

UNCLASSIFIED

AD NUMBER

AD827289

LIMITATION CHANGES

TO:

Approved for public release; distribution is unlimited.

FROM:

Distribution authorized to U.S. Gov't. agencies and their contractors; Critical Technology; JAN 1968. Other requests shall be referred to Army Materiel Command, ATTN: AMCRD-RV-E, Washington, DC 20315. This document contains export-controlled technical data.

AUTHORITY

AMC ltr dtd 22 Jul 1971

THIS PAGE IS UNCLASSIFIED

AD027289

TECHNICAL REPORT NO. 3-726 - 2

MOBILITY ENVIRONMENTAL RESEARCH STUDY
A QUANTITATIVE METHOD FOR DESCRIBING
TERRAIN FOR GROUND MOBILITY

Volume II

SURFACE COMPOSITION

by

R. C. Wright

J. R. Burns



January 1968

Sponsored by

Advanced Research Projects Agency
Directorate of Remote Area Conflict

Service Agency

U. S. Army Materiel Command

Conducted by

U. S. Army Engineer Waterways Experiment Station
CORPS OF ENGINEERS
Vicksburg, Mississippi

This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of U. S. Army Materiel Command.

DDC
RECEIVED
FEB 26 1968
REGISTRY
A

Wash. D.C. 20315
ATTN: AMCRD-RV-E

DISCLAIMER NOTICE

THIS DOCUMENT IS THE BEST
QUALITY AVAILABLE.

COPY FURNISHED CONTAINED
A SIGNIFICANT NUMBER OF
PAGES WHICH DO NOT
REPRODUCE LEGIBLY.

AD
922289

TAB-68-8



DEPARTMENT OF THE ARMY
WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS
VICKSBURG, MISSISSIPPI 39181

IN REPLY REFER TO: WESAR

28 February 1968

Errata Sheet

Technical Report No. 3-726

MOBILITY ENVIRONMENTAL RESEARCH STUDY
A QUANTITATIVE METHOD FOR DESCRIBING
TERRAIN FOR GROUND MOBILITY

Volume II

SURFACE COMPOSITION

January 1968

1. DD Form 1473, item 5, for Robert C. Wright, read Ramil C. Wright.

TECHNICAL REPORT NO. 3-726

**MOBILITY ENVIRONMENTAL RESEARCH STUDY
A QUANTITATIVE METHOD FOR DESCRIBING
TERRAIN FOR GROUND MOBILITY**

Volume II

SURFACE COMPOSITION

by

R. C. Wright

J. R. Burns



January 1968

Sponsored by

**Advanced Research Projects Agency
Directorate of Remote Area Conflict
Order No. 400**

Service Agency

U. S. Army Materiel Command

Conducted by

**U. S. Army Engineer Waterways Experiment Station
CORPS OF ENGINEERS
Vicksburg, Mississippi**

ARMY-MRC VICKSBURG, MISS.

This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of U. S. Army Materiel Command.

FOREWORD

The study reported herein was performed by the U. S. Army Engineer Waterways Experiment Station (WES) for the Office, Secretary of Defense (OSD), Advanced Research Projects Agency (ARPA). This report describes portions of two tasks of the overall Mobility Environmental Research Study (MERS) sponsored by OSD/ARPA for which the WES was the prime contractor and the U. S. Army Materiel Command (AMC) was the service agent. The broad mission of Project MERS is to determine the effects of the various features of the physical environment on the performance of cross-country, ground-contact vehicles and to provide therefrom data that can be used to improve both the design and employment of such vehicles. A condition of the project is that the data be interpretable in terms of vehicle requirements for Southeast Asia. The funds employed for this study were allocated to WES through AMC under ARPA Order No. 400. The study was performed during the period June 1964-November 1965 under the general guidance and supervision of the MERS Branch of the WES, the staff element of WES responsible for the technical management and direction of the MERS program.

This volume is one of an eight-volume report entitled A Quantitative Method for Describing Terrain for Ground Mobility. These volumes are

- I: Summary
- II: Surface Composition
- III: Surface Geometry
- IV: Vegetation
- V: Hydrologic Geometry
- VI: Selected Air-Photo Patterns of Terrain Features
- VII: Development of Factor-Complex Maps for Ground Mobility
- VIII: Terrain Factor-Family Maps of Selected Areas

Field data were collected in Thailand between July 1964 and May 1965. Personnel who actively participated in the collection of surface

composition data during part or all of this period were: Messrs. C. A. Blackmon, MERS Thailand Detachment; J. E. Lee, A. J. Romano, G. T. Ellis, S. T. Hodge, and L. Jackson, Army Mobility Research Branch, Mobility and Environmental (M&E) Division, WES; R. D. Leighty, U. S. Army Cold Regions Research and Engineering Laboratory; and Chalaj Choeyapunt, Phayond Trushigone, Kasem Imkasorn, Manit Churanokoses, Wichai Winchienwidtya, Boontham Penchan, and Boonlip Sirimontaporn, Thai personnel employed by the MERS Thailand Detachment. Field sampling was conducted under the direction of Messrs. Blackmon, Lee, and Romano. Data reduction and map preparation were accomplished by a team composed of Messrs. J. R. Burns, team captain, G. E. Schabilion, and CPT R. C. Wright, Area Evaluation Branch, M&E Division. This volume was written by Mr. Burns and CPT Wright. The data reduction and map preparation were conducted under the direction of Mr. J. H. Shamburger, Geology Branch, Soils Division, WES. Mr. A. A. Rula, Chief, Mobility and Environmental Research Studies Branch, provided technical assistance in various phases of the work. All phases of this study were under the direct supervision of Mr. W. E. Grabau and Dr. C. R. Kolb, Chiefs of the Area Evaluation and Geology Branches, respectively, and under the general supervision of Messrs. W. G. Shockley and S. J. Knight, Chief and Assistant Chief, respectively, of the M&E Division and Messrs. W. J. Turnbull and A. A. Maxwell, Chief and Assistant Chief, respectively, of the Soils Division.

Directors of the WES during the conduct of this study and preparation of this report were COL Alex G. Sutton, Jr., CE, and COL John R. Oswalt, Jr., CE. Technical Director was Mr. J. B. Tiffany.

CONTENTS

	<u>Page</u>
FOREWORD	iii
CONVERSION FACTORS, BRITISH TO METRIC UNITS OF MEASUREMENT.	vii
SUMMARY	ix
PART I: INTRODUCTION	1
Background.	1
Purpose	4
Scope	4
PART II: DATA COLLECTION PROCEDURES.	7
Site Selection.	7
Location and Description of Sites	8
Sampling Procedures	11
PART III: DATA SOURCES, REDUCTION, AND ANALYSIS.	12
Data Sources.	12
Data Reduction.	12
Data Analysis and Selection of Factor Value Classes	14
PART IV: INTERPRETATION AND MAPPING TECHNIQUES	20
Development of Photo-Interpretation Keys.	20
Map Preparation	26
PART V: CONCLUSIONS AND RECOMMENDATIONS.	36
Conclusions	36
Recommendations	37
LITERATURE CITED.	38
TABLES 1 AND 2	
PHOTOGRAPHS 1-14	
APPENDIX A: SURFACE COMPOSITION DATA SUMMARIES AND SITE LOCATION MAPS	

CONVERSION FACTORS, BRITISH TO METRIC UNITS OF MEASUREMENT

British units of measurement used in this report can be converted to metric units as follows:

<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>
inches	2.54	centimeters
pounds per square inch	0.070307	kilograms per square centimeter

SUMMARY

This volume presents the methods used to collect, tabulate, and analyze basic data on surface composition of six selected Thailand study areas--Nakhon Sawan, Lop Buri, Chiang Mai, Pran Buri, Khon Kaen, and Chanthaburi. Fifteen mapping classes that expressed the different soil mass strength and soil surface strength conditions were established. The criteria used in isolating these classes were (a) that each class be identifiable using air-photo interpretation techniques and (b) that each class exhibit similar variations in strength with moisture content. Areas with equivalent trafficability characteristics in terms of the 15 map classes were delineated on 25 surface composition maps together covering the six study areas. This delineation was accomplished through interpretation of maps and air photos with control data in the form of field and laboratory information. The maps are presented in Volume VIII of this report.

A compromise between the desired degree of mapping class refinement and that dictated by the photo-interpretation criteria was necessary because of the nature of the field data. During the mapping program when sample site data were extrapolated to unsampled areas, the degree of mapping refinement was of necessity only fair to low. It is recommended that additional studies be conducted on the use of air-photo identification techniques in classifying soil strength conditions. This approach is believed to be basically sound; however, more field verification of predicted values will help to determine the reliability of this approach.

BLANK PAGE

MOBILITY ENVIRONMENTAL RESEARCH STUDY
A QUANTITATIVE METHOD FOR DESCRIBING
TERRAIN FOR GROUND MOBILITY

VOLUME II: SURFACE COMPOSITION

PART I: INTRODUCTION

Background

1. The surface composition factor family is concerned with the composition and physical properties of the materials of the surface of the earth without regard to their origin. The study reported herein was concerned chiefly with classifying soils as an engineering material, excluding such materials as consolidated rocks, snow, and ice, although such materials are generally included in the surface composition factor family.

2. Strictly speaking, to classify soils is to arrange them into classes or groups according to a limited number of common characteristics. This presupposes that the characteristics have been first identified and described. Thus, the first step in classification is to identify the significant properties, then to measure or otherwise describe those properties, and finally to place all arrays of similar properties into categories that are meaningful for the purposes at hand. There are many systems for classifying soils currently in use; however, none is entirely adequate for mobility purposes.

3. The soil classification systems that presently appear to be most widely accepted for general engineering and mobility purposes are the Unified Soil Classification System (USCS) and the United States Department of Agriculture (USDA) system. The USCS is based on soil's textural, organic, and plasticity characteristics; the USDA system is based primarily on soil's texture, structure, consistency, and color. Usually it is necessary to obtain bulk samples of soils for laboratory analysis of textural, organic, and plasticity characteristics before reliable

classifications can be made. However, fairly consistent classification of soils can be made in the field by experienced personnel. Although procedures for describing and classifying soils according to the USCS and USDA system are not included in this report, they have been reported in detail.^{1,2}

4. The most useful single soil measurement for ground mobility purposes is its shear strength. Physical soil properties (i.e. soil factors) that are known to influence the shear strength include moisture content, grain size, grain shape, mineralogical composition, organic content, plasticity, density, and structure (the way the soil particles are aggregated into compound particles). Of these factors, moisture content appears to be by far the most important, especially for fine-grained soils (>50% of the soil < 0.074 mm in diameter), or soils having a relatively large proportion of fine-grained materials (characterized by particles less than 0.074 mm in diameter).

5. A major objective of research in soils for engineering and mobility purposes is to develop methods of deducing shear strength from basic soil data. Since moisture content is so important, it follows that information on the effect of varying moisture contents on the shear strength of the various soil types is of paramount importance, and a method for predicting soil moisture content from weather or other data is essential. The U. S. Army Engineer Waterways Experiment Station (WES) has developed a method for predicting soil moisture content that is based on certain site and soil characteristics plus a percentage of the amount of rainfall by 24-hour periods. From a knowledge of soil type and moisture content, a reasonably good estimate of the shear strength (in terms of cone index) can be made.³

6. Experiments conducted to elucidate soil-vehicle relations have revealed that, for practical purposes, soil strength can be divided into two categories--soil mass strength and soil surface strength. Mass strength refers to the overall consistency or firmness of the soil from the surface down to about 12 to 15 in.* below the surface. It largely

* A table of factors for converting British units of measurement to metric units is presented on page vii.

governs the amount of sinkage a vehicle will undergo. Surface strength refers to the strength of a thin layer of soil, usually from the surface to about a 1-in. depth. This layer largely governs the amount of traction a given vehicle can develop on its first pass. Although it is often convenient to divide soil strength into mass and surface components for study purposes, it should not be inferred that such a division presently has rigorous application in the analysis of vehicle performance on soils. Much research remains to be done to clarify the complex interrelation of mass strength and surface strength and their separate and combined effects on vehicle performance.

7. The soil mass strength-vehicle relations for fine-grained soils have been investigated in detail, and procedures for predicting the effect of soil mass strength on vehicle performance have been developed for cases in which adequate soil surface strengths are present. Simple and reliable instruments for measuring soil strength are the cone penetrometer and the remolding equipment. A discussion of these instruments and the procedures for their use is presented in a Department of the Army Technical Bulletin.⁴ The values measured with this equipment are the cone index (CI), which is an index of the shearing resistance of the soil, and the remolding index (RI), which is a ratio that expresses the change in strength that may occur under vehicular traffic. The product of the measured CI and RI for the same layer of soil is termed the rating cone index (RCI).

8. Soil surface strength has been less intensively studied than soil mass strength. As a result, less is understood about soil surface strength-vehicle relations than about soil mass strength-vehicle relations. The instrumentation required to obtain soil surface strength values is still very much experimental. A promising instrument, however, appears to be the Cohron sheargraph, which provides a rough measure of two soil shear strength parameters--cohesion and angle of internal friction. The values are computed from the instrument record of normal stress applied to the soil (in pounds per square inch) and shear stress (in pounds per square inch), which is the force required to rotate the sensing element of the instrument against the soil. A detailed discussion of both instrument and procedure is given by Cohron.⁵

Purpose

9. The overall purpose of this study was to (a) collect, tabulate, and analyze basic terrain data on surface composition, surface geometry, vegetation, and hydrologic geometry that would adequately describe the significant terrain variations occurring in selected areas representative of Thailand in such terms that estimates of vehicle performance could be made, (b) develop a method for interpreting, classifying, and mapping terrain factors from aerial photographs (air photos), and (c) utilize the field data collected and the air-photo interpretation method developed in preparing factor-family maps of six selected study areas in Thailand--Nakhon Sawan, Lop Buri, Chiang Mai, Pran Buri, Khon Kaen, and Chanthaburi (see fig. 1).

10. The specific purpose of the study reported herein was to delineate areas with equivalent trafficability characteristics on the basis of soil strength. This delineation was to be accomplished by the interpretation of maps and air photos, with control data supplied in the form of field and laboratory information. The delineated areas were to be classified for mapping, and an appropriate mapping symbology was to be developed. The maps compiled during this study are presented in Volume VIII of this report.

Scope

11. Areas were delineated and maps constructed for six selected study areas in Thailand. These study areas were chosen to represent a broad range of surface composition conditions. The methods and techniques used or developed to accomplish the classification and mapping were based on general terrain data obtained during several field surveys from 1962-1964. RCI, shear strength at zero normal load, and angle of internal friction were chosen for mapping in the six primary study areas. The actual delineation of areas was based on a reduced amount of specific field data taken from the study areas. The mapping classes developed herein were chosen and used without the benefit of any field verification and testing. The techniques for classifying and mapping surface

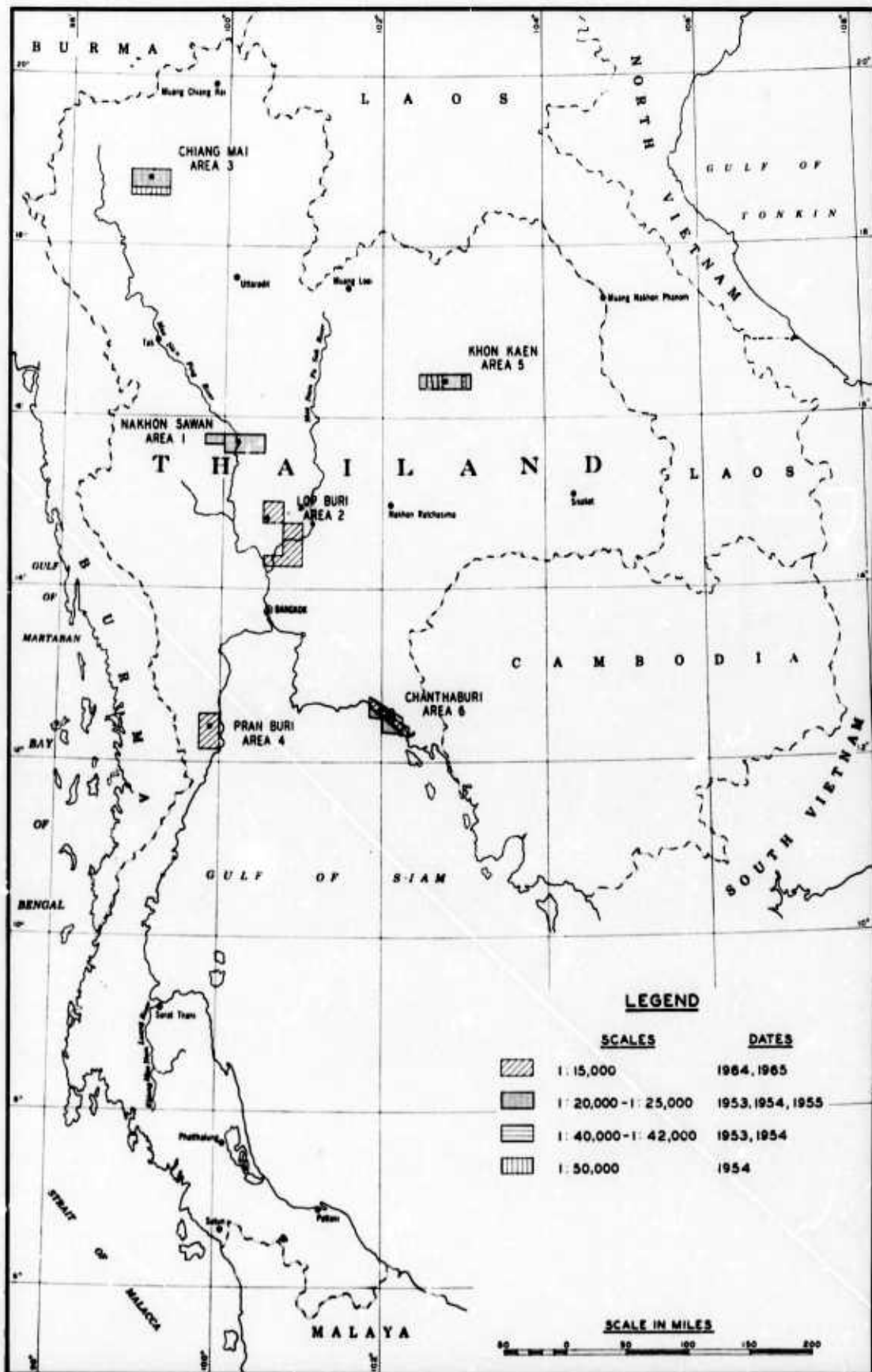


Fig. 1. Aerial photographic coverage of Thailand primary study areas

composition factors presented in this report are by no means being offered as final ones. The techniques and results are the best that could be developed from the particular data on hand.

PART II: DATA COLLECTION PROCEDURES

Site Selection

12. The selection of soil sites is largely dependent upon the purpose for which soils are being studied. A sample array chosen for an evaluation of the soils of an area for the construction of airfields would obviously be different from an array chosen for an evaluation of the soils of an area for construction of earth-fill dams. An array chosen for an analysis of soil characteristics for mobility purposes would be different from either of the above-mentioned arrays.

13. In this case, study sites were chosen to represent soil strength regime of each areally or positionally different soil type that was believed to be significant to ground mobility and that could be recognized on available air photos or maps. For example, in any area occupied by a particular soil type, topographic positions such as the tops, sides, and bottoms of hills were identified. Ideally, each site should have been visited several times in order to define the relations among soil moisture, seasonal precipitation or groundwater characteristics, and soil strength. However, multiple visits were seldom possible because of the severe time restrictions imposed by project scheduling.

14. Site selection was based on a combination of air-photo interpretation and ground reconnaissance. In those areas for which photography was available, a preliminary selection was made on the basis of differences in photo images that could be attributed to soil differences, or on the basis of topographic position in those areas where no obvious differences could be seen in the images. These sites were then checked on the ground by the team leader, who either confirmed or rejected them. Since the available photography was between 10 and 12 years old, many sites selected in this way were found to be redundant, the images having been controlled by minor vegetation differences or such things as variations in land use practices. When no air photos were available, sites were selected by on-the-ground reconnaissance, supplemented by low-altitude examination from the air where possible.

15. Because of the size of the primary study areas, a reasonable number of samples could be obtained only if travel time between sites could be held to a minimum. The effect of this constraint was to preclude examination of sites more than about 500 m from a passable road or trail or from a navigable stream. The general scarcity of passable roads and trails was such that nearly all sites were confined to narrow bands along roads. Obviously an important element in site selection was the ease with which examples of all soil types or moisture regimes could be located close to roads or trails. Because finding all soil types or moisture regimes close to roads was not always possible, obvious gaps in ground control did develop.

Location and Description of Sites

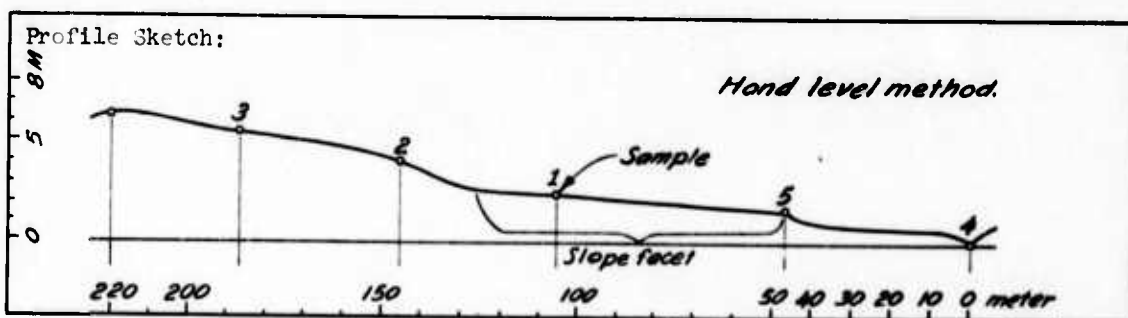
16. For interpretive and analytical purposes, it is usually necessary that the locations of soil sites be known very accurately, so that their positional relations to other soils, topographic features, or hydrologic features that might possibly affect their moisture regimes can be considered. For this reason, each site was meticulously located and marked on the best available map and/or air photo. Further, the soil site locations were described with such accuracy that they could be relocated at any time in the future. A topographic position data form (fig. 2) was prepared for all sites. Detailed instructions for filling out this form and supplementary instructions for preparing the profile sketch are given in another WES report.⁶

17. In most instances soils were sampled at such places or under such circumstances that vegetation, surface geometry, or other features of the site were obtained by the appropriate team for collecting factor-family data. In those instances where only soil samples were obtained, a certain amount of supplementary information was collected and recorded on a supplementary site data (soil moisture) form (fig. 3). Detailed instructions for filling out this form are presented in reference 6. Because the terms used in the form are mostly subjective, not all

TOPOGRAPHIC POSITION DATA FORM

Map reference: BAN PANG SOK, 52541, AMS Series L708, 1:50,000 Site No.: 27-SC
 Geographic coordinates of site: 14°36'08"N, 101°27'47"E
 Site elevation: 318 m Max topographic slope: <1° Slope azimuth: 233°
 Unit measure: meters Sheet 1 of 3

Position No.	Vertical Distance, m		Horizontal Distance, m	Notes
	HI	Rod		
1	1.6	-	39.0	Open at sample site
2	1.6	-	42.0	
3	1.6	0.8	33.0	Top of topographic high
4	1.6	-	47.0	Topographic low
5	1.6	0.9	59.0	Final sight to sample site
	6.3		220.0	Totals



Sampling Team: *Grabau, Jirote*

Fig. 2. Example of a topographic position data form used to describe soil site locations

SUPPLEMENTARY SITE DATA (SOIL MOISTURE)

Site No. 27-SC Location: 0.9 Km W of Ban Khanong Phra Nua

Sampling Team: Grabau, Jirata Page 2 of 3.

Land Use (Select as many as required to describe condition: circle appropriate terms.)

1. Not obviously used by man or domestic animals. Undisturbed.
2. Obviously used by man or domestic animals.
 - a. Cropland currently in use (excluding hayfields, orchards, vineyards, tree plantations)
 - b. Cropland currently lying fallow (excluding hayfields, orchards, vineyards, tree plantations)
 - c. Area grazed by domestic animals
 - d. Hayfields (not currently being grazed)
 - e. Orchards, vineyards, tree plantations
(type? _____)
 - f. Lawns, recreation areas
 - g. Logged, (cut for fuel), newly cleared for slash-and-burn agriculture

Depth of water over soil surface (if any): None

Depth below surface of free water (if any): None

Depth to bedrock (if any): No rock to 75 cm.

Vegetation (select one, if possible. If a choice between two is difficult, indicate both.)

- | | | |
|----------------------|--|-------------------------|
| 1. Forest | 5. Tall scrub woodland | 9. Tall-grass prairie |
| 2. Woodland | <input checked="" type="radio"/> 6. Tall scrub savanna | 10. Short-grass prairie |
| 3. Savanna | 7. Low scrub | 11. Barren |
| 4. Tall scrub forest | 8. Low scrub savanna | |

Fig. 3. Supplementary site data (soil moisture) form

observers will interpret the items in the same way. However, this is not regarded as serious in this context.

Sampling Procedures

18. Detailed procedures for sampling are described in reference 6. The procedures used in collecting soil data at sites sampled specifically for this study are described briefly in the following paragraphs.

19. Four or more CI profiles were measured in 2.5-cm* vertical increments to a depth of 46 cm at each site. Remolding index tests were made on two samples each from the 0- to 15-cm and 15- to 30.5-cm layers. If the results of the tests of the two samples from each layer were not in close agreement, a third remolding index test was made, and the average of the three test results was used. Sheargraph measurements were made on the surface using a grouser to determine soil cohesion and apparent angle of internal friction. A flat, rubber-coated shear head was used to determine soil-to-rubber adhesion and rubber-to-soil friction angle.

20. At most sites soil samples were taken for laboratory analysis of moisture content, density, texture, Atterberg limits, and organic content. Samples for moisture and density were taken in 7.5-cm increments to a depth of 30.5 cm with a Hvorslev sampler. A bulk sample was taken from each of the 0- to 15-cm and 15- to 30.5-cm layers for the other laboratory analyses. Those laboratory data that were utilized in the final classification of surface composition features are given in Tables A1-A6. In some instances (see site 1-T-13, table A1) not all data specified by the instructions were taken, and in a few instances data were lost in the transfer from the field to the office; such gaps in data are indicated by dashes in tables A1-A6.

* All field measurements were made in British units since all instruments were calibrated in such units. Subsequent conversions to approximate metric equivalents were made in the office.

PART III: DATA SOURCES, REDUCTION, AND ANALYSIS

Data Sources

21. All available soil strength data were used to establish mapping units and ranges of variations of soil strength within each unit. Data collected at 882 sites for this and other MERS tasks, including the preliminary study,⁷ were examined. Of the 882 sites, 579 yielded soil and site information pertinent to this study. These data are summarized in Appendix A. Only 367 of these sites were located within the limits of the study areas. Small-scale maps showing the location of these sites are also given in Appendix A.

22. Various soil survey reports of the Kingdom of Thailand^{8,9} together with Pendleton's Thailand¹⁰ provided very general background information on the characteristics, distribution, and general association pattern of soils. However, this information was of limited value because the distribution maps of the various sources are very small-scale and because no consistent relations between the mapped soil units and soil strength could be developed.

Data Reduction

23. The data presented in Appendix A provided the major source of information gathered from the study areas. Because of the large number of sites, these data were recorded or punch-coded along the margin of a special key-sort punch card to facilitate retrieval and statistical manipulation of the data. The key-sort punch card used is illustrated in fig. 4.

24. A modified binary coding system was used to enter data on the key-sort cards. The standard sequence of hole numbers (1-2-4-7) was modified to a system (1-2-4-8) that required less space. Despite the increased manipulation required for the modified system, it was preferred because more code bits per unit length of card perimeter could be used. To avoid the confusion of using both systems, the modified system was

applied to all parameters except one. Coding of color (hue) was accomplished by assigning a certain perimeter position to each hue. The coded card (fig. 4) can be read as follows:

<u>Hole Combinations Punched</u>	<u>Code Numbers Represented</u>
1	1
2	2
2-1	3
4	4
4-1	5
4-2	6
4-2-1	7
8	8
8-1	9
etc.	

Data Analysis and Selection of Factor Value Classes

25. The objective of the data analysis program was to develop a set of criteria for mapping the areal distributions of meaningful classes of soil strength. There were three important constraints. First, the soil strength classes had to be suitable as input to the analytical cross-country speed prediction model under development in a parallel research program being conducted under the MERS project. Second, the soil strength classes had to be based on recognizable air-photo patterns, because photo interpretation constituted the only practical method of extrapolating the detailed site data to the large areas encompassed by the study areas. This was obviously required for mapping purposes. Third, each soil strength class had to exhibit a distinctive soil strength regime in order to incorporate the obvious seasonal differences that were known to occur.

Soil mass strength

26. Straightforward statistical analyses of the field data for soil mass strength categories were not practical, because soil strength is a time-variable factor and the great majority of the field data represented one-time observations. Since soil mass strength regime is chiefly a function of soil type and soil moisture regime, the identification of

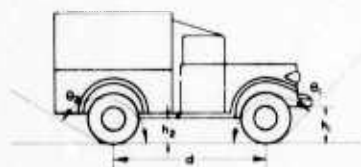
distinctive soil strength regimes resolved into a study of moisture content-soil type-soil strength relations. Therefore, emphasis was placed on relating strength to moisture content for different site characteristics.

