社会開発協力部報告書

NATURAL CONDITION SURVEY REPORT

FOR

THE STUDY

ON

THE DEVELOPMENT PROJECT OF

THE INDUSTRIAL PORT

ON

THE EASTERN SEABOARD

IN

THE KINGDOM OF THAILAND

MARCH 1983

JAPAN INTERNATIONAL COOPERATION AGENCY

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CONTENTS

1. PREFACE 1

2. OUTLINE OF SURVEY 2

2-1 Location of Survey Area 2

2-2 Contents of Survey 4

2-3 Servey Period 7

2-4 Survey Equipment 8

2-5 Field Survey Personnel 9

3. METHOD OF SURVEY 10

3-1 Control Point Survey 10

3-2 Topographic Survey 16

3-3 Hydrographic Survey 18

3-4 Soil Investigation 20

3-5 Geophysical Prospecting 23

3-5-1 Electrical Prospecting 24

3-5-2 Seismic Prospecting 32

3-6 Sonic Prospecting 43

3-7 Sea-Bottom Materials 48

3-8 Tide Observation 48

3-9 Tidal Current Observation 49

3-10 Wave Observation 50

3-11 Wind Observation 52

3-12 Littoral Drift 53

4. RESULTS OF SURVEY 55

4-1 Topography 55

4-1-1 Topography on Land Area 55

4-1-2 Topography of Shoreline 57

4-1-3 Islands and Rocky Outcrops 63

4-1-4 Bathymetry 63

4-2 Geology 6

4-2-1 Outline of Geology 6

4-2-2 Geological Classification 6

(1) Soil Investigation 6

(2) Electrical Prospecting 8

(3) Seismic Prospecting 8

(4) Sonic Prospecting 8

(5) Sea-Bottom Materials 9

4-2-3 Civil Engineering Study 9

(1) Rock Excability 9

(2) Bearing Layer 9

(3) Quarry 9

4-3 Tides 98

4-3-1 Tidal Harmonic Analysis 9

4-3-2 Tidal Diagram 9

4-3-3 Comparison between Ko Saket and Sattahip 10

4-4 Tidal Currents 10

4-4-1 Frequency of Tidal Currents 10

4-4-2 Harmonic Analysis of Tidal Currents 11

4-4-3 Drogue Survey 11

4-5 Waves 11

4-5-1 Frequency of Waves 11

4-5-2 Statistical Analysis of Waves 11

4-6 Wind 12

4-7 Littoral Drift 13

5. SUMMARY 13

ATTACHED SHEETS AND MAPS

ATTACHED SHEETS 139

1. Summary of Soil Test 140

2. Geological profiles 165

3. Tidal Current Curves 177

4. Tidal Current Ellipses 183

5. Tidal Chart 189

ATTACHED MAPS 196

1. Topographical Map (Scale 1:30,000)

2. Isopach Map of A-Member (Scale 1:50,000)

3. Isobathic Map of D-Group (Scale 1:50,000)

4. Isobathic Map of G-Group (Scale 1:50,000)

SEPARATED APPENDIX : SURVEY DATA

I. CONTROL POINT SURVEY

1. Results of Control Point
2. Control Survey Net Works

II. SOIL INVESTIGATION

1. Soil Profile
2. Specific Gravity
3. Water Contents
4. Grain Size Distribution
5. Atterberg Limits

III. GEOPHYSICAL PROSPECTING

1. Electrical Prospecting : Resistivity-Depth Curves
2. Seismic Prospecting : Travel Time Curves

IV. OCEANOGRAPHY & METEOROLOGY

1. List of Tidal Data
2. List of Tidal Current Data
3. List of Wave Data
4. List of Wind Data

V. TOPOGRAPHICAL MAPS

1. Topographical Maps on Land (Scale 1:10,000)
2. Isobath Maps (Scale 1:10,000)

LIST OF FIGURES

Fig. 2-1 Index Map 3
Fig. 2-2 Location Map 6
Fig. 3-1 Location of Control points 15
Fig. 3-2 Generalized Flow-Chart of Topographic Survey .. 17
Fig. 3-3 Truck Chart of Sounding 19
Fig. 3-4 Location of Boring and Geophysical Prospecting 21
Fig. 3-5 Principle of Specific Resistance Measurement .. 26
Fig. 3-6 Model of Two-Layer Structure 28
Fig. 3-7 Model of Three or More Layer Structure 30
Fig. 3-8 Sample of Analytical Procedures 31
Fig. 3-9 Snell's Law 33
Fig. 3-10 Mechanism for Transmission of Refracted Wave in Two-Layer Structure 34
Fig. 3-11 Wave Path and Relation between X and T 34
Fig. 3-12 Block-Diagram of Instruments 35
Fig. 3-13 Sample of Seismic Prospecting Record 36
Fig. 3-14 Method of Difference 37
Fig. 3-15 Method of Difference in Three-Layer Structure . 40
Fig. 3-16 Block-Diagram of Sonostrator 44
Fig. 3-17 Illustration of Hydrographic Survey 45
Fig. 3-18 Establishment of Current Meter 49
Fig. 3-19 Surface Wave 50
Fig. 3-20 Establishment of Wave Recorder 52
Fig. 3-21 Establishment of Sand Trap 54
Fig. 4-1 Topographical Map (Scale 1:100,000) 56
Fig. 4-2 Topographical Profiles .... 58~62
Fig. 4-3 Isobath Map (scale 1:100,000) 64
Fig. 4-4 Geological Map 68
Fig. 4-5 Drilling Logs .... 71~78
Fig. 4-6 Frequency of N-value 80
Fig. 4-7 Isobathic Map of Third Layer 85
Fig. 4-8 Example of Sonic Prospecting Record 87
Fig. 4-9 Isobathic Map of G-group 88
Fig. 4-10 Isobathic Map of D-group 89
Fig. 4-11 Isopach Map of A-group 90
Fig. 4-12 Distribution of Sea-Bottom Materials 93

Fig. 4-13 Stratigraphic Classification and Efficiency in Excavating ·· 95
Fig. 4-14 Tidal Diagram at Ko Saket ························ 101
Fig. 4-15 Monthly Mean Tide Level at Sattahip ············ 102
Fig. 4-16 Tidal Curve of Ko Saket and Sattahip ··········· 105
Fig. 4-17 Percentage Frequency of Tidal Current Direction and Velocity ·········· 107
Fig. 4-18 Tidal Current Curve ································ 109
Fig. 4-19 Tidal Current Ellipse ······························ 113
Fig. 4-20 Results of Drougue Survey ························ 114
Fig. 4-21 Frequency of Wave Height and Period ············ 118
Fig. 4-22 Relation among Wave Heights ················122~123
Fig. 4-23 Frequency of Wind Velocity and Direction (Average Velocity) ······ 127
Fig. 4-24 Frequency of Wind Velocity and Direction (Instantaneous Velocity) ······ 128
Fig. 4-25 Results of Fluorescent Sand Tracers ············ 133
Fig. 4-26 Results of Sand Trap (Tube)······················ 134
Fig. 4-27 Results of Sand Trap (Box)························ 134
Fig. 4-28 Illustration of Littoral Drift ··················· 135

LIST OF TABLES

Table 2-1	Contents of Natural Condition Survey	5
Table 2-2	Time-table of Natural Condition Survey	7
Table 2-3	List of Main Survey Equipment	8
Table 3-1	Existing Control Points	10
Table 3-2	Results of Control Points	11~14
Table 3-3	Quantity of Soil Investigation	22
Table 3-4	Outlines of Geophysical Prospecting.............	23
Table 3-5	Calculation Sheet	41
Table 4-1	Stratigraphy in Thailand	66
Table 4-2	Summary of Results on Geophysical Prospecting	84
Table 4-3	Results of Sea-Bottom Materials	92
Table 4-4	Adapting Ship for Dredging	96
Table 4-5	Result of Tidal Harmonic Analysis	100
Table 4-6	Tidal Harmonic Constants of Sattahip	104
Table 4-7	Characteristic Index of Tides	103
Table 4-8	Frequency of Tidal Current Direction and Velocity	108
Table 4-9	List of Harmonic Constants of Tidal Currents	111~112
Table 4-10	Frequency of Wave Height and Period	117
Table 4-11	Daily Wave Data (H_{max}, $H_{1/10}$, $H_{1/3}$, H_{mean}) .	119~121
Table 4-12	Frequency of Wind Velocity and Direction ...... (Average Velocity)	125
Table 4-13	Frequency of Wind Velocity and Direction ...... (Instantaneous Velocity)	126
Table 4-14	Daily Wind Data at Ko Saket	129~131

1 PREFACE

"THE STUDY ON THE DEVELOPMENT PROJECT OF THE INDUSTRIAL PORT ON THE EASTERN SEABOARD IN THE KINGDOM OF THAILAND" aims at the formulation of a master plan for the industrial port in the district of Rayong and the execution of a feasibility study for a short-term port development plan.

The study consists of two parts. The first is the port planning and the second part is the natural condition survey.

This report summarizes and presents the results of survey on natural conditions such as topography, geology, soil conditions, bottom materials, tides, tidal currents, waves, wind and so forth which must be taken into account in preparing a master plan for the industrial port.

For further details of the results of survey data, it is recommended to refer to the annex "Survey Data" prepared separately from this report.

With respect to the format of this report, we would like to express our sincere appreciation to all organizations and individuals who contributed advices and assistances for their kind cooperation during our field survey, especially to the Port Authority of Thailand and the survey vessel's crew.

2 OUTLINE OF SURVEY

2-1 Location of Survey Area

The survey area is located in the eastern seaboard of the central Thailand as shown in the location map (Figure 2-1), lying between eastern longitude 101° 00' and 101° 15', and between northern latitude 12°25' and 12°50' roughly.

The land area of the survey area is approximately 135 square kilometers, and is characterized by a coastal plain. The offshore area is approximately 520 square kilometers, and is faced on the upper part of the Gulf of Thailand.

On the west side of the survey area, a range of rocky hills and islands named Laem Samae San, Ko Samae San and Ko Nok between 100 meters and 170 meters high runs southwards. And the Sattahip Commercial Port is located behind the rocky hills and islands.

On the other hand, the estuary of the Rayong river is seen on the east side of the survey area.

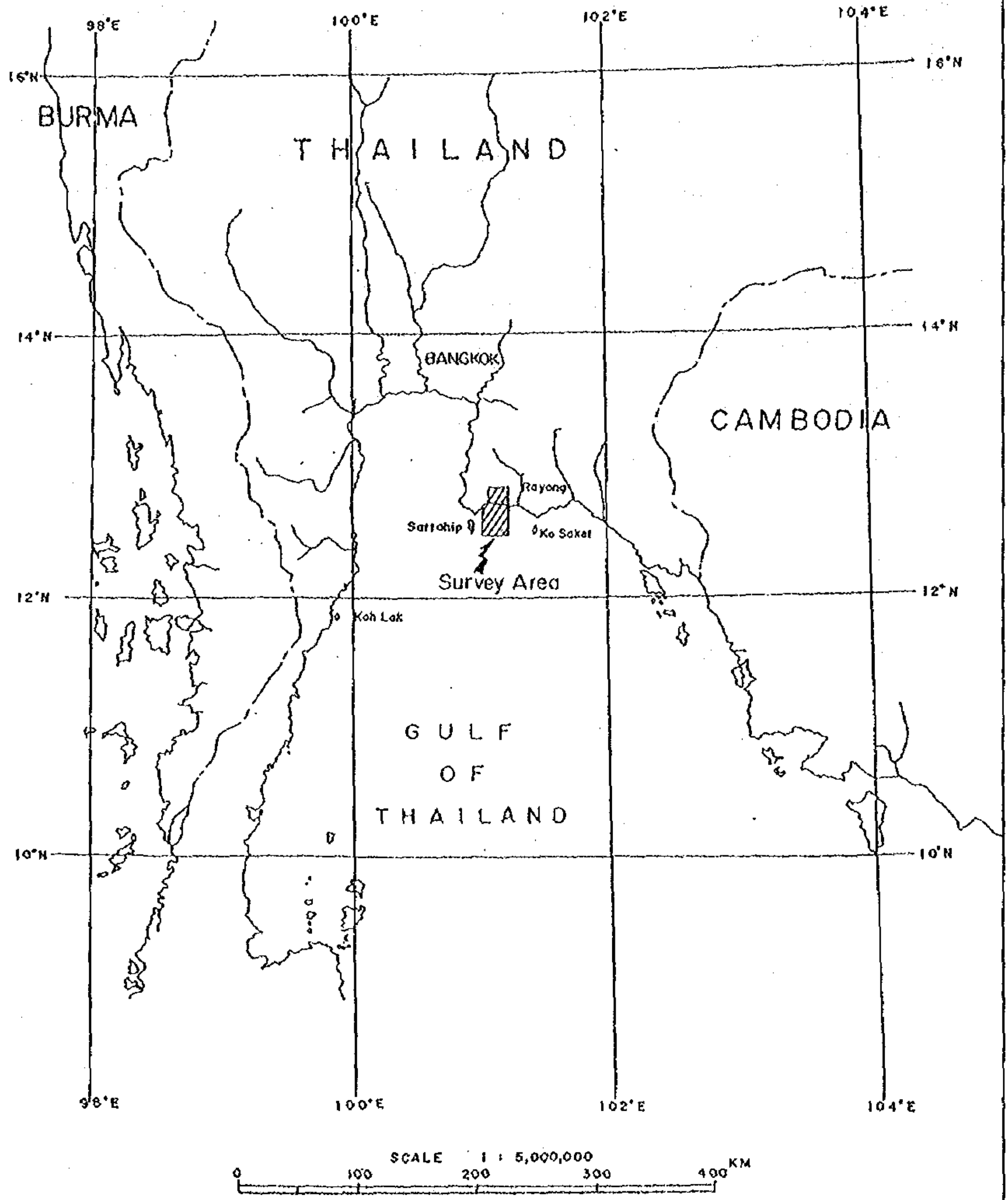


Fig. 2-1 INDEX MAP

2-2 Contents of Survey

The technical field surveys and investigations on natural conditions were carried out both on land area and on offshore area in the vicinity of Rayong seaboard.

The surveys were planned to provide all necessary data of the site to execute a feasibility study and to formulate a master plan for the industrial port.

The following is items of the performed surveys. The quantities and locations of the surveys were shown in the Contents of Natural Condition Survey (Table 2-1) and the Location Map (Figure 2-2).

1) Control Point Survey

2) Topographic Survey (Mapping on land area)

3) Hydrographic Survey (Sounding)

4) Soil Investigation (both on land area and offshore area)

5) Geophysical Prospecting on land area
(Seismic Prospecting and Electrical Prospecting)

6) Sonic Prospecting (on offshore area)

7) Sea-Bottom Materials

8) Tide Observation

9) Tidal Current Observation

10) Wave Observation

11) Wind Observation

12) Littoral Drift

Table 2-1 Contents of Natural Condition Survey

ITEMS	QUANTITIES
1 Control Point Survey	Control point: 52 points
2 Topographic Survey (Mapping)	Mapping area: appr. 132km^2 Scale : 1/10,000
3 Hydrographic Survey (Sounding)	Total length of survey lines: appr. 780km
4 Soil Investigation	Boring: 4 points, total 125m (land area) 4 points, total 80m (offshore area) Laboratory soil testing
5 Geophysical Prospecting	Seismic prospecting : 5.06km Electrical prospecting: 112 points
6 Sonic Prospecting	Total length of survey lines: appr. 760km
7 Sea-Bottom Materials	Sampling: 31 points Laboratory testing
8 Tide Observation	Station: 1 point (Ko Saket) Period : Aug. 18 to Oct. 3, 1982
9 Tidal Current Observation	Station: 4 points Period : 15 days and nights
10 Wave Observation	Station: 1 point (water depth: appr. 8m) Period : Aug. 1 to Oct. 21, 1982
11 Wind Observation	Station: 1 point (Ko Saket) Period : Aug. 17 to Oct. 21, 1982
12 Littoral Drift	Fluorescent sand tracers: 3 points Sand trap sand trap tube: 1 point sand trap box : 1 point

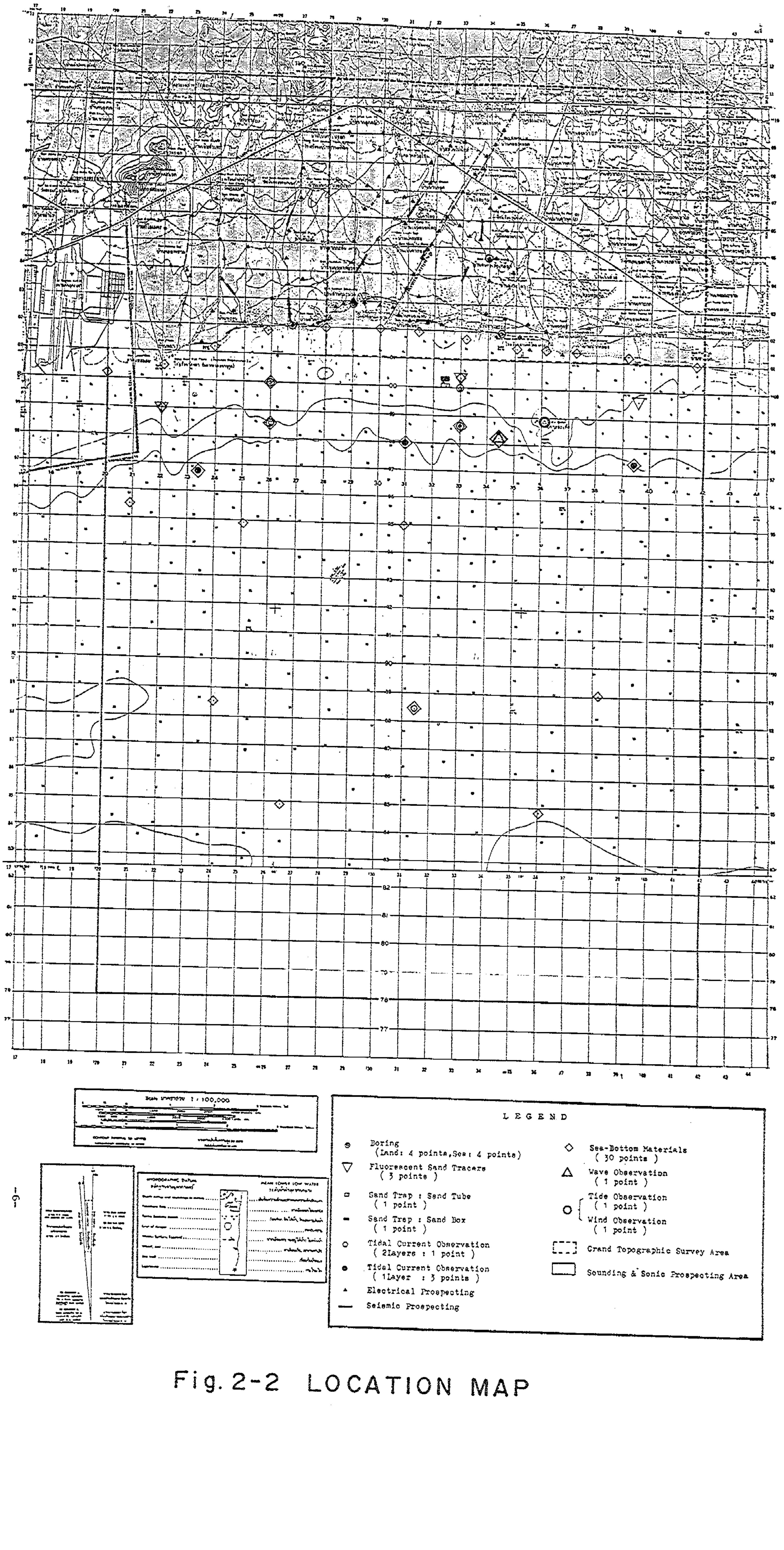


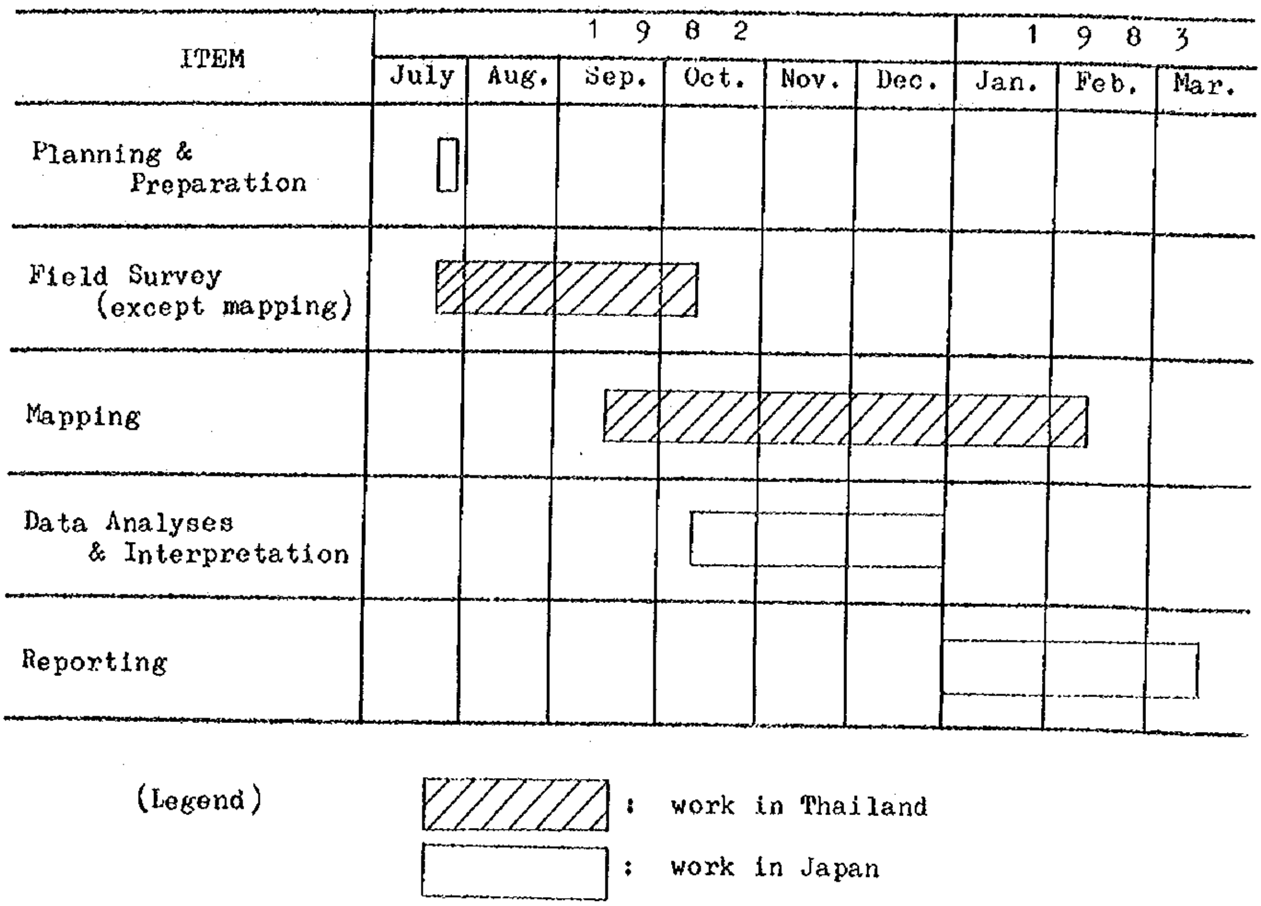
Fig. 2-2 LOCATION MAP

2-3 Survey Period

The period of the natural condition survey extended from July 20, 1982 to March 15, 1983 as shown in Table 2-2 which shows the time-table for each survey item from the planning and preparation to the submission of the report.

The field survey except mapping work was carried out from July 22 to October 12, 1982 and the mapping work was carried out from September 15, 1982 to February 11, 1983.

Table 2-2 Time-table of Natural Condition Survey



2-4 Survey Equipment

The main equipments used in the field survey are listed in Table 2-3 with names, types and specifications.

Table 2-3 List of Main Survey Equipment

NAME OF EQUIPMENT	TYPE (MAKER)	SPECIFICATIONS
Control Point Survey		
Distance Meter	3800B (Hewlett Packard)	Accuracy: ±(5mm+7mm/km)
Theodolite	TM10C (Sokkisha)	Reading: 10 second
Level	B-2 (Sokkisha)	Standard deviation for 1km double run levelling: ±1.5mm
Mapping		
Stereo Plotter	A-8 (Wild)	2nd class
Hydrographic Survey		
Distance Meter	MRD1 (Tellurometer)	Range: 100m to 100km Accuracy: 1m±3x10^{-6}D
Echo Sounder	RS-61 (Rasa Electronics)	Range: 0 to 61m Accuracy: 3cm±10^{-3}D Frequency: 200 KHz
Sub-Bottom Profiler	SP-2 (Kaijo Denki)	Range: 0 to 50m Frequency: 3 KHz
Tide Gauge	LPT-3 (Kyowa Shoko)	Range: 3m Magnification: 1/20
Current Meter	CC-1 (Kyowa Shoko)	Range: 0.1 to 4 knots
Wave Recorder	DW-3 (Kyowa Shoko)	Range: 3m or 6m Operation: 10min./every 2 hours
Geophysical Prospecting		
Refracting Seismic Amplifier	TR-4-24 (Oyo)	Channel: 24 Frequency: 3～5 KHz
Specific Earth Resistance Tester	3244 (Yokogawa Electric Works)	Range: 0 to 300Ω Output voltage: 150, 300, 600V
Wind Observation		
Anemometer	KDD-300 (Koshin Denki Kogyo)	Range: 2 to 70m/sec (instantaneous vel.) 2 to 50m/sec (average vel.)

2-5 Field Survey Personnel

The members of the field survey for the natural condition survey are listed below:

Mr. Takeyasu KIKUTA	:	Team Leader, Chief Engineer
Mr, Takeshi YOSHIHARA	:	Soil Investigation
Mr. Yoshikazu IBUSUKI	:	Grand Topographic Mapping
Mr. Mitsuru FUKASAWA	:	Sub-Marine Geology
Mr. Nobutoshi TOBARI	:	Hydrographic Survey
Mr. Noboru KUSUMI	:	--ditto--
Mr. Hidetaka TANAKA	:	Oceanographic Survey
Mr. Hirofumi YAMAUCHI	:	--ditto--
Mr. Yukio SATO	:	Geophysical Prospecting
Mr. Toichiro MAEKAWA	:	--ditto--

All above members are affiliated with Kokusai Kogyo Co., Ltd.

3 METHOD OF SURVEY

3-1 Control Point Survey

The control points are basic for all surveys and mapping included in this study to determine the exact position and elevation of the survey points and survey lines.

In this study, control points were established along the shoreline of the survey area at the interval of about one to two kilometers and in the mapping area, using the existing control points shown in Table 3-1.

Table 3-1 Existing Control Points

Control Point	Co-ordinate	Elevation
Khao Lan	E 713,787.785m ; N 1,395,597.237m	90.28m
Ban Phala	E 721,682.669m ; N 1,400,493.550m	3.16m

The results of the control point survey by traversing and levelling are summarized in Table 3-2 and Figure 3-1. Networks of the control point survey are shown in attached "Survey Data".

