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TECHNICAL REPORT NO. 3-723

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

Volume V

HYDROLOGIC GEOMETRY

by

E. E. Smith

J. H. Chamberlain



November 1967

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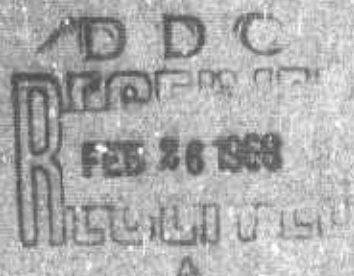
Advanced Research Projects Agency
Directorate of Remote Area Conflict

Service Agency

U. S. Army Materiel Command

Conducted by

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



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Volume V

HYDROLOGIC GEOMETRY

by

**E. E. Garrett
J. H. Shamburger**



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ARMY-MRC VICKSBURG, MISS.



Vicksburg, Mississippi

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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 was 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 by a three-man team. Personnel who served on this team at various times were: Messrs. H. W. West and B. T. Helmuth, Area Evaluation Branch (AEB), Mobility and Environmental (M&E) Division, WES; Mr. V. H. Anderson and PVT G. Cunningham, U. S. Army Cold Regions Research and Engineering Laboratory (CRREL); and Messrs. Ruangvitya Chotibitayathamin, Sarid Srithirom, Sriwiroj Chantawong, Anuvat Laophanich, Thamnoon Mongkol, Boonkiat Sirimontaporn, Suchart Supaphol, Taweesak Suwanpitak, and Tawee Klinproung, MERS Field Detachment, Bangkok, Thailand. Field sampling was under the direct supervision of a data collection leader. This position was occupied for periods of 3 to 4 months each by Messrs. W. K. Dornbusch, Jr., and J. D. Broughton, WES Geology Branch, and Mr. Ruangvitya Chotibitayathamin, MERS Thailand Detachment. The data collection accomplished by CRREL was under the direct supervision of Mr. R. E. Frost, Chief, Photographic Interpretation Division, CRREL. Data reduction and map preparation were accomplished by a team composed of Messrs. E. E. Garrett, team captain, H. W. West, W. W. Allred, and M. A. Zappi of AEB. The report was written by Messrs. Garrett and J. H. Shamburger, WES Geology Branch. The data reduction and map preparation phase was conducted under the direction of Mr. Shamburger. Technical assistance in various phases of the work was provided by Mr. A. A. Rula, Chief, Mobility and Environmental Research Studies Branch. All phases of this study were under the direct supervision of Mr. W. E. Grabau, Chief, AEB, and Dr. C. R. Kolb, Chief, Geology Branch, 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.

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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
feet	0.3048	meters
feet per second	0.3048	meters per second

SUMMARY

This volume presents the methods used in collecting hydrologic geometry data in selected areas in Thailand. The selection, analysis, and classification of parameters significant to vehicle mobility are discussed. The photo-interpretation methods used in identifying hydrologic geometry features from aerial photographs (air photos) and the extrapolation of these identifications to areas not investigated on the ground are presented. The rationale for cartographic portrayal of these parameters is explained. Utilizing the collected field data, available air photos, and the Army Map Service series of topographic maps, hydrologic geometry factor maps were prepared covering the six selected study areas (Nakhon Sawan, Lop Buri, Chiang Mai, Chanthaburi, Pran Buri, and Khon Kaen). The maps are presented in Volume VIII of this series.

It proved only partially possible to determine the existence and value of the chosen parameters from air photos since some of the individual factors are wholly or partially below the water surface. Nevertheless, photo interpretation plus extrapolation from measured sites made it possible to map the parametric values by class range with reasonable validity. Recommendations are made involving improvement in data-collection techniques.

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

VOLUME V: HYDROLOGIC GEOMETRY

PART I: INTRODUCTION

Background

1. Hydrologic geometry as a factor family, per se, comprises factors that are partially or wholly related to other factor families. That is, it includes factors that are treated more specifically in the consideration of surface geometry and surface composition. For example, the shape of a stream channel is properly a surface geometry feature, and the soils in the bed and banks are surface materials. The justification for making hydrologic geometry an independent factor family lies in the fact that surface geometry features and surface materials, in association with water, produce an array of unique effects on numerous military activities.

2. This array of effects tends to focus sharply, but not exclusively, on the water margins. Amphibious vehicles operate relatively independently of water depth, but they are extremely sensitive to the angle at which they can enter or leave the water. Progressive changes in buoyancy and center of gravity take place as a vehicle passes from a state of flotation, through partial support, to complete ground traction. Amphibious vehicles are also sensitive to current velocity and wave action. Through the operation of such factors, the water-land interface assumes great significance for cross-country mobility. Consequently, the data collection systems described herein are designed to provide detailed information on the dynamic characteristics of water in motion as well as the interface between water, land, and air. In view of this, the data array consists of details of three sets of properties: the surface geometry or cross-sectional shape of the entire channel, including its banks; the composition and strength of the materials forming the channel;

and the water depth and current velocity.

3. As with surface geometry,¹ no completely satisfactory method of describing and classifying surface-water bodies in an objective and quantitative manner is presently known. Hydrologic geometry is faced with the same problem of describing an irregular three-dimensional surface as is surface geometry. Also, hydrologic geometry encompasses the requirement of describing very large variations in geometric conditions that occur within short distances and/or even within relatively short periods of time. For example, a single period of rain may change streams from sluggish trickles to rapidly moving floods several meters deep.

4. These dynamic and transient characteristics, coupled with the complexity of an irregularly warped surface, make it impossible to fit descriptive data into an established classification system. Therefore, the investigator is faced with the necessity of measuring and recording sufficient basic data so that, hopefully, the requirements of any classification system that may emerge in the future can be met.

Purpose and Scope

Purpose

5. The overall purpose of this study was to collect, analyze, and present data on surface composition, surface geometry, vegetation, and hydrologic geometry in selected areas presumably representative of Thailand, with two definite objectives in view. The immediate objective was to assemble these data in such a form that they could be used to determine the effects of terrain on the cross-country mobility of ground-contact vehicles in environments characteristic of Southeast Asia. The long-term objective was to further the development of quantitative methods for describing those terrain factors that significantly affect vehicle mobility in terms suitable for their use as input to a mathematical or analytical vehicle-speed prediction model.

6. The specific purpose of this study was to measure the principal hydrologic geometry factors known or presumed to affect vehicle performance in selected areas of Thailand, to develop methods for estimating factor

values by the interpretation of aerial photographs (air photos), and to classify and map the significant factor values in the selected areas.

Scope

7. The results presented in this study were derived primarily from analyses of 554 sites within the six primary study areas (Nakhon Sawan, Lop Buri, Chiang Mai, Pran Buri, Khon Kaen, and Chanthaburi) (fig. 1). The data were collected in the field in the period July 1964-May 1965. Interpretation of air photos constituted a major source of information for the factor maps, but scale and vintage of the air photos (see legend in fig. 1) affected the accuracy and reliability of interpretation.

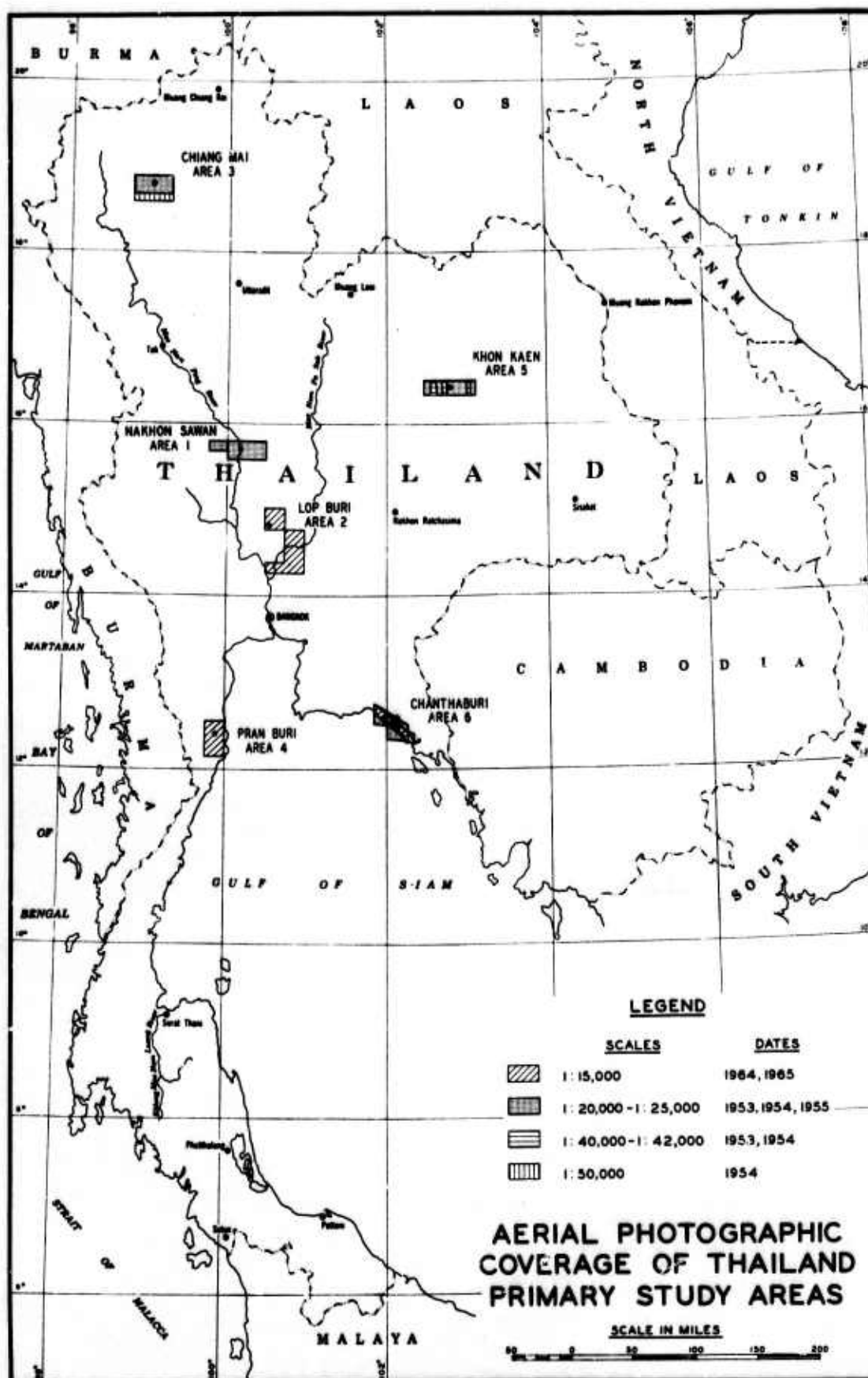


Fig. 1. Primary study areas in Thailand

PART II: DATA COLLECTION PROCEDURES

8. "Water body" is used as a general term to encompass such hydrologic features as canals, streams, lagoons, and even lakes and reservoirs. These hydrologic features within Thailand do, in fact, grade from one to another to such an extent that the categories are often indistinguishable.

9. For the purpose of collecting field data, a channel or basin with a water depth of 25 cm or greater for a total period of one week of the year was considered a hydrologic geometry feature. Conversely, a channel or basin with a lesser amount of water (or even a greater amount of water for a shorter period of time) was categorized as a surface geometry feature. However, before the data were analyzed and mapping was begun, these definitions were revised. The revisions are discussed in paragraph 18. It was evident that it would often be difficult or impossible to establish the proper category into which a specific feature should be placed. This was not regarded as serious because the precise categorization of a feature is of distinctly secondary importance. The important thing was to measure adequately all features. Therefore, borderline cases were placed in one category or another and thus recorded.

10. No attempt was made to actually measure the plan geometry of water bodies. Since most of the area studied is covered by adequate maps and/or air photos, it was felt that in most instances the areal arrangement could be more rapidly obtained from them than from time-consuming field measurements. However, sketches of the local channel configurations were always made.

Selection of Sites

11. Water channels vary so greatly within relatively short distances that no detailed instructions for the selection of sampling sites could be given. The general intent of the sampling program was to establish the nature and range of variation for the hydrologic geometry features in the areas studied. The following general considerations were given to the selection of sites:

- a. Channels of all sizes and types (natural and artificial) should be sampled.
- b. Channels of sinuous and meandering types, wherever possible, should be sampled both at a bend and an adjacent crossover (fig. 2).
- c. Each channel should be examined for basic variations in cross-sectional configuration, and each variation should be measured, if possible.
- d. Sites should be selected at bridges only as a last resort because the channel configurations at such sites are usually abnormal as a result of the presence of piers or control works. Where sites must be selected nearby, care must be taken to ensure that the locations are beyond the influence of the bridge.

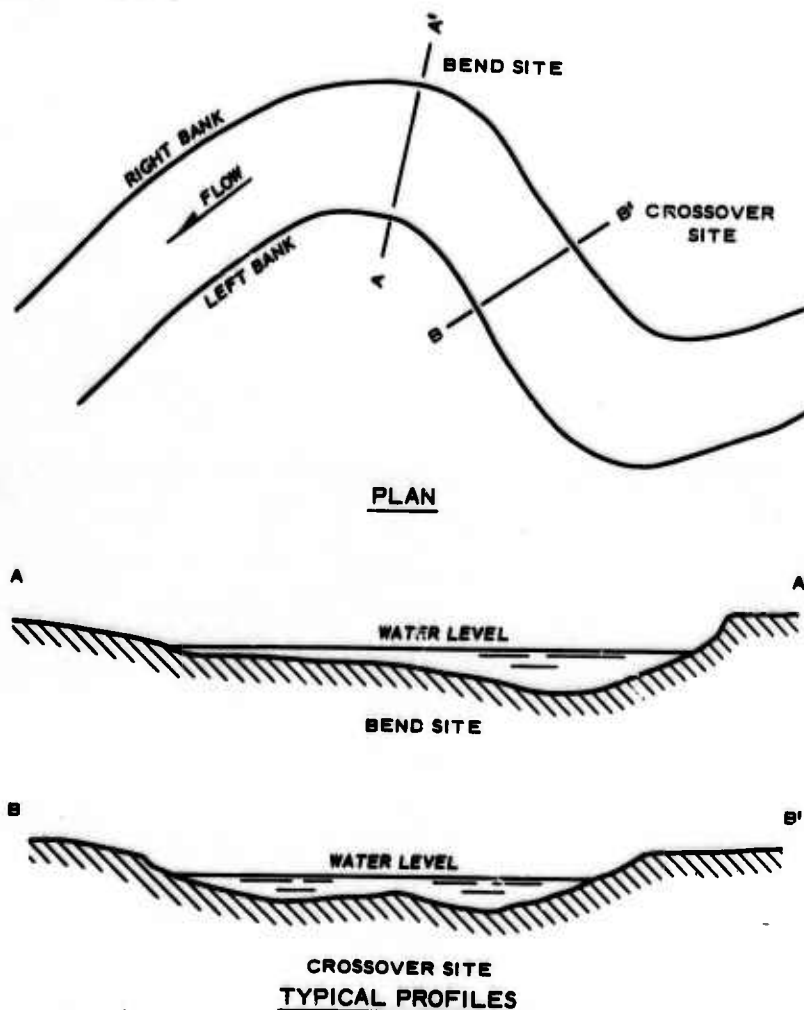


Fig. 2. Study site location on sinuous or meandering channels

Topographic Description and Measurement of Sites

12. The usefulness of an environmental description of a site depends upon a knowledge of its exact location, the physiographic context in which the site occurs, and the time at which features at the site were measured, since two identical configurations can occur as the result of different genetic processes. Often the only way to distinguish between the configurations is by identifying the geographic context and noting the time at which the description was made. Location is of absolute importance, because a mislocated point of ground truth can lead a photo interpreter badly astray; the sample point may be located on the photograph in a pattern different from that in which it actually occurs. Accordingly, for every sampled location data were recorded on a hydrologic geometry site description form. Fig. 3 is an example of this form with typical data inserted. Instructions for completing this form are given in the Environmental Data Collection Manual.²

13. Since a vehicle traversing any terrain reacts only to the surface with which it is in contact, it is necessary to determine the configuration of a 3-m-wide strip of terrain approximately corresponding to the vehicle width along the presumed course in order to reduce the vehicle/terrain relation to analytical terms. To determine the topographic configuration of this strip, an appropriate number of cross sections must be measured. The number of cross sections to be measured depends on the complexity of the surface. Ideally, there should be enough to enable reproduction of the surface from the data alone. Usually, two cross sections were measured at each site. However, artificial channels were often of such uniform cross section that a second cross section would have been superfluous. Occasionally, three cross sections were measured, but limitations of time usually dictated that not more than two be measured. The profiles were measured in a direction normal to the channel and were of sufficient length to encompass the maximum width of the channel under the highest expectable water conditions.

14. The procedures followed in measuring the cross sections are detailed in the previously cited Environmental Data Collection Manual

SITE DESCRIPTION DATA FORM

(HYDROLOGIC GEOMETRY)

SITE NO.: I-H-10 DATE: 21 Aug 61 COUNTRY: Thailand
MAP REFERENCE: Changwat Nakhon Sawan, Thailand, Sheet No. 5058 III
GEOGRAPHIC COORDINATES: Long. 100°04'52" East, Lat. 15°41'27" North
NAME OF WATER BODY: Map Name: - Khlong Bang Pong
SITE ELEVATION: 26 meters AZIMUTH OF PROFILE: 316° CURRENT DIRECTION: West
Grid Coordinates: 158948 SHEET 1 OF 1
POSITION OF SITE:

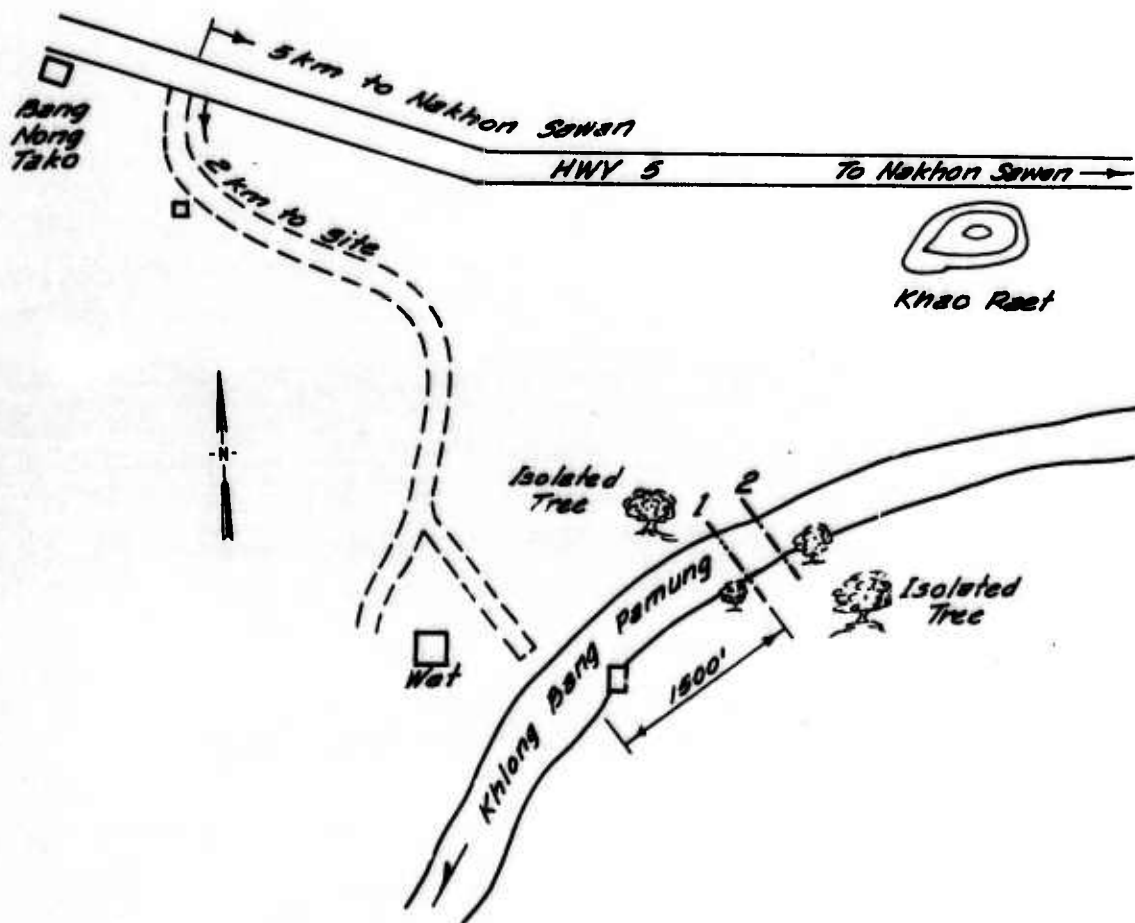


Fig. 3. Completed site description data form

(paragraph 12). The details of procedure varied from site to site in order that specific situations could be accommodated. Figs. 4 and 5 present examples of typically completed additional forms on which the data taken at all hydrologic geometry sites were recorded. Nearly all hydrologic geometry measurements in Thailand were recorded in British units, primarily because all of the readily available instruments were so calibrated. Since the field data were in British units, all subsequent data manipulations (see Appendix A) were also performed in British units.* In general, relative elevations were measured at every point along the cross section where there was an obvious change in slope. Cone index profiles were taken in every obviously different soil type or soil condition, and normally additional cone index profiles were taken at the edge of the water (fig. 4, second and third cone index records**) regardless of other considerations. Soil types were usually identified only by field observation, and then only the 0- to 6-in. layer was examined. Only rarely were samples taken for laboratory analysis. At the time of sampling, the water level was taken, and the maximum water level, as indicated by high-water marks, was noted. Where the depth was over 25 cm, it was usually obvious from looking at the water body that this depth persisted for greater than one week per year. Where water depths were less than 25 cm at the time of measurements, high-water marks, conversation with people living in the vicinity, etc., usually permitted establishment of the fact that the feature in question fit the definition of a hydrologic geometry feature. When practical, current velocities were measured at several points along the cross section, with the points chosen to give a reasonably reliable current velocity profile across the channel. Photographs were taken of all aspects of the site.

15. The body of data, as outlined above, constitutes the factual basis on which the subsequent analysis and interpretation were

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

** The values entered on this form are averages of multiple cone penetrometer values; the cone penetrometer data (cone index values) are recorded in the field on a "Trafficability Data Form," illustrated in fig. 5.

HYDROLOGIC GEOMETRY DATA FORM

SITE NO.: 1-H-10 DATE: 21 Aug 1964 COUNTRY: Thailand
NAME OF WATER BODY: Khlong Bang Pamung
GENERAL LOCATION: From Check Sta Hwy # 5, 5km NW - 2 km SE
MEASURED BY: West and Helmuth UNIT MEASURE: British

☒ MAXIMUM WATER LEVEL

SHEET 1 OF 2

☒ WATER LEVEL AT TIME OF SAMPLE

HI 3.70

PROFILE NUMBER	PROFILE OFFSET	DISTANCE FT	VERTICAL OFFSET, FT	CONE INDEX				SOIL TYPE 0-6" LAYER	CURRENT VELOCITY	REMARKS
				0"	6"	12"	18"			
1	0	-18.0	3.00							
		0.0	3.90	83	67	99	130	Clay		Bulk Sample 0-18"
		9.0	6.59							
		13.0	8.02	0	10	25	30	Clay		
		20.1	12.62						@1' 0.17 ft/sec	
		29.4	15.22						@1' 0.18 "	
		39.4	15.88							
		48.3	16.36							
		60.1	16.42						@1' 0.27 ft/sec	
		69.3	16.32							
		81.0	16.27						@1' 0.22 "	
		91.8	13.94						@1' 0.14 "	
		112.0	11.02							
		105.6	9.57							
		109.8	8.02	0	37	33	27	Clay		
		113.5	6.68							
		124.5	4.62							
		134.5	4.21							
2	10'	0.0	4.21							
		-18.0	2.59							
		0.0	3.94							
		7.0	5.76							
		14.0	7.86							
		18.5	10.86							
		26.5	14.91						@1' 0.16 ft/sec	
		36.0	15.56							
		46.4	16.22							
		54.3	16.21						@1' 0.26 "	
		63.3	16.61							
		74.6	16.19						@1' 0.20 "	

Fig. 4. Completed hydrologic geometry data form (sheet 1 of 2)

TRAFFICABILITY DATA FORM

(HYDROLOGIC GEOMETRY)

SITE NO. 1-H-10 DATE 5 Dec 64 COUNTRY Thailand
NAME OF WATER BODY Khleng Bang Parnung
MEASURED BY West and Suchart SHEET 1 OF 1

DISTANCE FT	CONE INDEXES AT INDICATED DEPTHS							NOTES
	SURFACE	7.5 CM (3 IN.)	15.0 CM (6 IN.)	22.5 CM (9 IN.)	30.0 CM (12 IN.)	37.5 CM (15 IN.)	45.0 CM (18 IN.)	
0.0	80	80	70	70	90	120	190	Bulk sample
	110	140	80	70	120	100	100	0"-12"
	60	40	80	70	70	80	100	clay
	SUM	250	260	200	210	280	300	390
AV	83	87	67	70	93	100	130	
13.0 Water level	0	10	10	15	25	30	50	clay
	0	5	5	20	25	20	20	
	0	10	15	20	25	25	20	
	SUM	0	25	30	55	75	75	90
AV	0	8	10	18	23	25	30	
109.8 Water level	0	40	40	40	30	40	40	clay
	0	30	30	40	40	30	20	
	0	10	40	20	10	20	20	
	SUM	0	80	110	100	100	90	80
AV	0	27	37	33	33	30	27	
SUM								
AV								
SUM								
AV								
SUM								
AV								

Fig. 5. Completed trafficability data form

established. Although the collection procedures incorporated all of the factors described above, it was anticipated that some of them, notably the soil type and cone index of bank and bottom and the current velocities, would be very difficult to interpret from air photos, especially if those photos were small scale. Data were collected, despite the expected interpretation problems, in order to provide as complete a description of each hydrologic geometry "type" as possible, on the chance that the data would subsequently prove useful, either for the MERS project or some later investigation. All of the basic data are on file at the U. S. Army Engineer Waterways Experiment Station.