27. The requirement that the soil mass strength classes be suitable as input to the speed prediction model could not be entirely met, because the model had not reached such a level of development that rigorous classes could be specified at the time when a decision on map units had to be made. Accordingly, soil mass strength value classes were initially specified on the basis of vehicle types that had been selected for MERS tests, since the range in their soil mass strength requirements was representative of that for most Army vehicles expected to operate off roads at least sometimes. Some of the characteristics of these vehicles that are pertinent to their cross-country performance are tabulated in fig. 5. The vehicle cone index (VCI) requirement, or the minimum soil strength in terms of RCI that will allow a vehicle to complete one or 50 passes in a straight-line path, is given in the following tabulation for the vehicles considered in this study.

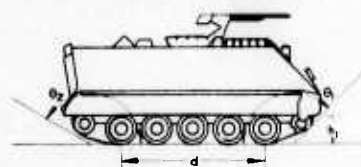
<u>Vehicle</u>	<u>VCI Required for 50 Passes</u>	<u>VCI Required for 1 Pass*</u>
M29C	25	13
M151	60	30
M37	65	33
M113	47	24
M35A1	69	35

* Estimated at 50 percent of the 50-pass requirement.

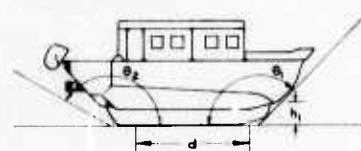
28. Consideration of the VCI_{50} and VCI_1 values of the vehicles suggested that useful classes would result if the divisions were made at RCI values of approximately 10, 25, 50, and 70, which would result in five mapping classes. The division at 10 RCI was introduced in order to define areas of extremely soft soil, in anticipation of the possible availability of very low-contact-pressure vehicles. The map classes used finally were: <10, 10-25, >25-60, >60-100, and >100 as explained in paragraph 40.



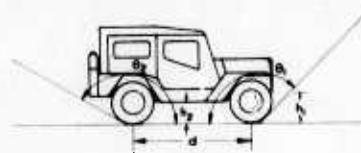
M37
3/4-TON CARGO TRUCK



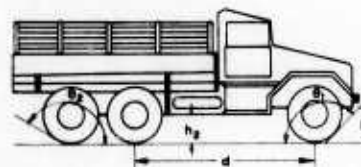
M113
ARMORED PERSONNEL CARRIER



M29C
AMPHIBIOUS CARGO CARRIER



M151
1/4-TON UTILITY TRUCK



M35A1
2-1/2-TON CARGO TRUCK

VC1 50	h_1^* CM	h_2^{**} CM	θ_1^\dagger DEG	$\theta_2^{\dagger\dagger}$ DEG	d^\ddagger CM	GRADE- ABILITY % DEG	WEIGHT KG
65	53	41	142	148	284	68 34.2	3180
47	58	--	110	140	267	60 31	9980
25	34	--	134.4	151	198	100 45	2720
60	36	26	112	143	216	60 31	1031
69	84	53	142	140	330	64 32.6	8840

NOTE: ALL DIMENSIONS PRESENTED IN THIS FIGURE WERE TAKEN DIRECTLY FROM THE TEST VEHICLES.¹¹

GRADEABILITY DATA TAKEN FROM ORDNANCE CORPS EQUIPMENT DATA SHEETS.¹²

* h_1 = HEIGHT FROM WHICH VEHICLE APPROACH ANGLE IS TAKEN

** h_2 = PROFILE HEIGHT BETWEEN WHEELS OR TRACKS

† θ_1 = VEHICLE APPROACH ANGLE

†† θ_2 = VEHICLE DEPARTURE ANGLE

‡ d = WHEEL BASE (NOTE DIAGRAM ABOVE FOR METHOD OF DETERMINATION FOR M35A1)

NOTE THAT ANGLES ARE MEASURED AS OBTUSE ANGLES; TO CONVERT TO PRACTICE AS GIVEN IN TM 9-500, USE: $180^\circ - \theta$.

Fig. 5. Vehicle characteristics related to vertical obstacle crossing capability

29. When the site data were sorted by USCS soil types, no recognizable pattern of RCI values was revealed. Plotting RCI versus moisture content revealed a family of curves that corresponded to the USCS in a general way (fig. 6). Too much scatter was present to distinguish specific classes, but broad groupings occupied recognizably different parts of the chart. It was therefore possible to establish the following preliminary classification of soils: (a) coarse-grained soils with fines, low plasticity or nonplastic; (b) fine-grained soils, low plasticity; (c) fine-grained soils, high plasticity; (d) fine-grained soils, high plasticity, high organic content; and (e) soils associated with shallow bedrock or hard laterite (see fig. 6).

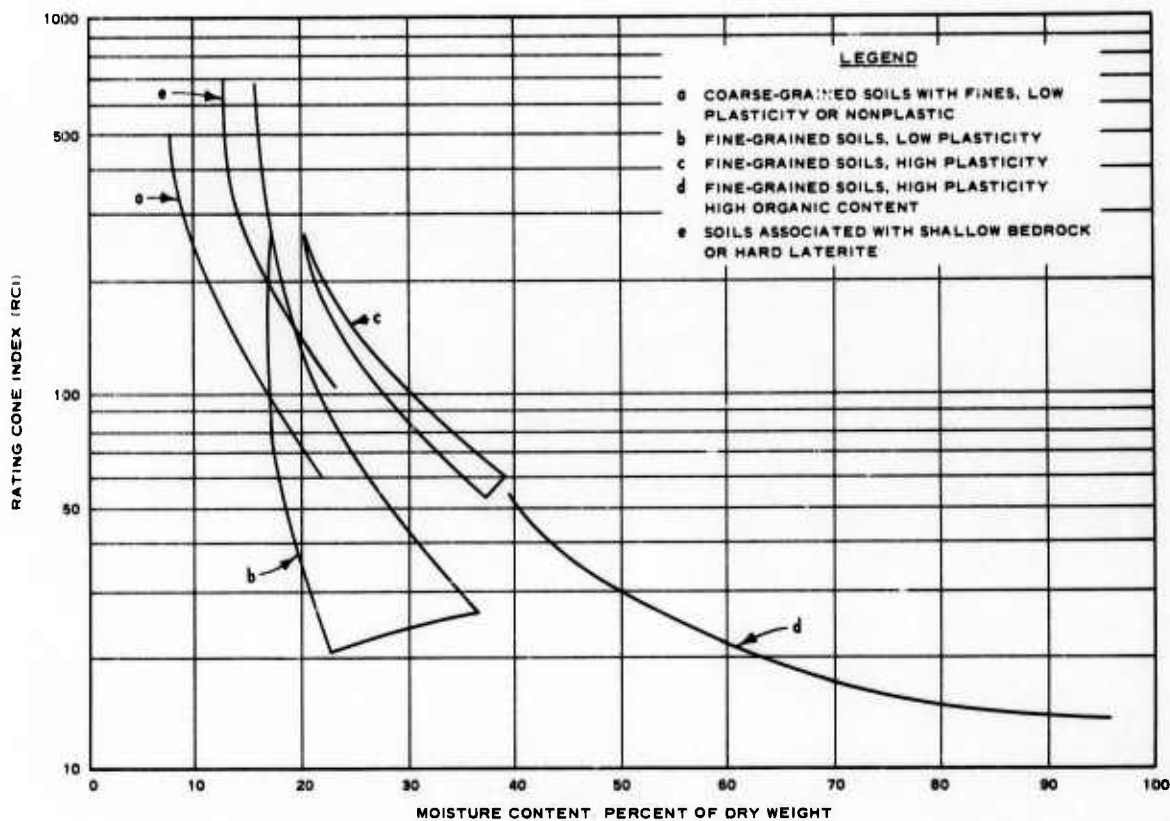


Fig. 6. Characteristic relations of rating cone index to moisture contents for preliminary soil classification

30. Soils occurring in (d) above fell on the same curve as those described in (c), but fell in a different range (higher moisture content and lower RCI) and were found to be associated with tidal flats. Soils

described in (e) were strong regardless of texture and topographic position. No soils occurring in (e) exhibited high moisture contents. Scatter of the RCI-moisture content plots* did not permit distinction of individual USCS soil types but did show general differences between certain associations of types. Soils along curve a in fig. 6 were mostly SM and SC; soils on curve b were mostly ML and CL; soils on curve c were mostly MH and CH; and those on curve d consisted primarily of CH, OH, and MH soils. The MH, CH, and OH soils distinguish the soft tidal flat deposits from the much stronger dry land soils. The USCS class of the soils associated with shallow bedrock or hard laterite was not relevant.

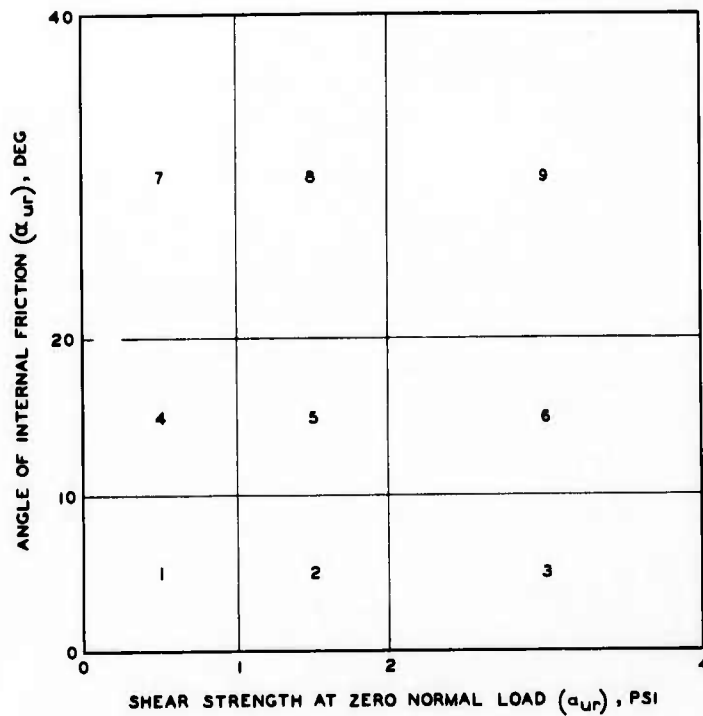
Soil surface strength

31. Soil mass strength is not the only soil factor that affects vehicle mobility. It is known, both from practical experience and from preliminary tests, that the slipperiness of a surface is also important, especially for a vehicle climbing slopes or crossing vertical obstacles. In an attempt to provide data for the evaluation of this factor, shear-graph measurements were included in the standard data collection procedure.

32. Upon completion of the investigation of soil mass strength, the soil surface strength as measured by the sheargraph was examined in order to establish appropriate class limits for mapping purposes. Soil surface strength is also time-variable. The relations between sheargraph values and moisture content in the surface layer of the soils in the six study areas were not known at the time of this study. However, previous experiments on tropical soils had demonstrated a general relation between shear strength at zero normal load a_{ur} and moisture content.¹⁴

33. In the absence of reliable knowledge of the effects of soil surface strength on vehicle performance, a completely arbitrary, but reasonable, division of the data into classes for the preliminary classification was used. The class units were chosen as illustrated in fig. 7. Both the shear strength at zero normal load a_{ur} and the angle of friction

* Specific relations among cone index, rating cone index, and soil moisture are given in detail in a previous WES report.¹³



NOTE: NUMBERS IDENTIFY SHEARGRAPH VALUE CLASSES.

Fig. 7 Soil surface strength classes

α_{ur} were divided into three unequal classes, resulting in nine distinctive classes, each of which was given an arbitrary code number, as indicated in fig. 7.

PART IV: INTERPRETATION AND MAPPING TECHNIQUES

Development of Photo-Interpretation Keys

34. It is difficult to describe in detail the analytical procedures or the developmental steps involved in the derivation of the photo-interpretation keys and the final classes for use as map units. The actual process was by no means simple and straightforward; instead, it was a process of continual compromise between the requirements of the analytical speed prediction model, the available ground data, and the recognizability of images on the air photos. The requirements of the analytical model would have best been served by very small class intervals for all three selected factors (i.e. RCI, shear strength at zero normal load, and angle of internal friction). However, such class intervals could not be made practical, chiefly because there was no hope of being able to recognize them reliably by photo interpretation. The result was a compromise between the broad classes demanded by the photo interpreters and the narrow classes desired by the engineers concerned with the analytical performance prediction model. A greatly simplified diagram of the process is given in fig. 8. The point of departure was the five general classes derived from the diagram illustrated in fig. 6, which identifies RCI-moisture content relations and relates them in a crude way with USCS soil types.

Topographic position

35. Within each of the above-mentioned broad groupings of soils, sites were sorted according to topographic position as contained in the site descriptions. The result of this process is indicated in the topographic position column in fig. 8. A few topographic positions, such as natural levees, tended to be associated with high RCI values regardless of other conditions. Others, such as tidal flats, exhibited consistently low RCI values.

Position with respect to water

36. The ease of drainage and the proximity to sources of water also were found to be significant criteria for classification. Therefore,

Soil Classes		Topographic Position	Position with Respect to Water	Land Use	Map Unit
From Fig. 6	USCS Types				
a	SM, SC	Broad, rolling upland	100 m from surface water	Not significant	11
b	CL, ML, some SM	Alluvial plains	Intermediate water table	Not significant	4
			Shallow water table	Not significant	2
		Drainageways and lower side slopes	Rapid changes in water table in short distances	Not significant	5
			Shallow water table	Not significant	3
	CL, SM, SP	Natural levees and village platforms	Near open water	Villages	13
c	MH, ML, CL	Broad alluvial plains	Intermediate water table	Not significant	9
	CH, some CL, MH	Flat, uniform alluvial plains	Shallow water table	Tilled	8
				Untilled	10
			Water table almost at surface	Tilled	6
Untilled	7				
d	CH, OH, MH	Tidal flats	Periodic inundation	Not significant	1
e	Not relevant	Hills, mountains, rock terraces	Deep water table	Not significant	12
		Flat to rolling	Deep to shallow water table in short distances	Tilled	14
				Untilled	15

Fig. 8. Development of photo-interpretation criteria (generalized)

the next stratification process tended to be based on water availability. In this category, slope appeared to be the dominant property for identification of fine-grained soils, whereas elevation above surface drainage level seemed to be the major determinant for coarse-grained soils. Although topographic position implies a general correlation with water table conditions, special classification was reserved for those areas where the water table remains so near the surface that the soils do not dry out even in the dry season.

Land use

37. When attempts were made to include recognition criteria for soil surface strength (i.e. sheargraph parameters), the soil-topographic classes already established for soil mass strength (RCI) had to be accepted, chiefly because no applicable field moisture data were available on the surface layer of soil. Within each soil-topographic position class already established, card sorts were run using other site factors as the basis of stratification. The only site descriptor found to correlate with soil surface strength was land use. In highly plastic soils, regularly tilled areas showed values different from those of untilled areas for the soil surface strength parameters. This stratification is indicated by the land use column in fig. 8. These correlations were valid only for the rubber-to-soil sheargraph measurements. Because the data taken with a grousered foot did not correlate with any site descriptor, they were discarded. The map unit column in fig. 8 shows the mapping class units into which each set of site descriptors was placed.

38. Land use also appears to be a significant factor in village areas; RCI values higher than those suggested by soil type or topographic position were observed in such locations. This probably is a result of artificial compaction of the soil and man-made drainage control. The land use effects of village platforms and soil tillage are the only ones reflected in the final classification. As an indicator of natural conditions, however, land use was extensively used in photo interpretation.

Special areas

39. Areas of bedrock and hard laterite at shallow depths where high strength prevailed regardless of soil type or topographic position were

often recognized from distinctive vegetation patterns or field configurations. Areas of consistently low RCI values such as swamps, marshes, sloughs, and tidal flats were recognized from certain consistencies in tone, texture, and topographic position.

Refinement of classification criteria

40. The air photos and topographic maps of data sites were constantly reexamined as new classification criteria were developed and preliminary classifications of site characteristics were erected. Every device of the interpretive art was used in the process of building up the recognition capability. The final product of the process is summarized in table 1. It should be noted that one result of the succession of compromises was alteration of the RCI classes that had been tentatively selected at the beginning of the study. The original classes, as described in paragraph 28, could not be reliably identified by photo interpretation. They were accordingly changed to the following: <10, 10-25, >25-60, >60-100, and >100. These new classes, though slightly less desirable for input into the analytical model than the old classes, were still acceptable.

Soil surface strength

41. A considerably more refined concept of soil surface strength (or sheargraph value) classes was also evolved after study of the data from Thailand, even though the original class intervals (fig. 7) remained unchanged. It was noted that maximum soil shear strength at zero normal load rarely occurred at maximum or minimum moisture content. It was also noted that all soils in a given surface composition class (table 1) exhibited similar sheargraph values. The relations that were eventually established as characterizing the sheargraph values of each class are illustrated in fig. 9.

42. The sheargraph categories in fig. 9 are constructed in the same way as those in fig. 7. The hatched areas indicate the intervals (i.e. the soil surface strength classes, see fig. 7) in which most of the sheargraph values fell in those samples at the indicated moisture content in the recognition class. For example, in surface composition class 1 (see table 1), most of the sheargraph values fell in sheargraph value class 1 when the soils were sampled at or near their maximum moisture content, and in sheargraph value class 5 when the soils were at or near minimum

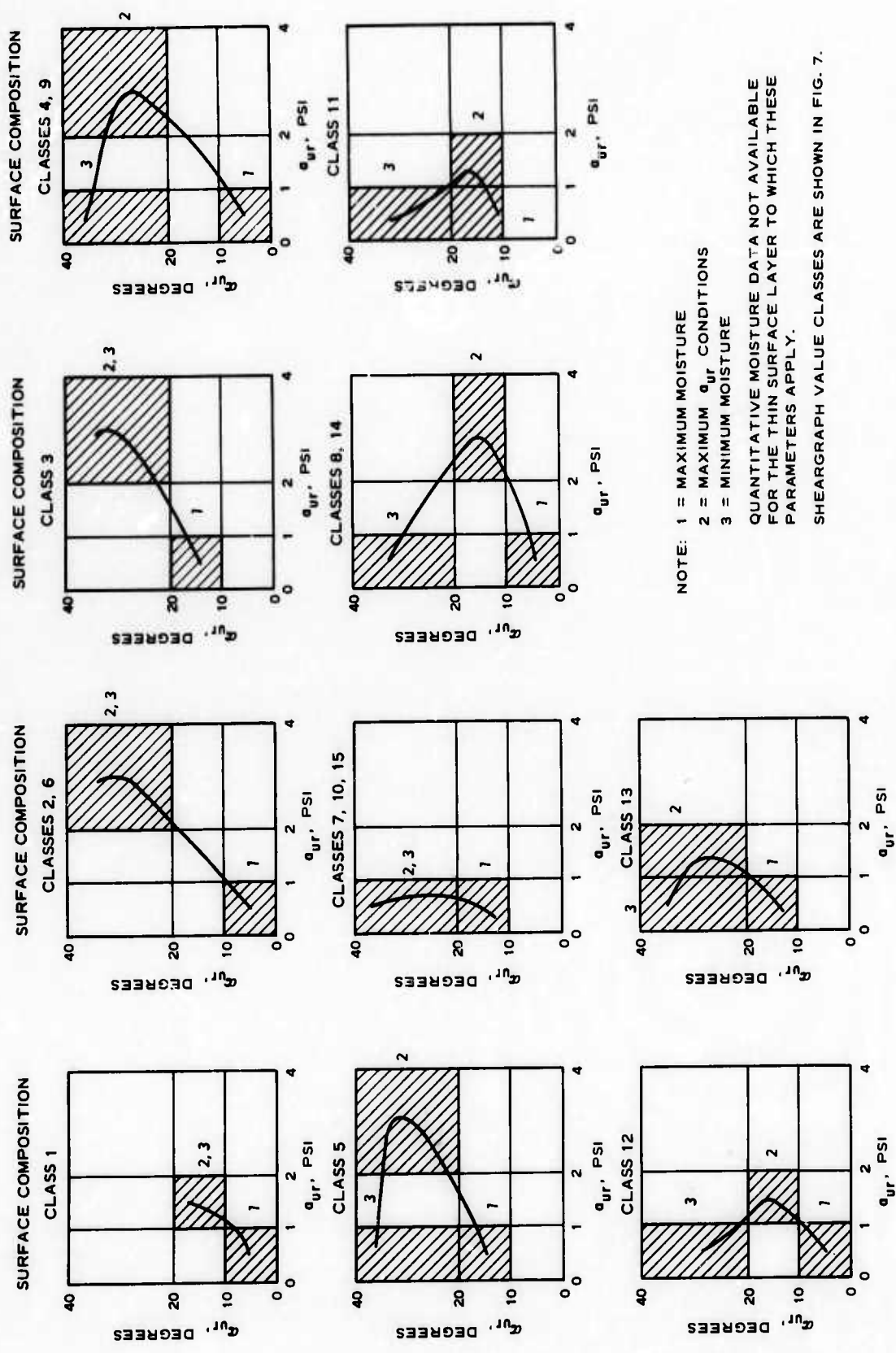


Fig. 9. Categorization of soil surface strength-moisture condition relations

moisture content and at that moisture content that produced the maximum a_{ur} value. The curves on the diagrams in fig. 9 indicate the estimated central tendency of the field data. These diagrams make it possible to associate each surface composition class with a sheargraph value class regime.

Application of recognition criteria

43. The sequence in which recognition criteria were applied in the actual interpretation process of surface composition classes (table 1) was as follows:

- a. The first step separated the broad, low, alluvial plains; the broad, rounded, upland terraces; and the strong relief features formed by bedrock. The bedrock relief features were assigned to class 12 without further subdivision.
- b. In the upland terraces, poorly drained valley bottoms and lower slopes were separated from the well drained upper slopes, using the criterion that well drained areas must be separated from surface drainage features by a slope of at least 2 percent over a distance of at least 100 m. The poorly drained areas were assigned to class 5, the well drained areas to class 11.
- c. In the broad alluvial plains, the dominant relief features were natural levees and village platforms; these were delineated as class 13. Most of the remaining areas consisted of low-lying paddies, in which distinction on the basis of soil textures was possible. Sandy soils were recognized from undulating surfaces reflected in mottled photo tones, numerous trees, and close association with the broad upland terraces of class 11; these soils were assigned to class 5. Fine-grained soils of low plasticity were characterized by numerous trees and termite mounds, faint mottling, and distribution along the margins of the plain or adjacent to natural levees. These were mapped as class 4.
- d. Although distinct relief features comparable to natural levees were lacking in these soils, in places they exhibited a rolling surface with slopes of more than 2 percent. Field data indicated that 2 percent slope was critical to the quality of drainage in these soils, and accordingly, areas exhibiting slopes steeper than 2 percent were distinguished as class 9.
- e. Fine-grained soils of high plasticity occurred in the broad, low central parts of the alluvial plains and in small pockets and depressions elsewhere; these showed highly uniform tones, almost complete absence of trees and termite mounds, and relatively large, regular field patterns. The tilled areas of these soils were mapped as class 8, the major untilled areas as class 10; this distinction was made

because of an apparent effect of regular tilling on surface strength parameters in these highly plastic soils.

- f. Swamps, marshes, and undrained depressions could be recognized from dark tones or standing water in photographs taken during the dry season. They were distinguished from all the other classes as areas in which the water table was sufficiently near the surface to prevent seasonal drying. These areas were mapped as class 2, 3, 6, or 7, depending on the primary class (4, 5, 8, or 10, respectively) with which they were associated.
- g. Two types of complexes occurred in the alluvial plains-- areas underlain at a shallow depth by hard laterite and areas underlain at a shallow depth by limestone. The lateritic areas were characterized by distinctive mottled dark tones combined with a thin and patchy pattern of cultivation. The limestone areas showed distinctive karst development with numerous sinkholes and lack of integrated drainage. Because of the unpredictable variations in depth of soil, both kinds of areas showed highly variable soil strengths within short distances. The tilled portions of both were mapped as class 14, the untilled portions as class 15.
- h. The final component of the alluvial plains consisted of highly organic portions of the tidal flats and coastal depressions of the Pran Buri and Chanthaburi areas. These were without visible relief and extremely dark-toned. They were mapped as class 1.

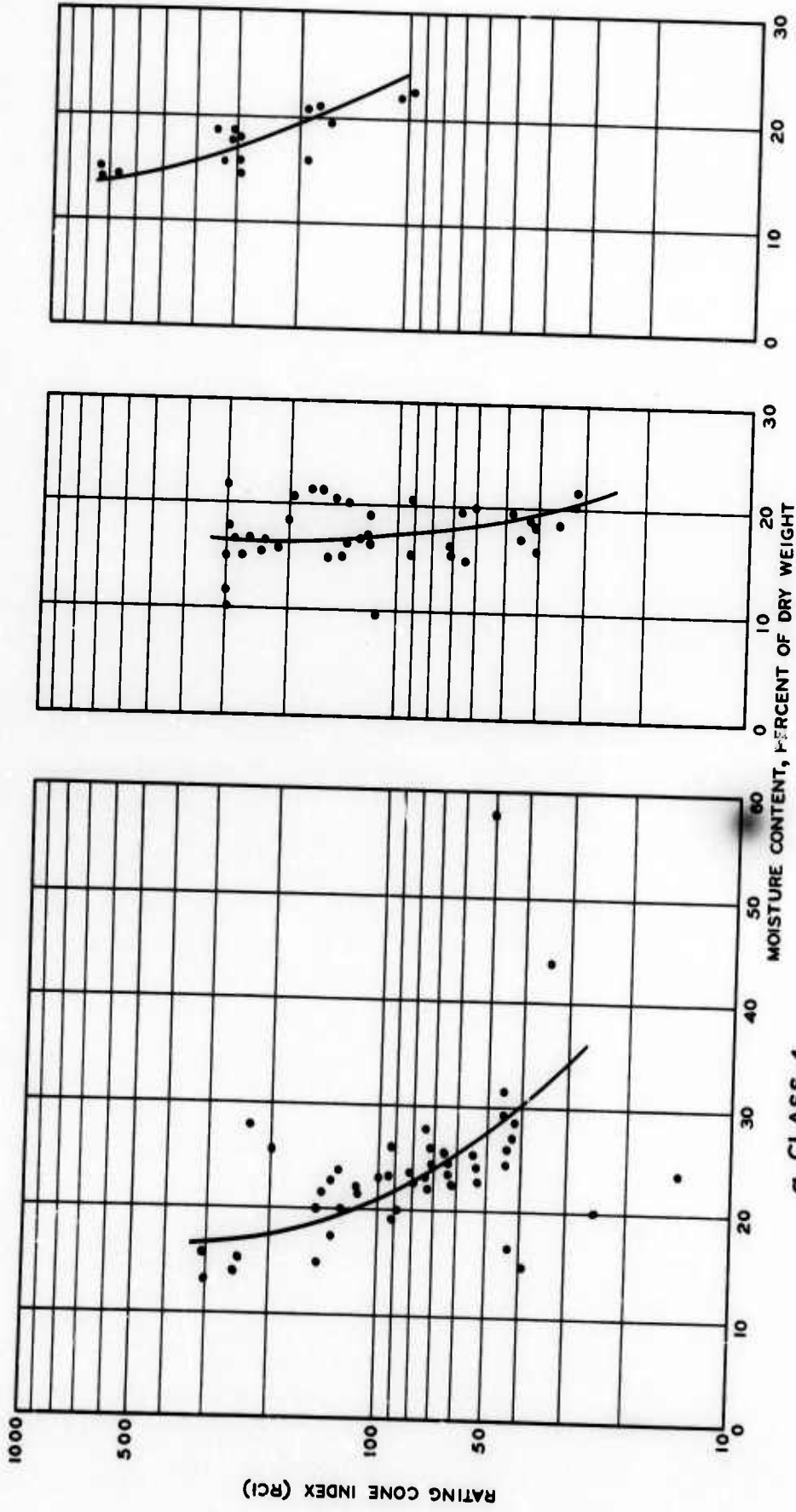
44. Photographs 1-4 are stereopairs of vertical aerial photographs where 9 of the 15 surface composition classes have been identified through the procedure described above. Photographs 5-14 are ground views of selected sample sites with the soil consistency classes indicated.

Map Preparation

45. With the completion of the photo-interpretation keys, it became possible to compile a legend for the soil factor-family maps. The 15 recognizable classes of combinations of photo features, as defined in table 1, were numbered consecutively, and the ranges of soil strength associated with each were tabulated, as illustrated in table 2. Thus, the column at the left in table 2 (headed "Map Unit") is identical with the column at the left in table 1 (headed "Class"); map unit 4 is equivalent to class 4, etc.

