interbedded sandstone, shale, dolomite, limestone, and quartzite. These deposits are characterized by poorly indurated material and complex, thin to medium bedding. The highly interbedded nature of these units prevents separation into individual rock types (e.g. limestone, dolomite). Undifferentiated sedimentary rocks are exposed in the Burbank Hills, southern Snake Range, and northern Needle Range (Drawing 2).

3.2.1.6 Granitic Rocks - Gr

Large areas of Cretaceous to Tertiary age intrusive granitic rocks are located in the northwestern portion of the study area in the southern Snake Range (Drawing 2). The granites are light gray, medium- to coarse-grained rocks composed of equidimensional quartz, plagioclase, orthoclase and mica grains. The unit is typically massive, poorly jointed and exhibits well-developed spheroidal weathering.

3.2.1.7 Basalt - Vb

Tertiary basalt was identified during the field investigation in the extreme southeastern portion of the study area in the Needle

Range (Drawing 2). This basalt is characteristically dense, dark gray to black, medium to thick bedded, locally vesicular and poorly jointed with scattered interbeds of volcanic agglomerate and pumice.

3.2.1.8 Volcanic Rocks Undifferentiated - Vu

Undifferentiated volcanic rocks comprise extensive deposits in the southern half of the study area (Drawing 2). These rocks are mostly Tertiary units, although they may range in age from Cretaceous to Pliocene. They consist predominantly of welded and nonwelded pyroclastics (air falls, ash flows, ignimbrites) of silicic composition as well as scattered lava flows of basaltic to rhyolitic composition. This unit also includes minor occurrences of interbedded sedimentary rocks consisting of conglomerate, sandstone, and siltstone derived from volcanic sources. Individual rock types have not been delineated because of map scale limitations and cryptic but similar composition. Extensive areas of this unit are exposed throughout the Needle and Wilson Creek ranges, and White Rock and Manogant mountains (Drawing 2).

3.2.2 Basin-Fill Units

Three basin-fill units are mapped and labelled within the study area (Drawing 2). These consist of alluvial fan (Aaf), stream channel and terrace (Aal), and undifferentiated alluvial (Au) deposits. Older lacustrine deposits were mapped during Verification studies as intermixed with or overlain by sediments of Hamlin Valley Wash. These units consist of fine grained silts and clays and are considered unsuitable as aggregate sources and will not be discussed.

3.2.2.1 Alluvial Fan Deposits - Aaf

Alluvial fans bordering the mountain fronts and extending out into the valley basins are the most extensive basin-fill deposit within the study area. They are typically homogeneous to stratified mixtures of boulders, cobbles, gravel, sand, silt, and clay that grade from very coarse-grained material near the rock/alluvium contact to fine-grained material near the valley center. Individual fan units contain poorly to well-graded, angular to subangular particles that exhibit considerable lateral and vertical textural variation. Composition of the surrounding source rock strongly controls the textural properties of material found in alluvial fan deposits. The coarser fan units are characteristically formed at the base of carbonate or quartzitic rock outcrops, whereas fans developed from volcanic source areas tend to be finer grained. Caliche development in soils (Appendix B), a natural process in arid climates, ranges from none in younger fans to Stage III in older fans.

3.2.2.2 Stream Channel and Terrace Deposits - Aal

Stream channel and terrace deposits within the study area are associated with primary and secondary ephemeral streams. Secondary ephemeral streams commonly traverse alluvial fan deposits from the nearby mountain ranges toward the valley axis. There, they join Hamlin Valley Wash, a primary ephemeral drainage system, that flows northward into Snake Valley. Most of these deposits are too small to be depicted on Drawing 2 and have been grouped with adjacent, more prominent units (i.e., alluvial fan, undifferentiated alluvium). These deposits range from homogeneous to poorly stratified mixtures of boulders, cobbles, gravel, sand, silt, and clay.

3.2.2.3 Alluvial Deposits Undifferentiated - Au

Undifferentiated alluvial deposits consist of combinations of basin-fill units that were not delineated and mapped during the Verification program. Included in this group are alluvial fan, older lacustrine, and stream channel and terrace deposits. These units are homogeneous to stratified mixtures of boulders, cobbles, gravel, sand, silt, and clay derived from a wide range of rock types. Composition varies according to the characteristics of the individual units and the source rock type. Undifferentiated alluvial deposits are generally located near the valley axis of the entire study area (Drawing 2).

4.0 POTENTIAL AGGREGATE SOURCES

Based on the results of field visual observations and aggregate testing, potential basin-fill and rock sources were divided into three basic material types (i.e., coarse, fine, and crushed rock) and classified into one of the three use categories (Section 2.5). Basin-fill deposits tested in the study area may be placed within a multiple type category, (coarse and fine aggregate source). Coarse aggregate (gravel to boulders) includes material predominantly retained on the No. 4 sieve (greater than 0.185 in.; 4.75 mm). Fine aggregate (predominantly sand) includes material entirely passing the 3/8 inch sieve (less than 0.375 in.; 9.5 mm) and almost entirely passing the No. 4 sieve.

Classification boundaries (Drawing 2) of basin-fill aggregate sources were generalized and will require additional studies to accurately define their location. Boundaries of identified crushed rock sources are based on the areal map extent of the geologic formations tested (i.e., Eureka Quartzite, Pogonip Group) and not on the aggregate geologic unit (i.e., Qtz, Ls) described in Section 3.2.1.

In the following discussion, the best potential coarse, fine, or crushed rock source within each Class I and Class II category is presented first; followed by sources with successively lower potential. This ranking of deposits is preliminary and based upon an analysis of Fugro National and exisiting data.

4.1 BASIN-FILL SOURCES

4.1.1 Coarse Aggregate

4.1.1.1 Potentially Suitable Concrete Aggregate and Road Base Material Sources - Class I

Extensive Class I coarse aggregate sources are located in the northern end of Hamlin Valley within alluvial fans (Aaf, Aafg, Aafs) and undifferentiated alluvial (Au) deposits that border the southern Snake and northern Needle ranges and the Burbank Hills (Drawing 2). The alluvial units consist predominantly of poorly to moderately well graded medium dense to dense, crudely stratified, sandy gravel or gravelly sand with subangular to subrounded carbonate and quartzitic clasts. Laboratory test data indicate these deposits have acceptable abrasion and soundness values for Class I coarse material (Table 2), but alkali reactivity tests were not performed. Sieve analyses for these samples suggest that the fan deposits are biased toward the fine end and may lack sufficient material in the coarse fraction for crushing. Fine aggregate material comprises as much as 47 percent of the tested deposits. Overburden averages 1 to 3 meters thick and consists predominantly of calichefied gravel (Stage II).

Access to these deposits is provided by Utah State Highway 21 which traverses the area and by numerous unpaved roads. Minability is considered good to excellent in these sources. Additional field reconnaissance and testing will be necessary to accurately define the tentatively delineated sources.

Class I coarse aggregate sources were also identified in alluvial fan (Aafs) and undifferentiated alluvial (Au) deposits west of the Needle Range along the eastern perimeter of Hamlin Valley (Drawing 2). Field observations indicate the deposits consist of medium dense, poorly graded, crudely stratified, gravelly sand or sandy gravel with gravel comprising as much as 56 percent of the examined units. The coarse fraction of these sources passed the soundness and abrasion tests for Class I coarse aggregate. Alkali reactivity tests were not performed. Boundaries of these units could not be drawn at this level of investigation. Access and minability of sources within this area are considered excellent.

A Class I coarse aggregate source was identified in a stream channel and terrace deposit (Aals) west of the central Needle Range within Hamlin Valley Wash (Drawing 2). This deposit passed abrasion and soundness requirements for a Class I source, however, an alkali reactivity test was not performed. Boundaries of this unit could not be drawn due to the limited nature of the field investigation and will require further field studies to accurately define. Access and minability are considered excellent for this source.

Additional sources of Class I coarse aggregate may be located within alluvial fans near the rock/alluvium contact of Class I or possibly Class II carbonate or quartzitic rock units bordering the valley basin.

4.1.1.2 Possibly Unsuitable Concrete Aggregate Potentially Suitable Road-Base Material Sources - Class II

No Class II coarse aggregate sources were identified in the Hamlin Valley study area from laboratory test results. However, based on field observations, Class II coarse material is present in alluvial fans (Aaf, Aafs) near the rock/alluvium contact of nearly all mountain ranges. Access and minability will vary but should generally be good.

4.1.1.3 Unsuitable Concrete Aggregate or Road-Base Material Sources - Class III

No unsuitable coarse aggregate sources were identified in the Hamlin Valley, Valley-Specific study area.

4.1.2 Fine Aggregate

4.1.2.1 Potentially Suitable Concrete Aggregate and Road-Base Material Sources - Class I

Class I fine aggregate sources were identified in undifferentiated alluvial deposits (Au) bordering the western flank of the Burbank Hills (Drawing 2). These deposits consist of medium dense, moderately well graded, crudely stratified, gravelly sand or sandy gravel with gravels comprising from 44 to 51 percent of the material. Abrasion and soundness tests for one of the coarse fractions passed Class I requirements and test results for both the fine fractions are within Class I standards. Alkalai reactivity tests were not performed on these sources. The high percentage of acceptable gravel makes these deposits potentially excellent multiple sources (Section 4.1.1.2). Overburden consists of less than 1 meter of slightly calichified soil. Good access to these deposits is provided by Utah State

Highway 21 which traverses the area and the minability is considered excellent. Boundaries of this Class I fine aggregate source could not be delimited at this level of investigation.

Based on field observations, other potential Class I fine aggregate sources may exist in alluvial fans or undifferentiated alluvium located adjacent to Class I crushed rock sources.

4.1.2.2 Possibly Unsuitable Concrete Aggregate/Potentially Suitable Road-Base Materials Sources - Class II

Class II fine aggregates were identified within alluvial fan (Aafs) and undifferentiated alluvial (Au) deposits west of the Needle Range and in alluvial fan deposits (Aafs) bordering the Limestone Hills in the central portion of Hamlin Valley (Drawing 2). These deposits are poorly to moderately well graded, lenticular to crudely stratified, medium dense to dense, gravelly sands and sandy gravels with gravels ranging from 15 to 56 percent of the tested units (multiple type sources). Gravel clasts consist predominantly of carbonate rocks with some intermediate volcanic rocks. Where tested the coarse fractions passed requirements for Class I coarse aggregate (Section 4.1.1.1). Soundness tests for the fine fractions were excessively high resulting in a Class II ranking. Alkali reactivity tests have not been performed on either the fine or coarse fractions of these potential sources. Due to the scope of this investigation, boundaries of the fine aggregate sources could not be delineated and will require further field studies for accurate location.

Based on field observations additional Class II fine aggregate sources may be available from most Class I and Class II basin-fill areas on Drawing 2.

4.1.2.3 Unsuitable Concrete Aggregate or Road-Base Material Cources - Class III

Class III fine aggregate sources generally coincide with the distribution of stream channel deposits of the Hamlin Valley Wash drainage system (Drawing 2). These sediments are typically composed of interbedded and stratified to cross-bedded, loose to moderately dense fine sand and soft to moderately stiff silt, and clay.

4.2 CRUSHED ROCK SOURCES

4.2.1 Potentially Suitable Concrete Aggregate and Road-Base Material Sources - Class I

Class I crushed rock sources are distributed predominantly in the northern half of the study area within the Limestone and Burbank hills, and southern Snake and northern Needle ranges. These deposits consist of undifferentiated carbonate rocks from the Guilmette Formation (Cau), the Simonson and Sevy dolomites (Do), and the Ely Limestone (Ls).

The Guilmette Formation (Cau) crops out in the Burbank Hills and the southern Snake and northern Needle ranges (Drawing 2). The formation consists primarily of moderately hard to har', dark gray to grayish-black limestones that are predominantly thick bedded and have favorable splitting characteristics for crushing. Field observations and limited laboratory testing (Appendix A) indicate that abrasion, soundness, and alkali reactivity tests are within Class I crushed rock aggregate requirements (Table 2). Access to this source is generally good and the minability should be excellent.

The Simonson and Sevy dolomites (Do) crop out in the Limestone Hills (Drawing 2) and consist primarily of dolomites and limestones, with thin interbeds of shale, and sedimentary breccia. Splitting characteristics of the dolomites are favorable for crushing and both abrasion and soundness tests indicate these units are within Class I standards for crushed rock aggregate. No alkali reactivity tests were run on these units, however, potential deleterious reactions may result from chert observed during field reconnaissance. Access to this unit is good to excellent and minability is generally considered good to very good.

Limited laboratory tests on the Ely Limestone (Ls) located within the Burbank Hills and northern Needle Range at the north end of the valley (Drawing 2), indicate that abrasion and soundness losses are well within Class I standards (Table 2). However, the formation contains scattered chert nodules, which may prove deleterious when alkali reactivity tests are made on this unit. Field observations indicate the formation is typically very hard, fine-grained, thick bedded and has favorable splitting characteristics for crushing. This unit has very good to excellent access and minability.

Tertiary basalt (Vb) which crops out in the southeastern portion of the study area within the Needle Range is a hard, dark, rock that weathers to a light, reddish brown color. Abrasion and soundness losses are within Class I requirements and field observations indicate splitting characteristics are favorable for crushing. Due to the presence of volcanic glass, alkali reactivity tests should be performed before conclusions regarding acceptability can be made. Access and minability are good.

Undifferentiated volcanic rock (Vu) was identified as a Class I crushed rock aggregate source in the Needle Range on the southeastern side of the study area (Drawing 2). Although boundaries could not be drawn due to lateral and vertical lithologic variations (see Section 4.2.2), acceptable abrasion and soundness test results indicate that volcanic rocks of this composition could make potentially suitable crushed rock sources in areas where boundaries can be defined. Alkali reactivity tests will be necessary for this source due to the presence of large quantities of volcanic glass. Field observations indicate splitting characteristics are favorable for crushing and access and minability are good.

4.2.2 Possibly Unsuitable Concrete Aggregate/Potentially Suitable Road-Base Material - Class II

A Class II crushed rock aggregate source was identified from laboratory tests of undifferentiated volcanic rocks (Vu) from the Needle Range within the central and southern half of the study area (Drawing 2). Based on field visual observations, extensive areas of similar volcanic lithology were identified throughout the southern half of the valley in the Wilson Creek and Needle ranges, and the White Rock, Needle, and Manogant mountains as well as a small area of the Snake Range. Rock samples are moderately hard, passing the abrasion tests but have excessively high soundness losses resulting in the Class II ranking. The one sample tested for alkali reactivity proved potentially deleterious. Because of its highly variable lithologic nature further examination and laboratory testing may result in defining areas of Class I or III material within this unit. Therefore, specific boundaries of this source could not be drawn and will require additional field reconnaissance and testing for delineation.

All other rock units indicated on Drawing 2 as Class II crushed rock sources were classified only by field visual observations. Paleozoic quartzite (Qtz), carbonate rocks (Cau, Ls), undifferentiated sedimentary rocks (Su), Tertiary undifferentiated volcanic rocks (Vu), and granite (Gr) compose the predominant rock types in this classification.

4.2.3 Unsuitable Concrete Aggregate or Road-Base Material Sources - Class III

No Class III crushed rock aggregate sources were identified within the Hamlin Valley study area during this investigation.

5.0 CONCLUSIONS

Results of the Valley-Specific aggregate investigation indicate that potentially good to high quality (Classes I and II) basin-fill and crushed rock aggregate sources are present within the Hamlin Valley-Specific area to meet construction requirements of the MX system (Drawing 2).

5.1 POTENTIAL BASIN-FILL AGGREGATE SOURCES

5.1.1 Coarse Aggregate

Major Class I coarse aggregate deposits listed in order of potential suitability, have been identified within the following areas:

a. Extensive alluvial fan deposits (Aaf, Aafs, Aafg) and undifferentiated alluvial (Au) deposits adjacent to the southern Snake and northern Needle ranges and the Burbank Hills in the northern portion of the study area.

b. Alluvial fan (Aaf) and undifferentiated alluvial (Au) deposits west of the Needle Range.

Field observations indicate additional sources of Class I coarse aggregate may be available in alluvial fan deposits adjacent to the rock/alluvium contact of Class I and/or Class II crushed rock sources.

Based on field observation, potential suitable Class II coarse aggregate sources are widespread and extensive in the study area. Although boundaries of specific deposits could not be delineated, they are typically located within alluvial fans (Aaf, Aafs) flanking Class I and/or Class II rock sources.

5.1.2 Fine Aggregate

While most coarse aggregate sources will supply quantities of fine aggregate either from the natural deposits or during processing, several fine aggregate sources were sampled and tested. Class I fine aggregate sources were identified within an undifferentiated alluvial unit (Au) west of the Burbank Hills.

Further field reconnaissance will be required to identify and delineate additional Class I fine aggregate sources, however, based on field observations, potential sources may exist in alluvial fan units derived from Class I and/or Class II rock sources.