Table 3-2(1) Results of Control Point

1

Control Point	Co-ordinate E	Co-ordinate N	H	
	m	m	m	
10454	736,099.47	1,412,757.54	54.275	
10464	734,630.52	1,410,168.51	31.986	
10465	740,868.20	1,409,370.12	34.009	
10474	735,830.41	1,406,115.49	15.054	
10475	741,202.93	1,405,493.98	6.040	
10476	741,824.94	1,406,822.49	24.343	
10484	735,989.32	1,402,176.93	5.124	
10485	741,500.70	1,402,799.50	6.570	
11524	744,144.55	1,404,969.34	3.723	
11534	743,282.11	1,402,864.10	5.692	
11744	728,577.45	1,402,674.37	10.865	
11754	732,023.28	1,406,044.38	20.696	
11755	730,220.14	1,402,884.21	7.257	
11764	733,002.17	1,407,754.82	35.562	
11765	729,334.87	1,409,893.46	55.055	

UTM ZONE 47 CM 99°E

Table 3-2(2) Results of Control Point

L 2

Control Point	Co-ordinate E	N	H	
	m	m	m	
BAN PHA LA	721,682.669	1,400,493.550	3.160	Existing Control Point
K- 1	721,139.878	1,400,470.315	2.882	
K- 2	722,078.562	1,400,655.236	2.399	
K- 3	722,550.727	1,400,688.715	1.376	
K- 4	722,809.084	1,401,150.981	7.668	
K- 5	723,299.801	1,401,234.916	2.694	
K- 6	723,763.442	1,401,217.769	1.603	
K- 7	724,178.221	1,401,339.489	3.515	
K- 8	724,328.564	1,401,504.327	2.240	
K- 9	725,269.900	1,401,820.608	1.732	
K-10	725,960.927	1,401,858.184	2.134	
K-11	726,390.181	1,401,853.231	1.900	
K-12	727,186.553	1,401,818.670	2.695	
K-13	727,662.136	1,401,839.208	2.574	
K-14	728,075.127	1,402,106.932	0.922	
K-15	728,788.705	1,402,262.887	2.441	
S	729,943.820	1,402,192.181	2.351	
K-17	731,155.805	1,402,096.979	3.542	
K-18	732,284.698	1,401,958.874	4.807	
K-19	733,023.281	1,401,895.508	5.040	
K-20	733,265.217	1,401,816.945	1.754	
K-21	733,917.362	1,401,725.972	1.956	
K-22	734,258.908	1,401,660.680	1.644	

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Table 3-2(3) Results of Control Point

3

Control Point	Co-ordinate E	Co-ordinate N	H	
	m	m	m	
K-23	734,828.269	1,401,568.806	1.921	
K-24	735,289.002	1,401,503.587	1.953	
K-25	735,742.952	1,401,417.837	2.221	
K-26	736,078.640	1,401,389.650	2.364	
K-27	736,500.871	1,401,356.621	2.644	
K-28	736,819.478	1,401,301.103	2.236	
K-29	737,101.617	1,401,237.158	1.886	
K-30	737,535.528	1,401,307.475	2.364	
K-31	738,095.605	1,401,315.757	2.194	
K-32	738,680.490	1,401,303.664	2.852	
K-33	739,300.411	1,401,248.216	2.658	
K-34	740,045.835	1,401,141.761	2.457	
K-35	740,557.232	1,401,111.859	2.893	
K-36	741,166.866	1,401,104.623	3.273	
K-37	741,674.004	1,401,040.517	3.132	
K-38	742,295.935	1,400,975.543	2.901	
K-39	742,673.665	1,400,931.781	2.908	
A	736,121.158	1,399,012.232	14.213	
KHAO LAN	713,787.785	1,395,597.237	90.280	Existing Control Point
S- 1	729,831.238	1,402,224.735		
S- 2	730,865.369	1,404,025.709		
S- 3	731,191.921	1,404,584.181		
S- 4	731,624.226	1,405,346.501		

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Table 3-2(4) Results of Control Point

4

Control Point	Co-ordinate E	N	H	
	m	m	m	
S- 5	732,293.838	1,406,500.918		
S- 6	732,751.428	1,407,315.919		
S- 7	733,013.414	1,407,748.869		
S- 8	732,527.180	1,408,028.761		
S- 9	731,136.685	1,408,828.573		
S-10	730,819.518	1,409,026.297		
S-11	730,113.526	1,409,425.887		
St 2	727,726.564	1,410,683.117	160.46	
Tr	733,723.02	1,407,259.55		Objective point
W. ROCK (Hin Khong)	727,945.09	1,400,380.35		"
W. TANK (Rayong)	750,993.91	1,399,293.32		"
K-1-1	720,639.185	1,400,431.339		
K-1-2	720,091.519	1,400,388.707		
K-40	743,179.557	1,400,871.119		

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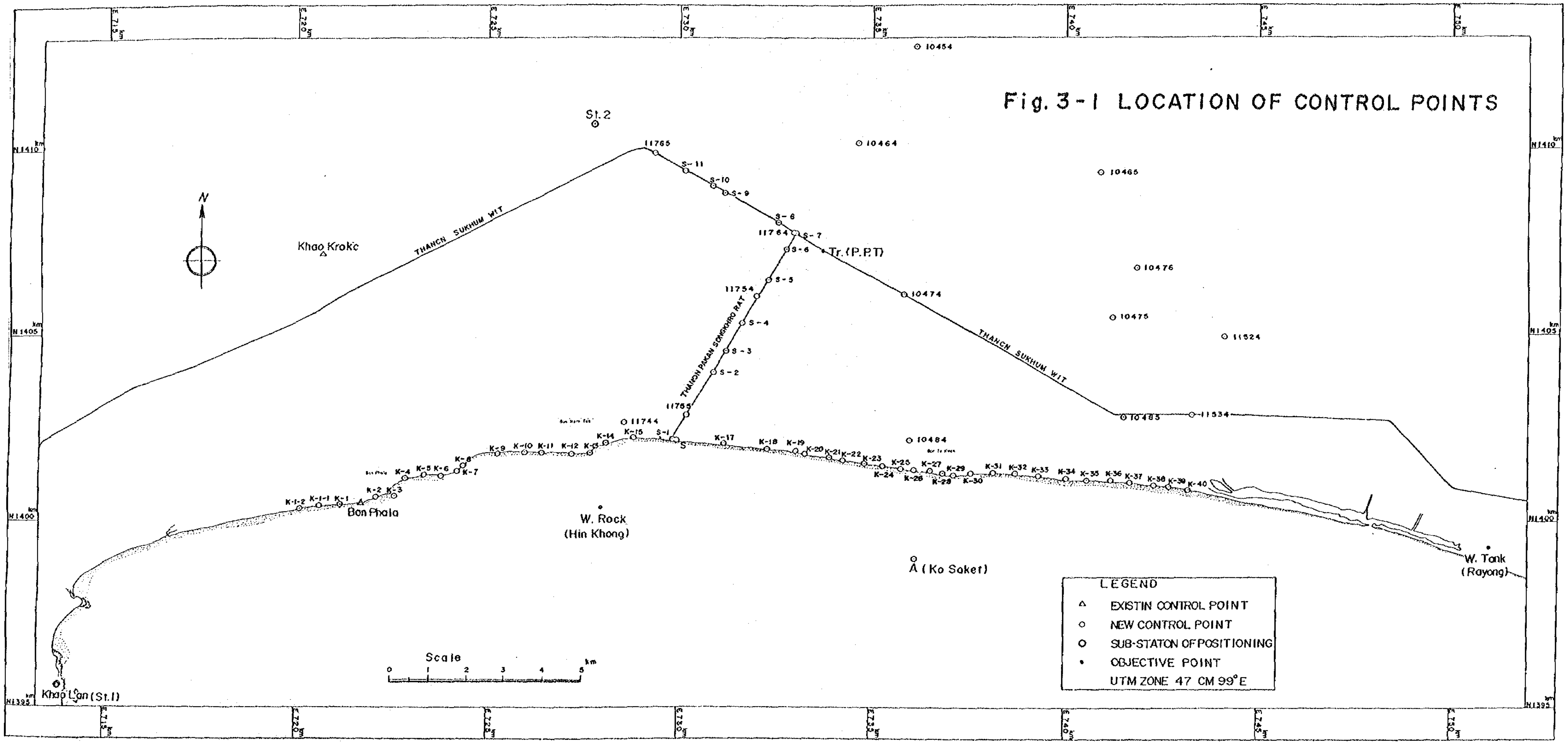


Fig. 3-1 LOCATION OF CONTROL POINTS

3-2 Topographic Survey

The topographic survey for the land area shown in Fig. 2-2 consists of a control point survey, aerial triangulation and stereo plotting for mapping by a photogrammetric method, dividing broadly. The generalized flow-chart of the topographic survey is shown in Figure 3-2.

Since a topographic map have existed in terms of about left half part of the survey area, amendment works of a existing map at scale of 1:8,000 were carried out using the map and existing aerial photographs to the area of approximately 72 square kilometers. On this area, primary concerns gave attention to the land classification.

On the other hand, new mapping works were carried out on the right part of the survey area, that is approximately 60 square kilometers, using existing aerial photographs at scale of 1:40,000 which had been teken by the Royal Thai Survey Department in 1981.

Field investigations were performed with reference to items difficult or impossible to identify on photographs, aiming at assisting interpretation for mapping. The main items investigated in the field were public office, road, river, town, village and their names, and the boundary of land use etc.

An analytical aerial triangulation was carried out by means of the block adjustment method. Pass points, sub-points and tie points were selected on the contact prints and pricked on the positive films, and were converted into the co-ordinate system using a computer after the measurement of the co-ordinates on the photographs.

Ground control points, pass points, sub-points and tie points were plotted on manuscript maps using the co-ordinategraph, and maps were drawn using a stereo plotter after absolute orientation with special attention to accuracy.

The mapping area is approximately 130 square kilometers in total.

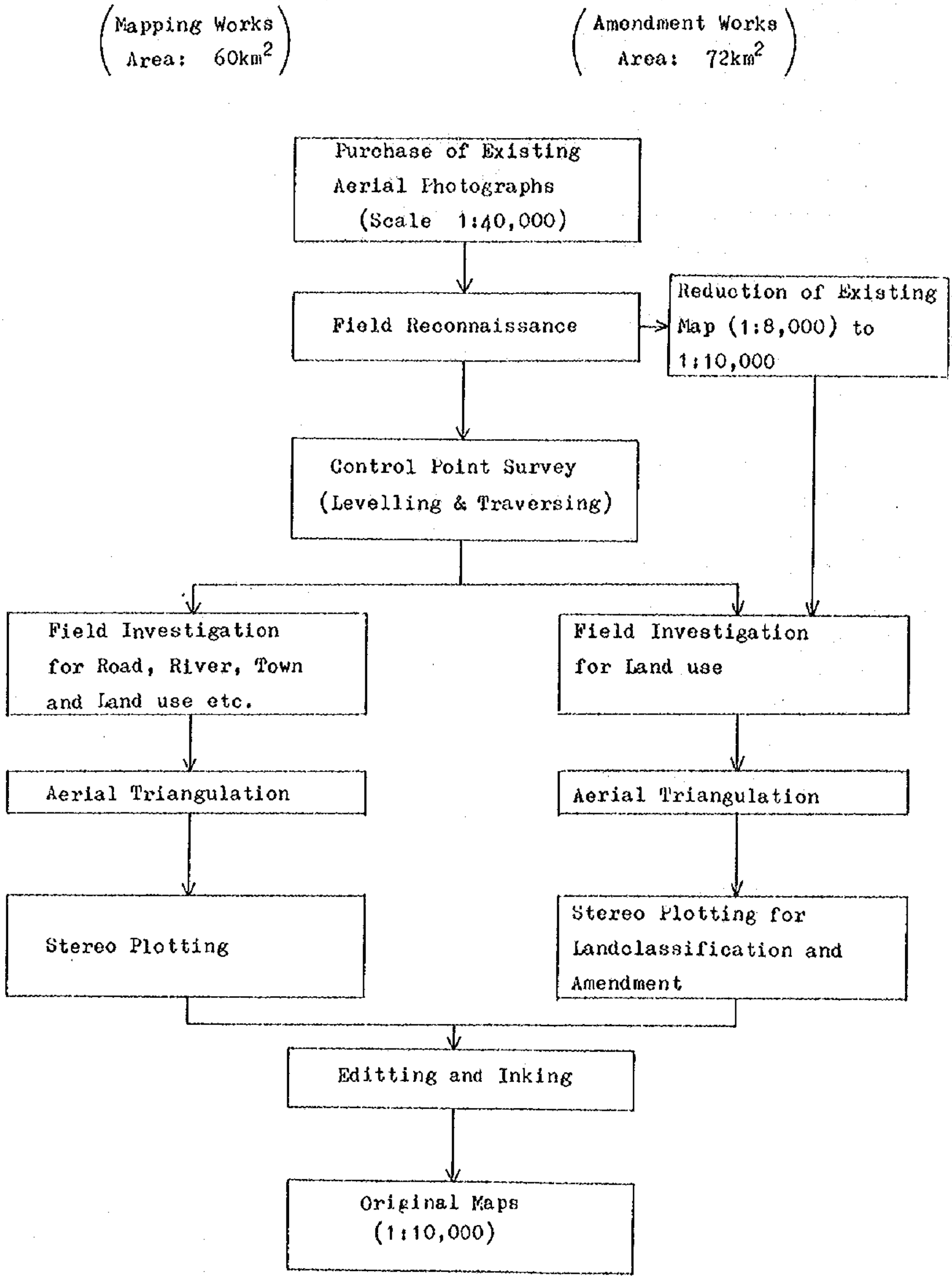


Fig. 3-2 Generalized Flow-chart of Topographic Survey for Land Area

3-3 Hydrographic Survey

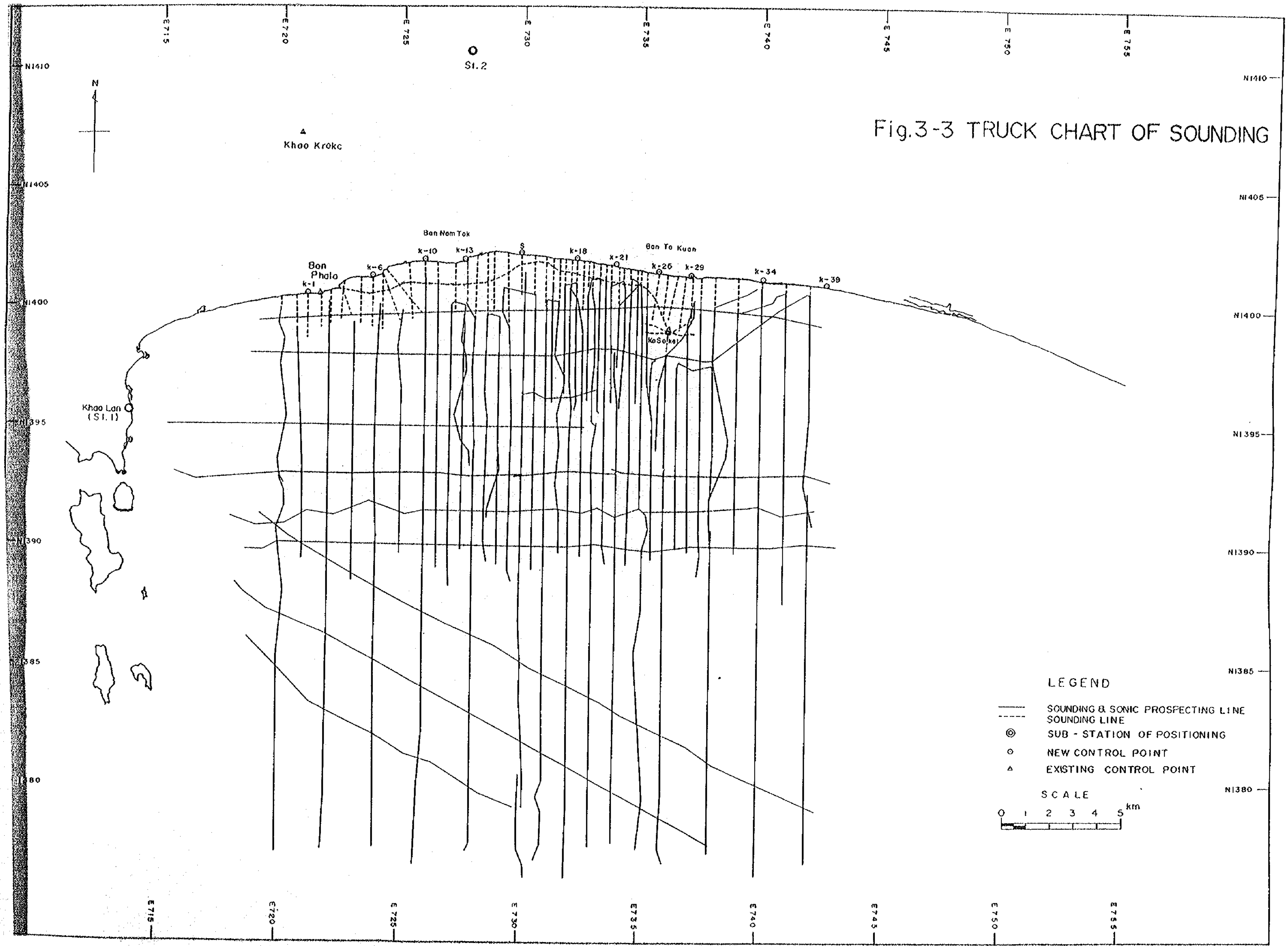
The continuous bathymetric survey (sounding) was carried out to grasp the topographic features of the sea bed in the survey area by using an echo sounder. In the shallow area which the survey vessel cannot be used in and on the shoreline in the survey area, the direct levelling was performed using a level.

For the positioning of the survey vessel on sea, an electronic positioning instrument (Tellurometer) was used. It's sub-stations were settled at the existing control points, that is Khao Lan and khao Khrok, whose co-ordinates are known.

The survey area extends over approximately 22 kilometers on the shore and approximately 24 kilometers offshore as shown in Figure 2-2. The survey lines used in the sounding were the north-to-south direction as main lines and east-to-west direction as complemental lines (tie lines). The spacing of main survey lines was 250 meters to 1 kilometer for the coastal area and 1 kilometer to 2 kilometers for the offshore area. The truck chart of sounding is shown in Figure 3-3.

The sounding data were corrected for tidal variation and sound velocity in sea in order to obtain actual depth. The correction for sound velocity was performed by a Bar-Check method. After corrections of the data, the water depth was read from the datum level. In this survey, the datum level of sounding is 2.19 meters below Mean Sea Level being coincident with the datum level at Sattahip Port.

Fig.3-3 TRUCK CHART OF SOUNDING



3-4 Soil Investigation

The soil investigation was carried out to grasp the soil structure, soil characteristics and the distribution of bed rock for the foundation engineering of this study.

The investigation consists of exploratory borings with Standard Penetration Tests (S.P.T.) and the following laboratory soil tests on samples obtained from S.P.T.. The S.P.T. and laboratory soil tests were practiced in conformity with American Society for Testing and Materials (ASTM).

1) Specific gravity

2) Moisture content

3) Grain size distribution
   Sieve analysis
   Hydrometer analysis

4) Atterberg limits
   Liquid limit
   Plastic limit

On the first plan, undisturbed samplings and laboratory soil tests of unconfined compression test and unit weight using undisturbed samples were planned in clay layers. However, most of soils were sand and weathered granite, so undisturbed samples could not be taken.

Borings were carried out at four points on land area and four points on offshore area shown in Figure 3-4, and the standard penetration test was carried out at every one meter for each bore hole in principal. The rotary boring method was mainly adopted for drilling, and the wash boring method was partly adopted. The total depth of borings is about 205 meters, and the quantity of laboratory soil tests is shown in Table 3-3 for each bore hole and each soil test item.

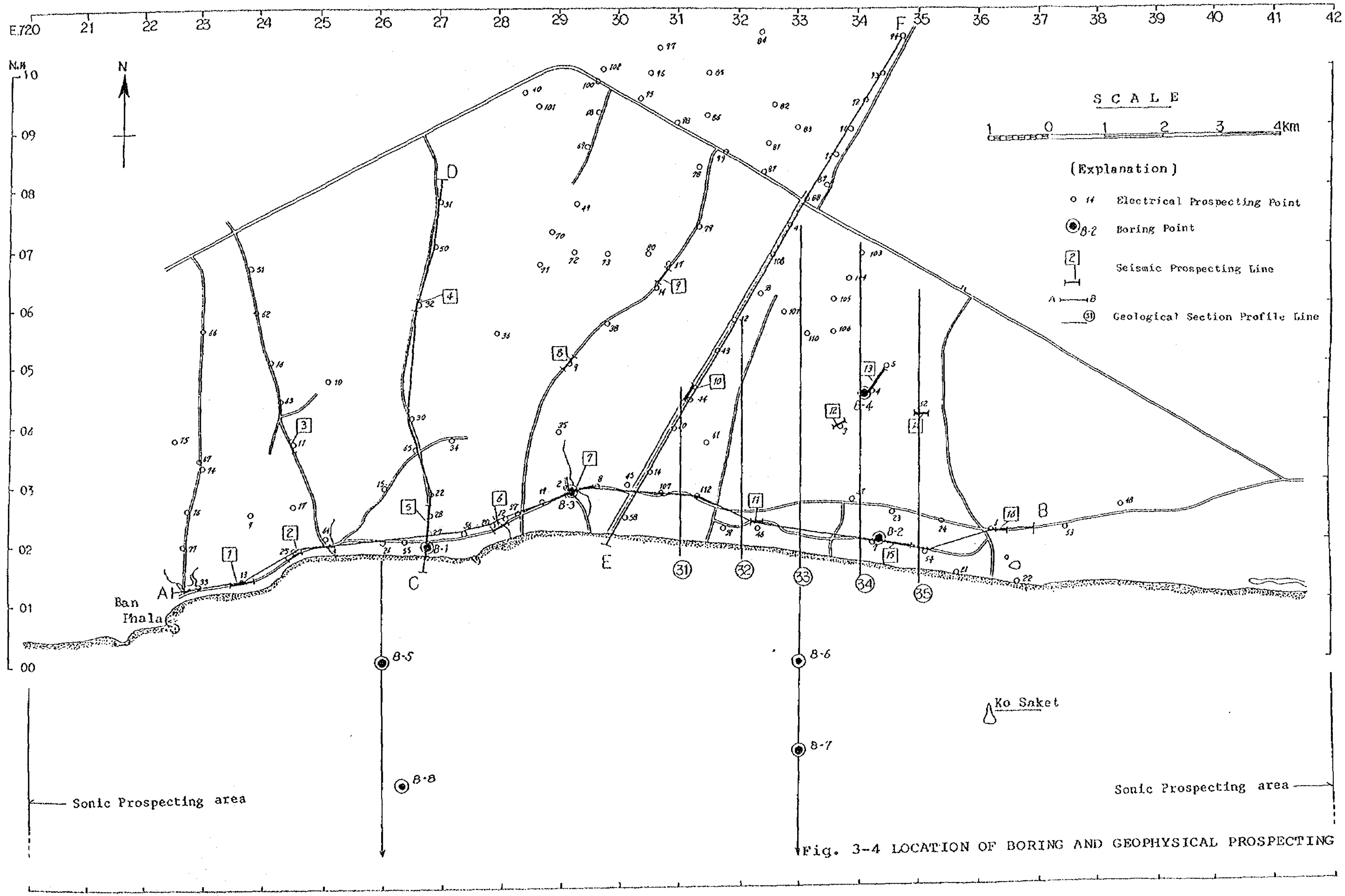


Fig. 3-4 LOCATION OF BORING AND GEOPHYSICAL PROSPECTING

Table 3-3 Quantity of Soil Investigation

BORING NO.	DRILLING DEPTH (Meters)	S.P.T. (Numbers)	LABORATORY SOIL TEST (Numbers)				
			SPECIFIC GRAVITY	MOISTURE CONTENT	GRAIN SIZE DISTRIBUTION	LIQUID LIMIT	PLASTIC LIMIT
NO.1	27.00	21	19	20	20	0	0
NO.2	37.01	28	26	26	26	0	0
NO.3	22.50	21	20	20	20	0	0
NO.4	38.50	34	33	33	33	0	0
NO.5	17.15	18	17	17	15	0	0
NO.6	21.23	21	19	19	19	0	0
NO.7	25.44	26	22	21	22	1	1
NO.8	15.94	16	14	14	11	1	1
TOTAL	204.77	185	170	170	166	2	2

3-5 Geophysical Prospecting

There are various methods for the geophysical prospecting, each having merits and demerits in terms of suitability and precision, depending on geological conditions and purposes. In this study, the seismic prospecting and electrical prospecting were carried out to understand soil textures in the alluvial formation, and depths and distribution of the basement rocks. On the first plan, the only seismic praspecting was planned. However, it took much time to get a permission for using explosives, so the electrical prospecting was performed in advance of the seismic prospecting.

The location of prospecting lines and points is shown in Figure 3-4, and the outlines of the geophysical prospecting is shown in Table 3-4.

Table 3-4 Outlines of Geophysical Prospecting

Item	Electrical Prospecting	Seismic Prospecting
Principal Purpose	Studying distribution of bedrock	Studying subsurface formations
Principal Instrument	Specific earth resistance tester	Refracting seismic amplifier & recording oscillograph
Method of Measurement	Wenner's four electrode resistivity sounding	Refracting method
Method of Analysis	Sundberg's standard curve	Analysis of travel time
Quantity of Prospecting	Standard depth of penetration: 52 meters Nos. of prospecting: 112 points	Geophone spacing: 10 meters Total length: 5,060 meters 16 lines

3-5-1 Electrical Prospecting

There are several methods of measuring earth resistivities (specific earth resistances), most of which are variations of the method originally conceived by Wenner. In Wenner's four driven-rod electrode method, four electrical contacts are made with the ground by driving into the ground the metal spikes, called electrodes, C_1, P_1, P_2 and C_2 placed in a straight line at equal intervals of a (m) as shown in Figure 3-5(a). Between the current electrodes C_1 and C_2, a current I (A) is passed and the resulting voltage drop (V) between the potential electrodes P_1 and P_2 is measured.

If the ground has a uniform resistiviry , an equation of measurement is attained:

$$\rho = 2\pi aV/I = 2\pi aR \ (\Omega \cdot m) \qquad R = V/I \ (\Omega)$$

where R is the resistance measured between the potential electrodes. The above equations are called Wenner's formula, which proved to be very practical in case the depth of driven electrodes is within 1/20 of the electrode interval separation a. Therefore, earth resistivity ρ can be calculated from the measured value of R.

The earth resistivity ρ in the Wenner's formula is constant irrespective of the electrode separation distance a if the ground has a uniform structure. However, the ground is generally composed of more than one layer involving rocks of differing resistivity. Therefore, the resistivity calculated from the above formula will not refer to any specific rock or layer but will be a mean value of the individual resistivities of distributed rocks and layers. Such a measured value is called "apparent resistivity", which varies according to the electrode separation a and the position of the electrode system. By obtaining the relations between a and ρ with respect to a particular ground, it is possible to roughly conjecture geological structure, layer formation and location of underground water supplies. Standard and auxiliary curves showing the relation between a and ρ are available, and by placing upon them an $a-\rho$ curve made from actual measurement, the approximate resistivity and depth of each layer involved may easily be obtained on the curve. The resistivity thus obtained is generally taken as a guide for elucidating the nature of the layer.