46. Mapping was accomplished by stereoscopic examination of air photos. The scales of the air-photo coverage within the mapped areas are shown in fig. 1. Map boundaries were drawn using the predetermined photo-interpretation criteria shown in table 1. As mapping progressed, each field study site was identified as to its mapping class, and data on strength values and moisture conditions were entered on charts for that class (see fig. 10). This site identification was made according to photo-interpretation criteria rather than consideration of the data actually obtained. The latter would have involved map correction in only insignificant small areas surrounding the data point, whereas the method used gave an objective appraisal of map reliability and degree of variation within a mappable unit. The predetermined photo-interpretation criteria were consistently followed. Therefore, the spread of values for field data within any one class is fairly indicative of the range and pattern of strength variations with moisture as shown in table 2 and figs. 9 and 11. The overlapping of several USCS soil types in the classes shown in table 1 as well as the degree of scatter of the RCI-moisture content plots (fig. 10) is an indication of the less-than-perfect nature of the photo-interpretation criteria. The classification techniques and map delineations are the best that could be developed from the data available, but are not necessarily those that would result if additional data had been available. Because of the somewhat crude and overlapping boundaries of the photo-interpretation criteria, the soil strength data presented are less useful for predicting individual vehicle performance than for selecting vehicle types for strategic planning and development of vehicle design.

47. It should be noted that all the soils of a given region rarely, if ever, exhibit the same extreme of moisture conditions simultaneously. This is particularly notable in the wet season when soils may range from saturated to dry within short distances merely as a result of local rainfall conditions. A rough approximation of this variability is indicated in figs. 12 and 13, which show the frequency distribution of RCI values actually observed during a major wet season that lasts from mid-June to mid-December. Only those classes from which the data base was large enough to be of likely significance are charted. It should also be noted and



a. CLASS 4

b. CLASS 5

c. CLASS 13

Fig. 10. Rating cone index versus moisture content for surface composition classes 4, 5, and 13

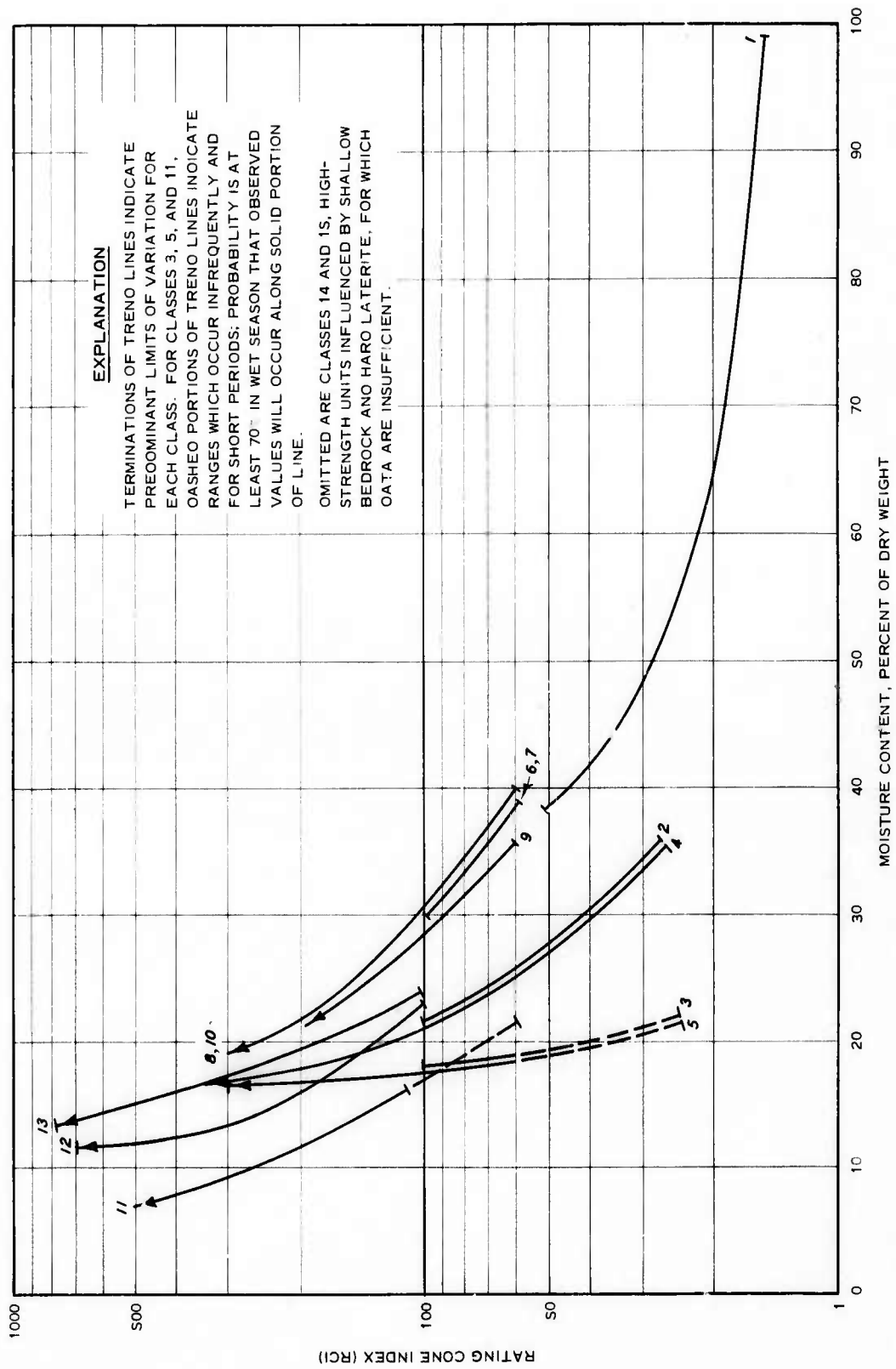


Fig. 11. Characteristic relations of rating cone index to moisture contents for surface composition classes

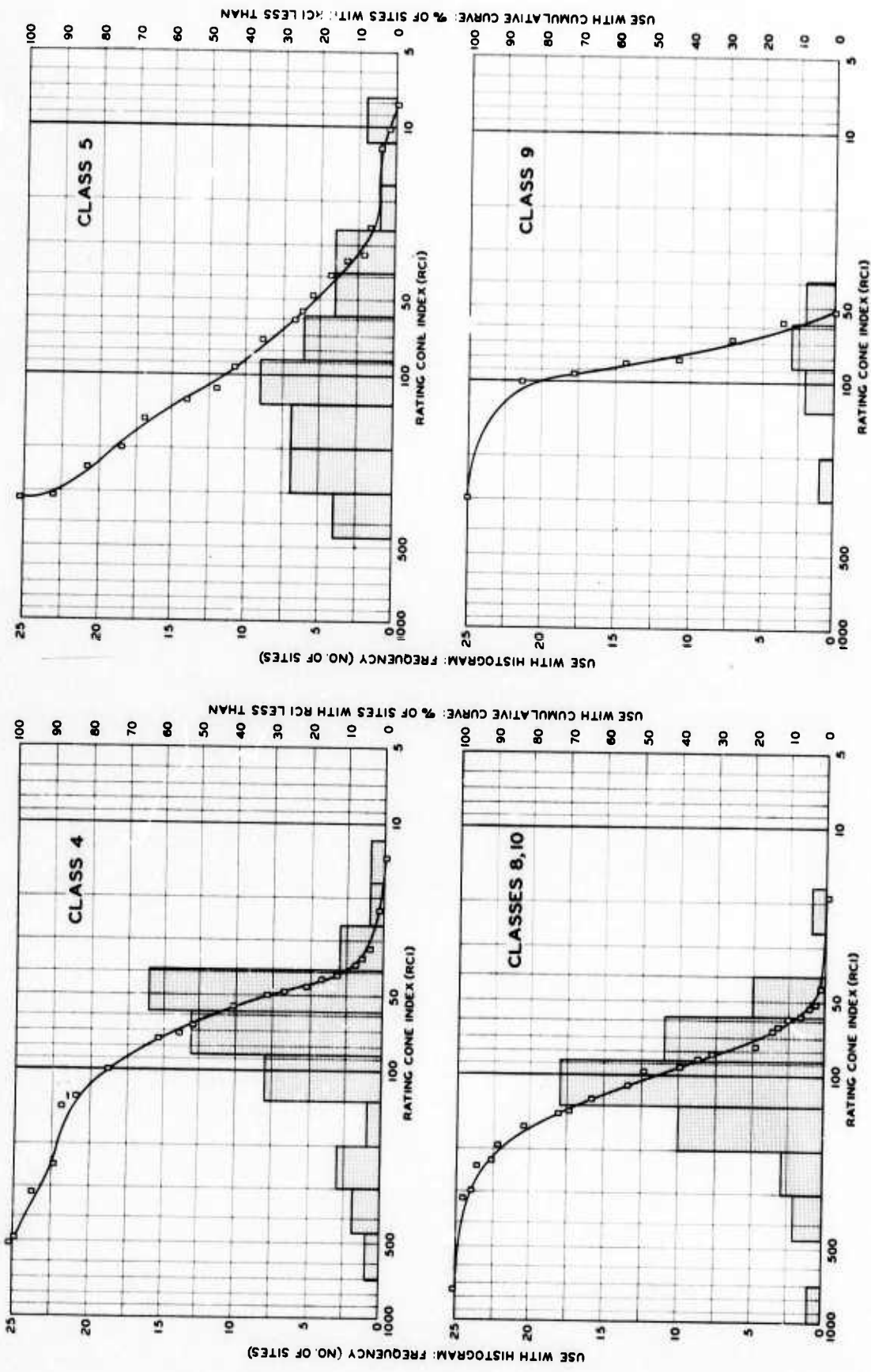


Fig. 12. Frequency of observed values for rating cone index (15- to 13-cm layer) from mid-June through mid-December from mapping classes 4, 5, 8, 9, 10, and 9

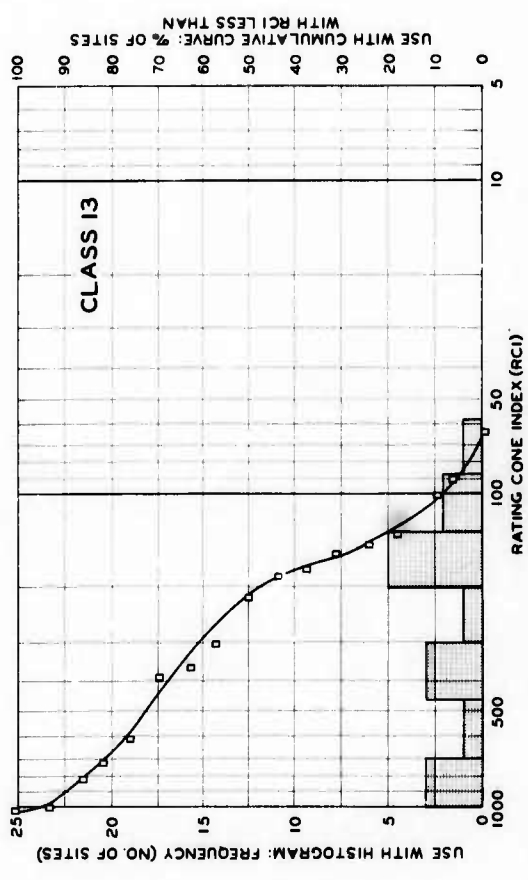
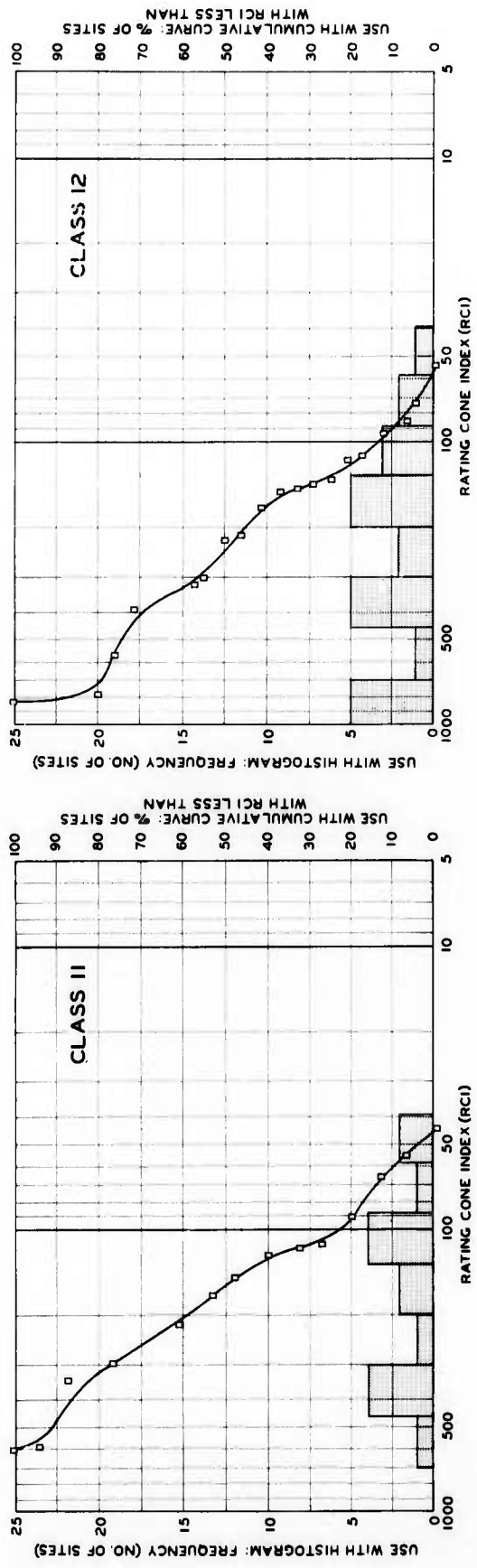


Fig. 13. Frequency of observed values for rating cone index (15- to 30-cm layer) from mid-June through mid-December for mapping classes 11, 12, and 13

emphasized that the frequency distributions illustrated in figs. 12 and 13 are derived from site data, and that the sites were not randomly distributed within the study areas, or distributed in proportion to the area of occurrence of the condition being sampled. Thus, no interpretation of areal extent or of temporal frequency should be made on the basis of these diagrams; they are intended only to indicate the total range of variation and the distribution of values within the sample population.

48. Factor-family maps were prepared by transferring class boundaries from air photos to the maps. Because the map scale (1:50,000) was usually smaller than the scale of the air photos, the data had to be reduced when the area outlines were transferred from the air photos to the maps.

49. The surface composition factor-family maps of the six study areas are presented in Volume VIII of this report series. These maps are on base sheets at a scale of 1:50,000 taken from the Army Map Service (AMS) Series L708. The limits of these maps do not, in all instances, coincide with those of the AMS sheets because new base sheets were made, where needed, to reduce the number of partially mapped sheets (see fig. 14). These limit changes were in most cases a matter of shifting the latitude or longitude 5 or 10 deg from those of the AMS sheets. Preparation of new base sheets resulted in a reduction of the total number of base sheets covering the six study areas from 32 to 25.

50. A portion of a surface composition factor-family map of the Lop Buri study area (sheet LB III) and the accompanying legend are shown in fig. 15. Since only a portion of the map is shown, all combinations included in the legend do not occur on the map segment.

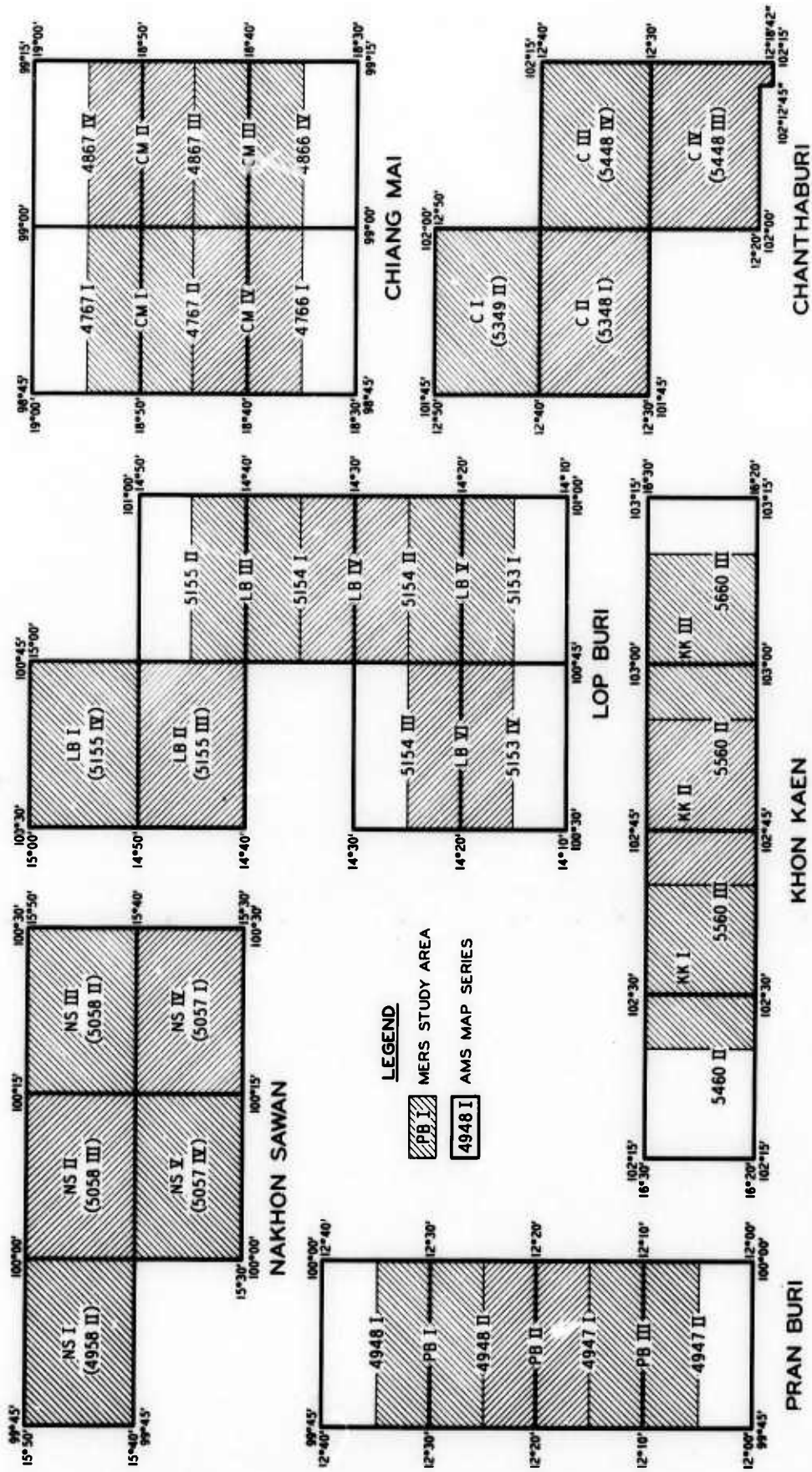


Fig. 14. Relation of MERS and AMS quadrangles

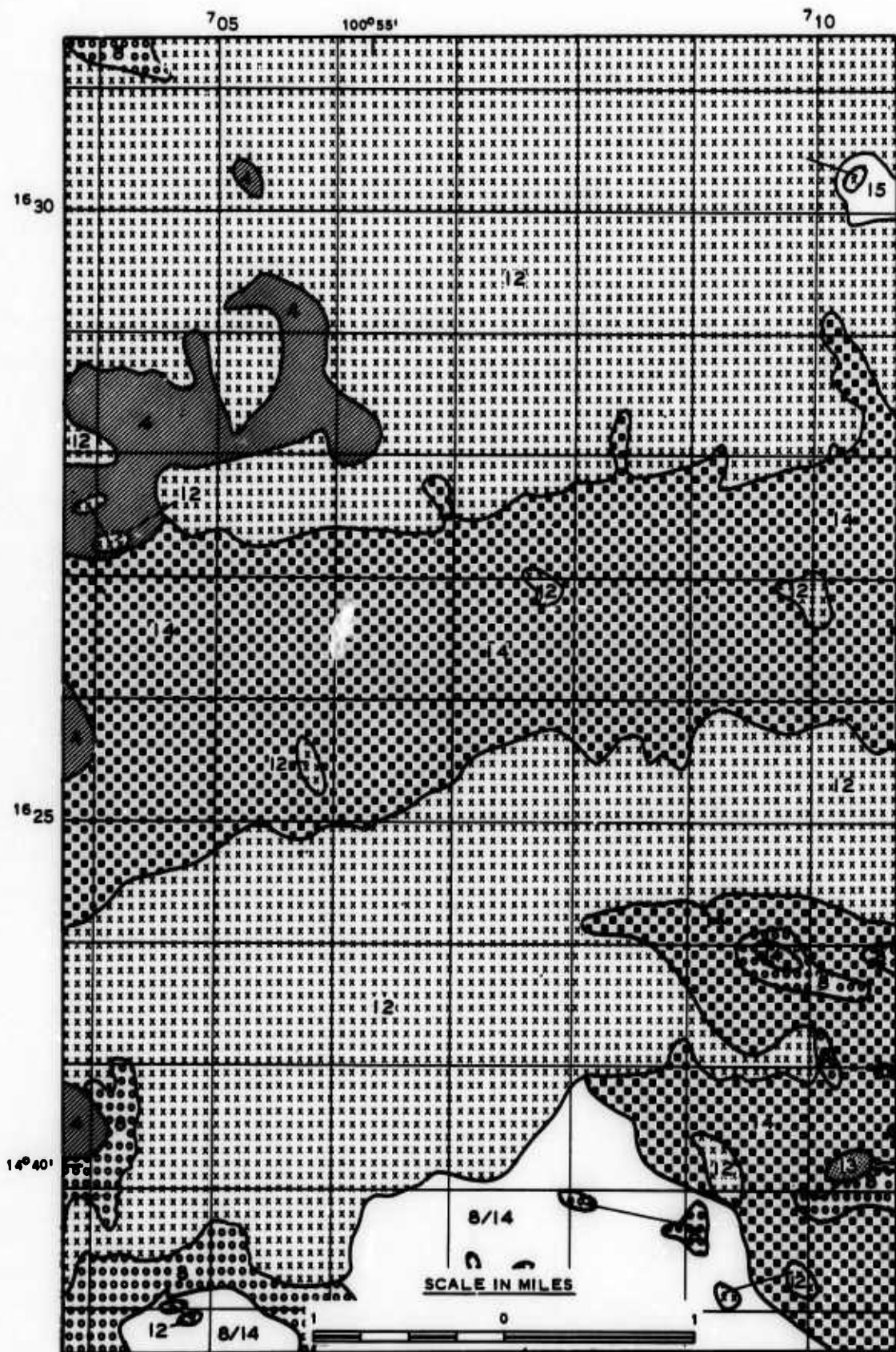


Fig. 15. Surface composition factor-family map of a portion of MERS sheet LB III in the Lop Buri study area (sheet 1 of 2)

LEGEND

Unit	Soil Mass Strength		Soil Surface Strength								
	Maximum Moisture	Minimum Moisture	Maximum Moisture			Minimum Moisture			Conditions where maximum a_{ur} occurs		
	RCI	RCI	a_{ur}		α_{ur} deg	a_{ur}		α_{ur} deg	a_{ur}		α_{ur} deg
			psi	kg/cm ²		psi	kg/cm ²		psi	kg/cm ²	
	10-25	>25-60	0-1	0-0.07	0-10	1-2	0.07-0.14	10-20	Minimum moisture conditions		
	>25-60	>60-100	0-1	0-0.07	0-10	2-4	0.14-0.28	20-40	Minimum moisture conditions		
	>25-60*	>60-100	0-1	0-0.07	10-20	2-4	0.14-0.28	20-40	Minimum moisture conditions		
	>25-60	>100	0-1	0-0.07	0-10	0-1	0-0.07	20-40	2-4	0.14-0.28	20-40
	>25-60*	>100	0-1	0-0.07	10-20	0-1	0-0.07	20-40	2-4	0.14-0.28	20-40
	>60-100	>60-100	0-1	0-0.07	0-10	2-4	0.14-0.28	20-40	Minimum moisture conditions		
	>60-100	>60-100	0-1	0-0.07	10-20	0-1	0-0.07	20-40	Minimum moisture conditions		
	>60-100	>100	0-1	0-0.07	0-10	0-1	0-0.07	20-40	2-4	0.14-0.28	10-20
	>60-100	>100	0-1	0-0.07	0-10	0-1	0-0.07	20-40	2-4	0.14-0.28	20-40
	>60-100	>100	0-1	0-0.07	10-20	0-1	0-0.07	20-40	Minimum moisture conditions		
	>60-100*	>100	0-1	0-0.07	10-20	0-1	0-0.07	20-40	1-2	0.07-0.14	10-20
	>100	>100	0-1	0-0.07	0-10	0-1	0-0.07	20-40	1-2	0.07-0.14	10-20
	>100	>100	0-1	0-0.07	10-20	0-1	0-0.07	20-40	1-2	0.07-0.14	20-40
	Complex of 60-100 and >100	>100	0-1	0-0.07	0-10	0-1	0-0.07	20-40	2-4	0.14-0.28	10-20
	Complex of 60-100 and >100	>100	0-1	0-0.07	10-20	0-1	0-0.07	20-40	Minimum moisture conditions		

Note: Blank areas are water bodies.

a_{ur} Shear strength at zero normal load.

α_{ur} Angle of internal friction.

* Maximum moisture has less than 30 percent probability of occurrence during the wet season. Lowest strengths commonly observed are >60-100 for Units 3 and 5, more than 100 for Unit 11.

Units do not occur on this map.

Fig. 15. (sheet 2 of 2)

PART V: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

51. Soils of the study areas have been mapped according to the classes shown in table 1, and the results are shown in 25 plates in Volume VIII. The criteria used in establishing these classes were (a) that each class must be identifiable through use of air-photo techniques, and (b) that each class must exhibit a distinctive pattern of strength associated with variation in moisture content.

52. It is concluded that:

- a. The moisture content-soil type-soil strength relations are the most valuable in developing a classification system for mapping purposes (paragraph 26).
- b. Because moisture content is time-variable, the one-time observations used to a large extent in this study offer only a good indication of the soil strength-moisture content relations that exist. Neither these relations nor the classification system derived from them is to be construed as final, but only as approximations (paragraph 29).
- c. The soil surface strength has a modifying influence on the classification system developed from the soil moisture relations. In certain soil types the tillage of the soil proved to be significant (paragraph 37).
- d. Maximum shear strength at zero normal load rarely occurs at the maximum or minimum soil moisture content for a given soil (paragraph 41).
- e. A compromise between the desired degree of mapping class refinement and that dictated by the photo-interpretation criteria is necessary because of the nature of the field data (paragraphs 34 and 40).
- f. The significant photo-interpretation criteria are topographic position, drainage, land use, and vegetation (paragraphs 35, 36, and 37).
- g. The mapping program delineates areas with roughly equivalent trafficability characteristics based on soil strength. When sample site data are extrapolated to unsampled areas, the degree of mapping refinement is, of necessity, only fair to low (paragraph 46).
- h. The greatest variation in soil strength and therefore the greatest trafficability problems occur under maximum soil moisture conditions. Conversely, few trafficability

problems resulting from insufficient soil strength occur under minimum soil moisture conditions. Areas exhibiting exception to this generalization are marshes, swamps, and other areas with an extremely high water table where moisture contents are high all year (table 2).

Recommendations

53. It is recommended that:

- a. Additional studies be conducted on the use of air-photo identification techniques in classifying soil strength conditions. This approach is believed to be basically sound; however, more field verifications of predicted values will help to determine the reliability of this approach. Similarly, an increase in the number of strength measurements at field sample sites is needed where the variance of the maximum and minimum RCI values used to obtain the RCI spreads across several class ranges. Additional measurements may tend to group values within narrow limits.
- b. The feasibility of establishing a more comprehensive breakdown of moisture conditions should be studied. Even the maximum and minimum moisture conditions used in this study are not always adequate to describe soil strength. For example, the maximum angle of internal friction of most soil classes occurs at a moisture content intermediate between maximum and minimum moisture contents.

LITERATURE CITED

1. U. S. Department of Defense, "Unified Soil Classification System for Roads, Airfields, Embankments, and Foundations," MIL-STD-619A, 20 Mar 1962, U. S. Government Printing Office, Washington, D. C.
2. U. S. Department of Agriculture, "Soil Survey Manual," Agricultural Handbook No. 18, Aug 1961, U. S. Government Printing Office, Washington, D. C.
3. U. S. Army Engineer Waterways Experiment Station, CE, "Forecasting Trafficability of Soils," Technical Memorandum No. 3-331, Vicksburg, Miss.
 - a. Report 1, "Meteorological and Soil Data, Vicksburg, Mississippi, 1948-1949," Oct 1951.
 - b. Report 2, "Meteorological and Soil Data, Vicksburg, Mississippi, 1949-1951," June 1952.
 - c. Report 3, "The Development of Methods for Predicting Soil Moisture Content," Oct 1954 (in three volumes and one appendix).
 - d. Report 4, "Information for Predicting Moisture in the Surface Foot of Various Soils," Feb 1957.
 - e. Report 5, "Development and Testing of Some Average Relations for Predicting Soil Moisture," June 1959.
4. Department of the Army, "Soil Trafficability," Technical Bulletin TB ENG 37, 10 July 1959, U. S. Government Printing Office, Washington, D. C.
5. Cohron, G. T., "Soil Sheargraph," Agricultural Engineering, Vol 44, No. 10, Oct 1963, pp 554-556.
6. U. S. Army Engineer Waterways Experiment Station, CE, "Soil Moisture and Strength," Environmental Data Collection Manual, Vol 2 (unpublished).
7. Rula, A. A., et al, "Environmental Factors Affecting Ground Mobility in Thailand," Technical Report No. 5-625, May 1963 (Appendixes B and C), U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.
8. Kingdom of Thailand, Ministry of National Development, "Interim Report on the Great Soil Group Survey," Vols I, II, III, and IV, Oct 1964-June 1965.
9. _____, "Interim Reports on Semi-detailed Soil Surveys," Vol I.
10. Pendleton, R. L., Thailand; Aspects of Landscape and Life, Duell, Sloan, and Pearce, New York, 1962.
11. Randolph, D., "An Analytical Model for Predicting Cross-Country Vehicle Performance; Appendix B: Vehicle Performance in Lateral and Longitudinal Obstacles," Technical Report No. 3-783, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss. (in preparation).