Potential Class II fine aggregate sources are widespread and extensive throughout the study area. Specific boundaries could not be delineated but typically occur in alluvial fan (Aaf, Aafs) and undifferentiated alluvial (Au) deposits basinward of most Class I and Class II rock exposures.

5.2 POTENTIAL CRUSHED ROCK AGGREGATE SOURCES

Class I crushed rock sources exist in several sections of the study area. The most suitable deposits and their corresponding locations are as follows:

a. Guilmette Formation (Cau) - Northern Hamlin Valley study area (southern Snake and northern Needle ranges, and the Burbank Hills)

b. Simonson and Sevy dolomites (Do) - West-central Hamlin Valley study area Limestone Hills)

c. Ely limestone (Ls) - Northeastern Hamlin Valley study area (Burbank Hills and northern Needle Range)

d. Tertiary Basalt (Vb) - Southeastern Hamlin Valley study area (southern Needle Range)

Extensive carbonate (Cau, Do, Ls) Class I crushed rock sources, exposed within the southern Snake Range, Limestone Hills, and Burbank Hills because of their close proximity to the valley basin and good to excellent minability, could provide crushed rock material for much of the study area.

Undifferentiated volcanic rocks, limestone, granite, and undifferentiated carbonate and sedimentary rocks, which are widely distributed throughout the study area compose most of the Class II crushed rock sources classified by field visual observations and delineated on Drawing 2.

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APPENDIX A

Fugro National Field Station and Supplementary Test Data and Existing Test Data Summary Tables - Hamlin Valley

EXPLANATION OF FUGRO NATIONAL FIELD STATION AND SUPPLEMENTARY TEST DATA

Fugro National field stations were established at locations throughout the Valley-Specific study area where detailed descriptions of potential basin-fill or rock aggregate sources were recorded (Drawing 1). All field observations and laboratory test data on samples collected at selected stations are presented in Table A-1. Data entries record conditions at specific field station locations that have been generalized in the text and Drawing 2. Detailed explanations for the column headings in Table A-1 are as follows:

Column Heading	Explanation
Map Number	This sequentially arranged numbering system was established to facilitate the labelling of Fugro National field station locations and existing data sites on Drawing 1 and to list the correlating information on Tables A-1 and A-2 in an orderly arrangement.
Field Station	Fugro National field station data are comprised of information collected during: o The Valley-Specific Aggregate Resources Study; sequentially numbered field stations were completed by two investigative teams (A and B). The Hamlin Valley Candidate Deployment Area (HVCDP) is obsolete. o The general aggregate investigation in Utah (UGS). The general aggregate investigation in Nevada (NV); R and H indicate ground and aerial reconnaissance stops, respectively.
Location	Lists major physiographic or cultural feature in/or near which field stations or existing data sites are situated.
Geologic Unit	Generalized basin-fill or rock geologic units at field station or existing data locations. Thirteen classifications, emphasizing age and lithologic distinctions

Column Heading	Explanation
	were developed from existing geologic maps to accomodate map scale of Drawing 2.
Material Description	Except in cases where soil or rock samples were classified on laboratory results, the descriptions are based on field visual observations utilizing the Unified Soil Classification System (See Appendix C for detailed USCS information).
Field Observations	
Boulders and/or Cobbles, Percent	The estimated percentage of boulders and cobbles is based on an appraisal of the entire deposit. Cobbles have an average diameter between 3 and 12 inches (8 and 30 cm); boulders have an average diameter of 12 inches (30 cm) or more.
Gravel	Particles that will pass a 3-inch (76 mm) and are retained on No. 4 (4.75 mm) sieve.
Sand	Particles passing No. 4 sieve and retained on No. 200 (0.075 mm) sieve.
Fines	Silt or clay, soil particles passing No. 200.
Plasticity (Index)	Plasticity index is the range of water content, expressed as percentage of the weight of the oven-dried soil, through which the soil is plastic. It is defined as the liquid limit minus the plastic limit. Field classification followed standard descriptions and their ranges are as follows: None - Nonplastic (NP) (PI, 0 - 4) Low - Slightly plastic (PI, 4 - 15) Medium - Medium plastic (PI, 15 - 30) High - Highly plastic (PI, > 31)
Hardness	A field test to identify materials that are soft or poorly bonded by estimating their resistance to impact with a rock hammer; classified as either soft, moderately hard, hard, or very hard.
Weathering	Changes in color, texture, strength, chemical composition or other properties of rock outcrops or rock particles due to the action

Column Heading	Explanation
	of weather; field classified as either fresh or slight(ly) moderate(ly) or very weathered.
Deleterious Materials	Substances potentially detrimental to concrete performance that may be present in aggregate; includes organic impurities, low density material, (ash, vesicules, pumice, cinders), amorphous silica (opal, chert, chalcedony), volcanic glass, caliche coatings, clay coatings, mica, gypsum, pyrite, chlorite, and friable materials, also, aggregate that may react chemically or be affected chemically by other external influences.
Laboratory Test Data	
Sieve Analysis (ASTM C 136)	The determination of the proportions of particles lying within certain size ranges in granular material by separation on sieves of different size openings; 3-inch, 1 1/2-inch, 3/4-inch, 3/8-inch, No. 4, No. 8, No. 16, No. 30, No. 50, No. 100 and No. 200.
No. 8, No. 50	Asterisked entries used No. 10 and No. 40 sieves, respectively.
Abrasion Test (ASTM C 131)	A method for testing abrasion resistance of an aggregate by placing a specified amount in a steel drum (the Los Angeles testing machine), rotating it 500 times, and determing the material worn away.
Soundness Test (ASTM C 88) CA, FA	CA = Coarse Aggregate FA = Fine Agregate The testing of aggregates to determine their resistance to disintegration by saturated solutions of magnesium sulfate. It furnishes information helpful in judging the soundness of aggregates subject to weathering action, particularly when adequate information is not available from service records of the material exposed to actual weathering conditions.

Column Heading	Explanation
Specific Gravity and Absorption (ASTM C 127 and 128)	Methods to determine the Bulk Specific Gravity, Bulk SSD Specific Gravity (Saturated - Surface Dry Basis), and Apparent Specific Gravity and Absorption as defined in ASTM E12-70 and ASTM C 125, respectively.
Alkali Reactivity (ASTM C 289)	This method covers chemical determination of the potential reactivity of an aggregate with alkalies in portland cement concrete as indicated by the amount of reaction during 24 hours at 80°C between 1 N sodium hydroxide solution and aggregate that has been crushed and sieved to pass a No. 50 (300- m) sieve and be retained on a No. 100 (150- m) sieve.
Aggregate Use	I = Class I; potentially suitable concrete aggregate and road-base material source. II = Class II; possibly unsuitable concrete aggregate/potentially suitable road-base material source. III = Class III; unsuitable concrete aggregate or road base material source. c = coarse aggregate f = fine aggregate f/c = fine and coarse aggregate cr = crushed rock All sources not specifically identified as Class I, II, or III from the abrasion, soundness, or alkali reactivity tests or the content of clay- and silt-sized particles, are designated as Class II sources.

MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES, PERCENT	DISTR MATER THAN
							GRAVEL
1	HVCDP-A1	Hamlin Valley	Aalg	Gravelly Sand	SP		
2	HVCDP-A2	Hamlin Valley	Aafg	Silty Sand	SM	0	10
3	HVCDP-A3	Hamlin Valley	Su	Conglomerate			
4	HVCDP-A4	Hamlin Valley	Aolg	Sandy Gravel	GP	7	70
5	HVCDP-A5	Hamlin Valley	Aalg	Sandy Gravel	GW		
6	HVCDP-A6	Hamlin Valley	Aafg	Sandy Gravel	GP		
7	HVCDP-A7	Hamlin Valley	Aafs	Silty Sand	SM	0	5
8	HVCDP-A8	Hamlin Valley	Vu	Rhyolite			
9	HVCDP-A9	Hamlin Valley	Aafs	Gravelly Sand	SW		
10	HVCDP-A10	Hamlin Valley	Vu	Volcanic Breccia			
11	HVCDP-A11	Hamlin Valley	Vu	Welded Ashflow			
12	HVCDP-A12	Hamilin Valley	Qtz	Quartzite			
13	HVCDP-A13	Hamlin Valley	Aafs	Gravelly Sand	SW		

	FIELD OBSERVATIONS							SIEVE ANALYSIS, PERCENT PASSING (AST							
	DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT														
PERCENT	GRAVEL	SAND	FINES	PLASTICITY	HARDNESS	WEATHERING	DELETERIOUS MATERIALS	3"	1½"	¾"	⅜"	NO. 4	NO. 8	NO. 16	NO. 30
				None			None	100	100	96.3	77.6	53.9	37.4	23.2	12.6
	10	75	15	Low			None								
					Soft	Slight	5 to 10% Chert, <5% Volcanic Glass, Caliche Coatings								
	[illegible]0	25	5	None			<5% Volcanic Glass								
				None			None	93.2	75.6	60.4	48.5	35.3	27.0	19.4	12.5
				Low			<5% Volcanic Glass	100	87.1	69.7	54.9	43.7	34.9	25.3	15.4
	5	80	15	Low			<5% Volcanic Glass								
					Very Hard	Fresh	<5% Volcanic Glass								
				None			10% Altered Volcanics	100	99.9	98.8	95.0	84.6	71.0	52.6	31.[illegible]
					Soft	Moderate	30 to 50% Low Density Materials								
					Hard	Moderate	<5% Volcanic Glass, 5 to 10% Pumice								
					Very Hard	Fresh	None								
				Low			80% Intermediate Volcanics	100	93.7	88.5	84.3	79.6	73.5	64.7	49.[illegible]

LABORATORY TEST DATA

…G (ASTM C 136)					ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)								ALKALI REACTIVI… (ASTM C …
								COARSE AGGREGATE				FINE AGGREGATE				
								SPECIFIC GRAVITY			PERCENT ABSORPTION	SPECIFIC GRAVITY			PERCENT ABSORPTION	
	NO. 30	NO. 50	NO. 100	NO. 200	PERCENT WEAR	PERCENT LOSS CA	PERCENT LOSS FA	BULK	BULK SSD	APPARENT		BULK	BULK SSD	APPARENT		CA
2	12.6	7.2	4.3	2.2	37.4	8.12	23.96	2.67	2.68	2.70	0.38					
.4	12.5	6.3	3.0	1.6	26.1	12.21		2.48	2.51	2.55	1.18					
3	15.4	7.2	2.2	0.[illegible]	[illegible].9	16.51	41.29									
					43.3	59.16										
6	31.3	16.9	8.3	4.3			44.91									
					46.0	36.58										Potentially Deleterious
7	49.1	32.4	18.4	8.5			26.86									

DEPART…

...ATE ...TY ...AR ...T	PERCENT ABSORPTION	ALKALI REACTIVITY (ASTM C 289) CA	ALKALI REACTIVITY (ASTM C 289) FA	AGGREGATE USE
				IIf Ic
				IIf
				IIcr
				IIc/f
				Ic IIf
				Ic IIf
				IIf
				IIcr
				IIf
				IIcr
		Potentially Deleterious		IIcr
				IIcr
				IIf

FUGRO NATIONAL FIELD STATION
AND SUPPLEMENTARY TEST DATA
HAMLIN VALLEY, NEVADA-UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

TABLE A-1
PAGE 1 OF 3

FUGRO NATIONAL, INC.

MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES, PERCENT	DIST MATE THA
							GRAVEL
14	HVCDP-A14	Hamlin Valley	Aalg	Sandy Gravel	GW/SW		
15	HVCDP-A15	Snake Valley	Aalg	Gravelly Sand	SP		
16	HVCDP-A16	Snake Valley	Aafs	Sandy Gravel	GP		
17	HVCDP-A17	Hamlin Valley	Aafs	Gravelly Sand	GW		
18	HVCDP-A18	Hamlin Valley	Aafg	Sandy Gravel	GP		
19	HVCDP-A19	Hamlin Valley	Aafg	Sandy Gravel	GP		
20	HVCDP-A20	Hamlin Valley	Aafg	Sandy Gravel	GP		
21	HVCDP-A21	Hamlin Valley	Aafg	Gravelly Sand	SP	T	40
22	HVCDP-B1	Hamlin Valley	Ls	Limestone			
23	HVCDP-B2	Snake Range	Vu	Quartz Monzonite			
24	HVCDP-B3	Hamlin Valley	Ls	Limestone			
25	HVCDP-B4	Hamilin Valley	Do	Dolomite			
26	HVCDP-B5	Escalante Desert	Vb	Basalt			

FIELD OBSERVATIONS								SIEVE ANALYSIS, PERCENT PASSING (ASTM							
DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT			PLASTICITY	HARDNESS	WEATHERING	DELETERIOUS MATERIALS									
GRAVEL	SAND	FINES					3"	1½"	¾"	⅜"	NO. 4	NO. 8	NO. 16	NO. 30
			Medium			Caliche Coatings	100	97.2	87.3	72.4	52.3	39.7	30.2	22.1
			None			4% Chert	100	99.0	91.7	77.3	59.9	45.4	32.6	22.1
			None			Caliche Coatings	100	96.7	86.1	66.1	49.3	40.4	35.7	30.5
			None			Caliche Coatings	100	94.9	86.8	71.4	56.5	49.6	45.0	40.6
			None			Caliche Coatings	100	89.3	70.2	48.0	32.5	26.0	21.9	19.4
			None			None	100	100	95.9	71.9	37.7	21.2	15.9	13.1
			None			Caliche Coatings	100	98.6	78.1	51.5	34.0	22.1	15.4	11.6
40	60	T	None											
				Very Hard	Slight	<5% Chert								
				Hard	Slight	None								
				Hard	Slight	None								
				Hard	Slight	None								
				Very Hard	Slight	Vesicular								

2

LABORATORY TEST DATA

(ASTM C 136)				ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)								ALKALI REACTIVITY (ASTM C 289)	
							COARSE AGGREGATE				FINE AGGREGATE					
							SPECIFIC GRAVITY			PERCENT ABSORPTION	SPECIFIC GRAVITY			PERCENT ABSORPTION		
NO. 30	NO. 50	NO. 100	NO. 200	PERCENT WEAR	PERCENT LOSS CA	PERCENT LOSS FA	BULK	BULK SSD	APPARENT		BULK	BULK SSD	APPARENT		CA	FA
2.1	14.2	7.0	3.2	30.3	15.59	27.15	2.61	2.67	2.78	2.40						
2.1	12.6	5.7	2.8	29.8	8.89	21.59	2.50	2.56	2.65	2.28						
0.5	20.7	7.5	1.7			12.28					2.42	2.48	2.56	2.15		
0.6	32.2	14.4	2.6	24.2	9.30	12.24	2.58	2.62	2.69	1.54						
9.4	17.4	11.9	3.2	31.2	3.17		2.74	2.76	2.82	1.16						
3.1	11.3	8.8	4.8	23.0	14.73											
1.6	8.9	5.8	2.9	26.5	3.61		2.73	2.75	2.80	0.83						
				25.8	6.42											
				37.9	15.75										Innocuous	
				23.4	10.08										Innocuous	
				26.2	7.76		2.49	2.52	2.57	1.27						

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ABSORPTION	ALKALI REACTIVITY (ASTM C 289)		AGGREGATE USE
	CA	FA	
			Ic IIf
			IIf Ic
5			IIc If
			If/c
			Ic IIf
			Ic IIf
			Ic IIf
			IIf/c
			Icr
			IIcr
	Innocuous		Icr
	Innocuous		Icr
			Icr

FUGRO NATIONAL FIELD STATION
AND SUPPLEMENTARY TEST DATA
HAMLIN VALLEY, NEVADA-UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

TABLE A-1
PAGE 2 OF 3

FUGRO NATIONAL, INC.

4

MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES, PERCENT	DIST MATE THA
							GRAVEL
27	HVCDP-B6	Hamlin Valley	Vu	Rhyolite-Dacite			
28	HVCDP-B7	Hamlin Valley	Do	Dolomite			
29	UGS-A47	Hamlin Valley	Do	Limestone			
30	UGS-A68	Escalante Desert	Vu	Dacite			
31	UGS-A91	Snake Valley	Cau	Limestone			
32	UGS-A92	Snake Valley	Qtz	Quartzite			
33	NV-H-20	Snake Range	Cau	Limestone			

FIELD OBSERVATIONS								SIEVE ANALYSIS, PERCENT PASSING (A							
AND/OR COBBLES, PERCENT	DISTRIBUTION OF MATERIAL FINER THAN COBBLES, PERCENT: GRAVEL	SAND	FINES	PLASTICITY	HARDNESS	WEATHERING	DELETERIOUS MATERIALS	3"	1½"	¾"	⅜"	NO. 4	NO. 8	NO. 16	N 3
					Hard	Slight	5 to 10% Volcanic Glass								
					Hard	Slight	<5% Chert								
					Mod. Hard	Moderate	<5% Chert								
					Mod. Hard	Moderate	None								
					Hard	Moderate	<5% Chert								
					Very Hard	Fresh	None								

LABORATORY TEST DATA

...NG (ASTM C 136)					ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		SPECIFIC GRAVITY AND ABSORPTION (ASTM C 127 AND C 128)								ALKAL... REACTIV... (ASTM C ...
								COARSE AGGREGATE				FINE AGGREGATE				
								SPECIFIC GRAVITY			PERCENT ABSORPTION	SPECIFIC GRAVITY			PERCENT ABSORPTION	
...	NO. 30	NO. 50	NO. 100	NO. 200	PERCENT WEAR	PERCENT LOSS CA	PERCENT LOSS FA	BULK	BULK SSD	APPAR-ENT		BULK	BULK SSD	APPAR-ENT		CA
					27.4	11.67		2.40	2.44	2.53	2.13					
					24.1	2.03		2.89	2.89	2.89	0.03					
					16.4	5.9										

DEPART...