(1) Principle of Specific Resistance Measurement

Now assume that in the drawing of Figure 3-5(b), a point source of electric current having a magnitude of I (amp.) is placed at a point C on the surface of a ground having a uniform specific resistance ρ (Ω-m), and that a potential P is applied at a point P under the ground. Since the electric current radiates hemispherically into the ground, the current density at the point P will be $1/2\pi r^2$ (amp./m2) where CP = r (m). Accordingly, the micro-potential difference between P and a point separated by a distance of dr is obtained as follows.

$$dv = \rho \frac{I}{2\pi r^2} \cdot dr \quad \text{(volt)}$$

Therefore, the potential V at P due to the current I can be expressed by the following formula.

$$V = -\int_{\infty}^{r} dv = \frac{\rho I}{2\pi r} \text{ (volt)} \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots (1)$$

Then, assume a pair of positive and negative point sources of electric current, C_1 with + I (amp.) and C_2 with - I (amp.), placed on the surface of the same ground as shown in Figure 3-5(c). In this case, the potential at the point P will be the sum of the potentials from C_1 and C_2. Namely, the potential V_1 at P due to C_1 is obtained from Formula (1) as follows.

$$V_1 = \frac{\rho I}{2\pi} \cdot \frac{1}{\overline{C_1 P}} \text{ (volt)}$$

Similarly, the potential V_2 at P due to C_2 is found as follows,

$$V_2 = \frac{-\rho I}{2\pi} \cdot \frac{1}{\overline{C_2 P}} \quad \text{(volt)}$$

Therefore, the potential at P due to C_1 and C_2 is expressed as follows.

$$V = V_1 + V_2 = \frac{\rho I}{2\pi} \left(\frac{1}{\overline{C_1 P}} - \frac{1}{\overline{C_2 P}} \right) \quad \text{(volt)} \quad \cdots\cdots\cdots\cdots (2)$$

Next assume that as shown in the drawing of Figure 3-5(a), four point electrodes, C_1, P_1, P_2 and C_2, are spaced with an equal interval of a (m) on one straight line drawn on the surface of the ground. In this setup, electric current (direct) is allowed to flow to the outer electrodes C_1 and C_2 (current electrodes) so as to deliver electric current having the magnitude of I (amp.) into the ground, while a potentiometer Ⓥ is arranged so as to measure the potential difference between the inner electrodes P_1 and P_2 (potential electrodes). This electrode system is referred to as Wenner's 4-electrode system and it forms the basis of specific resistance prospecting.

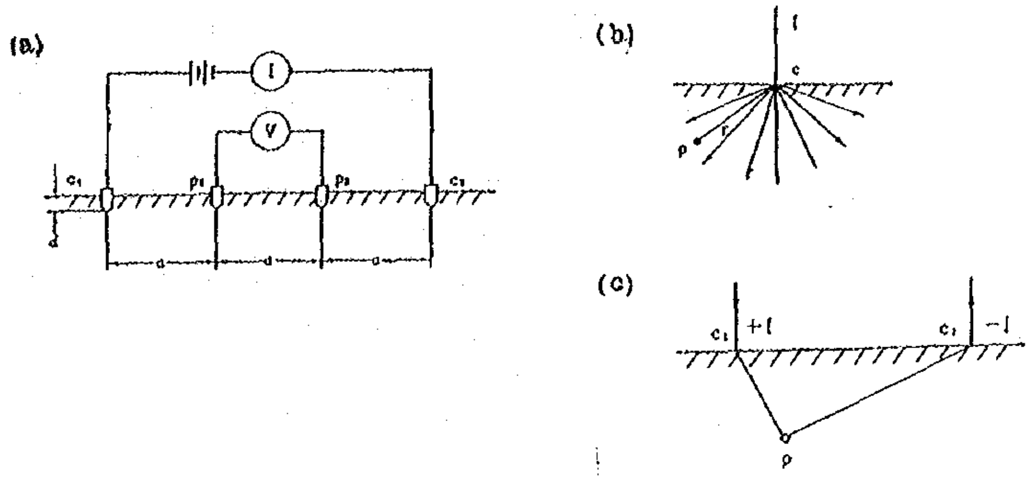


Fig. 3-5 Principle of Specific Resistance Measurement

Assuming the specific resistance of the ground is ρ (Ω - m) uniformly, the potential of P_1 can be obtained from Formula (2) as follows.

$$V_1 = \frac{\rho I}{2\pi}\left(\frac{1}{a} - \frac{1}{2a}\right) \quad \text{(volt)}$$

Similarly, the potential of P_2 is found as follows.

$$V_2 = \frac{\rho I}{2\pi}\left(\frac{1}{2a} - \frac{1}{a}\right) \quad \text{(volt)}$$

Therefore, the potential difference V between the electrodes P_1 and P_2 will be found as follows.

$$V = V_1 - V_2 = \frac{\rho I}{2\pi a}$$

From the preceding equation, we can derive the following.

$$\begin{aligned} \rho &= 2\pi a \left(\frac{V}{I}\right) \qquad (\Omega\cdot m) \\ &= 2\pi a \cdot R \qquad (\Omega\cdot m) \\ R &= \frac{V}{I} \qquad (\Omega) \end{aligned} \quad \cdots\cdots\cdots\cdots (3)$$

The equation (3) is referred to as Wenner's Formula. The results calculated according to Formula (3) show satisfactory agreement with measured values so long as the buried depth d of the electrode is smaller than 1/20 of the electrode interval a. As is apparent from Formula (3), the value of can be calculated directly by determining $R\ (=\frac{V}{I})$. In this case, however, it is necessary to measure the value of V potentiometrically. Unless the potentiometer Ⓥ is of the type precluding the consumption of electric current, it will be affected by the earth contact resistance of electrode and therefore fail to provide accurate determination of R.

In the practical application, if the direct current is allowed to flow to the ground, it may have the possibility of causing polarization in the neighborhood of electrodes. It is likewise possible that natural current will produce an error in the determination of potential. For these reasons, alternating current is used generally.

a) Two-Layer Structure

Refer to Figure 3-6(a).

- d_1: depth of surface layer
- ρ_1: specific resistance of surface layer
- ∞ : depth of under lying layer
- ρ_2: specific resistance of unuer lying layer

The potential difference between P_1 and P_2 is nearly not affected by underlying layer. So far as the distance between C_1 and C_2 is small compared with d_1 the current flows through the surface layer.
However, the longer the electrode separation is the more the potential difference will be influenced by underlying layer as shown in Figure 3-6(b) and its value is changed from one in uniform structure case, that is, the apparent specific resistance will be changed. When $\rho_2 > \rho_1$, the apparent specific resistance ρ will increase, and vice versa as shown in Figure 3-6(c) and (d) respectively. Accordingly, by measuring the co-relation between the electrode separation a and the apparent specific resistance ρ , we can elucidate how the specific resistance of the under grounu varies with the depth.

Assume that as shown in Figure 3-6(e), a point source of electric current C is placed at a point C on the surface of ground having a 2-layer structure, and that an electric current I (amp.) is allowed to flow. Then, the potential V_p at a point P separated from C by an interval of a (m) can be expressed as follows.

$$V_p = \frac{\rho_1 I}{2\pi} \cdot \frac{1}{a} + 2\sum_{n=1}^{\infty} \frac{K^n}{\sqrt{a^2 + (2nd_1)^2}} \quad \text{(volt)}$$

where,

$$K = \frac{\rho_2 - \rho_1}{\rho_2 + \rho_1} \quad \cdots\cdots\cdots\cdots\cdots\cdots (5)$$

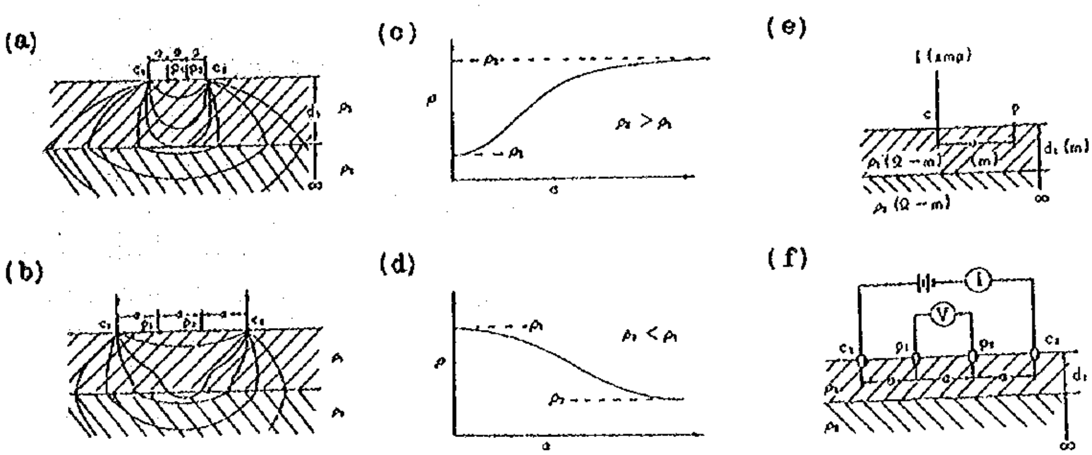


Fig. 3-6 Model of 2-Layer Structure

By the same procedure described before, the potential difference between the electrodes P_1 and P_2 in Wenner's 4-electrode system can be obtained from the preceding formula as follows.

$$V = \frac{\rho_1 I}{2\pi a}\left[1 + 4\sum_{n=1}^{\infty}\frac{K^n}{\sqrt{1+4n^2\left(\frac{d_1}{a}\right)^2}} - 2\sum_{n=1}^{\infty}\frac{K^n}{\sqrt{1+n^2\left(\frac{d_1}{a}\right)^2}}\right] \cdot (6) \quad \text{(Volt)}$$

The formula for the calculation of apparent specific resistance for 2-layer structure can be obtained by sub-stituting Formula (6) in Wenner's Formula (3). Because $\rho = 2\pi a\frac{V}{I}$, we obtain the following equations.

$$\frac{\rho}{\rho_1} = 1 + 4\sum_{n=1}^{\infty}\frac{K^n}{\sqrt{1+4n^2\left(\frac{d_1}{a}\right)^2}} - 2\sum_{n=1}^{\infty}\frac{K^n}{\sqrt{1+n^2\left(\frac{d_1}{a}\right)^2}}$$

$$K = \frac{\rho_2-\rho_1}{\rho_2+\rho_1} = \frac{\frac{\rho_2}{\rho_1}-1}{\frac{\rho_2}{\rho_1}+1} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(7)}$$

In other words, curves showing the relation between d_1/a and ρ/ρ_1 are obtained for various values of K or ρ_2/ρ_1. For the convenience of practical application, curves of the relation between a/d_1, the inverse number of d_1/a, and ρ/ρ_1 are prepared as the "standard curve". The values of ρ_1, ρ_2 and d_1, etc. can be obtained by comparing measured curves of a and ρ with those standard curves. Those standard curves are also usable in the case of three or more layer structure.

b) Three or More Layer Structure

Analysis of 3 or more layer structure is grounded on one of 2-layer structure. It can be considered that 3-layer structure as shown in Figure 3-7(a) is equivalent to 2-layer structure (b). If depth of first and second layer is d_1 and $d_2 - d_1$, respectively, the specific resistance ρ_2' of equivalent single layer of the first and second layers in Figure 3-7(b) is represented as follows, since it can be thought that the specific resistance of the first layer and that of the second layer are connected in parallel.

$$\rho_2' = \frac{\rho_1 \rho_2 d_2}{\rho_1 (d_2 - d_1) + \rho_2 d_1}$$

$$\frac{\rho_2'}{\rho_1} = \frac{\frac{\rho_2}{\rho_1} \cdot \frac{d_2}{d_1}}{\frac{\rho_2}{\rho_1} + \frac{d_2}{d_1} - 1} \qquad \cdots\cdots\cdots\cdots\cdots\cdots (8)$$

The "auxiliary curve" which shows the relation between d_2/d_1 and ρ_2'/ρ_1 against various value of ρ_2/ρ_1 is used for elucioating of 3 and more layer structure with standard curve mentioned above. And for 4, 5 and more layers, auxiliary curve can be used by assuming an equivalent single layer of the 1~3 layers, 1~4 layers and more.

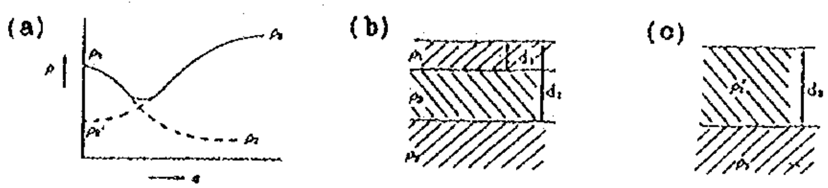


Fig. 3-7 Model of 3 or More Layer Structure

(2) Procedure of Analyses

Plot the relation of apparent resistance ρ and electrode separation a on the semi-transparent log-log section paper, which should be equal in size with the "standard curve" and the "auxiliary curve". Analysis will be described on the example curves a, b, c, and d in Figure 3-8.

a) Divide the curve in increasing and decreasing part respectively.
b) Place the curve upon the standard curve, and search the most identical one to the a, b portion by trying to slide in various way (the curve I). Trace the original point O_1 ($\rho/\rho_1 = 1$, $a/d_1 = 1$) on the curve under analysis. The value of a and ρ of this point O_1 in scale of the curve under analysis represents specific resistance ρ_1 and depth d_1 of the first layer. ρ_2 can be calculated from ρ_2/ρ_1 of the most identical standard curve and ρ_1.

c) Place O_1 upon the original point ($\rho_2'/\rho_1 = 1$, $d_2 / d_1 = 1$) of auxiliary curve, and trace a curve which has the same value of ρ_2 / ρ_1 as one of ρ_2 / ρ_1 of the curve (I), (chain line II) on the curve under analysis.

d) Again place it on the standard curve and search a curve III which is most identical to the b, c portion sliding the original point of standard curve on the curve II.

This traced point O_2 gives the apparent specific resistance ρ_2' of equivalent single layer of the first layer and second layers and d_2 of the second layer in unit of a and ρ .

Since ρ_3 / ρ_2' is, in this case, corresponding to the ρ_2/ρ_1 of the standard curve, ρ_3 can be calculated from ρ_3/ρ_2' and ρ_2' .

e) Trace the curve (IV) by means of the same method as described in c).

f) O_3 is obtained by means of the same method of d). O_3 gives ρ_3' and d_3 of the third layer. Since ρ_4/ρ_3' is, in this case, corrsponding to the ρ_2 / ρ_1 of the standard curve, ρ_4 can be calculated from ρ_4 / ρ_3' and ρ_3' .

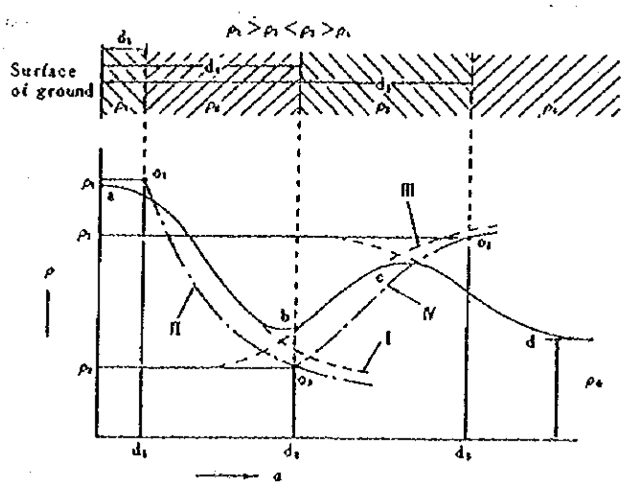


Fig. 3-8 Sample of Analytical Procedures

3-5-2 Seismic Prospecting

Seismic prospecting is a typical method of geophysical prospectings which provide data on the physical ptoperties of material under the ground. Seismic method is divided into two methods depending on the type of waves utilized. One is the seismic refraction method in which refracted waves are utilized. The other is the seismic reflection method making use of reflected waves. The former is theoretically applicable to the shallower subsurface. With this technique, the rock condition of construction sites can be investigated through the medium of the velocity obtained from the time required for a refracted wave to return from its original point to the detector. Recently, the seismic refraction method, therefore, is widely used in engineering study of the foundation of dams, tunnels and many other engineering projects. The latter is used more to research into the deeper parts of the underground in search of natural resources such as oil deposits.

(1) Principle of Seismic Refraction Method

A near-surface explosion generates several types of elastic waves such as longitudinal waves, transverse waves rayleigh waves and love waves, which propagate into media depending on respective physical properties. In the seismic refraction method, used in this study, the first-arrival waves from the shot-point to the detecting point were utilized. They are longitudinal, direct and refracted waves. The principle of the seismic refraction method is based on the law of refraction, so-called Snell's Law. This method is explained as follows;

As is evident from Figure 3-9,

$$\sin I = \frac{BC}{AB} \qquad \sin R = \frac{AD}{AB}$$

So that

$$\frac{\sin I}{\sin R} = \frac{V_1\ t}{V_2\ t} = \frac{V_1}{V_2} \quad (\ t:\ \text{unit time})$$

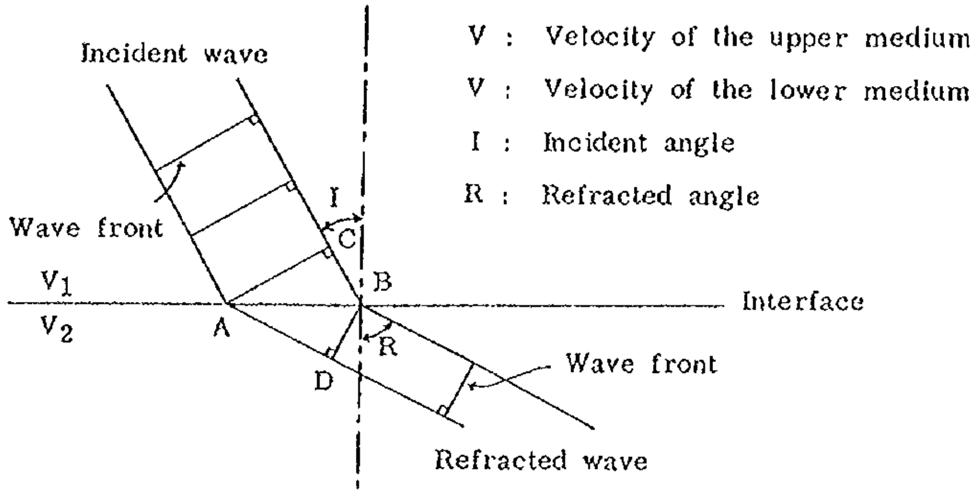


Fig. 3-9 Snell's Law

As an essential assumption of the seismic refraction method, velocity increases with depth. If the velocity is greatest at or near the surface and the lower velocity layer lies below, the refracted wave is bent away from the surface and the refraction methods can not be used theoretically. So that $V_1 < V_2$ and $R > I$. When $\sin I = V_1/V_2$, $\sin R$ becomes unity, and R becomes 90°. This means that the refracted wave does not penetrate into the medium, but travels along the interface. The angle $I = \sin^{-1} V_1/V_2$ is known as the "Critical Angle" of incidence for longitudinal refraction. For any value of I greater than this critical value, there is no refraction into the second medium and the wave is totally reflected. This concept of the critical angle is the most important in seismic refraction work, since the wave actually used is the one which hits the top surface of a higher speed bed at the critical angle, travels horizontally along this surface with velocity V_1, and eventually is refracted back to the surface at the same angle.

This mechanism for transmission of a refracted wave in a hypothetical two-layer structure is shown in Figure 3-10. The ray path mentioned above, and the relation between the distance (X) and the time (T) is shown in Figure 3-11. This graph representing the relation between (X) and (T), illustrated in the upper part of Figure 3-11, is called the "Time-Distance Curve".

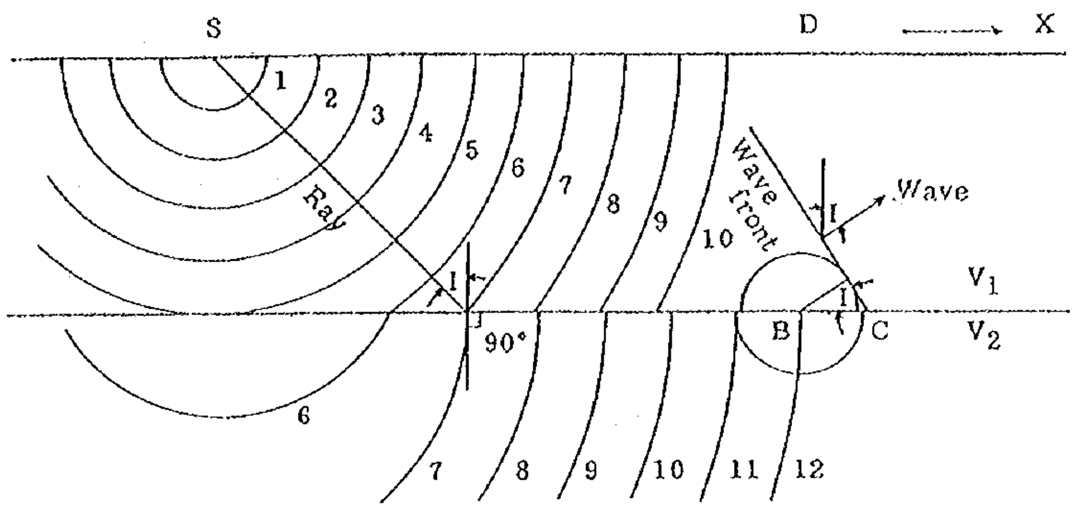


Fig. 3-10 Mechanism for Transmission of Refracted Wave in Two-Layer Structure

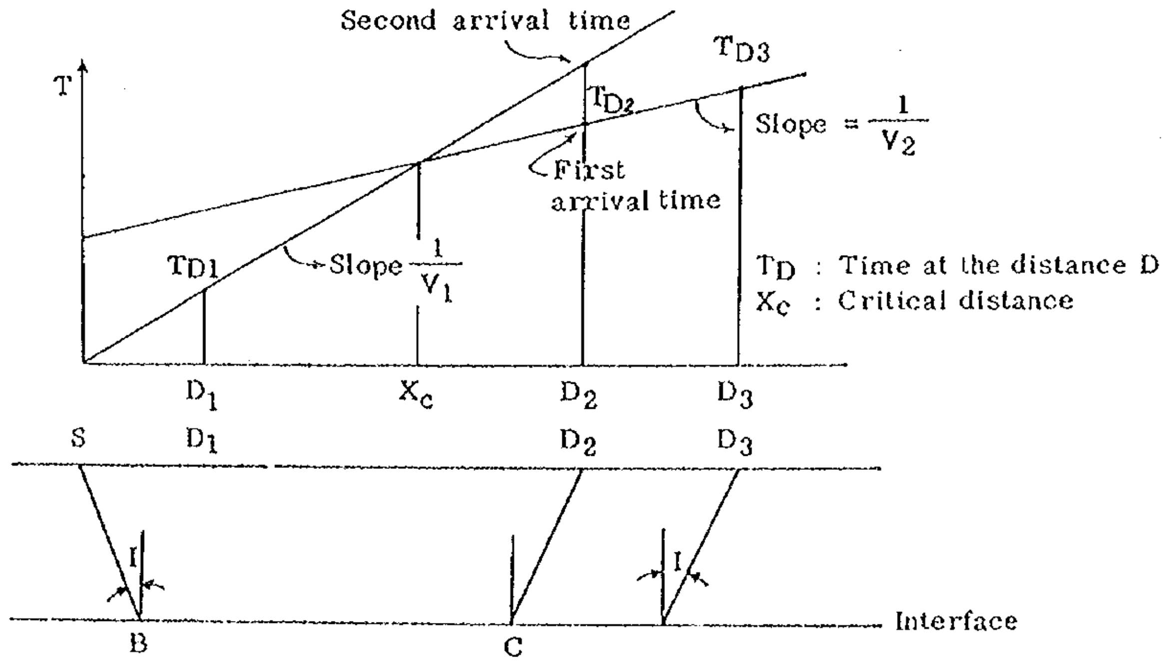


Fig. 3-11 Wave Path and Relation between X and T

As seen in Figure 3-11, if a seismic wave is generated at point (S) on the surface, the energy travels out from it in hemispherical wavefronts. When a detecting instrument is at point (D), a distance (X) from (S), the wave SD travelling horizontally through the upper medium will reach (D) before any other waves, if (X) is small enough. For large value of (X), the wave travelling along the top of the lower medium, which has a higher speed, will overtake the direct wave, and so the refracted wave will arrive first. Upon this basic principle, the depth to the interface can be calculated as described later in detail.

(2) Procedure of Observation

The explosion makes the ground vibrate. These seismic oscillations are received with the geophone and converted into electrical energy to be transmitted to the amplifier through the take-out cable and the relay cable. This small amount of electrical energy is increased by an amplifier and enter into the recording units by way of a series of filters included in the amplifier. In the recording units, the amplified and filtered electrical energy is converted again into mechanical energy by galvanometers which correspond to the respective geophones. This energy, at last, is registered photographically on recording paper. The block-diagram of instruments is shown in Figure 3-12, and a sample of a record is shown in Figure 3-13. On the record, each first arrival of the water is characterized by an "upkick".

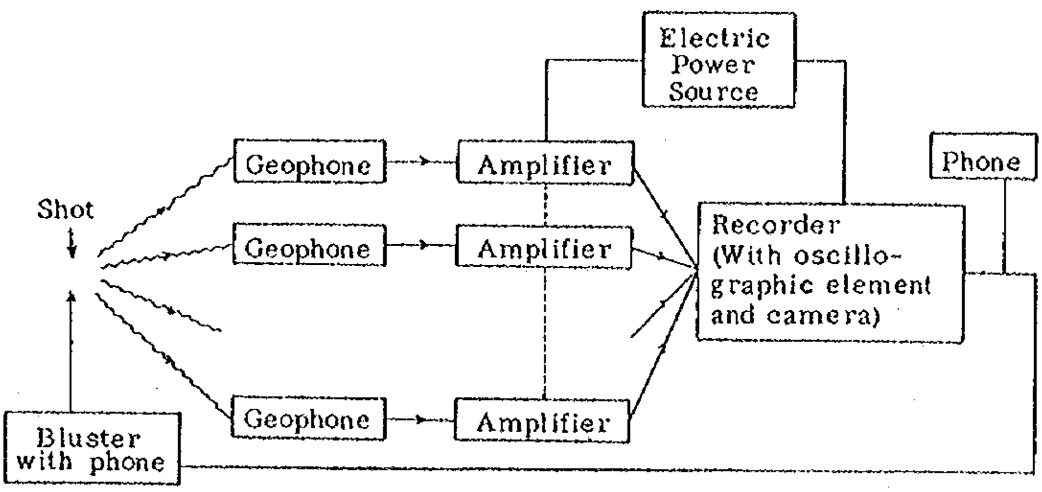
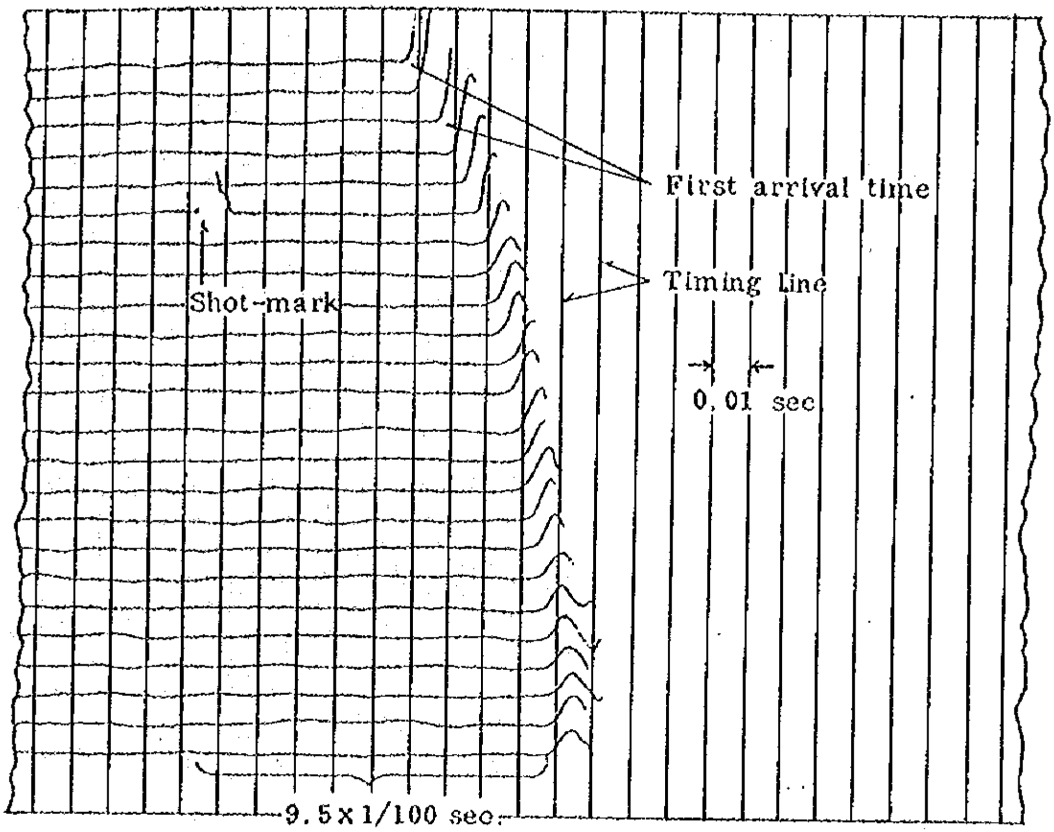


Fig. 3-12 Block-diagram of Instruments



9.5 x 1/100 sec. shows the total time required for the first arrival wave to travel to the geophone No.24.