12. Department of the Army, "Data Sheets for Ordnance Type Materiel," Technical Manual 9-500, Sept 1962, Washington, D. C.
13. Kennedy, J. G., Collins, J. G., and Smith, M. H., "Moisture-Strength Characteristics of Selected Soils in Thailand," Technical Report No. 3-791, Aug 1967 (in two volumes), U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.
14. Meyer, M. P., "Comparison of Engineering Properties of Selected Temperate and Tropical Surface Soils," Technical Report No. 3-732, June 1966, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

BLANK PAGE

Table 1
Characteristics of Surface Composition Classes

Class	Recognition Characteristics	Soils	Drainage	Land Use
1	Tidal flats and coastal depressions; swampy, marshy, or barren; dark tone on photo	Fine-grained, high plasticity, high organic content; OH, MH, CH	Very poor; soil rarely if every dry because of a shallow water table	*
2	Topographic depressions within class 4 areas	Same as class 4 below	Very poor; shallow water table; soil rarely dries out during dry season	*
3	Topographic depressions within class 5 areas	Same as class 5 below	Very poor; shallow water table; soil rarely dries out during dry season	*
4	Alluvial plains, low relief, paddy; termite mounds and trees common	Fine-grained, low plasticity; CL with some CH, ML	Poor	*
5	Drainageways and lower side slopes of class 11; and adjacent rolling areas of low relief with mottled photo tones; generally in paddy, with numerous trees and termite mounds in rolling areas	Fine-grained, low plasticity, occasional coarse-grained soils with fines; CL, ML, with some SM	Variation from good to poor within short distances	*
6	Topographic depressions within class 8 areas	Same as class 8 below	Very poor; shallow water table; soil rarely dries out during dry season	Tilled
7	Topographic depressions within class 10 areas; usually very small in areal extent	Same as class 8 below	Very poor; shallow water table; soil rarely dries out during dry season	Untilled
8	Extremely flat, treeless, uniform alluvial plains. Predominantly paddy without trees or termite mounds	Fine-grained, high plasticity; CH with some CL, MH	Poor	Tilled
9	Areas of broad, low alluvial plains in which slopes exceed 2 percent. Primarily paddy; orchards common in coastal areas. Generally adjacent to more gently sloping areas of class 4	Fine-grained, high and low plasticities; MH, ML, CL, and some SM	Imperfect	*
10	Untilled areas of moderate areal extent associated with and otherwise similar to class 8	Same as class 8	Same as class 8	Untilled
11	Broad, rolling upland areas (high terraces), generally wooded. Separated from surface water bodies by at least 2 percent slope over distance of at least 100 m	SM, with occasional fine-grained soils	Good	*
12	Strong relief features: hills, mountains, and rock terraces. Predominantly uncultivated	Coarse-grained with fines, low or no plasticity; CL, SM, ML, CH with some SC-SM, MH, shallow bedrock	Good	*
13	Natural levees, village platforms. Distinct, generally linear relief features at least 1 to 2 m above surrounding alluvial plains. Villages, orchards, gardens, woods	Fine-grained, low plasticity; CL with SM or SP, ML, CL-ML	Good	Village use
14	Flat to rolling surfaces with mottled tones indicating shallow limestone or hard laterite. Cultivated and uncultivated plots closely intermingled. Areas predominantly cultivated are mapped as class 14 areas; predominantly uncultivated areas are mapped as class 15 areas	Fine-grained, variable plasticity; CL, CH with some SM, shallow bedrock or hard laterite	Prevaillingly good but with numerous, small, poorly drained depressions	Tilled
15	Same as class 14	Same as class 14	Same as class 14	Untilled

* No significant effect upon soil strength.

Table 2

Legend for Surface Composition Factor-Family Mapping Units

Map Unit	Soil Mass Strength		Soil Surface Strength					
	Maximum Moisture RCI	Minimum Moisture RCI	Maximum Moisture		Minimum Moisture		Conditions Where Maximum a_{ur} Occurs*	
			a_{ur}	α_{ur}	a_{ur}	α_{ur}	a_{ur}	α_{ur}
1	10-25	>25-60	0-1	0-10	1-2	10-20	Minimum moisture conditions	
2	>25-60	>60-100	0-1	0-10	2-4	20-40	Minimum moisture conditions	
3	>25-60**	>60-100	0-1	10-20	2-4	20-40	Minimum moisture conditions	
4	>25-60	>100	0-1	0-10	0-1	20-40	2-4	20-40
5	>25-60**	>100	0-1	10-20	0-1	20-40	2-4	20-40
6	>60-100	>60-100	0-1	0-10	2-4	20-40	Minimum moisture conditions	
7	>60-100	>60-100	0-1	10-20	0-1	20-40	Minimum moisture conditions	
8	>60-100	>100	0-1	0-10	0-1	20-40	2-4	10-20
9	>60-100	>100	0-1	0-10	0-1	20-40	2-4	20-40
10	>60-100	>100	0-1	10-20	0-1	20-40	Minimum moisture conditions	
11	>60-100**	>100	0-1	10-20	0-1	20-40	1-2	10-20
12	>100	>100	0-1	0-10	0-1	20-40	1-2	10-20
13	>100	>100	0-1	10-20	0-1	20-40	1-2	20-40
14	Complex of >60-100 and >100	>100	0-1	0-10	0-1	20-40	2-4	10-20
15	Complex of >60-100 and >100	>100	0-1	10-20	0-1	20-40	Minimum moisture conditions	

Note: a_{ur} , shear strength at zero normal load, psi. α_{ur} , ultimate angle of internal friction, degrees.

* Maximum surface strength occurs under minimum moisture conditions except where otherwise indicated; e.g. maximum surface strength for map unit 4 occurs with a_{ur} between 2 and 4 and α_{ur} between 20 and 40.

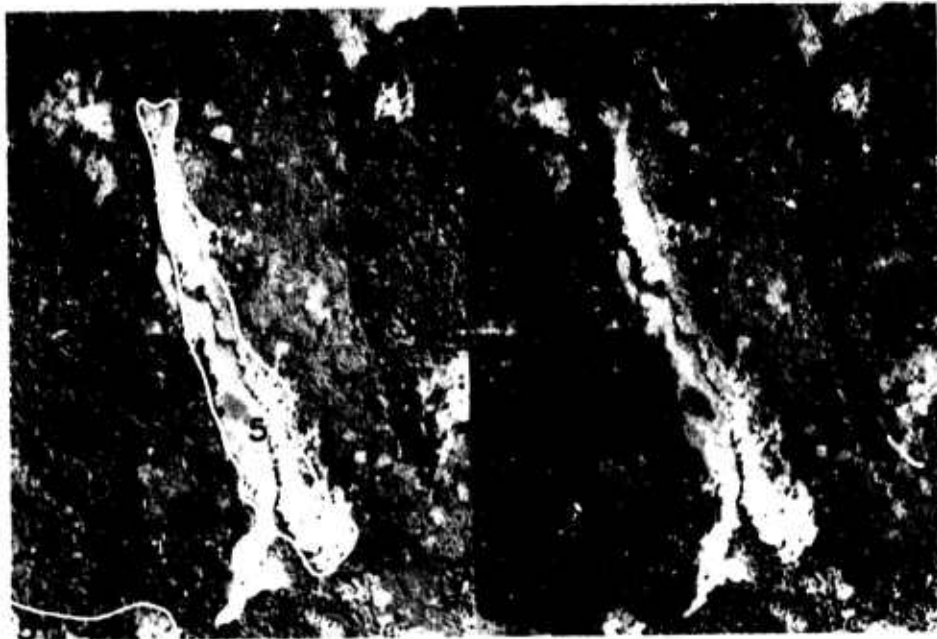
** Maximum moisture has less than 30 percent probability of occurrence during the wet season. Lowest strengths commonly observed are >60-100 for map unit 3 and 5, more than 100 for map unit 11.



Photograph 1. Stereopair of vertical aerial photographs of a part of the Lop Buri study area with surface composition classes 4, 8, and 13 identified



Photograph 2. Stereopair of vertical aerial photographs of a part of the Lop Buri study area with surface composition classes 8 and 15 identified



Photograph 3. Stereopair of vertical aerial photographs in the Khon Kaen study area with surface composition classes 5 and 11 identified



Photograph 4. Stereopair of vertical aerial photographs within the Chanthaburi study area showing surface composition classes 1, 6, 8, and 12



Photograph 5. Site TC-4C in the Nakhon Sawan study area. This site was located on a natural levee and mapped as class 13



Photograph 6. View of Nakhon Sawan site TC-8C, which was classified as surface composition class 12



Photograph 7. Surface composition class 10 that occurs within the Nakhon Sawan study area at site TC-6C



Photograph 8. A rice paddy in the Nakhon Sawan study area where site TC-8E was located. Surface composition at this site was mapped as class 8



Photograph 9. View of site TC-13C in the Lop Buri study area. Surface composition at this site was mapped as class 14



Photograph 10. Lop Buri site TC-10A. This site was located in a rice paddy and was mapped as class 8



Photograph 11. Surface composition site TC-21E in the Chiang Mai study area; mapped as class 4.



Photograph 12. View of the Chiang Mai site TC-19A, which was classified as class 12.



Photograph 13. Loess clay at site TC-60C in the Pran Bari study area, which was mapped as class 15



Photograph 14. Pran Bari site TC-39B, which was mapped as surface composition class 5

NAKHON SAWAN STUDY AREA

Table A1
Summary of Surface Composition Field Data
Nashua Basin

Map Class*	Site No.	Date Sampled	APN Map Sheet**	Location Grid Coordinates	Figure No.	Topographic Position	Slope %	Unified Soil Classification System				Soil Strength Measurements					Moisture Content %	
								Fines % by Weight	Atterberg Limits			Roll Type	Cone Index	Remold. Ind. Index	Rating Cone Index	Sheargraph		
									CL	PL	LI					Sur. psi		Sur. deg.
12	1-T-1	20/7/64	5057IV	213317	A5	BF	--	64	37	18	19	CL	258	--	--	0.0	29	--
8	1-T-2	21/7/64	5058III	115380	AF	BF	--	34	14	14	0	SM	300	--	--	1.5	21	--
nm	1-T-3	21/7/64	4958I	935603	--	BF	--	65	30	17	13	CL	165	--	--	2.0	29	--
nm	1-T-4	21/7/64	4958I	930660	--	BF	--	45	18	10	8	SC	223	--	--	0.6	25	--
10	1-T-5	22/7/64	5058III	130350	AD	BD	--	99	63	30	33	CH	137	--	--	0.9	15	--
8	1-T-6	22/7/64	5058III	143345	AD	BF	--	81	36	24	14	CL	125	--	--	0.0	31	--
12	1-T-7	22/7/64	5058III	135375	AD	BF	--	38	21	14	7	SM-SC	600	--	--	0.7	27	--
13	1-T-8	22/7/64	5058III	162345	AD	BF	--	66	29	20	9	CL	121	--	--	0.5	23	--
nm	1-T-9	1/8/64	4958I	908452	--	BD	--	84	50	21	29	CH	173	--	--	0.3	37	--
nm	1-T-10	1/8/64	4958I	849672	--	BF	--	81	25	17	8	CL	91	--	--	1.3	24	--
12	1-T-11	4/8/64	5057IV	210380	A5	BF	--	52	25	15	10	CL	183	--	--	0.5	27	--
12	1-T-12	4/8/64	5057IV	210660	A5	BF	--	82	70	23	47	CH	132	--	--	0.8	20	--
nm	1-T-13	4/8/64	5057IV	230140	--	BF	--	80	--	--	--	--	--	--	--	1.1	14	--
nm	1-T-14	4/8/64	5057IV	223147	--	TB	--	--	--	--	--	--	--	--	--	0.2	31	--
nm	1-T-15	4/8/64	5057IV	200140	--	NL	--	76	36	26	10	ML	429	--	--	1.8	12	--
nm	1-T-16	4/8/64	5057IV	200163	--	BD	--	49	42	18	24	SC	222	--	--	0.8	30	--
nm	1-T-17	4/8/64	5057IV	210190	--	BF	--	70	29	16	13	CL	519	--	--	1.0	18	--
5	1-T-18	5/8/64	4958II	835425	A1	BF	--	51	17	13	4	CL-ML	182	--	--	1.0	24	--
5	1-T-19	5/8/64	4958II	863437	A1	BF	--	65	26	19	7	CL	170	--	--	--	--	--
5	1-T-20	5/8/64	4958II	880415	A1	BF	--	--	--	--	--	--	--	--	--	--	--	--
nm	1-T-21	15/8/64	5057IV	261201	--	BF	--	46	21	12	9	SC	161	--	--	1.4	15	--
nm	1-T-22	15/8/64	5057IV	294178	--	BF	--	44	20	15	5	SM-SC	300+	--	--	1.9	22	--
nm	1-T-23	20/8/64	5057I	576207	A4	BF	--	45	23	12	11	SC	97	--	--	1.7	26	--
nm	1-T-24	20/8/64	5057I	570220	A4	BF	--	22	11	NP	--	SM	209	--	--	0.8	28	--
8	1-T-25	20/8/64	5057I	528246	A4	BF	--	54	25	14	11	CL	136	--	--	0.2	33	--
8	1-T-26	20/8/64	5057I	510250	A4	BF	--	46	37	14	23	SC	111	--	--	2.0	8	--
4	1-T-27	20/8/64	5057I	450235	A4	BF	--	88	82	25	57	CH	210	--	--	0.3	27	--
8	1-T-28	20/8/64	5057I	350290	A4	BF	--	51	34	16	18	CL	178	--	--	1.6	28	--
nm	1-TC-1A	18/8/64	5958I	955583	--	BF	0	52	27	13	14	CL	83	0.40	33	1.4	35	18.9
nm	1-TC-1B	18/8/64	5958I	957584	--	T	0	61	33	14	19	CL	132	1.00	132	0.8	32	20.6
nm	1-TC-1C	18/8/64	5958I	950589	--	UD	0	58	24	12	12	CL	58	0.67	34	2.1	27	24.0
nm	1-TC-1D	18/8/64	5958I	950589	--	UF	0	83	33	16	17	CL	133	0.63	84	0.8	31	26.3
nm	1-TC-1E	19/8/64	5958I	975562	--	BF	0	53	36	17	18	CL	305	0.67	204	0.2	25	25.2
nm	1-TC-1F	19/8/64	5958I	978563	--	BF	0	63	21	12	9	CL	140	0.58	81	1.9	28	18.7
nm	1-TC-1G	19/8/64	5958I	982568	--	TS	0.5	67	25	15	10	CL	253	0.70	177	0.0	29	15.7
nm	1-TC-2D	19/8/64	5958I	984570	--	T	0	90	29	17	12	CL	172	0.46	79	1.0	30	25.2
nm	1-TC-2E	19/8/64	5958I	994588	--	T	0	27	--	NP	SM	57	0.56	32	0.2	22	12.1	
5	1-TC-3A	19/8/64	4958II	987476	A1	T	0	49	19	14	5	SM-SC	382	0.32	122	0.0	31	10.1
5	1-TC-3B	19/8/64	4958II	993480	A1	BF	0	68	24	14	10	CL	107	0.54	58	0.7	45	21.8
13	1-TC-4A	20/8/64	5058III	115373	A2	NL	0	70	34	20	14	CL	238	0.58	138	0.2	30	20.8
4	1-TC-4B	20/8/64	5058III	115373	A2	SB	0	88	34	20	14	CL	135	0.41	55	1.6	12	22.5
13	1-TC-4C	20/8/64	5058III	115374	A2	NL	11	65	21	16	5	CL-ML	607+	1.86	1129+	0.6	13	14.2
5	1-TC-4D	20/8/64	5058III	101395	A2	BF	0	42	12	10	2	SM	87	0.22	19	0.0	20	13.3
13	1-TC-4E	20/8/64	5058III	110392	A2	T	0	41	15	14	1	SM	151	2.05	310	0.2	22	12.0
nm	1-TC-5A	21/8/64	5057IV	213215	--	LS	0.5	75	42	24	18	CL	255	--	tf	0.0	27	23.7
nm	1-TC-5B	21/8/64	5057IV	215214	--	LB	0.5	69	31	17	14	CL	211	1.23	260	0.2	30	20.1
nm	1-TC-5C	21/8/64	5057IV	224212	--	US	13	60	27	25	2	ML	750+	--	tf	--	--	15.8
nm	1-TC-5D	21/8/64	5057IV	227211	--	UF	0	82	43	24	19	CL	750+	--	tf	0.0	28	14.1
nm	1-TC-5E	21/8/64	5057IV	233209	--	UD	0	68	41	16	25	CL	129	0.70	90	0.7	13	26.4
13	1-TC-6A	22/8/64	5058I	207343	A2	NL	0	85	30	20	10	CL	277	0.62	172	0.0	31	28.4
12	1-TC-6B	22/8/64	5058III	207342	A2	BF	0	52	36	17	19	CL	693+	--	tf	0.2	27	23.5
10	1-TC-6C	22/8/64	5058III	207341	A2	BF	0	80	55	21	34	CH	80	0.81	55	0.4	15	30.4
12	1-TC-6D	22/8/64	5058III	207341	A2	T	0	81	56	20	36	CH	93	0.81	75	0.0	26	32.6
10	1-TC-6E	22/8/64	5058III	207341	A2	LS	1	86	70	27	43	CH	139	0.94	131	0.0	19	35.1
6	1-TC-6F	23/8/64	5057IV	226322	A5	BF	0	90	49	21	28	CL	96	0.72	69	0.1	7	36.5
12	1-TC-7B	23/8/64	5057IV	227322	A5	TB	4	51	35	18	17	CL	543+	--	tf	0.2	15	22.8
12	1-TC-7C	23/8/64	5057IV	227322	A5	T	0	73	60	28	32	CH	321	--	tf	0.7	19	26.6
12	1-TC-7D	23/8/64	5057IV	244318	A5	T	0	52	39	23	16	CL	713+	--	tf	1.4	11	10.5
4	1-TC-7E	23/8/64	5057IV	244318	A5	BF	0	58	28	12	16	CL	79	0.48	38	0.3	5	16.5
4	1-TC-7F	23/8/64	5057IV	243318	A5	BD	0	66	28	12	16	CL	271	0.48	130	1.0	27	17.9
12	1-TC-8A	24/8/64	5057IV	206259	A5	BF	0	66	30	16	14	CL	142	1.00	142	0.0	14	17.9
12	1-TC-8B	24/8/64	5057IV	206259	A5	TS	0.5	82	63	23	40	CH	382	--	tf	1.0	9	22.3
12	1-TC-8C	24/8/64	5057IV	233266	A5	US	5	48	25	18	7	SM-SC	750+	--	tf	1.0	12	8.7
12	1-TC-8D	24/8/64	5057IV	217268	A5	SB	0	95	35	28	7	ML	741+	--	tf	0.7	15	8.4
8	1-TC-8E	24/8/64	5057IV	207264	A5	BF	0	57	31	17	14	CL	127	0.74	94	3.4	7	32.6
12	1-TC-9A	25/8/64	5057IV	209322	A5	BF	0	59	43	19	24	CL	168	0.66	111	0.0	5	34.5
nm	1-TC-9B	25/8/64	5057IV	214187	A5	BD	0	23	26	13	13	GC	430+	--	tf	0.0	11	12.6
nm	1-TC-9C	25/8/64	5057IV	214187	A5	BF	0	41	18	12	6	SM-SC	750+	--	tf	0.0	14	6.8
nm	1-SGT-20	18/8/64	4958I	989526	--	BF	--	78	39	18	21	CL	281	--	--	0.2	35	--
5	1-SGT-23	18/8/64	4958II	900426	A1	BF	--	22	15	7	CL-ML	178	--	--	0.2	27	--	
5	1-SGT-27	18/8/64	4958II	997446	A1	BF	--	52	28	13	15	CL	277	--	--	0.2	47	--
nm	1-SGT-30	19/8/64	5057IV	233146	A5	BF	--	67	16	12	4	CL-ML	530	--	--	1.0	24	--

Note: All soil strength measurements except sheargraph measurements were made at a 15- to 30.5-cm depth. Sheargraph measurements were made at the surface.
 * nm, not mapped.
 ** Series L708, scale 1:50,000.
 † BF, bottomland flat; BD, bottomland depression; LS, lower slope; MS, middle slope; NL, natural levee; T, terrace; TS, terrace slope;
 SB, stream bottom; UD, upland depression; UF, upland flat; US, upper slope.
 †† sur, shear strength at zero normal load.
 ‡ sur, ultimate angle of internal friction.
 ††† tf, too firm

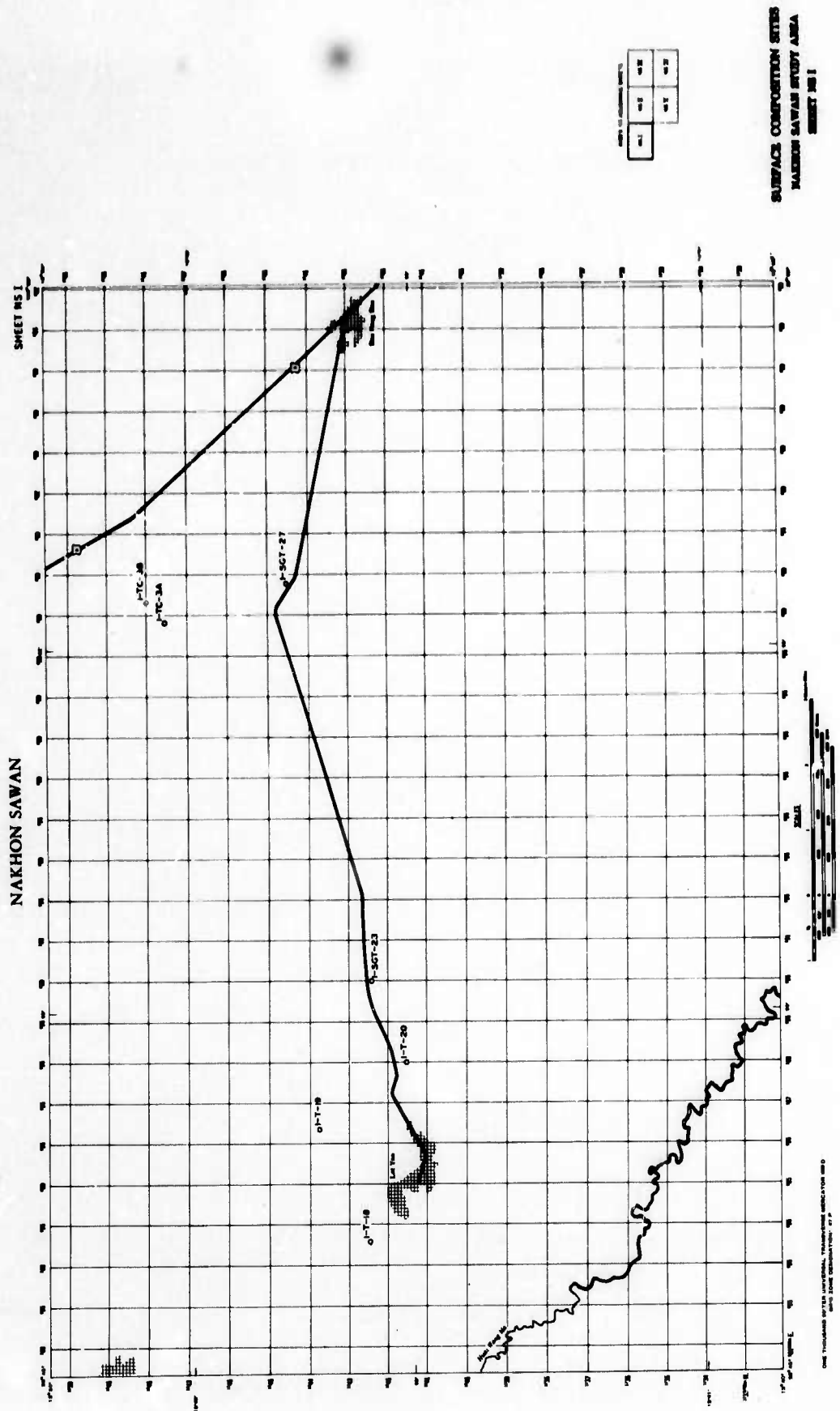
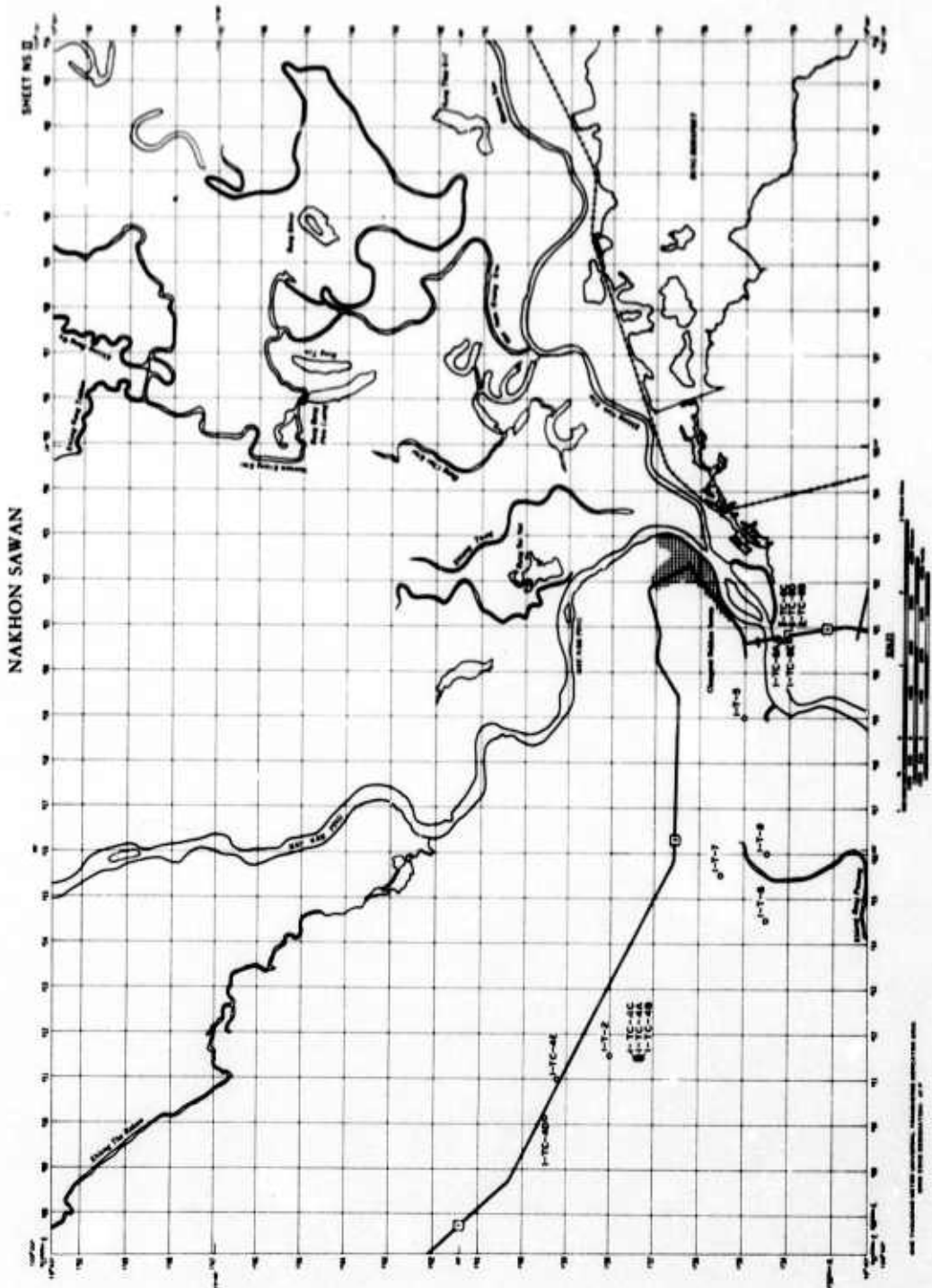