3

GATE TY PAR- NT	GATE PERCENT ABSORPTION	ALKALI REACTIVITY (ASTM C 289) CA	ALKALI REACTIVITY (ASTM C 289) FA	AGGREGATE USE
				Icr
				Icr
				IIcr
				IIcr
				IIcr
				IIcr
				Icr

FUGRO NATIONAL FIELD STATION AND SUPPLEMENTARY TEST DATA
HAMLIN VALLEY, NEVADA-UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

TABLE A-1
PAGE 3 OF 3

FUGRO NATIONAL, INC.

EXPLANATION OF EXISTING DATA

Existing data pertaining to aggregates were extracted from the Utah State Department of Highways' Materials Inventory county reports. These reports are compilations of avaiable site data from existing files and records and are intended to accurately locate, investigate, and catalog materials needed for highway construction. Explanations for column headings which appear in Table A-2, that have not been previously discussed in Table A-1, are given below:

Column Heading	Explanation
Site Number	Utah State Department of Highways pit or site number. Locations correspond to map numbers listed on this table and placed on Drawing 2.
Material Description USCS Symbol	To maintain conformity within the study, the Utah State Department of Highways classification system (A.A.S.H.O.) was converted to the Unified Soil Classification System (USCS) utilizing the sieve analyses' size distribution and the plasticity indices.
Sieve Analysis	The size distribution of fine and coarse aggregate samples was determined by sieving. In some samples, particles greater than 1 inch in size (>1 inch) were crushed to 1 inch maximum size and remixed with the remaining sample before sieving. In these cases, data entries under 1 inch are 100 percent, preceeded by before crushing percentages.
No. 10, No. 40	Samples tested after mid-1963 used No. 8 and No. 50 sieves, respectively. These entries are marked with asterisks.
Soundness Test	The testing of aggregates to determine their resistance to disintegration by saturated solutions of sodium sulfate. It furnishes information helpful in judging the soundness of aggregates subject to weathering action,

Column Heading	Explanation
Soundness Test (cont.)	particularly when adequate information is not available from service records of the material exposed to actual weathering conditions.

MAP NUMBER	SITE NUMBER	DATA SOURCE	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION
34	14114	USDH Millard County	Garrison	Aals	Silty Sand
35	14115	USDH Millard County	Big Wash	Aals	Sandy Gravel
36	14116	USDH Millard County	Burbank Hills	Aals	Sandy Gravel
37	14117	USDH Millard County	Burbank Hills	Aals	Sand Gravel
38	14118	USDH Millard County	Burbank Hills	Aafs	Gravelly Sand
39	14119	USDH Millard County	Snake Valley	Aals	Sandy Gravel
40	14120	USDH Millard County	Snake Valley	Aals	Sandy Gravel

USCS SYMBOL	SIEVE ANALYSIS: BEFORE CRUSHING, PERCENT		PERCENT PASSING AFTER CRUSHING TO 1" MAXIMUM SIZE						ABRASION TEST (ASTM C 131)	SOUNDNESS TEST (ASTM C 88)		PLASTICITY INDEX (ASTM D 423 and D 424)
	>3"	>1"	1"	½"	NO. 4	NO. 10	NO. 40	NO. 200	PERCENT WEAR	PERCENT LOSS CA	PERCENT LOSS FA	
SM						66.9	58.6	27.9				1.9
GP-GM	0	29.6	100		44.9	29.2	15.8	7.9	23.8			NP
GP-GM	0	22.1	100		36.6	26.3	15.9	7.7	22.2			NP
GP-GM	0	9.7	100		49.6	38.1	24.1	5.8	19.0			NP
SP-SM	6.3	24.9	100		55.2	46.4	35.8	6.3	21.4			NP
GC-GM	0	20.3	100		48.2	34.7	23.6	10.0	19.7			8.6
GP-GM	0	9.0	100		54.6	41.3	30.3	12.7	18.8			NP

EXISTING TEST DATA
HAMLIN VALLEY, NEVADA-UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

TABLE A-2
PAGE 1 OF 1

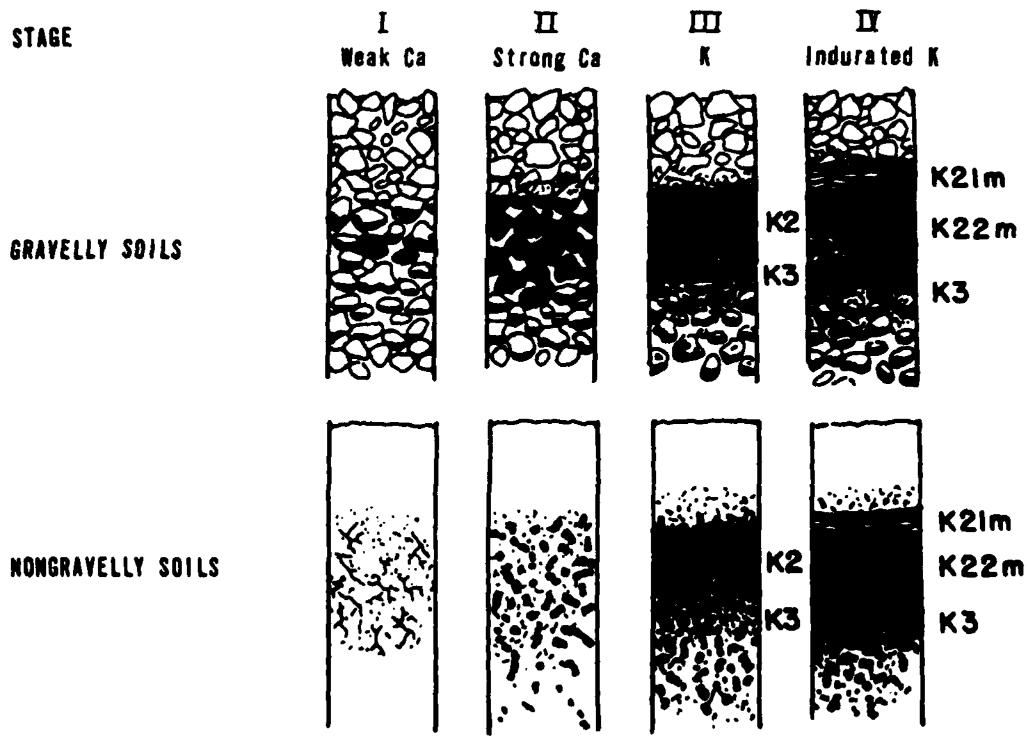
FUGRO NATIONAL, INC.

APPENDIX B

Summary of Caliche Development

DIAGNOSTIC CARBONATE MORPHOLOGY

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	Laminar horizon overlying plugged horizon



Stages of development of a caliche profile with time. Stage I represents incipient carbonate accumulation, followed by continuous build-up of carbonate until, in Stage IV, the soil is completely plugged.

SUMMARY OF CALICHE DEVELOPMENT

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

FIGURE B-1

FUGRO NATIONAL, INC.

Reference: Gile, L.H. Peterson, F.F., and Grossman, R.B., 1965, The K horizon: A master horizon of carbonate accumulation: Soil Science, v. 99, p. 74-82.

APPENDIX C

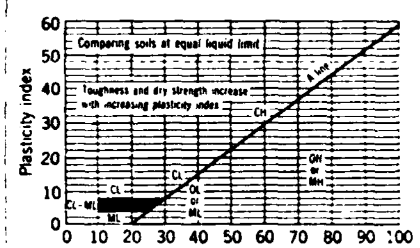
Unified Soil Classification System

Major Divisions		Field Identification Procedures (Excluding particles larger than 3 in. and basing fractions on estimated weights)	Group Symbols [a]	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria
Coarse-grained soils. More than half of material is *larger* than No. 200 sieve size[b] (The No. 200 sieve size is about the smallest particle visible to naked eye). Gravels: More than half of coarse fraction is larger than No. 4 sieve size (For visual classification, the ¼ in. size may be used as equivalent to the No. 4 sieve size)	Clean gravels (little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	*GW*	Well graded gravels, gravel-sand mixtures, little or no fines	Give typical name; indicate approximate percentages of sand and gravel; maximum size, angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbols in parentheses	$C_U = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
	Clean gravels	Predominantly one size or a range of sizes with some intermediate sizes missing	*GP*	Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for *GW*
	Gravels with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures see *ML* below)	*GM*	Silty gravels, poorly graded gravel-sand-silt mixtures	For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics	Atterberg limits below "A" line, or *PI* less than 4 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
	Gravels with fines	Plastic fines (for identification procedures, see *CL* below)	*GC*	Clayey gravels, poorly graded gravel-sand-clay mixtures		Atterberg limits above "A" line, with *PI* greater than 7
Sands: More than half of coarse fraction is smaller than No. 4 sieve size	Clean sands (little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes	*SW*	Well graded sands, gravelly sands, little or no fines	Example: *Silty sand*, gravelly; about 20% hard, angular gravel particles ½-in. maximum size; rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength; well compacted and moist in place; *alluvial sand*; (*SM*)	$C_U = \frac{D_{60}}{D_{10}}$ Greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
	Clean sands	Predominantly one size or a range of sizes with some intermediate sizes missing	*SP*	Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for *SW*
	Sands with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures, see *ML* below)	*SM*	Silty sands, poorly graded sand-silt mixtures		Atterberg limits below "A" line or *PI* less than 5 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
	Sands with fines	Plastic fines (for identification procedures, see *CL* below)	*SC*	Clayey sands, poorly graded sand-clay mixtures		Atterberg limits below "A" line with *PI* greater than 7

Laboratory classification criteria (all coarse-grained soils): Use grain size curve in identifying the fractions as given under field identification. Determine percentages of gravel and sand from grain size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse grained soils are classified as follows: Less than 5% *GW, GP, SW, SP*; More than 12% *GM, GC, SM, SC*; 5% to 12% *Borderline* cases requiring use of dual symbols.

Identification Procedures on Fraction Smaller than No. 40 Sieve Size

Major Divisions		Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)	Group Symbols	Typical Names	Information Required for Describing Soils
Fine-grained soils. More than half of material is *smaller* than No. 200 sieve size (The No. 200 sieve size is about the smallest particle visible to naked eye)	Silts and clays liquid limit less than 50	None to slight	Quick to slow	None	*ML*	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses
		Medium to high	None to very slow	Medium	*CL*	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions
		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	Example: *Clayey silt*, brown; slightly plastic; *small percentage of fine sand*; numerous vertical root holes; firm and dry in place; loess; (*ML*)
		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	



Plasticity chart for laboratory classification of fine grained soils

From Wagner, 1957.

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

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

Field Identification Procedure for Fine Grained Soils or Fractions

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

Dilatancy (Reaction to shaking):

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

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

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

Dry Strength (Crushing characteristics):

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

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

Toughness (Consistency near plastic limit):

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

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

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

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

UNIFIED SOIL CLASSIFICATION SYSTEM

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

TABLE C-1

FUGRO NATIONAL, INC.

APPENDIX D

Hamlin Valley
Study Area Photographs

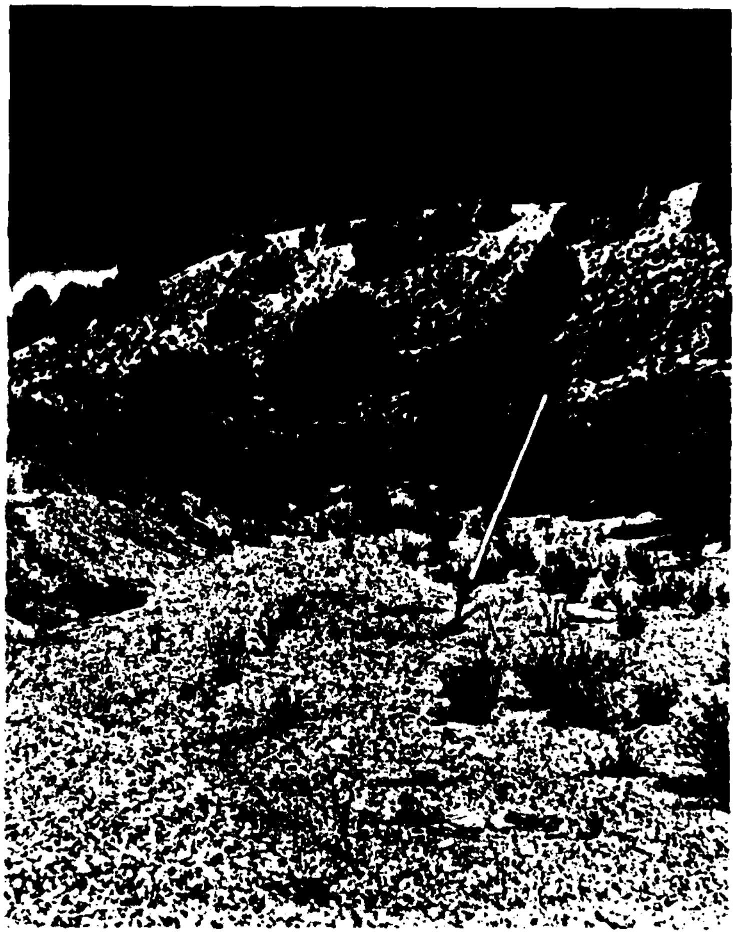
Alluvial Fan Deposit (Aaf) exposed in northeastern Hamlin Valley; Class I coarse and fine (multiple) aggregate source (Station 17).

HAMLIN VALLEY
STUDY AREA PHOTOGRAPH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

FIGURE
D-1

FUGRO NATIONAL, INC.



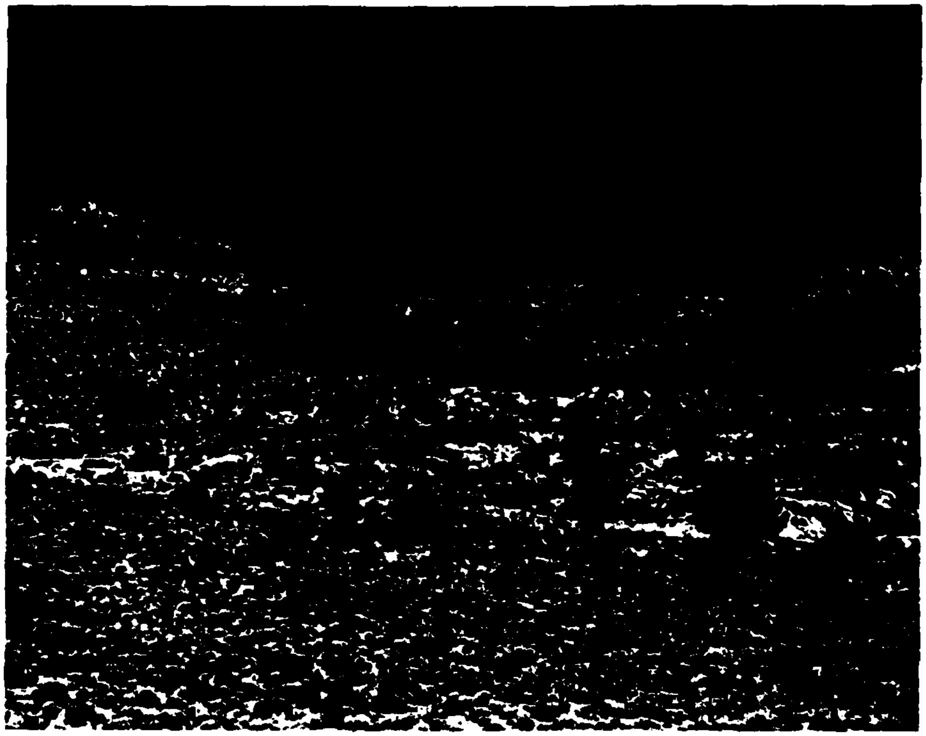
Stream Channel Deposit (Aal) located in southern Hamlin Valley; Class I coarse aggregate source (Station 1).