PART III: DATA REDUCTION AND ANALYSIS

16. The sources of information that were consulted for the program of data reduction and analysis were: (a) the field measurements taken during the preliminary survey in 1962;³ (b) Army Map Service (AMS) Series L708 topographic maps (scale 1:50,000); and (c) the information assembled under the MERS data collection program from July 1964 to May 1965. The availability of published data was determined through a literature survey⁴ conducted as a separate MERS task. This survey revealed a considerable number (274) of references to hydrologic geometry of Thailand. However, only about 5 percent of these were pertinent to the study areas. Where references pertained to the areas of interest, usable information concerning profiles, soil type, and bank conditions of streams and rivers was consistently absent. Only a very limited number of the preliminary survey sites were positioned where the data could be applied. Therefore, the only practicable and useful data for this study came from the MERS data collection program and the AMS topographic maps.

17. During the period of data collection, 554 hydrologic geometry sites were sampled within the study areas shown in fig. 1. These sites were distributed among the study areas as follows: (a) Nakhon Sawan--46, (b) Lop Buri--125, (c) Chiang Mai--133, (d) Pran Buri--81, (e) Khon Kaen--105, and (f) Chanthaburi--64. Locations of these sites are shown on maps in Appendix A. These sites were selected from preliminary examination of air photos followed by ground reconnaissance. They encompassed as wide a variety of water body characteristics as time and accessibility allowed. Accessibility of sites was a limiting factor in Thailand because of the restricted road network. Sampling points were located where they could be reached by a 4-wheel-drive vehicle or by boat without undue loss of time.

Data Reduction

18. At the inception of the study and when the field data were being collected, the term hydrologic geometry was defined as inclusive

of any feature occupied by water to at least a 25-cm depth for a minimum of one week per year. On this basis, data appropriate to the factor family were recorded. However, after the conclusion of the data collection program, and when the analysis of the resultant information was contemplated, it became apparent that the original definition was not realistic in that it did not adequately accommodate the vehicle reaction to topographic configurations containing shallow water. In actuality, a vehicle crossing a water body of insufficient depth to alter significantly its ground-contact pressure or to affect its engine operation does not respond to the presence of the water. Consideration of this brought the obvious conclusion that such features should be considered as pertaining to surface geometry rather than hydrologic geometry. A decision had to be reached arbitrarily on the minimum depth of a water body that would significantly affect vehicle movement. To reach such a decision, specific vehicles had to be considered. Two were chosen: the M37 as representative of nonamphibious military vehicles, and the M113 as representative of vehicles with a "swimming" capability. The former has a maximum fording depth of 1.1 m. The latter becomes free-floating at a depth of 1.37 m. On this basis, and allowing an adequate safety margin, the minimum water depth chosen to distinguish a hydrologic geometry feature was fixed at 91 cm.

19. In addition, the obvious fact that many water bodies change depth and configuration very markedly on a seasonal cycle or even, in some cases, on a diurnal cycle (e.g. tidal channels) made it nearly mandatory that the maps contain information on both high- and low-water states. Obviously, in view of this, the time criteria described above (25-cm or more depth for a minimum of one week per year) had to be abandoned. Instead, a far less rigorous (and unfortunately partly qualitative) criterion was adopted: any feature containing water is a hydrologic geometry feature if it characteristically contains more than 91 cm of water during the appropriate "season." That is, a feature would be a hydrologic geometry feature during the dry season only if it characteristically contained more than 91 cm of water during that season, and

similarly for the wet season. In this context, "season" may imply either a yearly or a diurnal (i.e. tidal) cycle.

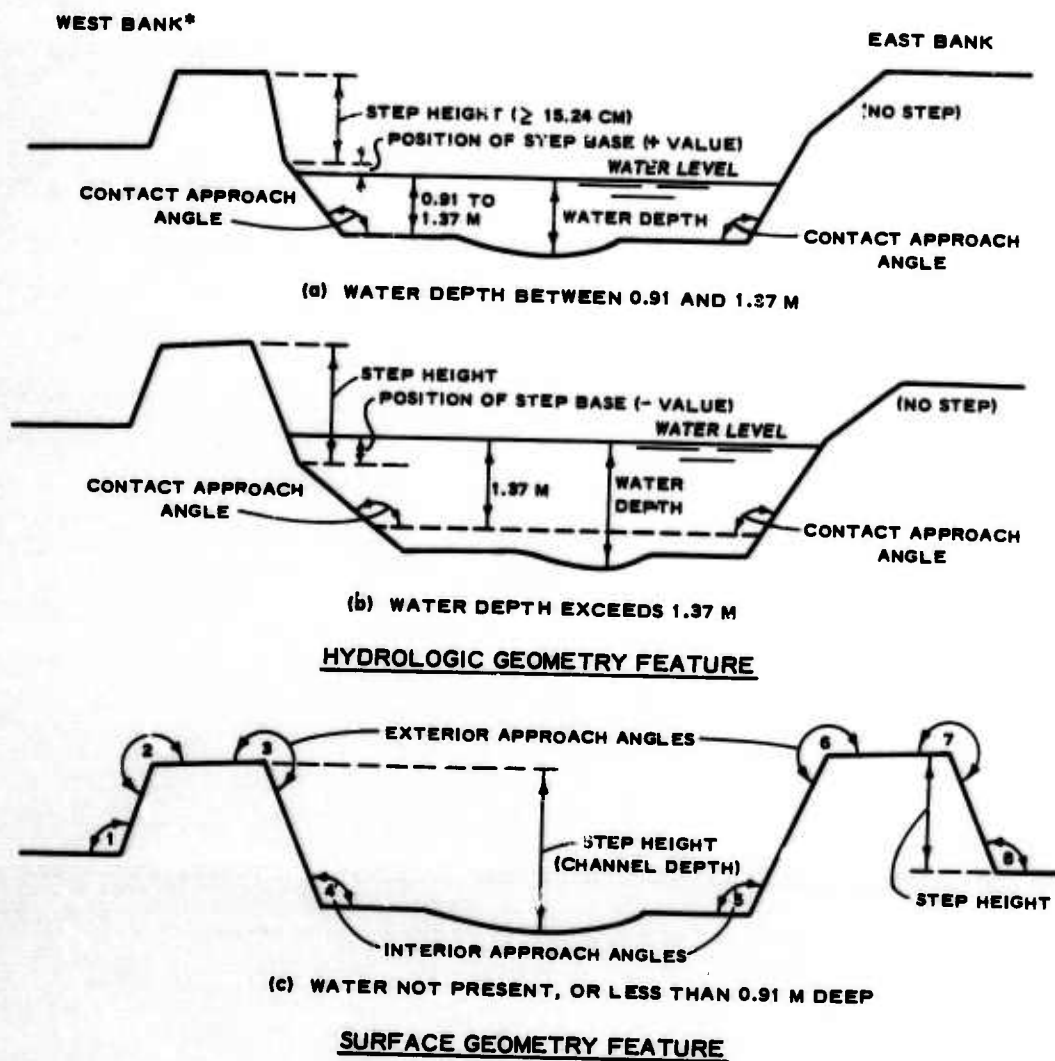
20. It was apparent that the division of water-containing features into wet-season and dry-season types would result in many features that would be hydrologic geometry features in the wet season and surface geometry features in the dry season. Such was, of course, found to be the case. Further, the redefinition of hydrologic geometry features by limiting consideration only to those containing 91 cm of water or more led to the conversion of many of the features that had previously been accepted as hydrologic geometry features (regardless of season) into surface geometry features, since the hydrologic geometry data collection teams selected sites on the basis of a minimum depth of 25 cm. Thus, a substantial body of data became available which, by all logic, should have been incorporated in the surface geometry data base. The difficulty lay in the fact that surface geometry (see Volume III of this series of reports) features were to be mapped on an areal basis, whereas all of the transformed hydrologic geometry data could be reasonably considered only on a linear basis, since without exception such data consisted of descriptions of shallow streams, canals, borrow pits, lake margins, and the like. In view of this, it was decided arbitrarily to include all linear surface geometry features on the same map used to present hydrologic geometry information. Since somewhat different parameter arrays had been developed for describing the two factor families (surface geometry and hydrologic geometry), these distinctions were maintained; therefore, the hydrologic geometry map requires a legend that encompasses both hydrologic and surface geometry (for example, see plate 1.1d of Volume VIII).⁵

21. There is no intent to map the width of channels or to indicate width by symbols. Standard conventions for the use of single or double lines for channels, as given in the AMS maps, indicate relative widths. These are not to be accepted as precise scalar representations. Lakes or other water-filled basins are shown as in the AMS base maps. The boundaries represent water-land contacts, not the 91-cm depth line, and are not based on conditions at a specified time in relation to seasonal water-land fluctuations.

22. In order to prepare a map of optimum utility, it was necessary to choose those parameters that are of greatest significance to vehicle mobility and that could be extracted from the available information. The number of parameters had to be limited so they could be comprehensibly presented on a map. Since vehicle test data were not available at the time this analysis was made, advantage could not be taken of that information to guide the choice of parameters. Within this framework, the following parameters (illustrated in fig. 6) were chosen:

<u>Hydrologic Geometry</u>	<u>Surface Geometry</u>
Contact approach angle (1)	Exterior terrain approach angle (6)
Step (2) height (3)	Interior terrain approach angle (6)
Position of step base (4)	Step height (7)
Water depth (5)	

-
- (1) Contact approach angle is defined under two conditions:
 - (a) where the water is between 0.91 and 1.37 m deep, and
 - (b) where the water depth is greater than 1.37 m. The contact approach angle under condition (a) is the angle between the bed and the bank of the water body; under condition (b) it is the angle formed by a line parallel to and 1.37 m below the water surface, and the bank of the water body.
 - (2) A step is a facet of the channel bank that (a) is steeper than that portion of the bank where the contact approach angle is measured, (b) exceeds 35 deg in slope, and (c) is at least 15 cm in vertical height.
 - (3) Step height is the difference in elevation between the top and base of a step.
 - (4) Position of step base is defined as the vertical distance of the base of a step above or below the surface of the water.
 - (5) Water depth is the greatest vertical distance between the water surface and the bottom of a channel.
 - (6) An interior terrain approach angle is the angle formed between the bed and bank of a drainage channel. An exterior approach angle is the angle formed between the stream bank and the ground surface above the channel.
 - (7) Step height for surface geometry is the vertical distance from the lowest point in the channel to the top of the lower bank.



* NOTE: WEST BANK IS THE FIRST BANK ENCOUNTERED WHILE TRAVERSING AN AREA IN AN EASTERLY DIRECTION (I.E. AZIMUTH > 0 TO 180 DEG) AND THE EAST BANK IS THE FIRST BANK ENCOUNTERED WHILE TRAVERSING AN AREA IN A WESTERLY DIRECTION (I.E. AZIMUTH > 180 TO 360 DEG), ASSUMING THAT THE VEHICLE INTERSECTS THE FEATURE AT A RIGHT ANGLE.

Fig. 6. Nomenclature and location of components of features described under hydrologic geometry

Analysis of Data

23. The data analysis was accomplished by the following steps:
 (a) constructing cross sections from the field data, (b) measuring the appropriate factors to be mapped, and (c) recording those measurements on an appropriate form.

24. The cross sections were constructed (fig. 7) at an undistorted scale from the data on the Hydrologic Geometry Data Forms (figs. 4 and 5). All cross sections at a site were plotted on the same sheet and identified. Since the classification to be used as the basis for mapping was dependent upon water depth, every effort was made to define the various water stages. The first step in the process was to plot the water level at the time the sample was taken (fig. 7). If the maximum and minimum levels were noted on the data sheets (as in fig. 4) they were also plotted (fig. 7, cross section 2). An effort was then made to establish the mean maximum and mean minimum water levels. As used herein, the terms are deliberately chosen to exclude extreme water levels that may be reached only for a few hours, at intervals of several years, immediately following unusually heavy rains, or, conversely, only after abnormally protracted periods of drought. The estimation of mean maximum water level was based on such indications as the presence of "nicks" on the banks or the presence of floodplain features on the level of the surface in which the channel is incised. In some instances, the field teams noted evidences of high water, such as drift caught in trees, water marks on vegetation along the banks, reports by the local inhabitants, etc. The estimation of mean minimum water levels was much more difficult, and in many instances was hardly better than a guess. In a few fortunate cases, members of the field teams had seen the channel at a low water stage. In some instances the teams were able to obtain information from the local inhabitants. Lacking these sources of information, it was usually assumed that the mean minimum stage would just cover the flattest portion of the channel bottom.

25. Measuring and recording values along the cross sections were accomplished concurrently. Since the various angles on the actual profiles were often complex (e.g. a series of small facets together may compose any one of the angles as defined), the precise angle to be measured was often not apparent. The angle to which the vehicle responds depends on the geometry of the specific vehicle itself. In order to determine this precisely, scaled outline figures of the two vehicles previously chosen as representative of the types of military logistic carriers to be considered

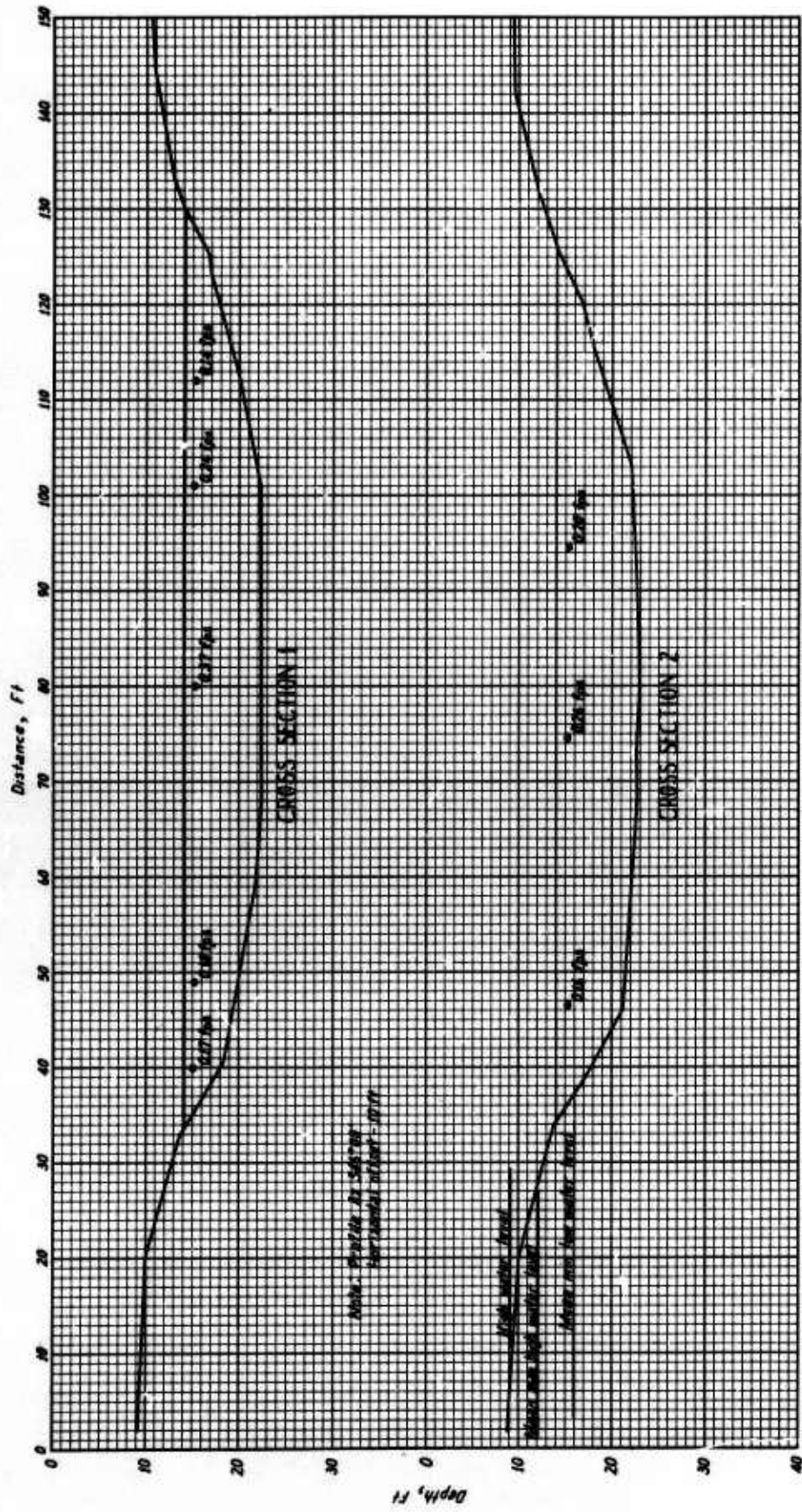


Fig. 7. Typical cross sections, Site 1-H-10, Nakhon Sawan study area

(the M37 and M113) were prepared on transparent acetate. These figures were then superimposed on the profiles (the M113 on hydrologic features and the M37 on surface geometry features), and the minimum angles encountered were measured with a protractor.

26. For the purpose of standardizing the location of all angular measurements, a numbering system was used to which the angles recorded for surface geometry features were referred. This is illustrated in fig. 6. It will be noted that angles 3, 4, 5, and 6, which are also termed the interior and exterior approach angles, are the only ones used for the factor map.⁵ Angles 1, 2, 7, and 8, not always present, are positioned on surface geometry features lying outside the channel area. They were measured and recorded with the corresponding step height (applicable to the surface features external to the channel--not to be confused with the step height corresponding to the channel depth).

27. A form (fig. 8) was devised to record the measurements and other pertinent data. In order to separate hydrologic geometry features from surface geometry features, the data form was designed so that both types were recorded on the same sheet. Thus, all terrain factor values describing a site are given on the same form. The forms were designed so that there would be a space for a notation (i.e. the recording of a factor value) for every possible factor. Since not all features exhibited every possible factor, many of the completed forms contain blanks (fig. 8). The data form does not incorporate either the current velocity data or the cone index data collected at each site. The current velocity measurements were omitted because it proved to be impractical to interpret that factor from the available air photos. Since the site data could not be extrapolated to unsampled areas, there was little point in including it on the data sheets. The cone index values collected at each site were also omitted on the data form, since these factors were not included as elements in the classification of either hydrologic geometry or surface geometry. These data were, however, used as a part of the ground truth for the mapping of surface composition.⁶

Site No.	AMS Map Sheet	MMS Quad No.	Military Grid Coordinates	Hydrologic Geometry at East and West Banks										Water Depth				Surface Geometry																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
				Contact				Stream Height, in.				Position of Step Base, ft.		Depth		1				2				3				4				5				6				7				8																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
				Approach Angle, deg	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max 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Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr

Notes: Max Wtr--Mean maximum water conditions.
 Min Wtr--Mean minimum water conditions.
 CD--Channel depth is the measurement used to map the step height factor.
 A minus sign (-) is below water level.
 A plus sign (+) is above water level.
 For definitions of west bank and east bank see fig. 6.

* Coordinates are set up according to the Military Grid System. First three numbers represent longitude; second three numbers represent latitude.
 ** A step is a slope change that is >35 deg.
 † Position of step base is referenced to water level.
 ‡ For position of numerically designated approach angle and step height see fig. 6.
 § Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.

Fig. 8. Hydrologic and surface geometry field data from Nakhon Sawan study area.

Development of Class Ranges for Mapping

28. The data were analyzed to establish class ranges for mapping that would be meaningful in terms of vehicle response and recognizable or interpretable from air photos. It was desirable to correlate the class ranges with any naturalistic breaks if any could be detected. The criterion of potential recognition from air photos was required since the relatively low density of measured sites made it necessary to extrapolate the information to unsampled areas. Class ranges that could not be interpreted from air photos would render the mapping process almost totally impracticable.

29. Since the measured water depths did not reveal any preferred frequencies, class ranges of this factor were established on the basis of fording and floating depths of selected military vehicles (see paragraph 18).

30. Frequencies of occurrence of the other parameters were examined but failed to yield any pronounced modal concentrations. Consequently, the class ranges were selected more or less arbitrarily; however, items that would prohibit movement, such as maximum gradeability of the vehicles and the height of slopes exceeding 35 deg, influenced these "arbitrary" selections. The surface geometry data were analyzed in conjunction with the study of the surface geometry factor family, and the same classes were used. The rationale for selecting the surface geometry class ranges is discussed in Volume III of this series of reports. The mapping classes for the hydrologic geometry and surface geometry factors are shown in fig. 9.

31. After establishing the mapping classes, the data were placed on manually manipulated key-sort punch cards to facilitate rapid retrieval and comparison during map preparation. An example of a key-sort card with site data placed upon it is given in fig. 10. These cards contain both punched and written information. Punched information (fig. 10) consists of military grid coordinates of the site, code number of the study area, type of data (including both surface geometry and hydrologic geometry; the latter is categorized as "Water-Land Interface" on the cards),

HYDROLOGIC GEOMETRY FEATURES

CONTACT APPROACH ANGLE

Unit	Range
	deg
1	< 145
2	145-155
3	> 155-165
4	> 165-180

STEP HEIGHT

Unit	Range	
	in.	cm
1	< 12	< 30.48
2	12-< 24	30.48-< 60.96
3	24-< 36	60.96-< 91.44
4	36-48	91.44-121.92
5	> 48	> 121.92
x	step absent	step absent

POSITION OF STEP BASE

Unit	Range	
	in.	cm
1	> 48	> 121.92
2	> 36-48	> 91.44-121.92
3	> 18-36	> 45.72-91.44
4	1-18	2.54-45.72
5	at water level	
6	1-12	2.54-30.48
7	> 12-30	> 30.48-76.22
8	> 30-48	> 76.22-121.92
9	> 48	> 121.92
x	step absent	step absent

¹Below water level.

²Above water level.

WATER DEPTH

Unit	Range	
	ft	m
1	3-4.5	0.91-1.37
2	> 4.5	> 1.37

LINEAR SURFACE GEOMETRY FEATURES

TERRAIN APPROACH ANGLE

Unit	Range
	deg
1	< 100
2	100-< 125
3	125-< 150
4	150-< 165
5	165-< 180
6	180-< 200
7	200-< 210
8	210-< 220
9	≥ 220

STEP HEIGHT

Unit	Range	
	in.	cm
1	0-4	0-10.16
2	> 4-10	> 10.16-25.40
3	> 10-18	> 25.40-45.72
4	> 18-30	> 45.72-76.20
5	> 30-48	> 76.20-121.92
6	> 48-66	> 121.92-167.64
7	> 66-84	> 167.64-213.36
8	> 84	> 213.36

Fig. 9. Mapping class ranges of hydrologic geometry and linear surface geometry features

site number, and classes for each factor--contact approach angle, step height, position of step base, and water depth for hydrologic geometry, and approach angle and step height for surface geometry features. The classes that describe each factor for both high- and low-water conditions for the hydrologic geometry factors were punched for each site. Written information consists of geographic coordinates, air-photo and pattern reference (see Volume III, this report), all samples taken in the vicinity for other factor families (entitled "Proximity Samples" on the card; see left side of fig. 10), sampling date, and information on the "Summary of Hydrologic Field Data" sheet.

PART IV: INTERPRETATION AND MAPPING TECHNIQUES

32. The data collected by the field teams describe only the exact places at which the data were taken. In order to map the distributions of factors and factor values for every point in the six primary study areas, a method had to be developed for extrapolating the point data represented by the samples to the entire area. Since the only sources of information on the areas of consideration were maps and air photos, this meant that for all practical purposes the problem was reduced to one of the development of map and air-photo interpretation techniques, principally the latter. A subsidiary effort involved the development of appropriate symbol systems for placing the interpreted information on the factor maps. Since all features of concern for the hydrologic geometry maps were linear, a system substantially different from that used for the other factor families (surface composition, surface geometry, and vegetation) was required.

33. The available air photos for this project varied in scale and quality. The scales varied from 1:50,000 to 1:15,000 (see fig. 1). The smaller-scale photographs, which were the only ones available for four of the six study areas, were taken approximately 12 years prior to this study. They are the photographs from which the AMS base maps were constructed. Consequently, all changes in drainage features developed within the past 12 years are not reflected on the maps. Air photos obtained in 1965 under a MERS contract were available for two areas (Lop Buri and Pran Buri) during the hydrologic factor mapping phase.

Air-Photo Interpretation Techniques

34. Two approaches can be followed for ascertaining the characteristics of features in an air photo. These are (a) direct measurement and (b) inference or interpretation based on the pattern the features exhibit in the photograph. Naturally, where ground measurements were available, these data were known characteristics and were used to identify the feature as well as to assist in extrapolating to similar patterns

in unsampled areas. The scale of the air photos coupled with the characteristics of the hydrologic features to be identified made direct measurements from air photos impossible. Therefore, a procedure had to be established whereby the characteristics could be inferred or interpreted.

35. The patterns exhibited by water bodies on air photos were identified on the basis of their tone, texture, and geometry. These characteristics are discussed in the following paragraphs. The method used to identify the physical characteristics of the water bodies will be discussed later in this report.

Pattern geometry

36. The origin of a water body, whether man-made or natural, is indicated by the geometric configuration of its air-photo pattern. For example, the uniformity with respect to width and straightness of a man-made canal contrasts greatly with a meandering river. Therefore, the discussion of pattern geometry of water bodies will be with respect to the origin of the feature.

37. Man-made water bodies within the study areas reported herein include canals, irrigation ditches, borrow pits, man-altered streams, etc. Photographs 1 and 2 are ground views of an irrigation canal and a borrow pit, respectively. Photograph 3 shows stream patterns that have been altered for irrigation purposes. Though canals vary in width, a specific canal can usually be identified by a pair of parallel lines a uniform distance apart. Several canals usually are associated to form a network of interconnecting parallel lines on an air photo. Included in this network are ditches that take off from the canals to the cultivated fields. Along the larger canals the parallel lines are broken by bridges, locks, and dams. Borrow pits are suggested by narrow elongate bands intermittently spaced along either or both sides of a railroad or road.