FIG. A1



0.1	0.2	0.3
0.4	0.5	0.6
0.7	0.8	0.9

SURFACE COMPOSITION SITES
NAKHON SAWAN STUDY AREA
SHEET NO. 2

A5

FIG. A2

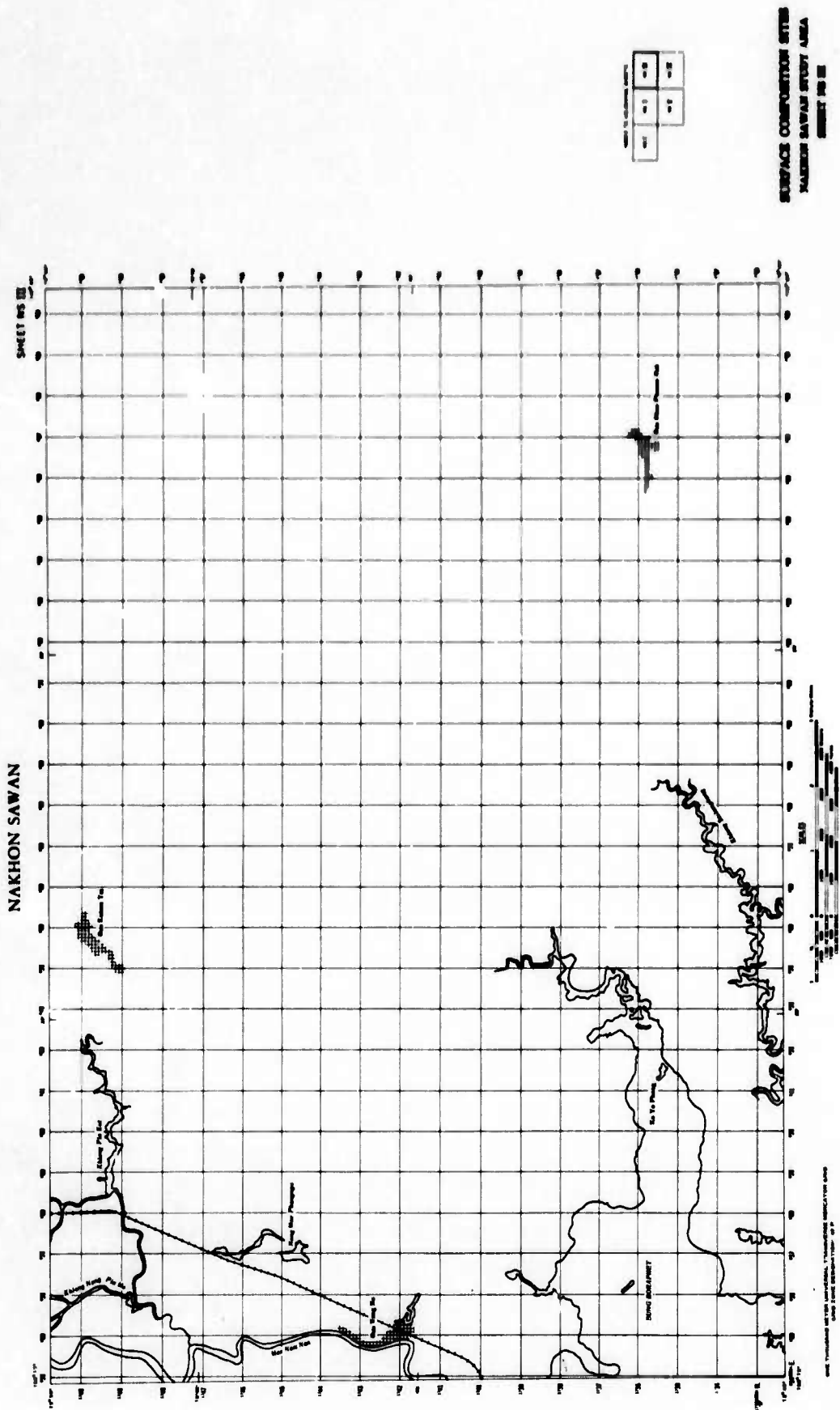
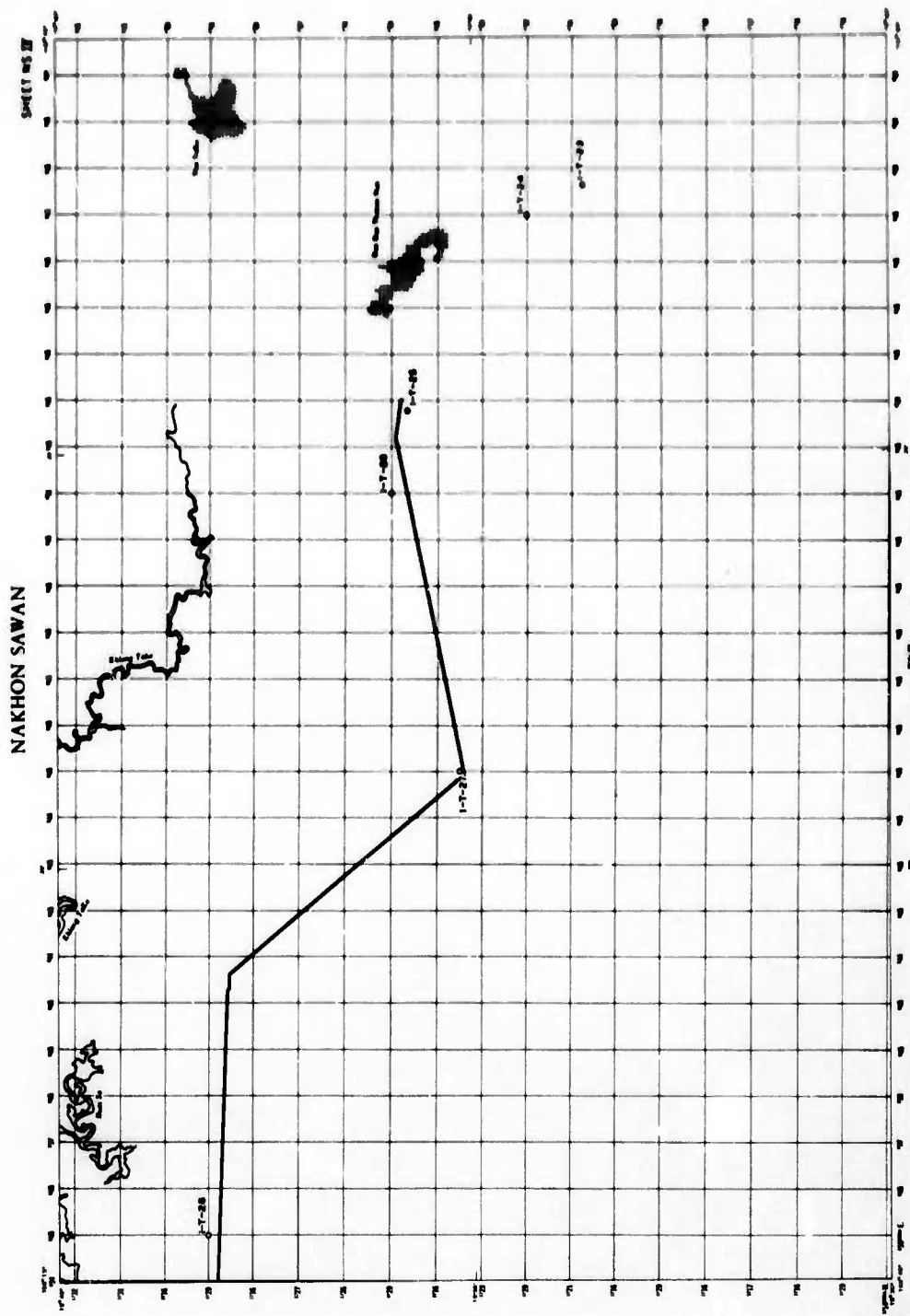


FIG. A3



0.1	0.2	0.3
0.4	0.5	0.6

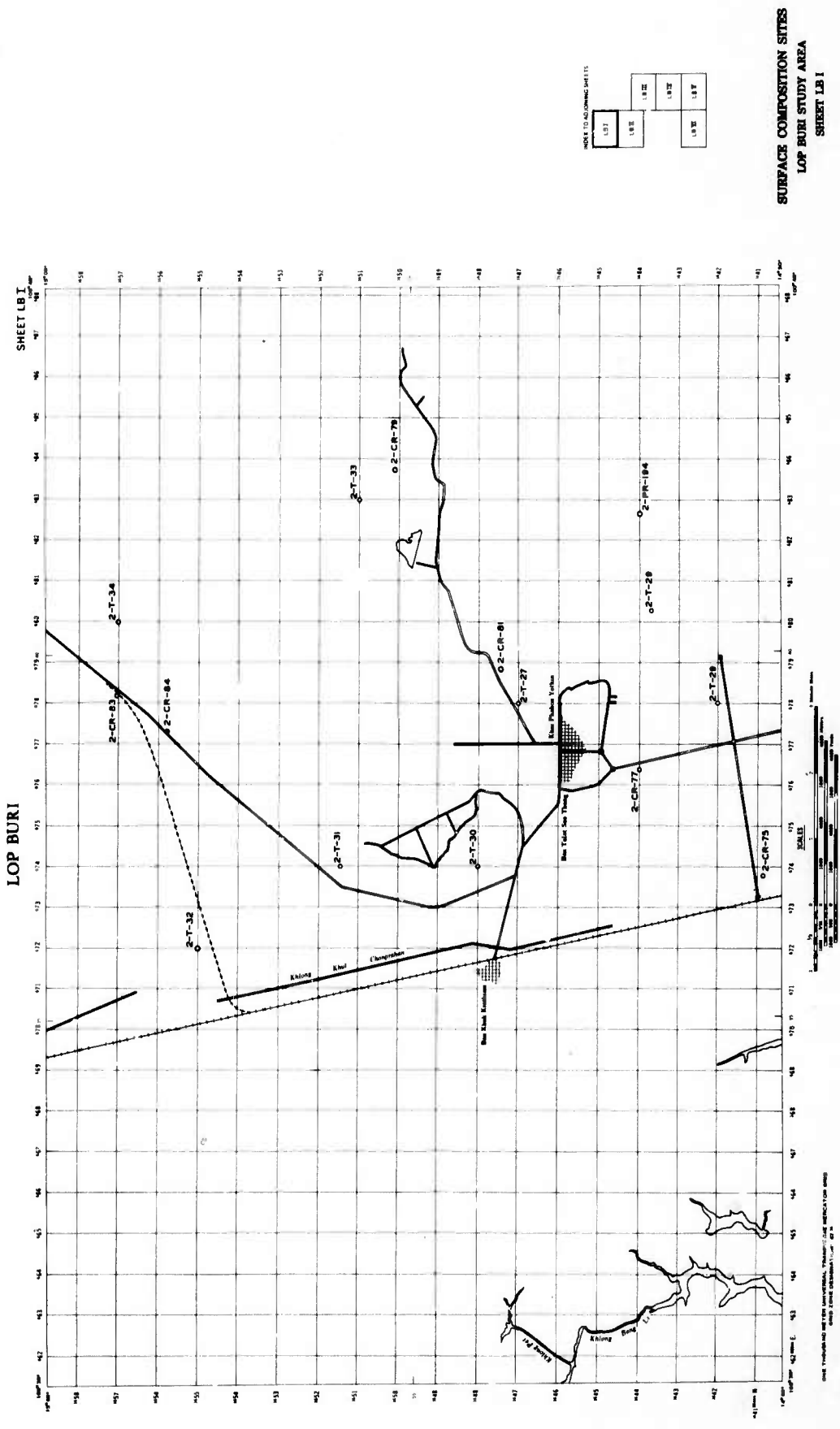
SURFACE COMPOSITION BYTES
 NAKHON SAWAN DISTRICT AREA
 SHEET NO. IV

LOP BURI STUDY AREA

BLANK PAGE

Table A2 (Continued)

Map Class	Site No.	Date Sampled	AMS Map Sheet	Location		Topographic Position	Slope %	Unified Soil Classification System				Soil Strength Measurements			Moisture Content %			
				Grid Coords	Figure No.			Plasticity	Atterberg Limits	Soil Type	Cone Index	Rating Index	Rating Index	Shear Strength				
								Flines % by Weight	LL	PL	TI		Sur	Sur				
8	2-TC-16B	4/9/64	51541	123125	A9	T	0	60	27	23	4	ML	356	1.07	381	0.0	17	15.9
4	2-TC-16C	4/9/64	51541	106974	A9	NL	0	89	37	22	15	CL	70	0.61	43	0.0	20	27.0
4	2-TC-16D	4/9/64	51541	103076	A9	BD	0	98	62	22	40	CH	95	0.48	46	0.0	12	31.5
12	2-TC-16K	4/9/64	51541	104077	A9	LS	3	86	38	21	17	CL	201	0.68	137	0.0	12	25.2
4	2-TC-17A	5/3/64	51541	038929	A10	BF	0	77	31	19	12	CL	116	0.56	65	0.0	6	25.5
4	2-TC-17B	5/3/64	51541	037931	A10	T	0	69	67	23	44	CH	198	0.65	129	2.4	5	28.0
4	2-TC-17C	5/3/64	51541	037932	A10	LS	1	92	59	21	38	CH	106	0.39	41	1.1	10	28.5
4	2-TC-17D	5/3/64	51541	092995	A9	BF	0	81	26	18	8	CL	165	0.24	40	0.0	16	16.9
12	2-TC-17E	5/3/64	51541	060999	A9	TS	1	92	--	NP	NP	ML	750+	--	tr	0.0	16	13.3
12	2-TC-17F	5/3/64	51541	060999	A9	TS	0.5	92	11	11	NP	ML	750+	--	tr	1.8	18	21.0
5	2-TC-18A	6/3/64	51541	102988	A9	BD	0	63	17	16	1	ML	205	0.15	31	0.0	14	25.5
13	2-TC-18B	6/3/64	51541	101989	A9	TS	1	72	17	16	1	ML	379	0.48	182	0.0	18	16.3
13	2-TC-18C	6/3/64	51541	101991	A9	T	0	94	--	NP	ML	433	1.66	719	0.8	14	15.9	
4	2-TC-18D	6/3/64	51541	081012	A9	T	0	57	--	NP	ML	687+	0.46	316+	0.0	11	18.9	
8	2-IN-9	7/6/62	51531	135624	A10	BF	0	94	77	39	36	MH	193	1.00	193+	--	--	34.9
12	2-IN-170	8/9/62	51541	142990	A9	LS	15	28	25	17	8	SC	67	--	--	--	--	18.4
5	2-IN-171	8/9/62	51541	140994	A9	LS	52	22	17	16	1	ML	118	0.33	39	--	--	19.8
5	2-IN-172	8/9/62	51541	121997	A9	BD	0	43	26	21	5	SC-BC	68	0.12	8	--	--	23.8
4	2-IN-173	8/9/62	51541	115004	A9	BF	0	47	16	14	2	SM	51	0.27	14	--	--	22.9
5	2-IN-174	8/9/62	51541	095994	A9	US	2	52	17	17	0	ML	60	0.17	10	--	--	22.8
4	2-IN-175	8/9/62	51541	078013	A9	BF	0	63	18	14	4	CL-ML	106	0.22	23	--	--	20.4
4	2-IN-176	8/9/62	51541	071019	A9	T	0	77	17	16	2	ML	303	--	--	--	--	20.8
8	2-IN-186	8/9/62	51551	056379	A7	RF	0	93	46	22	24	CL	430	1.00	430+	--	--	--
8	2-IN-187	8/9/62	51551	041379	A7	HO	0	97	59	27	32	CH	117	1.00	117	--	--	--
8	2-IN-188	8/9/62	51551	043374	A7	BF	0	--	--	--	--	CH	750	1.00	750+	--	--	--
10	2-IN-189	8/9/62	51551	803349	A7	BF	0	76	48	25	23	CL	155	1.00	155+	--	--	--
10	2-IN-190	8/9/62	51551	803356	A7	RF	0	--	70	30	40	CH	65	1.00	65	--	--	--
12	2-IN-194	8/9/62	51551	802440	A6	UY	0	--	--	--	--	CL	107	--	--	--	--	--
8	2-IN-195	9/3/62	51551	863315	A7	BF	0	93	89	43	46	MH	77	0.84	65	--	--	--
14	2-IN-196	9/3/62	51551	914228	A8	BF	0	--	116	44	72	CH	67	--	--	--	--	--
14	2-IN-197	9/3/62	51541	904299	A8	BF	0	--	--	--	--	CH	94	--	--	--	--	--
8	2-IN-199	9/3/62	51541	043172	A8	BF	0	--	--	--	--	CH	238	1.00	238+	--	--	--
8	2-IN-200	9/3/62	51541	043170	A8	BF	0	--	--	--	--	CH	175	1.00	175+	--	--	--
8	2-IN-201	9/3/62	51541	043193	A8	BF	0	83	34	17	17	CL	101	--	--	--	--	23.4
4	2-IN-202	9/3/62	51551	004236	A8	BF	0	63	37	18	19	CL	97	0.68	66	--	--	22.6
8	2-IN-203	10/9/62	51551	014276	A8	BF	0	--	--	--	--	CH	119	--	--	--	--	--
8	2-IN-204	10/9/62	51551	897242	A8	BF	0	--	--	--	--	CL	89	--	--	--	--	--
8	2-IN-205	10/9/62	51551	897246	A8	BF	0	--	--	--	--	CL	87	--	--	--	--	--
8	2-IN-206	10/9/62	51541	134194	A9	BF	--	96	41	22	39	CH	68	0.24	74	--	--	--
4	2-IN-207	10/9/62	51541	134193	A9	BF	0	--	--	--	--	CH	94	--	--	--	--	--
4	2-IN-1	4/9/64	51541	944123	A9	--	--	93	57	22	35	CH	118	--	--	--	--	28.4
8	2-IN-2	4/9/64	51531	800785	A11	--	--	95	69	25	44	CH	127	--	--	--	--	--
8	2-IN-3	5/3/64	51551	924265	A8	--	--	87	70	27	43	CH	82	--	--	--	--	--
10m	2-IN-6	5/3/64	51541	868128	--	--	--	93	59	28	31	CH	98	--	--	--	--	42.4
10m	2-IN-7	5/3/64	51551	920348	--	--	--	94	84	30	54	CH	143	--	--	--	--	--
4	2-IN-11	6/3/64	51551	118387	A7	NL	--	89	46	24	22	CL	221+	--	--	--	--	--
4	2-IN-14	7/3/64	51541	118979	A10	--	--	98	28	21	7	CL-ML	156+	--	--	--	--	26.5
4	2-IN-17	8/3/64	51541	024087	A9	--	--	81	47	20	27	CL	66	--	--	--	--	24.6
8	2-IN-19	14/9/64	51541	049389	A9	--	--	96	54	24	30	CH	102	0.32	94	--	--	24.5
4	2-IN-26	14/9/64	51541	084093	A9	--	--	94	57	22	35	CH	101	1.43	43	--	--	28.1
8	2-IN-21	14/9/64	51541	091130	A8	--	--	99	32	22	10	CL	204+	0.19	43	--	--	29.4
8	2-IN-23	14/9/64	51541	053164	A8	--	--	88	51	21	30	CH	71	0.77	52	--	--	27.8
10m	2-IN-27	15/9/64	51541	623046	--	--	--	92	39	24	15	CL	300+	--	tr	--	--	25.5
10m	2-IN-28	15/9/64	51541	657940	--	--	--	92	53	27	26	CH	300+	--	tr	--	--	20.2
10m	2-IN-30	15/9/64	51531	891751	--	--	--	79	69	35	34	MH	117	0.49	57	--	--	35.5
8	2-IN-31	16/9/64	51531	944788	A10	--	--	87	62	27	35	CH	91	0.83	76	--	--	34.8
8	2-IN-33	16/9/64	51531	964793	A10	--	--	83	79	39	40	MH	150	0.99	149	--	--	41.9
8	2-IN-37	16/9/64	51541	040917	A10	--	--	70	25	15	11	CL	25	1.00	25	--	--	21.2
4	2-IN-39	17/9/64	51541	071967	A10	--	--	81	19	19	9	ML	750+	--	--	--	--	15.7
4	2-IN-41	17/9/64	51541	081873	A10	--	--	78	20	17	3	ML	185	0.63	116	--	--	20.8
4	2-IN-44	17/9/64	51541	908952	A9	--	--	89	63	40	23	MH	85	--	--	--	--	37.7
8	2-IN-46	18/9/64	51541	046963	A9	--	--	86	61	35	26	MH	85	1.02	87	--	--	31.9
8	2-IN-47	18/9/64	51541	053974	A9	--	--	82	--	--	NP	SC	750+	--	tr	--	--	13.8
4	2-IN-48	18/9/64	51541	080823	A9	--	--	85	17	16	1	ML	750+	--	--	--	--	20.1
8	2-IN-49	18/9/64	51541	123124	A9	--	--	58	21	--	NP	ML	294+	0.46	89+	--	--	20.6
4	2-IN-50	18/9/64	51541	116087	A9	--	--	84	54	22	31	CH	59	1.28	64	--	--	25.1
8	2-IN-54	19/9/64	51541	011092	A9	--	--	96	49	2	26	CL	105	0.99	104	--	--	27.0
8	2-IN-56	19/9/64	51541	972190	A9	--	--	85	40	18	22	CL	148	1.00	148	--	--	21.9
10m	2-IN-59	19/9/64	51541	881164	--	--	--	95	88	30	58	CH	50	1.28	64	--	--	47.2
10m	2-IN-60	19/9/64	51541	881164	--	--	--	87	62	24	36	CH	110	1.16	128	--	--	27.5
14	2-IN-62	20/9/64	51541	920210	A8	--	--	83	66	30	36	CH	131	1.20	157+	--	--	29.3
10m	2-IN-63	20/9/64	51551	856240	A7	--	--	91	73	42	31	CH	49	1.33	65	--	--	39.7
8	2-IN-64	20/9/64	51551	892842	A8	--</												



SURFACE COMPOSITION SITES
 LOP BURI STUDY AREA
 SHEET LB I

A13

FIG. A6

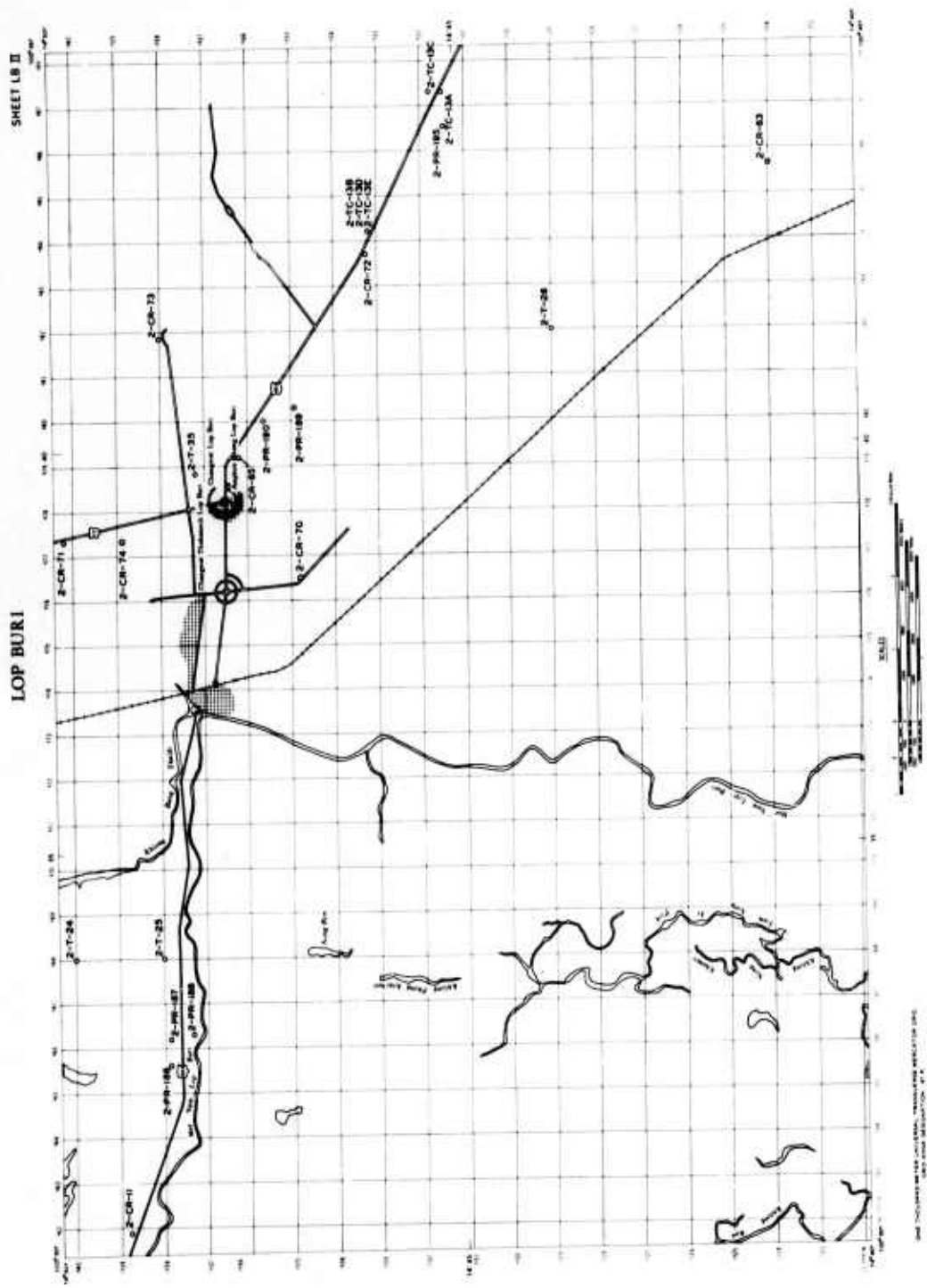
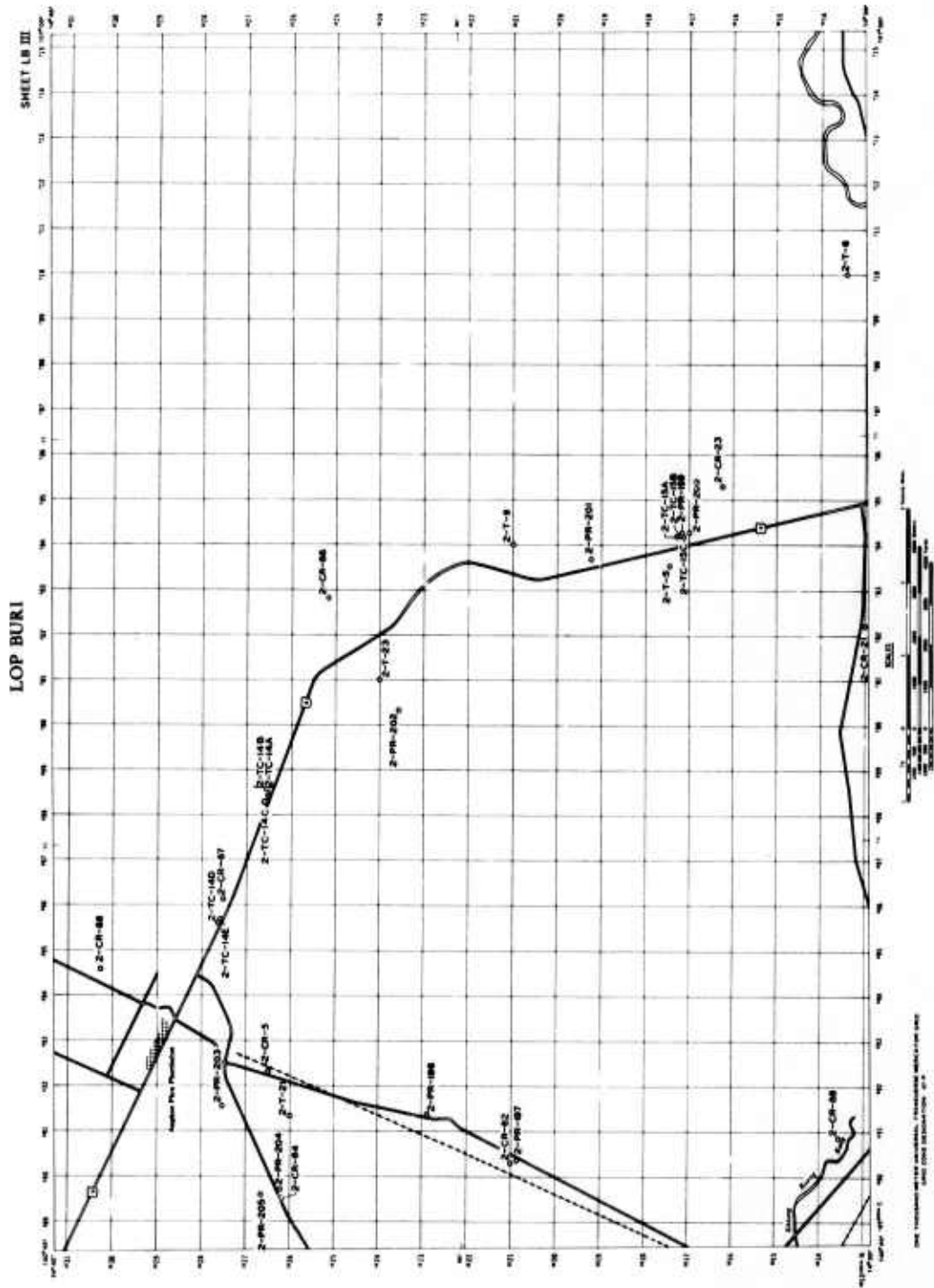