Fig. 3-13 Sample of Record

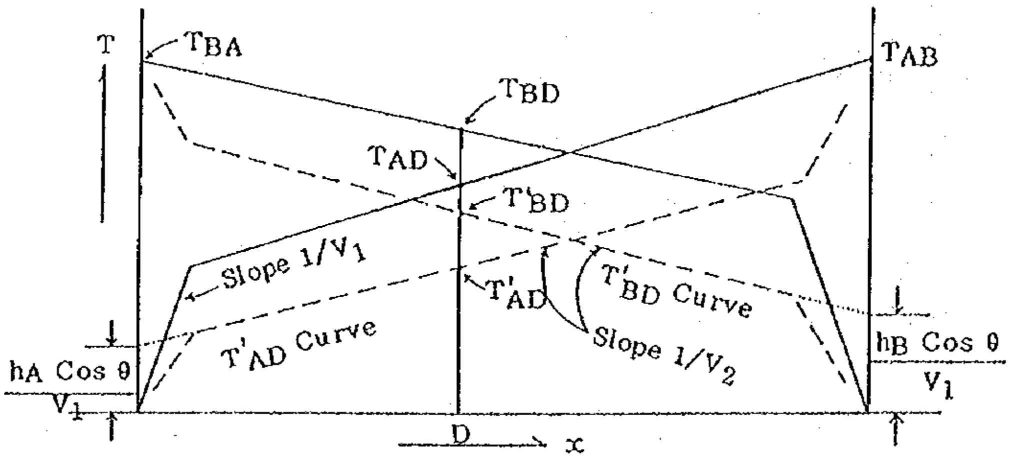
(3) Procedure of Analysis

Various procedures for depth calculation were proposed in the seismic refraction method. One is the "Method of Differences" proposed by T. Hagiwara (1938). In this method the irregularities of surface and the inclination of interface do not need to be taken into account in the procedure of calculation as well as in the "Reciprocal Method" by Hawkins (1959).

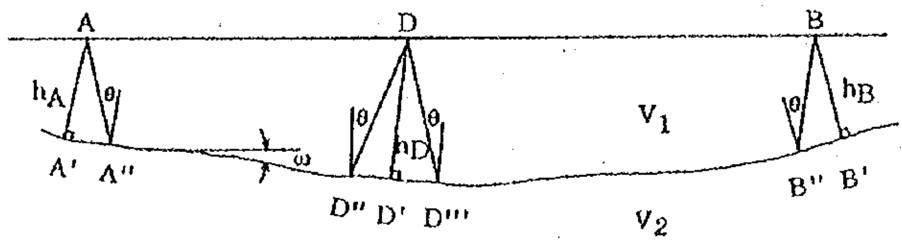
a) Two-Layer Structure

To determine the depth, a typical case, illustrated in Figure 3-14, will be given where there are two media under the ground with respective speeds of V_1 and V_2 , separated by a dipping discontinuity.

(a) T-D Curves



(b) Profile



A.B : shot point

D : detecting point

V_1 : velocity of the upper medium

V_2 : velocity of the lower medium

θ : critical angle

ω : dip of the interface

h_A : length of the perpendicular AA'

h_B : length of the perpendicular BB'

h_D : length of the perpendicular DD'

Fig. 3-14 Method of Differences

In Figure 3-14(a), a pair of T-D Curves T_{AD} and T_{BD} are called the "Reciprocal T-D Curves" between A and B.

The direct wave travels from shot to geophone near the surface at a speed of V_1 .
so that

$$T = \frac{X}{V_1} \qquad \cdots\cdots (1)$$

The travel time along the refraction path AA"D"D is

$$T_{AD} = \frac{\overline{AA''}}{V_1} + \frac{\overline{A''D''}}{V_2} + \frac{\overline{D''D}}{V_1} \qquad \cdots\cdots (2)$$

This can be written in the form of

$$T_{AD} = \frac{hA/\cos\theta}{V_1} + \frac{1}{V_2}\int_{D''}^{A''} \frac{dx}{\cos\omega} + \frac{hD/\cos\theta}{V_1}$$

$$= \frac{hA/\cos\theta}{V_1} + \frac{1}{V_2}\left\{\int_{D}^{A} \frac{dx}{\cos\omega} - \int_{A''}^{A'} \frac{dx}{\cos\omega} - \int_{D}^{D''} \frac{dx}{\cos\omega}\right\} + \frac{hD/\cos\theta}{V_1} \qquad \cdots\cdots (3)$$

Here, $\int_{A''}^{A'} \frac{dx}{\cos\omega}$ and $\int_{D'}^{D''} \frac{dx}{\cos\omega}$ can be regarded as $h_A \cdot \tan\theta$ and $h_D \cdot \tan\theta$, and by making use of Snell's Law $\sin\theta = V_1 / V_2$, equation (3) can be readily transformed into

$$T_{AD} = \frac{1}{V_2}\int_{D}^{A} \frac{dx}{\cos\omega} + (hA + hD)\ \frac{\cos\theta}{V_1} \qquad \cdots\cdots (4)$$

In a similar way of thinking, T_{BD} and T_{AD}, along the path BB"D"D and AA"B"B, are

$$T_{BD} = \frac{1}{V_2}\int_B^D \frac{dx}{\cos\omega} + (h_B + h_D)\frac{\cos\theta}{V_1} \qquad \cdots\cdots (5)$$

$$T_{AB} = \frac{1}{V_2}\int_B^A \frac{dx}{\cos\omega} + (h_A + h_B)\frac{\cos\theta}{V_1} \qquad \cdots\cdots (6)$$

From equation (4), (5) and (6), the following is obtained,

$$T_{AD} + T_{BD} - T_{AD} = \frac{2h_D\cos\theta}{V_1} \qquad \cdots\cdots (7)$$

So that, the depth under D is

$$h_D = \frac{V_1}{2\cos\theta}(T_{AD} + T_{BD} - T_{AB}) \qquad \cdots\cdots (8)$$

where V_1', T_{AD}, T_{BD} and T_{AB} are given by the observation data (refer to Figure 3-14). If θ, derived from $\sin\theta = V_1/V_2$, is known, the depth h_D can be easily calculated. For that purpose, the speed V_2 must be determined. When T_{AD}' is put as follows,

$$T_{AD}' = T_{AD} - \frac{T_{AD} + T_{BD} - T_{AB}}{2} \qquad \cdots\cdots (9)$$

T_{AD}' is

$$T_{AD}' = \frac{1}{V_2}\int_D^A \frac{dx}{\cos\omega} + \frac{h_A\cos\theta}{V_1} \qquad \cdots\cdots (10)$$

For small values of ω, $\cos\omega$ is approximately equal to unity.

Therefore, equation (10) can be written as follows.

$$T_{AD}' = \frac{1}{V_2}x + \frac{h_A\cos\theta}{V_1} \qquad (11)$$

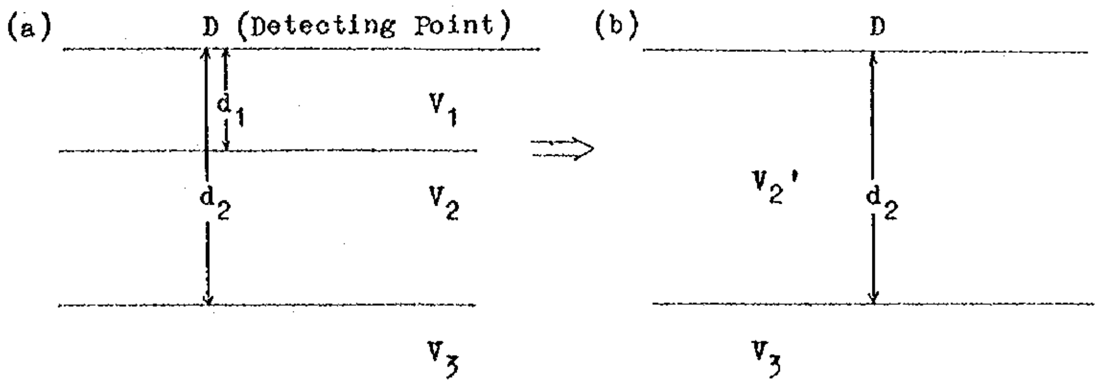
Equation (11) shows a simple equation with coeffecient of $1 / V_2$. So that, on plots of a group of T_{AD}' at detecting points on T-D Graph, these make a straight line and its gradient provides the speed of V_2. This straight line is called the "Velocity T-D Curves" or simply the "T' Curves".

Now, the depth to the refractor under each geophone can be determined from equation (8). When arcs with a radius equal to the value computed are drawn at each detecting point, a smooth-line tangent to the arcs gives the depth profile.

b) Three or More Layer Structure

The method of depth calculation in the case of three layers is derived from the theory of considering the three-layer structure as two-layer by use of the concept of the average velocity of the first and the second layer.

To clarify the description, the following Figure 3-15 are given.



d_1 : depth to the first interface

d_2 : depth to the second interface

V_1 : Velocity of the first layer

V_2 : Velocity of the second layer

V_3 : Velocity of the third layer

V_2' : Average velocity of the first and the second layer

Fig. 3-15 Method of Difference in Three-Layer Structure

If the average velocity of the first and the second layer is taken as

$$\frac{d_2}{V_2'} = \frac{d_1}{V_1} + \frac{d_2 - d_1}{V_2} \quad \text{.................... (12)}$$

the three-layer can be regarded as being two-layer, mathematically in travel time (Figure 3-15(a)). Then, the depth d_2 can be determined if the average velocity V_2' is known. But the unknown quantity d_2 is involved in equation (12) to to solve for V_2'. In practice, the following procedure is done to solve for d_2.

Table 3-5 Calculation Sheet

Distance	d_1	$\frac{T_p}{2}$	d_2'	p	(1-p)n	p	V_2'	$\frac{V_2'}{V_3}$	$\cos\theta$	$\frac{V_2'}{\cos\theta}$	d_2

d_1 : depth to the first interface

d_2' : estimated depth to the second interface

$p = d_1 / d_2'$

$n = V_1 / V_2$

$p = p + (1-p)n$

V_2' : average velocity of the first and the second layer

$\theta' = \sin^{-1} V_2' / V_3$

d_2 : depth to the second interface

In Table 3-5, d_1, V_1 and V_2 are given from the calculation and the Reciprocal T-D Curves for the smaller distance, and V_3 and T_p for the larger distance.

First, d_2'is estimated, and the calculations proceed following a fixed order, from left to right, of the computation sheet. Then, d_2 is obtained. If $d2 > d2'$, $d2'$ must be estimated larger than d_2 obtained above and d_2 is solved again. In case of $d_2 < d2'$, smaller than d_2, is given.

Thus these procedures of calculation are continued until the estimated d_2' becomes approximately equal to d_2 calculated within a certain range regarded as an error accompanying each measured value. The last d_2 is the depth to the second refractor. A smooth-line tangent to the arcs with a radius of d_2 shows the second velocity discontinuity.

In case of multi-layers, the concept of this average velocity is employed in the same way as three-layer.

It is necessary to make a velocity correction for the slope of terrain, because distances between geophones are horizontal. In the seismic survey on the slope, therefore, velocities obtained graphically from the gradient of T' Curves are apparent values. When θ, Va and Vt are used as the average dip angle, the apparent velocity and the true velocity, the relation between them is formulized as follows.

$$V_t = \frac{Va}{\cos\theta} \qquad \text{..............................} \quad (13)$$

Thus, the slope correction is based on the above formula.

(4) Interpretation

Strata in geology are classified according to the meterials, such as granite, slate, sand and so on, of which the strata themselves are composed. This is called the rock-stratigrafic classification. In the meantime, velocity layers are classified according to the difference between velocities. It, therefore, may be said that the former investigation is qualitative, the latter is quantitative, and so they provide different information. But it is important that the velocities obtained must be geologically interpretated by correlating each other. For instance, granite with a speed of 3.0 km/sec shows comparatively weathered rock. On the contrary, the rock of the Neogene system with the same speed of 3.0 km/sec do not suffer from weathering.

Interpretating the results of the seismic prospecting finally, the results of the electrical prospecting, by which specific resistance layers are classified according to the difference between specific resistances, the results of borings and other data shall be considered.

3-6 Sonic Prospecting

The sonic prospecting was carried out to obtain continuous profiles of sea beds and sub-bottom geological formations, using Sub-Bottom Profiler (Sonostrator) on the sea area simultaneously with the sounding.

(1) Principle of Sonic Prospecting

Sonostrator consists of a transmitter, receiver, recorder, transmitting transducer, receiving transducer and generator. The sound source creates a strong acoustic pulse which transmits sound waves to the sea bed and sub-bottom. The reflected energy is received by a hydrophone, amplified, filtered and recorded on a time graphic sweep recorder. The block diagram of the Sonostrator is shown in Figure 3-16. The sound source of the Sonostrator consists of a magnetostrictive oscillation transducer which creates an acoustical elastic pulse mainly in 1 to 9 KHz. The significant energy is between 3 and 4 KHz. The recorder provides the synchronized trigger pulse corresponding to a writing stylus situated at the top of the recording paper. The trigger pulse switches on the current which charges up to 1,500 volts. The current passing through the magneto-strictive oscillation transducer produces a loud sould of short duration.

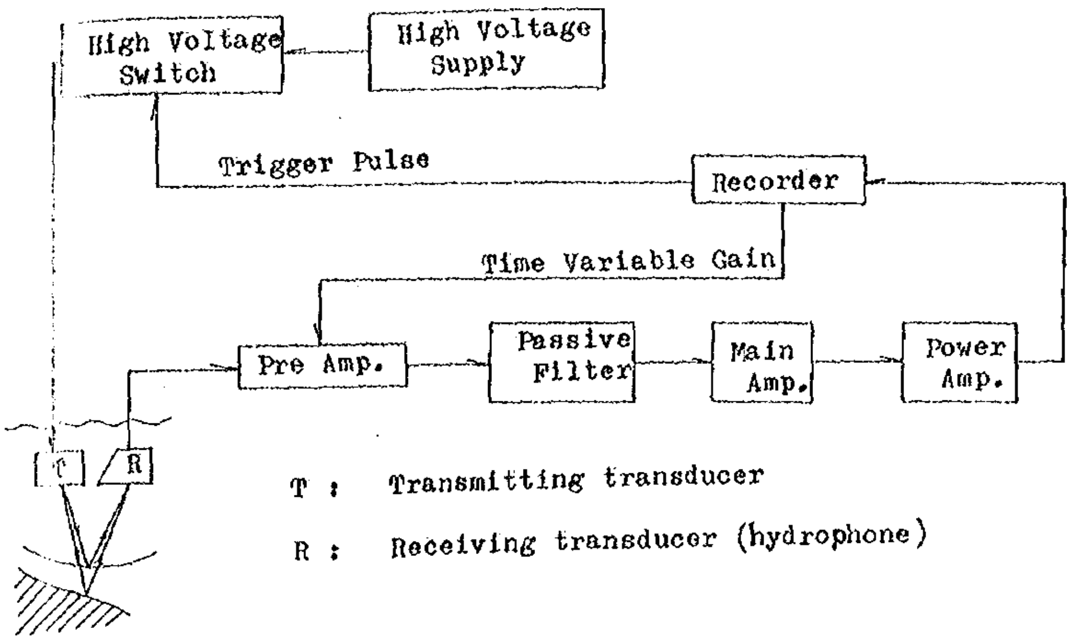


Fig. 3-16 Block-Diagram of Sonostrator

The main units of the Sonostrator (transmitter, receiver, recorder) were installed in the vessel, and the transmitting transducer and receiving transducer were fixed alongside the vessel at depth of 1.5 meters below sea level.

The illustration of the hydrographic survey is shown in Figure 3-17, which also shows the positioning system using Tellurometer.

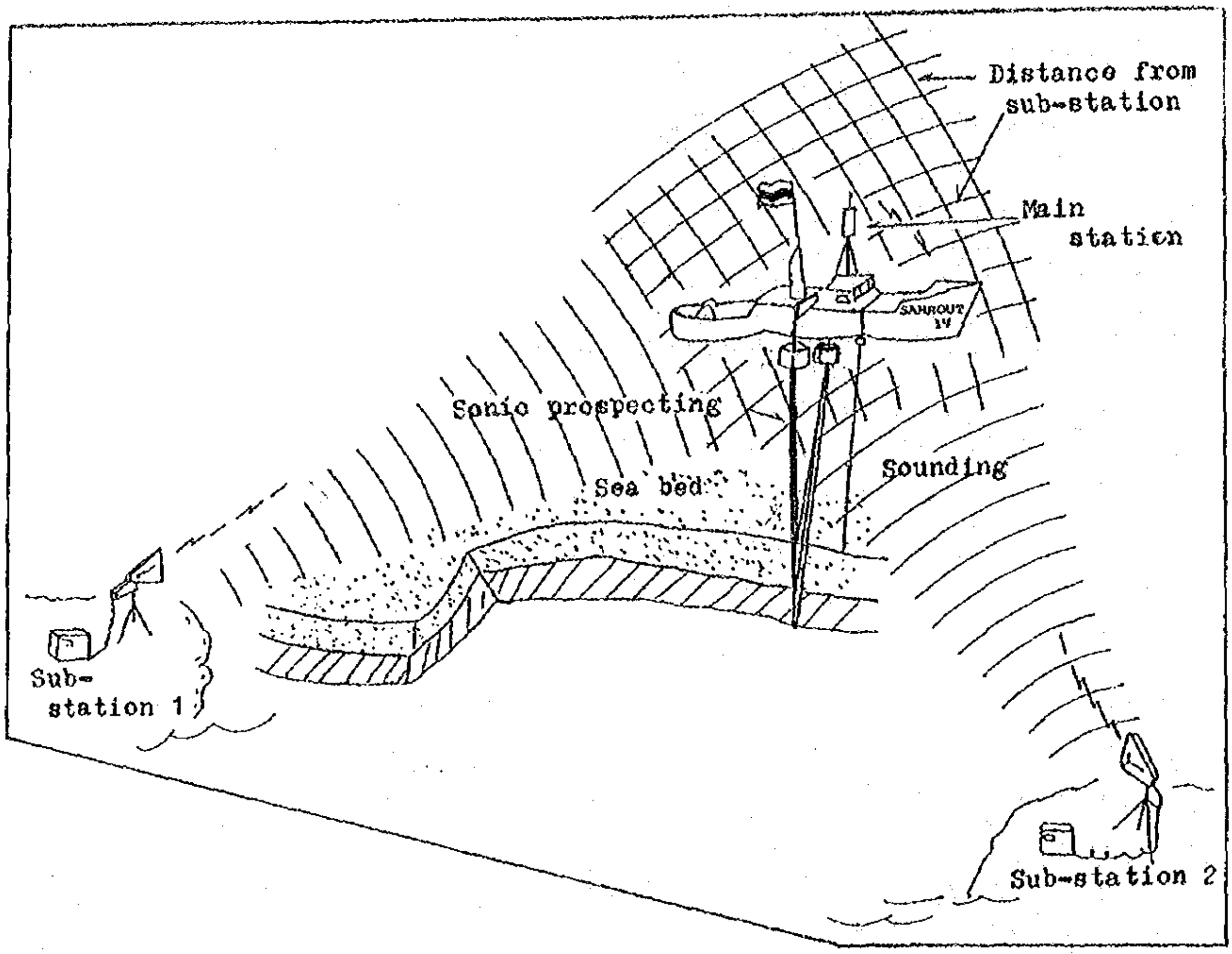


Fig. 3-17 Illustration of Hydrographic Survey

(2) Procedure of Analysis and Interpretation

On the recording paper of sonic prospecting, the sounds are reproduced as light and dark shades corresponding to the strength of the reflected signals from the sea bed and sub-bottom layers which are printed as geologic informations.

Analysis and interpretation of these records were made as follows:

a) Interpretation of Reflected Information and Selection of Reflected Data

The records printed with a striped pattern of light and dark shades include informations not only related but also unrelated to marine geology. Informations unrelated directly to geology are also recorded, such as multi-reflections, side-reflections, diffraction waves, effects from depth of the transmitting and receiving tranducer, and effects of the oscillated wave pattern. The multi-reflections from the sea bed and sub-bottom layers are occasionally indirectly used as geologic informations, however, they generally make the real geologic data ambiguous. Therefore, it is necessary to eliminate these unrelated data, taking into consideration the origin of the data, and then selecting only the geologic informations. By this method of interpreting, the best geologic data are selected from the records and then geologic classifications are made.

b) Comparison with Other Records, Investigation and Cross Correlation of Records

If the positions of the survey vessel are correctly determined and thoroughly interpreted, the water depth, the reflected data and other geologic informations should coincide with each other where the two survey lines cross. In general, there is a possibility that the reflected data does not coincide at the crossing points even though the depths coincide with each other. This is due to the selection of the reflected data. On the other hand, when the depths do not coincide with each other, the positioning must be reviewed, taking into consideration the topography of the sea floor and the reflected data. The same procedure must also be followed for the parallel survey lines. By this method, the records are interpreted and compared with other records, and finally a determination is made on the best reflected surfaces of each stratum and on the significance of other geologic information. At the same time, confirmation and corrections of the position of the survey lines are made.

c) Pattern of Records and Interpretation of Lithofacies

In this stage, various geologic data are finally interpreted into concrete form from the standpoint of geology. Depending on the pattern of the records, the depth of the reflected data and its form, the lithofacies are interpreted for each stratum which was classfied from the reflected data.

At this juncture, it is necassary to compare the existing data with geologic informations. Comparisons with available data obtained from borings make the interpretation complete.

In general, the pattern of the Quarternary lithofacies on the sonic prospecting records is characterized as follows:

Glay silt, Fine Sand:	Shows a light pattern, sometimes has several weak reflections parallel to the surface of stratum.
Medium sand, coarse sand:	Shows striped to bedded pattern, at places includes many fine reflections oblique to surface of stratum.
Gravel:	Shows fine radial pattern congregated irregularly (diffraction waves) and wavy pattern that is congregation of irregular reflections. Below this pattern, records are normally poor and too light.

At the surface of the rock basement, most of the sonic waves are reflected and are not absorbed, therefore relatively stronger reflections are recorded. Below this, there is almost no trace of reflected data recorded.

d) Depth Correction of Reflected Data

The depth information obtained from the reflected data is determined by the time it takes from the emission of the sonic wave to the hydrophone (travel time) as computed by the following equation:

$$D = 1/2 \; VT \; (m)$$

T = travel time (sec)

V = average transmitting velocity in water and layers (m/sec)

D = depth (m)

However, V is taken to be constant (sonic wave velocity of 1,500 m/sec in sea water), so only the travel time is used for determination of the depth.

3-7 Sea-Bottom Materials

Sea-bottom materials sampling was carried out in order to examine the condition of the sea bed in the area under survey. The sampling positions are shown in Figure 2-2 and a cylinder type bottom sampler was used for sampling.

The bottom samples sampled at the shoreline and on the sea were brought in the laboratory for the soil testing of grain size distribution.

3-8 Tide Observation

The tide observation was carried out in order to know the tidal properties, expecially to calculate the harmonic constants and to correct the tidal variation for sounding.

A hydraulic recording tide gauge was installed at Ko Saket. The relation between the tide gauge and the Mean Sea Level at Ko Lak, which is the standard level of topographic maps on land in Thailand, was surveyed by two methods. One is the levelling from the top of Ko Saket, at which it is said that one control point had been before and the elevation of this point is still known. The other is simultaneous comparative tide observations at Ko Saket and at Ban Phala, the elevation at which is known.

The period of the observation was approximately two months from August 17 to October 21, 1982.

3-9 Tidal Current Observation

The tidal current observation was carried out to know the general currents in the area and to evaluate its effects on the movement of sands.

The observation was performed in one layer of two meters below sea surface at three points near the shoreline and in two layers of two meters below sea surface and two meters above sea bed at one offshore point, using Ono's Current Meters for the period of fifteen days and nights in principal.

This current meter is designed to record mechanically the velocity and the direction of tidal currents at the same time. The establishment of the current meter is illustrated in Figure 3-18.

Drogue survey was also carried out in the shallow water area to know the coastal current.

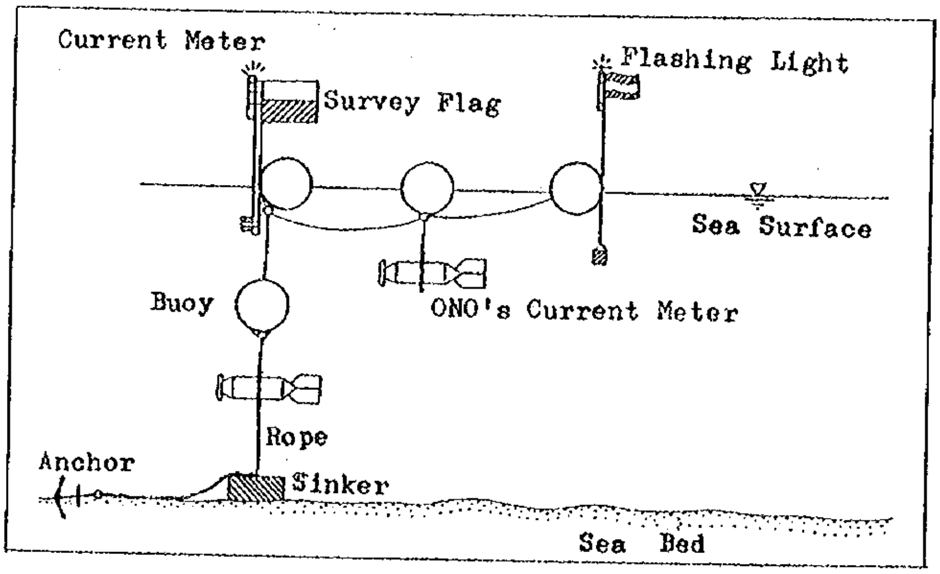


Fig. 3-18 Establishment of Current Meter

3.10 Wave Observation

The wave observation was carried out using a pressure type wave recorder which was installed at the point of about eight meters water depth at the center of the survey area shown in Figure 2-2.

This wave recorder consists of a sensory unit and recorder. The sensory unit conveys the hydraulic change caused by waves to a recorder through the pipe. In this study, the wave recorder operated for ten minutes every two hours.

As the hydraulic type wave recorder cannot indicate the wave shape similar to the actual shape of the surface wave on the record, care should be taken to read actual wave heights from data. This is due to the reason that even their heights are the same, a wave with a longer period has a longer wave length. Accordingly, taking the period for the wave length, the longer the wave length becomes, the stronger the bottom pressure is recorded. For this reason, even if wave height is considerably big, a wave with a short wave length is not recorded clearly. Generally speaking, in the water where the depth is greater than the half of wave length, the wave at the surface don't affect the bottom pressure wave. Therefore, when using this wave recorder, it is necessary to set it at the bottom of such a water that has the depth of less than the half wave length of a wave to be observed.

Since the hydraulic type wave recorder measures the change of bottom water pressure and does not measure the actual surface wave height as described above, it is necessary to perform the following procedure to obtain an actual surface wave height.