38. Natural water bodies vary more in shape than man-made features. The shapes and patterns of natural water bodies are influenced by several factors, including type of drainage (underground or surface), topography, volume of water and amount of sediment, type of material (soil type or rock), and tide. The resulting shapes vary from slightly curved to sinuous parallel or subparallel lines of various widths to irregular or circular or elliptical outlines.

39. Natural water bodies within the Thailand study areas are of the following types: (a) coastal features, (b) streams and rivers, (c) lakes, and (d) sinks.

40. Natural coastal features in the Chanthaburi and Pran Buri study areas include lagoons, estuaries, and tidal rivers. The shapes of these features vary from irregular for the lagoons and estuaries to sinuous subparallel lines that decrease in width inland for the tidal rivers. Tributaries joining the streams form irregular branching lines.

41. Streams and rivers vary in width and planimetric shape. Streams in areas of high relief (mountains and hills) are generally straighter and narrower than meandering streams with wide floodplains. In heavily vegetated areas some of these streams are obscured and are difficult to delineate. Stereoscopic examination is very useful in these areas. Meandering streams and rivers with wide floodplains exhibit circuitous parallel lines of various widths. Some of these water bodies are joined by numerous tributaries and abandoned courses, and their networks present distinctive identifiable patterns of crooked to looping connecting sets of parallel or subparallel lines. Arcuate swales (depressions) are common within the bends of these streams. Photograph 4 shows a natural lake in the vicinity of a bend at which a sample site was located in the Nakhon Sawan study area, and photograph 5 is a ground view of a medium-sized stream in the Khon Kaen study area.

42. The geometric outlines of lakes vary from two parallel or subparallel lines with arcuate shape to irregular bodies covering many square kilometers. Most of these water bodies are recognizable in air photos from their tone and texture. Photograph 6 shows a portion of a river segment and a natural lake. Note that the aquatic vegetation shown in the ground view of the sample site location (photograph 7) is also apparent in the air photo (photograph 6).

43. Sinks, typical of karst regions, are elliptical or circular depressions forming randomly oriented or subparallel patches that extend over a considerable area. These sinks may or may not contain water, depending upon their underground drainage characteristics.

Pattern tone and texture

44. Identification of water bodies (both hydrologic and surface geometry by definition) was aided considerably by the presence of water. Water usually produces a distinctive image on air photos; it can normally be identified by an amorphous texture and a light gray tone. This statement should not be construed to mean that every tone-texture of this type represents water, because in many cases other associations (such as topography) must be made. An amorphous texture simply means that there are no visible grains that form the tone. The tone of water bodies on a photograph can be altered by the presence of organic matter or vegetation, suspended soil particles in the water, and the reflection of sunlight on the surface.⁷ Vegetation and soil particles usually darken the tone, and the reflection of solar rays tends to lighten the tone almost to white. In contrast to light-toned water bodies, certain water bodies such as swamps exhibit a dark tone that can be attributed primarily to organic content and presence of vegetation. The texture of these patterns varies between smooth for the exposed water to grainy for the water with vegetation in or on it. These features are associated with a low, undrained topographic position in reference to the surrounding terrain.

45. Contrast between the light gray tone of water and the medium to dark gray tone of vegetation along banks or levees is also a key to identification.

Stereoscopic examination

46. Stereoscopic examination of the photographs, which emphasizes differences in elevation, assists in identification of water bodies. For example, the sides or banks of larger canals appear to be higher than the surrounding terrain. In contrast the water-retaining depressions (sinks, swamps, borrow pits, etc.) lie at lower elevations than the surrounding surface. The water in rivers and streams also normally appears lower than the banks.

General comments

47. The photo interpretation process, with its requirement for very detailed examination of large numbers of air photos, was the most time-consuming component of the entire mapping procedure. Furthermore,

it was also the component that required the highest levels of experience and judgment. Since the factual base was necessarily restricted to spot locations, the interpolation between them was guided primarily by the appearance of the channels or water bodies on the photographs. Had it been possible to derive the factor values directly from the photographs, little more would have been required to produce a map of high reliability. Unfortunately, these factors could only be inferred. To further complicate the photo interpretation, some of the factors mapped were always partially or entirely below the surface of the water. Even if they were above the surface, their magnitude at the scale of photography available was too small for mensuration. This was true, in most cases, even with the new 1:15,000-scale photographs. Nevertheless, the inferences that could be drawn from the tonal gradations and image associations in the photos were numerous and valuable. By combining the measured data with the photo images, reasonably valid analogies could be drawn, and these analogies were used to interpolate between control points.

Mapping Procedures

48. The mapping phase of this study entailed the interpretation of the hydrologic geometry parameters from available data and the portrayal of the results on maps in terms of class ranges. As previously mentioned, two distinctive conditions were portrayed--high- and low-water conditions. An ambiguous situation exists in regard to the cyclical succession of high and low water, which should be explained. For the greater part of the areas mapped this cycle is seasonal and annual. However, for small areas in the Pran Buri and Chanthaburi study areas the cycle is daily (tidal), in which one high and one low tide occur in each ± 24 -hour period. Since the map legends specify only that they pertain to mean maximum and minimum water conditions without regard to time cycle, no distinction is made between the seasonally and the tidally controlled areas. Also, in regard to the alternation of high and low water, a possibly misleading portrayal of some of the irrigation canals exists. Many of these are indicated as being hydrologic geometry features on the high-water maps

and surface geometry features on the low-water maps. A distinct possibility exists that the times of high and low water are reversed from seasonal rainfall periods for those irrigation features in which water for agricultural purposes may be concentrated at times when water in the natural drainage system is reduced. However, since no definite information is available concerning this possibility, no such indications are shown on the maps. The possibility also exists that fluctuation of high and low water in the artificial channels is irregular and not correlated with the seasonal cycle, but is controlled by local agricultural demands.

49. Before detailing the mapping rationale, the sources of information on which it was based should be mentioned again: (a) field measurements,* (b) air photos, (c) AMS topographic maps, (d) ground photography, (e) personal observation of the areas, and (f) background knowledge of hydrologic principles. All these items were used by personnel preparing the maps.

50. The development of the hydrologic geometry factor maps and the hydrologic geometry factor-family map⁵ involved seven very general steps, as follows.

- a. Plotting of sample locations. All of the points sampled by the field teams were plotted carefully on the 1:50,000 AMS topographic maps (AMS Series L708). In most cases the sample points were clearly associated with a hydrologic geometry feature such as a stream, canal, or lake, but in some instances the points fell in positions not obviously related to any mapped feature.
- b. Construction of base map. With the sample point locations as a guide, a base map of all hydrologic geometry and linear surface geometry features was constructed (see paragraph 51). Where the points fell on mapped features, the entire extent of that feature as presented on the topographic map was traced. In those instances where the point was not related to a mapped feature, the sample location was transferred to the best available air photo; the feature that the sample described was examined, and that feature was traced throughout its extent. Where recent large-scale (1:15,000) photographs were available, many hydrologic

* In most cases two profiles were prepared for each sample site. These frequently differed with respect to their angular and step parameters. In such cases, one profile was arbitrarily chosen as representative of the site.

geometry or linear surface geometry features not shown on the AMS maps were identified and delineated. Examination of the new (1965) large-scale photos also revealed that a number of modifications in the planimetric shape and even the locations of hydrologic geometry features had occurred since the AMS mapping photos had been taken (chiefly from 1953 to 1955). Where such changes were noted, the base map was corrected accordingly. Where only small-scale (1:40,000 and 1:50,000) photos were available, very few features not mapped on the AMS maps were discovered. The only significant exceptions consisted of a few cases in which the map compilers had generalized very complex and fine-grained drainage patterns (as seen on the photographs) into much simpler patterns. All of the features delineated in the photographs were then transferred by visual means to the base map. Some positional errors were undoubtedly introduced by this procedure, but it is believed that they are not so large as to compromise the value of the resulting base map.

- c. Construction of hydrologic geometry high-water-stage factor map. All sample sites exhibiting a water depth of 91 cm or more were plotted on an overlay fitted to the base map. Each site thus plotted was annotated with the measured depth and with the estimated or recorded depth at the mean maximum stage. Each feature on which such a sample was located was then examined on the air photos, and an interpretation was made as to the extent of water depths of 91 cm or more along that feature. All possible sources of background information, of which a major source was the interpreters' personal experiences with Thailand hydrologic conditions, were invoked to assist in this process. The photos were then examined for features of similar size and configuration that had not been "flagged" by having a sample point located on them. Any such features were also traced off the base map onto the overlay. All features delineated on the overlay were accepted as being those required for portrayal on the high-water-stage map. After the high-water-stage features had been determined, the chosen factors had to be identified and portrayed by class ranges (fig. 9). The key-sort punch cards for the sites plotted for the high water stage were sorted out, and the factor values exhibited at each site were noted. With these data, the air photos were again closely scrutinized in an effort to establish recognition criteria for the various factor value classes. These criteria having been established as well as possible, each selected feature was closely studied, and appropriate codes were used to annotate the overlay with the assigned value classes. Where a discontinuity occurred, an index mark was placed on the feature. Each bank of the streams and canals was

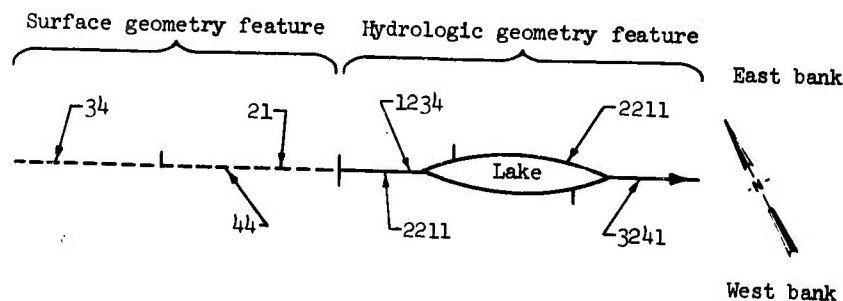
treated individually, and it was noted⁵ that discontinuities rarely occurred at the same place on both banks. When all notations were complete, the factor value classes along each discrete segment of bank (i.e. the segment between index lines marking discontinuities) were coded according to the numerical unit codes given in fig. 9. The order was as given in fig. 9; thus, a bank exhibiting a contact approach angle of 150 deg, a step height of 76 cm, a position of step base 51 cm below water level, and a water depth of 122 cm would be characterized by the code 2331.

- d. Construction of hydrologic geometry low-water-stage factor map. The analytical process for the compilation of these maps was analogous to that used for the high-water-stage maps (subparagraph c above). The only difference, of course, was that the depth of water at the mean minimum water level stage was the controlling criterion. Thus, each feature on which a sample was located that exhibited a water depth of 91 cm or more at mean minimum water level was accepted as being a hydrologic geometry feature at the low water stage. The same interpretive procedures and the same annotation and coding devices used for the high-water-stage factor maps were used for the low-water-stage factor maps. It is apparent that many features classified as hydrologic geometry features at high water stage were reclassified as surface geometry features at low water stage. Furthermore, even in those instances where the feature remained in the hydrologic geometry category, there were many features in which every factor value class changed. This occurred because the interpretation of contact approach angle, step height, and the position of step base is dependent upon the position of the water level with respect to the bank; on many complexly configured banks, even a modest change in water level will result in completely different values for those factors that describe bank configuration.
- e. Construction of linear surface geometry low-water-stage factor map. The base map incorporates all features described by the hydrologic geometry field teams. Thus, the surface geometry low-water-stage features could be identified by abstracting from the base map all of those features identified as hydrologic geometry low-water-stage features. This process was accomplished by placing the hydrologic geometry low-water-stage map over the base map, placing an overlay over both, and drawing on the overlay only those features not covered by the hydrologic geometry low-water-stage map. The process of interpreting for the factor value classes was the same as that used for the hydrologic geometry factors, except of course that the

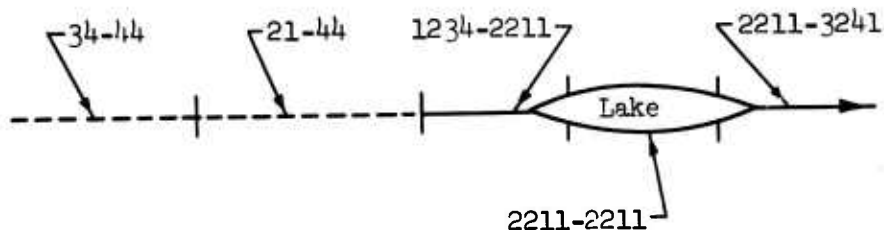
interpretations were made for the surface geometry factors (fig. 9). Symbol assignment and annotation procedures were also analogous.

- f. Construction of the linear surface geometry high-water-stage factor map. A process analogous to that used for the construction of the surface geometry low-water-stage maps was used to construct the surface geometry high-water-stage factor maps. The map on which all hydrologic geometry high-water-stage features had been delineated was fitted over the base map, and a third sheet was overlaid on the two. All features on the base map not covered by the features on the hydrologic geometry high-water-stage map were traced onto the overlay; all of the features thus transferred are linear surface geometry high-water-stage features. The process of interpreting for factor values was the same as that used for the surface geometry low-water factors. Symbol assignment and annotation procedures were identical.
- g. Compilation of combined hydrologic geometry and linear surface geometry factor-family maps. The compilation process for combined hydrologic and linear surface geometry factor-family maps is as follows:

- (1) The hydrologic geometry high-water-stage (HG-HW) factor maps and the surface geometry high-water-stage (SG-HW) factor maps are exclusive; that is, there is no overlap of features, but together they incorporate all linear features that are to be considered. These two factor maps were combined, and a single summary high-water-stage map was traced. All features were assumed to have a west and an east bank. The west bank is the one encountered first by a vehicle traveling in an easterly direction (azimuth 0 to 180 deg measured counterclockwise), and conversely the east bank is the one encountered first by a vehicle moving in a westerly direction (azimuth 180 to 360 deg). All features, including those shown with a double line on the base maps, were treated in this way. Each feature was followed carefully, and the code combinations for each segment were recorded. On the factor maps, each bank was classified separately, as indicated on the stylized diagram below:

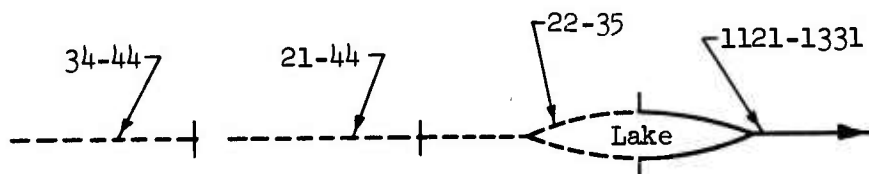


However, on the combined map the codes for both banks were combined into a single symbol combination, as illustrated below:

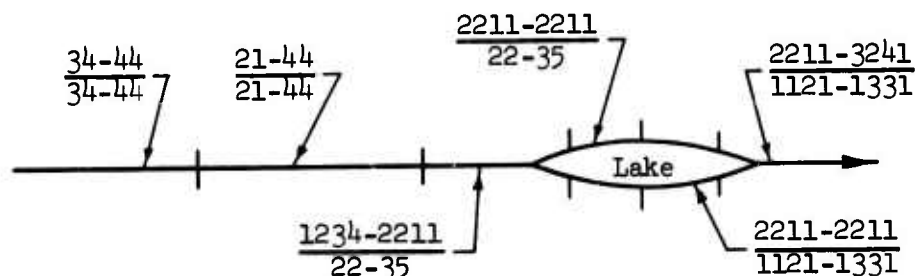


The digit array to the left of the hyphen is the code for east bank conditions, and that to the right of the hyphen is for west bank conditions.

- (2) The hydrologic geometry low-water-stage (HG-LW) factor maps and the surface geometry low-water-stage (SG-LW) factor maps are also exclusive, and were combined in the same manner as described for the high-water-stage maps. For the same stylized feature illustrated above, the resulting combined diagram would be:



- (3) The two compilations described above (i.e. the high-water-stage maps and the low-water-stage maps) were then combined, and a final compilation was made. The diagram resulting from the synthesis of the two maps for the stylized feature previously illustrated is shown below:



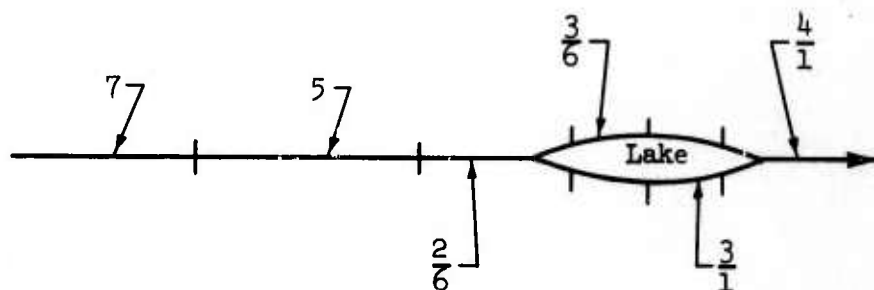
Note that the numerator of the fraction is the annotation of the high-water conditions, and the denominator identifies the low-water-stage conditions. All existing combinations were then on the final map.

- (4) In areas on the final map where hydrologic geometry

and linear surface geometry features were close together, it became impractical to use the long strings of symbols illustrated previously. Accordingly, a simplified map symbol system was devised. The symbols were first divided into hydrologic geometry and surface geometry groups; this was simple and direct, because the former are all 4-digit symbols and the latter are all 2-digit groups. Both of the resulting lists of symbols were then placed in a convenient order by arranging them in numerical sequence. Thus, from the illustration on the previous page, two lists of numbers were obtained:

<u>Hydrologic Geometry Symbols</u>	<u>Assigned Map Identi- fication No.</u>	<u>Surface Geometry Symbols</u>	<u>Assigned Map Identi- fication No.</u>
1121-1331	1	21-44	5
1234-2211	2	22-35	6
2211-2211	3	34-44	7
2211-3241	4		

Then, a map identification number was assigned to each, as illustrated above. A simple numerical sequence was used. This greatly simplifies the problem of placing all the required information on the map. For the map example used above, the result was:



Note that in those instances where the numerator and denominator are identical for the surface geometry features, only one number is used. Thus, the absence of a fraction indicates that the feature is a surface geometry feature at both high and low water stages.

51. A total of 1004 combinations of factor value classes occur in all six study areas, of which 633 (map units 1-633) refer to hydrologic geometry features, and 371 (map units 635-1005) describe linear surface geometry features. In the map folio⁵ the combined legend, listing every combination found in any of the six study areas and their assigned map

identification number, is printed on the page facing the hydrologic geometry maps. The hydrologic geometry factor-family maps of the six study areas are on base sheets at a scale of 1:50,000 taken from the 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 (fig. 11). 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. An example of a portion of a hydrologic geometry factor-family map of the Lop Buri study area (LB III sheet) and the accompanying legend are shown in fig. 12. Since only a portion of the map is shown, all combinations included in the legend do not occur on the map segment. In fact the legend shown is only a partial legend.

52. It should be noted that the ground control consisted of 554 sample points about equally distributed among the six primary study areas. Thus, the sample density was only about one per 16 km². In addition, the sample points were concentrated along roads and motorable trails, so that large numbers of features, readily noted on maps and air photos, were not sampled at all. Interpretation of the subtle configurations of bank and bottom in such features was very difficult indeed, and the results are probably much less reliable than those from sites where ground control was available.

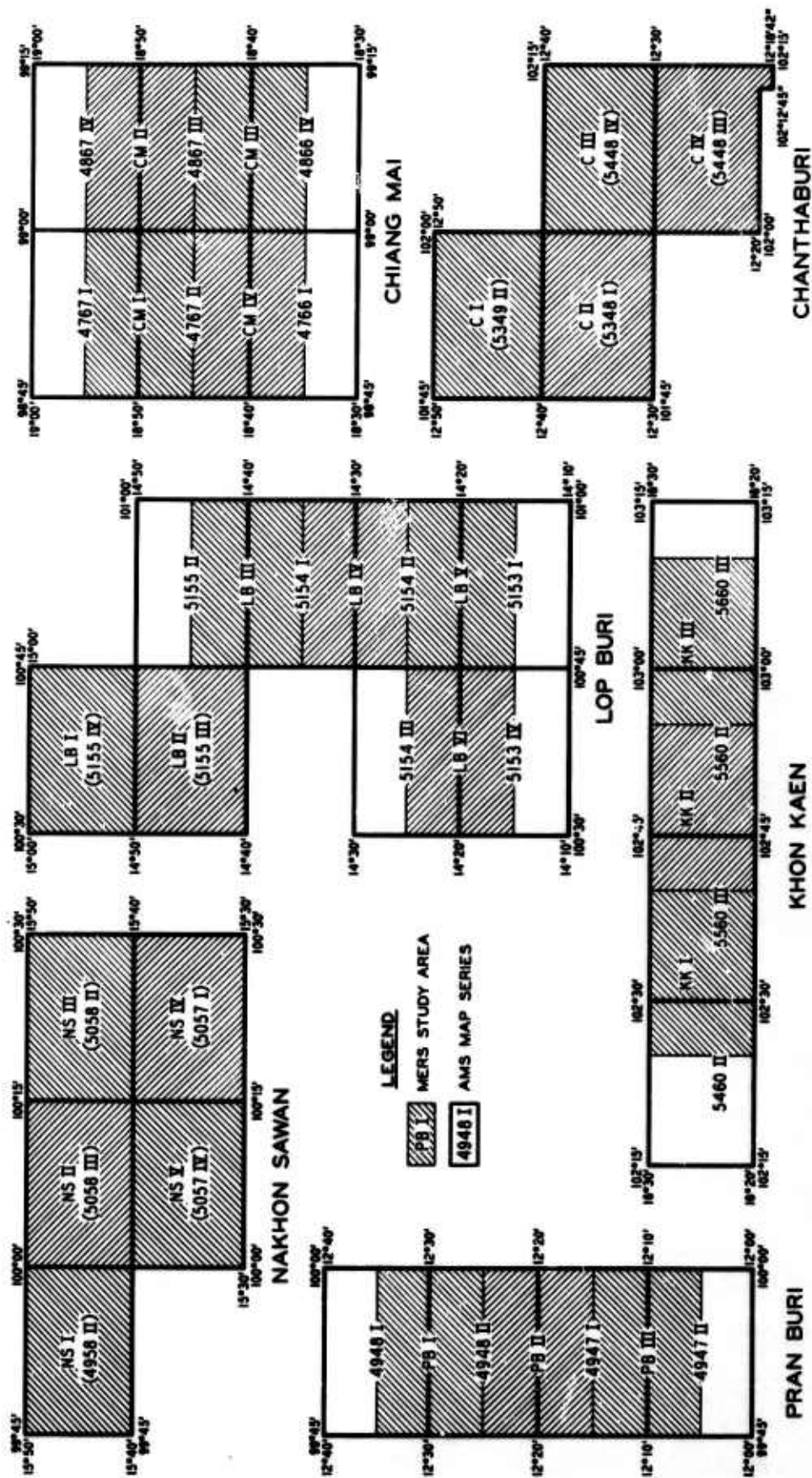


Fig. 11. Relation of MERS and AMS quadrangles

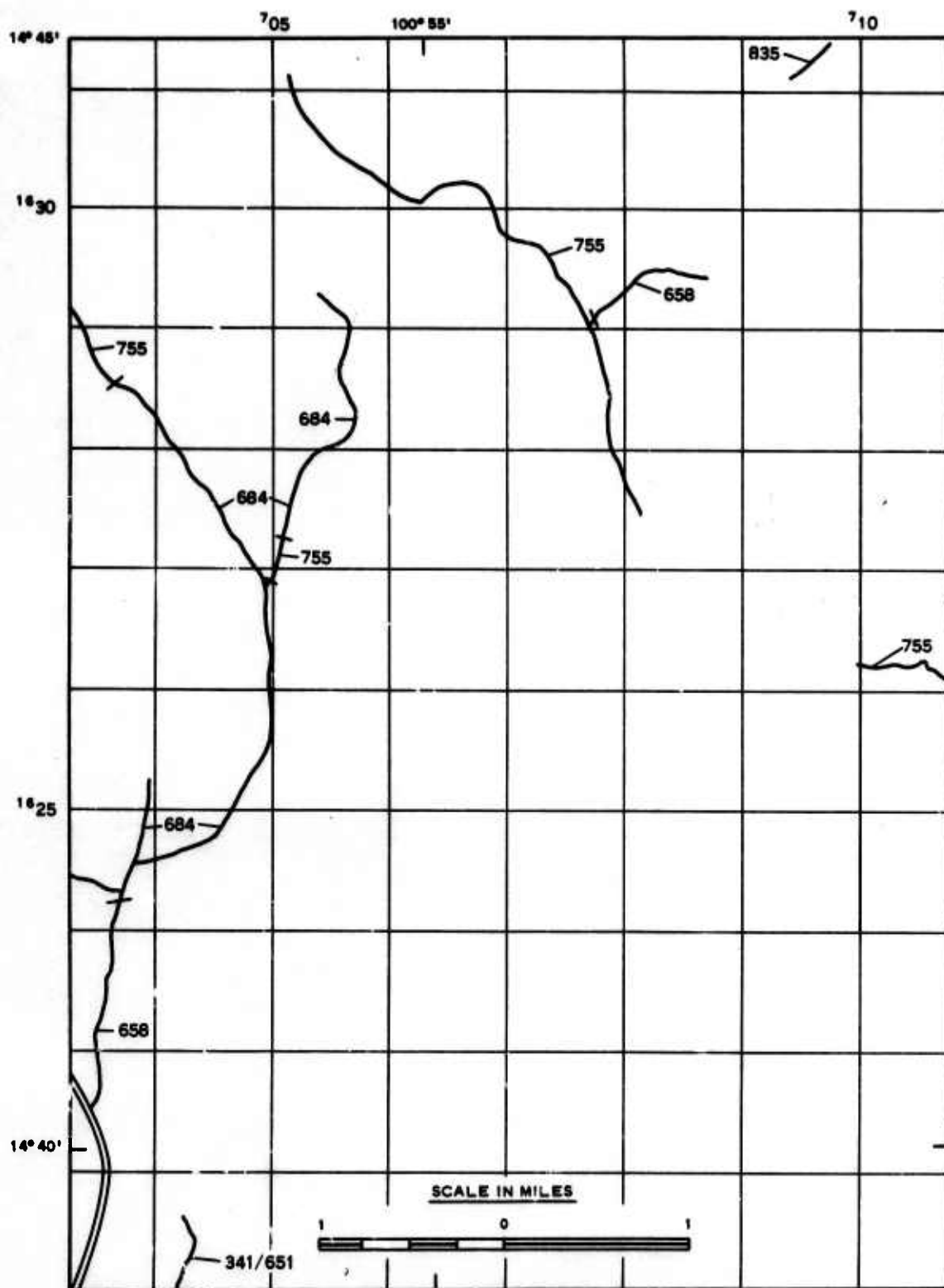


Fig. 12. Hydrologic geometry map of a portion of LB III in the Lop Buri study area (sheet 1 of 2)