FIG. A7

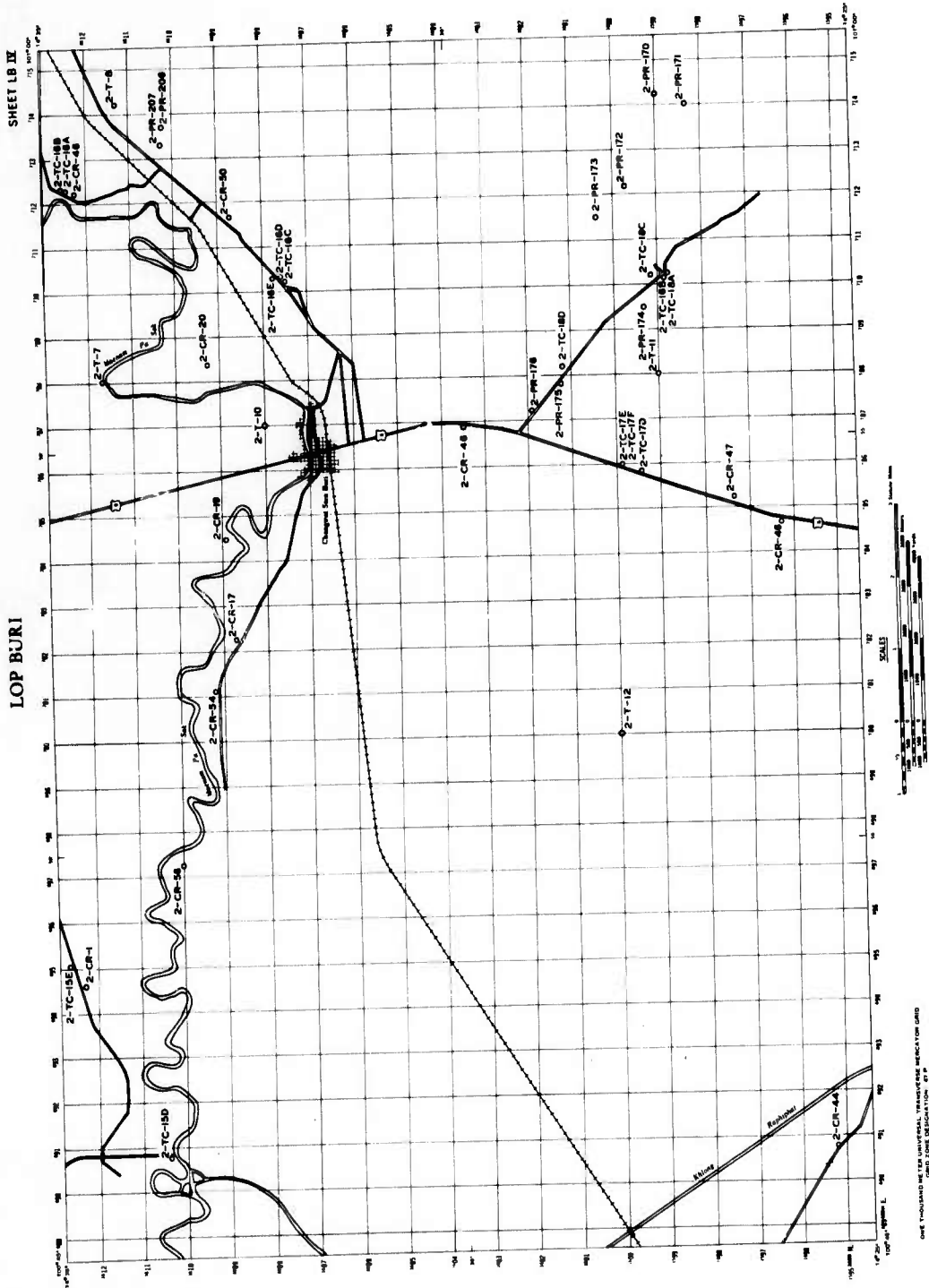
SURFACE COMPOSITION SITES
 LOP BURI STUDY AREA
 SHEET LB II



INDEX TO ADJOINING SHEETS

S1	S2	S3
S4	S5	S6

SURFACE COMPOSITION SITES
 LOP BURI STUDY AREA
 SHEET LB III



INDEX TO ADJOINING SHEETS

181	182	183
184	185	186

SURFACE COMPOSITION SITES
 LOP BURI STUDY AREA
 SHEET LB IV

FIG. A9

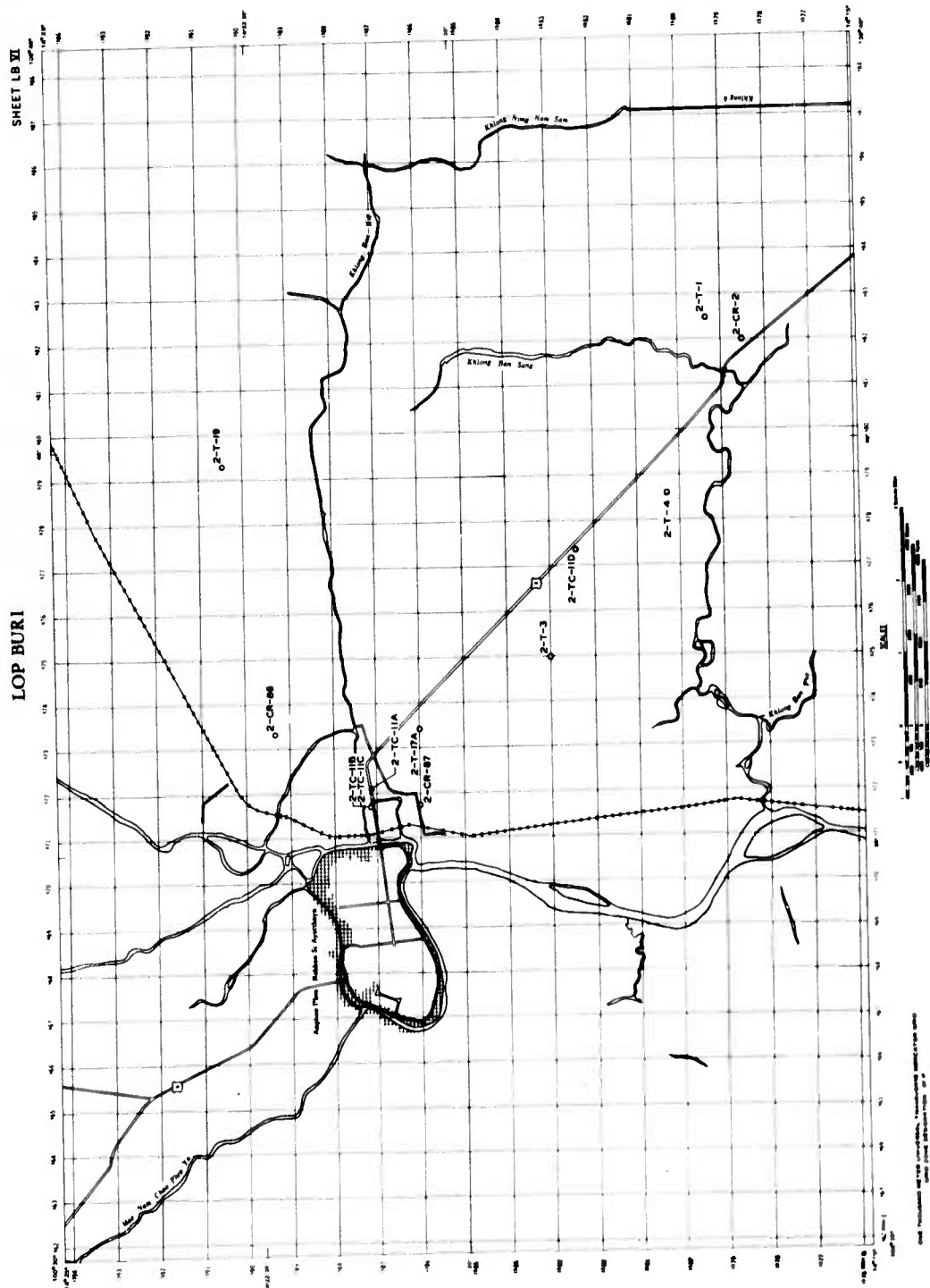


FIG. A11

CHIANG MAI STUDY AREA

BLANK PAGE

Table A3
Summary of Surface Composition Field Data
Chiang Mai

Map Class*	Site No.	Date Sampled	AMS Map Sheet**	Location		Figure No.	Elevation	Slope %	Unified Soil Classification System			Soil Strength Measurements					Moisture Content %	
				Grid Coordinates	Figure No.				Fines % by Weight	Atterberg Limits	Soil Type	Cone Index	Remolding Index	Rating Cone Index	Sheargraph	Sheargraph		
									LL	PL	FI				Sur††	Int‡‡		
11	3-T-1	4/10/64	4767I	968842	A12	---	---	---	---	---	---	138	0.48	66	1.3	27	---	
run	3-T-2	4/10/64	4767I	950891	A12	---	---	---	---	---	---	121	0.66	80	0.7	27	---	
run	3-T-3	5/10/64	4767I	942909	A12	---	---	---	---	---	---	74	0.51	38	1.1	23	---	
run	3-T-4	5/10/64	4767I	932907	A12	---	---	---	---	---	---	19	0.32	6	0.8	25	---	
4	3-T-5	6/10/64	4867III	071755	A13	---	---	---	---	---	---	150	0.47	73	1.1	31	---	
5	3-T-6	6/10/64	4867III	220700	A14	---	---	---	---	---	---	51	---	---	2.1	14	---	
4	3-T-7	6/10/64	4867III	173702	A14	---	---	---	---	---	---	32	---	---	2.4	15	---	
run	3-T-9	6/10/64	4767I	946963	---	---	---	---	---	---	---	124	0.38	47	1.4	11	---	
run	3-T-10	8/10/64	4767I	969922	---	---	---	---	---	---	---	93	0.62	58	2.2	15	---	
5	3-T-11	9/10/64	4867IV	049832	A13	---	---	---	---	---	---	310	---	---	1.8	28	---	
run	3-T-12	9/10/64	4867IV	027882	A13	---	---	---	---	---	---	238	0.95	226	1.2	22	---	
5	3-T-13	9/10/64	4867IV	145864	A13	---	---	---	---	---	---	158	0.92	145	1.2	22	---	
4	3-T-14	9/10/64	4867III	036800	A13	---	---	---	---	---	---	107	0.34	36	2.5	9	---	
4	3-T-15	11/10/64	4766I	964961	A15	---	---	---	---	---	---	118	0.64	75	---	---	---	
5	3-T-16	11/10/64	4767II	956723	A15	---	---	---	---	---	---	120	0.45	54	3.7	21	---	
5	3-T-17	11/10/64	4767II	958718	A15	---	---	---	---	---	---	82	0.30	25	2.0	26	---	
4	3-T-18	11/10/64	4766I	879968	A15	---	---	---	---	---	---	398	1.20	478	1.0	22	---	
run	3-T-19	11/10/64	4766III	085335	---	---	---	---	---	---	---	169	0.74	125	3.2	25	---	
run	3-T-20	11/10/64	4766III	070326	---	---	---	---	---	---	---	287	0.53	152	1.8	22	---	
run	3-T-21	11/10/64	4766III	073283	---	---	---	---	---	---	---	155	0.65	101	2.2	20	---	
4	3-T-22	22/10/64	4867III	060732	A13	---	---	---	---	---	---	170	0.59	100	1.0	30	---	
8	3-T-23	22/10/64	4867III	063707	A14	---	---	---	---	---	---	265	0.88	233	0.6	23	---	
8	3-T-24	22/10/64	4867III	085674	A14	---	---	---	---	---	---	147	0.75	110	1.2	23	---	
run	3-T-25	22/10/64	4866IV	022536	---	---	---	---	---	---	---	160	0.80	128	2.0	27	---	
run	3-T-26	22/10/64	4866IV	057527	---	---	---	---	---	---	---	153	0.23	35	0.2	28	---	
run	3-T-27	22/10/64	4866IV	129456	---	---	---	---	---	---	---	196	0.69	135	0.5	37	---	
run	3-T-28	22/10/64	4766I	973496	---	---	---	---	---	---	---	156	0.79	123	2.0	5	---	
run	3-T-29	22/10/64	4766I	966472	---	---	---	---	---	---	---	179	0.63	113	0.4	24	---	
run	3-T-30	22/10/64	4766I	935475	---	---	---	---	---	---	---	192	0.66	127	0.3	37	---	
4	3-T-31	23/10/64	4766I	959576	A15	---	---	---	---	---	---	159	0.53	84	0.2	39	---	
run	3-T-32	23/10/64	4766I	993544	---	---	---	---	---	---	---	168	0.74	124	1.8	24	---	
12	3-TC-19A	11/9/64	4867IV	166967	A13	BD	0	29	---	---	---	175	0.53	93	0.7	8	16.1	
11	3-TC-19B	11/9/64	4867IV	166877	A13	T	0	32	---	---	---	174	0.52	90	0.9	19	19.5	
5	3-TC-19C	11/9/64	4867IV	164806	A13	BF	0	37	24	13	11	112	0.28	31	---	---	22.3	
5	3-TC-19D	11/9/64	4867IV	163866	A13	SB	0	57	35	18	17	156	0.59	92	0.0	13	22.9	
12	3-TC-19E	11/9/64	4867IV	162865	A13	LS	3	33	---	---	---	197	0.86	169	0.3	15	15.1	
12	3-TC-19F	11/9/64	4867IV	160864	A13	MS	2	48	---	---	---	116	0.98	114	1.1	18	13.3	
run	3-TC-20A	12/9/64	4866IV	135458	---	SB	0	13	---	---	---	118	1.01	tf**	0.8	11	19.7	
run	3-TC-20B	12/9/64	4866IV	135458	---	BF	0	47	23	18	5	SM-SC	199	1.01	201	0.1	27	14.6
run	3-TC-20C	12/9/64	4866IV	134458	---	T	0	81	34	11	13	CL	115	0.56	64	0.4	17	23.9
run	3-TC-20D	12/9/64	4866IV	131458	---	US	7	52	16	14	2	ML	156	0.32	50	0.7	13	17.6
run	3-TC-20E	12/9/64	4866IV	133458	---	UF	0	63	22	13	9	CL	153	0.60	92	0.0	20	16.6
run	3-TC-20F	12/9/64	4866IV	133458	---	LS	18	49	25	17	8	SC	212	0.69	146	0.3	10	16.3
13	3-TC-21A	13/9/64	4867III	028793	A13	NL	0	46	20	17	3	SH	119	0.54	64	1.2	18	20.1
4	3-TC-21B	13/9/64	4867III	029794	A13	T	0	54	30	18	12	CL	90	0.53	48	0.5	3	27.4
4	3-TC-21C	13/9/64	4867III	029724	A13	TS	1	57	28	18	10	CL	117	0.35	41	0.1	10	21.5
4	3-TC-21D	13/9/64	4867III	030794	A13	TS	1	57	28	18	10	CL	123	0.37	46	0.6	8	25.6
4	3-TC-21E	13/9/64	4867III	031795	A13	BF	0	46	24	17	7	SM-SC	142	0.36	51	0.3	17	21.9
4	3-TC-21F	13/9/64	4867III	031795	A13	BF	0	20	---	---	---	380	0.24	91	---	---	18.8	
run	3-TC-22A	14/9/64	4866IV	014533	---	NL	4	76	31	17	14	CL	111	0.53	59	0.5	8	22.8
run	3-TC-22B	14/9/64	4866IV	014533	---	BD	0	88	47	23	24	CL	48	0.54	26	0.4	10	33.4
run	3-TC-22C	14/9/64	4866IV	015533	---	TS	5	78	40	21	19	CL	84	0.73	61	0.7	11	21.5
run	3-TC-22D	14/9/64	4866IV	026531	---	BD	0	94	33	20	13	CL	226	0.29	66	1.0	5	24.1
run	3-TC-22E	14/9/64	4866IV	027530	---	TS	1	91	34	22	12	CL	313	0.25	78	0.2	2	24.3
run	3-TC-23A	15/9/64	4866IV	097456	---	BF	0	66	54	26	28	CH	157	0.43	68	0.5	10	33.2
run	3-TC-23B	15/9/64	4866IV	097456	---	LS	9	68	78	35	43	CH	220	---	tf	1.2	5	37.3
run	3-TC-23C	15/9/64	4866IV	090457	---	UF	0	63	72	35	37	NH	219	---	tf	1.2	3	31.7
run	3-TC-23D	15/9/64	4866IV	053510	---	TS	1	75	32	19	13	CL	672+	---	tf	0.0	10	28.5
run	3-TC-23E	15/9/64	4866IV	054509	---	TS	1	48	---	---	---	182	0.18	33	0.5	14	14.8	
run	3-TC-23F	15/9/64	4866IV	055509	---	TS	1	54	---	---	---	108	0.18	19	0.2	17	21.1	
run	3-TC-23G	15/9/64	4866IV	058507	---	TS	1	51	---	---	---	295	0.25	74	0.4	13	12.4	
run	3-TC-24A	16/9/64	4766I	856484	---	BF	0	94	42	24	18	CL	168	0.54	91	0.8	8	28.7
run	3-TC-24B	16/9/64	4766I	855484	---	TS	2	79	27	18	9	CL	750+	---	tf	0.0	10	15.0
run	3-TC-24C	16/9/64	4766I	855484	---	T	0	75	33	19	14	CL	130	0.69	90	0.1	14	22.6
run	3-TC-24D	16/9/64	4766I	854483	---	NL	0	48	---	---	---	252+	1.60	403+	0.2	16	20.2	

(Continued)

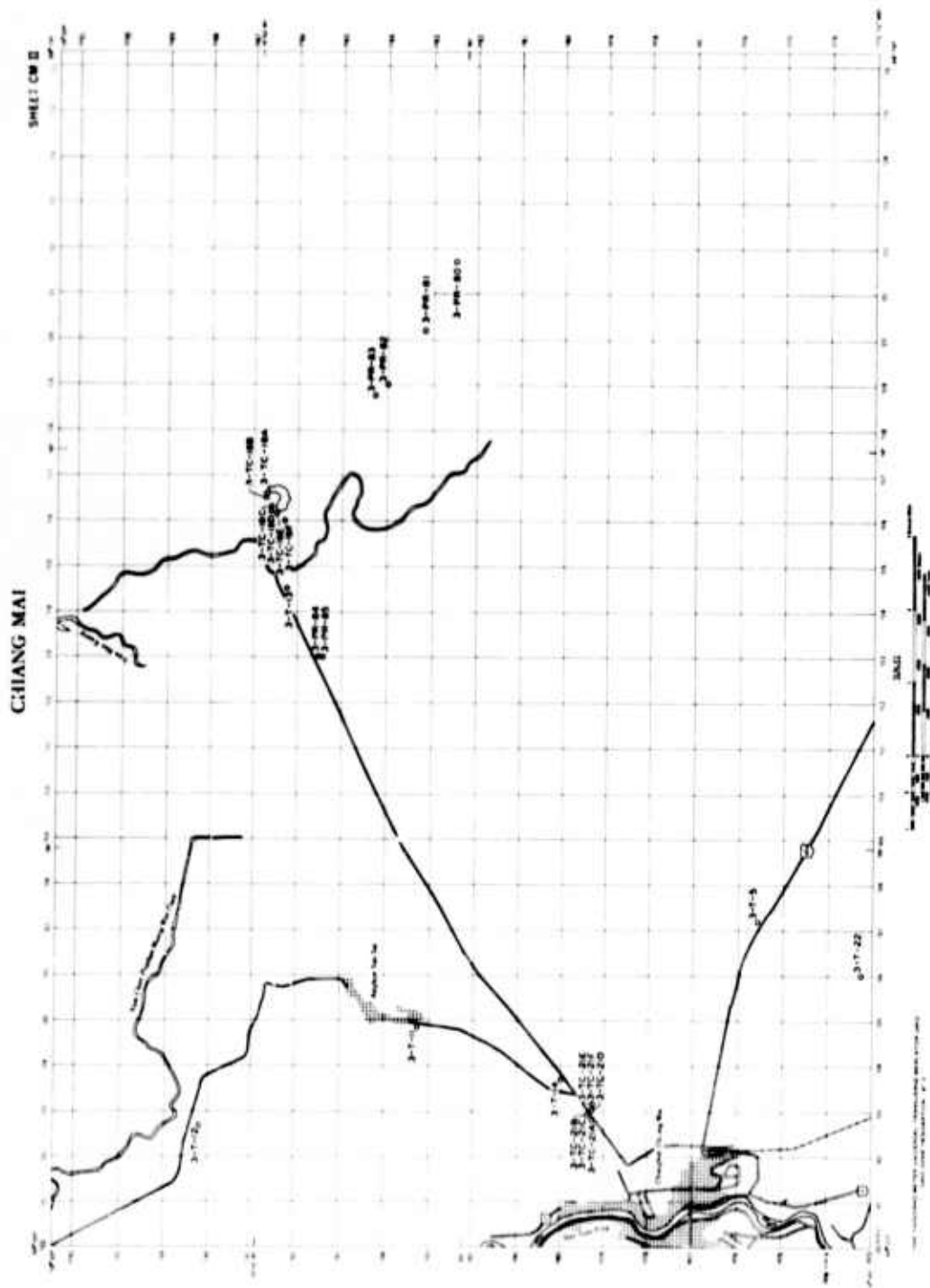
Note: All soil strength measurements except sheargraph measurements were made at a 15- to 30.5-cm depth. Sheargraph measurements were made at the surface.

- * run, not mapped.
- ** Series L708, scale 1:50,000.
- † BF, bottomland flat; BD, bottomland depression; LS, lower slope; MS, middle slope; NL, natural levee; T, terrace; TS, terrace slope; SB, stream bottom; UD, upland depression; UF, upland flat; US, upper slope.
- †† σ_{ur} , shear strength at zero normal load.
- ‡ α_{ur} , ultimate angle of internal friction.
- ** tf, too firm.

Table A3 (Concluded)

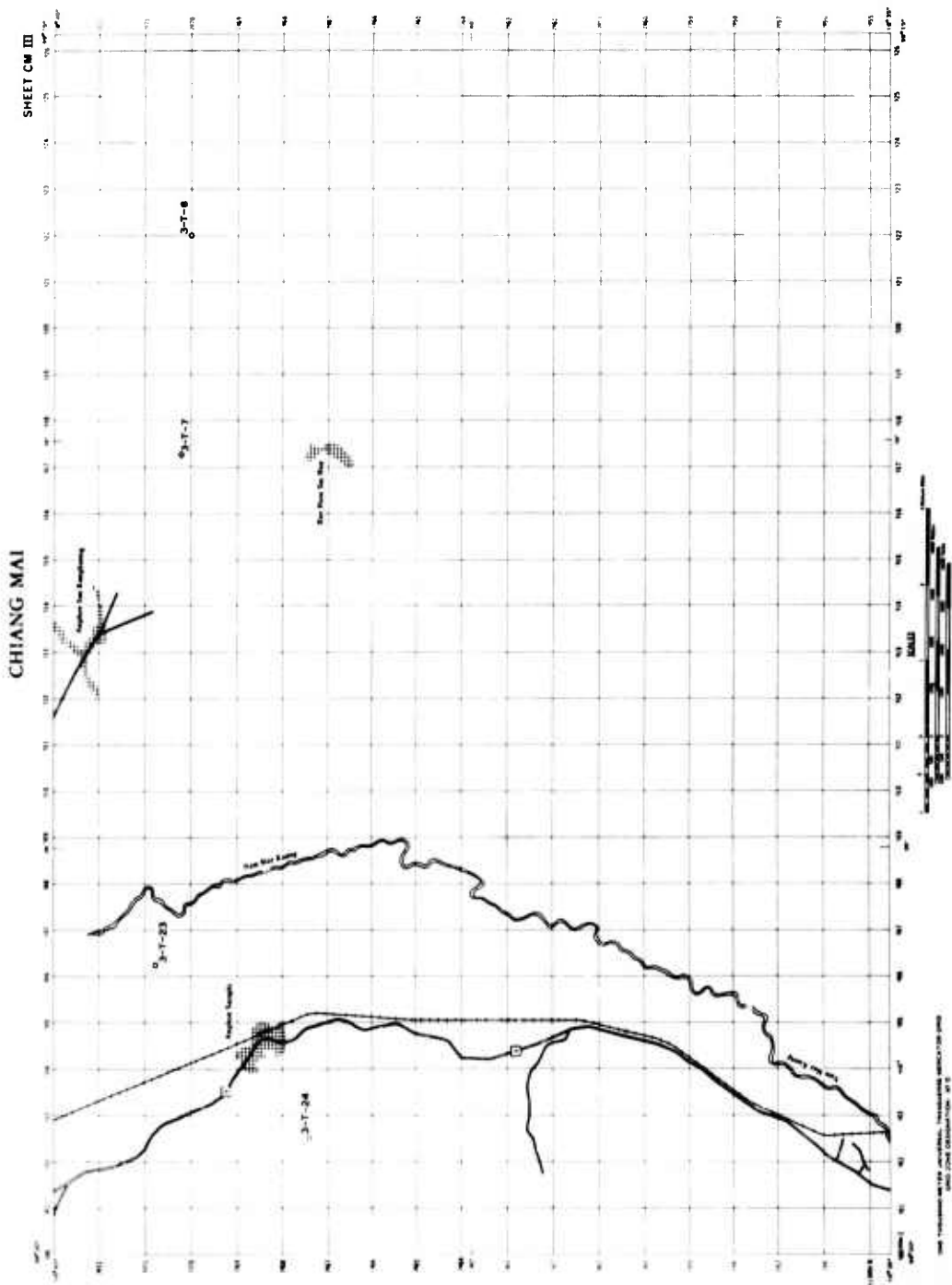
Map Class	Site No.	Date Sampled	Location			Topographic Position	Slope %	Unified Soil Classification System				Soil Strength Measurements				Moisture Content %		
			AMS Map Sheet	Grid Coords	Figure No.			Fines % by Weight	Atterberg Limits			Soil Type	Cone Index	Remold- ing Index	Rating Cone Index		Sheargraph	
									LL	PL	FI						σ _{ur} psi	φ _{ur} deg
4	3-TC-25A	16/9/64	47661	892573	A15	BF	0	68	33	20	11	CL	150	0.93	100	0.0	17	14.5
15	3-TC-25B	16/9/64	48661	891572	A15	TS	2	66	26	16	10	CL	136	0.67	91	1.1	12	17.0
15	3-TC-25C	16/9/64	48661	889571	A15	T	0	32	--	--	--	NP SM	93	0.81	79	0.0	23	11.7
nm	3-TC-26A	17/9/64	47671	948978	--	BF	0	51	25	12	13	CL	195	0.40	78	--	--	15.2
nm	3-TC-26B	17/9/64	47671	948978	--	T	0	62	28	18	10	CL	58	0.33	19	0.0	24	30.4
nm	3-TC-26C	17/9/64	47671	947978	--	LS	9	28	--	--	NP SM	111	1.93	214	0.0	18	10.7	
nm	3-TC-26D	17/9/64	47671	947978	--	US	9	28	--	--	NP SM	158	3.69	583	0.6	19	10.8	
nm	3-TC-26E	17/9/64	47671	947978	--	UF	0	31	--	--	NP SM	239	--	tr**	0.6	12	11.8	
11	3-TC-27A	18/9/64	47671I	962791	A12	T	0	47	19	13	6	SM-SC	173	0.32	55	0.7	12	15.6
11	3-TC-27B	18/9/64	47671I	961792	A12	LS	1	52	22	14	8	CL	356	0.65	231	0.3	17	12.4
11	3-TC-27C	18/9/64	47671I	959793	A12	LS	1	42	17	14	3	SM	420	0.35	147	0.3	13	15.3
11	3-TC-27D	18/9/64	47671I	959794	A12	HL	0	49	22	15	7	SM-SC	115	0.47	54	0.0	16	17.5
11	3-PR-80	25/7/62	4867IV	217825	A13	T	2	22	24	16	8	CL	89	0.53	47	--	--	20.1
12	3-PR-81	25/7/62	4867IV	202832	A13	UF	1	37	16	16	0	SM	146	1.00	146	--	--	14.0
12	3-PR-82	25/7/62	4867IV	190840	A13	MS	35	42	22	14	8	SC	103	0.51	53	--	--	15.9
12	3-PR-83	25/7/62	4867IV	188843	A13	MS	6	14	21	15	6	SM-SC	301	1.00	301	--	--	10.3
13	3-PR-84	25/7/62	4867IV	130856	A13	NL	0	88	40	24	16	CL	132	0.78	103	--	--	23.8
4	3-PR-85	25/7/62	4867IV	130855	A13	BD	0	77	41	24	17	CL	80	0.60	48	--	--	23.8
4	3-PR-96	28/7/62	47661	892577	A15	BF	0	55	26	15	11	CL	95	0.58	55	--	--	23.6
5	3-PR-97	29/7/62	47671I	917686	A15	T	1	53	23	16	7	CL-ML	140	--	--	--	--	11.1
11	3-PR-98	29/7/62	47671I	962792	A12	T	1	53	19	12	7	CL-ML	171	1.00	171	--	--	11.8
12	3-PR-99	29/7/62	47671	965840	A12	MS	35	62	57	30	27	MH	118	0.71	84	--	--	30.6