Suppose a wave with a height H, Length L is running at the water with a depth of h, as in Figure 3-19. Assume the period of this wave as T, then the following relation theoretically exists between L and T.

$$L = \frac{gT^2}{2\pi} \tanh \frac{2\pi h}{L} \qquad \text{..... (1)}$$

Here, g is the acceleration of gravity, which is 9.8 m/sec^2.

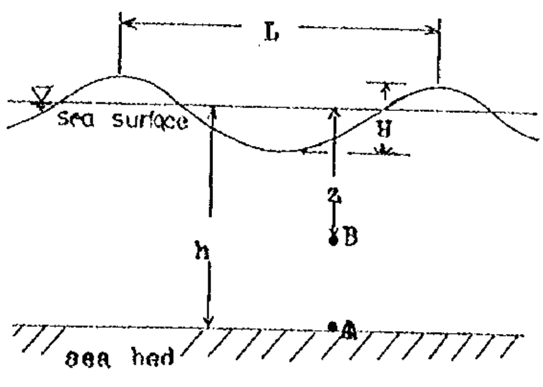


Fig. 3-19 Surface Wave

Hence, the length of the wave is obtained from this relation formula if the depth and the period are known. That is, the length of wave L, is one-valued function of the period T.
Then, the height of pressure wave, $\frac{\Delta PB}{\rho} = P_2$ at a point B with a depth of Z from the surface is theoretically obtained from the following formula.

$$P_2 = \left(\frac{\Delta PB}{\rho}\right) = H \frac{\cosh \frac{2\pi(h-z)}{L}}{\cosh \frac{2\pi h}{L}} \qquad \cdots\cdots\cdot(2)$$

Here, ρ is the density of sea water which is practically considered to be 1.03. Therefore, the height of pressure wave at a point A at the bottom, $\frac{\Delta PA}{\rho} = P_1$, is obtained from the formula (2), considering Z = h.

$$P_1 = \left(\frac{\Delta PA}{\rho}\right) = H \frac{1}{\cosh \frac{2\pi h}{L}} \qquad \cdots\cdots\cdot(3)$$

Therefore, when the period T and the height P of a pressure wave are known from the data recorded by a hydraulic type wave recorder, L can be obtained from the formula (1), and then using the value obtain, H can be obtained from the formula (2) and (3).
That is,

$$H = P_2 \frac{\cosh \frac{2\pi h}{L}}{\cosh \frac{2\pi(h-z)}{L}} \quad \text{(observed at point B)} \qquad \cdots\cdots(2')$$

or

$$H = P_1 \cosh \frac{2\pi h}{L} \quad \text{(observed at point A)} \qquad \cdots\cdots(3')$$

In this way, read the period T and height P of a pressure wave from the record. And when the depth h at the place at the time is known, the height of a surface wave H can be obtained.

The period of the wave observation was approximately two and half months from August 1 to October 21, 1982. The establishment of the wave recorder is illustrated in Figure 3-20.

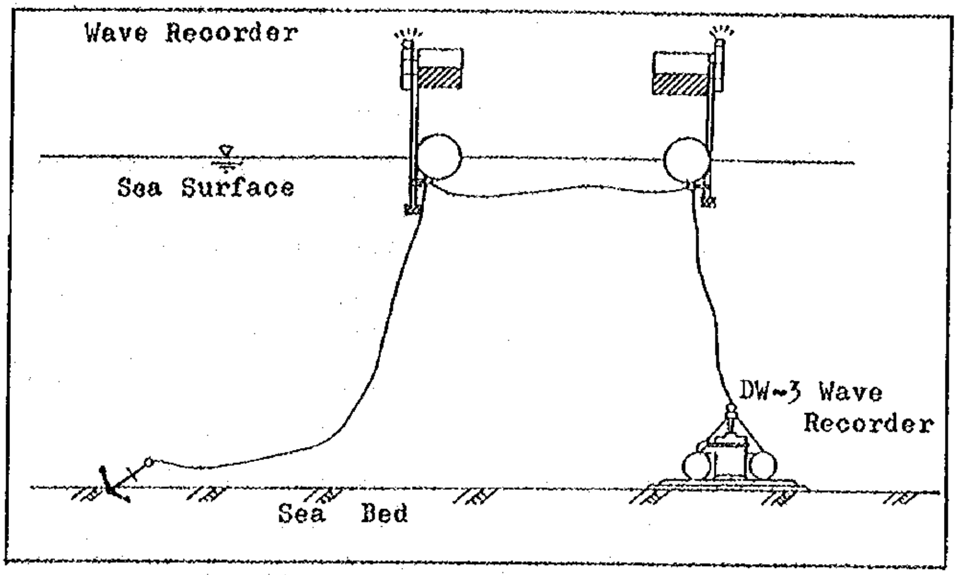


Fig. 3-20 Establishment of Wave Recorder

3-11 Wind Observation

The wind observation was carried out using a wind recorder which was installed at the top of Ko Saket in order to ascertain local wind conditions. The period of observation was approximately two months from August 17 to October 21, 1982.

The wind recorder records the wind direction and the two kinds of wind velocities, that is, average velocity during every ten minutes and instantaneous velocity.

The meteoralogical data were also collected from the meteorological station in U-Tapao as materials of the analysis and interpretation of observed data.

3-12 Littoral Drift

There are various methods for the investigation of littoral drifts, each having merits and demerits in terms of suitability and precision depending on the conditions of the area considered.

In this study, methods of fluorescent sand tracers and two kinds of sand traps were used.

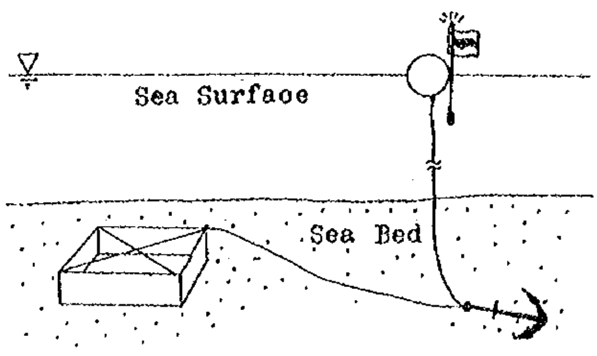
Fluorescent sand tracers, which have different colors, were set at three points at the depth of about five meters shown in Figure 2-2. After setting fluorescent sand tracers, bottom materials were sampled five times around the setting point at some interval to grasp the daily variation of the sand movement, and were brought in a loboratory to counter the numbers of fluorescent sands. Then, the distribution of fluorescent sands can be gained corresponding to the sampling time. This method, so to speak, is Lagrangian method to estimate the littoral drift from places and times of the setting point and sampling point.

Regarding to the sand trap, two kinds of sand traps were set at the center of the survey area. One was a sand trap what is called a sand tube for floating sands, and the other was a sand trap what is called a sand box for sliding and rolling sands. The sand trap tube was set on the sea bed at the depth of about five meters. The mouths of the trap were directed to four directions (north, east, south, west), and the heights of mouths were 30 cm, 60 cm, and 90 cm above the sea bed.

The sand trap box was flatly set on the sea bed at the depth of about four meters on the north side of the sand trap tube. The inside of the sand trap box was divided into four rooms, that is directional rooms which set to the direction of the north, east, south and west.

The establishment of sand traps is illustrated in Figure 3-21. This sand trap method, so to speak, is Euler's method to estimate the littoral drift from volumes of sands trapped in some points.

(a) Sand Box



(b) Sand Tube

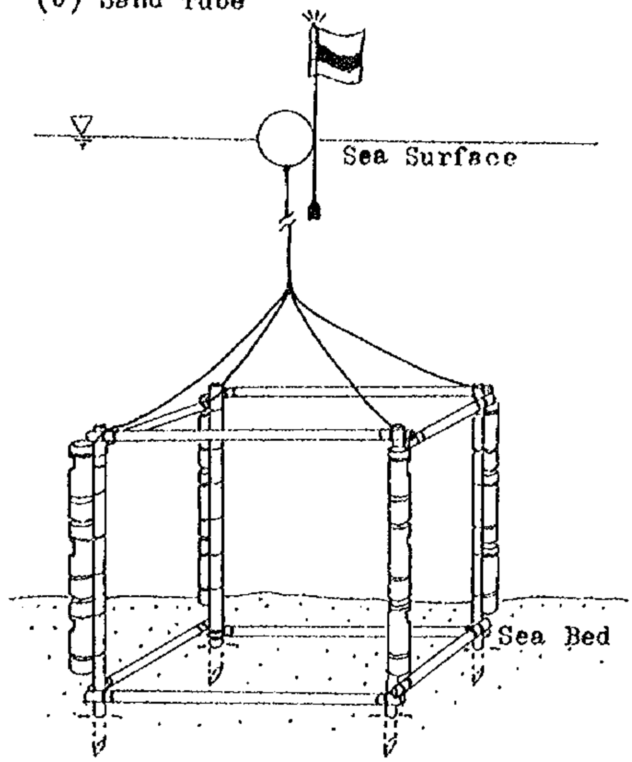


Fig. 3-21 Establishment of Sand Trap

4. RESULTS OF SURVEY

4-1 Topography

4-1-1 Topography on Land Area

The topographical features on land around the survey area are characterized by hills, terraces and low land plains.

Khao Khrok and Khao Noen Kraprok are representative hills which are distributed in the northern part of the survey area. The elevation of these hills are approximately 400 meters. Other typical hills are running south to north around Sattahip adjacent to the west side of the survey area and around Khao Yai Da to Laem Ya adjacent to the east side of the survey area. The elevation is approximately 200 to 300 meters around Sattahip and 600 to 700 meters around Khao Yai Da. Generally speaking, the slope of the hills descends at the gradient over 1/10.

Terraces expand from the surrounding of hills to the vicinity of the shoreline. The terrace plain is gentle rise and fall, being dissected by small rivers. The slope of the terrace plain is generally approximately 1/100, and partly over 1/20. Sea cliffs are in the west side of Ban Ao Pradu, which is situated on the opposite shore of Ko Saket, and at which the terrace fronts are close to the shoreline. The relative height of the sea cliff is approximately 5 to 10 meters. In the vicinity of piedmonts of hills, there are recent alluvial fans.

Low land plains are distributed from the eastern part of the survey area to the vicinity of Rayong and to the basin of the Khlong Yai in the north part of Rayong. The low lands near the shoreline are alternation of sand bands (sand-dunes) and back swamps parallel to the shoreline. The low land of the inland area is mainly floodplain of the Khlong Yai, in which swamps are widely observed. The slope of the low land plain is under 1/100.

The topographical map at scale of 1:100,000 reduced from the existing maps is shown in Figure 4-1, and the topographical map of the survey area is shown in attached map at the end of this report at scale of 1:30,000 including sea area. This topographical map is reduced from the topographical maps at 1:10,000 which is the final result of the topographic survey of this study, and which is shown in the separate report "Survey Data".

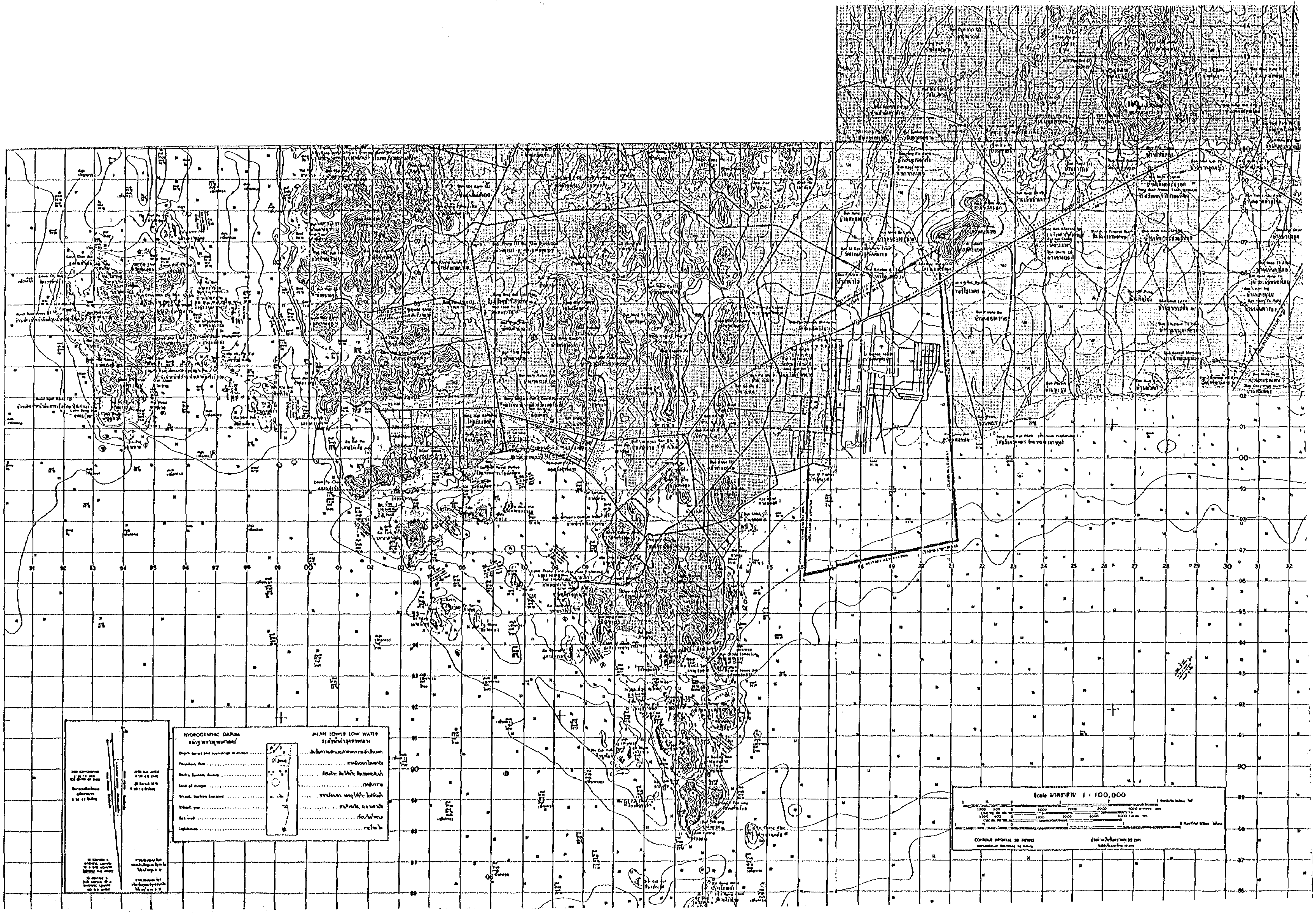
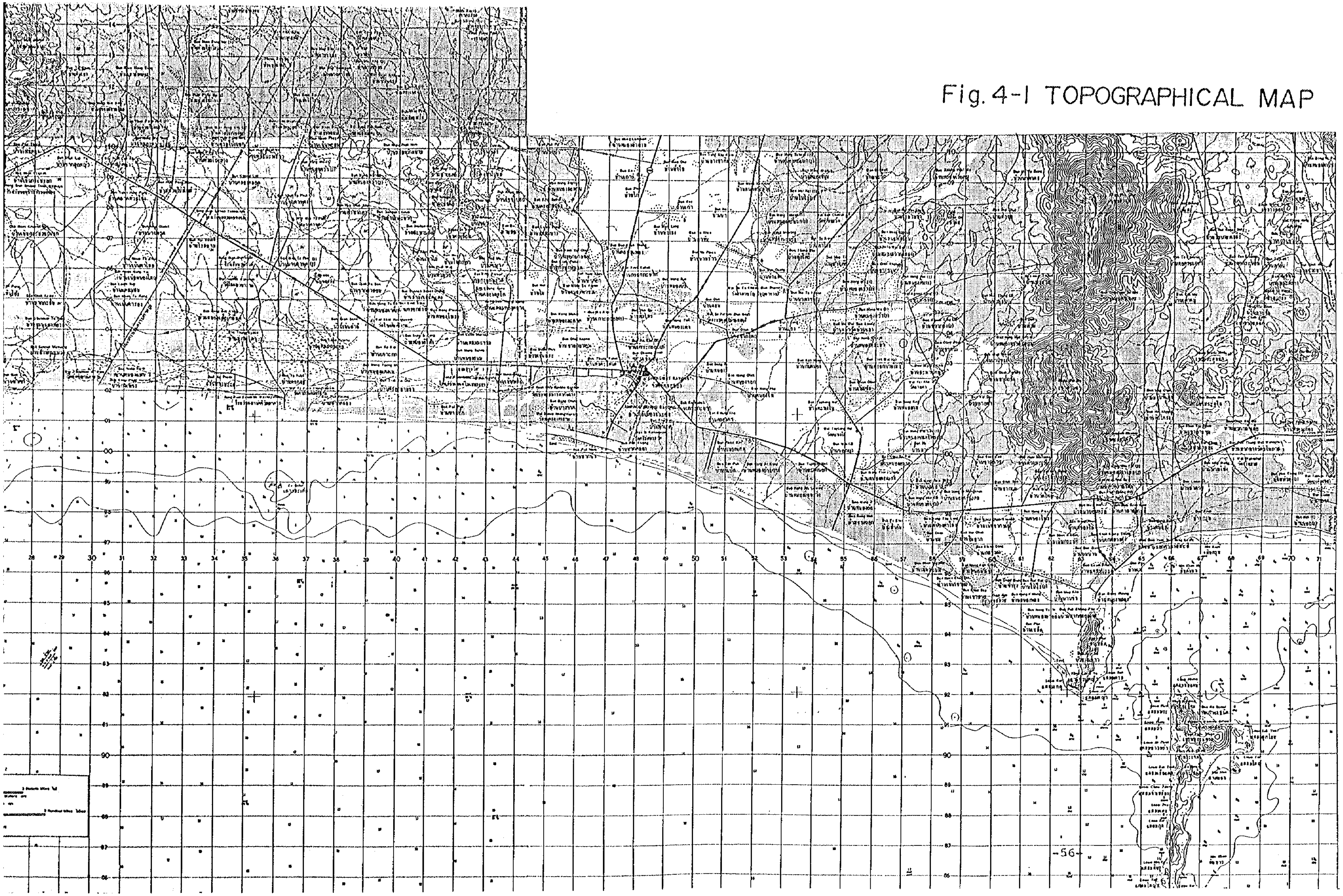

HYDROGRAPHIC DATUM
MEAN LOWER LOW WATER
1 : 100,000
CONTOUR INTERVAL 20 METERS

Fig. 4-1 TOPOGRAPHICAL MAP



4-1-2 Topography of Shoreline

The shoreline in the vicinity of the survey area makes a big curve as the center of the survey area is put aside to north. In the eastern end and western end of the shoreline, the capes named Laem Ya and Laem Samae San respectively run out into the sea. The coastal area between Laem Ya and Laem Samae San is composed of a sand beach except the vicinity of control points "Ban Phala", K-7 to K-8 (near Ban Phayun), and K-13 to K-14 (near Ban Nam Tok) where rocky outcrops are observed.

Sea cliffs, described above, are observed at Ban Ao Pradu to Ban Phala having a relative height of over 1.0 meter in maximum at the north part of control points K-13 to K-14.

On the other hand, in the east side of Ban Ao Pradu sand bands having a elevation of 2 to 3 meters above M.S.L. (Koh Lak standard) are widely observed in front of the sea.

Small rivers flow into the sea in the survey area and make estuarine sand bars which vary their features all the time.

The representative topographical profiles of the shore zone perpendicular to the shoreline are shown in Figure 4-2 based upon the results of the shoreline survey. The number of these profiles is the control point number shown in Figure 3-1. Therefore, the profiles show the topographical features of the shore zone between 130 meters inland and 330 meters offshore from the control points with a few exceptions.

Seeing the topographical profiles in survey area, the topography of the fore-shore is divided broadly into four areas. The first one is the west side of the contol point "Ban Phala" (E 721.683 km) having a gentle gradient of about 4/100 between + 4 meters and - 1 meter with Chart Datum Level (CDL) which is 2.19 meters below Mean Sea Level at Koh Lak (MSL). The second one is the area including the control points K-6 (E 723.763) and K-10 (E 725.961), which has a comparatively sharp gradient of about 12/100 to 15/100 between + 4 meters and + 1 meter above CDL because of the sea cliff's approach to the shoreline. The profile of K-13 (E 727.662) is a typical feature in a rocky outcrops zone. The last one is the wide area including the control points S (E 729.944) to K-34 (E 740.046), namely the eastern half of the survey area. The gradient of the fore-shore (+ 4m to zero above CDL) is 5/100 to 10/100 and the gradient from zero to - 2m is 1/100 to 1/200 in general.