LEGEND

Map Unit	Hydrologic Geometry					
	West Bank			East Bank		
	SA	IA	SH	SA	IA	SH
000	2	5	9	2	5	9
001	2	5	9	2	5	9
002	2	5	9	2	5	9
003	2	5	9	2	5	9
004	2	5	9	2	5	9
005	2	5	9	2	5	9
006	2	5	9	2	5	9
007	2	5	9	2	5	9
008	2	5	9	2	5	9
009	2	5	9	2	5	9
010	2	5	9	2	5	9
011	2	5	9	2	5	9
012	2	5	9	2	5	9
013	2	5	9	2	5	9
014	2	5	9	2	5	9
015	2	5	9	2	5	9
016	2	5	9	2	5	9
017	2	5	9	2	5	9
018	2	5	9	2	5	9
019	2	5	9	2	5	9
020	2	5	9	2	5	9
021	2	5	9	2	5	9
022	2	5	9	2	5	9
023	2	5	9	2	5	9
024	2	5	9	2	5	9
025	2	5	9	2	5	9
026	2	5	9	2	5	9
027	2	5	9	2	5	9
028	2	5	9	2	5	9
029	2	5	9	2	5	9
030	2	5	9	2	5	9
031	2	5	9	2	5	9
032	2	5	9	2	5	9
033	2	5	9	2	5	9
034	2	5	9	2	5	9
035	2	5	9	2	5	9
036	2	5	9	2	5	9
037	2	5	9	2	5	9
038	2	5	9	2	5	9
039	2	5	9	2	5	9
040	2	5	9	2	5	9
041	2	5	9	2	5	9
042	2	5	9	2	5	9
043	2	5	9	2	5	9
044	2	5	9	2	5	9
045	2	5	9	2	5	9
046	2	5	9	2	5	9
047	2	5	9	2	5	9
048	2	5	9	2	5	9
049	2	5	9	2	5	9
050	2	5	9	2	5	9

Map Unit	Surface Geometry					
	West Bank			East Bank		
	SA	IA	SH	SA	IA	SH
000	6	2	4	6	2	4
001	6	2	4	6	2	4
002	6	2	4	6	2	4
003	6	2	4	6	2	4
004	6	2	4	6	2	4
005	6	2	4	6	2	4
006	6	2	4	6	2	4
007	6	2	4	6	2	4
008	6	2	4	6	2	4
009	6	2	4	6	2	4
010	6	2	4	6	2	4
011	6	2	4	6	2	4
012	6	2	4	6	2	4
013	6	2	4	6	2	4
014	6	2	4	6	2	4
015	6	2	4	6	2	4
016	6	2	4	6	2	4
017	6	2	4	6	2	4
018	6	2	4	6	2	4
019	6	2	4	6	2	4
020	6	2	4	6	2	4
021	6	2	4	6	2	4
022	6	2	4	6	2	4
023	6	2	4	6	2	4
024	6	2	4	6	2	4
025	6	2	4	6	2	4
026	6	2	4	6	2	4
027	6	2	4	6	2	4
028	6	2	4	6	2	4
029	6	2	4	6	2	4
030	6	2	4	6	2	4
031	6	2	4	6	2	4
032	6	2	4	6	2	4
033	6	2	4	6	2	4
034	6	2	4	6	2	4
035	6	2	4	6	2	4
036	6	2	4	6	2	4
037	6	2	4	6	2	4
038	6	2	4	6	2	4
039	6	2	4	6	2	4
040	6	2	4	6	2	4
041	6	2	4	6	2	4
042	6	2	4	6	2	4
043	6	2	4	6	2	4
044	6	2	4	6	2	4
045	6	2	4	6	2	4
046	6	2	4	6	2	4
047	6	2	4	6	2	4
048	6	2	4	6	2	4
049	6	2	4	6	2	4
050	6	2	4	6	2	4

Map Unit	Surface Geometry					
	West Bank			East Bank		
	SA	IA	SH	SA	IA	SH
000	7	4	3	7	4	3
001	7	4	3	7	4	3
002	7	4	3	7	4	3
003	7	4	3	7	4	3
004	7	4	3	7	4	3
005	7	4	3	7	4	3
006	7	4	3	7	4	3
007	7	4	3	7	4	3
008	7	4	3	7	4	3
009	7	4	3	7	4	3
010	7	4	3	7	4	3
011	7	4	3	7	4	3
012	7	4	3	7	4	3
013	7	4	3	7	4	3
014	7	4	3	7	4	3
015	7	4	3	7	4	3
016	7	4	3	7	4	3
017	7	4	3	7	4	3
018	7	4	3	7	4	3
019	7	4	3	7	4	3
020	7	4	3	7	4	3
021	7	4	3	7	4	3
022	7	4	3	7	4	3
023	7	4	3	7	4	3
024	7	4	3	7	4	3
025	7	4	3	7	4	3
026	7	4	3	7	4	3
027	7	4	3	7	4	3
028	7	4	3	7	4	3
029	7	4	3	7	4	3
030	7	4	3	7	4	3
031	7	4	3	7	4	3
032	7	4	3	7	4	3
033	7	4	3	7	4	3
034	7	4	3	7	4	3
035	7	4	3	7	4	3
036	7	4	3	7	4	3
037	7	4	3	7	4	3
038	7	4	3	7	4	3
039	7	4	3	7	4	3
040	7	4	3	7	4	3
041	7	4	3	7	4	3
042	7	4	3	7	4	3
043	7	4	3	7	4	3
044	7	4	3	7	4	3
045	7	4	3	7	4	3
046	7	4	3	7	4	3
047	7	4	3	7	4	3
048	7	4	3	7	4	3
049	7	4	3	7	4	3
050	7	4	3	7	4	3

Map Unit	Surface Geometry					
	West Bank			East Bank		
	SA	IA	SH	SA	IA	SH
000	8	2	6	8	2	6
001	8	2	6	8	2	6
002	8	2	6	8	2	6
003	8	2	6	8	2	6
004	8	2	6	8	2	6
005	8	2	6	8	2	6
006	8	2	6	8	2	6
007	8	2	6	8	2	6
008	8	2	6	8	2	6
009	8	2	6	8	2	6
010	8	2	6	8	2	6
011	8	2	6	8	2	6
012	8	2	6	8	2	6
013	8	2	6	8	2	6
014	8	2	6	8	2	6
015	8	2	6	8	2	6
016	8	2	6	8	2	6
017	8	2	6	8	2	6
018	8	2	6	8	2	6
019	8	2	6	8	2	6
020	8	2	6	8	2	6
021	8	2	6	8	2	6
022	8	2	6	8	2	6
023	8	2	6	8	2	6
024	8	2	6	8	2	6
025	8	2	6	8	2	6
026	8	2	6	8	2	6
027	8	2	6	8	2	6
028	8	2	6	8	2	6
029	8	2	6	8	2	6
030	8	2	6	8	2	6
031	8	2	6	8	2	6
032	8	2	6	8	2	6
033	8	2	6	8	2	6
034	8	2	6	8	2	6
035	8	2	6	8	2	6
036	8	2	6	8	2	6
037	8	2	6	8	2	6
038	8	2	6	8	2	6
039	8	2	6	8	2	6
040	8	2	6	8	2	6
041	8	2	6	8	2	6
042	8	2	6	8	2	6
043	8	2	6	8	2	6
044	8	2	6	8	2	6
045	8	2	6	8	2	6
046	8	2	6	8	2	6
047	8	2	6	8	2	6
048	8	2	6	8	2	6
049	8	2	6	8	2	6
050	8	2	6	8	2	6

05- Units not mapped.

• Features are usually identified by a fraction. Each component of the fraction is a map unit that represents an array of seven symbols or less describing a particular feature. The numerator indicates high-water conditions and the denominator indicates low-water conditions. Features identified by only one map unit contain less than 3 ft of water at all times and are mapped as surface geometry features. Map units 1-53 describe hydrologic geometry features and map units 53-1005 describe surface geometry features. Hydrologic geometry symbols represent class ranges of contact approach angle (see Hydrologic Geometry Diagram below), step height SH, position of step base PB, position of exterior approach angle EA (see Surface Geometry Diagram below), interior approach angle IA, and step height SA for each bank. West bank is the first bank encountered while traversing an area in an easterly direction (i.e. azimuth > 0 to 180 deg) and the east bank is the first bank encountered while traversing an area in a westerly direction (i.e. azimuth > 180 to 360 deg), assuming that the vehicle intersects the feature at a right angle.

† Class ranges for each factor are:

Surface Geometry			
Terrain Approach Angle (EA & IA)		Step Height (SH)	
Unit	Range	Unit	Range
	deg		in. cm
1	< 100	1	0-4
2	100-125	2	> 4-10
3	125-150	3	> 10-18
4	150-175	4	> 18-30
5	175-200	5	> 30-48
6	200-225	6	> 48-66
7	225-250	7	> 66-84
8	250-275	8	> 84-102
9	> 275	9	> 102-120

Hydrologic Geometry					
Contact Approach angle (AA)			Step Height (SH)		
Unit	Range		Unit	Range	
	deg			in. cm	
1	< 143		1	< 12	< 30.48
2	143-155		2	12-24	30.48-60.96
3	> 155-165		3	24-36	60.96-91.44
4	> 165-180		4	36-48	91.44-121.92
			5	> 48	> 121.92
			x	step absent	step absent

PART V: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

53. Despite the fact that most of the factors significant to cross-country mobility and associated with hydrologic geometry features are too small to be measured at standard air-photo scales (1:15,000, 1:40,000, and 1:50,000), it is still possible to achieve reasonably reliable estimates of the factor values by inference, assuming that a sufficient set of ground control points is available.

54. Some regions in the primary study areas were insufficiently represented by ground control sampling points to permit reliable photo interpretation and mapping. For a regional study, all major terrain types should be represented in the sample array; otherwise extrapolation from measured points becomes extremely tenuous for the unsampled terrain types. Such a balance was not entirely achieved in this study, primarily because of the difficulty of access to the sites. This was especially critical in areas of high-relief terrain.

55. The processes of photo interpretation and the compilation of factor-family maps are both extremely time-consuming. In fact, the expenditures of labor time are so large as to make the procedure practical only for limited areas, assuming present techniques are used.

56. It is technically possible to map those hydrologic geometry factors that significantly affect the cross-country mobility of ground-contact vehicles in such a form that the map units can be used as inputs to an analytical model relating terrain conditions to vehicle speed.⁵

Recommendations

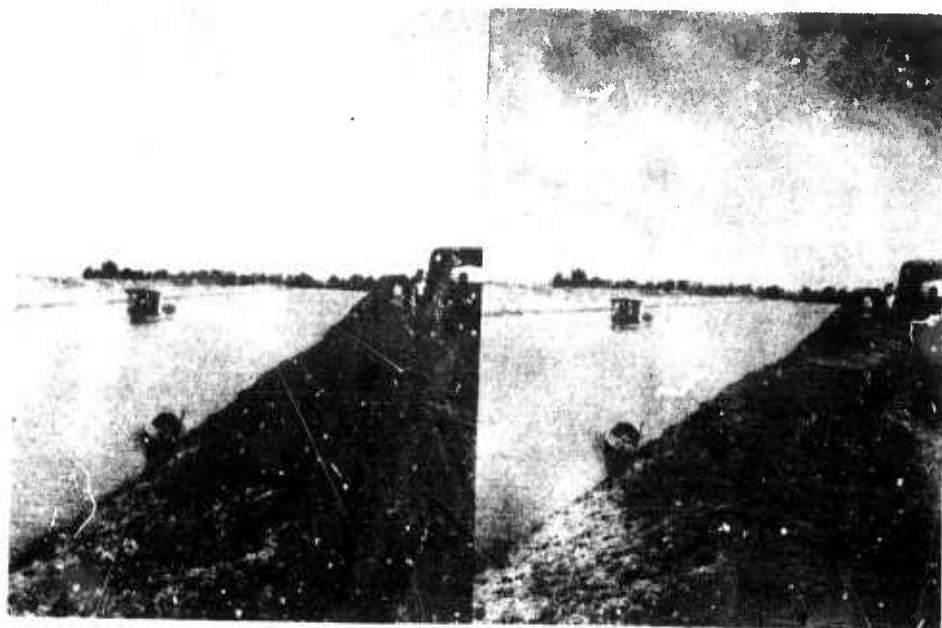
57. It is recommended that ground photographs be used to a greater extent by the field teams responsible for measuring hydrologic geometry factors. Stereopairs should be taken not only of the immediate sites, but of adjacent features, including bank configurations on adjacent reaches, as well. Taken under controlled conditions, such photography can yield

reliable estimates of factor values through standard photogrammetric procedures.

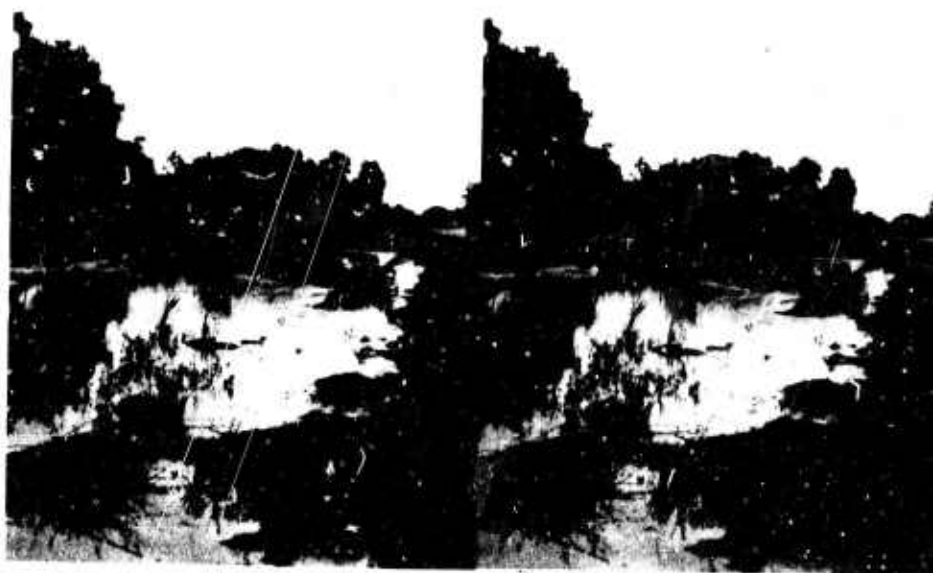
58. It is recommended that a research effort be launched to simplify and mechanize the factor-family map compilation process. Since the process is entirely mechanistic, it should be readily amenable to treatment by automatic data processing machines. It is anticipated that the product of such a data manipulation process would include the drawing of the factor and factor-family maps by a computer-plotter link.

LITERATURE CITED

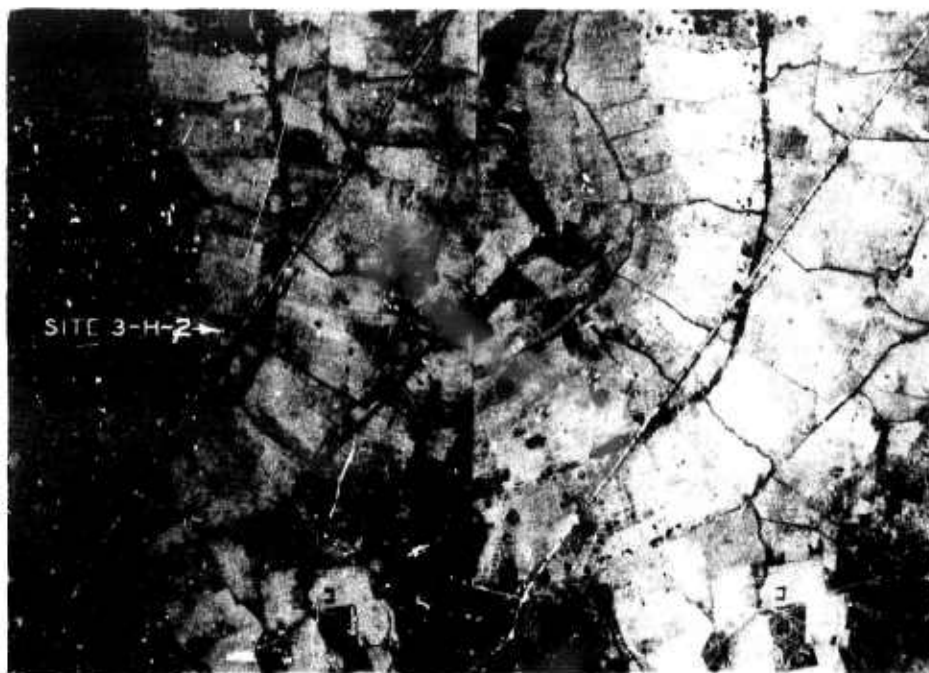
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Photograph 1. Stereopair of an irrigation canal at site 2-H-15-7
in the Lop Buri study area



Photograph 2. Stereopair of a borrow pit paralleling
the highway at site 5-H-2 in the Khon Kaen study area



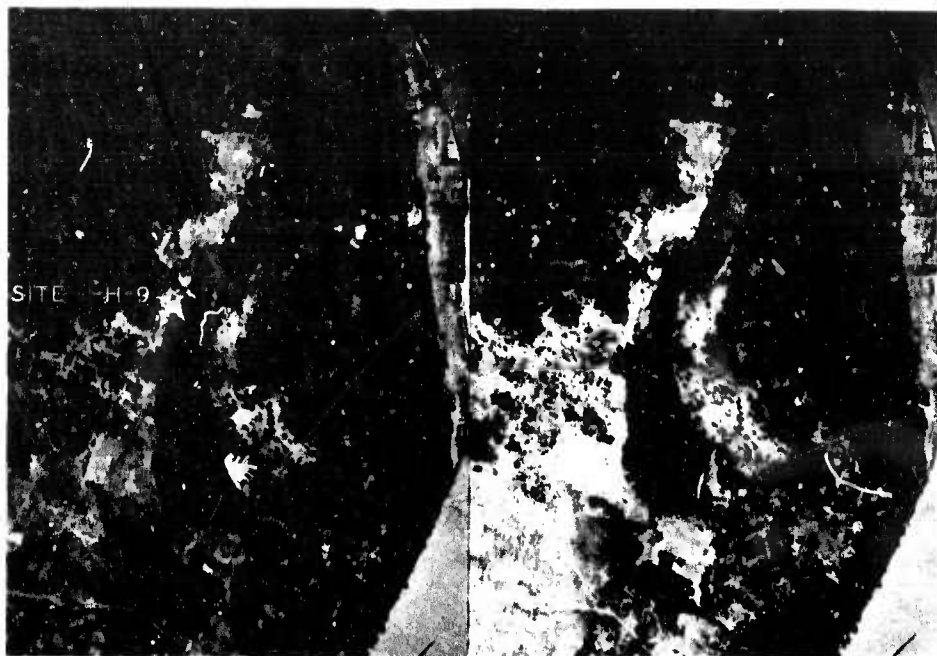
Photograph 3. Stereopair of site 3-H-2 and vicinity in the Chiang Mai study area showing stream patterns that have been changed for irrigation purposes (1:25,000)



Photograph 4. Stereopair of site 1-H-28 and vicinity in the Nakhon Sawan study area showing natural lakes and bends (1:20,000)



Photograph 5. Stereopair of a stream being sampled at site 5-H-25 in the Khon Kaen study area



Photograph 6. Stereopair of site 1-H-9 and vicinity in the Nakhon Sawan study area showing a portion of the Chao Phraya River and a natural lake. Note that the aquatic vegetation visible in photograph 7 is also apparent in this photograph (1:20,000)



Photograph 7. Stereopair of a lake at site 1-H-9 in the Nakhon Sawan study area

APPENDIX A: SUMMARY OF HYDROLOGIC GEOMETRY FIELD DATA
AND SITE LOCATION MAPS

NAKHON SAWAN

Table A1
Summary of Hydrologic and Surface Geometry Field Data
Mekong Savan

Site No.	AMS Map Sheet No.	Military Grid Coordinates*	Hydrologic Geometry at East and West Banks						Contact			Position of Step Base, † in.						Water Depth						Surface Geometry																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
			Approach Angle, deg			Steps** Height, in.			of Step Base, † in.			Max Wtr			Min Wtr			Max Wtr			Min Wtr			App Angle			Step Angle			App Angle			Step Angle			App Angle			Step Angle																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
			W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E	Angle	W	E

(Continued)

Note: Max Wtr--Mean maximum water conditions.
Min Wtr--Mean minimum water conditions.
CD--Channel depth is the measurement used to map the step height factor.
A minus sign (-) is below water level.
A plus sign (+) is above water level.
For definitions of west bank and east bank see fig. 6.
* Coordinates are set up according to the Military Grid System. First three numbers represent longitude; second three numbers represent latitude.
** A step is a slope change that is >35 deg.
† Position of step base is referenced to water level.
†† For position of numerically designated approach angle and step height see fig. 6.
‡ Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.

NAKHON SAWAN

Table A1
Summary of Hydrologic and Surface Geometry Field Data
Bathor Swann

Site No.	AMS Map Sheet	Military Grid Coordinates	Hydrologic Geometry at East and West Banks				Position of Step Base, ft.				Water Surface				Critical Approach Angle, deg and Step Height, ft.				Surface Geometry			
			Contact		Step Height, ft.		Max Wtr		Min Wtr		Max Wtr		Min Wtr		App Angle		Step Height		App Angle		App Angle	
			W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E
1-B-1	4958II	MS I	175	160	175	160	24	90	20	90	-24	0	0	0	195	160	115	230	155	60	155	40
1-B-2	4958II	MS I	165	155	165	155	20	90	20	90	-36	0	0	0	185	165	140	200	155	60	155	40
1-B-3	4958II	MS I	175	170	175	170	60	60	60	60	-12	0	0	0	220	190	165	300	190	150	150	7
1-B-4	4958II	MS I	90	165	90	165	16	36	36	36	-36	0	0	0	220	190	165	300	190	150	150	5
1-B-5	4958II	MS I	150	155	150	155	36	36	36	36	-36	0	0	0	220	190	165	300	190	150	150	6
1-B-6	5097II	MS IV	175	170	175	170	36	36	36	36	-36	0	0	0	220	190	165	300	190	150	150	6
1-B-7	5097II	MS IV	175	170	175	170	36	36	36	36	-36	0	0	0	220	190	165	300	190	150	150	6
1-B-8	5097II	MS IV	175	170	175	170	36	36	36	36	-36	0	0	0	220	190	165	300	190	150	150	6
1-B-9	5097II	MS IV	175	170	175	170	36	36	36	36	-36	0	0	0	220	190	165	300	190	150	150	6
1-B-10	5098III	MS II	155	175	155	175	72	72	72	72	-54	0	0	0	220	190	165	300	190	150	150	6
1-B-11	5098III	MS II	165	170	165	170	60	60	60	60	-60	0	0	0	220	190	165	300	190	150	150	6
1-B-12	5098III	MS II	165	170	165	170	60	60	60	60	-60	0	0	0	220	190	165	300	190	150	150	6
1-B-13	5098III	MS II	165	170	165	170	60	60	60	60	-60	0	0	0	220	190	165	300	190	150	150	6
1-B-14	5098III	MS II	165	170	165	170	60	60	60	60	-60	0	0	0	220	190	165	300	190	150	150	6
1-B-15	5098III	MS II	165	170	165	170	60	60	60	60	-60	0	0	0	220	190	165	300	190	150	150	6
1-B-16	5098III	MS II	165	170	165	170	60	60	60	60	-60	0	0	0	220	190	165	300	190	150	150	6
1-B-17	5098III	MS II	165	170	165	170	60	60	60	60	-60	0	0	0	220	190	165	300	190	150	150	6
1-B-18	5098III	MS II	165	170	165	170	60	60	60	60	-60	0	0	0	220	190	165	300	190	150	150	6
1-B-19	5098III	MS II	165	170	165	170	60	60	60	60	-60	0	0	0	220	190	165	300	190	150	150	6
1-B-20	5098III	MS II	165	170	165	170	60	60	60	60	-60	0	0	0	220	190	165	300	190	150	150	6
1-B-21	5098III	MS II	165	170	165	170	60	60	60	60	-60	0	0	0	220	190	165	300	190	150	150	6
1-B-22	5098III	MS II	165	170	165	170	60	60	60	60	-60	0	0	0	220	190	165	300	190	150	150	6
1-B-23	5098III	MS II	165	170	165	170	60	60	60	60	-60	0	0	0	220	190	165	300	190	150	150	6
1-B-24	5098III	MS II	165	170	165	170	60	60	60	60	-60	0	0	0	220	190	165	300	190	150	150	6
1-B-25	5098III	MS II	165	170	165	170	60	60	60	60	-60	0	0	0	220	190	165	300	190	150	150	6
1-B-26	5098III	MS II	165	170	165	170	60	60	60	60	-60	0	0	0	220	190	165	300	190	150	150	6
1-B-27A	5098III	MS II	165	170	165	170	60	60	60	60	-60	0	0	0	220	190	165	300	190	150	150	6
1-B-27B	5098III	MS II	165	170	165	170	60	60	60	60	-60	0	0	0	220	190	165	300	190	150	150	6
1-B-28	5098III	MS II	165	170	165	170	60	60	60	60	-60	0	0	0	220	190	165	300	190	150	150	6
1-B-29	5098III	MS II	165	170	165	170	60	60	60	60	-60	0	0	0	220	190	165	300	190	150	150	6
1-B-30	5098III	MS II	165	170	165	170	60	60	60	60	-60	0	0	0	220	190	165	300	190	150	150	6
1-B-31	5098III	MS II	165	170	165	170	60	60	60	60	-60	0	0	0	220	190	165	300	190	150	150	6
1-B-32	5098III	MS II	165	170	165	170	60	60	60	60	-60	0	0	0	220	190	165	300	190	150	150	6
1-B-33	5098III	MS II	165	170	165	170	60	60	60	60	-60	0	0	0	220	190	165	300	190	150	150	6
1-B-34	5098III	MS II	165	170	165	170	60	60	60	60	-60	0	0	0	220	190	165	300	190	150	150	6
1-B-35A	5098III	MS II	165	170	165	170	60	60	60	60	-60	0	0	0	220	190	165	300	190	150	150	6