** tr, too firm.



SURFACE COMPOSITION SITES
 CHIANG MAI STUDY AREA
 SHEET CM II

FIG. A13



SURFACE COMPOSITION SITES
 CHIANG MAI STUDY AREA
 SHEET CM III

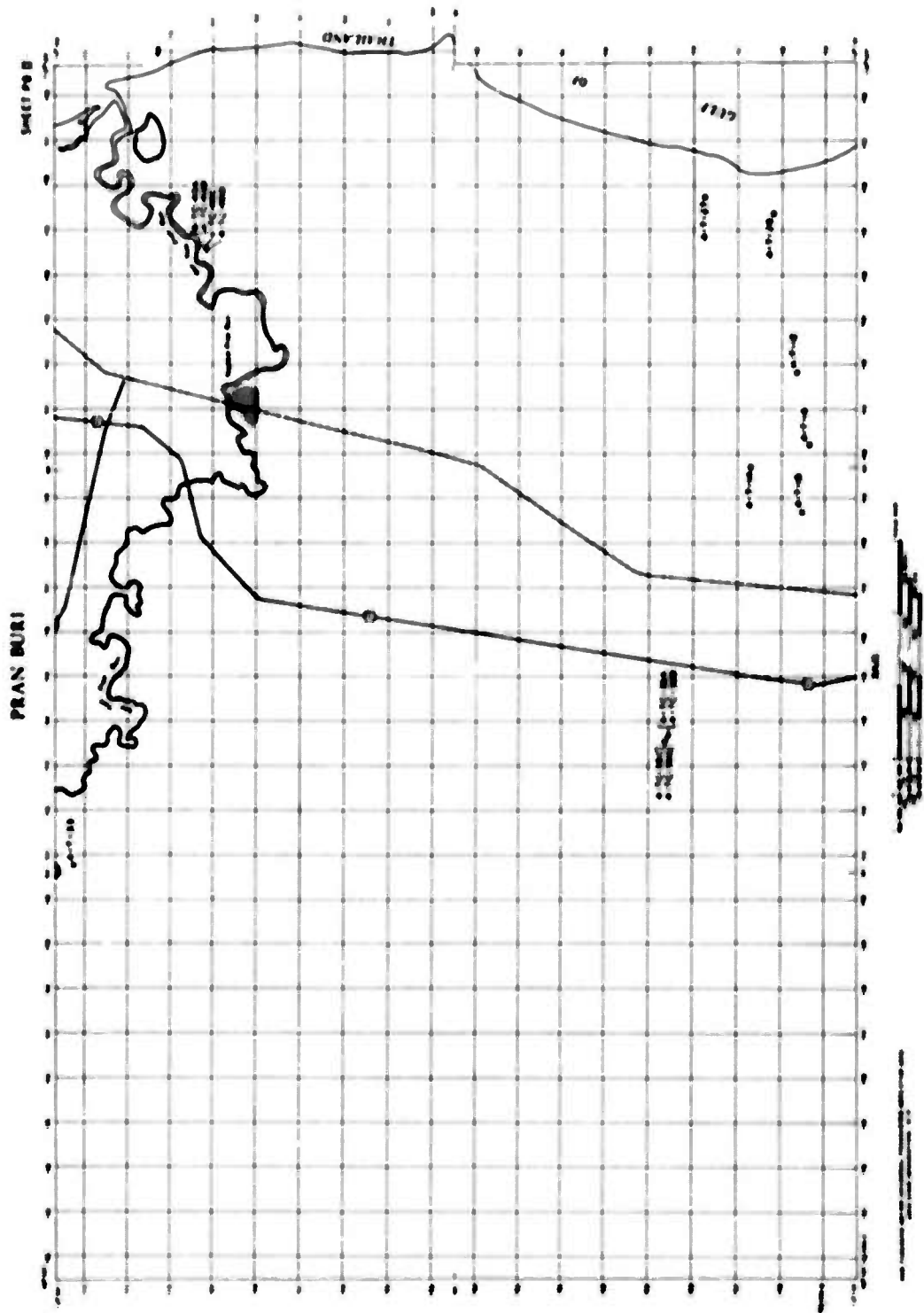
FRAN BURI STUDY AREA

BLANK PAGE

Table A4
Summary of Surface Composition Field Data
Prun Buri

Map Class*	Site No.	Date Sampled	Location			Topo-graphic Position	Slope %	Unified Soil Classification System				Soil Strength Measurements			Moisture Content %			
			AMS Map Sheet**	Grid Coords	Figure No.			Fine		Atterberg Limits		Soil Type	Cone Index	Remold-ing Cone Index		Rating Cone Index	Sheargraph	
								% by Weight	Cl.	Pl.	FI						psi	φ _{ur}
1	4-T-1	15/4/65	4947I	991506	A18	BF	1	--	--	--	--	31	0.68	21	--	--	--	
1	4-T-2	15/4/65	4947I	994502	A18	BF	1	--	--	--	--	27	0.67	18	--	--	--	
2	4-T-3	15/4/65	4947I	008489	A18	BF	1	--	--	--	--	82	1.17	96	--	--	--	
1	4-T-4	17/4/65	4947I	977463	A18	BF	1	--	--	--	--	74	0.82	61	--	--	--	
1	4-T-5	17/4/65	4947II	982446	A18	BF	1	--	--	--	--	53	0.81	43	--	--	43.2	
1	4-T-6	18/4/65	4947I	973451	A18	BF	1	--	--	--	--	58	0.79	46	--	--	38.6	
1	4-T-7	18/4/65	4947II	970446	A18	BF	1	--	--	--	--	45	0.51	23	--	--	58.6	
1	4-T-8	19/4/65	4947II	969439	A18	BF	1	--	--	--	--	43	0.53	23	--	--	--	
1	4-T-9	19/4/65	4947II	969427	A18	BF	1	--	--	--	--	32	0.75	24	--	--	--	
1	4-T-10	20/4/65	4947II	984425	A18	BF	1	--	--	--	--	54	0.81	44	--	--	--	
2	4-T-11	20/4/65	4947I	011526	A18	BF	1	--	--	--	--	77	0.77	59	--	--	--	
2	4-T-12	20/4/65	4947I	018556	A17	BF	1	--	--	--	--	48	0.92	44	--	--	49.6	
1	4-T-13	21/4/65	4947I	996512	A18	NL	1	--	--	--	--	37	--	--	--	--	--	
6	4-T-14	22/4/65	4947I	997567	A17	BF	1	--	--	--	--	83	0.64	53	--	--	--	
1	4-T-15	22/4/65	4947I	986556	A17	BF	1	--	--	--	--	77	0.55	42	--	--	--	
1	4-T-16	22/4/65	4947I	001554	A17	NL	1	--	--	--	--	46	0.70	32	--	--	--	
1	4-T-17	23/4/65	4947I	977481	A18	BF	1	--	--	--	--	69	0.77	53	--	--	54.9	
1	4-T-18	23/4/65	4947II	993446	A18	BD	1	--	--	--	--	46	1.09	50	--	--	--	
15	4-T-19	24/4/65	4948II	909746	A16	NL	1	--	--	--	--	671	--	tf**	--	--	13.6	
5	4-T-20	24/4/65	4948II	901741	A16	BF	1	--	--	--	--	730+	--	tf	0.0	24	9.4	
15	4-T-21	24/4/65	4948II	904778	A16	BF	1	--	--	--	--	640	--	tf	1.9	15	4.5	
nm	4-T-22	24/4/65	--	--	--	BF	1	--	--	--	--	750+	--	tf	0.0	23	5.7	
15	4-T-23	25/4/65	4948II	879752	A16	BF	1	--	--	--	--	750+	--	tf	0.0	31	3.6	
15	4-T-24	25/4/65	4948II	862776	A16	BF	1	--	--	--	--	750+	--	tf	0.0	38	3.7	
15	4-T-25	25/4/65	4948II	837739	A16	NL	1	--	--	--	--	750+	--	tf	0.0	38	5.9	
15	4-T-26	25/4/65	4948II	945745	A16	BF	1	--	--	--	--	750+	--	tf	0.0	38	5.6	
15	4-T-27	26/4/65	4947I	056578	A17	BD	1	--	--	--	--	750+	--	tf	0.2	46	12.9	
8	4-T-28	26/4/65	4947I	054562	A17	BF	1	--	--	--	--	750+	--	tf	0.0	48	15.1	
6	4-T-29	27/4/65	4947I	986530	A18	BF	1	--	--	--	--	113	0.69	78	--	--	28.7	
6	4-T-30	27/4/65	4947I	982522	A18	BF	1	--	--	--	--	92	0.68	63	1.5	41	50.4	
15	4-T-31	28/4/65	4948II	929750	A16	BF	1	--	--	--	--	750+	--	tf	--	--	5.4	
15	4-T-32	28/4/65	4948II	918744	A16	BF	1	--	--	--	--	750+	--	tf	0.0	44	12.7	
5	4-T-33	28/4/65	4948II	908723	A17	BF	1	--	--	--	--	328	--	tf	0.0	39	10.8	
5	4-TC-38A	4/10/64	4947I	943509	A18	SB	0	--	--	--	CL	172	0.67	115	0.8	17	18.5	
5	4-TC-38B	4/10/64	4947I	943508	A18	TS	0	--	--	--	CL	95	0.76	72	0.0	22	14.4	
5	4-TC-38C	4/10/64	4947I	943508	A18	TS	3	--	--	--	CL-ML	118	0.74	87	0.0	17	14.1	
5	4-TC-38D	4/10/64	4947I	943507	A18	T	0	--	--	--	CL-ML	73	0.45	33	0.0	16	16.7	
5	4-TC-38E	4/10/64	4947I	937585	A17	T	0	--	--	--	ML	49	0.22	11	0.2	18	20.2	
5	4-TC-39B	4/10/64	4947I	937585	A17	I	6	--	--	--	ML	106	0.37	39	0.0	20	16.2	
5	4-TC-39C	4/10/64	4947I	936586	A17	LS	6	--	--	--	CL	85	0.84	71	0.0	23	15.1	
5	4-TC-39D	4/10/64	4947I	936586	A17	MS	10	--	--	--	ML	79	0.81	64	0.0	22	13.3	
15	4-TC-40A	5/10/64	4948II	046693	A17	NL	1	--	--	--	SM	143	--	--	0.2	21	17.4	
15	4-TC-40B	5/10/64	4948II	046693	A17	NL	1	--	--	--	CL	155	0.67	104	0.6	18	23.6	
15	4-TC-40C	5/10/64	4948II	046692	A17	T	0	--	--	--	CL	345	--	--	0.3	25	16.5	
8	4-TC-40D	5/10/64	4948II	045691	A17	BF	0	--	--	--	CL	91	0.48	44	0.2	17	28.0	
8	4-TC-41A	5/10/64	4948I	049853	A16	TS	1	--	--	--	CL	199	--	--	0.0	26	18.3	
8	4-TC-41B	5/10/64	4948I	050850	A16	TS	0.5	--	--	--	CL	264	--	--	0.0	26	16.0	
8	4-TC-41C	5/10/64	4948I	052847	A16	TS	0.5	--	--	--	CL	185	0.58	107	0.7	15	21.0	
15	4-TC-41D	5/10/64	4948I	053844	A16	TS	1	--	--	--	CL	293	--	--	0.9	15	15.9	
nm	4-TC-42A	6/10/64	4949II	038059	--	T	0	--	--	--	SM	518	--	--	0.4	10	8.5	
nm	4-TC-42B	6/10/64	4949II	038062	--	T	0	--	--	--	SM	482	--	--	0.8	10	6.6	
nm	4-TC-42C	6/10/64	4949II	039066	--	T	0	--	--	--	SM	668	--	--	0.0	18	9.0	
nm	4-TC-42D	6/10/64	4949II	040069	--	T	0	--	--	--	CL-ML	567	--	--	0.2	9	12.7	
nm	4-TC-43A	6/10/64	4949II	036010	--	T	0	--	--	--	SM	472	--	--	0.2	16	9.0	
nm	4-TC-43B	6/10/64	4949II	036013	--	T	0	--	--	--	SM	224	--	--	0.7	20	7.2	
nm	4-TC-43C	6/10/64	4949II	036017	--	T	0	--	--	--	CL-ML	112	0.45	50	0.6	13	15.0	
nm	4-TC-43D	6/10/64	4949II	037030	--	T	0	--	--	--	CL-ML	713	--	--	0.0	18	13.3	
nm	4-TC-44A	7/10/64	4949II	045156	--	BF	0	--	--	--	CL	159	0.84	134	--	--	22.2	
nm	4-TC-44B	7/10/64	4949II	043156	--	TS	1	--	--	--	CL-ML	244	0.40	98	0.0	11	18.3	
nm	4-TC-44C	7/10/64	4949II	041156	--	TS	1	--	--	--	CL	348	0.53	184	0.0	21	17.5	
nm	4-TC-44D	7/10/64	4949II	040155	--	TS	1	--	--	--	CL	269	--	--	0.3	21	15.4	
nm	4-TC-44E	7/10/64	4949II	039155	--	T	0	--	--	--	CL-ML	236	0.67	158	0.2	20	11.7	
nm	4-TC-44F	7/10/64	4949II	037155	--	T	0	--	--	--	CL	143	0.47	67	--	--	18.8	
nm	4-TC-45A	8/10/64	4949II	072143	--	B	13	--	--	--	SP	250	2.04	510	0.0	18	20.3	
nm	4-TC-45B	8/10/64	4949II	072143	--	B	0	--	--	--	SP	190	1.40	266	0.6	3	5.0	
nm	4-TC-45C	8/10/64	4949II	071144	--	T	0	--	--	--	SP	243	0.78	190	0.0	17	3.0	
nm	4-TC-45A	8/10/64	4949II	072144	--	B	13	--	--	--	SP	218	1.50	327	0.3	8	21.7	
nm	4-TC-45B	8/10/64	4949II	072144	--	B	0	--	--	--	SP	187	1.65	309	0.2	3	3.5	
nm	4-TC-45C	8/10/64	4949II	072144	--	T	0	--	--	--	SP	283	0.82	232	0.8	8	2.5	
nm	4-TC-45D	8/10/64	4949II	071144	--	T	0	--	--	--	CH	336	1.03	346	0.5	20	19.1	
nm	4-TC-47B	8/10/64	4949II	063148	--	T	0	--	--	--	CL	310	--	--	--	--	22.5	
nm	4-TC-48A	9/10/64	4948I	041960	--	B	12	--	--	--	SP	286	--	--	0.0	20	14.7	
nm	4-TC-48B	9/10/64	4948I	041961	--	B	8	--	--	--	SP	170	--	--	--	--	3.1	
nm	4-TC-48C	9/10/64	4948I	040961	--	TS	3	--	--	--	SP-SM	431	--	--	1.7	13	4.6	
nm	4-TC-48D	9/10/64	4948I	038961	--	TS	1	--	--	--	SM	548	--	--	0.0	20	6.8	

Note: All soil strength measurements except sheargraph measurements were made at a 15- to 30.5-cm depth. Sheargraph measurements were made at the surface.
* nm, not mapped.
** Series L708, scale 1:50,000.
† BF, bottomland flat; BD, bottomland depression; LS, lower slope; MS, middle slope; NL, natural levee; T, terrace; TS, terrace slope;
SB, stream bottom; UD, upland depression; UF, upland flat; US, upper slope.
†† a_{ur}, shear strength at zero normal load.
‡ φ_{ur}, ultimate angle of internal friction.
‡‡ tf, too firm.



SURFACE COMPOSITION SITES
 PRAN BURI STUDY AREA
 SHEET PB B

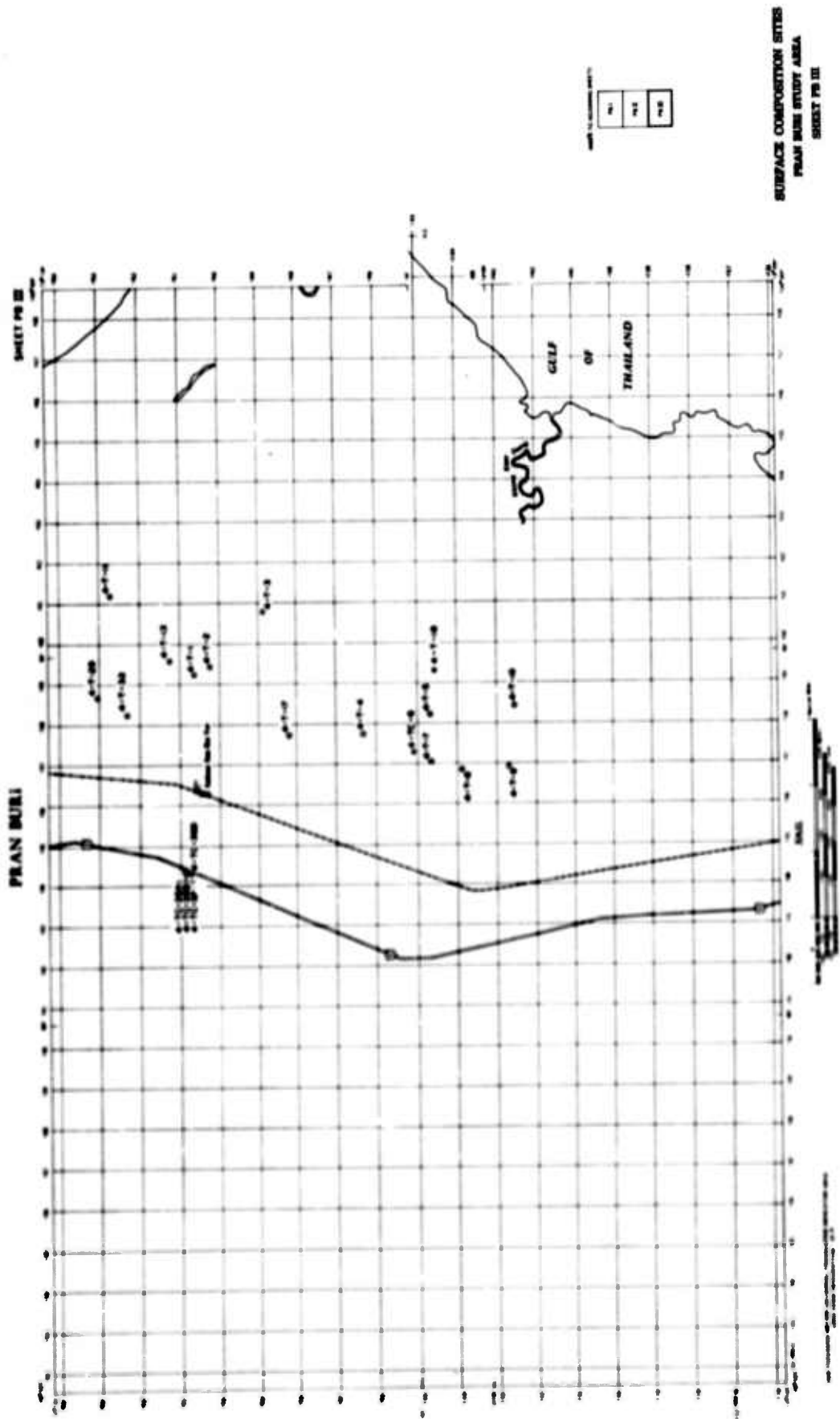


FIG. A18

KHON KAEN STUDY AREA

A3?

BLANK PAGE

Table A5

Summary of Surface Composition Field Data

Evanston

Map Class*	Site No.	Date Sampled	AME Bag Sheet**	Location Grid Coordinates	Figure No.	Topographic Position	Slope %	Unified Soil Classification System				Soil Strength Measurements				Water Content %		
								Plains		Atterberg		Cone Index	Penetration Index	Shear Stress Index	Angle of Internal Friction			
								Moist. %	Weight	LL	PL							
4	5-T-1	10/11/66	556011	735470	A20	**	**	75	20	17	11	CL	106	0.41	60	0.1	73	25.8
8	5-T-2	10/11/66	556011	766184	A20	**	**	90	79	47	37	ML	100	1.19	176	0.6	23	24.8
4	5-T-3	10/11/66	556011	805180	A21	**	**	79	69	30	17	CL	211	1.15	190	2.4	26	30.7
4	5-T-4	16/11/66	556011	806050	A21	**	**	31	**	**	**	**	176	0.87	169	0.2	24	25.7
5	5-T-5	16/11/66	556011	810845	A21	**	**	53	**	**	**	**	308	**	189	0.7	21	24.6
nn	5-T-6	16/11/66	556011	827557	**	**	**	22	**	**	**	**	195	0.80	168	0.2	23	27.7
nn	5-T-7	17/11/66	556011	850377	**	**	**	79	18	14	12	CL	203	0.77	157	0.0	25	15.2
4	5-T-8	19/11/66	556011	735148	A20	**	**	80	25	17	8	CL	108	0.75	81	0.4	24	23.4
5	5-T-9	19/11/66	556011	907186	A21	**	**	31	**	**	**	**	140	1.70	660	0.0	17	15.0
11	5-T-10	19/11/66	556011	933170	A21	**	**	31	**	**	**	**	167	1.31	363	1.0	19	8.0
4	5-T-11	19/11/66	556011	718018	A20	**	**	79	**	**	**	**	134	0.40	53	1.8	20	17.0
4	5-T-12	20/11/66	556011	730747	A20	**	**	60	11	13	10	CL	169	0.63	108	0.7	14	23.0
11	5-T-13	20/11/66	556011	610175	A20	**	**	66	30	20	15	CL	130	1.00	230	0.0	8	36.4
4	5-T-14	20/11/66	556011	660152	A20	**	**	68	31	17	14	CL	163	0.80	144	0.7	23	26.3
nn	5-T-15	21/11/66	556011	169053	**	**	**	34	**	**	**	**	213	0.73	270	0.0	24	24.4
nn	5-T-16	23/11/66	556011	105460	**	**	**	58	**	**	**	**	173	0.76	146	1.1	24	26.1
13	5-T-17	24/11/66	556011	665090	A20	**	**	41	25	16	9	CL	136	0.76	104	0.5	25	26.8
11	5-T-18	25/11/66	556011	667064	A20	**	**	40	**	**	**	**	163	0.60	105	0.1	23	22.8
nn	5-T-19	11/12/66	556011	217777	**	**	**	33	71	10	7	CL	71	1.39	70	0.8	27	36.0
nn	5-T-20	11/12/66	556011	236087	**	**	**	48	30	14	12	CL	107	1.43	153	0.2	19	25.0
nn	5-T-21	11/12/66	556011	134346	**	**	**	44	24	18	6	ML-CL	133	1.10	130	1.0	25	17.0
nn	5-T-22	11/12/66	556011	203304	**	**	**	64	29	14	15	CL	150	1.05	157	1.4	24	21.0
nn	5-T-23	10/12/66	556011	163395	**	**	**	75	**	**	**	**	160	1.19	130	1.1	17	8.0
nn	5-T-24	10/12/66	556011	143363	**	**	**	34	**	**	**	**	169	1.07	170	0.8	21	13.0
nn	5-T-25	12/12/66	556011	188253	**	**	**	67	41	29	17	CL	90	0.51	74	0.8	15	17.0
5	5-T-26	10/12/66	556011	293960	A19	**	**	50	21	18	5	ML	115	0.56	70	1.0	6	7.0
nn	5-T-27	13/12/66	556011	990405	**	**	**	48	19	14	10	CL	175	0.83	163	0.5	29	24.0
11	5-T-28	13/12/66	556011	166100	A19	**	**	67	16	16	10	CL	110	0.80	99	0.2	25	21.0
11	5-T-29	14/12/66	556011	570215	A20	**	**	60	**	**	**	**	108	1.06	114	0.7	25	20.0
5	5-T-30	14/12/66	556011	375025	A19	**	**	59	10	10	5	ML	130	0.71	137	1.8	21	16.0
5	5-T-31	14/12/66	556011	377173	A19	**	**	38	17	15	9	CL	71	0.89	66	1.0	27	27.0
5	5-T-32	14/12/66	556011	504145	A19	**	**	17	**	**	**	**	140	1.13	272	1.3	20	16.0
11	5-T-33	15/12/66	556011	563137	A20	**	**	39	**	**	**	**	306	**	87	0.0	20	1.0
5	5-T-34	15/12/66	556011	517237	A20	**	**	79	11	13	4	ML	127	0.73	114	7.3	20	20.0
11	5-T-35	15/12/66	556011	560377	A20	**	**	34	**	**	**	**	304	**	57	0.2	19	20.0
15	5-T-36	31/3/65	556011	197160	A21	LS	1	**	**	**	**	**	194	**	17	0.0	26	17.1
15	5-T-37	31/3/65	556011	730150	A21	ML	2	**	**	**	**	**	175	**	17	0.0	27	15.0
15	5-T-38	31/3/65	556011	744157	A21	ML	1	**	**	**	**	**	163	**	17	0.0	24	16.4
15	5-T-39	1/4/65	556011	738154	A21	ML	1	**	**	**	**	**	190	**	17	0.0	23	16.3
15	5-T-40	1/4/65	556011	754152	A21	ML	1	**	**	**	**	**	180	**	17	0.0	25	18.0
15	5-T-41	1/4/65	556011	758110	A21	ML	1	**	**	**	**	**	170	**	17	0.0	20	13.1
8	5-T-42	2/4/65	556011	708040	A20	ML	1	**	**	**	**	**	173	**	17	0.0	25	24.0
8	5-T-43	2/4/65	556011	709037	A20	ML	1	**	**	**	**	**	175	**	17	0.0	25	25.7
4	5-T-44	2/4/65	556011	711040	A20	ML	1	**	**	**	**	**	170	**	17	0.0	26	18.0
4	5-T-45	2/4/65	556011	710237	A20	ML	1	**	**	**	**	**	170	**	17	0.0	29	15.8
4	5-T-46	2/4/65	556011	760021	A20	ML	1	**	**	**	**	**	170	**	17	0.0	26	8.0
nn	5-T-49A	15/10/66	556011	200433	**	T	0	48	24	16	8	ML	81	0.52	44	0.0	17	20.8
nn	5-T-49B	15/10/66	556011	202430	**	LS	3	46	34	17	17	ML	140	0.75	107	0.0	20	23.0
nn	5-T-49C	15/10/66	556011	203631	**	TS	2	45	16	15	1	ML	117	0.40	56	0.2	18	18.1
nn	5-T-49D	15/10/66	556011	204409	**	UP	0	35	**	**	**	**	79	0.20	20	0.4	18	18.4
nn	5-T-50A	15/10/66	556011	210361	**	ML	0	5	**	**	**	**	7	0.03	62	0.5	7	15.0
nn	5-T-50B	15/10/66	556011	210362	**	LS	3	23	**	**	**	**	157	0.40	37	0.3	19	18.0
nn	5-T-50C	15/10/66	556011	214361	**	LS	2	25	**	**	**	**	134	0.38	41	0.1	20	18.0
nn	5-T-50D	15/10/66	556011	217358	**	UP	0	16	**	**	**	**	102	0.63	77	0.2	19	18.7
nn	5-T-50E	16/10/66	556011	671366	**	T	0	43	18	16	7	ML	64	0.39	33	0.7	17	18.4
nn	5-T-50F	16/10/66	556011	674365	**	LS	4	28	**	**	**	**	140	1.17	270	0.0	23	8.0
nn	5-T-50G	16/10/66	556011	675363	**	UP	3	36	**	**	**	**	153	1.13	173	0.4	20	10.0
nn	5-T-50H	16/10/66	556011	676364	**	UP	0	27	**	**	**	**	143	1.14	187	0.0	20	6.6
nn	5-T-50I	16/10/66	556011	687088	**	TS	1	40	29	17	17	CL	64	0.67	43	0.2	20	21.5
nn	5-T-50J	16/10/66	556011	688085	**	TS	0	73	30	16	16	CL	79	0.60	54	0.6	21	25.0
nn	5-T-50K	16/10/66	556011	689081	**	TS	2	70	24	18	6	CL-ML	113	0.59	81	0.4	17	20.0
nn	5-T-50L	16/10/66	556011	689079	**	T	0	56	16	**	**	**	90	1.51	47	0.2	20	15.4
5	5-T-51A	17/10/66	556011	425230	A19	T	0	57	34	17	17	CL	114	0.50	93	0.2	20	23.1
11	5-T-51B	17/10/66	556011	427031	A19	LS	4	37	**	**	**	**	150	1.40	145	0.2	16	10.0
11	5-T-51C	17/10/66	556011	428031	A19	LS	4	35	**	**	**	**	174	1.73	214	0.0	20	11.8
11	5-T-51D	17/10/66	556011	429031	A19	UP	0	28	**	**	**	**	111	1.00	104	0.7	18	8.1
11	5-T-51E	17/10/66	556011	429030	A19	UP	0	30	**	**	**	**	28	1.05	160	0.0	20	8.7
5	5-T-51A	17/10/66	556011	534190	A20	TS	2	79	37	16	21	CL	104	0.83	145	0.0	19	21.8
5	5-T-51B	17/10/66	556011	530390	A20	TS	1	57	30	14	1	CL	71	0.73	46	**	**	21.0
5	5-T-51C	17/10/66	556011	529197	A20	TS	1.5	46	16	15	**	**	175	0.34	37	0.3	20	13.7
5	5-T-51A	7/10/66	556011	507196	A20	T	0	33	**	**	**	**	143	1.05	147	0.3	21	16.4
11	5-T-51A	11/10/66	556011	510171	A21	ML	0	30	**	**	**	**	104	0.54	115	**	**	21.8
11	5-T-51B	11/10/66	556011	503188	A21	TS	3	38	**	**	**	**	131	0.40	56	0.2	20	15.1
11	5-T-51C	11/10/66	556011	503189	A21	TS	2	31	**	**	**	**	160	**	**	0.0	20	10.1
11	5-T-51D	11/10/66	556011	504189	A21	TS	2	37	**	**	**	**	170	1.09	130	0.0	19	16.4
4	5-T-56A	18/10/66	556011	749173	A20	TS	1	57	30	17	15	CL	144	0.76	107	0.4	7	26.1
4	5-T-56B	18/10/66	556011	748173	A20	T	0	77	30	17	15	CL	105	0.54	77	0.0	10	25.1
4	5-T-56C	18/10/66	556011	748170	A20	T	0	66	29	18	11	CL	103	0.45	46	0.4	11	26.1
4	5-T-56D	18/10/66	556011	747170	A20	TS	1	64	27	17	10	CL	103	0.54	56	0.0	20	26.7
11	5-T-56	8/7/62	556011	685231	A20	ML	1	38										