HAMLIN VALLEY
STUDY AREA PHOTOGRAPH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

FIGURE D-2

FUGRO NATIONAL, INC.



Limestone of the Guilmette Formation exposed in the southern Snake Range; Class I crushed rock aggregate source (Station 24).

HAMLIN VALLEY STUDY AREA PHOTOGRAPH	
MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - BMO	FIGURE D-3

FUGRO NATIONAL, INC.

Simonson Dolomite (Do) exposed in the Limestone Hills between the Snake and Wilson Creek Ranges; Class I crushed rock aggregate source (Station 28).

HAMLIN VALLEY
STUDY AREA PHOTOGRAPH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

FIGURE
D-4

FUGRO NATIONAL, INC.

APPENDIX E

Fugro National Geologic Unit Cross Reference

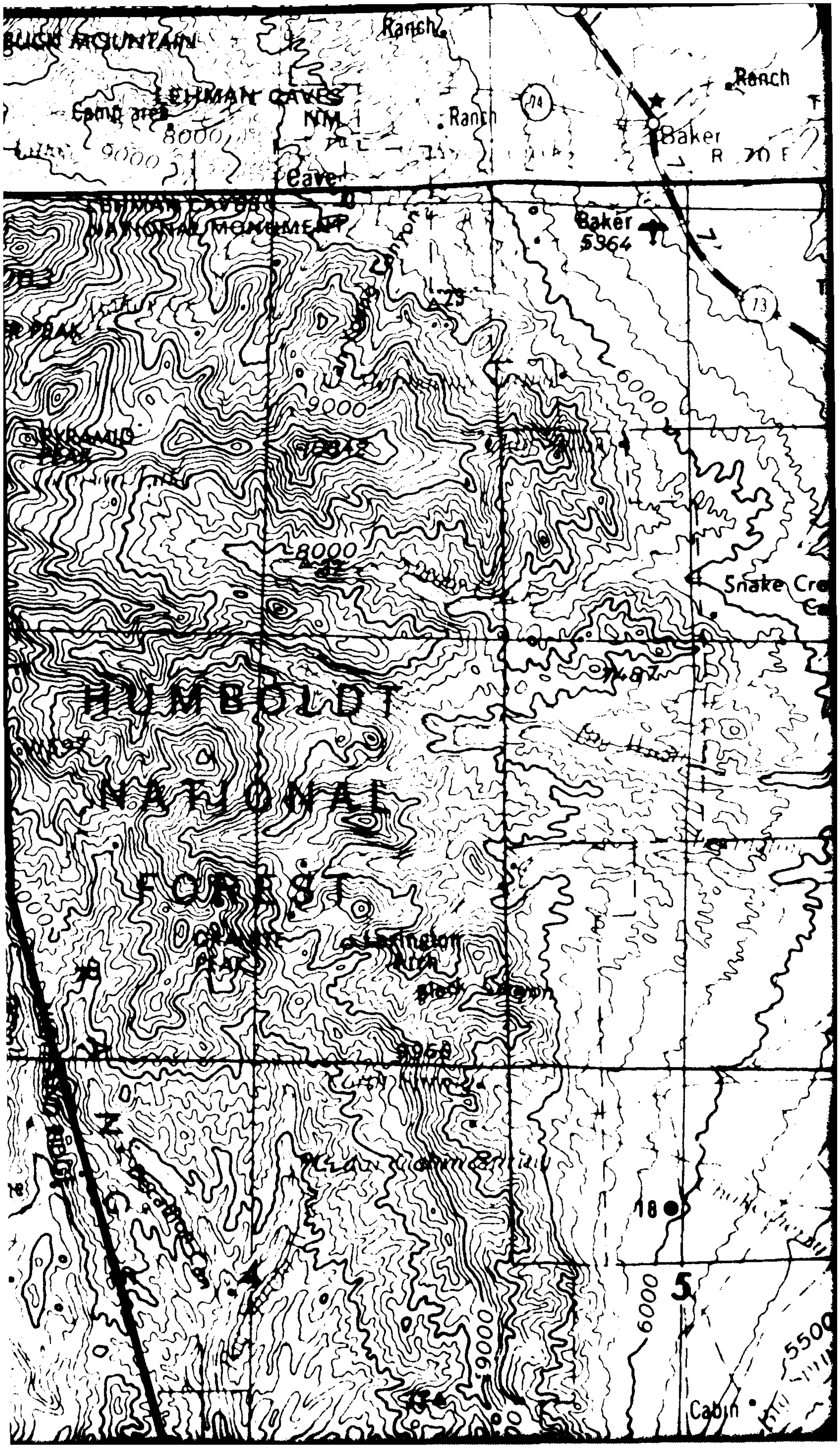
UARSA POTENTIAL AGGREGATE SOURCE SYMBOLS	FUGRO NATIONAL GENERAL GEOLOGIC UNIT EXPLANATION	
		ROCK
		Shown in regions where rock is exposed, the areally predominant (greater than 70 percent) rock type is indicated. In those areas where two rock types occur the predominant rock type is shown followed by the subordinate rock type (e.g. $S_{1}/_{I_4}$). Rock may be subdivided into bedrock (B).
	I	IGNEOUS (UNDIFFERENTIATED) Rocks formed by solidification of a molten or partially molten mass
Gr	I_1	Intrusive. Plutonic rocks formed by solidification of molten material beneath the surface (e.g. granite, granodiorite, diorite, gabbro)
Vu	I_2	Extrusive (intermediate and acidic). Volcanic rocks of intermediate and acidic composition formed by solidification of molten material at or near the surface (e.g. rhyolite, latite, dacite, andesite)
Vb	I_3	Extrusive (basic). Volcanic rocks of basic composition generally formed by solidification of molten materials at or near the surface (e.g. basalt)
Vu	I_4	Extrusive (pyroclastic). Rocks formed by accumulation of volcanic ejecta (e.g. ash, tuff, welded tuff, agglomerate)
Su	S	SEDIMENTARY (UNDIFFERENTIATED) Rocks formed by accumulation of clastic solids, organic solids and/or chemically precipitated minerals
Su, QTz	S_1	Arenaceous and/or Siliceous Rocks. Composed of sand size particles (e.g. sandstone, orthoquartzite) or of cryptocrystalline silica (e.g. opal, chert)
Ls, Do, Cau	S_2	Carbonate Rocks. Composed predominantly of calcium carbonate detritus or chemical precipitates (e.g. limestone, dolomite, chalk
	S_3	Argillaceous Rocks. Composed of clay and silt-sized particles (e.g. siltstone, shale, claystone)
	S_4	Evaporite Rocks. Precipitated from solution as a result of evaporation (e.g., halite, gypsum, anhydrite, sylvite)
Su	S_5	Coarse Clastic Rocks. Composed of gravel-sized or larger clasts (e.g. conglomerate, breccia)
Mu	M	METAMORPHIC (UNDIFFERENTIATED) Rocks formed through recrystallization in the solid state of preexisting rocks by heat and pressure
Mu	M_1	Coarse grained, rocks formed by higher-grade regional metamorphism, either banded or granular (e.g. gneiss, granulite, amphibolite)
Mu	M_2	Fine grained, schistose rocks formed by lower grade regional metamorphism, e.g. schist, slate, phyllite
Mu	M_3	Nonfoliated, rocks formed chiefly by contact metamorphism, e.g. hornfels, marble
QTz	M_4	Metaquartzite, rocks formed by metamorphism of highly siliceous rocks
		BASIN-FILL
	A	BASIN-FILL DEPOSITS. Fine- to coarse-grained materials deposited principally by wind, water or gravity
Aal	A_1	Younger Fluvial Deposits. Major modern stream channel and flood-plain deposits
Au, Aal	A_2	Older Fluvial Deposits. Older incised stream channel and flood-plain deposits in elevated terraces bordering major modern drainages
Au	A_3	Eolian Deposits. Wind-blown deposits of sand occurring as either thin sheets (A_{3s}) or dunes (A_{3d})
Aol	A_4	Playa and Lacustrine Deposits. Deposits occurring in modern, active playas (A_4) or in either inactive playas or older lake beds and abandoned shorelines associated with extinct lakes (A_{4o})
Aaf	A_5	Alluvial Fan Deposits. Alluvial deposits consisting of debris flow and water-laid alluvium near mountain fronts, grading into predominantly water-laid alluvium deposited in shifting distributary channels near the basin center. Younger (A_{5y}), intermediate (A_{5i}) and older (A_{5o}) alluvial fans are differentiated by surface soil development, terrain conditions and present depositional/drainage environment
Au	A_5/A_3	Mixed non-rock units. Most areally extensive unit is listed first
Aaf	A_{5y} (A_{5i})	Parenthetic unit underlies thin veneer of overlying mapped unit

FUGRO NATIONAL GEOLOGIC UNIT CROSS REFERENCE

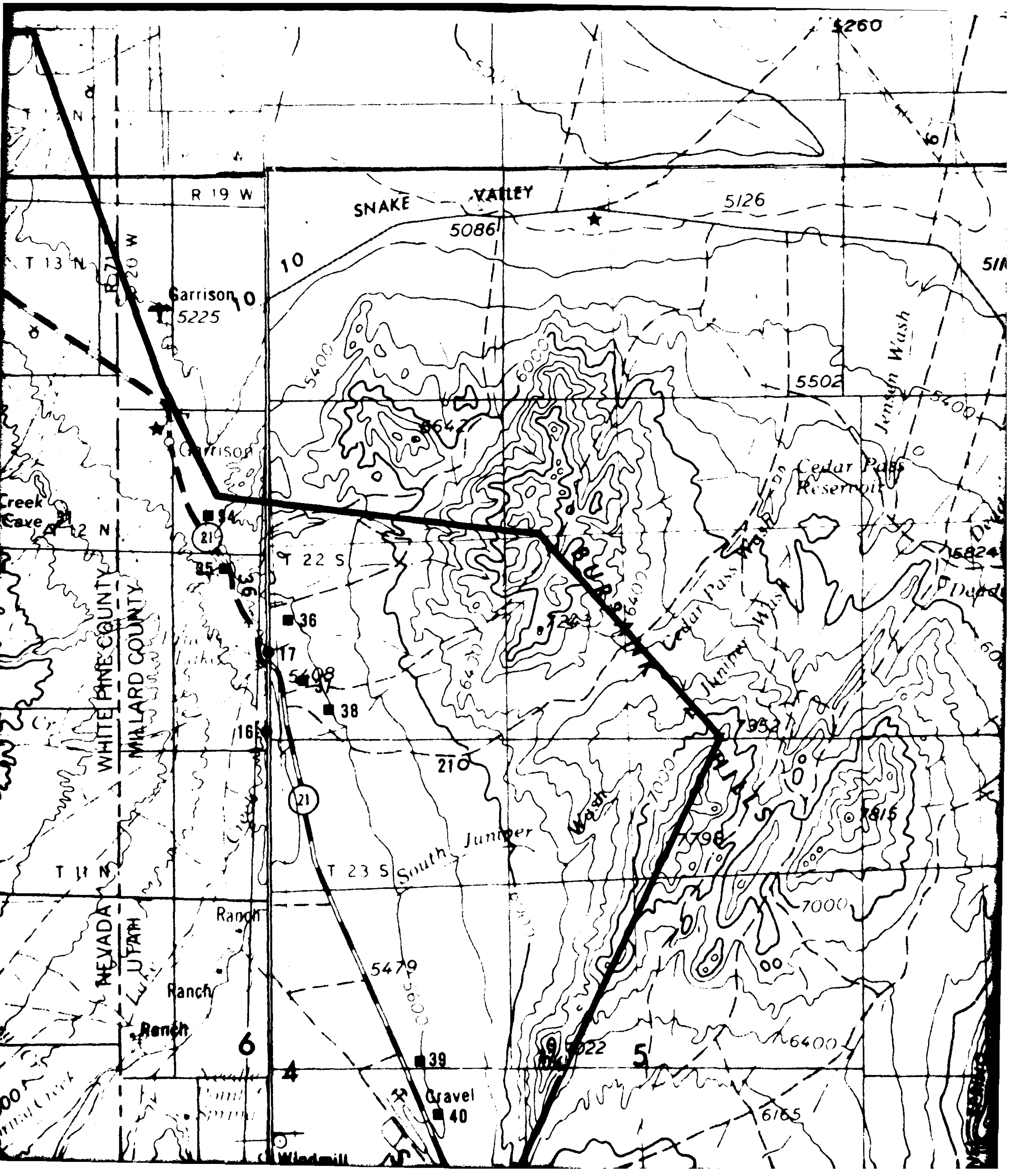
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

FIGURE
E-1

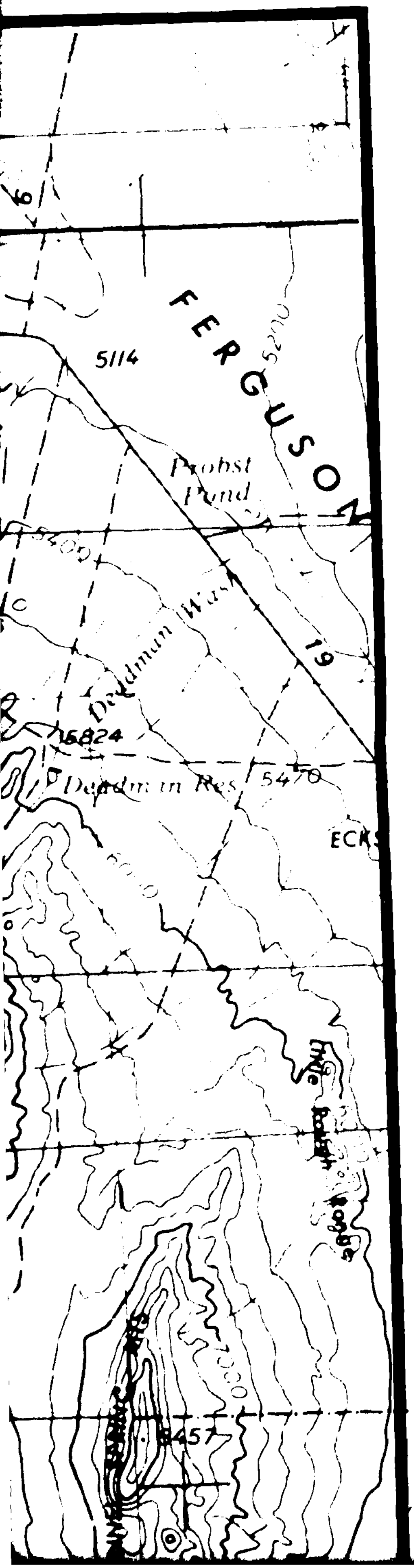
FUGRO NATIONAL, INC.