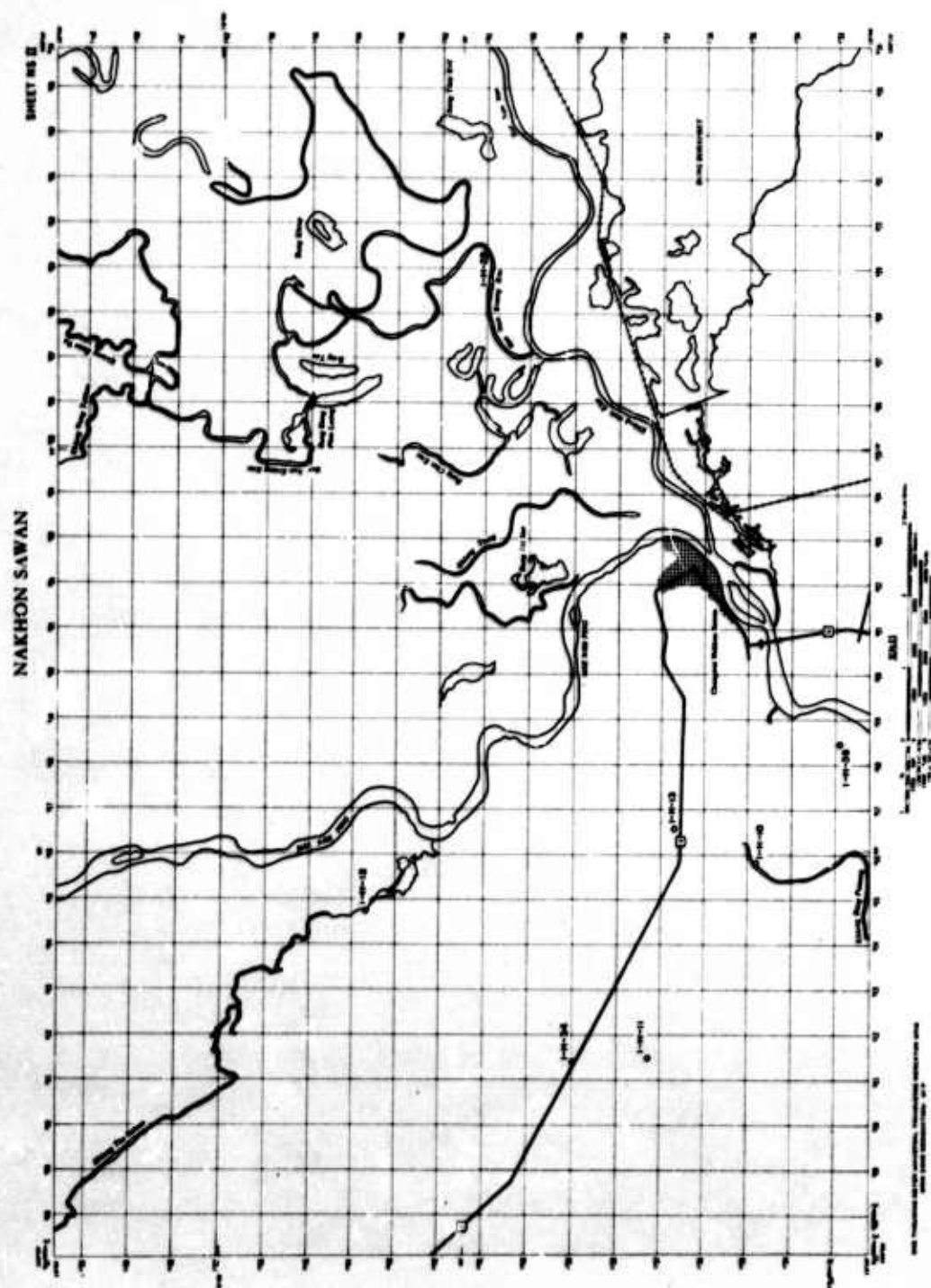
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Note: Max Wtr--Mean maximum water conditions.
Min Wtr--Mean minimum water conditions.
CD--Channel depth is the measurement used to map the step height factor.
A minus sign (-) is below water level.
A plus sign (+) is above water level.
For definitions of west bank and east bank see Fig. 6.
** Coordinates are set up according to the Military Grid System. First three numbers represent longitude; second three numbers represent latitude.
† Position of step base is referenced to water level.
‡ For position of numerically designated approach angle and step height see Fig. 6.
§ Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.

Table A1 (Continued)

Site No.	AMS Map Sheet	MDS Grid Coord. - meters	Hydrologic Geometry at East and West Banks						Position of Study Bank						Water Depth		Surface Geometry											
			Constant		Step Height, in.		of Study Bank		Max Vtr	Min Vtr	Max Vtr	Min Vtr	Critical Approach		Step		Approach		Step		Approach		CD					
			V	I	V	I	V	I					V	I	Angle	Max Vtr	Angle	Max Vtr	Angle	Max Vtr	Angle	Max Vtr		Angle	Max Vtr	Angle	Max Vtr	
1-E-35B	4958III	MS I	90	90	60	60	-60	-60			5.5	2.5	150	24	220	105	120	210	210	105	120	210	105	120	210	105	6	
1-E-35A	4958II	MS I									2.5	0.5			270	125	160	230	230	125	160	270	125	160	270	125	3	
1-E-36A	4958II	MS I									2.5	0.5			230	160	90	270	270	160	90	230	160	90	270	160	3	
1-E-37	5057IV	MS V	175	175							2.5	0.5	160	36	200	160	160	200	200	160	160	200	160	160	200	160	4	
1-E-38	5058III	MS II									4	1.5	165	32	205	155	170	190	190	155	170	205	155	170	190	205	2	
1-E-39	5057I	MS IV									2	0	155	36	200	160	170	190	200	160	170	200	160	170	190	200	2	
1-E-40	5057I	MS IV									2.5	0	155	12	205	155	170	190	205	155	170	205	155	170	190	205	3	
1-E-41	4958II	MS I									1.5	0			230	130	130	230	230	130	130	230	130	130	230	130	2	
1-E-42	4958II	MS I									1.5	0.5	160	16	190	170	125	240	190	170	125	240	190	170	125	240	2	
1-E-43	4958II	MS I	175	150			-60				5	0.5			200	115	150	190	200	115	150	200	115	150	190	200	6	
1-E-44	4958II	MS I			12						1.5	0	160	12	270	90	115	240	270	90	115	270	90	115	240	270	2	
1-E-45	4958I	MS I									2	0	168	42	190	165	160	230	190	165	160	190	165	160	230	190	2	
1-E-46	5057IV	MS V	172	172							4.5	1.5	170	60	190	172	172	190	190	172	172	190	172	172	190	190	5	

† Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation process area.



AREA TO BE STUDIED

10	11	12
13	14	15
16	17	18

HYDROLOGIC GEOMETRY STUDY
NAKHON SAWAN STUDY AREA
SHEET NO. 11

FIG. A2

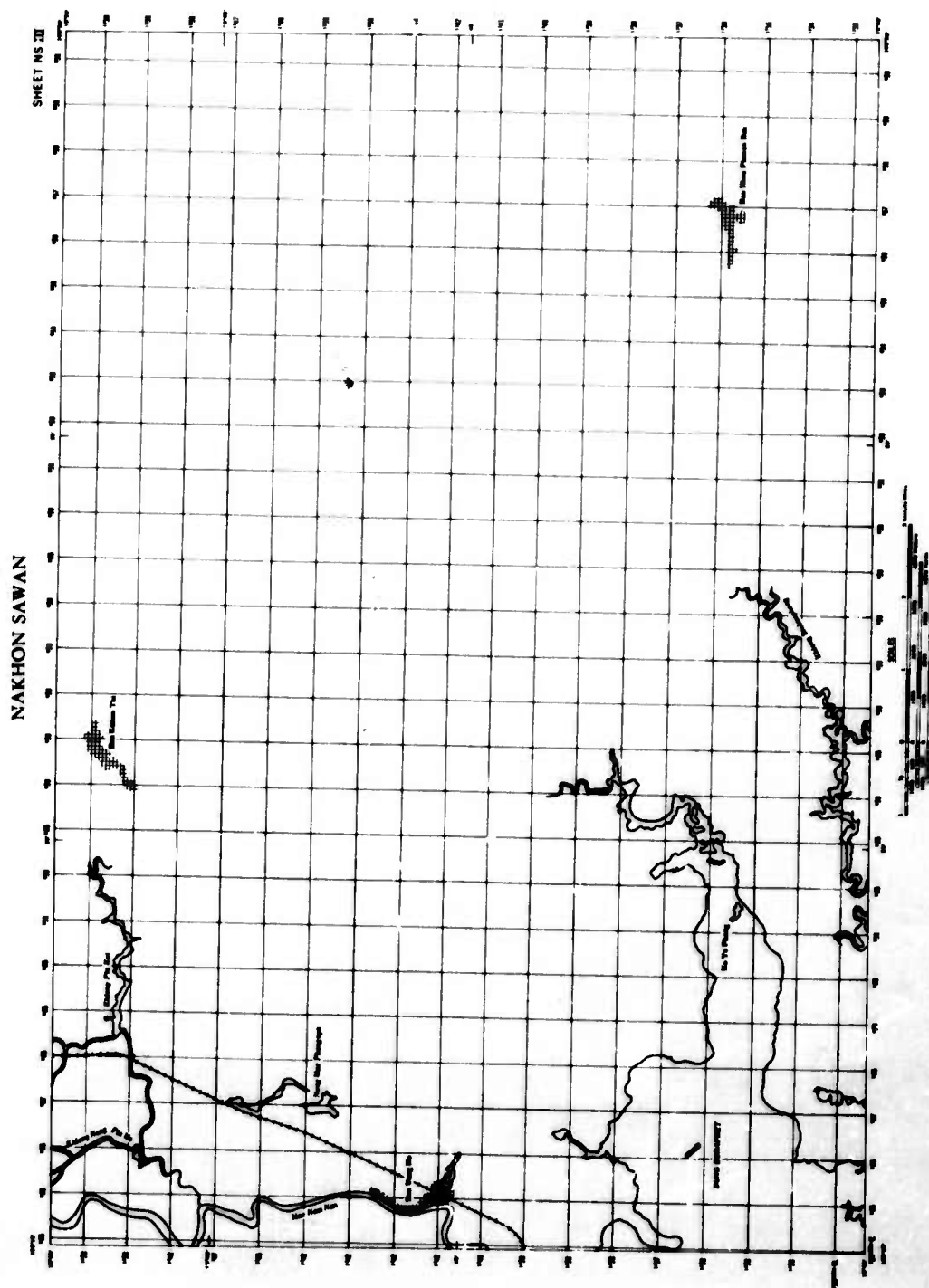


TABLE 1. TO BE COMPLETED BY USER

NO. 1	NO. 2	NO. 3	NO. 4

FIG. A3

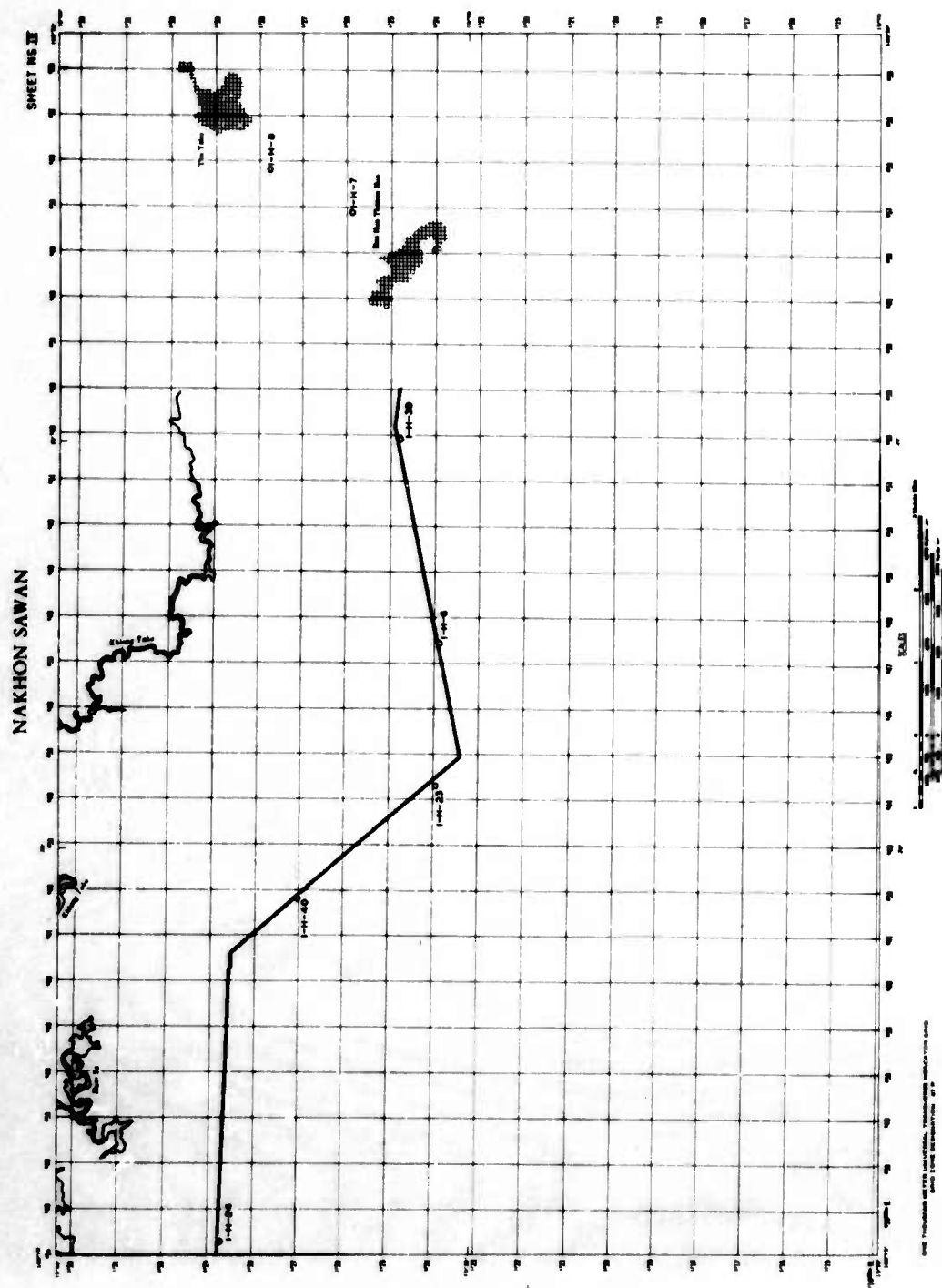


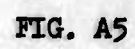
FIG. A4

TABLE 1 TO ACCOMPANY SHEET NO. II

NO. 1	NO. 2	NO. 3	NO. 4
1	2	3	4

HYDROLOGIC GEOMETRY SITES
NAKHON SAWAN STUDY AREA
SHEET NO. IV

100	100	100
100	100	100



LOP BURI

Table A2
Summary of Hydrologic and Surface Geometry Field Data
Lop Burt

Site No.	AMS Map Sheet No.	Military Grid Coord. nates	Hydrologic Geometry at East and West Banks										Surface Geometry									
			Contact					Position of Step Base, f in.					Critical Approach Angle, deg and Step Height, in.					Surface Geometry				
			Max Wtr	Min Wtr	W	E	Max Wtr	Min Wtr	W	E	Max Wtr	Min Wtr	App Angle	Step Ht	App Angle	Step Ht	App Angle	Step Ht	App Angle	Step Ht	App Angle	Step Ht
2-E-1	5154-II	12 V	971801																			
2-E-2	5155-III	12 II	786364																			
2-E-3	5155-III	12 II	804357																			
2-E-4	5155-III	12 II	834357																			
2-E-5	5154-I	12 IV	075090																			
2-E-6	5154-I	12 III	094201																			
2-E-7	5153-I	12 IV	097032																			
2-E-8	5154-I	12 IV	075092																			
2-E-9	5154-I	12 IV	075092																			
2-E-3-1A	5154-I	12 IV	960092																			
2-E-3-1B	5154-I	12 IV	960092																			
2-E-3-2	5154-I	12 IV	903097																			
2-E-3-3	5154-I	12 IV	903100																			
2-E-4-1	5154-I	12 III	907133																			
2-E-4-2	5155-III	12 II	860055																			
2-E-5-1	5153-I	12 IV	970011																			
2-E-5-2	5153-I	12 IV	970705																			
2-E-5-3	5154-III	12 I	664995																			
2-E-6-1	5155-IV	12 I	721476																			
2-E-6-2	5155-IV	12 I	721476																			
2-E-6-3A	5155-III	12 II	617298																			
2-E-6-3B	5155-III	12 II	617298																			
2-E-6-3C	5155-III	12 II	617298																			
2-E-6-4	5155-III	12 II	632301																			
2-E-6-5	5155-III	12 II	694375																			
2-E-6-6A	5155-III	12 II	721375																			
2-E-6-6B	5155-III	12 II	721375																			
2-E-7-1	5154-I	12 IV	103057																			
2-E-7-2	5154-I	12 IV	100075																			
2-E-7-3	5154-I	12 IV	117117																			
2-E-7-4	5154-I	12 IV	081118																			
2-E-7-5	5154-I	12 IV	135142																			
2-E-8-1	5154-II	12 V	131085																			
2-E-10-1A	5154-II	12 V	095932																			
2-E-10-1B	5154-II	12 V	095932																			
2-E-10-2	5154-II	12 V	021923																			
2-E-10-3	5154-II	12 V	966924																			
2-E-10-4	5154-II	12 V	966924																			
2-E-10-5	5154-II	12 IV	903098																			
2-E-10-6	5154-II	12 IV	903093																			

Notes: Max Wtr--Mean maximum water conditions.
Min Wtr--Mean minimum water conditions.
CD--Channel depth is the measurement used to map the step height factor.
A minus sign (-) is below water level.
A plus sign (+) is above water level.
* Coordinates are set up according to the Military Grid System. First three numbers represent longitude; second three numbers represent latitude.
** A step is a slope change that is >35 deg.
† Position of step base is ref. reamed to water level.
‡ For position of numerically designated approach angle and step height see fig. 6.
§ Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.

Table A2 (Continued)

AMS Map Sheet	AMS Quad No.	Military Grid Coord.	Hydrographic Geography at East and West Ends										Water										Surface Geometry																																																																																																																																																																																																																																																																																																																																																																																																																																								
			Contact					Position					Depth					Critical Approach					Angle, deg and fms					Angle, deg and fms																																																																																																																																																																																																																																																																																																																																																																																																																																			
			Approach Angle Max Min V	Angle Max Min V	deg Max Min V	deg Max Min V	deg Max Min V	of Ship Max Min V	of Ship Max Min V	of Ship Max Min V	of Ship Max Min V	of Ship Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V	Max Min V

(Continued)

* Site located beyond limit of mapped stud, area; included in data tables because it was used in analysis to develop photo-interpretation procedures.

(2 of 3 sheets)

Table A2 (continued)

Site No.	AMS Map Sheet	MERS Quad No.	Military Grid Coordinates	Hydrologic Geometry at East and West Banks						Water Depth				Surface Geometry																			
				Contact			Position			Step Height, in.		of Step Base, in.		Max		Min		Critical Approach		App		App		App		App		Step		Step		Step	
				Approach Angle, deg	Max Wtr	Min Wtr	Max Wtr	Min Wtr	Max Wtr	Min Wtr	Max Wtr	Min Wtr	Max Wtr	Min Wtr	Max Wtr	Min Wtr	Max Wtr	Min Wtr	Max Wtr	Min Wtr	Max Wtr	Min Wtr	Max Wtr	Min Wtr	Max Wtr	Min Wtr	Max Wtr	Min Wtr	Max Wtr	Min Wtr	Max Wtr	Min Wtr	Max Wtr
2-B-25-1	51551V	12 I	731530	No data																													
2-B-25-2	51551V	12 I	613497	No data																													
2-B-25-3	51551III	12 II	736372	175	170	175	175	170	175	175	170	175	175	170	175	175	170	175	175	170	175	175	170	175	175	170	175	175	170	175	175	170	
2-B-25-4	51551III	12 II	704376	168	130	170	175	170	175	175	170	175	175	170	175	175	170	175	175	170	175	175	170	175	175	170	175	175	170	175	175	170	
2-B-25-5	51551III	12 II	704372	168	130	170	175	170	175	175	170	175	175	170	175	175	170	175	175	170	175	175	170	175	175	170	175	175	170	175	175	170	
2-B-25-6	51551II	12 III	933866	135	130	165	160	148	90	48	90	48	90	48	90	48	90	48	90	48	90	48	90	48	90	48	90	48	90	48	90	48	
2-B-27-1	51541	12 IV	923114	115	115	155	160	148	108	108	108	108	108	108	108	108	108	108	108	108	108	108	108	108	108	108	108	108	108	108	108	108	
2-B-27-2	51541	12 III	905133	140	155	170	170	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	
2-B-27-3	51541V	12 IV	862174	140	130	145	155	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	
2-B-27-4	51541V	12 IV	879172	135	160	166	175	132	70	132	70	132	70	132	70	132	70	132	70	132	70	132	70	132	70	132	70	132	70	132	70	132	

* Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.