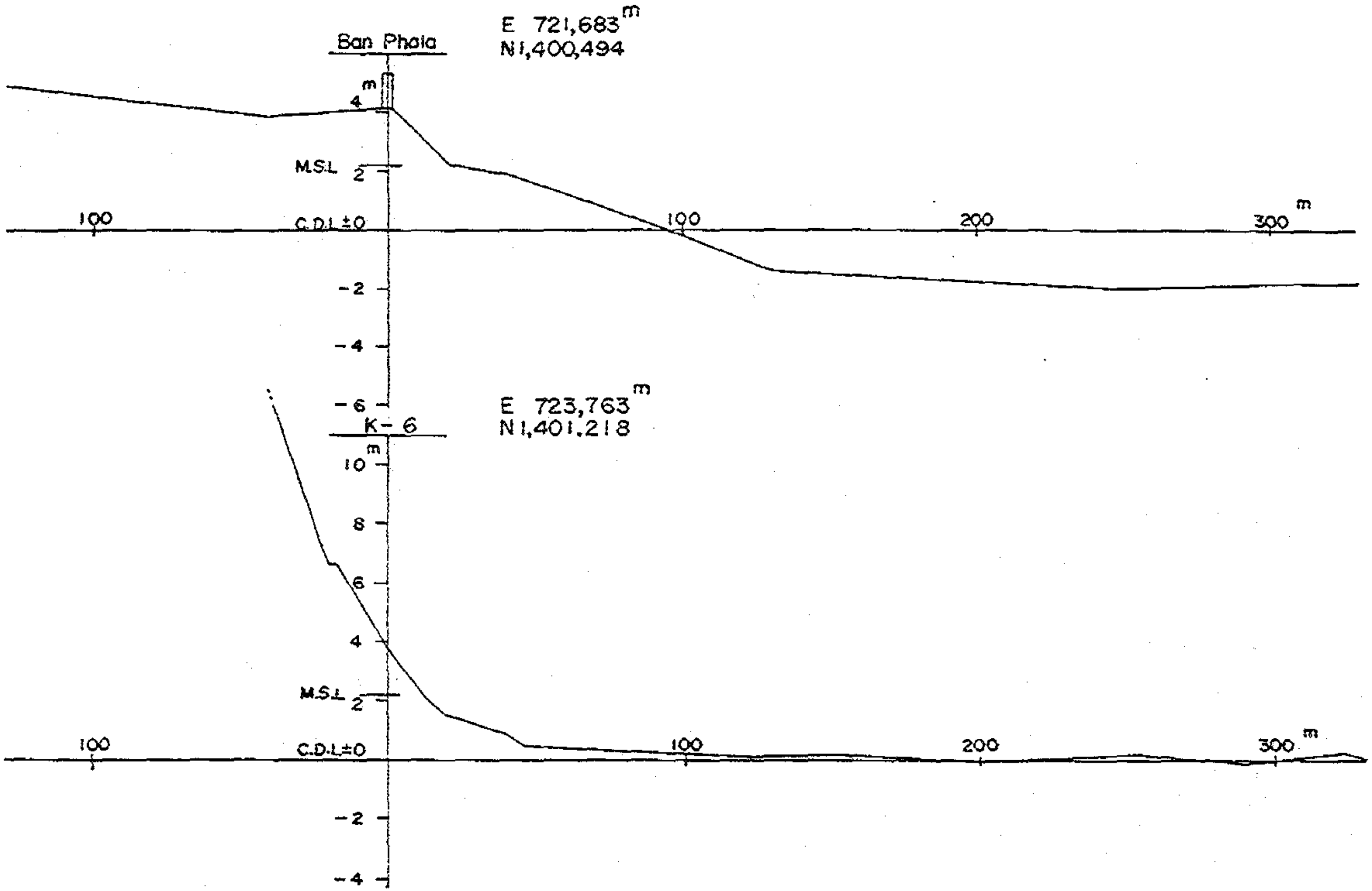


Fig. 4-2(1) Topographical Profiles

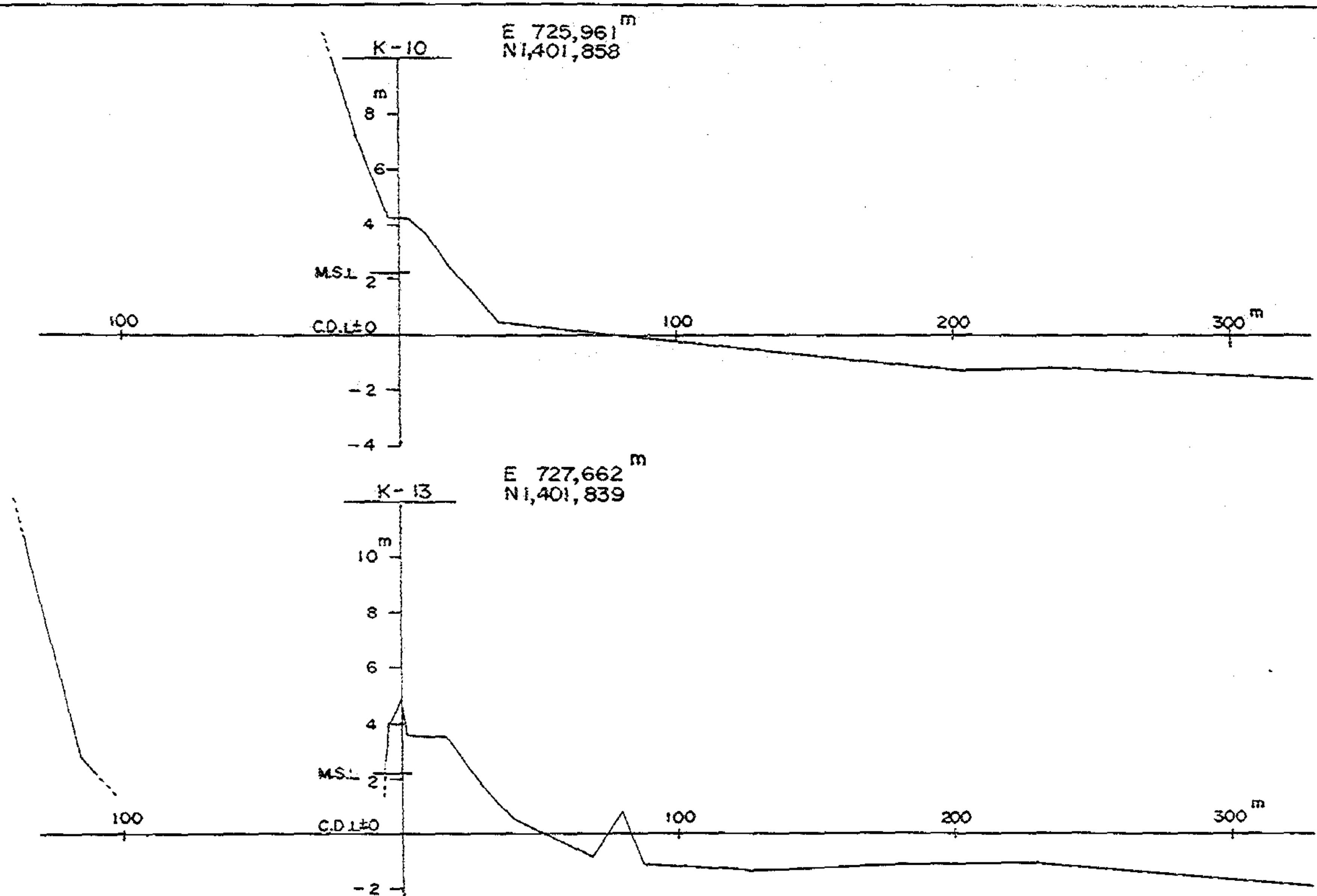


Fig. 4-2 (2) Topographical Profiles

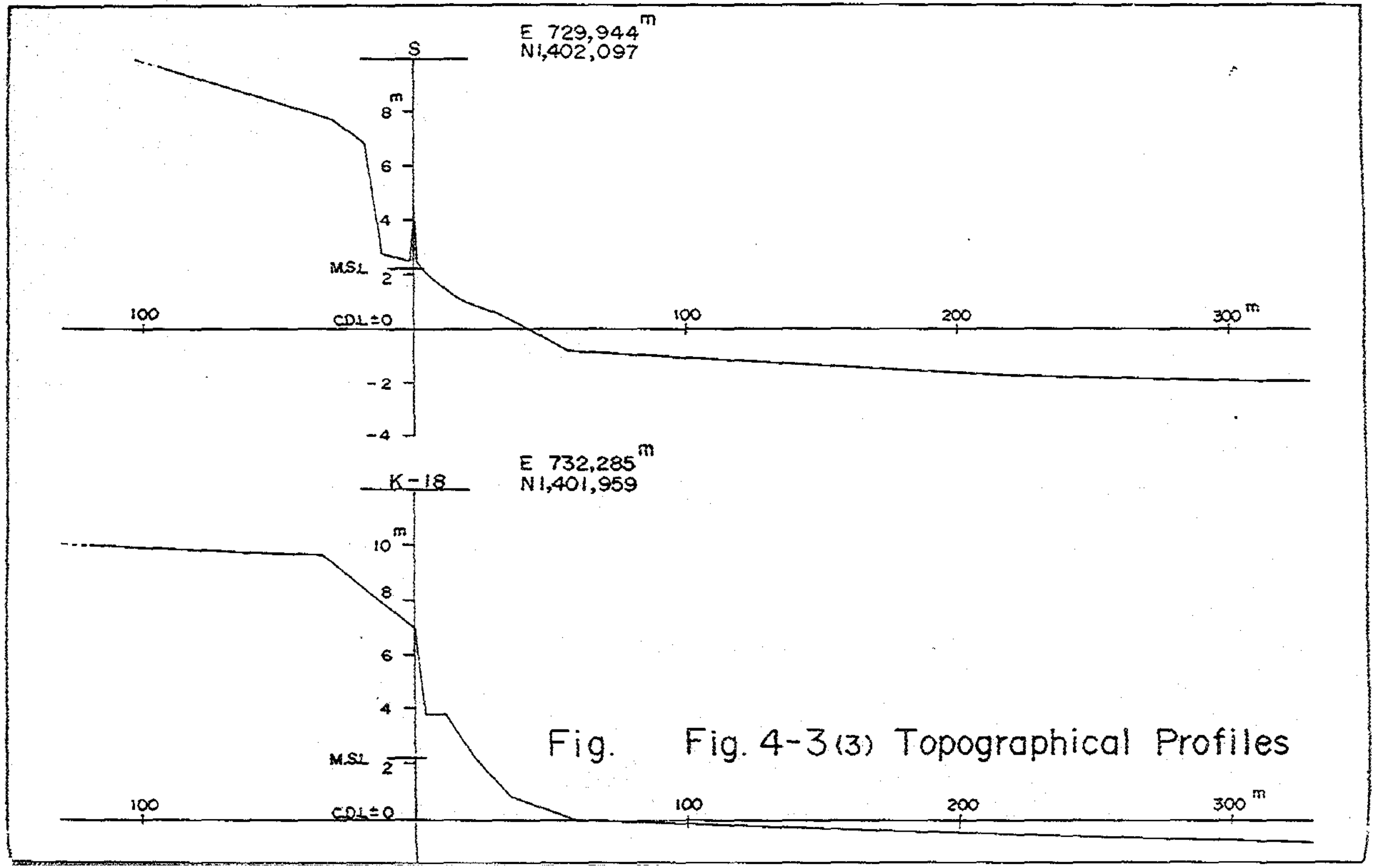


Fig. Fig. 4-3 (3) Topographical Profiles

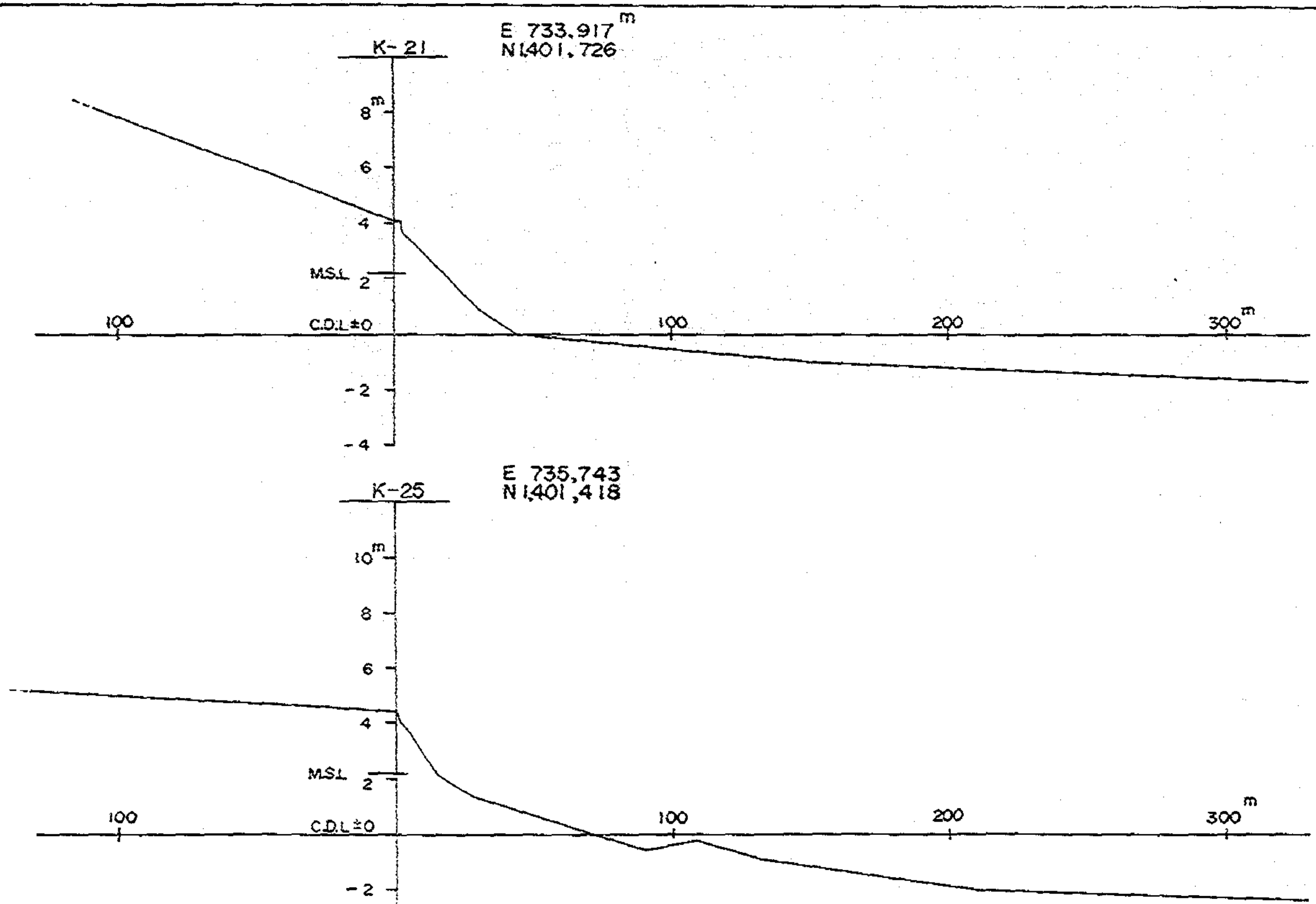


Fig. 4-2 (4) Topographical Profiles

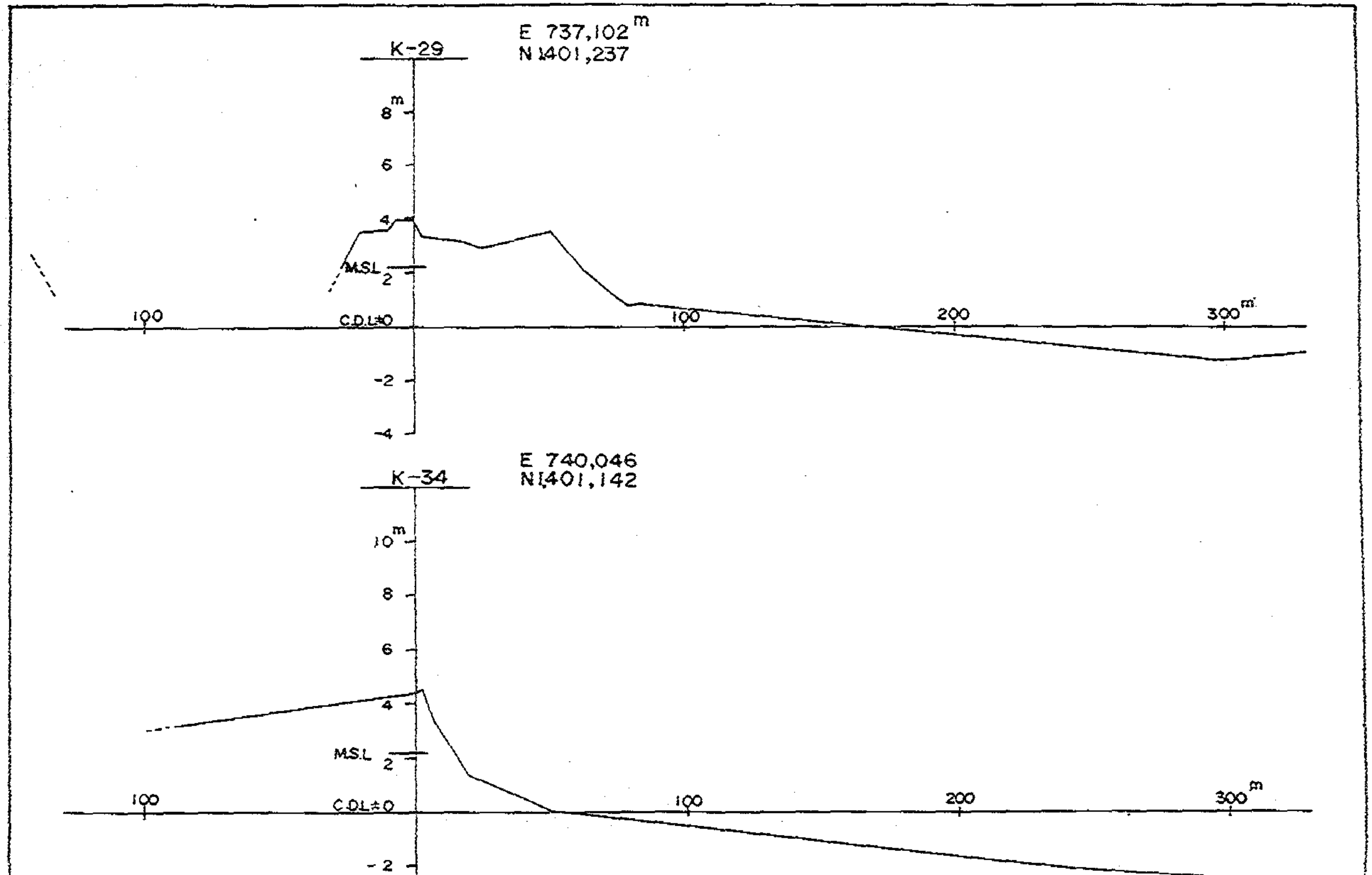


Fig. 4-2 (5) Topographical Profiles

4-1-3 Islands and Rocky Outcrops

The representative island in the survey area is Ko Saket, which is the Tai ward for the island of Saket. Ko Saket is located approximately two kilometers offshore from the shoreline near Ban Ta Kuan which is called the Saithon Beach, and less than one kilometer in circumference.

On the west side of the survey area, a range of islands named Ko Raet, Ko Samae San and Ko Nok runs southwards from Laem Samae San. On the other hand, Ko Samet is located at south of Laem Ya on the east side of the survey area.

Rocky outcrops, as described before, are distributed on the west side of the pipeline. Especially, "Hin Khong" outcrops 1.5 kilometers offshore of the control point K-13 near Ban Nam Tok is typical and some rocky outcrops are observed from the vicinity of Hin Khong to the offshore area of Ban Phala. Many rocky outcrops are also observed within 500 meters of the surrounding of Ko Saket.

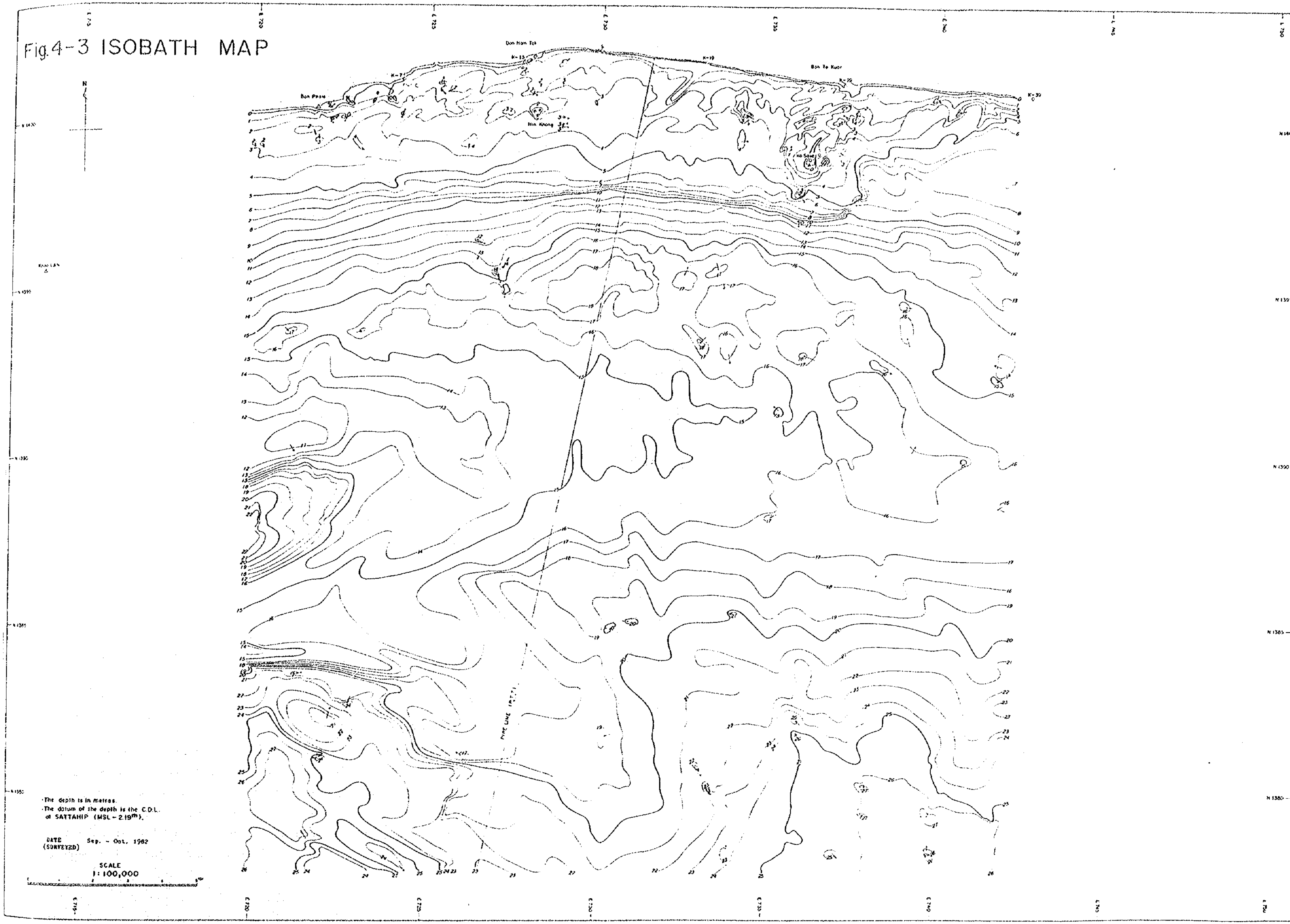
4-1-4 Bathymetry

The topography of the sea bed in the survey area is divided broadly into four morphologic sections. The first morphologic section is a planation surface observed in the shoreline to the water depth of about 6 meters to 9 meters with the datum of Chart Datum Level (CDL = MSL - 2.19 m; hereafter used CDL as the datum of hydrography). The second morphologic section is another planation surface observed on the offshore area more than about 5.5 kilometers apart from the shoreline. The third morphologic section is the slope between the first section and the second section. The fouth morphologic section is a depression like a caldron observed in the southwest part of the survey area.

The isobath map of the survey area is shown in Figure 4-3 based upon the results of the sounding. More detailed maps at scale of 1:10,000 is attached in the separated report "Survey Data", and the topographical map reduced from the above maps and including the land area is shown in attached map at scale of 1:30,000 at the end of this report.

(1) The first morphologic section is subdivided into four tracts; namely the east side of Ko Saket, the vicinity of Ko Saket, the area between Ko Saket and the pipeline, and the west side of the pipeline.

Fig.4-3 ISOBATH MAP



In the east side of Ko Saket, the sand bar with strikes NE and oblique to the shoreline is found in the shallow area less than 5 meters. The planation surface is apparent in the water depth of 6 to 9 meters.

The feature of the sea bed in the vicinity of Ko Saket is characterized by rocky outcrops. The sand bar with strikes ENE is also found between Ko Saket and the Ban Takuan beach.

On the area between Ko Saket and the pipeline, the contour line of 6 meters which is the outer boundary of the planation surface is 3.5 kilometers offshore. This area have a wide and gentle planation surface on the whole. Outcrops, however, are found in the center of this area which is located about 1.3 kilometers offshore of Ban Ao Pradu. The sand bar with strikes NE is found between these outcrops and the pipeline.

The sea bed in the west side of the pipeline is flat on the whole till the contour line of 6 meters. Outcrops, however, are scattered all over the area.

(2) The second morphologic section is subdivided into two tracts. One is the tongue-like salient distributing widely from the center of the west side in the survey area about 10 to 11 kilometers offshore towards the west, having the water depth of 15 meters or so. In the northern and eastern parts of the above tongue-like salient, the depression of 16 to 18 meters water depth is found.

The other tract is the offshore area in the east side of the pipeline. In this area, the water depth increases gently towards the southeast. Small depressions are found here and there more than 20 meters water depth.

(3) The third morphologic section is the slope located between the above first section and second section.

The average grade is about 4/1,000 between 6 and 13 meters water depth on the western part, and about 6/1,000 between 6 and 15 meters water depth from the vicinity of the pipeline to the offshore area of Ko Saket. On the eastern part, the slope is obscure.

Some outcrops are found in the area of about 3 kilometers apart towards the west from the pipeline.

(4) The last morphologic section is located in the southwest side of the second section described above and located in the west side of the pipeline. The feature of this section is characterized by the elliptic depression with strikes NE which is found at the western boundary of the survey area.

On the southeast side of this depression, some depressions and salients are arranged extending southeastward.

4-2 Geology

4-2-1 Outline of Geology

The stratigraphy in Thailand ranges in age from Precambrian to Recent as shown in Table 4-1.

Table 4-1 Stratigraphy in Thailand

ERA	PERIOD		Brown et al.	C. Javanaphet et al.
Cenozoic	Quaternary	Recent	Alluvium	Alluvium & River gravel
		Pleistocone	Terrace deposits	Terrace deposits
	Tertiary	Neogene	Krabi Series	Krabi Group
		Paleogene	Mae Sot Series	Mae Moh & Li Formation
Mesozoic	Cretaceous		Khorat Series	Khorat Group Salt & Khok Kruat Formation
	Jurassic			Phu Kradung Formation
	Triassic			Lampang Group Marine Formation
Paleozoic	Permian		Ratburi Limestone	Ratburi Group Ratburi Formation
	Carboniterous			
	Devonian		Kanchanaburi Series	Tanaosi Group Kaeng Krachan & Kanchanaburi Formation
	Silurian			
	Ordovician		Thungson Limestone	Thungson Group
	Cambrian		Phukot Series	Tarutao Group
Eozoic	Precambrian		Interred from pebbles in Phuket Series	

(NEDECO. 1972)

The stratigraphy of Sattahip to Rayong area consists of Precambrian, Paleozoic, Mesozoic and Quarternary in age as shown in Figure 4-4.

Precambrian basement rocks are distributed around Khao Yai Da and Ko Samet which are adjacent to the eastern boundary of the survey area. The basement rocks may be divided into two typical belts. One is composed of quartz-mica schist, quartz-kyanite schist and other crystalline schist rocks. The other is composed of gneisses, amphybolite and calc-silicate rocks.

Paleozoic may be divided into two groups. One is "Tanaosi Group" (C. Javanaphet, 1969) distributed in the hills around the Sattahip area. This Tanaosi group is composed of quartzite, quartz schist, sandstone, metasandstone, metasiltstone, slate, phyllite, phyllitic shale, hornfels, marble, limestone and other sedimentary or metamorphic rocks. The limestone is often mixed with dalomatic and argillaceous rocks. The group around Sattahip is considered to be of Ordovician age (S. Sarapirome, 1982). The other group of Paleozoic is named "Ratburi Group" (C. Javanaphet, 1969) distributed in the east side of Khao Yai Da. The Ratburi group is composed of sandstone, conglomerate, tuffaceous shale, chert and other sedimentary rocks. This group is considered to be of Carboniferous to Permian (S. Sarapirome, 1982).

Granitic rocks are distributed in the hills belt of the northern part of the investigated area. These granitic rocks are characterized by coarse-grained porphyritic texture of adamellite type and are regarded as of Triassic age by an isotopic age determination.

As the Tertiary rock does not exist in this area, Quarternary deposits overlie the above bedrock directly and unconformably. Pleistocene terrace deposits are fan deposits provided mainly from granitic rocks and are composed of gravel, sand, silt and clay.
Recent deposits are distributed in the law plain of the Khlong Yai Basin and near the shoreline. These deposits are mainly composed of alluvium and beach sand.

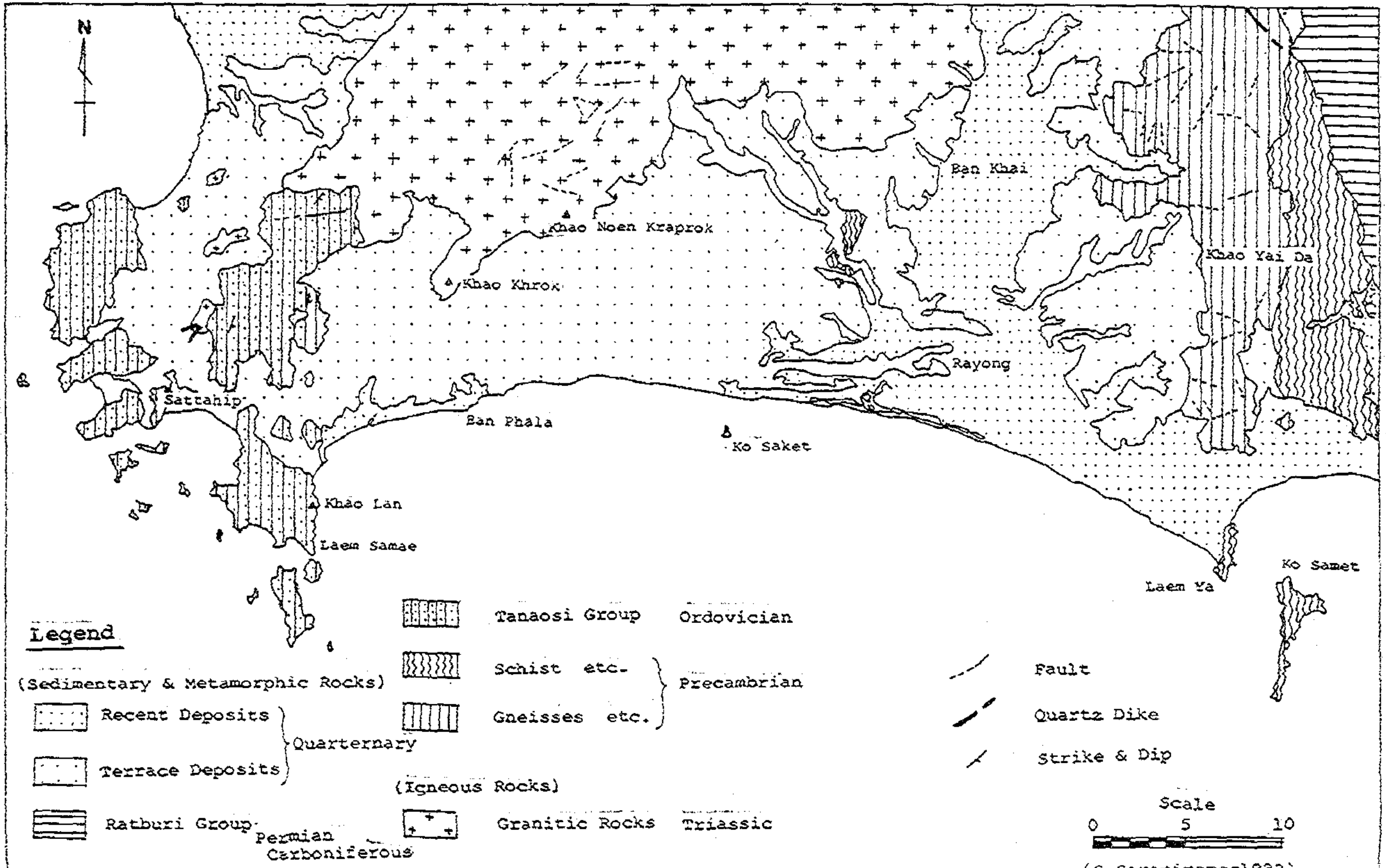


Fig. 4-4 GEOLOGICAL MAP (Sattahip to Rayong Area)

4-2-2 Geological Classification

The stratigraphy in the investigated area consists of granitic rocks, terrace deposits and recent deposits as described above.

From the results of the soil investigation, the seismic prospecting, the electrical prospecting and the sonic prospecting, the geological classification of the investigated area and the characteristics of layers classified are as fallows.

(1) Soil Investigation

The results of exploratory borings are shown in Figure 4-5 as Drilling Logs. With regard to the representative cross sections, geological profiles are shown in attached figures at the end of this report including the results of geophysical prospeatings.

It has been made clear that the stratigraphy in the investigated area consists of granites as basement rocks and unsolid deposits of Quarternary age which overlie the granites unconformably.

a) Granite

The granite is characterized by coarse-grained porphyritic texture of rock-forming minerals and by leucocratic rocks composed of achromatic minerals, nemely quarty and feldspar.

According to the results of exploratory borings, the granite is highly weathered even in the deeper part both on land area and on offshore area.

Generally speaking, the reason why the weathered layer of granite is distributed in broad ranges comparing with other layers is considered to be the physical and chemical properties of granite itself. Namely, the granite is easy to be weathered by the physical weathering because of its large crystals. Under the conditions of the repetition of heating and coaling for a long period, the combination of minerals is decomposed because of the partial concentration of the stresses by expansion and constriction corresponding to the physical characters. Adding that, the mica and feldspar of rock-forming minerals of granite are physically and chemically unstable comparing with quarts. and are granulated and transformed into secondary minerals like clay and so by the chemical weathering.

The granite in the investigated area has developped joints and cracks, and is abundant with feldspars which are easy to be weathered.