BUCK MOUNTAIN
Ranch
LEHMAN CAVES
NM
Camp area
Ranch
Baker
Ranch
8000
9000
Cave
LEHMAN CAVES
NATIONAL MONUMENT
Baker
5364
74
73
6000
9000
8000
PYRAMID
PEAK
Snake Cr
HUMBOLDT
NATIONAL
FOREST
Arch
18
5
6000
5500
9000
Cabin



5260
SNAKE VALLEY
5126
5086
R 19 W
T 13 N
R 20 W
10
Garrison
5225
5400
6000
5502
Jensen Wash
Cedar Pass Reservoir
Cedar Pass Wash
Juniper Wash
Creek Cave
34
21
T 22 S
35
36
17
5408
37
38
16
WHITE PINE COUNTY
MILLARD COUNTY
210
7352
7000
7815
South Juniper Wash
T 23 S
T 11 N
NEVADA
UTAH
Ranch
Ranch
Ranch
5479
6400
6
4
5
39
Gravel
40
6165
Windmill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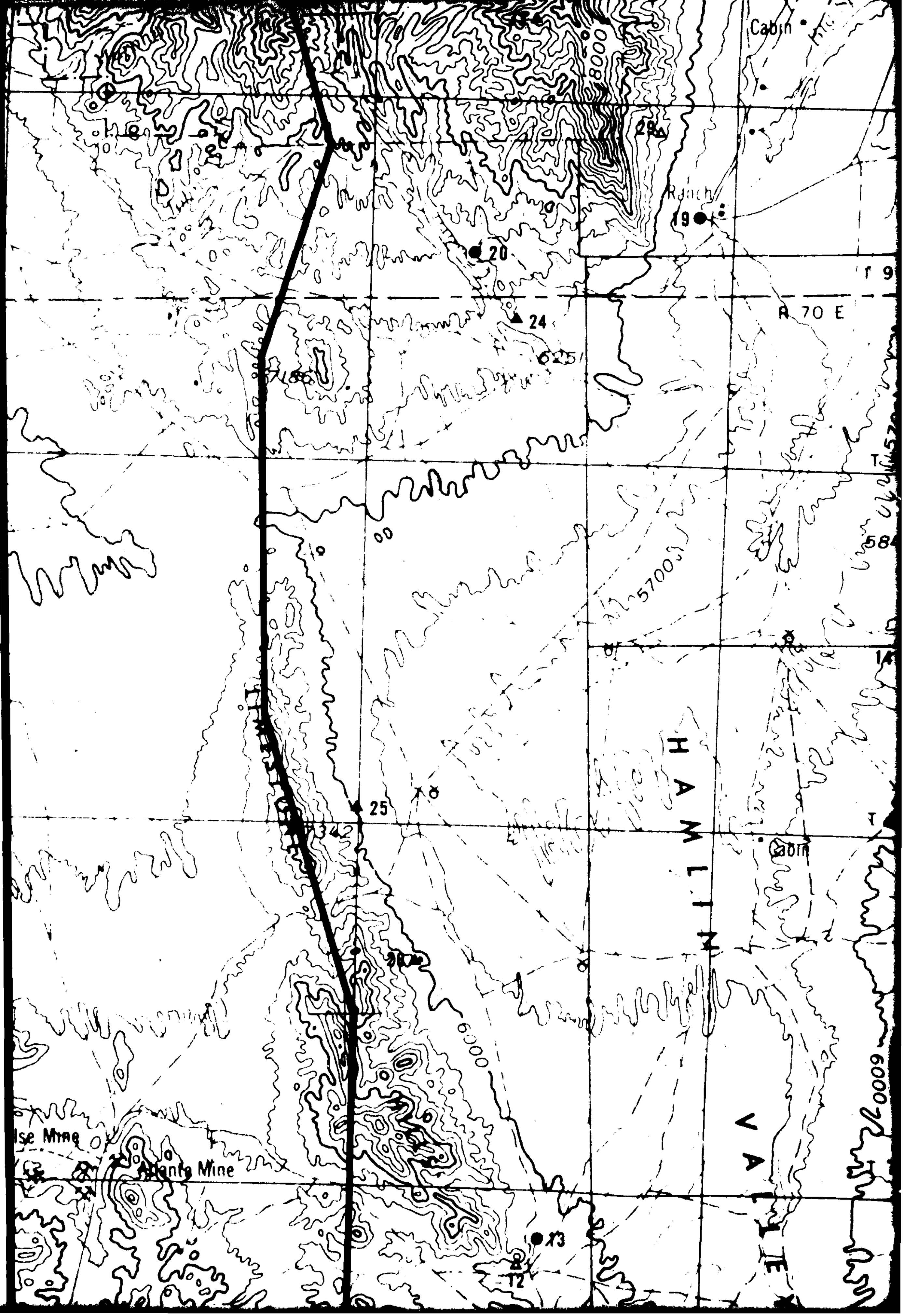
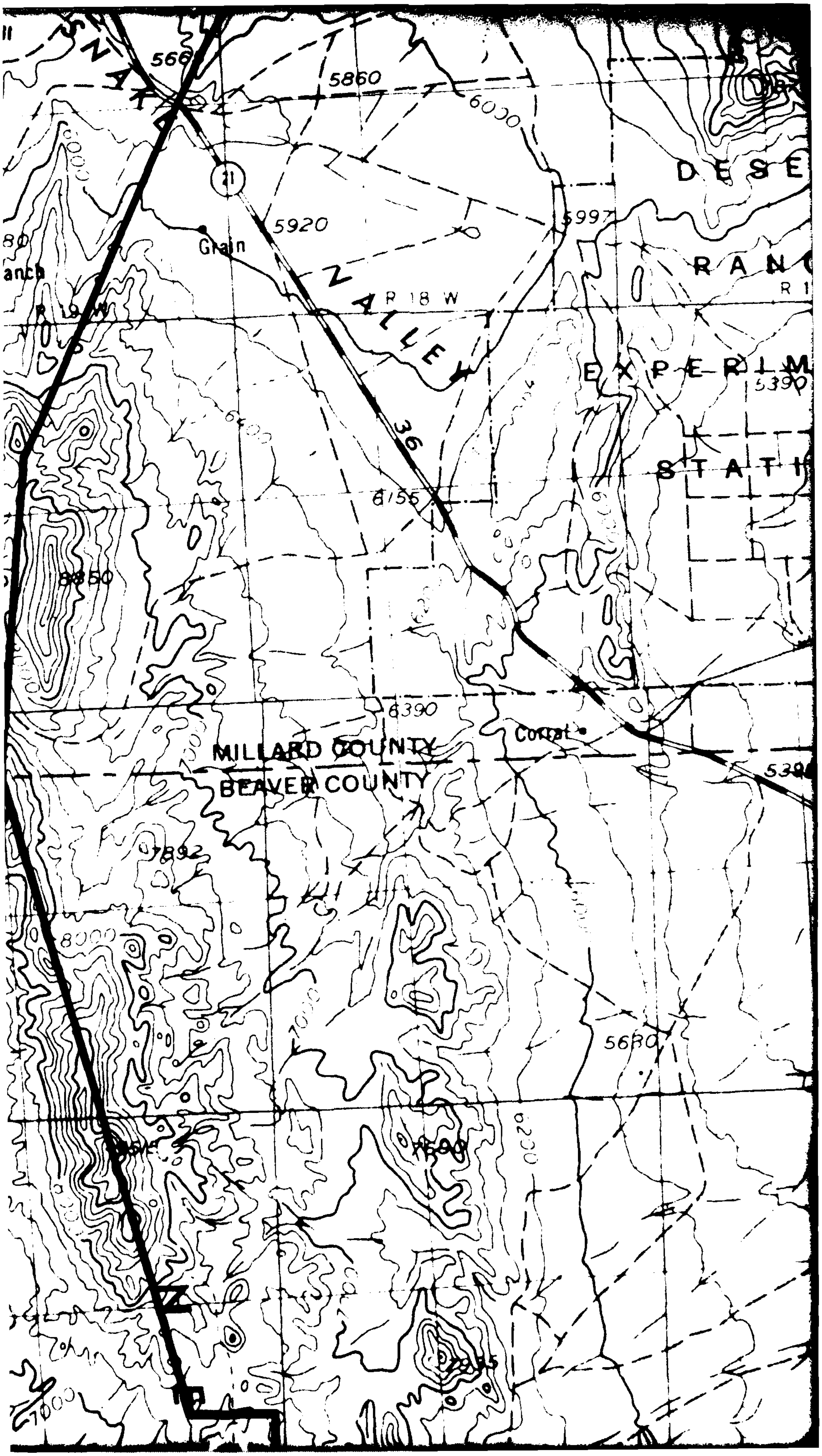
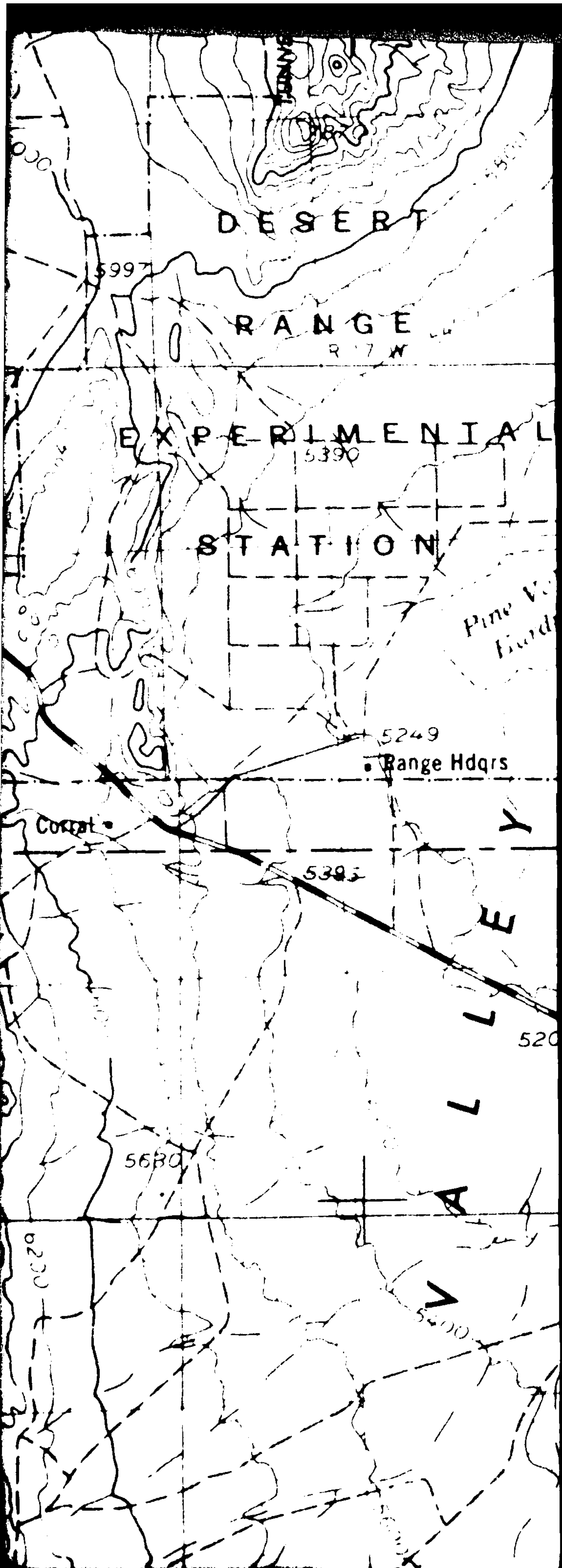
5200
Probst
Pond
Deadman Wash
19
5824
Deadman Res
5470
ECKS
6457

4


Cabin
28
Ranch
19
20
T 9
R 70 E
24
6251
7186
5700
584
H A M L I N
V A L L E Y
25
7342
Cabin
6000
6000
Else Mine
Atlanta Mine
13
12



5860
6000
D E S E
21
5920
Grain
5997
R A N
anch
R 18 W
R 19 W
N A L L E Y
E X P E R I M
5390
36
S T A T I
6155
8850
6390
Corral
MILLARD COUNTY
BEAVER COUNTY
7892
8000
5680
6200
7000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EXPERIMENTAL
STATION
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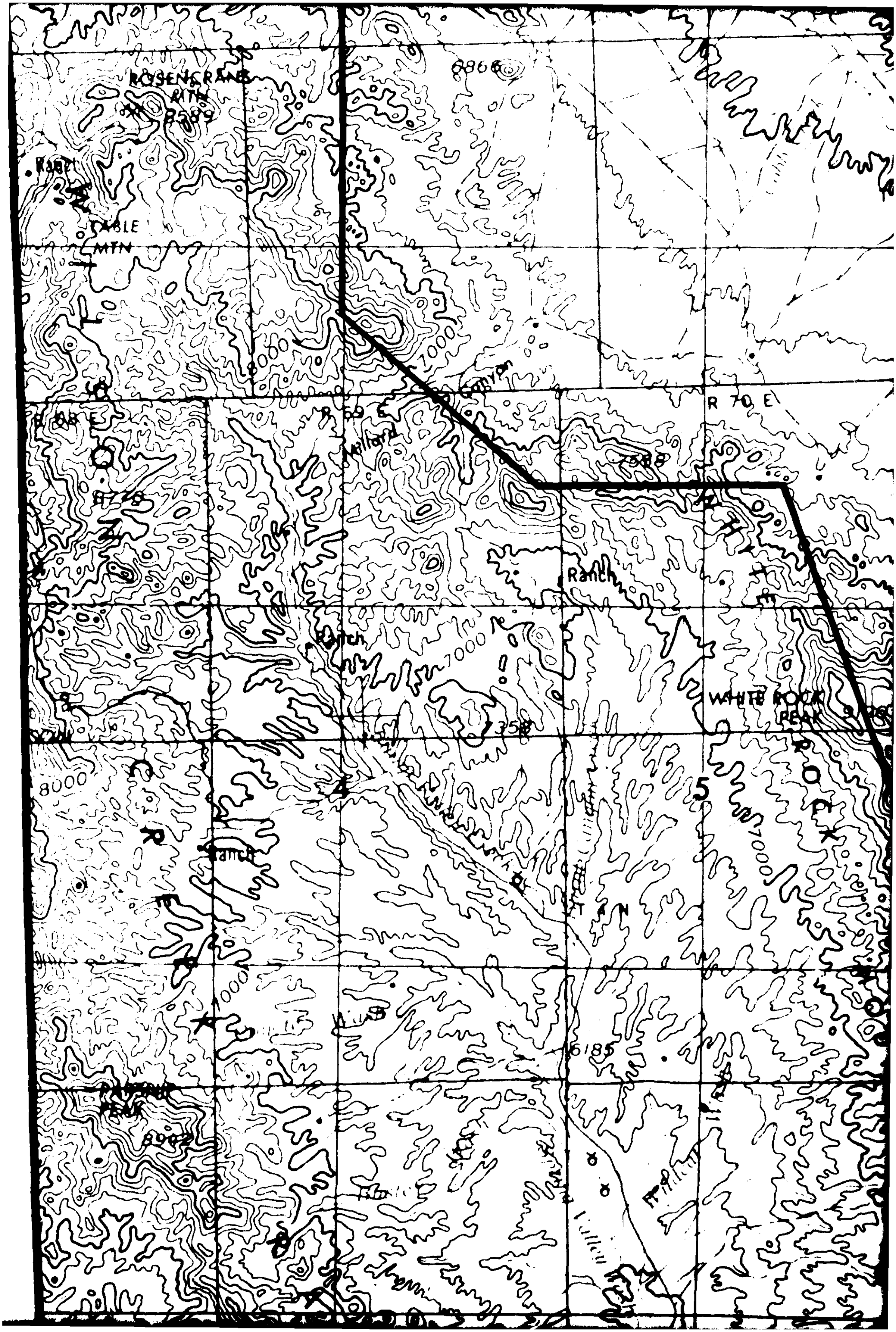
5249
Range Hdqrs
Corral
VALLEY
5680