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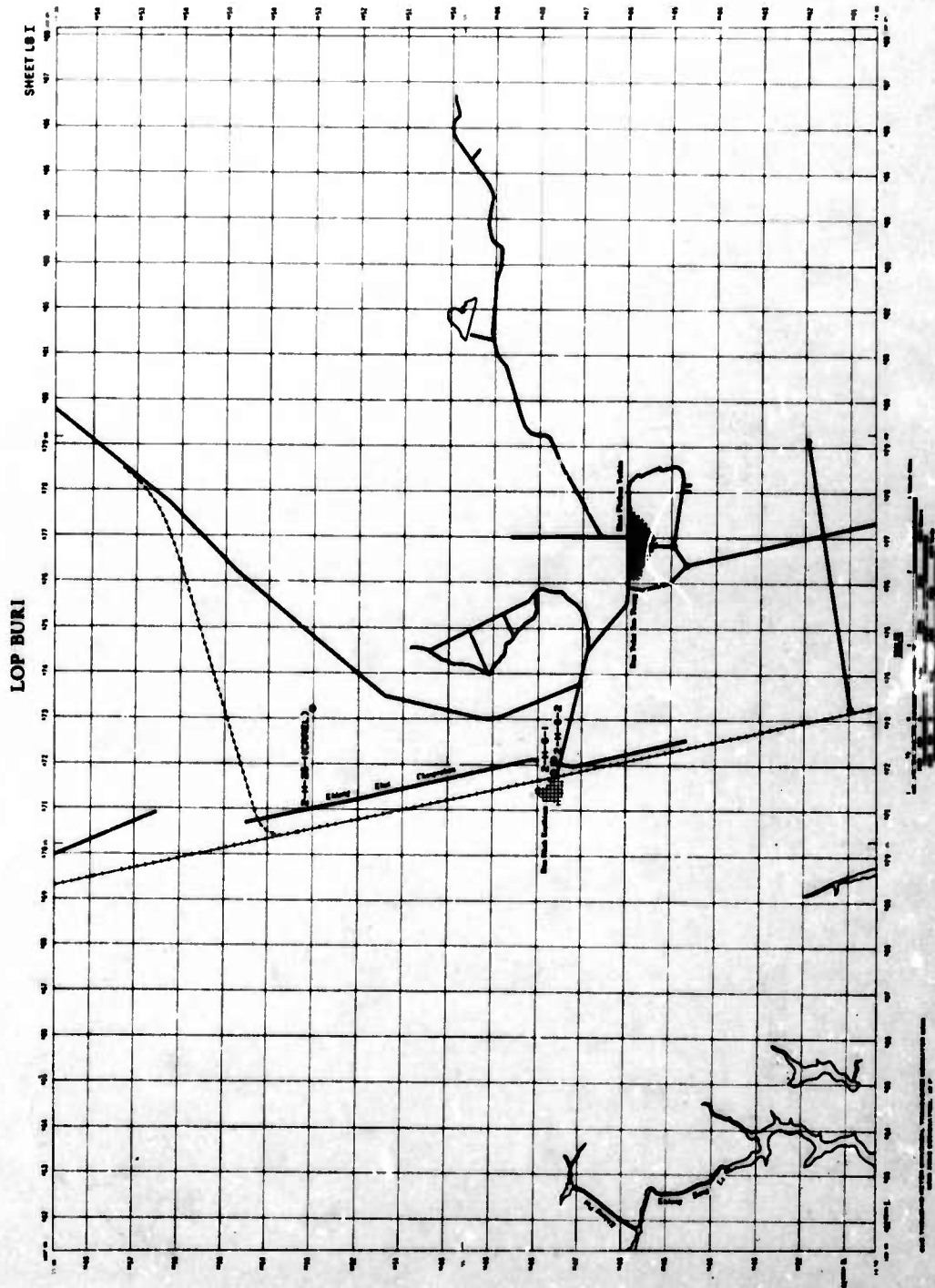


FIG. A6

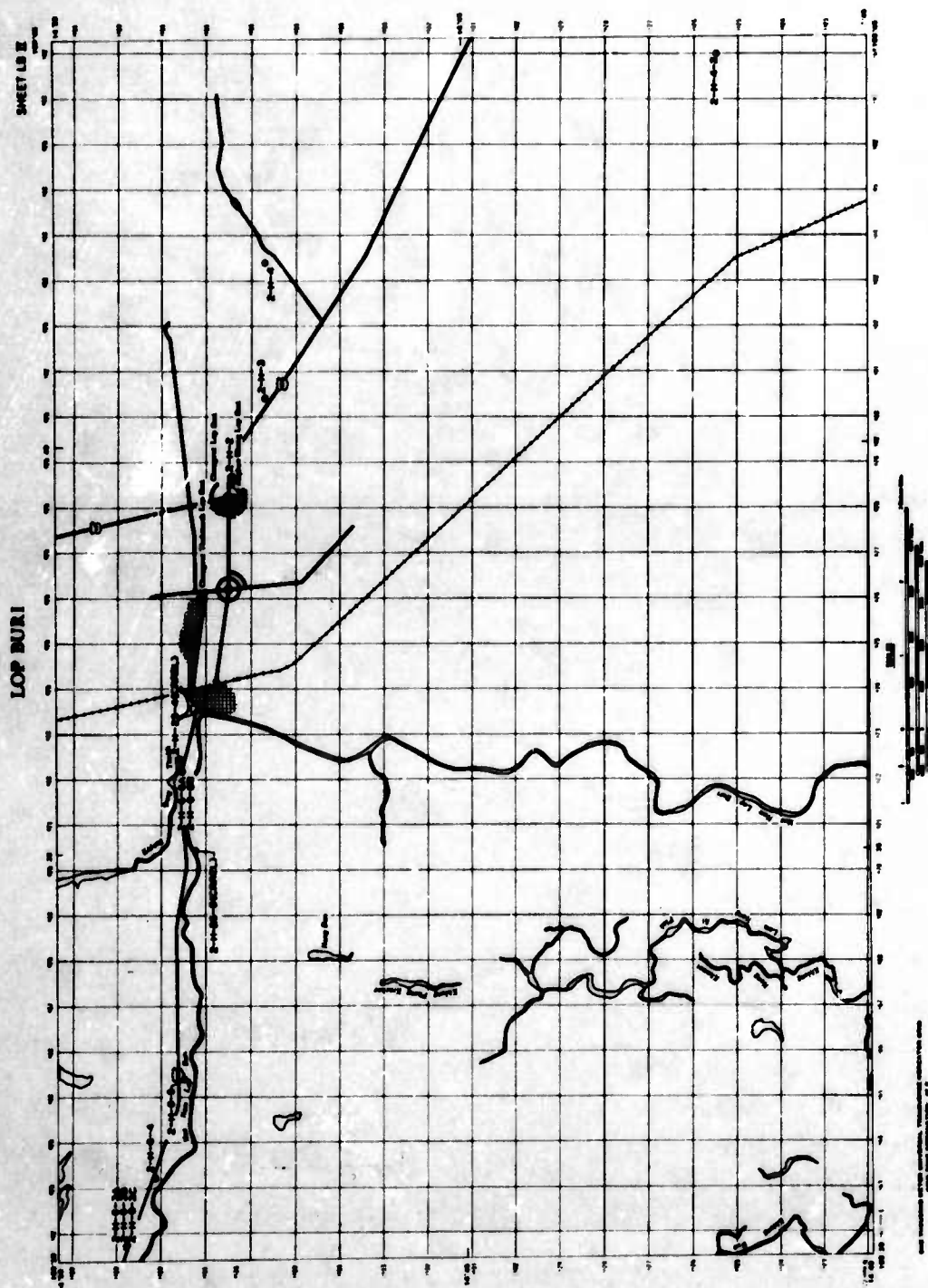


FIG. A7

Legend

131	132	133	134
135	136	137	138

HYDROLOGIC CIRCUMSTANCES
LOP BURI STUDY AREA
SHEET 13 E

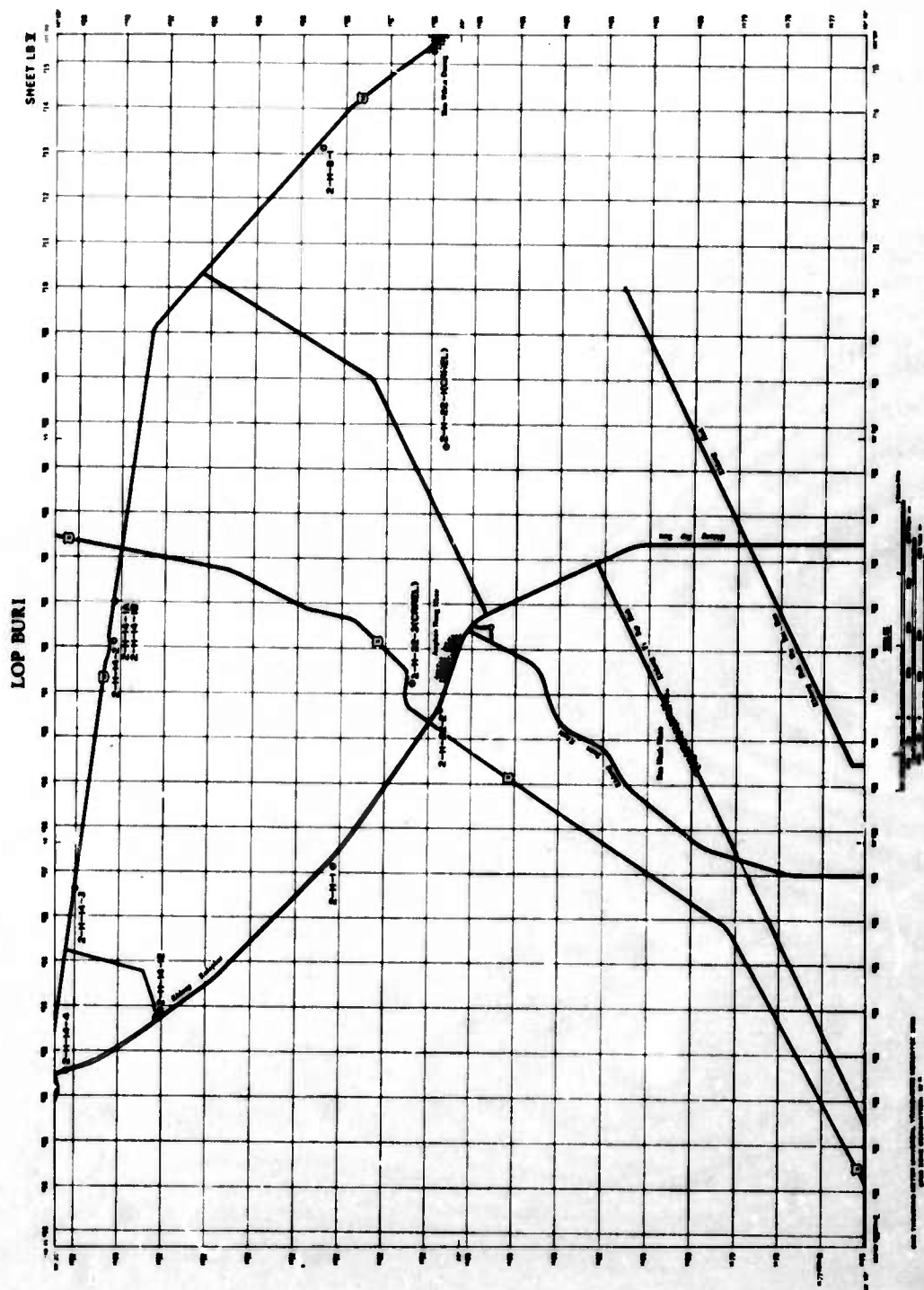


FIG. A10

CHIANG MAI

Table A3
Summary of Hydrologic and Surface Geometry Field Data
Chiang Mai

Stn. No.	AMS Map Sheet	MERS Quad No.	Military Grid Coordin- ates*	Hydrologic Geometry at East and West Banks						Water						Surface Geometry					
				Contact			Position			Depth			Critical Approach			Angle			Step	Angle	St. Angle
				Approach	Angle	deg	Step	Height	ft.	Max	Min	Max	App	Step	Angle	App	Step	Angle			
				Max	Min	Wtr	Max	Min	Wtr	Max	Min	Max	App	Step	Angle	App	Step	Angle	St.	Angle	St.
3-B-1	4867III	CM II	137794	140	168		42			7	2		125	18		225	140	210	160	22	7
3-B-2	4767II	CM I	977746							2.5	1		135	18		235	130	250	132	54	3.5
3-B-3	4766I	CM IV	877602	140	110					2.5	0		160	20		222	130	227	132	54	3
3-B-4	4767III	CM I	971737							4.0	1		125	12		210	130	200	160	4	2.5
3-B-5	4767III	CM IV	955683							2	0		130	36		230	130	200	140	10	2.5
3-B-6	4767III	CM IV	955728	110	108					3	0		125	24		238	108	230	140	10	2.5
3-B-7	4767III	CM IV	954711	130	95					4.5	1		145	10		230	130	250	140	36	3.5
3-B-8	4767III	CM IV	954711	130	95					4.5	1		145	10		230	130	250	140	36	3.5
3-B-9	4767II	CM I	976915	100	130					4.5	1		145	10		230	130	250	140	36	3.5
3-B-10	4767III	CM IV	946699							2.5	0		130	36		230	130	250	140	36	3.5
3-B-11	4767III	CM IV	914645	158	140					2.5	0		130	36		230	130	250	140	36	3.5
3-B-12	4766I	CM IV	843775							4	0		175	12		212	140	210	110	30	3.5
3-B-13	4766I	CM IV	829569							2.0	0		140	08		240	110	270	140	18	3
3-B-14	4766I	CM IV	847405							2.0	0		140	08		240	110	270	140	18	3
3-B-15	4766I	CM IV	859488							2.5	0.5		160	66		220	140	245	135	12	3
3-B-16	4766I	CM IV	867595	148	160					7.0	2.5		120	32		210	110	220	164	30	2
3-B-17	4766I	CM IV	814562							2.0	0.0		110	15		200	130	240	164	30	2
3-B-18	4766I	CM IV	833573							2.5	0.5		110	15		290	90	270	164	30	2
3-B-19	4766I	CM IV	833492							1.5	0.0		110	15		210	90	270	164	30	2
3-B-20	4867III	CM II	045762							2.7	0.5		150	24		200	150	240	137	48	3
3-B-21	4867III	CM II	092763	110	150					10.0	5.1		150	18		240	90	220	150	12	12
3-B-22	4867III	CM II	066758	165	160					8.0	1.0		150	18		200	125	200	150	12	12
3-B-23	4867III	CM II	060754							2.5	0.5		115	14		210	155	200	170	18	6.5
3-B-24	4867III	CM III	137709	158	173					5.5	0.5		160	18		240	130	220	170	18	6.5
3-B-25	4867III	CM II	104736							2	0		160	18		240	130	220	170	18	6.5
3-B-26	4867III	CM II	104731	100	125					4	1		150	24		220	125	210	130	20	4
3-B-27	4867III	CM II	088793	140	130					10	10		135	27		270	140	195	158	45	2
3-B-28A	4867III	CM II	095814	155	170					2	0		135	27		195	160	220	157	45	2
3-B-28B	4867III	CM II	095814	155	170					3	0		135	27		220	150	220	157	45	2
3-B-29	4867III	CM II	098818	155	145					6	2		158	40		220	150	220	157	45	2
3-B-30	4867III	CM II	068820	140	130					4	1		160	35		210	140	205	158	45	2
3-B-31	4867IV	CM II	077828	155	175					5	1		145	57		225	152	230	150	30	8
3-B-32	4867IV	CM II	079831	198	90					3	0		160	9		220	100	200	145	10	4
3-B-33	4867IV	CM II	083834	157	160					5	1		145	27		200	140	220	145	10	4
3-B-34	4867IV	CM II	089831	145	110					3	0		130	8		215	110	200	130	30	6
3-B-35	4867IV	CM II	140861	125	105					4	0		150	20		220	110	230	150	20	5
3-B-36A	4867IV	CM II	156868	145	140					2	0		155	15		260	145	225	170	17	3
3-B-36B	4867IV	CM II	156868	145	140					4	1		175	5		220	145	190	165	46	5
3-B-37	4867IV	CM II	048828	105	140					4	1		175	5		193	140	200	135	36	7
3-B-38	4867III	CM II	089821							2	0		160	48		190	135	230	125	30	3

(Continued)

Notes: Max Wtr--Mean maximum water conditions.
Min Wtr--Mean minimum water conditions.
CD--Channel depth is the measurement used to map the step height factor.
A plus sign (+) is above water level.
A minus sign (-) is below water level.
For definitions of west bank and east bank see fig. 6.
* Coordinates are set up according to the Military Grid System. First three numbers represent longitude; second three numbers represent latitude.
** A step is a slope change that is >35 deg.
† Position of step base is referenced to water level.
†† For position of numerically designated approach angle and step height see fig. 6.
‡ Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.

Table A3 (Continued)

Hydrologic Geometry at East and West Banks										Water Depth				Surface Geometry												
AMS Map Sheet	MBS Quad No.	Military Grid Coordinates	Contact				Position				Water Depth				Critical Approach				Step				Height			
			Approach Angle, deg	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	Max Wtr	Min Wtr	W	App Angle	Step Angle	App Angle	Step Angle	App Angle	Step Angle	App Angle	Step Angle	App Angle	Step Angle	
3-E-39	4867IV	CM II	05091	150	90																					
3-E-40	4867IV	CM II	04989	125	125	60	48	-48																		
3-E-41	4867IV	CM II	01189A	130	130	34	30	-34	-60																	
3-E-42	4867IV	CM II	02189																							
3-E-43	4867IV	CM II	02598A	155	145	24	46	-36	0																	
3-E-44	4867III	CM III	04591	115	90																					
3-E-45A	4867III	CM III	04591	160	175																					
3-E-46	4867III	CM III	04609A																							
3-E-47	4867III	CM III	04607	90	120	24	18	-36	-28																	
3-E-48	4867III	CM III	073703	150	90	20	26	-36	-28																	
3-E-49	4866IV	CM III	04606	165	165	18	25	-35	-30																	
3-E-50	4866IV	CM III	01668A	115	140																					
3-E-51	4866IV	CM III	051436																							
3-E-52	4866IV	CM III	041513	155	130																					
3-E-53	4866IV	CM III	070523	150	158																					
3-E-54	4866IV	CM I	047042																							
3-E-55	4866IV	CM I	053891	130	150	25	26	0	-26																	
3-E-56	4866IV	CM I	045962	120	130																					
3-E-57	4866IV	CM III	043475	165	145																					
3-E-58	4867III	CM III	016670	125	90																					
3-E-59	4867III	CM IV	046058	160	165																					
3-E-60	4866IV	CM IV	046058	160	165																					
3-E-61	4866IV	CM IV	046058	160	165																					
3-E-62	4866IV	CM IV	046058	160	165																					
3-E-63	4866IV	CM IV	046058	160	165																					
3-E-64	4866IV	CM IV	046058	160	165																					
3-E-65A	4866IV	CM IV	046058	160	165																					
3-E-66	4866IV	CM IV	046058	160	165																					
3-E-67	4866IV	CM IV	046058	160	165																					
3-E-68	4867III	CM II	046058	160	165																					
3-E-69	4867III	CM II	046058	160	165																					
3-E-70	4867III	CM II	046058	160	165																					
3-E-71	4866III	CM II	046058	160	165																					
3-E-72	4866III	CM II	046058	160	165																					
3-E-73	4866III	CM II	046058	160	165																					
3-E-74	4866III	CM II	046058	160	165																					
3-E-75	4866III	CM II	046058	160	165																					
3-E-76	4866III	CM II	046058	160	165																					
3-E-77	4866III	CM II	046058	160	165																					
3-E-78	4866III	CM II	046058	160	165																					
3-E-79	4866III	CM II	046058	160	165																					
3-E-80	4866III	CM II	046058	160	165																					
3-E-81	4866III	CM II	046058	160	165																					
3-E-82	4866III	CM II	046058	160	165																					
3-E-83	4866III	CM II	046058	160	165																					
3-E-84	4866III	CM II	046058	160	165																					
3-E-85	4866III	CM II	046058	160	165																					
3-E-86	4866III	CM II	046058	160	165																					
3-E-87	4866III	CM II	046058	160	165																					
3-E-88	4866III	CM II	046058	160	165																					
3-E-89	4866III	CM II	046058	160	165																					
3-E-90	4866III	CM II	046058	160	165																					

(Continued)

* Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.

(2 of 3 sheets)

Table A3 (concluded)

Site No.	AMS Map Sheet	MERS Quad No.	Military Grid Coordinates	Hydrologic Geometry at East and West Ends				Position of Step Base, in.				Water Depth, ft		Critical Approach				Surface Geometry				CD
				Contour		Step Height, in.		Max Per		Min Per		Max	Min	App Angle		Step		App Angle		Step		CD
				Approach Angle, deg	Min Per	Max Per	Min Per	Max Per	Min Per	Max Per	Min Per			App Angle	Step Angle	App Angle	Step Angle	App Angle	Step Angle	App Angle	Step Angle	
3-E-858	47661	+	984471	140	140							4	0.5	90	30			210	150	210	150	5
3-E-86	47661	+	911466									2.5	1.0					270	100	240	240	8
3-E-87	47671	CH I	974801	150	127							3.5	0.0					185	130	230	230	2.5
3-E-88	47671	CH I	974801									2	0					240	120	155	210	5.5
3-E-89	47671	CH I	905913									2.5	1					210	150	110	250	5.5
3-E-90	47671	+	945004	145	145							7.5	1.5			167	96	205	163	145	220	10
3-E-91	47671	CH IV	976655	100	120							3	6					220	120	110	270	3.5
3-E-92	47671	CH IV	976654	110	125							6	1.5					250	120	110	200	12
3-E-93	47671	CH IV	981660	160	130							2.5	0					210	125	120	220	3
3-E-94	47671	CH IV	904670	160	130							3	0					220	130	90	250	16
3-E-95	47671	CH IV	912671	120	110							2.5	0.5					230	130	120	220	3.5
3-E-96	47661	+	904499	90	90							4	1					260	110	90	260	24
3-E-97	47661	+	901496	90	90							5	1					255	90	90	260	6
3-E-98	47661	+	876510	90	90							7	2.5					270	90	90	230	9.5
3-E-99	47671	CH IV	947720	150	130							4	0					210	110	140	230	5
3-E-100	48671	CH III	187718	90	100							4.5	1.0					240	90	100	250	5.5
3-E-101	48671	CH III	254728	125	132							7.5	2.5					225	132	140	230	7
3-E-102	48671	CH III	223719	90	105							3.5	0.0					220	105	90	260	5.5
3-E-103	48671	CH II	172767									2.5	0.0			150	24	210	150	140	220	3.5
3-E-104	48671	CH II	184784									2.5	0.0					200	150	160	195	5.5
3-E-105A	47661	+	819534	140	140							3.5	0.5					265	140	140	220	5.5
3-E-105B	47661	+	819534									2.0	0.0					240	140	110	220	3
3-E-106	47661	+	821519									2.5	0.5					250	90	110	220	3.5
3-E-107	47661	+	841603	165	160							2.0	0.0					220	115	130	220	2
3-E-108	47661	CH IV	843606									4.0	0.0					220	100	110	230	9
3-E-109	48671	CH II	111846									2.5	0.0					210	130	110	260	3.5
3-E-110	48671	CH II	170857									2.5	0.7					200	160	160	200	3
3-E-111	48671	CH II	177853	130	145							5.0	0.5					210	145	130	210	7
3-E-112	48671	CH II	211819	120	120							6.0	1.5					210	145	130	210	7
3-E-113	48661	CH III	063612	160	170							5.5	3.0					240	130	120	240	1
3-E-114	48661	+	076533	160	177							6.5	1.5					190	160	135	210	10
3-E-115	48661	CH III	105594									1.5	0.0					210	130	125	210	2
3-E-116	48661	CH III	093542									1.5	0.0					200	140	110	250	2
3-E-117	48661	CH III	088949	110	100							3.0	0.5					240	112	110	230	4
3-E-118	47671	CH I	876731									2.5	0.0					195	165	130	220	3
3-E-119	47671	CH IV	897714	140	145							3.0	0.5					210	155	150	220	3.5
3-E-120	47671	+	980999	140	110							4.0	1.0					210	140	110	240	8
3-E-121	47671	+	981977	90	90							5.0	1.5					255	90	90	270	6
3-E-122	48671	CH II	046856									2.5	0					200	147	130	200	3
3-E-123	48671	CH II	048842									2.0	0					210	120	140	200	10
3-E-124	48671	CH II	080795									2.5	1					220	140	130	220	3
3-E-125	47671	CH I	965742									2.5	0					270	90	110	165	3

* Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.

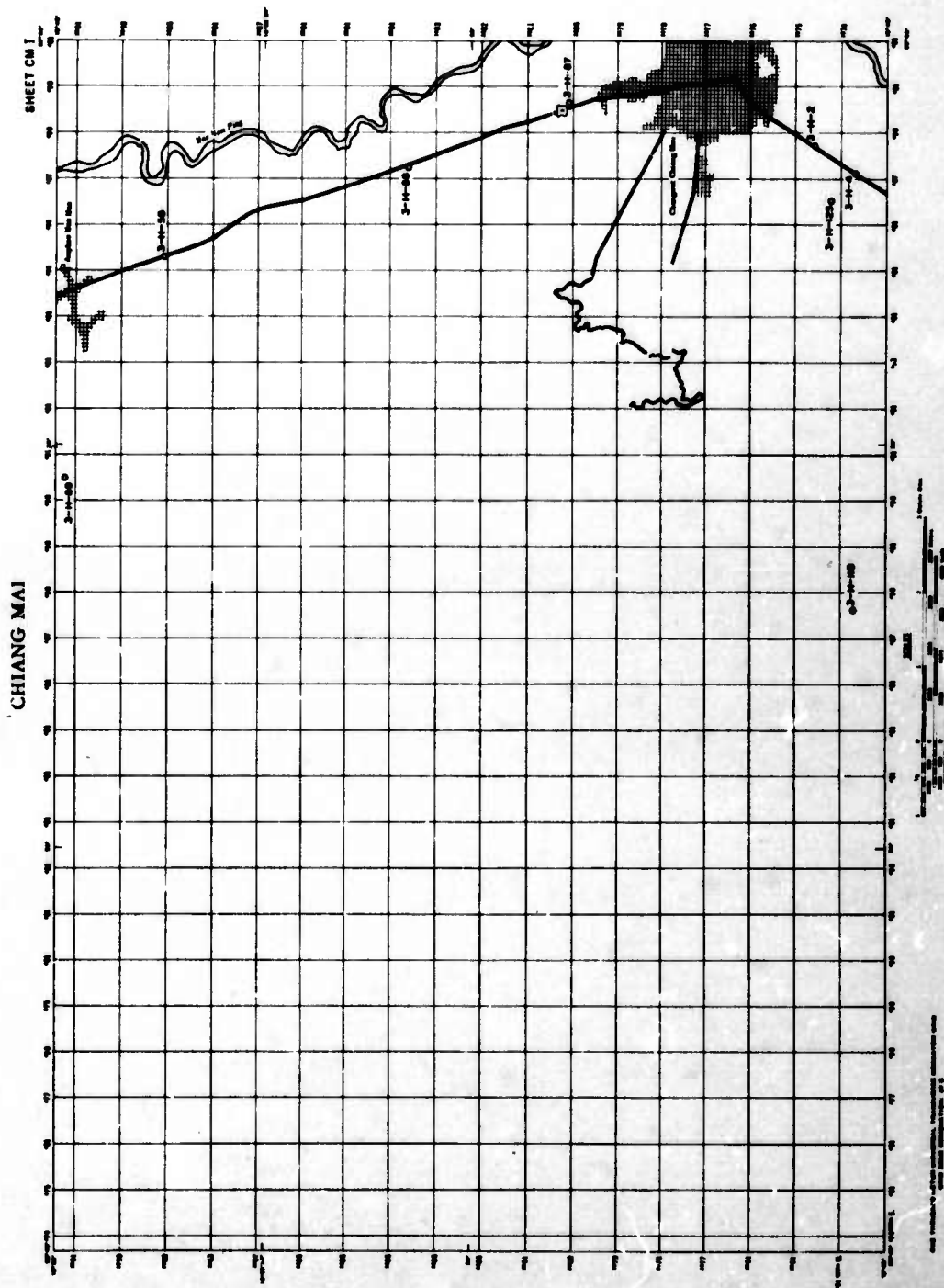


FIG. A12



FIG. A14

10	11	12	13
14	15	16	17

HYDROLOGIC GEOMETRY STUDY
CHIANG MAI STUDY AREA
SHEET CM III

PRAN BURI

Table AA
Summary of Hydrologic and Surface Geometry Field Data
From Mari

Site No.	AMS Map Sheet	MERS Quad	Military Grid	Hydrologic Geometry at East and West Banks				Position				Water				Surface Geometry											
				Contact		Approach Angle		Slope Height, ft.		of Step Bank, ft.		Min		Max		Critical Approach Angle		Step Angle		Step Angle		Step Angle		Step Angle		Step Angle	
				E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W
1-1	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												17
1-2	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												39
1-3	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												31
1-4	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												41
1-5	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												18
1-6	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												16.5
1-7	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												8
1-8	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												10
1-9	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												23
1-10	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												18
1-11	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												23
1-12	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												13.5
1-13	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												11
1-14	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												23.5
1-15	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												13
1-16	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												7
1-17	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												5
1-18	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												5
1-19	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												5
1-20	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												5
1-21	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												5
1-22	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												5
1-23	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												5
1-24	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												5
1-25	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												5
1-26	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												5
1-27	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												5
1-28	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												5
1-29	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												5
1-30	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												5
1-31	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												5
1-32	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												5
1-33	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												5
1-34	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												5
1-35	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												5
1-36	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												5
1-37	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												5
1-38	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												5
1-39	194-811	19 I	059736	135	120	150	165	36	84			0	0	13	9												5

Notes: Max Wtr.-Mean maximum water conditions.
Min Wtr.-Mean minimum water conditions.
CD-Channel depth is the measurement used to map the step height factor.
A minus sign (-) is below water level.
A plus sign (+) is above water level.
* Coordinates are set up according to the Military Grid System. First three numbers represent longitude; second three numbers represent latitude.
** A step is a slope change that is >35 deg.
† Position of step base is referenced to water level.
‡ For position of numerically designated approach angle and step height see fig. 6.
§ Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.