On the other hand, outcrops of unweathored granites are observed at Ko Saket, in the coastal area from Ban Nam Tok to Ban Phala, and at Khao Khrok located in the north part of the inrestigated area.

By the observation of boring samples, it was clarified that feldspars have throughly been decomposed into clayey secondary minerals in the uppermost part where the weathering is in its final stage. The quartz, however, remains granulated gravels of 2 to 5 milimeters in diameter. We call this weathered part "Highly Weathered Granite". The thickness of highly weathered granite is approximately 13 to 17 meters on the shore area, namely at Boring Point No.1, No.2 and No.3, and very thick on the inland area, namely 31 meters or more at Boring Point No.4. Though the original rock structures can be also found in highly weathered granite, it is easy to crush down by finger-tips.

With respect to the degree of weathering, it becomes weaker with depth. Therefore, it is difficult to distinguish clear boundaries of the degree of weathering. In this study, we call the granite in lower stage of weathering "Weakly Weathered Granite" judging from the time spent for drilling and the observation of samples.

On this exploration borings, the fresh granite could not be found out.

b) Quarternary Deposits

The quarternary deposits are composed of fluviatile and marine un-consolidated clastic deposits and divided into terrace deposits, sand dune deposits and alluvium.

The terrace deposits widely overlie the granite both on land area and offshore area, and are mainly composed of particles of granite origin. These deposits are classified into clayey sand, clayey gravel, sandy clay and gravely clay. Sand and gravel mainly consist of quartz and gravels are pebble as much as 2 to 5 milimeters in maximum diameter. Fine-grained soils are abundant in clay and sticky.

The sand dune deposits are distributed in the coastal area of the east side of the pipeline and consist of fine-grained sands, which were reconognized at Boring Point No.2.

Alluvium is seen in the law plain along the rivers and covers terrace deposits, and composed of very loose sands.

Fig. 4-5(1) DRILLING LOG

No. 1

Location On land, RAYONG PROV (26^78, 01^96)

Elevation G.L. [illegible]

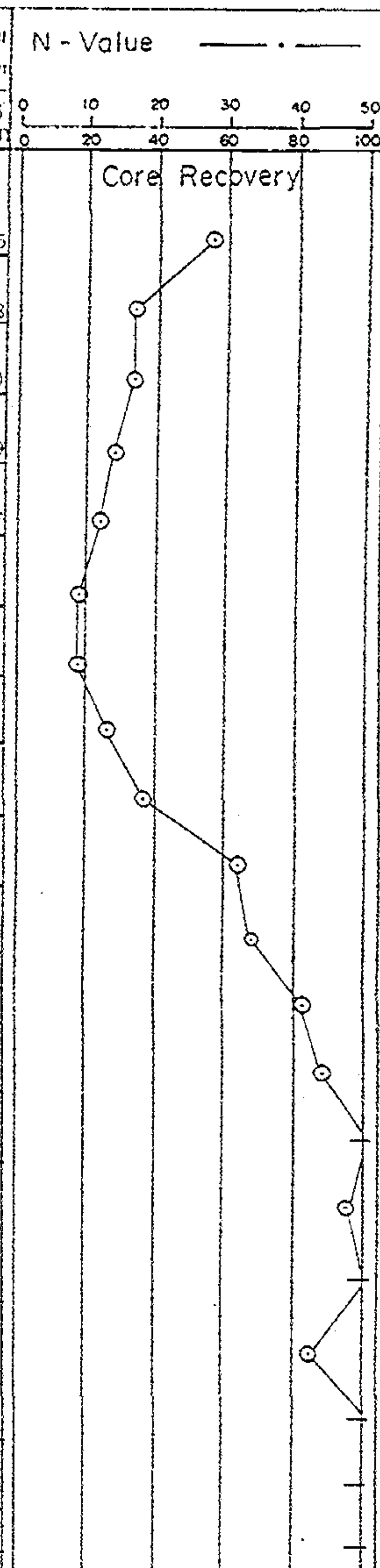
Date 14. Aug ~ 19. Aug. 1982

Wate Table GL -1.0 m

Scale in m	Elevation in m	Depth in m	Thickness	Legend	Colour	Type of soil	General Remarks	Relative Density or Consistency
0–1.30	+ 9.90	1.30	1.30		Yellowish brown	Silty fine to medium sand		
1.30–3.70	+ 7.50	3.70	2.40		Yellowish grey	Gravely clay	·With higher content of gravel ·With pebble of quartz as much as 2 ~ 3 mm in maximum diameter	
3.70–5.50	+ 5.70	5.50	1.80		Light grey	Medium to coarse sandy clay	·With sand	
5.50–7.70	+ 3.50	7.70	2.20		Yellowish grey ~ Brownish grey	Fine sandy clay	·With pebble of granite	
7.70–9.60	+ 1.60	9.60	1.90		Yellowish brown	Silty fine to medium sand	·With pebble of granite	
9.60–26.50	-15.30	26.50	16.90		Brownish grey ~ Dark yellowish grey ~ Brownish grey ~ Dark yellowish brown	Highly weathered granite	·Becoming " masa - do " condition by the weathering, and feldspar becomes completely clay condition ·Remains the original rock structure of granite, but can be crushed easily by a finger ·Degree of the weathering becomes lower from the depth of about 18m.	
26.50–27.00	-15.80	27.00	0.50		Grey	Weathered granite	·Drill using the diamond bit	

Standard Penetration Test

Depth in m	N-Value Blows / 30 cm	Blows Per Each 10cm: 15 cm	15 cm	15 cm
1.15 – 1.45	28	5	13	15
2.15 – 2.45	17	10	9	8
3.15 – 3.45	17	5	7	10
4.15 – 4.45	14	3	5	9
5.15 – 5.45	12	4	5	7
6.15 – 6.45	9	3	4	5
7.15 – 7.45	9	3	4	5
8.15 – 8.45	13	3	5	8
9.15 – 9.45	18	5	7	11
10.15 – 10.45	32	10	14	18
11.15 – 11.45	34	8	12	22
12.15 – 12.45	41	8	16	25
13.15 – 13.45	44	10	18	26
14.15 – 14.45	51	13	20	31
15.15 – 15.45	18	14	20	28
16.15 – 16.45	70	14	30	10
17.15 – 17.45	43	13	18	25
18.15 – 18.45	120	20	43	77
19.15 – 19.45	169	28	63	106
20.00 – 20.13	165/13	165/13		



Sampling Depth in m | In-situ Test Depth in m

Kokusai Kogyo Co. Ltd.

Fig. 4-5(2) DRILLING LOG

No. 2

Location On land. RAYONG PROV. (34.34.01.96)

Elevation C.D.L. +6.7 m

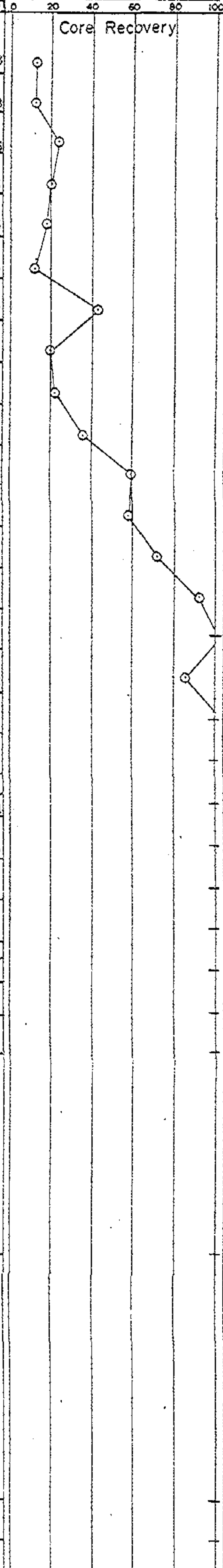
Date 14. Aug ~ 20. Aug. 1982

Wate Table m

Elevation in m	Depth in m	Thickness	Colour	Type of soil	General Remarks	Relative Density or Consistency
+5.00	1.70	1.70	Dark Brown	Fine sand		
-0.10	6.80	5.10	Greyish brown / Light grey	Fine to medium sand	·Almost consists quartz sand ·With pebble of quartz about 2 ~ 3 mm in maximum diameter. ·With clay fraction.	
-4.90	11.60	4.80	Light grey	Clayey medium to coarse sand	·With much clay fraction ·With pebble of quartz of ø 2 ~ 3 mm. ·Mainly consists of quartz sand.	
-8.20	14.90	3.30	Light grey	Clayey gravel	·Gravel consists of pebble of quartz as much as 2~5mm in maximum diameter.	
-12.10	18.80	3.90	Light grey	Sandy clay	Consists of high sticky clay.	
-14.30	21.00	2.20	Dark Brown	Clayey gravel	With mica flakes and decayed feldspar.	
-16.30	23.00	2.00	Light grey	Clayey medium to coarse sand	With much clayfraction and with pebble of quartz	
-29.30	36.00	13.00	Grey / Light grey	Highly weathered granite / Weatherd granite	·Becoming "masa - do" condition by the weathering. ·Feldspar becomes completely clay ·Remains the original rock structure of granite, but can be crushed easily by a finger.	
-30.31	37.01	1.01	Light grey	Weathored granite		

Standard Penetration Test

Depth in m	N-Value Blows/30cm	Blows Per Each 10cm: 15cm	15cm	15cm
1.15–1.45	6	2	3	3
2.15–2.45	6	[illegible]	3	3
3.15–3.45	12	6	6	6
4.15–4.45	10	5	5	5
5.15–5.45	9	4	4	5
6.15–6.45	6	3	3	3
7.15–7.45	21	11	12	9
8.15–8.45	10	3	5	5
9.15–9.45	11	4	5	6
10.15–10.45	18	6	9	9
11.15–11.45	30	12	15	15
12.15–12.45	29	9	12	17
13.15–13.45	36	13	19	17
14.15–14.45	46	19	21	25
15.15–15.45	60	12	25	35
16.15–16.45	43	15	21	22
17.15–17.45	60	17	27	33
18.15–18.45	84	21	42	42
19.15–19.41	124/26	36	54	70/11
20.15–20.45	73	20	33	40
21.15–21.45	95	23	40	55
22.15–22.45	79	30	35	44
23.15–23.41	119/26	19	39	80/11
24.15–24.21	80/6	36 80/6		
24.21–25.00	70/13	70/13		
25.13				
30.00–30.05	90/5	90/5		
36.00–36.03	80/3	80/3		
37.00–37.01	80/1	80/1		



Kokusai Kogyo Co. Ltd.

Fig.4-5(3) DRILLING LOG

No. 3

Location On land, RAYONG PROV. (29.18, 02.94)

Elevation G.L. [illegible] m

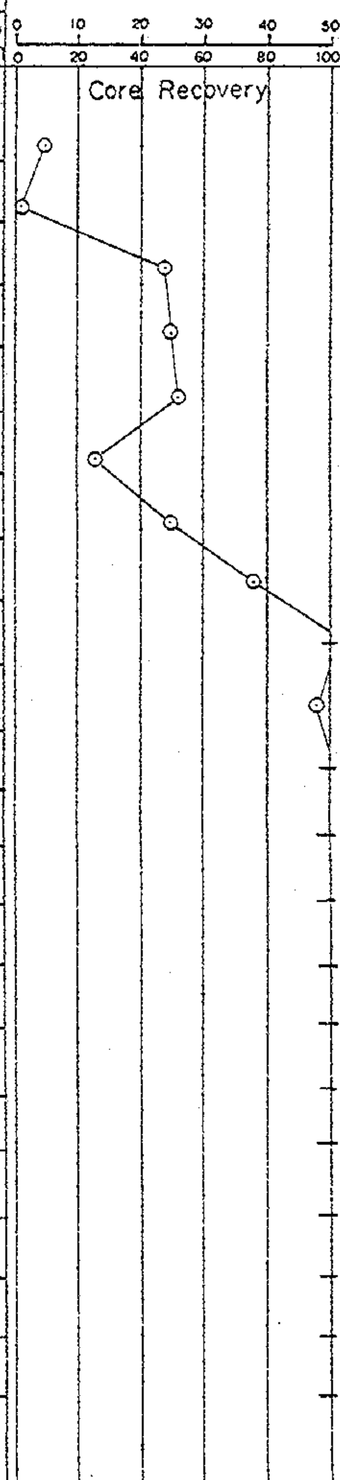
Date 21. Aug ~ 25. Aug, 1982

Wate Table GL-1.0 m

Scale in m	Elevation in m	Depth in m	Thickness	Legend	Colour	Type of soil	General Remarks	Relative Density or Consistency
0 – 3.40	+ 4.30	3.40	3.40		Grey ~ Light grey	Silty medium to coarse sand	·Contain quartz pebbles of about 2 ~ 3 mm in diameter	
3.40 – 5.75	+ 1.95	5.75	2.35		Light yellowish brown	Clayey gravel	·Gravel consists of quartz pebbles of Ø 2 ~ 5 mm. ·Matrix consists of clay	
5.75 – 22.00	-14.30	22.00	16.25		Light bluish white ~ Light yellowish brown ~ Light brownish grey ~ Brownish grey	Highly weathered granite	·Consists of decomposed feldspar untill the depth of about 8 m. ·Becoming "masa-do" condition by the weathering. ·Feldspar becomes completely clay condition. ·Remains the original rock structure of granite, but can be crushed easily by a finger. ·Becomes somewhat hard from the depth of 20 m.	
22.00 – 22.50	-14.80	22.50	0.50		Grey	Weathered granite		

Standard Penetration Test

Depth in m	N-Value Blows/30cm	Blows Per Each 10cm: 15 cm	15 cm	15 cm
1.15 – 1.45	5	2	2	3
2.15 – 2.15	1	1/30		1
3.15 – 3.45	24	9	10	14
4.15 – 4.45	25	8	12	13
5.15 – 5.45	26	7	11	15
6.15 – 6.45	13	5	6	7
7.15 – 7.45	25	7	10	15
8.15 – 8.45	38	9	16	22
9.15 – 9.15	77	15	27	50
10.15 – 10.45	48	10	18	30
11.15 – 11.45	130	26	50	80
12.15 – 12.36	120/21	21	70	50/6
13.15	80/10	28	80/10	
13.25 – 14.15	80/10	34	80/10	
14.25 – 15.15	80/11	40	80/11	
15.26 – 16.15	90/15	35	90	
16.30 – 17.00	90/15	90		
17.15 – 18.15	80/8	60	80/8	
18.23 – 19.00	80/13	80/13		
19.13 – 20.00	80/10	80/10		
20.10 – 21.00	80/4	80/4		
21.04				



Sampling Depth in m

in-situ Test Depth in m

Kokusai Kogyo Co. Ltd.

Fig.4-5(4) DRILLING LOG

No. 4

Location On land . RAYONG PROV . (34.⁰⁰, 04.⁶⁶)

Elevation C.D.L.+17.7 m

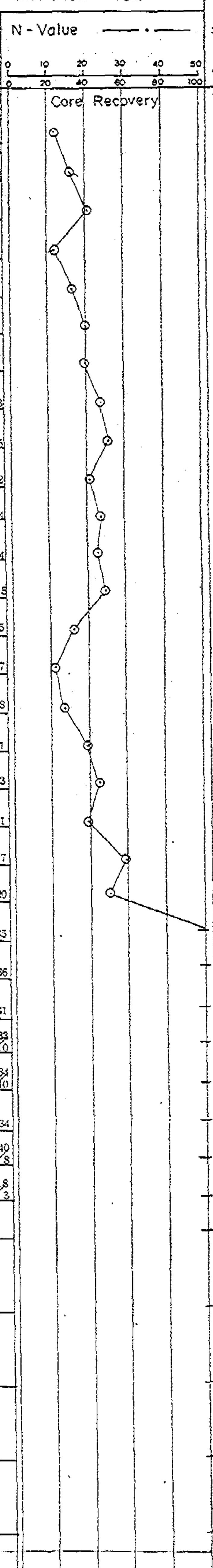
Date 20. Aug ~ 26. Aug . 1982

Wate Table m

Elevation in m	Depth in m	Thickness	Legend	Colour	Type of soil	General Remarks	Relative Density or Consistency
+10.80	6.90	6.90		Dark reddish brown ~ Light yellowish grey	Gravely clay	·With pebble of quartz of about ∅ 2~3 mm. ·At deeper than the depth of 4 m, with high water content and high sticky	
-20.30	38.00	31.10		Light yellowish grey ~ Whitish grey ~ Reddish purple ~ Light yellowish grey ~ Light whitish grey ~ Reddish purple ~ Light yellowish grey ~ Light grey ~ Grey	Highly weathered granite	·Becoming "masd-do" condition by the weathering, and becoming completely clay condition ·Remains the original rock structure of granite at deeper than the depth of about 19m. but can be crushed easily by a finger ·Remains the feldspar of less degree of weathering from the depth of 29 m.	
-20.80	38.50	0.50		Grey	Weathered granite		

Standard Penetration Test

Depth in m	N-Value Blows/30cm	Blows Per Each 10cm: 15 cm	15 cm	15 cm
1.15 – 1.45	13	5	6	7
2.15 – 2.45	17	8	8	9
3.15 – 3.45	21	8	9	12
4.15 – 4.45	13	5	6	7
5.15 – 5.45	17	6	8	9
6.15 – 6.45	20	6	9	11
7.15 – 7.45	20	6	9	11
8.15 – 8.45	24	6	11	13
9.15 – 9.45	26	8	11	15
10.15 – 10.45	21	7	9	12
11.15 – 11.45	24	7	10	14
12.15 – 12.45	23	7	9	14
13.15 – 13.45	25	5	10	15
14.15 – 14.45	17	5	7	15
15.15 – 15.45	12	4	5	7
16.15 – 16.45	14	4	6	8
17.15 – 17.45	20	5	9	11
18.15 – 18.45	23	7	10	13
19.15 – 19.45	20	6	9	11
20.15 – 20.45	30	7	13	17
21.15 – 21.45	36	8	16	20
22.15 – 22.45	58	12	23	35
23.15 – 23.45	61	14	25	36
24.15 – 24.45	71	19	30	41
25.15 – 25.40	71/25	17	38	33/10
26.15 – 26.40	72/25	22	38	34/10
27.15 – 27.45	61	15	27	34
28.15 – 28.38	84/23	12	44	40/8
29.15 – 29.33	80/18	22	62	18/3
30.15 – 30.28	90/13	30	90/13	
32.15 – 32.28	89/13	50	89/13	
34.00 – 34.06	126/6	126/6		
36.00 – 36.10	86/10	86/10		
38.00 – 38.04	100/4	100/4		



Kokusai Kogyo Co. Ltd.

Fig.4-5(5) DRILLING LOG

No. 5

Location: Off Shore (26[00], 00[00])

Elevation: [illegible] m

Date: 4. Sep ~ 7. Sep. 1982

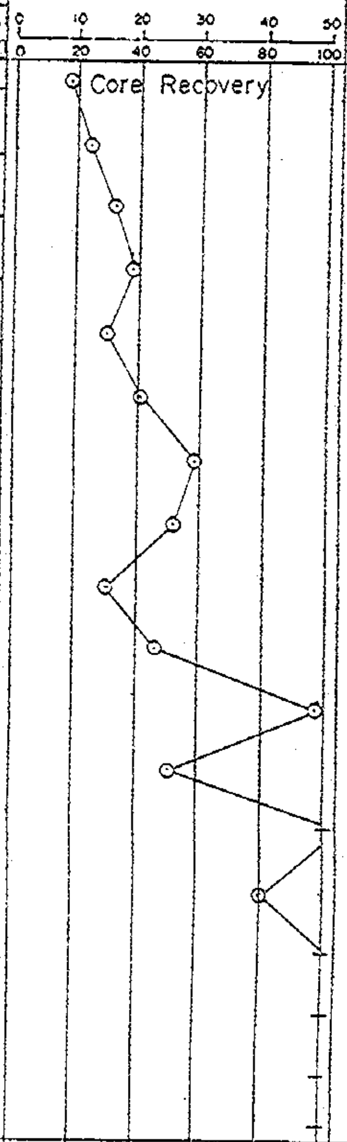
Wate Table: m

Scale in m	Elevation in m	Depth in m	Thickness	Legend	Colour	Type of soil	General Remarks	Relative Density or Consistency
1	-4.50	0.90	0.90		Light yellowish grey	Coarse sand	·Mainly consists of quartz sand	
2	-5.30	1.70	0.80		Light grey	Clayey coarse sand	·With high clay fraction	
4	-8.20	4.60	2.90		Light grey	Fine to medium sandy clay	·With high sticky ·With sand and gravel unsystematically ·With tiny organic matters at the lower part	
8	-12.10	8.50	3.90		Light grey	Clayey medium to coarse sand	·Contains much sticky clay ·With pebble of quartz of about Ø 2 ~ 3 mm.	
10	-14.50	10.90	2.40		Light grey ~ Whitish grey	Clayey gravel	·Gravel consists of pebble of quartz of about Ø 2 ~ 5 mm. ·Matrix consists of high sticky clay	
11	-15.20	11.60	0.70		Light grey	Fine sandy clay	·With pebble of quartz	
13	-16.85	13.25	1.65		Light grey	Clayey gravel	·With much clay fraction at the lower part	
17	-20.73	17.15	3.90		Light yellowish brown ~ yellowish brown	Highly weathered granite	·Remains the original rock structure of granite from the depth of 14 m. ·Becoming "masa-do" condition by the weathering	

Standard Penetration Test

Depth in m	N-Value Blows/30cm	Blows Per Each 10cm: 15 cm	15 cm	15 cm
0.15 – 0.45	9	3	4	5
1.15 – 1.45	12	4	5	7
2.15 – 2.45	16	5	8	8
3.15 – 3.45	19	7	8	11
4.15 – 4.45	15	7	7	8
5.15 – 5.45	20	9	10	10
6.15 – 6.45	29	7	12	17
7.15 – 7.45	26	7	12	14
8.15 – 8.45	15	8	7	8
9.15 – 9.45	23	8	9	14
10.15 – 10.45	49	15	21	28
11.15 – 11.45	25	8	11	14
12.15 – 12.45	52	16	23	29
13.15 – 13.45	40	18	17	23
14.15 – 14.38	81/23	31	17	36/8
15.15 – 15.36	87/21	25	54	33/6
16.15 – [illegible]	89/18	36	75	14/3
16.90 – 17.15	83/25	35	13	12/10

N-Value —·—



Sampling Depth in m

In-situ Test Depth in m

Kokusai Kogyo Co. Ltd.

Fig.4-5(6) DRILLING LOG

No. 6

Location Off shore (33^{00}, 00^{00})

Date 8. Sep ~ 12 Sep, 1982

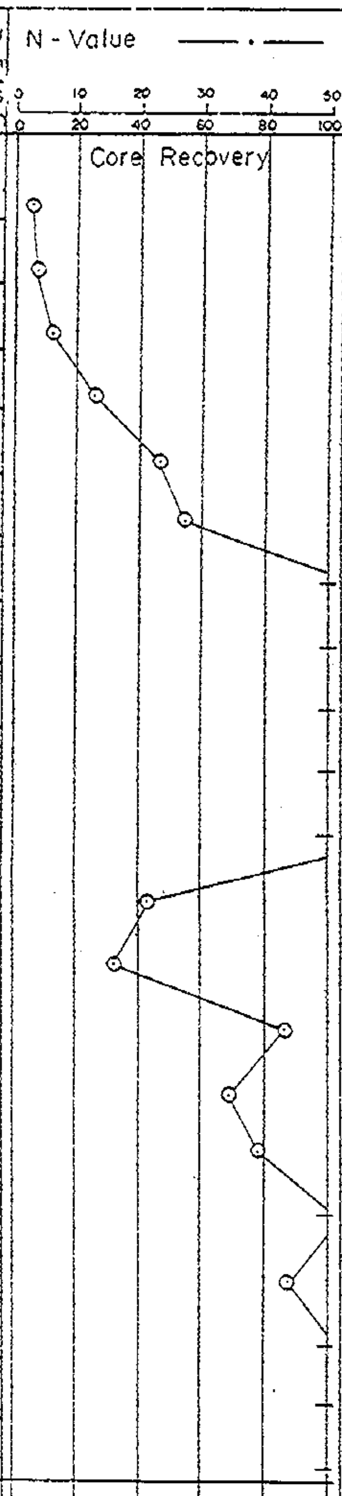
Elevation [illegible] m

Wate Table m

Scale in m	Elevation in m	Depth in m	Thickness	Legend	Colour	Type of soil	General Remarks	Relative Density or Consistency
0–1.50	- 5.30	1.50	1.50		Light yellowish grey	Coarse sand	·Mainly consists of quartz sand	
1.50–3.40	- 7.20	3.40	1.90		Dark grey	Clayey medium to coarse sand	·With high clay fraction	
3.40–6.90	-10.70	6.90	3.50		Light greenish grey ~ Light grey	Clayey fine to medium sand	·With high clay fraction ·With high sticky clay	
6.90–11.60	-15.40	11.60	4.70		Light grey ~ Yellowish grey	Clayey gravel	·Gravel consists of pebble of quartz of Ø 2 ~ 5 mm. ·Matrix consists of high sticky clay.	
11.60–21.23	-25.03	21.23	9.63		Whitish grey ~ Yellowish grey ~ Whitish grey ~ Light yellowish grey	Highty weathered granite	·Consists of feldspar becoming completely clay condition untill the depth of about 14 m. ·Remains the original rock structure of granite, but can be crushed easily by a finger. ·Remains feldsper of less degree of weathering from the depth of 20 m.	

Standard Penetration Test

Depth in m	N-Value Blows/30cm	Blows Per Each 10cm: 15 cm	15 cm	15 cm
1.05–1.35	3	1	2	1
2.05–2.35	4	1	2	2
3.05–3.35	6	2	2	4
4.05–4.35	13	3	5	8
5.05–5.35	23	5	9	14
6.05–6.35	27	10	12	15
7.05–7.35	50	14	20	30
8.05–8.35	52	18	26	26
9.05–9.35	98	20	36	62
10.05–10.35	78	25	34	44
11.05–11.35	68	18	31	37
12.05–12.35	21	7	10	11
13.05–13.35	16	6	7	9
14.05–14.35	43	10	18	25
15.05–15.35	34	10	16	18
16.05–16.35	39	11	17	22
17.05–17.35	60	20	29	31
18.05–18.35	44	9	17	27
19.05–19.35	100	16	32	68
20.05–20.33	96/28	25	32	46/13
21.05–21.23	85/18	37	70	15/3



Sampling Depth in m

in-situ Test Depth in m

Kokusai Kogyo Co. Ltd.