6



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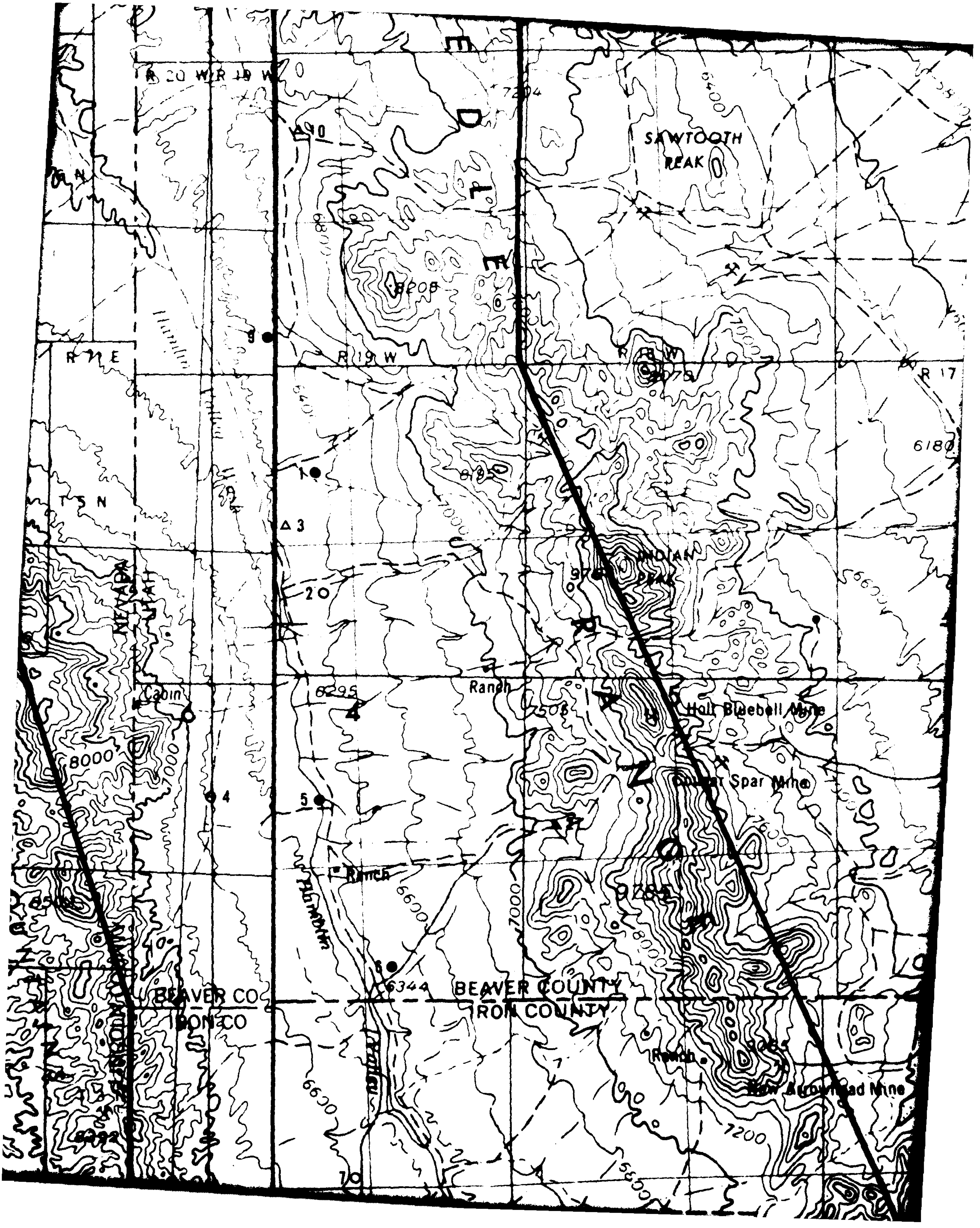
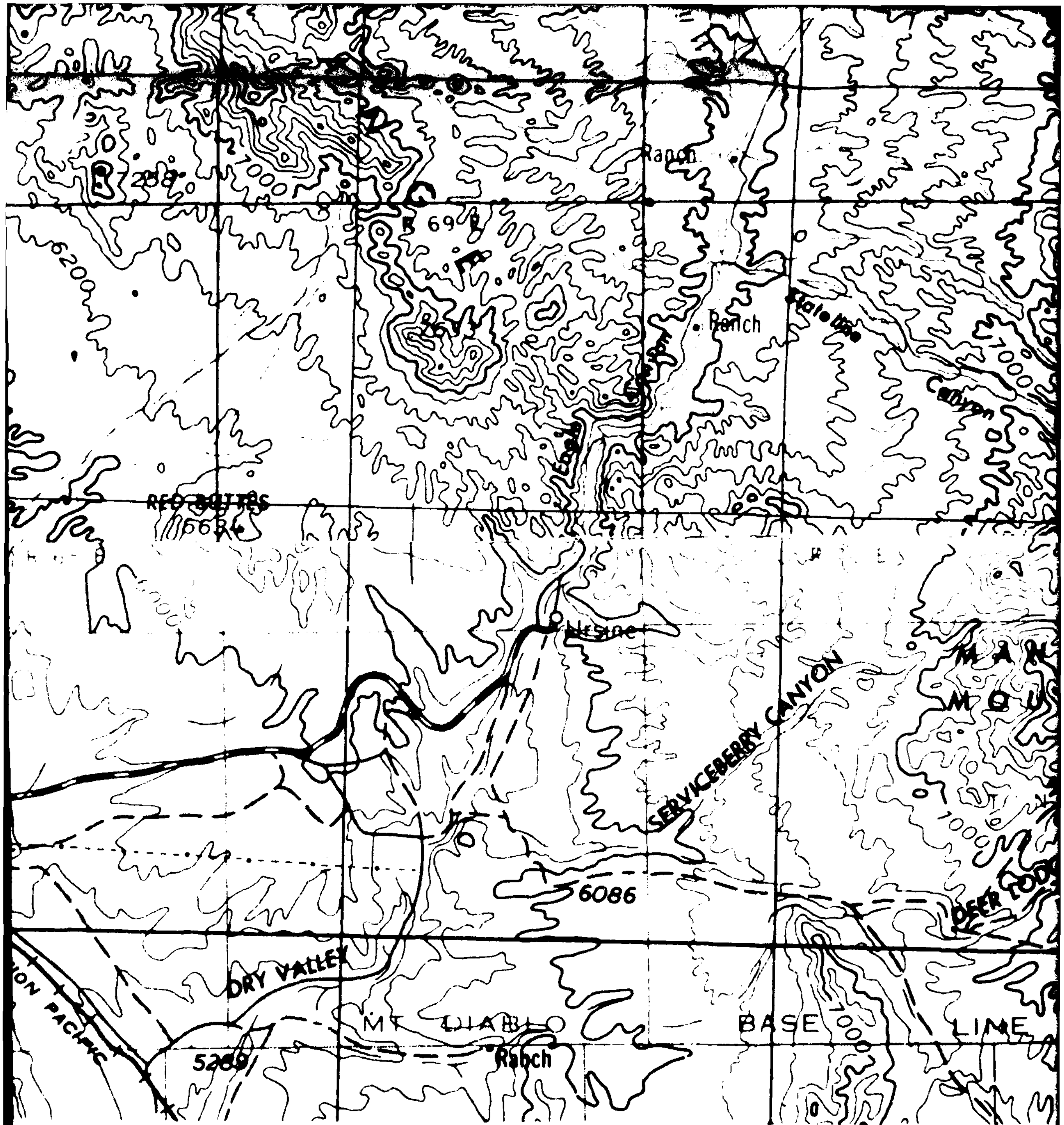
8866
TABLE MTN
Canyon
R 68 E
R 69 E
R 70 E
Willard
7588
Ranch
Ranch
7000
7000
WHITE ROCK PEAK
7358
8000
5
7000
Ranch
6185
8962


SAWTOOTH PEAK
INDIAN PEAK
Holt Bluebell Mine
Spar Mine
Arrowhead Mine
BEAVER COUNTY
IRON COUNTY
BEAVER CO
IRON CO
NEVADA
UTAH
Cabin
Ranch
R 19 W
R 18 W
R 17
R 20 W
T 5 N
6180
8000
7000
6600
7200
6295
6344

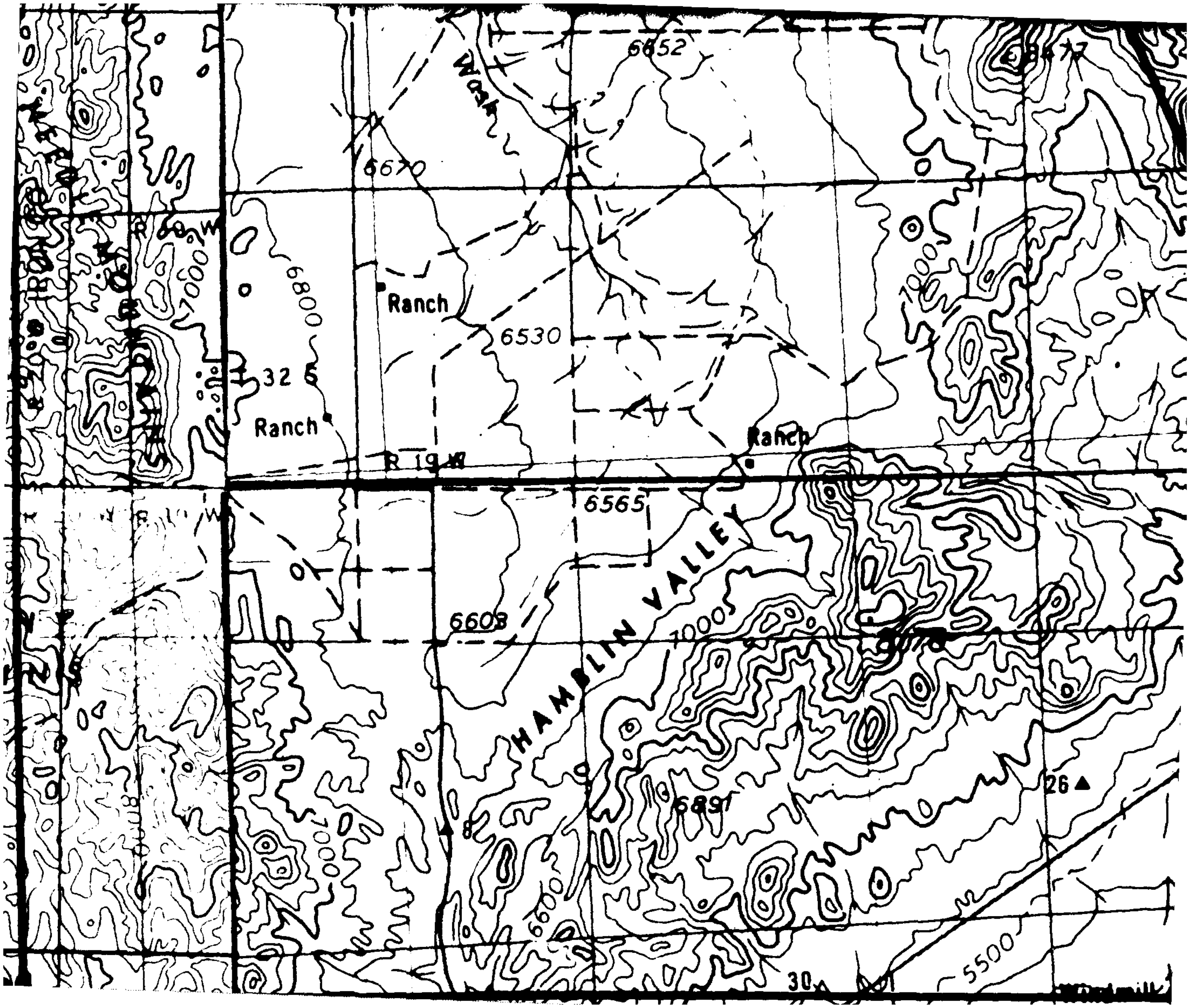
9



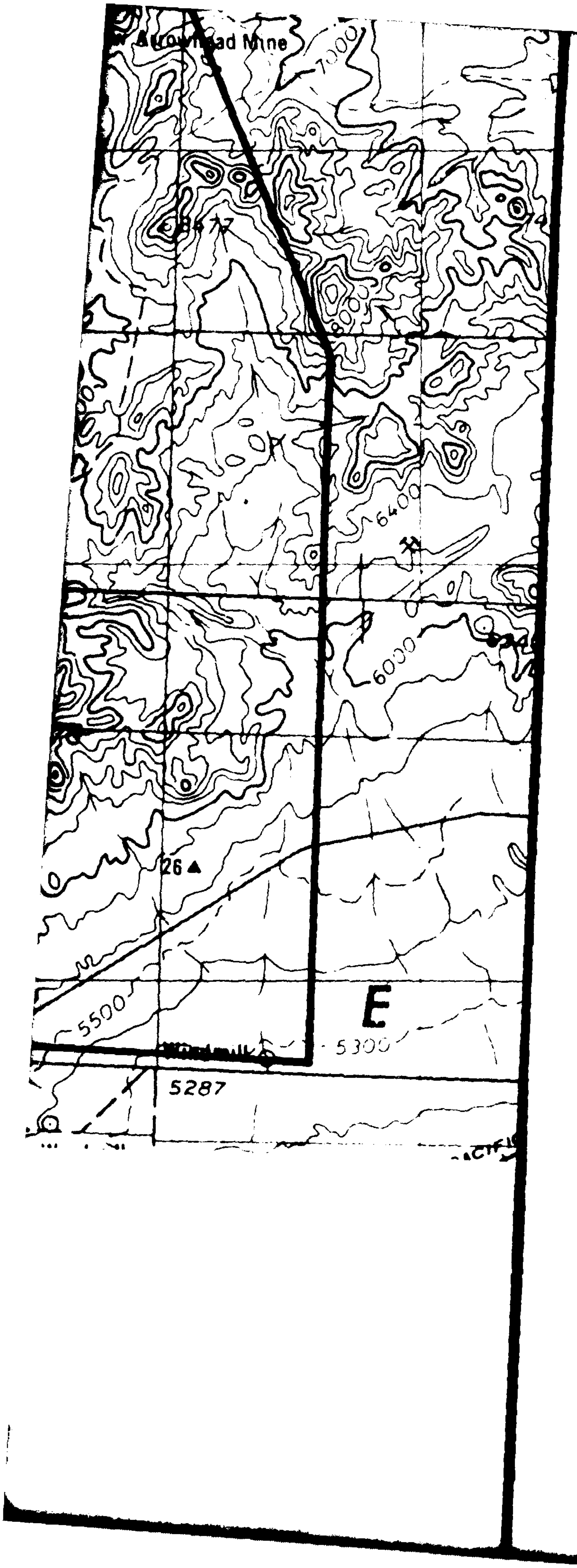
EXPLANATION

FUGRO NATIONAL FIELD STATIONS

BASIN-FILL U"ITS	(Potential Coarse and/or Fine Aggregates)
●	Data Stop, Sampled and Tested
○	Data Stop
ROCK UNITS	(Potential Crushed Rock Aggregates)


6652
6670
Wash
Ranch
6800
6530
7000
T 32 S
Ranch
R 19 W
Ranch
6565
HAMBLIN VALLEY
6603
7000
6891
26
8
7000
6600
5500
30
Windmill

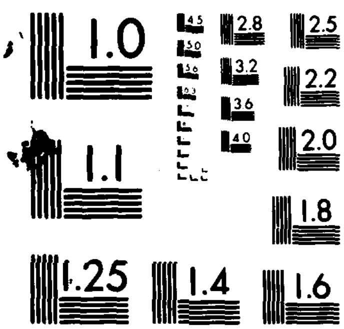
12



AD-A112 405 FUGRO NATIONAL INC LONG BEACH CA F/G 8/7
MX SITING INVESTIGATION. GEOTECHNICAL EVALUATION. AGGREGATE RES--ETC(U)
JUN 80 F04704-80-C-0006
UNCLASSIFIED FN-TR-37-D NL

2 2

END



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

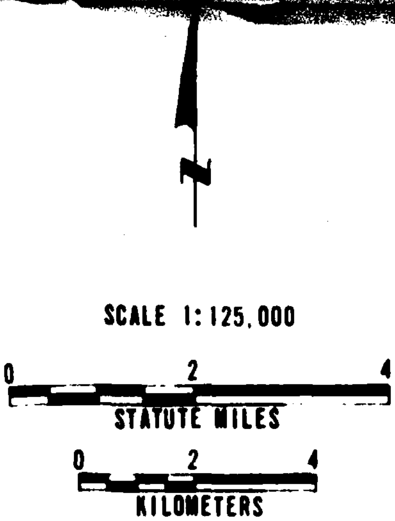
●	Data Stop, Sampled and Tested
○	Data Stop

<u>ROCK UNITS</u>	(Potential Crushed Rock Aggregates)
▲	Data Stop, Sampled and Tested
△	Data Stop