Table A4 (Continued)

Site No.	ANS Map Sheet	MERS Quad No.	Military Grid Coordinates	Hydrologic Geometry at East and West Banks				Water Depth				Position of Step Base, in.				Approach Angle, deg				Critical Approach Angle, deg and Step Height, in.				Surface Geometry					
				Concave		Convex		Max		Min		Max		Min		Max		Min		Max		Min		Max		Min		Max	
				W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E
1-E-10	194711	FB II	896696	145	135																								
1-E-11	194711	FB I	892702																										
1-E-12	194711	FB I	846744																										
1-E-13	194711	FB II	928701	150	150																								
1-E-14	194711	FB II	970571																										
1-E-15	194711	FB III	906514	160	155																								
1-E-16	194811	FB II	923702																										
1-E-17	194711	FB III	908520	140	120																								
1-E-18	194711	FB III	879517																										
1-E-19	194711	FB III	896517																										
1-E-20	194811	FB I	974865	160	120																								
1-E-21	194811	FB I	987853																										
1-E-22	194711	FB III	889485																										
1-E-23	194711	FB III	873477	165	145																								
1-E-24	194711	FB III	905458																										
1-E-25	194711	FB III	922466	140	110																								
1-E-26	194711	FB II	910598																										
1-E-27	194711	FB II	908609																										
1-E-28	194711	FB II	897604																										
1-E-29	194711	FB II	956610																										
1-E-30	194711	FB III	931474	170	160																								
1-E-31	194711	FB III	944512																										
1-E-32	194711	FB III	944512	125	150																								
1-E-33	194811	FB I	903744	120	115																								
1-E-34	194811	FB I	892736																										
1-E-35	194811	FB I	882741																										
1-E-36	194811	FB I	887741																										
1-E-37	194711	FB III	909508																										
1-E-38	194711	FB III	002518	175	175																								
1-E-39	194711	FB III	005923	90	90																								
1-E-40	194711	FB III	005922	90	90																								
1-E-41	194711	FB III	010528																										
1-E-42	194711	FB III	984510																										
1-E-43	194711	FB III	984516																										
1-E-44	194711	FB III	992740																										
1-E-45	194711	FB III	010525																										
1-E-46	194711	FB III	968455																										
1-E-47	194711	FB III	978470																										
1-E-48	194711	FB III	977466																										
1-E-49	194711	FB III	970465																										
1-E-50	194711	FB III	983460																										
1-E-51	194711	FB III	984456																										
1-E-52	194711	FB III	984431																										
1-E-53	194711	FB III	971428																										
1-E-54	194711	FB III	972480																										
1-E-55	194711	FB III	977467																										
1-E-56	194711	FB III	007469																										
1-E-57	194711	FB III	003468																										
1-E-58	194711	FB III	907443																										

Sinkholes, no data recorded

Sinkholes, no data recorded

(Continued)

(2 of 3 sheets)

Table A4 (Continued)

Site No.	Map Sheet	MGRS Quad	Military Grid Coord. - meters	Topographic Locality at East and West Ends						Water						Surface Geometry												CD																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
				Approach Angle, Deg			Stop Height, in.			Position			Depth			CRITICAL APPROACH ANGLE, DEG AND STOP HEIGHT, in.						Surface Geometry																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
				Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr		Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr	Max Vcr	Min Vcr	Max Vcr

* Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.

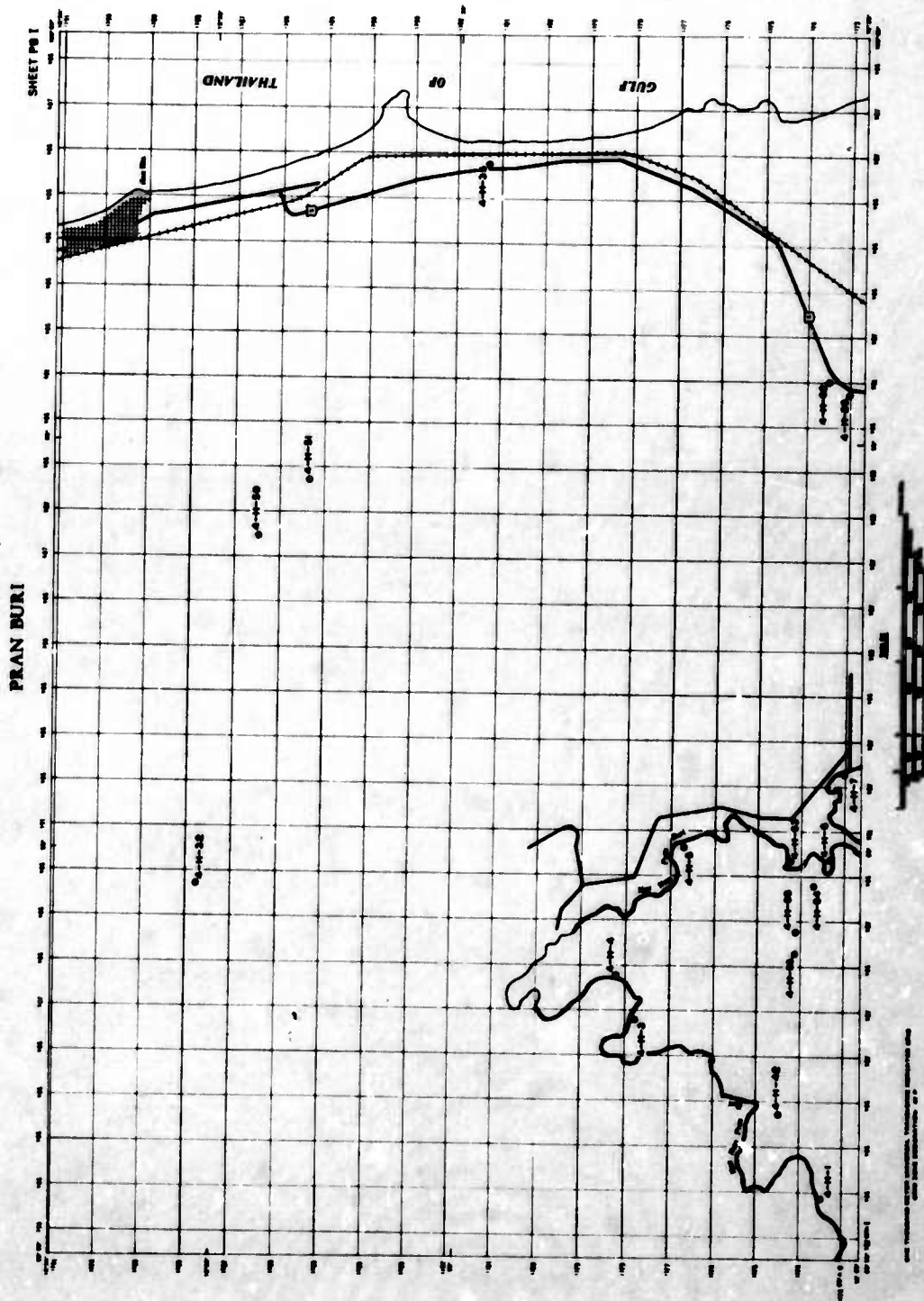


FIG. A16

HYDROLOGIC GEOMETRY STUDY
PRAN BURI STUDY AREA
SHEET NO 1

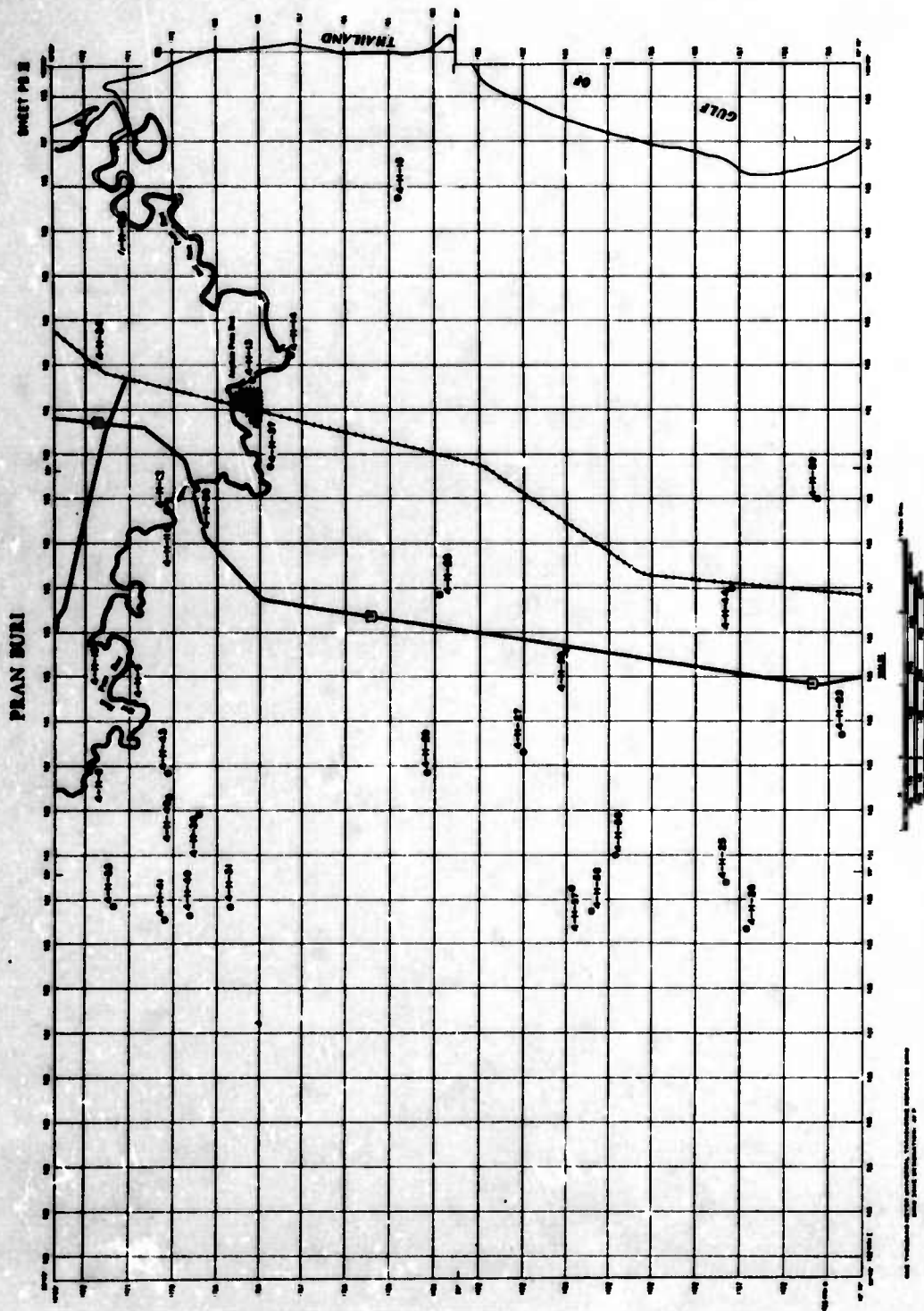


FIG. A17

HYDROLOGIC GEOMETRY SITES
PRAN BURI STUDY AREA
SHEET PG 2

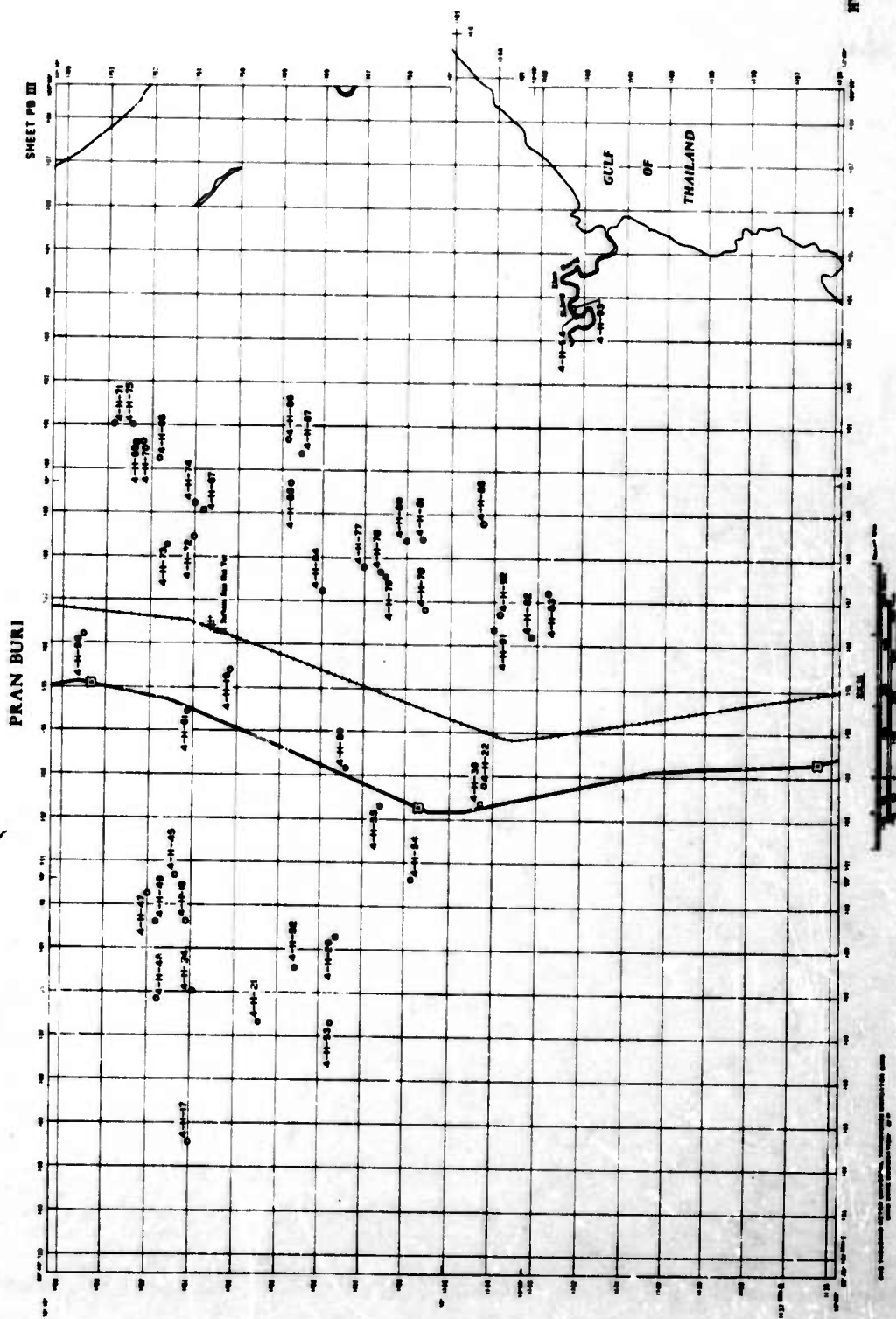


FIG. A18

KHON KAEN

Table A5
 7 of Hydrologic and Surface Geometry Field Data
 Moon Run

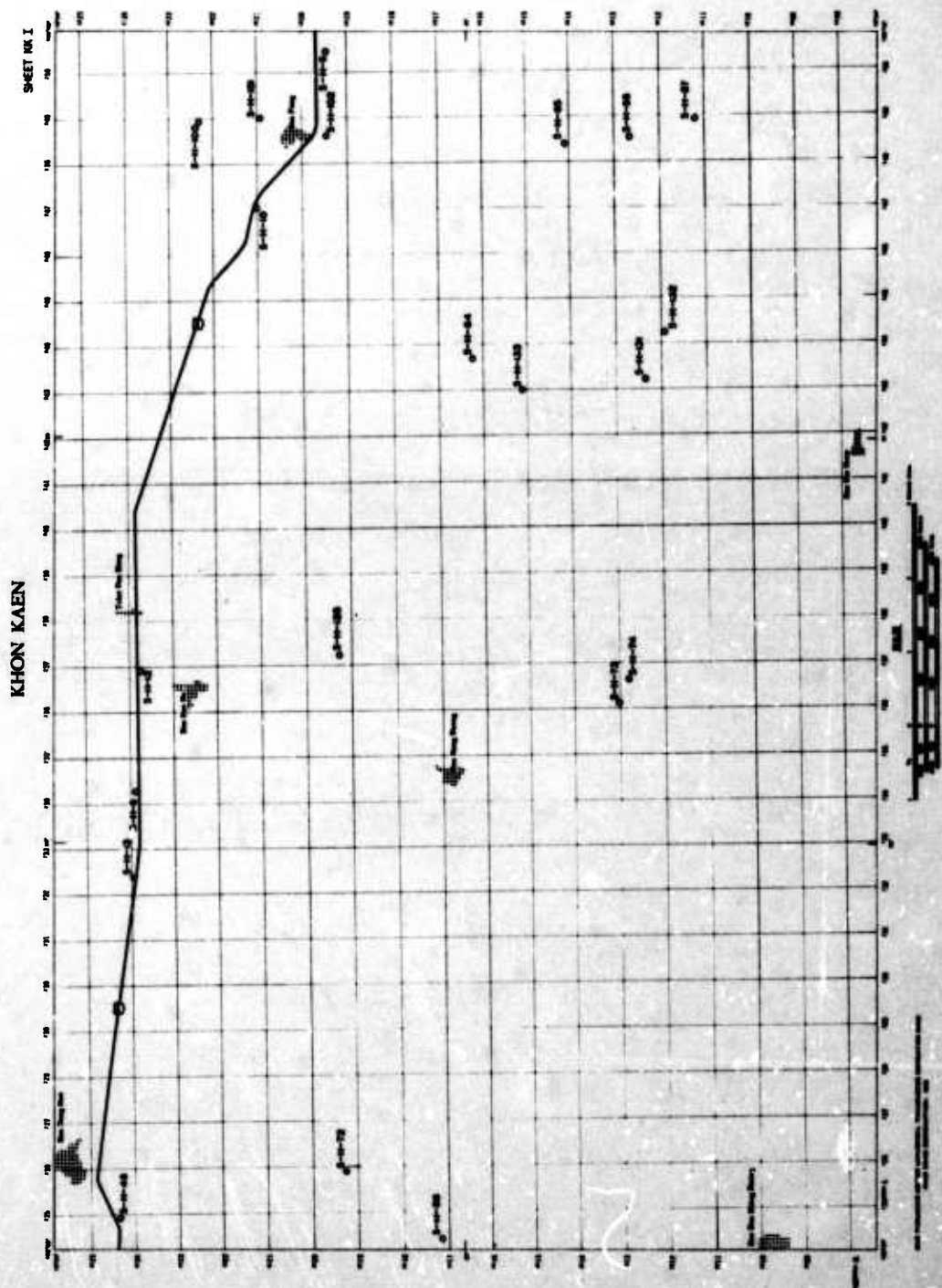
Site No.	ANS Map Sheet	MMS Quad No.	Military Grid	Contact				Hydrologic Geometry at East and West Banks				Position				Water				Vertical Approach				Surface Geometry				CD						
				Approach Angle, deg		Step Height, in.		Step Base, ft		of Step Base, ft		Max Wtr		Min Wtr		Depth		Max Wtr		Min Wtr		App Angle		Step Angle		Ht			App Angle		Step Angle		Ht	
				I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II		I	II	I	II	I	II
5-1-1	5660III	KX III	909187																													3		
5-1-2	5660III	KX III	909171																													2		
5-1-3	5660III	KX III	909171																													2		
5-1-4	5660I		686296																													6		
5-1-5	5660III	KX II	583800																													8		
5-1-6	5660III	KX II	573800																													5		
5-1-7	5660III	KX II	573800																													5		
5-1-8	5660III	KX I	342239																													2		
5-1-9	5660III	KX I	505195																													2		
5-1-10	5660III	KX I	471210																													4		
5-1-11	5660IV		413261																													12		
5-1-12	5660III	KX I	359237																													5		
5-1-13	5660III	KX I	348340																													3		
5-1-14	5660II		170274																													3		
5-1-15	5660I		239323																													5		
5-1-16	5660I		240275																													5		
5-1-17	5660I		239321																													5		
5-1-18	5660I		239321																													3		
5-1-19	5660I		240348																													3		
5-1-20	5661II		376272																													3		
5-1-21	5661II		121450																													5		
5-1-22	5661II		121449																													5		
5-1-23	5661II		121445																													15		
5-1-24	5660III	KX III	124445																													4		
5-1-25	5660II	KX II	694092																													10		
5-1-26	5660II	KX II	643866																													3		
5-1-27	5660I		634875																													4		
5-1-28	5660I		666289																													2		
5-1-29	5660III	KX II	590103																													6		
5-1-30	5660III	KX II	601347																													2		
5-1-31	5660III	KX II	607273																													2		
5-1-32	5660III	KX II	170251																													2		
5-1-33	5660III	KX II	109430																													6		
5-1-34	5660III	KX II	239319																													1		
5-1-35	5660III	KX II	571188																													1		
5-1-36	5660III	KX II	572184																													7		
5-1-37	5660III	KX II	572186																													6		
5-1-38	5660III	KX II	572186																													3		
5-1-39	5660III	KX II	564286																													8		

Notes: Max Wtr--Mean maximum water conditions.
 Min Wtr--Mean minimum water conditions.
 CD--Channel depth is the measurement used to map the step height factor.
 A minus sign (-) is below water level.
 A plus sign (+) is above water level.
 * For definitions of step base and east bank see fig. 6.
 * Coordinates are set up according to the Military Grid System. First three numbers represent longitude; second three numbers represent latitude.
 * A step is a slope change that is 7.5 deg.
 * Position of step base is referenced to water level.
 * For position of numerically designated approach angle and step height see fig. 6.
 * Site located beyond limit of mapped study area; included in data tables because it was used in analytical to develop photo-interpretation procedures.