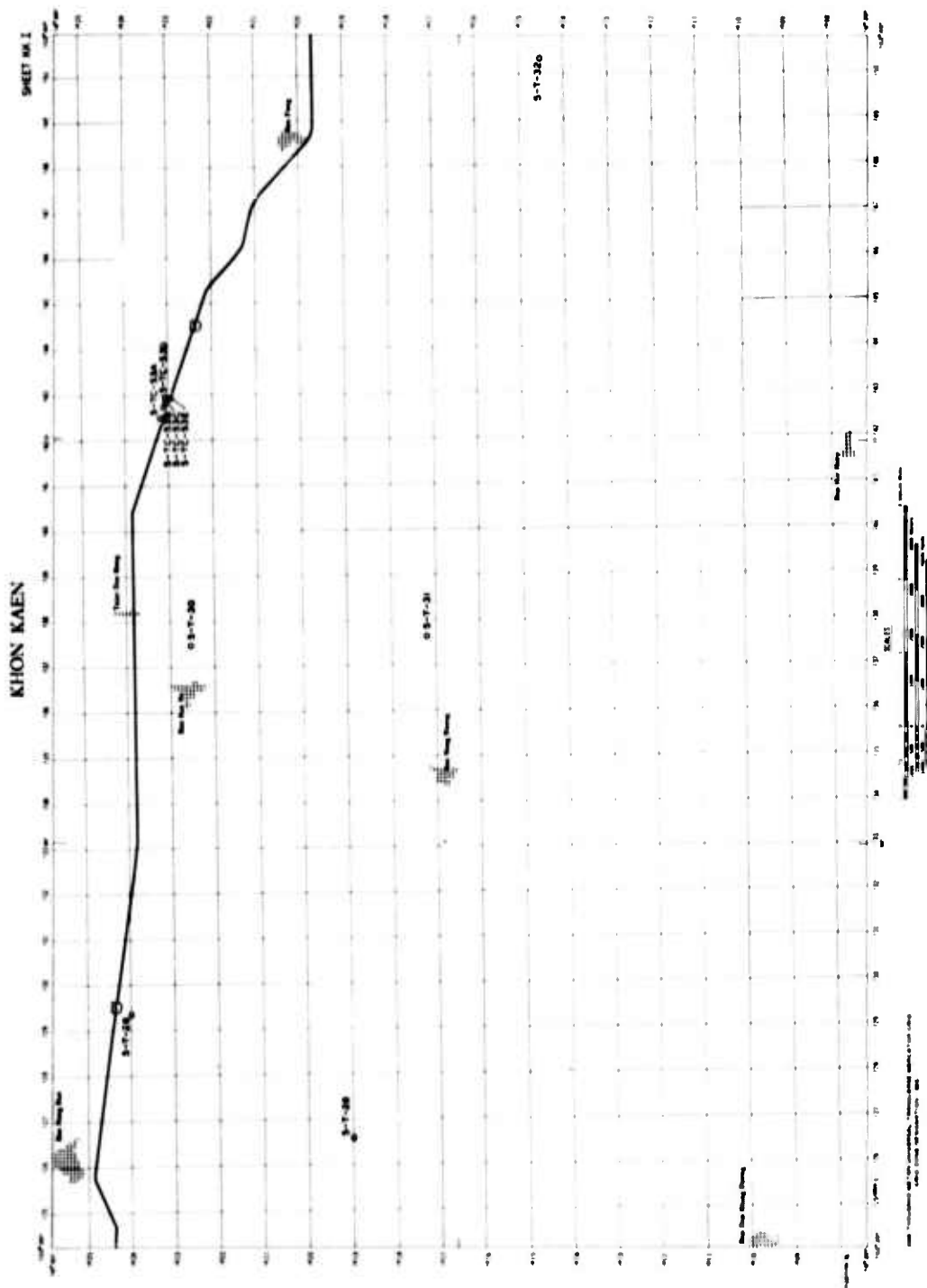
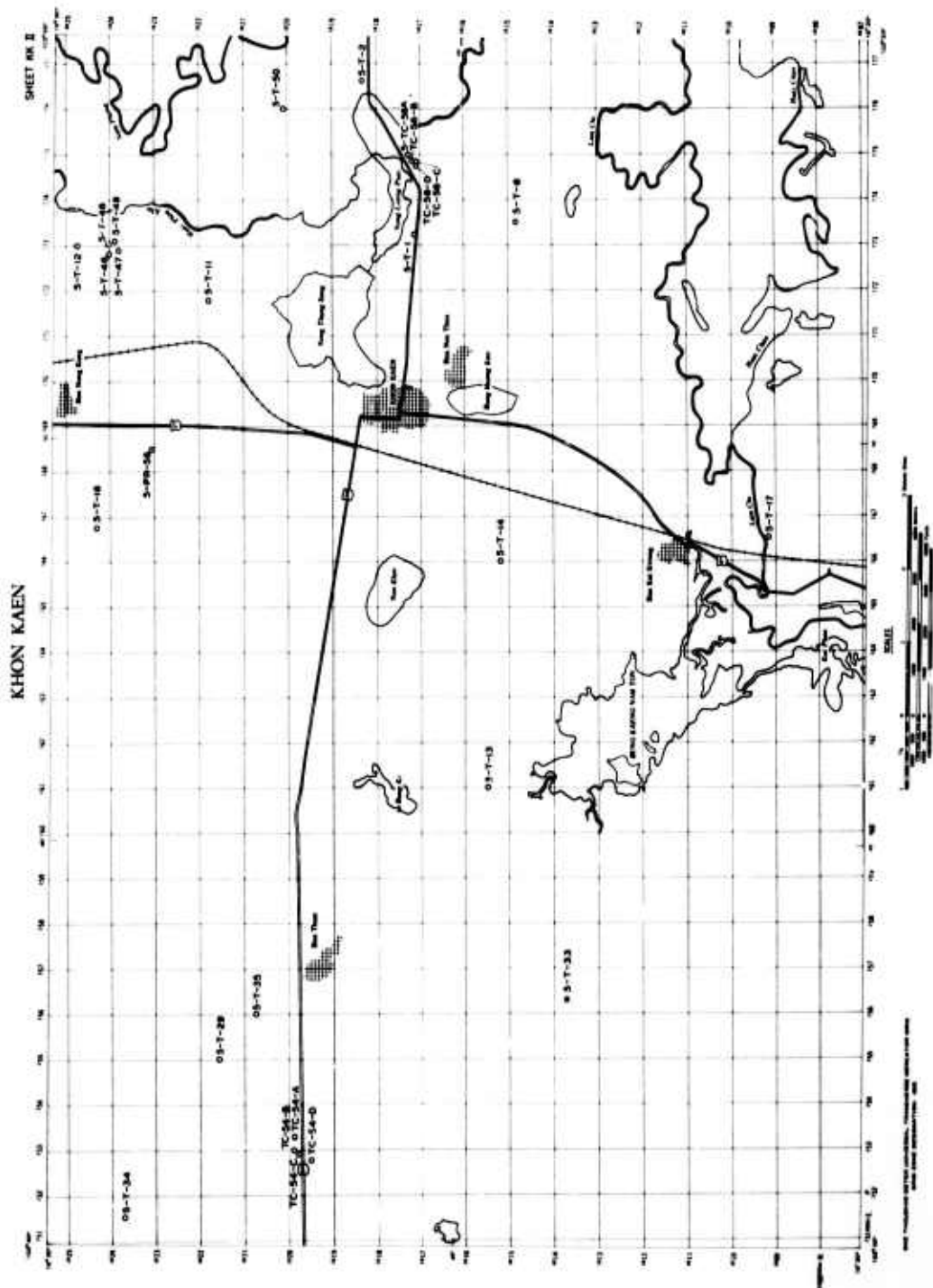


FIG. A19



CHANTHABURI STUDY AREA

BLANK PAGE

Table A6
Summary of Surface Composition Field Data
Chanthaburi

Map Class*	Site No.	Date Sampled	Location			Topographic Position	Slope %	Unified Soil Classification System					Soil Strength Measurements				Moisture Content %	
			AMS Map Sheet**	Grid Coords	Figure No.			Fines % by Weight	Atterberg Limits			Soil Type	Cone Index	Remolding Index	Rating Cone Index	Sheargraph		
									LL	PL	PI					σ_{ur} psi		α_{ur} deg
1	6-TC-28A	23/9/64	5448IV	889951	A24	TS	2	54	32	14	18	CL	153	0.54	83	0.5	13	18.2
1	6-TC-28B	23/9/64	5448IV	889952	A24	TS	2	52	24	15	9	CL	112	0.68	76	0.0	13	17.2
1	6-TC-28C	23/9/64	5448IV	889952	A24	TS	2	51	25	16	9	CL	147	0.50	74	0.2	13	19.4
run	6-TC-28D	23/9/64	5448IV	889953	A24	T	0	58	28	17	11	CL	145	0.54	78	0.2	14	18.8
run	6-TC-29A	23/9/64	5448IV	840993	A24	BF	0	67	44	24	20	CL	93	0.38	35	0.0	7	37.6
run	6-TC-29B	23/9/64	5448IV	838932	A24	BF	0	78	88	33	55	CH	47	0.51	24	--	--	93.8
run	6-TC-29C	23/9/64	5448IV	841934	A24	BF	0	78	34	17	17	CL	88	0.48	42	0.6	9	31.5
run	6-TC-30A	24/9/64	5448IV	759003	A24	NL	0	58	28	16	12	CL	103	0.49	50	0.2	10	21.5
run	6-TC-30B	24/9/64	5448IV	758004	A24	TS	2	48	23	15	8	SC	50	0.64	32	0.2	10	20.5
run	6-TC-30C	24/9/64	5448IV	758005	A24	TS	2	41	17	12	5	SM-SC	91	0.46	42	0.0	15	16.7
run	6-TC-30D	24/9/64	5448IV	758006	A24	T	0	51	23	14	9	CL	99	0.54	53	0.2	13	19.1
run	6-TC-31A	24/9/64	5339II	213078	A22	NL	5	76	41	25	16	CL	69	0.52	36	0.2	16	32.3
run	6-TC-31B	24/9/64	5339II	213078	A22	BF	0	93	65	33	32	MH	63	0.68	43	1.1	6	41.3
run	6-TC-31C	24/9/64	5339II	212078	A22	BD	0	94	55	28	27	CH	49	0.61	30	--	--	38.3
run	6-TC-31A	25/9/64	5339II	141101	A22	T	0	49	--	--	NP	SM	109	0.07	8	0.0	21	22.3
run	6-TC-32B	25/9/64	5339II	141101	A22	LS	8	49	12	--	NP	SM	115	0.36	41	0.0	18	16.6
run	6-TC-32C	25/9/64	5339II	141102	A22	MS	10	61	27	16	11	CL	96	0.51	49	0.9	12	18.9
run	6-TC-32D	25/9/64	5339II	141102	A22	US	11	61	24	14	10	CL	124	0.52	64	0.8	14	17.5
run	6-TC-33A	25/9/64	5448IV	759001	A24	BD	0	92	53	33	20	MH	199	0.29	58	0.0	17	42.5
run	6-TC-33B	25/9/64	5448IV	761000	A24	TS	3	87	56	43	13	MH	326	--	tf**	0.0	19	41.7
run	6-TC-33C	25/9/64	5448IV	762999	--	T	0	86	--	--	NP	SM	79	0.68	54	0.0	20	43.3
run	6-TC-34A	26/9/64	5349III	951136	--	NL	0	88	--	--	NP	SM	114	0.54	62	0.7	4	30.3
run	6-TC-34B	26/9/64	5349III	951137	--	T	1	60	--	--	NP	SM	112	0.59	66	0.2	15	19.9
run	6-TC-34C	26/9/64	5349III	950138	--	TS	4	42	48	24	24	SC	186	0.83	154	0.8	14	17.7
run	6-TC-34D	26/9/64	5349III	950139	--	TS	3	42	36	19	17	SC	583+	0.55	321+	0.7	19	18.8
run	6-TC-34E	26/9/64	5349III	940139	--	LS	5	58	36	22	14	CL	686+	--	tf	0.8	17	21.4
run	6-TC-35A	27/9/64	5349III	743027	--	BF	0	70	22	15	7	CL-ML	81	0.35	28	0.5	20	20.2
run	6-TC-35B	27/9/64	5349III	743028	--	TS	4	67	26	13	13	CL	105	0.73	77	0.0	17	17.7
run	6-TC-35C	27/9/64	5349III	743028	--	T	0	52	12	12	0	ML	119	0.48	57	0.2	20	16.7
run	6-TC-35D	27/9/64	5349III	742028	--	LS	5	45	14	--	NP	SM	114	1.28	146	0.3	15	16.0
run	6-TC-35E	27/9/64	5349III	742029	--	MS	10	66	26	16	10	CL	115	0.60	69	1.0	20	18.6
run	6-TC-36A	28/9/64	5248I	578980	--	BF	0	33	34	16	18	SC	119	0.47	56	0.0	13	25.3
run	6-TC-36B	28/9/64	5248I	578979	--	TS	2	13	11	--	NP	SM	117	0.38	44	0.3	14	25.5
run	6-TC-36C	28/9/64	5248I	577979	--	T	0	9	--	--	NP	SP-SM	149	0.77	115	0.9	15	20.7
run	6-TC-36D	28/9/64	5248I	576979	--	LS	2	6	--	--	NP	SP-SM	208	1.13	235	0.0	15	7.0
run	6-TC-36E	28/9/64	5248I	575979	--	UF	0	8	--	--	NP	SP-SM	171	0.87	149	0.3	15	9.0
run	6-TC-37A	29/9/64	5149II	059082	--	BF	0	60	30	12	18	CL	96	0.57	55	1.0	15	18.2
run	6-TC-37B	29/9/64	5159II	059082	--	TS	3	63	36	13	23	CL	128	0.38	49	0.3	13	17.3
run	6-TC-37C	29/9/64	5159II	059081	--	T	0	46	20	12	8	SC	68	0.60	41	0.4	15	16.8
run	6-TC-37D	29/9/64	5149II	058080	--	T	0	71	29	14	15	CL	81	0.42	34	0.0	15	25.0
run	6-CR-100	6/10/64	5448IV	986980	A24	--	--	41	26	16	10	SC	290+	--	tf	--	--	16.4
run	6-CR-101	6/10/64	5448IV	987982	A24	--	--	31	48	31	17	SM	221+	--	--	--	--	16.4
run	6-CR-109	7/10/64	5448IV	885977	A24	--	--	27	--	--	NP	SM	178+	--	tf	--	--	13.9
run	6-CR-113	7/10/64	5349III	128096	A22	--	--	36	21	17	4	SM-SC	177	--	--	--	--	16.6
run	6-CR-116	7/10/64	5448IV	770991	A24	--	--	60	52	--	19	MH	135	1.10	146	--	--	44.5
9	6-CR-118	8/10/64	5448III	002774	A25	--	--	66	79	44	35	MH	128	0.63	81	--	--	40.0
1	6-CR-119	8/10/64	5448III	973767	A25	--	--	78	57	25	32	CH	--	--	--	--	--	142.0
13	6-CR-120	8/10/64	5448III	969788	A25	--	--	10	--	--	NP	SP-SM	108	--	--	--	--	18.2
1	6-CR-126	9/10/64	5448III	897782	A25	--	--	83	64	36	28	MH	37	0.52	19	--	--	77.6
4	6-CR-127	9/10/64	5448III	895783	A25	--	--	90	67	32	35	CH	56	0.94	53	--	--	57.5
4	6-CR-129	9/10/64	5448III	903820	A25	--	--	71	54	26	28	CH	110	0.58	64	--	--	26.5
13	6-CR-130	9/10/64	5448III	904830	A25	--	--	0	--	--	NP	SP	300+	--	tf	--	--	20.0
4	6-CR-131	9/10/64	5448IV	908835	A24	--	--	38	40	19	21	SC	142	0.59	84	--	--	24.4
13	6-CR-132	9/10/64	5448IV	882954	A24	--	--	44	43	30	13	SM	203+	0.96	195	--	--	23.5
13	6-CR-133	10/10/64	5448IV	866877	A24	--	--	23	--	--	NP	SM	116	--	--	--	--	13.4
4	6-CR-137	10/10/64	5448IV	900857	A24	--	--	46	49	28	21	SM	127	0.49	62	--	--	30.3
run	6-CR-139	10/10/64	5448IV	911931	A24	--	--	22	33	19	14	SC	185+	0.45	83+	--	--	21.6
run	6-CR-140	10/10/64	5448IV	896343	A24	--	--	18	27	19	8	SC	153	--	--	--	--	12.6
run	6-CR-141	10/10/64	5448IV	895966	A24	--	--	49	22	17	5	SM-SC	74	0.46	34	--	--	19.1
1	6-CR-143	11/10/64	5448IV	804875	A24	--	--	68	80	46	34	CH	29	0.49	14	--	--	99.8
2	6-CR-144	11/10/64	5448IV	811869	A24	--	--	71	49	27	22	CL	82	0.73	60	--	--	44.1
4	6-CR-145	11/10/64	5448IV	812917	A24	--	--	75	26	17	9	CL	50	0.64	32	--	--	45.5
run	6-CR-146	11/10/64	5448IV	757002	A24	--	--	59	38	23	15	CL	290+	0.46	133+	--	--	22.7
9	6-CR-147	11/10/64	5448IV	757993	A24	--	--	47	23	--	NP	SM	170+	0.60	102+	--	--	17.5
9	6-CR-148	11/10/64	5448IV	752981	A24	--	--	50	46	35	11	ML	300+	0.97	291+	--	--	26.2
13	6-CR-149	11/10/64	5448IV	773974	A24	--	--	53	63	47	16	ML	216	1.29	279	--	--	41.5
9	6-CR-150	11/10/64	5448IV	786958	A24	--	--	56	56	43	13	MH	104	--	--	--	--	34.6
run	6-CR-151	12/10/64	5448IV	790998	A24	--	--	59	60	29	31	CH	213	--	--	--	--	42.8
run	6-CR-152	12/10/64	5448IV	788991	A24	--	--	44	41	26	15	SM	159	1.23	196	--	--	22.5
run	6-CR-154	12/10/64	5448IV	783984	A24	--	--	61	57	44	13	MH	94	1.52	143	--	--	52.8
11	6-CR-157	13/10/64	5448IV	791948	A24	--	--	66	61	46	15	MH	150	0.82	123	--	--	46.4
9	6-CR-158	13/10/64	5448IV	784968	A24	--	--	56	57	44	13	MH	130	0.46	60	--	--	--
run	6-CR-159	13/10/64	5448IV	807970	--	--	--	58	36	20	16	CL	229+	0.59	135+	--	--	19.0
run	6-CR-160	13/10/64	5448IV	811969	--	--	--	46	37	21	16	SC	133	1.14	152	--	--	24.6
run	6-CR-165	14/10/64	5448IV	755009	A24	--	--	40	34	20	14	CL	187	0.64	120	--	--	17.4

(Continued)

Note: All soil strength measurements except sheargraph measurements were made at a 15- to 30.5-cm depth. Sheargraph measurements were made at the surface.

* run, not mapped.

** Series L70B, scale 1:50,000.

† BF, bottomland flat; BD, bottomland depression; LS, lower slope; MS, middle slope; NL, natural levee; T, terrace; TS, terrace slope;

SB, stream bottom; UD, upland depression; UF, upland flat; US, upper slope.

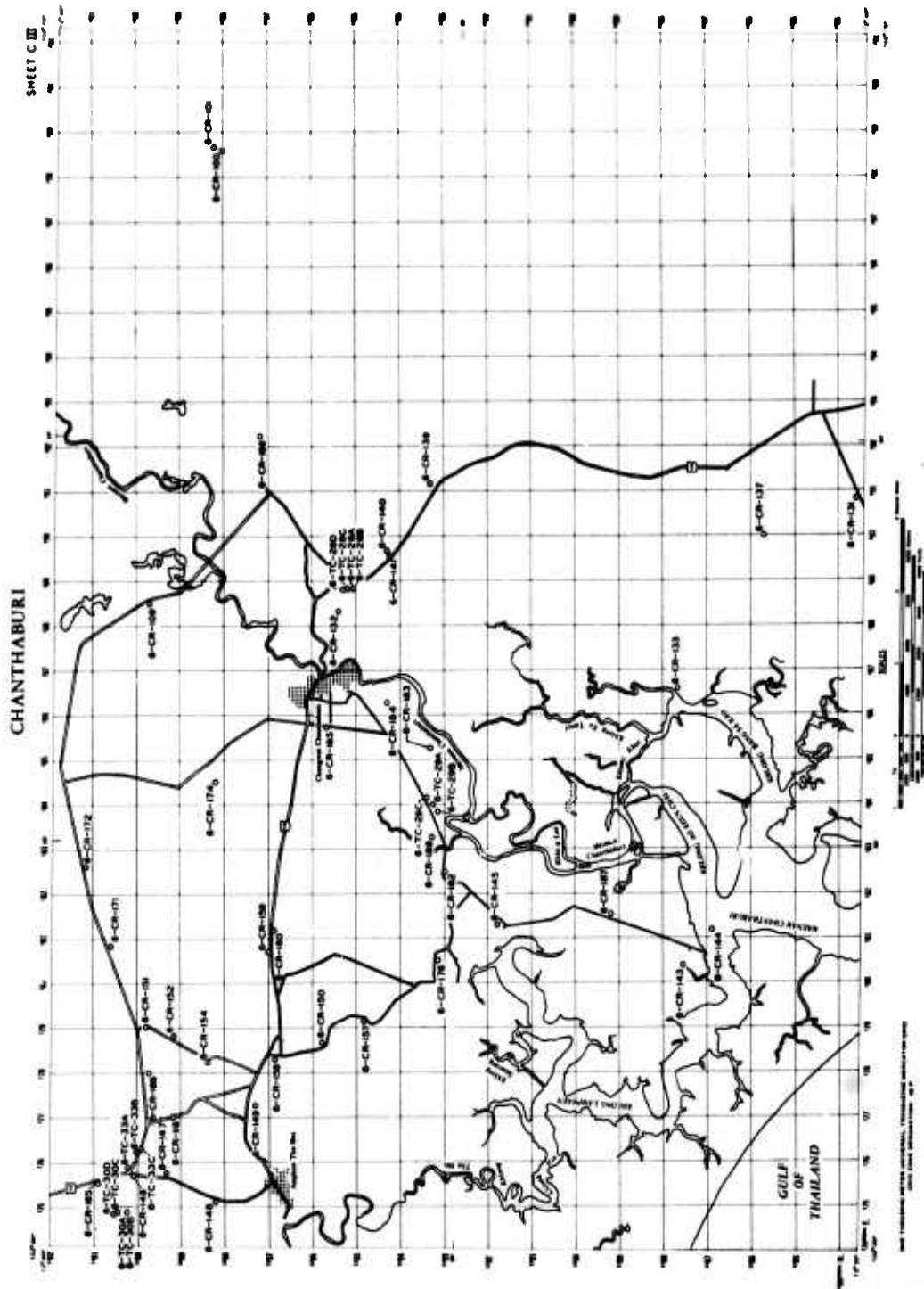
†† σ_{ur} , shear strength at zero normal load.

* α_{ur} , ultimate angle of internal friction.

** tf, too firm.

Table A6 (Concluded)

Map Class	Site No.	Date Sampled	Location			Topo-graphic Position	Slope %	Unified Soil Classification System					Soil Strength Measurements				Moisture Content %	
			AMS Map Sheet	Grid Coords	Figure No.			Fines % by Weight	Atterberg Limits			Soil Type	Cone Index	Remold-ing Index	Rating Cone Index	Sheargraph		
									LL	PL	PI					Sur psi		Sur lbs
nm	6-CR-168	14/10/64	5448IV	780997	A24	--	60	61	44	17	MH	300*	--	--	--	--	44.2	
nm	6-CR-171	14/10/64	5448IV	809007	A24	--	34	46	28	18	SH	151	--	--	--	--	19.6	
nm	6-CR-172	14/10/64	5448IV	826012	A24	--	31	43	24	19	SC	235*	0.78	183*	--	--	19.6	
nm	6-CR-174	14/10/64	5448IV	845988	A24	--	59	44	27	17	ML	120	1.19	143*	--	--	30.8	
11	6-CR-176	15/10/64	5448IV	805932	A24	--	48	55	41	14	SM	108	1.15	13*	--	--	44.5	
nm	6-CR-177	15/10/64	5449III	977056	--	--	65	39	24	15	CL	173	0.79	137	--	--	25.9	
nm	6-CR-178	15/10/64	5449III	973084	--	--	39	16	--	NP	SH	141	0.11	16	--	--	20.0	
4	6-CR-182	16/10/64	5448IV	825930	A24	--	36	45	26	19	SC	241*	--	--	--	--	16.2	
12	6-CR-183	16/10/64	5448IV	853934	A24	--	86	47	28	19	ML	219*	--	--	--	--	--	
9	6-CR-184	16/10/64	5448IV	862943	A24	--	58	58	43	15	MH	109	0.53	58	--	--	49.0	
nm	6-CR-185	16/10/64	5448IV	858957	A24	--	86	61	41	20	MH	94	0.76	71	--	--	--	
nm	6-CR-186	17/10/64	5448IV	923973	A24	--	26	26	19	7	SC	217	--	--	--	--	15.7	
1	6-CR-187	17/10/64	5448IV	815892	A24	--	69	59	34	25	OH	18	--	--	--	--	91.2	
1	6-CR-189	17/10/64	5448IV	832933	A24	--	45	56	11	45	SC	53	--	--	--	--	65.9	
nm	6-CR-190	18/10/64	5349II	153084	A22	--	52	47	28	19	ML	245*	1.00	300*	--	--	20.0	
11	6-CR-191	18/10/64	5349II	151067	A22	--	83	54	34	25	CH	157*	1.05	165*	--	--	22.6	
11	6-CR-194	18/10/64	5349II	124028	A22	--	41	28	17	11	SC	202*	1.12	226*	--	--	18.6	
11	6-CR-195	18/10/64	5348I	137992	A23	--	75	27	18	9	CL	280*	0.75	210*	--	--	17.8	
12	6-CR-197	18/10/64	5348I	127948	A23	--	0	--	--	NP	SP	207	--	--	--	--	8.4	



11	12
13	14
15	16

SURFACE COMPOSITION SITES
 CHANTHABURI STUDY AREA
 SHEET C III

Unclassified

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract) and indexing annotation must be entered when the report is classified

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP

3. REPORT TITLE
MOBILITY ENVIRONMENTAL RESEARCH STUDY; A QUANTITATIVE METHOD FOR DESCRIBING TERRAIN FOR GROUND MOBILITY; SURFACE COMPOSITION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Volume II of an eight-volume report

5. AUTHOR(S) (First name, middle initial, last name)
Ramil C. Wright
James R. Burns

6. REPORT DATE January 1968	7a. TOTAL NO. OF PAGES 95	7b. NO. OF PAGES 14
--------------------------------	------------------------------	------------------------

8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. Order No. 400 d.	9a. ORIGINATOR'S REPORT NUMBER Technical Report No. 3-726
	9b. OTHER REPORT NUMBER (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT
This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of U. S. Army Materiel Command.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Advanced Research Projects Agency; Service Agency: U. S. Army Materiel Command, Washington, D. C.
-------------------------	--

13. ABSTRACT
This volume presents the methods used to collect, tabulate, and analyze basic data on surface composition of six selected Thailand study areas--Nakhon Sawan, Lop Buri, Chiang Mai, Pran Buri, Khon Kaen, and Chanthaburi. Fifteen mapping classes that expressed the different soil mass strength and soil surface strength conditions were established. The criteria used in isolating these classes were (a) that each class be identifiable using air-photo interpretation techniques and (b) that each class exhibit similar variations in strength with moisture content. Areas with equivalent trafficability characteristics in terms of the 15 map classes were delineated on 25 surface composition maps together covering the six study areas. This delineation was accomplished through interpretation of maps and air photos with control data in the form of field and laboratory information. The maps are presented in Volume VIII of this report. A compromise between the desired degree of mapping class refinement and that dictated by the photo-interpretation criteria was necessary because of the nature of the field data. During the mapping program when sample site data were extrapolated to unsampled areas, the degree of mapping refinement was of necessity only fair to low. It is recommended that additional studies be conducted on the use of air-photo identification techniques in classifying soil strength conditions. This approach is believed to be basically sound; however, more field verification of predicted values will help to determine the reliability of this approach.

DD FORM 1473

REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

Unclassified
Security Classification

10. REV WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROL	WT	ROLE	WT
Aerial photography						
Environmental studies						
Mobility						
Soils--strength						
Soils--trafficability						
Terrain analysis						
Terrain--Thailand						
Thailand						