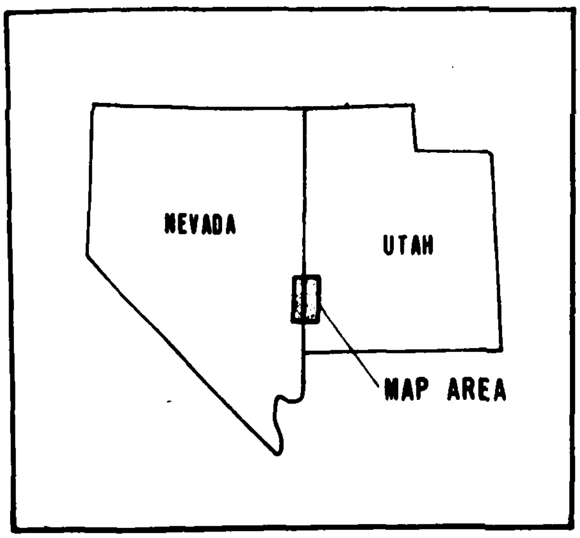
<u>EXISTING TEST DATA SITES</u>

■	Test Data Available

Note: See Corresponding Map Number in Appendix A for Detailed Information



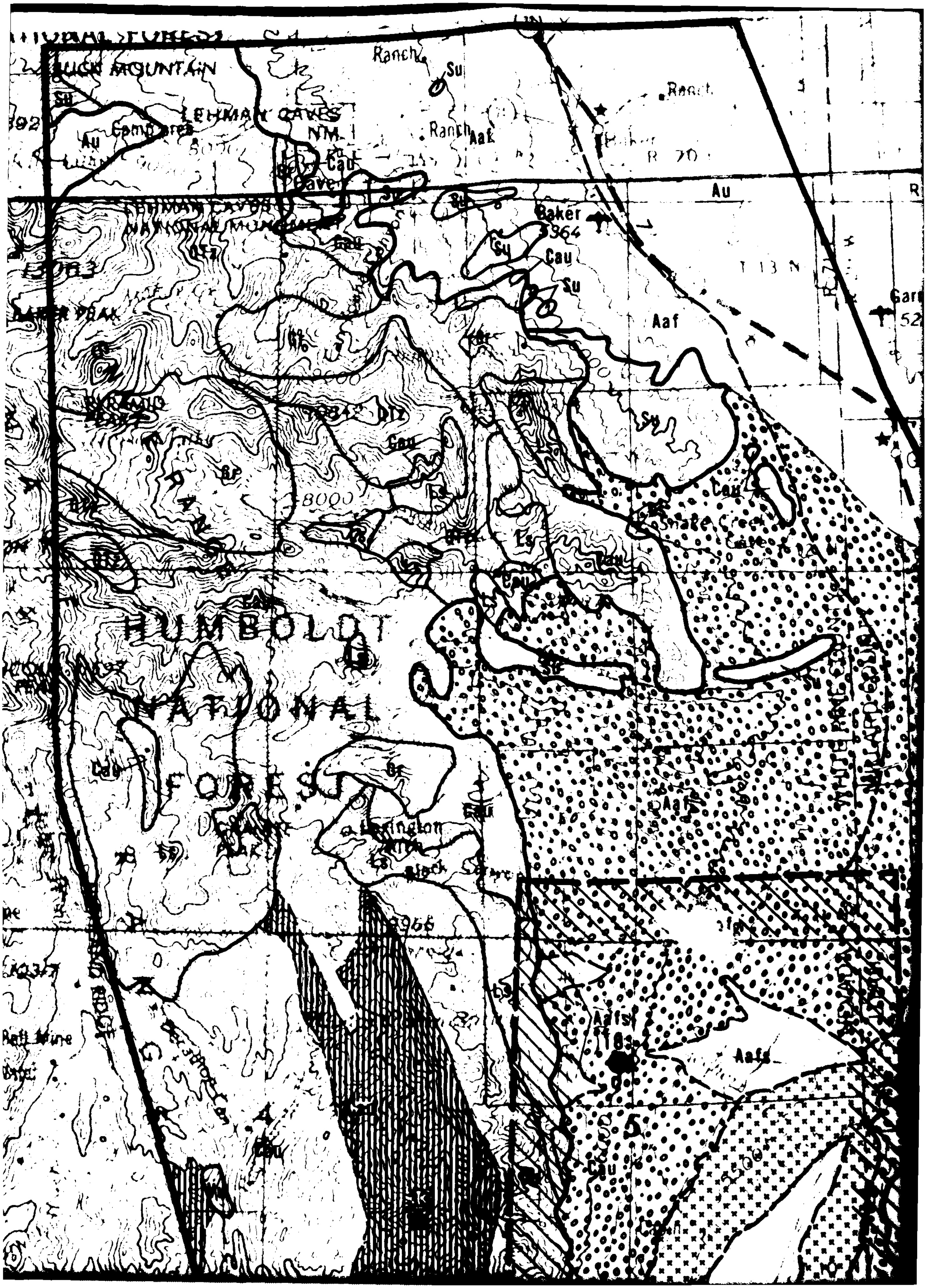
LOCATION MAP



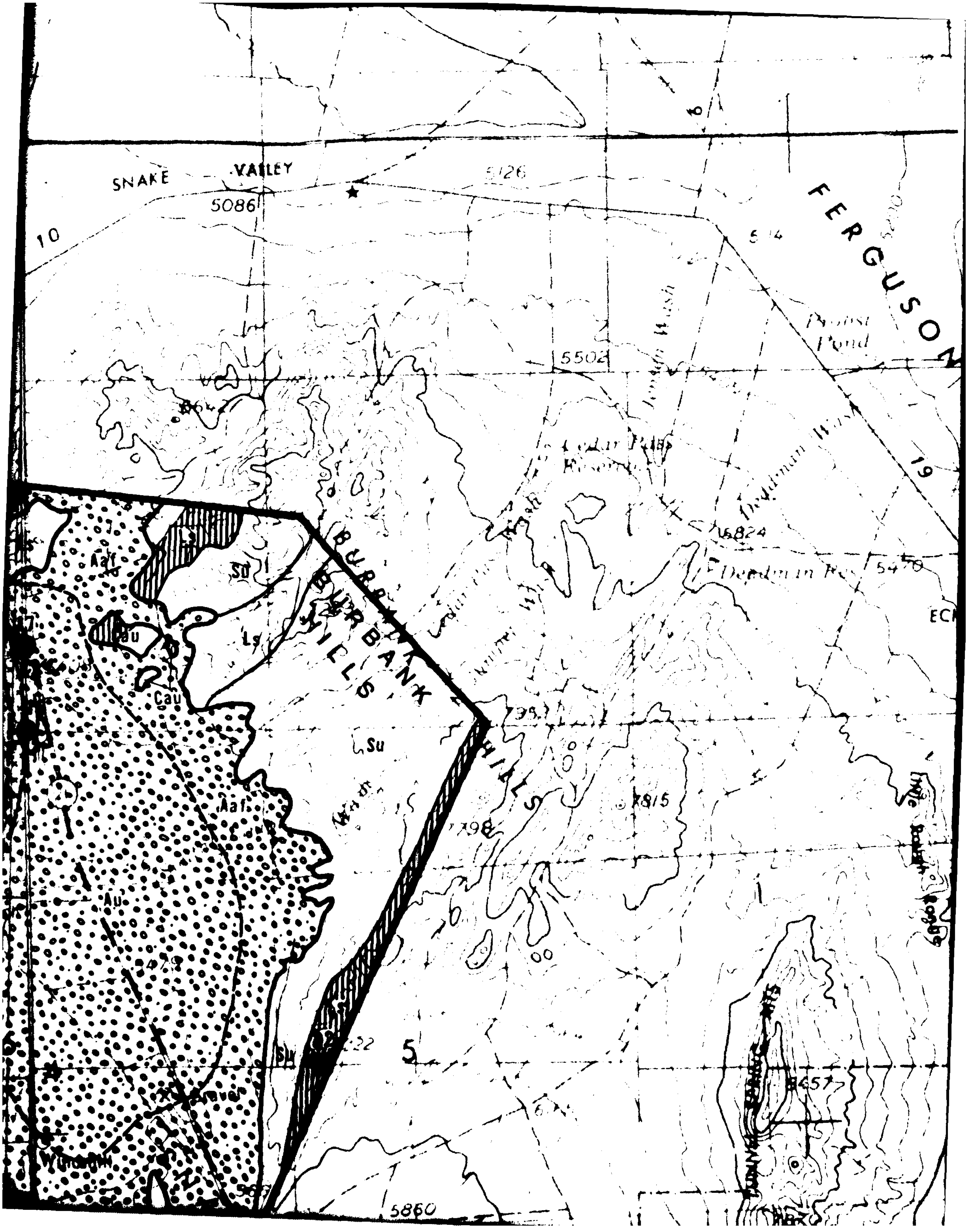
FUGRO NATIONAL FIELD STATION
AND EXISTING DATA SITE LOCATIONS
HAMLIN VALLEY, NEVADA-UTAH

MX SITING INVESTIGATION DEPARTMENT OF THE AIR FORCE - BMO	DRAWING 1

FUGRO NATIONAL, INC.



LEHMAN CAVES
NM
Baker
Cau
Su
Aaf
HUMBOLDT
NATIONAL
FOREST
Lexington
Snake Creek
Aafs
WHITE PINE CO
MILLARD CO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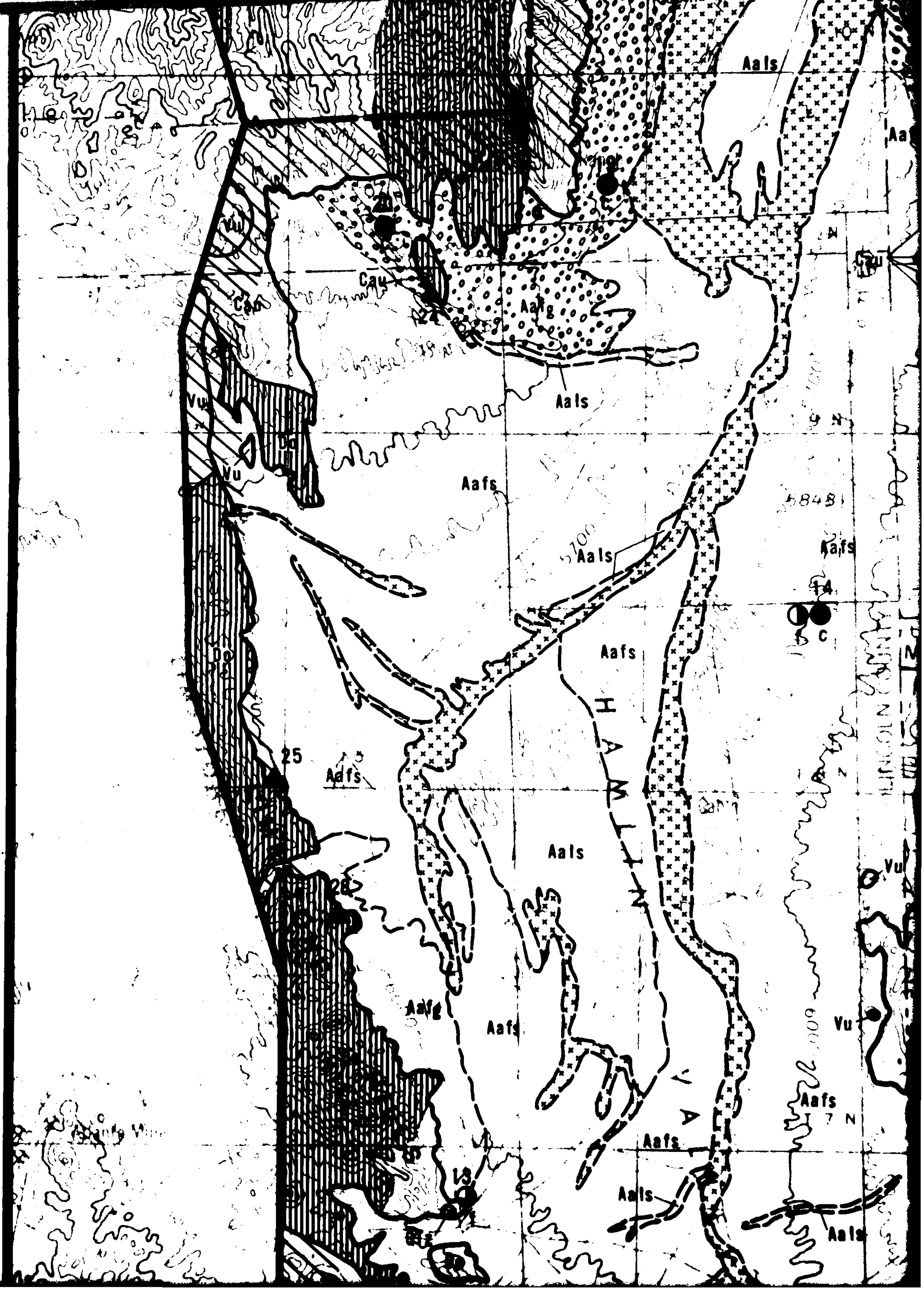
5086
10
FERGUSON
5502
19
6824
5470
BURBANK HILLS
Su
Ls
Aaf
Cau
Au
5
5860
HILLS
7815

3



Aals
Vu
Cau
Aafg
Aals
Vu
Dg
Vu
Aafs
Aals
Aafs
14
Aafs
HAMLIN VALLEY
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Aafs
Aals
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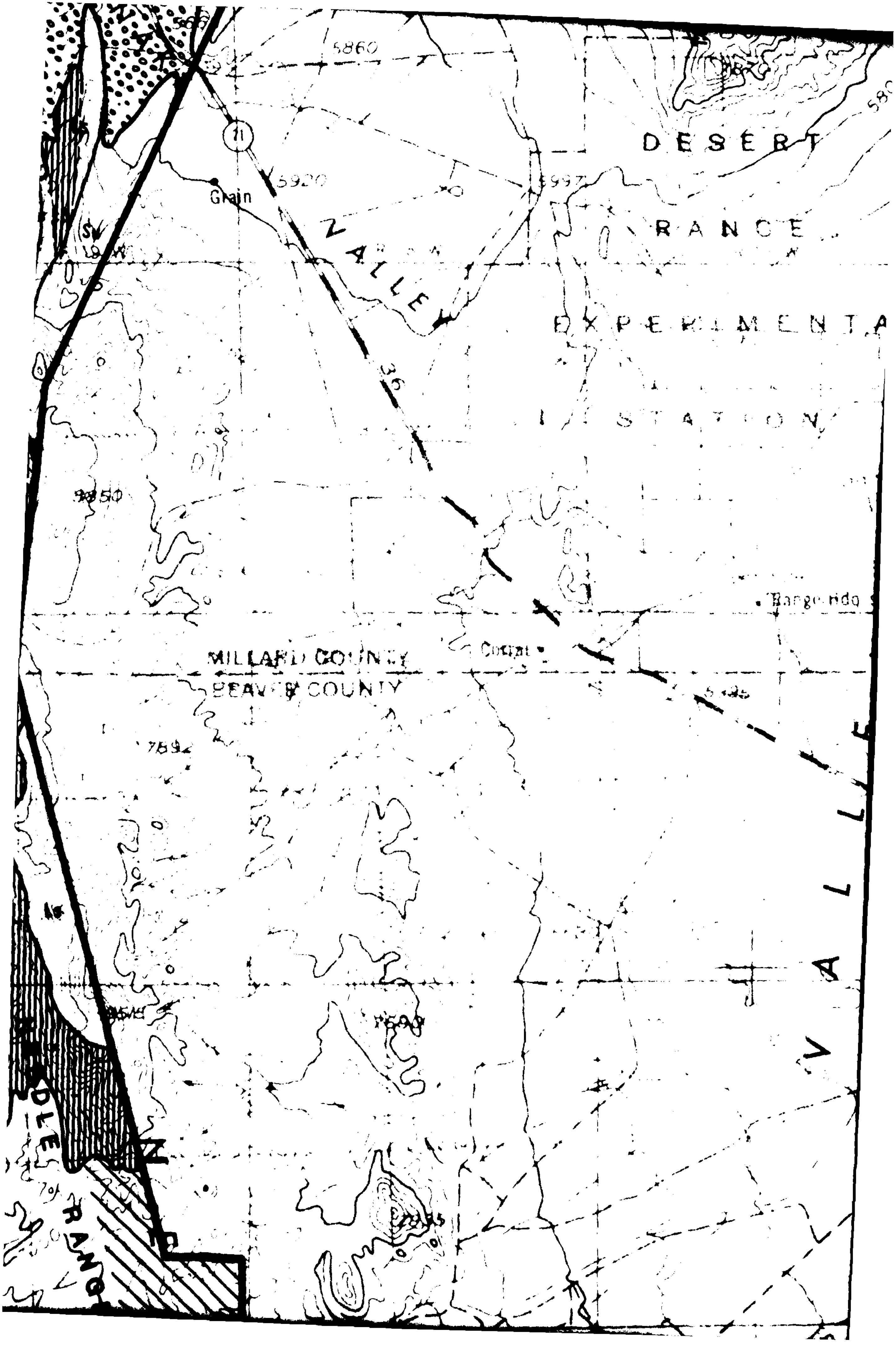
Vu
Aafg
Aafs
Vu
Aafs
7 N
Aafs
Aals
13
Aals