Table A5 (continued)

Topographic Coordinates in Feet and Meters										Position of Study Area, in Feet and Meters										Water Depth, in Feet and Meters										Critical Approach Angle, Distance, and Height, in Feet and Meters										CD																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
Site No.	AMS Map Sheet	MMS Quad No.	Military Grid Coordinates	Approach Angle, Deg		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist. Vg		Dist. Hgt		Dist	

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FIG. A19

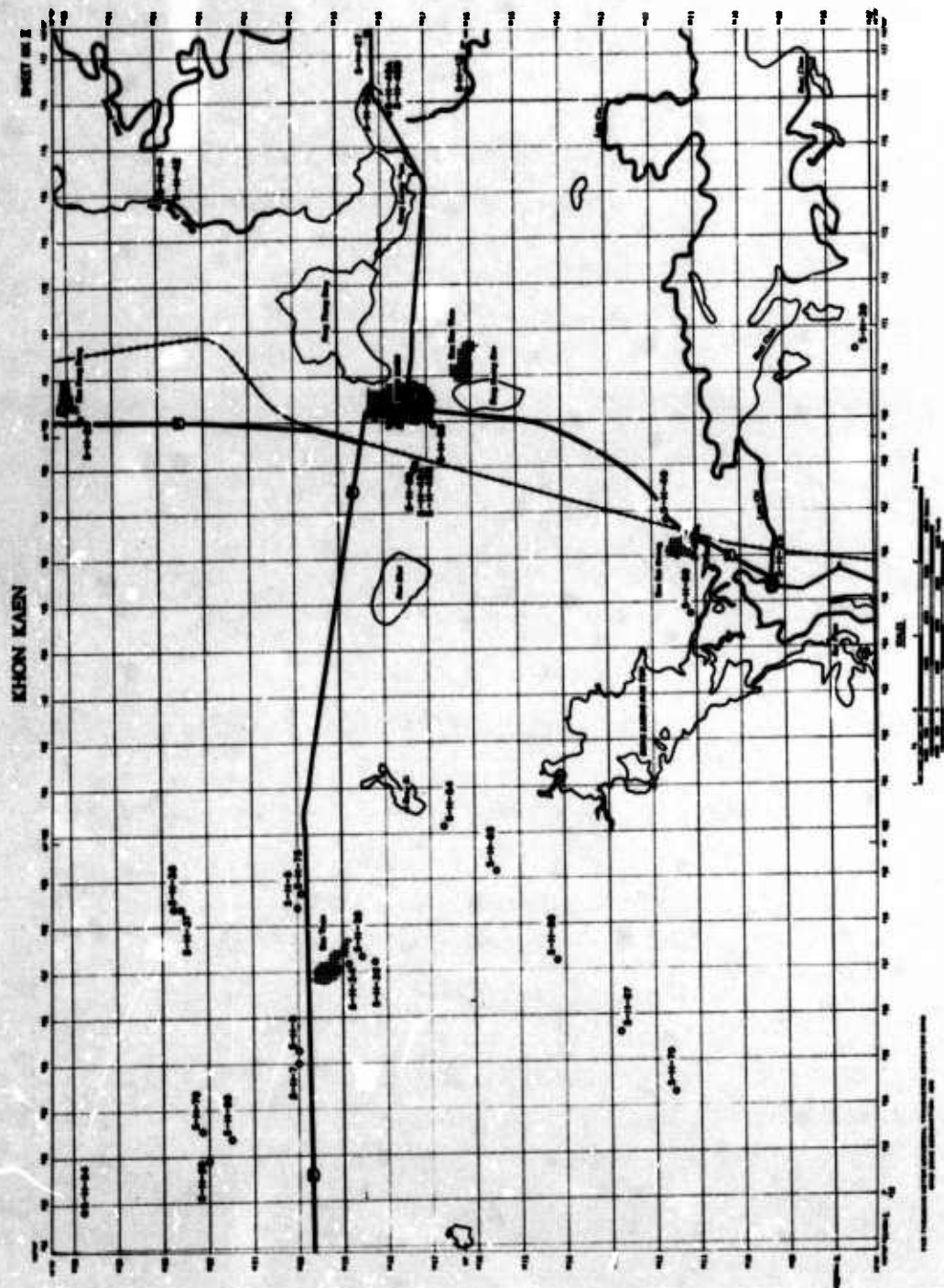
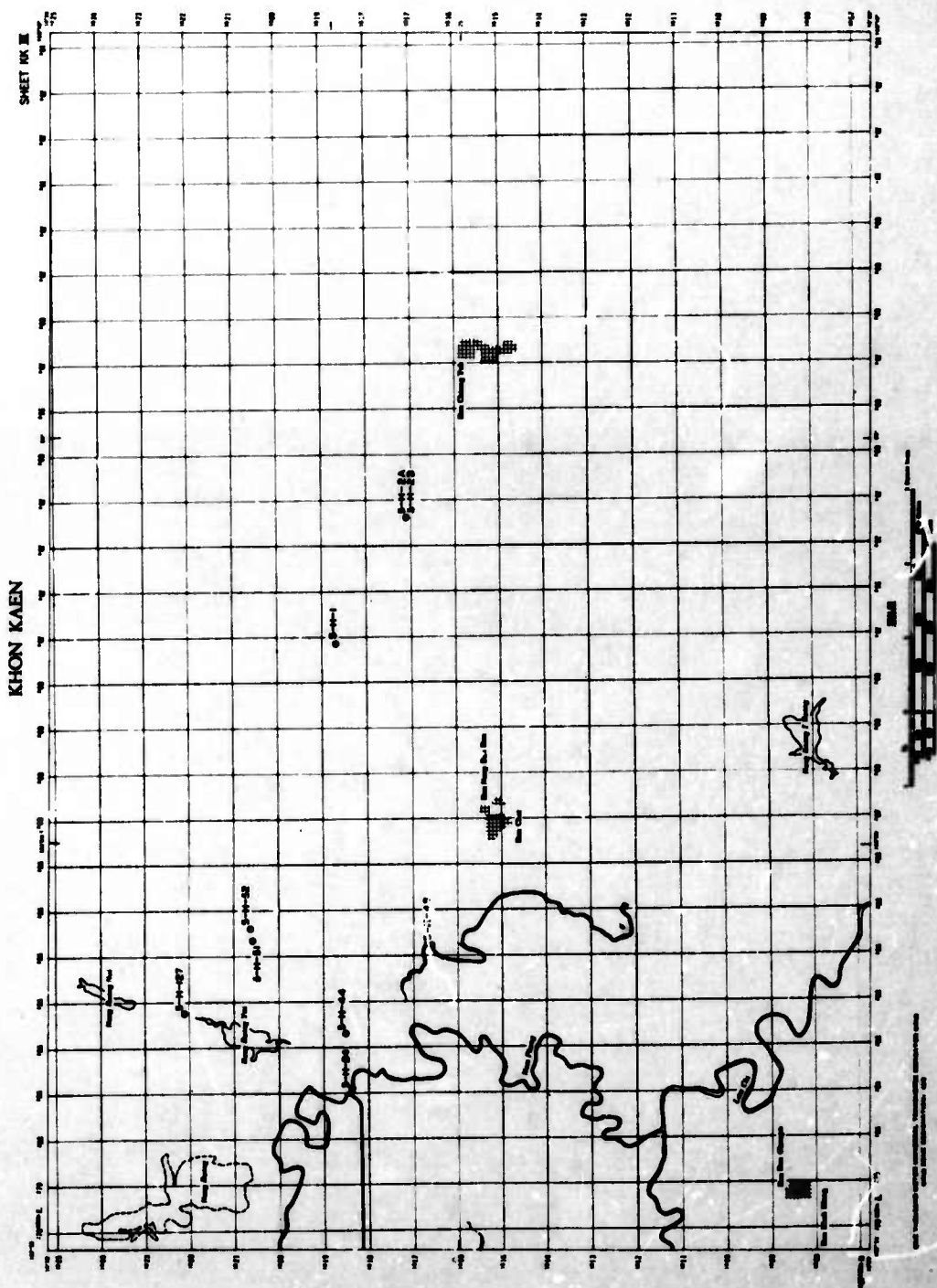


FIG. A20

1-1	1-2	1-3	1-4	1-5	1-6	1-7	1-8	1-9	1-10	1-11	1-12	1-13	1-14	1-15	1-16	1-17	1-18	1-19	1-20	1-21	1-22	1-23	1-24	1-25	1-26	1-27	1-28	1-29	1-30	1-31	1-32	1-33	1-34	1-35	1-36	1-37	1-38	1-39	1-40	1-41	1-42	1-43	1-44	1-45	1-46	1-47	1-48	1-49	1-50	1-51	1-52	1-53	1-54	1-55	1-56	1-57	1-58	1-59	1-60	1-61	1-62	1-63	1-64	1-65	1-66	1-67	1-68	1-69	1-70	1-71	1-72	1-73	1-74	1-75	1-76	1-77	1-78	1-79	1-80	1-81	1-82	1-83	1-84	1-85	1-86	1-87	1-88	1-89	1-90	1-91	1-92	1-93	1-94	1-95	1-96	1-97	1-98	1-99	1-100
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HYDROLOGIC GEOMETRY STUDY
KHON KAEN STUDY AREA
SHEET XX II



SHEET NK 11			
1	2	3	4

HYDROLOGIC GEOMETRY SETTING
KHON KAEN STUDY AREA
SHEET NK 11

FIG. A21

CHANTHABURI

Table A6
Summary of Hydrologic and Surface Geometry Field Data
Chauthaburi

Site No.	AMS Map Sheet No.	Military Grid Coordinates	Hydrologic Geometry at East and West Banks										Surface Geometry									
			Contact					Position					Water					Critical Approach				
			Approach Angle, deg	Min Wtr	Max Wtr	Step Height, in.	of Step Base, ft	Min Wtr	Max Wtr	Min Wtr	Max Wtr	Min Wtr	Max Wtr	Min Wtr	Max Wtr	Min Wtr	Max Wtr	App Angle	App Step	App Angle	App Step	App Angle
6-E-1	534911	G I	16092	130	95													230	125	95	265	5
6-E-2	534912	G I	15090	140	170													220	140	170	190	3
6-E-3	534913	G I	15090															190	170	175	190	3
6-E-4	534914	G I	21085	155	115													240	135	120	210	11
6-E-5	534915	G I	21085	90	130													195	125	120	190	10
6-E-6	534916	G I	151068	172	170													240	170	175	185	5
6-E-7	534917	G I	153079	172	175													195	165	160	185	7
6-E-8	534918	G I	156088	155	160													190	170	190	195	8
6-E-9	534919	G II	809955															270	90	165	185	1
6-E-10	534920	G II	130998	125	125													230	145	125	195	1
6-E-11	534921	G I	200996	145	165													215	165	165	230	5
6-E-12	534922	G III	801961	175	170													190	130	130	185	9
6-E-13	534923	G III	808990	175	170													270	160	155	190	10
6-E-14	534924	G III	917983	130	150													210	155	160	200	16
6-E-15	534925	G III	918913	90	135													190	110	100	230	5
6-E-16	534926	G III	917064	160	155													195	130	155	195	3
6-E-17	534927	G III	893811	100	110													185	160	160	185	2
6-E-18	534928	G III	893817	160	150													200	160	90	260	2
6-E-19	534929	G III	893822	160	130													195	170	160	250	3
6-E-20	534930	G III	871930	160	160													250	100	165	220	12
6-E-21	534931	G III	984985	170	155													215	120	160	215	20
6-E-22	534932	G III	799003	140	140													195	150	180	230	5
6-E-23	534933	G III	819012	140	130													200	160	160	200	7
6-E-24	534934	G III	994017	125	120													260	110	145	210	4
6-E-25	534935	G III	893999	170	160													200	165	170	200	11
6-E-26	534936	G III	893999	110	145													230	135	180	215	1
6-E-27	534937	G IV	893999	170	170													200	160	160	200	2
6-E-28	534938	G I	21085	130	105													200	155	120	190	7
6-E-29	534939	G I	21085	170	130													210	170	160	200	4
6-E-30	534940	G I	247056															260	110	145	210	4
6-E-31	534941	G I	247056	130	105													200	170	130	240	2
6-E-32	534942	G I	749039															200	165	170	200	11
6-E-33	534943	G III	793016	180	145													230	135	180	215	1
6-E-34	534944	G IV	899794															200	155	150	190	1
6-E-35	534945	G III	918903	125	115													200	160	100	260	5
6-E-36	534946	G III	918903	155	125													210	90	90	220	2
6-E-37	534947	G III	918903	90	135													250	135	90	270	5

Note: Max Wtr--Mean maximum water conditions.
Min Wtr--Mean minimum water conditions.
Channel depth is the measurement used to map the step height factor.
A minus sign (-) is below water level.
A plus sign (+) is above water level.
Per definitions of west bank and east bank see Fig. 6.
Coordinates are set up according to the Military Grid System. First three numbers represent longitude; second three numbers represent latitude.
A step is a slope change that is >35 deg.
Position of step base is referenced to water level.
Per position of numerically designated approach angle and step height see Fig. 6.
Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.

(continued)

[illegible]

(Continued)

* Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.

(2 of 3 sheets)

Table A6 (Concluded)

Site No.	AMS Map Sheet	MERIS Quad No.	Military Grid Coord. notes	Hydrologic Geometry at East and West Banks						Contact		Surface Geometry											
				Approach Angle, deg			Step Height, in.			Position		Water Depth		Critical Approach Angle, deg and Step Height, in.			Surface Geometry						
				Max	Min	Var	Max	Min	Var	Max	Min	Var	Max	Min	Var	Max	Min	Var	Max	Min	Var		
				V	E	Rt	V	E	Rt	V	E	Rt	V	E	Rt	App Angle	Step Angle	App Angle	Step Angle	App Angle	Step Angle	App Angle	Step Angle
6-E-8-3	5449III	+	978058	145	150		24	48		-30	-35		7.5	1.5		270	120	110	260			8	
6-E-9-1	5449III	+	158090	135	145								9	1.5		190	140	135	200			10	
6-E-9-3	5449III	+	200079											2.5	0		190	160	130	250			3
6-E-9-5	5449III	+	238077	130	140								7	0		190	130	140	200			7	
6-E-9-6	5449III	+	258092	115	125		36	36		-54	-42		5	0		230	125	115	250			5.5	
6-E-9-7	5449III	+	750038										2.5	0		210	145	110	250			3	
6-E-9-8	5449III	+	752087										2.5	0		250	145	110	250			3.5	
6-E-11-5	5448IV	CM III	938563	165	135		36	42		-56	-36		5	1		260	120	90	270			5.5	
6-E-13-1	5448IV	+	754090	90	90								5	1		210	110	90	240			5.5	
6-E-13-4	5448IV	C III	819012	90	90								5	0		200	90	90	210			7	
6-E-13-6	5448IV	C III	868014										2	0		200	160	90	220			2.5	
6-E-15-8	5448IV	C III	969042	90	90								4.5	1		240	90	90	240			5	
6-E-17-4	5448III	C IV	934923	90	90								4	1		250	110	90	230			5	
6-E-17-5	5448III	C IV	936817	160	130		48						5.5	0		200	130	120	240			6	
6-E-17-6	5448III	C IV	937677	90	165								3	0									
6-E-17-7	5448III	C IV	927959	125	160								7	0.5		225	90	90	215			7.5	
6-E-17-8	5448III	C IV	966796				42						2.0	0		270	90	90	290			2.5	
6-E-17-9	5448III	C IV	956799	140	140		48	36		-24	-66		6.5	0		210	90	90	220			7	
6-E-19-2	5448III	C IV	933760	110	90								5	2		230	100	90	240			5.5	

* Site located beyond limit of mapped study area; included in data tables because it was used in analysis to develop photo-interpretation procedures.
 * Not recorded on maps.

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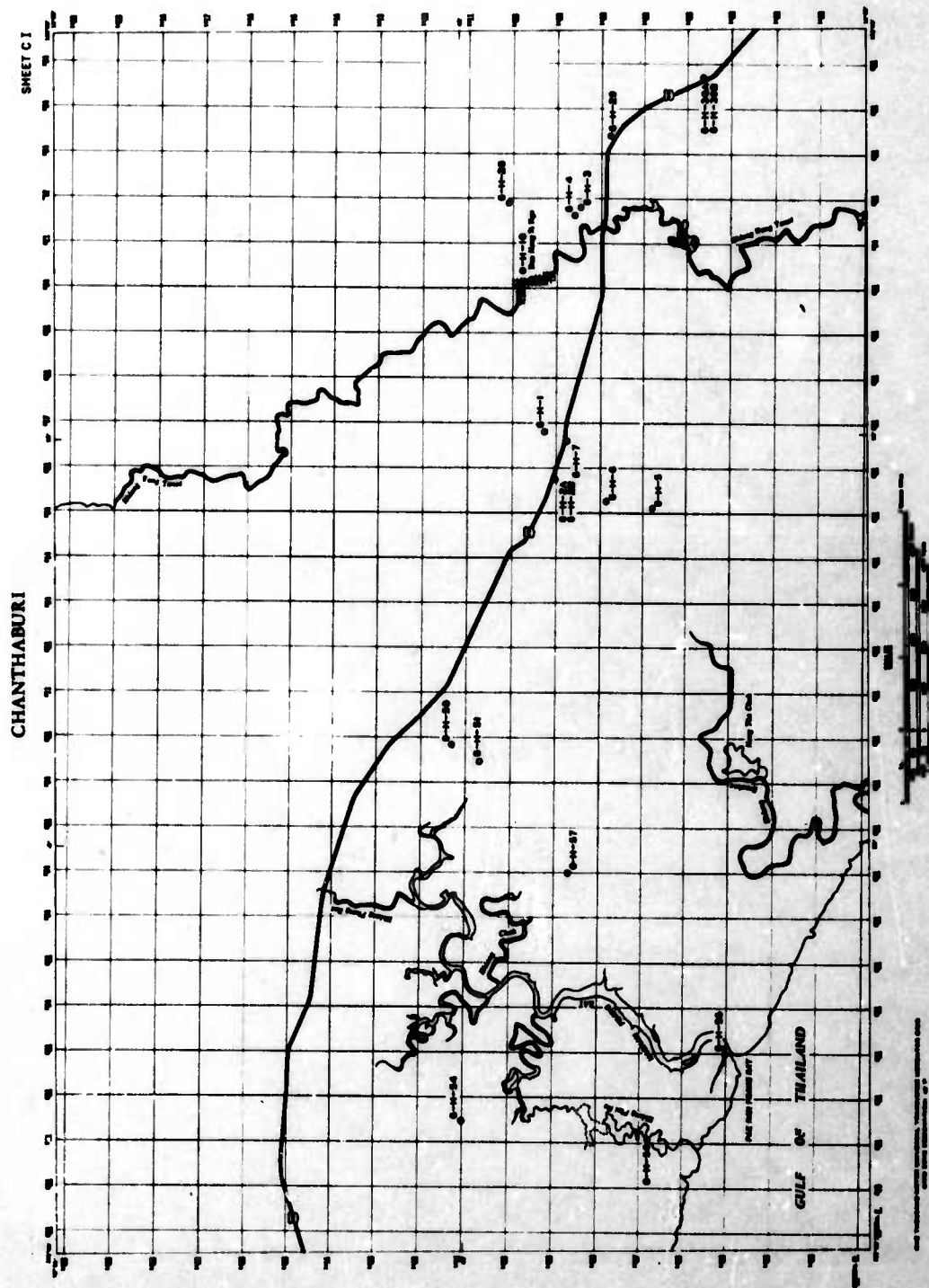


FIG. A22

CHANTHABURI STUDY AREA

C1	C2	C3
C4	C5	C6

HYDROLOGIC GEOMETRY STUDY
CHANTHABURI STUDY AREA
SHEET C1

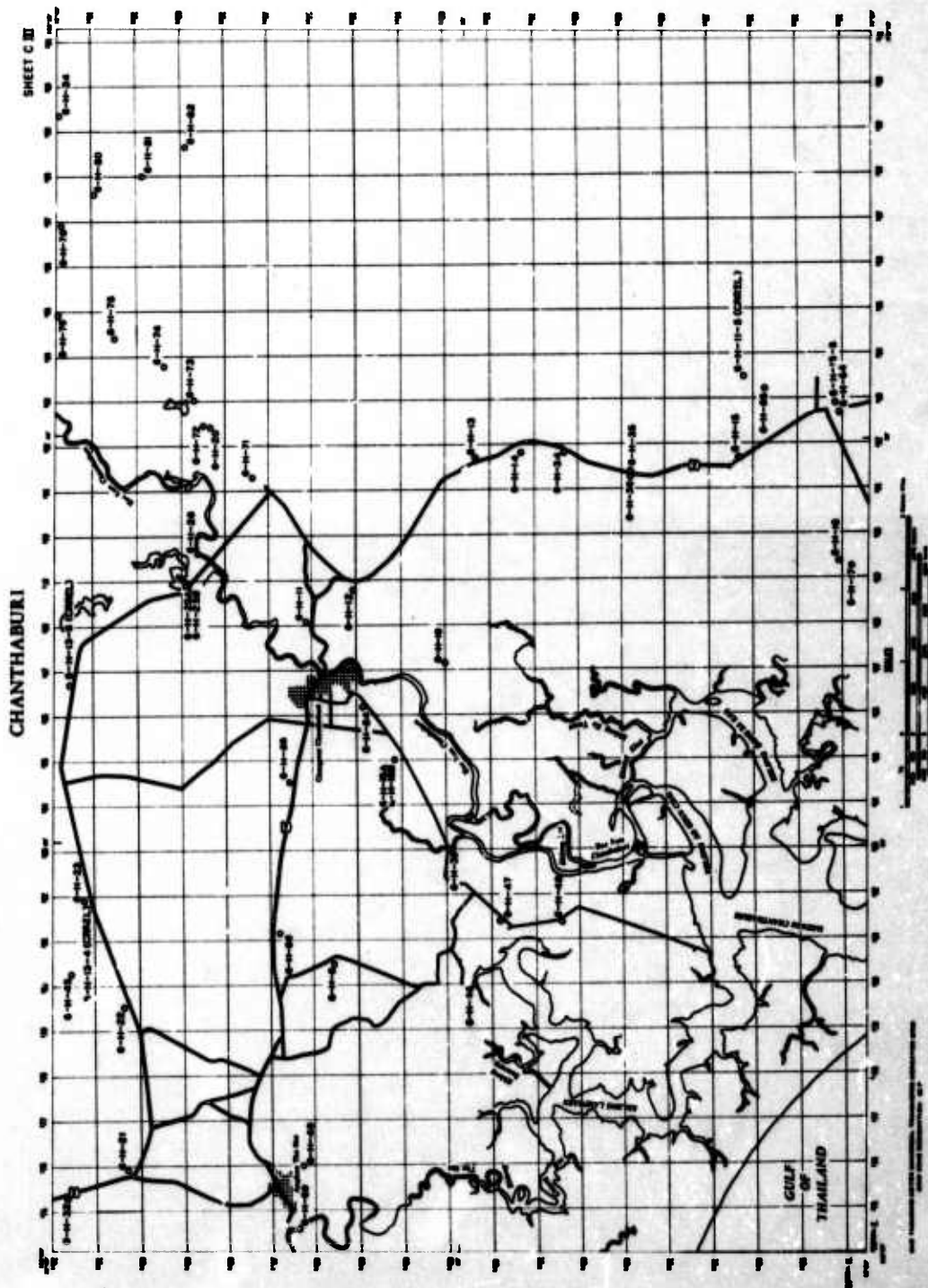
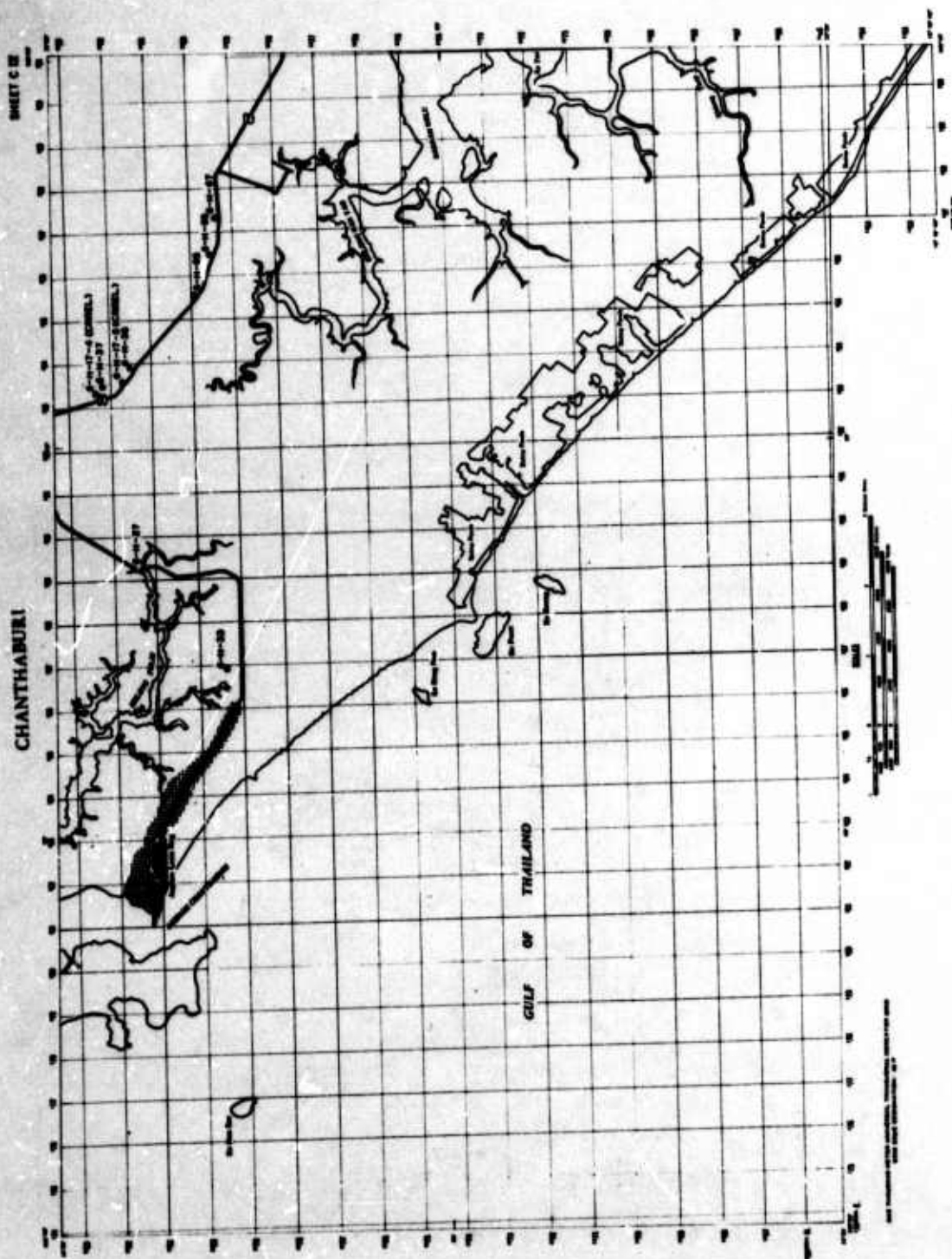


FIG. A24

KEY TO SYMBOLS

CL	CE	CDE
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HYDROLOGIC GEOMETRY DATA
CHANTHABURI STUDY AREA
SHEET C II



Sheet to adjacent sheets

41	42	43
44	45	46

HYDROLOGIC GEOMETRY STUDY
CHANTHABURI STUDY AREA
SHEET C IV

FIG. A25

Unclassified

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall 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; HYDROLOGIC GEOMETRY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Volume V of report

5. AUTHOR(S) (First name, middle initial, last name)

Edgar E. Garrett
John H. Shamburger

6. REPORT DATE

November 1967

7a. TOTAL NO. OF PAGES

103

7b. NO. OF REFS

7

8a. CONTRACT OR GRANT NO.

a. PROJECT NO.

c. Order No. 400

4

8b. ORIGINATOR'S REPORT NUMBER(S)

Technical Report No. 3-726
Volume V8c. OTHER REPORT NO(S) (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
Engineer Waterways Experiment Station.

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 in collecting hydrologic geometry data in selected areas in Thailand. The selection, analysis, and classification of parameters significant to vehicle mobility are discussed. The photo-interpretation methods used in identifying hydrologic geometry features from aerial photographs (air photos) and the extrapolation of these identifications to areas not investigated on the ground are presented. The rationale for cartographic portrayal of these parameters is explained. Utilizing the collected field data, available air photos, and the Army Map Service series of topographic maps, hydrologic geometry factor maps were prepared covering the six selected study areas (Nakhon Sawan, Lop Buri, Chiang Mai, Chanthaburi, Pran Buri, and Khon Kaen). The maps are presented in Volume VIII of this series. It proved only partially possible to determine the existence and value of the chosen parameters from air photos since some of the individual factors are wholly or partially below the water surface. Nevertheless, photo interpretation plus extrapolation from measured sites made it possible to map the parametric values by class range with reasonable validity. Recommendations are made involving improvement in data-collection techniques. ()

DD FORM 1473

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OBSOLETE FOR ARMY USE.

Unclassified

Security Classification

Unclassified

Security Classification

14.	KEY WORDS	LINK A		LINK B		LINK C	
		ROLE	WT	ROLE	WT	ROLE	WT
	Aerial photographs Environmental studies Hydrology -- Thailand Mobility Terrain Thailand						

Unclassified

Security Classification