DESERT
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EXPERIMENTA
STATION
Grain
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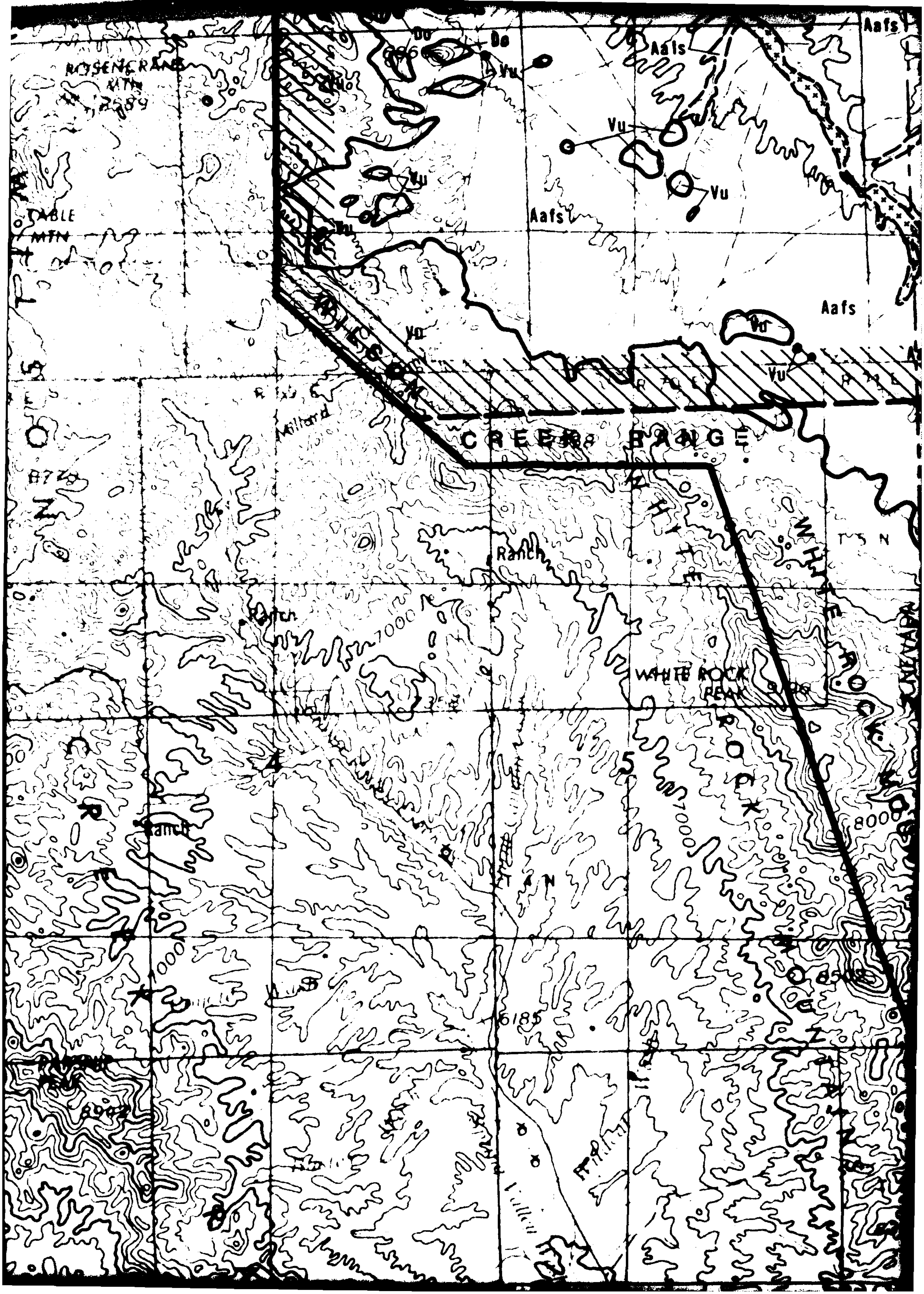
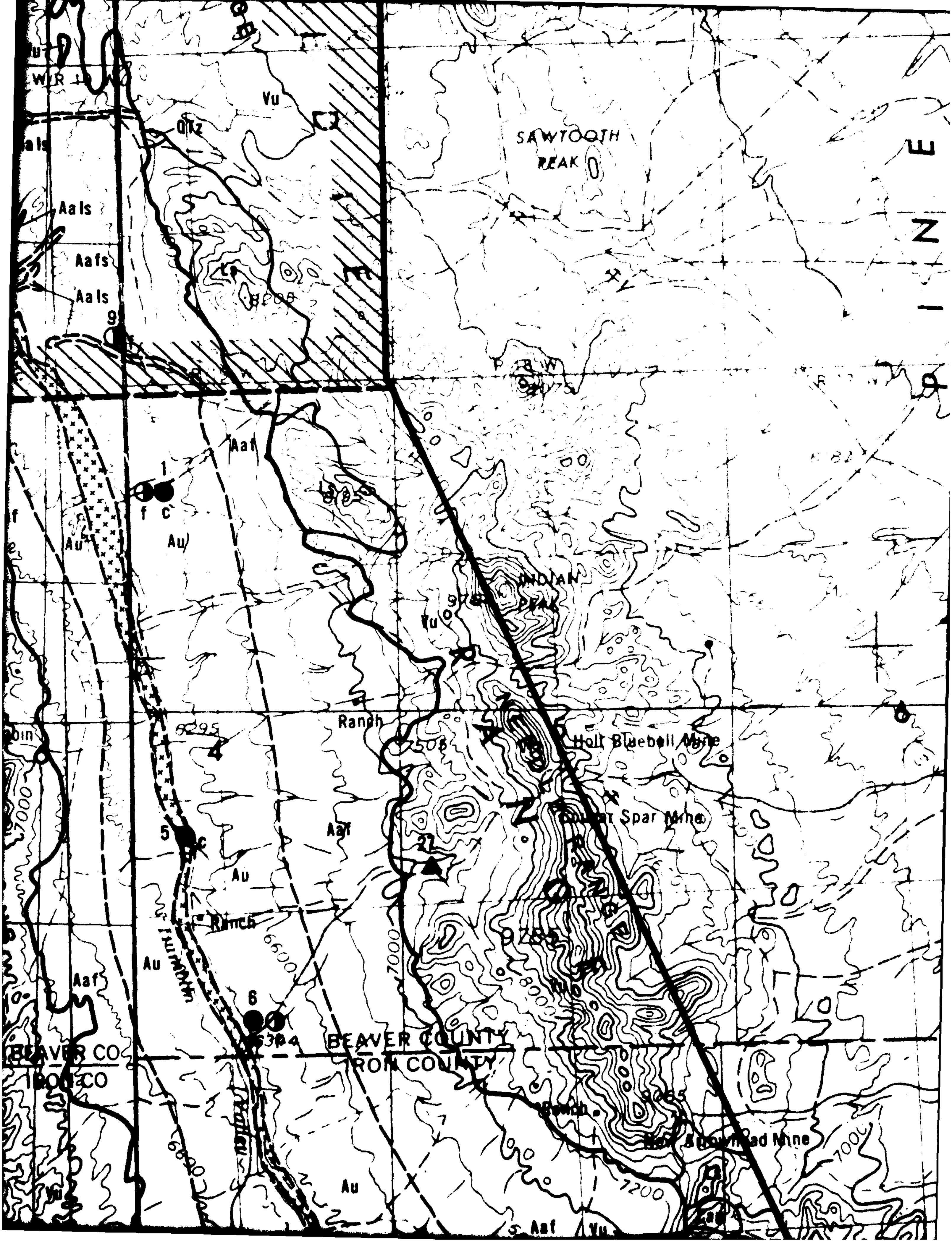
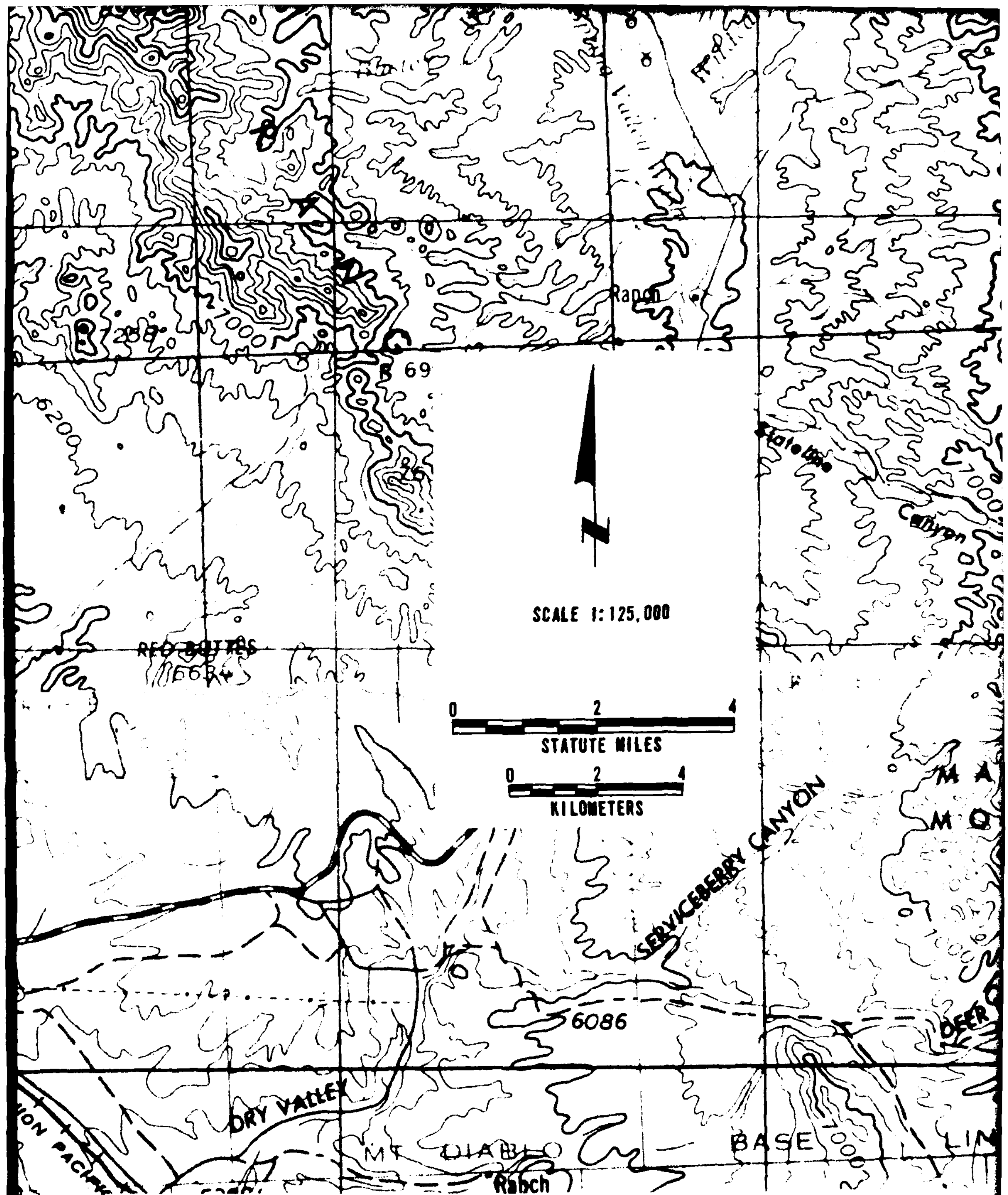
5920
71
36
MILLARD COUNTY
BEAVER COUNTY
Corral
VALLE



ROSENCRANS MTN
TABLE MTN
Do
Vu
Aafs
Millard
WILSON
CREEK RANGE
WHITE
WHITE ROCK
Ranch
7000
WHITE ROCK PEAK
4
5
8000
6185
NEVADA



SAWTOOTH PEAK
INDIAN PEAK
Holt Bluebell Mine
Spar Mine
Arrowhead Mine
BEAVER COUNTY
IRON COUNTY
BEAVER CO
IRON CO
Ranch
Ranch
Aals
Aafs
Aals
Aaf
Au
Vu
Qtz
7000
6600
8000
7200



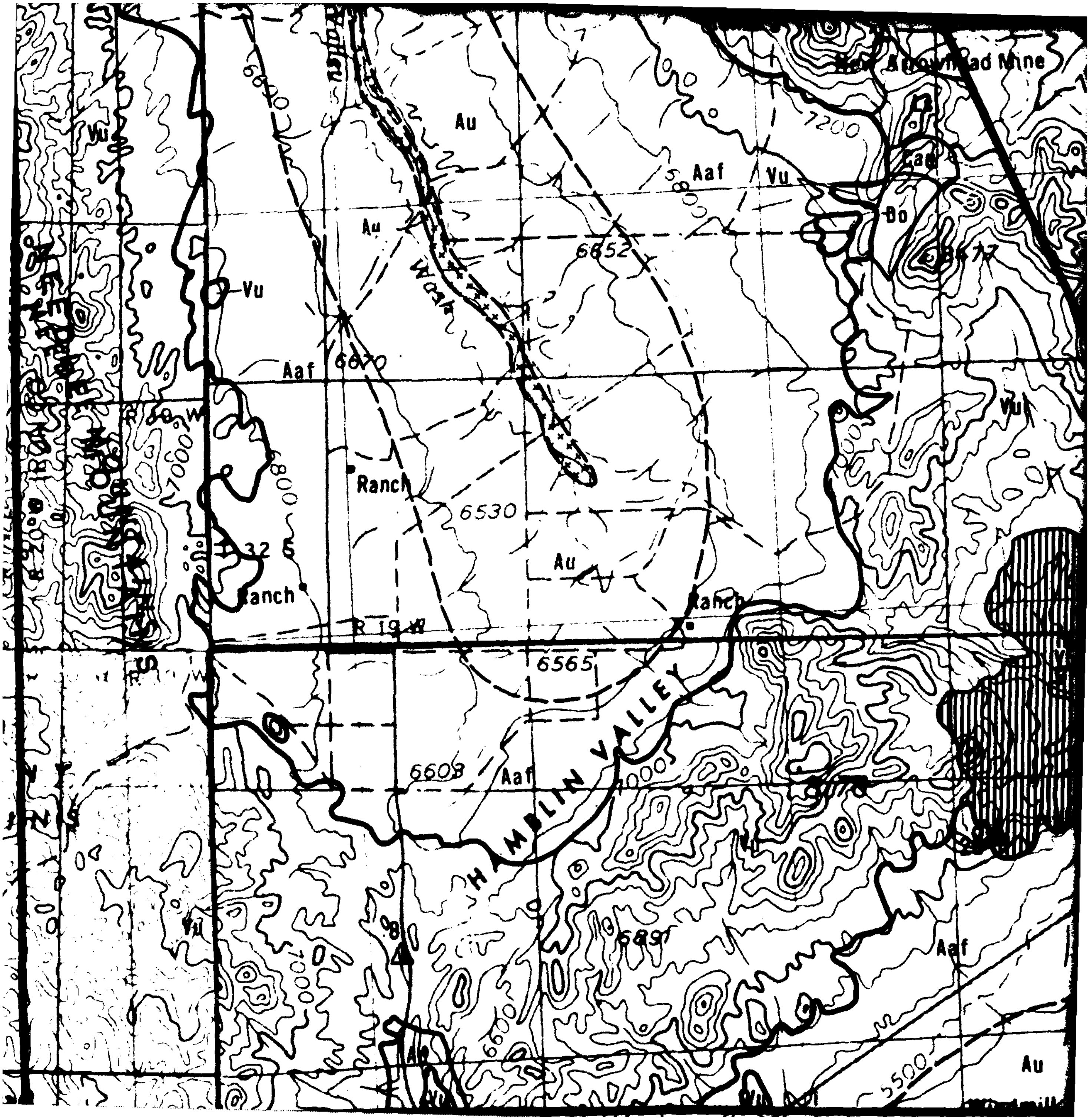
EXPLANATION

~~POTENTIAL AGGREGATE SOURCES~~

BASIN-FILL UNITS*

Aal	Stream Channel and Terrace Deposits	(A1)
Aaf	Alluvial Fan Deposits	(A5)
Au	Alluvial Deposits Undifferentiated	

ROCK UNITS*



Au
Aaf
Vu
7200
New Arrowhead Mine
Do
6652
6670
Wash
R 19 W
Ranch
6530
Ranch
Ranch
6565
HAMBLIN VALLEY
6603
6891
7000
5500

9

Au	Alluvial Deposits Undifferentiated

ROCK UNITS*

Vb	Basalt	(I3)
Vu	Volcanic Rocks Undifferentiated	(I2 and/or I4)
Gr	Granitic Rocks	(I1)
QTz	Quartzite	(M4 and/or S1)
Ls	Limestone	(S2)
Do	Dolomite	(S2)
Cau	Carbonate Rocks Undifferentiated	(S2)
Su	Sedimentary Rocks Undifferentiated	(S)

*Reference Appendix E for Symbol Explanation and Comparison

SYMBOLS

Aafg	Material type (Aaf) and Grain Size Designation (g) Grain size designations are gravel (g) and sand (s) and are assigned only in Verification Study Areas
——— — —	Geologic Contact, Dashed Where Approximate
– – – – –	Approximate Concrete Aggregate and/or Road-Base Materials Source Boundary
	Verification Study Area

FUGRO NATIONAL AGGREGATE RESOURCES <u>SAMPLED AND TESTED FIELD STATIONS</u>

BASIN-FILL AGGREGATE SAMPLE COARSE (c) AND FINE (f)	CRUSHED ROCK SAMPLE	CLASSIFICATION
●	▲	CLASS I
◐	◭	CLASS II
○	△	CLASS III

Note: See Corresponding Map Number in Appendix A for Detailed Information

11

ROCK SOURCES

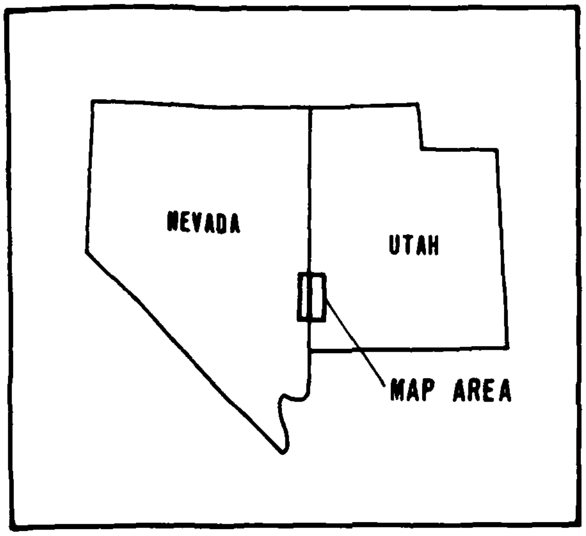
Class I - Potentially Suitable Crushed Rock, Concrete Aggregate and Road-Base Material Source

BASIN-FILL AND ROCK SOURCES

Class II - Possibly Unsuitable Coarse, Fine and/or Crushed Rock Concrete Aggregate/Potentially Suitable Road-Base Material Source

CLASS III - Unsuitable Coarse, Fine and/or Crushed Rock Concrete

LOCATION MAP



AGGREGATE RESOURCES MAP
HAMLIN VALLEY, NEVADA-UTAH

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - BMO

DRAWING 2

FUGRO NATIONAL, INC.