Fig.4-5(7) DRILLING LOG

No. 7

Location Off shore (33.985)

Date 12.Sep ~ 18.Sep . 1982

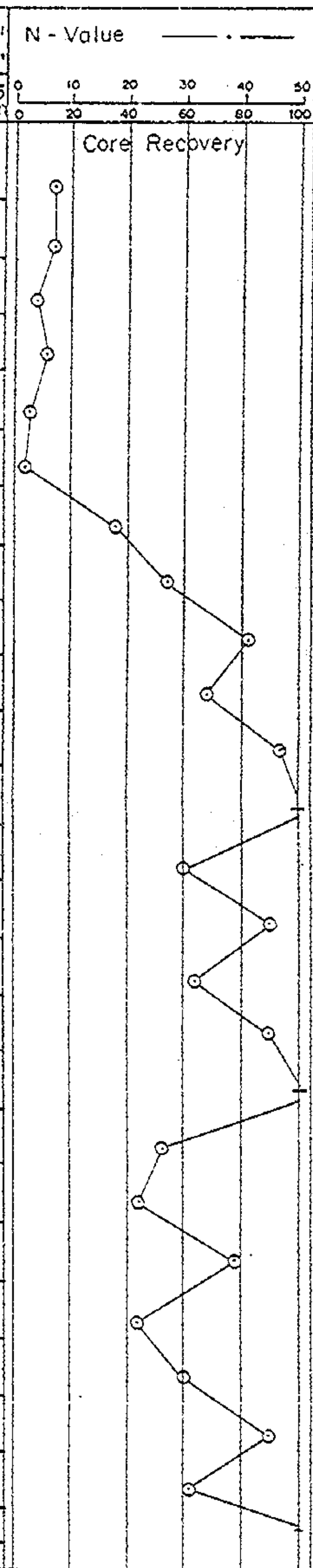
Elevation [illegible] m

Water Table m

Scale in m	Elevation in m	Depth in m	Thickness	Colour	Type of soil	General Remarks	Relative Density or Consistency
0–6.65	-11.85	6.65	6.65	Light brownish grey ~ Grey ~ Light grey	Medium to coarse sand	With much shell fragments at the depth from 7.15m to 1m. With pebble of quartz of ⌀2mm. With silt partly. Mainly consists of quartz sand.	
6.65–10.55	-15.75	10.55	3.90	Grey ~ Light grey	Clayey fine to coarse sand	With higher content of clay. With high sticky clay. With pebble of quartz of about ⌀2~3mm.	
10.55–12.75	-17.95	12.75	2.20	Light grey	Clayey gravel	Consists of pebble of quartz of about ⌀2~5mm. With high sticky clay.	
12.75–13.65	-18.85	13.65	0.90	Light grey	Clayey medium to coarse sand	With pebble of quartz	
13.65–17.45	-22.65	17.45	3.80	Light yellowish grey	Clayey fine to medium sand	With pebble of quartz. With decomposed feldspar and mica flakes. With higher sticky clay.	
17.45–19.55	-24.75	19.55	2.10	Light grey	Clayey medium to coarse sand	With clay fraction. With pebble of quartz of ⌀2~3mm.	
19.55–20.65	-25.85	20.65	1.10	Light grey	Clayey fine to medium sand	With a little content of clay.	
20.65–21.65	-26.85	21.65	1.00	Grey	Fine sandy clay	With mica flakes	
21.65–23.45	-28.65	23.45	1.80	Light whitish grey	Clayey fine to medium sand	With many pebble of quartz. With mica flakes	
23.45–24.35	-29.55	24.35	0.90	Light grey	Clayey gravel	Consists of pebble of quartz.	
24.35–25.44	-30.64	25.44	-1.09	Light grey	Withered granite	Remains the original rock structure	24.95 / 25.44

Standard Penetration Test

Depth in m	N-Value Blows/30cm	Blows Per Each 10cm: 15cm	15cm	15cm
1.00–1.30	7	2	3	4
2.00–2.30	7	2	4	3
3.00–3.30	4	1	2	2
4.00–4.30	6	2	2	4
5.00–5.30	3	1	2	1
6.00–6.30	2	1	1	1
7.00–7.30	18	3	6	12
8.00–8.30	27	7	10	17
9.00–9.30	41	8	15	26
10.00–10.30	34	11	17	17
11.00–11.30	47	14	21	26
12.00–12.30	79	19	37	42
13.00–13.30	30	10	13	17
14.00–14.30	45	14	21	24
15.00–15.30	32	11	13	19
16.00–16.30	45	15	19	26
17.00–17.30	74	25	37	37
18.00–18.30	26	11	13	13
19.00–19.30	22	14	11	11
20.00–20.30	39	13	18	21
21.00–21.30	22	8	10	12
22.00–22.30	30	12	14	16
23.00–23.30	45	19	25	20
24.00–24.30	31	14	13	18
24.85–25.14	100/10	100/10		
25.14–25.44	100/4	100/4		



Sampling Depth in m | In-situ Test Depth in m

Kokusai Kogyo Co. Ltd.

Fig. 4-5(8) DRILLING LOG

No. 8

Location: Off Shore (26.4, 97.9)

Elevation: CDL-8.2 m

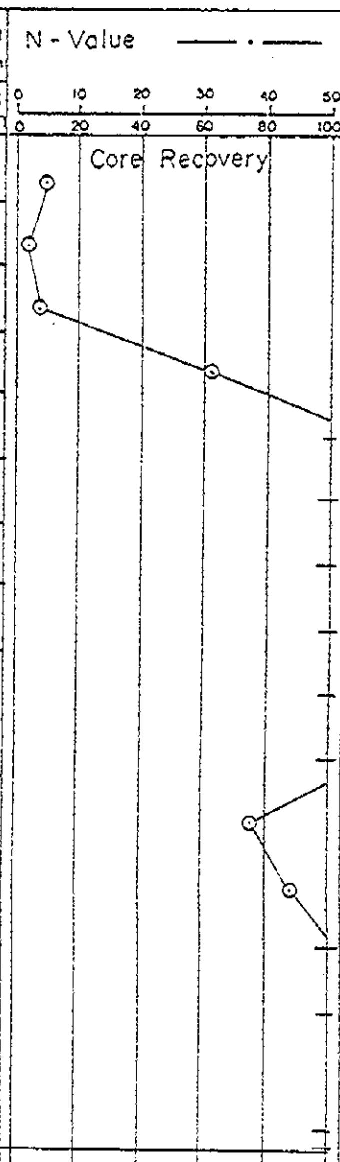
Date: 19. Sep ~ 21. Sep, 1982

Wate Table: m

Scale in m	Elevation in m	Depth in m	Thickness	Legend	Colour	Type of soil	General Remarks	Relative Density or Consistency
1–3	-11.50	3.30	3.30		Lith yellowish grey ~ Light grey	Medium to coarse sand	·With much shell fragments ·Mainly consists of quartz sand ·With pebble of quartz	
4	-12.40	4.20	0.90		Light yellowish brown	Clay	·With pebble of quartz	
5	-13.50	5.30	1.10		Light grey	Gravely clay	·With many pebble of quartz	
6–11	-19.20	11.00	5.70		Light yellow ~ Whitish grey ~ Light yellowish grey ~ Light yellowish brown	Clayey gravel	·Consists of pebble of quartz of about Ø 2 ~ 3 mm ·Matrix consists of high sticky clay.	
12–15	-24.00	15.80	4.80		Light grey	Highly weathered granite	·Consists of feldspar becoming completely clay condition untill the depth of 14 m. ·Remains the original rock structure of granite, but, can be crushed easily by a finger	
16	-24.14	15.94	0.14		Light grey	Weathered granite		

Standard Penetration Test

Depth in m	N-Value Blows/30cm	Blows Per Each 10cm: 1.5 cm	1.5 cm	1.5 cm
0.75–1.05	5	3	3	2
1.75–2.05	2	2	1	1
2.75–3.05	4	3	2	2
3.75–4.05	31	5	11	20
4.75–5.05	51	13	22	29
5.75–6.05	72	21	30	42
6.75–7.05	66	19	30	36
7.75–8.05	93	19	32	61
8.75–[illegible]	76/15	41	76/15	
9.75–10.05	76	30	36	40
10.75–11.05	38	15	18	20
11.75–12.05	44	9	17	27
12.75–13.05	65	14	24	41
13.75–14.05	59	15	24	35
15.60–15.71	100/11	100/11		
15.90–15.94	100/4	100/4		



Sampling Depth in m | In-situ Test Depth in m

Kokusai Kogyo Co. Ltd.

c) Standard Penetration Test

The standard penetration test was carried out to grasp the relative soil strength at the same time with the exploratory borings. The results of the standard penetration tests are shown in Drilling Logs and Figure 4-6. Figure 4-6 shows the frequencies of N-value for each layer.

(Recent Deposits)

Sand : N-value is under 10 for the most part. The majority of N-value is less than 5. This means that the sand is very loose.

(Terrace Deposits)

Clayey sand : N-value is between 6 and 45 for the most part, and the majority is less than 30.

Clayey gravel : N-value is between 20 and over 70, and the frequency over 70 is high.

Sandy gravely clay : N-value is between 6 and over 70, and between 6 and 25 for the most part.

(Granitic Rocks)

Highly weathered granite : N-volue is between 10 and over 70, and the Frequency over 70 is high.

Weathered granite : N-value is entirely over 70.

d) Laborratory Sail Test

Laboratory soil tests were carried out using the samples obtained by the standard penetration tests regarding physical soil tests, namely specific gravity, moisture content, grain size distribution, liquid limit and plastic limit.

The results of the laboratory soil tests are shown in the attached sheets at the end of this report, and are shown in separated appendix "Survey Data" in details.

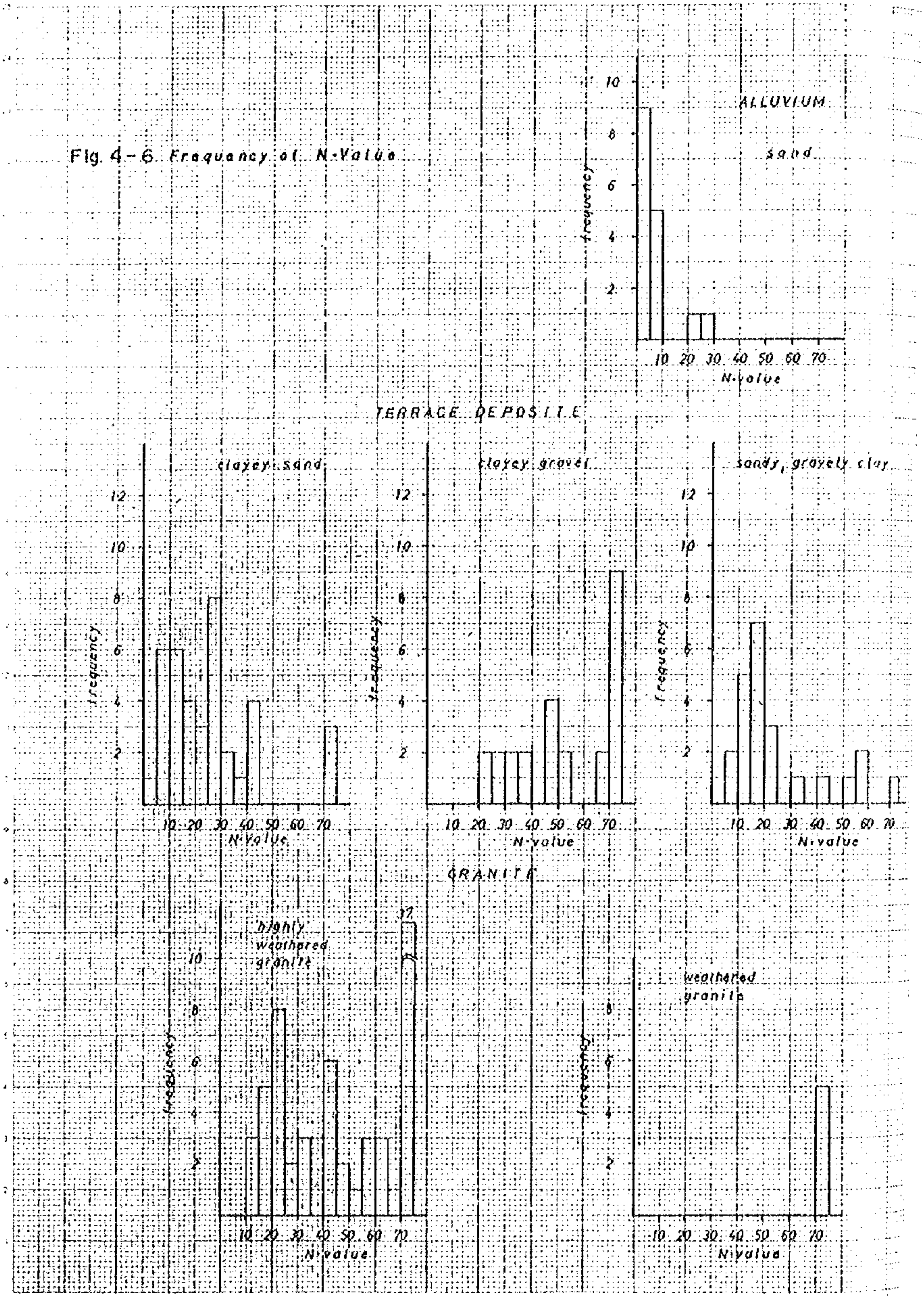


Fig. 4-6 Frequency of N-Value

(Specific Gravity : Gs)

The specific gravity is between 2.50 and 2.65 for the most part. Seeing for each layer, the specific gravity is 2.603 to 2.649 for Alluvium sand (As), and 2.582 to 2.658 for clayey sand (Ts), 2.534 to 2.643 for clayey gravel (Tg), 2.571 to 2.670 for sandy gravely clay (Tc) within terrace deposits, and 2.560 to 2.648 for highly weathered granite.

(Natural Moisture Content : Wn)

The natural moisture content is 7.8 to 22.3% for As, 7.2 to 26.4% for Ts, 10.1 to 15.2% for Tg and 8.9 to 24.8% for Tc. That of highly weathered granite is 6.1 to 28.4% and have a tendency of decrease with depth.

(Grain Size Distribution)

Alluvium sand is composed of sand fraction and gravel fraction with the content of about 90% , and contains little clay. Terrace deposits contain much silty and clayey contents, especially clayey contents. Regarding the highly weathered granite, the coase-grained soil fractions increase with depth corresponding with the degree of weathering. In the upper part of the granite layer, the contents of sands and gravels are about 40 to 50%.

(Atterberg Limits)

Atterberg limits were carried out using clay samples of terrace deposits (Tc). The results are 30.8 to 46.0% for liquid limit (LL) and 17.1 to 26.1% for plastic limit (PL). The plasticity index (PI) is calculated as 13.7 to 19.9.

(2) Electrical Prospecting

Resistivity vs. depth curves, namely ρ-a curves, gained from field data are shown in the separated appendix "Survey Data". As the results of the electrical prospecting, subsurface formations are classified into the following five layers according to the resistivity interpreting ρ-a curves.

The first layer with relatively high resistivity of 300 to 1,000 Ω-m is considered to be surface soil.

The second layer with resistivity of 100 to 300Ω-m is considered to be terrace deposits.

The third layer with resistivity less than 100Ω-m is considered to highly weathered granite. In the case where this layer is distributed in sea area, the resistivity becomes lower.

The fourth layer with higher resistivity of 20 to 500Ω-m than the third layer is considered to bo weathered granite.

The last layer with high resistivity more than 500Ω-m is considered to be fresh granite.

Generally speaking, it is said that the electrical resistivity in the investigated area is relatively low. Table 4-2 shows the summary of the resistivity classification by electrical prospecting with the velocity classification by seismic prospecting and other classifications.

(3) Seismic Prospecting

Travel time curves gained from field data are shown in the separated appendix "Survey Data". As the results of the seismic prospecting, subsurface formation are classified into the following five layers according to the velocity interpreting the travel time curves. The geological profiles for representative cross sections are also shwn in the attached figures at the end of this report as the velocity classification together with other classifications.

The first layer with the seismic velocity less than 1.0 km/sec is considered to be surface soil. This layer has a thickness of 2 to 5 meters in general. The thickness on the terrace plain and around the eastern coastal area, however, is more than 6 meters in some places.

The second layer with the velocity of 0.6 to 1.4 km sec is considered to be terrace deposits composed of sands, pebbles and clay which have been provided fan-shapely from northern highlands of granite. This layer has a thickness of about 10 meters in genenal, and as much as 20 meters in some places on the coastal area.

The third to the fifth layer is considered to be granite. According to the velocity, this granite layer is classified into three layers, namely the third layer with the velocity of 1.1 to 1.4 km/sec, the fourth layer of 2.4 to 2.6 km/sec and the fifth layer more than 4.4 km/sec which are considered to be highly weathered granite, weathered granite and fresh granite respectively. The third layer has a thickness of 20 meters in maximum, and does not exist around the eastern coastal area where the second layer overlies the fourth layer directly. The fourth layer has a thickness of 15 to 20 meters.

Figure 4-7 shows the depth of the granite surface, namely highly weathered granite surface, by contour lines with the datum of M.S.L. (Koh Lak).

Table 4-2 Summary of Results on Geophysical Prospecting

Era	Period	Epoch	Geological Condition	Classification on Borimg	Velocity Classification (Seismic Prospecting)	Resistivity Classification (Electrical Prospecting)	Classfication on Sonic Prospecting	Soil and Rock Classification
Cenozoic	Quarternary	Holocene	Recent deposits Dune littoral sediment	Recent deposits N-Value: below 10	0.3 ~ 1.0 Km/sec	300~ 1000 Ωm	A-menber	Soil- I
		Pleistocene	Terrace depositus	Terrace deposits N-Value; 10~50	0.6 ~ 1.4 Km/sec	100 300 Ωm	D 1 formation D-2 formation	Soil- II Soft-Rock- I
Mesozoic	Triassic		Granitic Rocks	Highly Weathered granitic rocks N-Value; 20~50	1.1~1.4 Km/sec	below 100 Ωm	D-group	Soft-Rock- II Hard-Rock- I
				Weathered Granitic rocks N-Value: above 50	2.4~2.6 Km/sec	20~ 50 Ωm	G-group	Hard-Rock- II Hard-Rock- III
				Unconfirmed	above 4.4 Km/sec	above 500 Ωm		Hard-Rock- IV

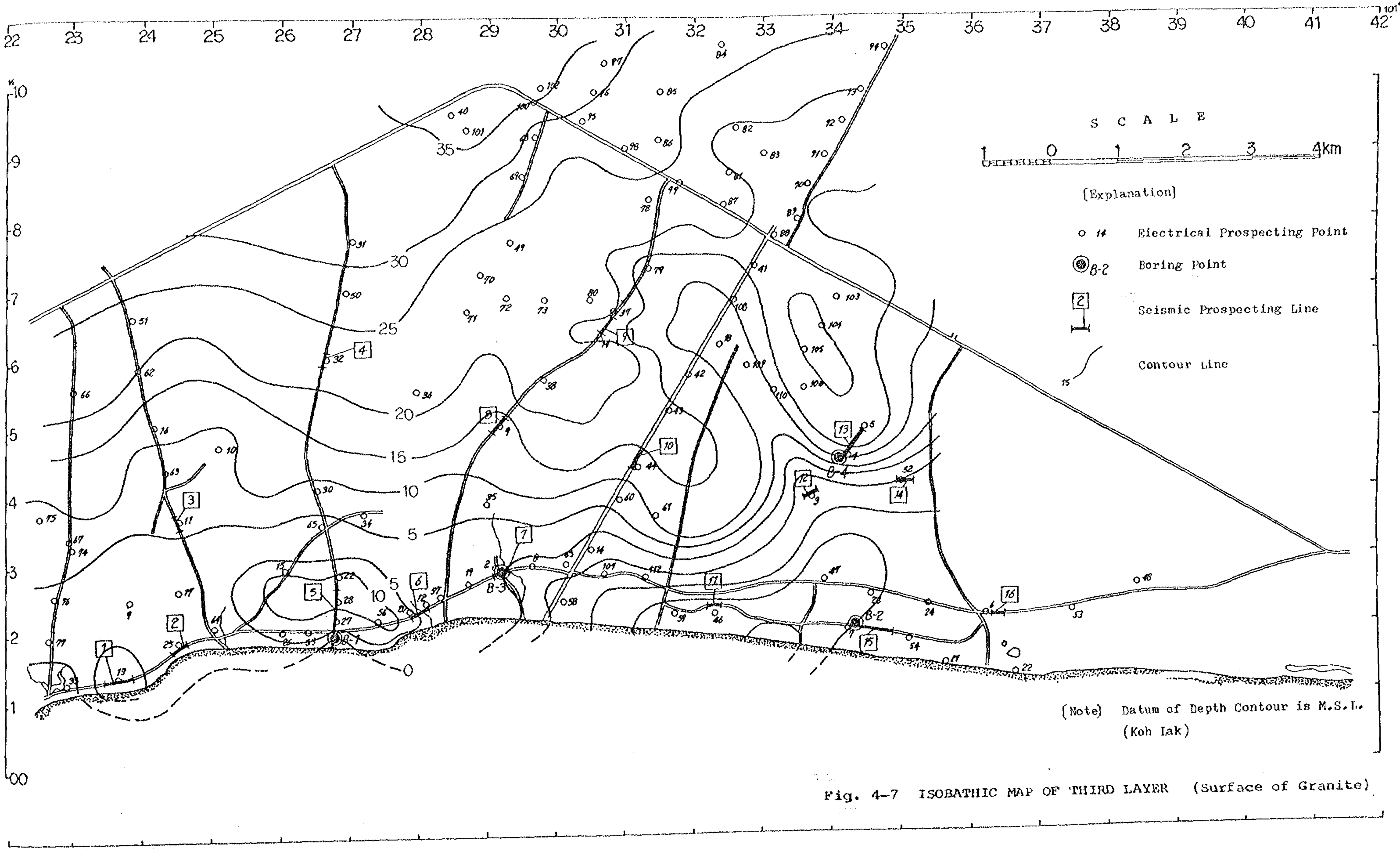


Fig. 4-7 ISOBATHIC MAP OF THIRD LAYER (Surface of Granite)

(4) Sonic Prospecting

The stratigraphy of the submarine geology in the investigated area may be classified into three layers, which we call G-group, D-group and A-member from the lower layer to the upper layer.

(G-Group)

The G-group is recorded with the blackish and dispersive pattern on the original recording paper, and the surface of this group is undulated as shown in Figure 4-8 (1).

This group can be correlated with "Weathered Granite" of the stratigraphic chassification on the soil investigation, and with "Forth Layer" of the velocity classification on the seismic prospecting. This means that the N-value is more than 50 and the seismic velocity is more than about 2.5 km/sec.

Figure 4-9 shows the geological feature of the G-group's surface on offshore area and of the forth layer's surface on land area at a scale of 1:100,000 scaled down from a large original which is shown in the attached map at the end of this report at a scale of 1:50,000.

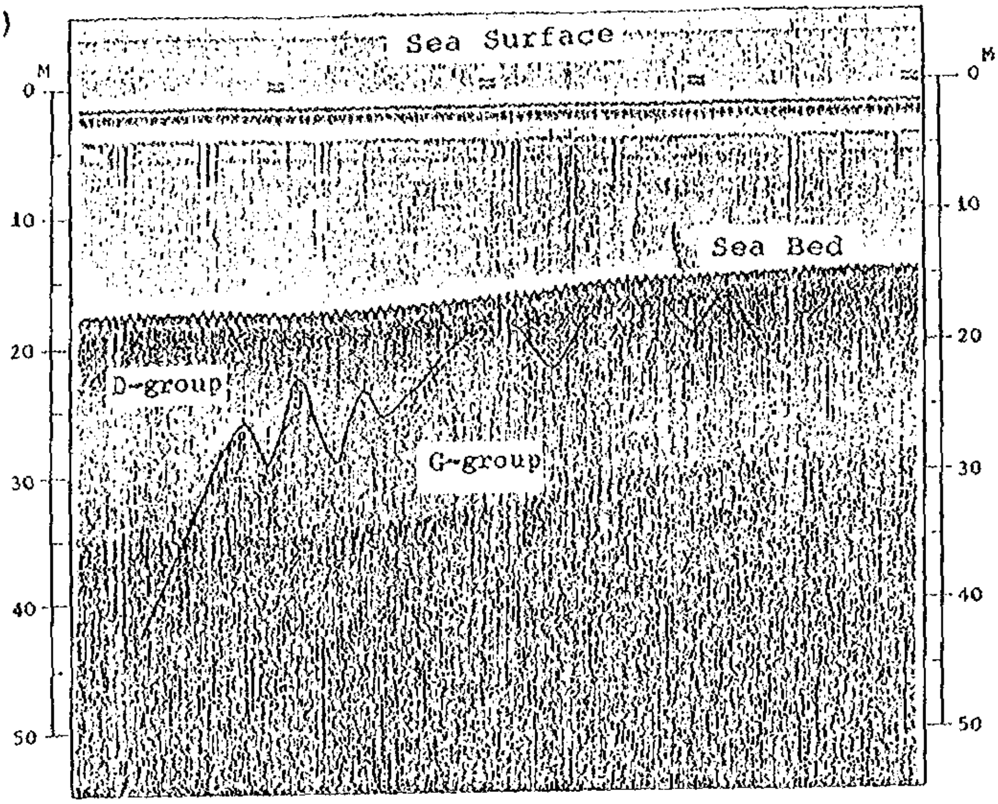
(D-Group)

The D-group is recorded with two typical patterns. One is the darkish and simple caloured pattern as shown in Fig 4-8 (1), and the other is the bedding plane as shown in Fig. 4-8 (2).

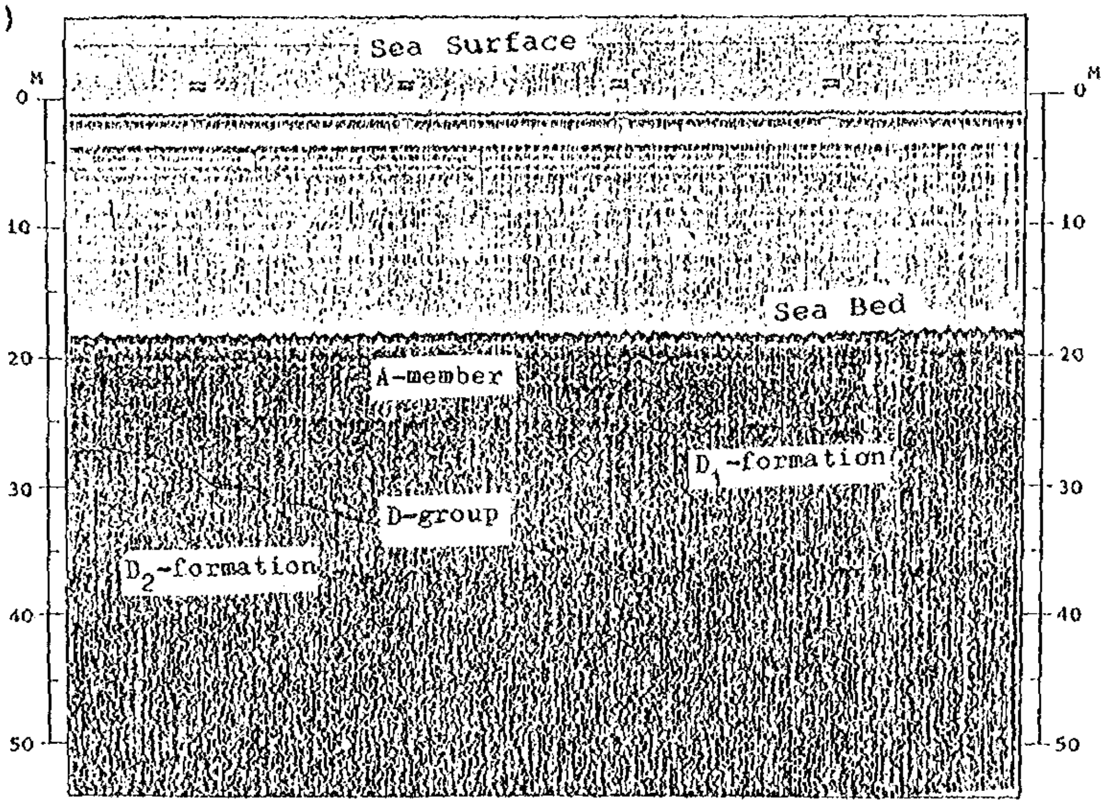
This group may be subdevided into two formations on offshore area. The lower formanation is called "D_2-formation" which can be mainly correlated with "Terrace Deposits" and the lower part of which can be correlated with "Highly Weathered Granite". In other ward, this D_2-formation can be correlated with the "Second and Third Layers" of the velocity classification on land area which have 0.6 to 1.4 km/sec in seismic velocity and about 15 to 50 in N-value.

The upper formation of D-group is called "D_1-formation" which is distributed on offshore area only having a water depth more than 15 meters and a distance more than 7 kilometers from the shoreline. This D_1-formation may be composed of gravels, sands and silts in age of later pleistocene which has about 15 to 30 in N-value.

(1)



(2)



(examples of reords reduced to a scale of seven-tenth the original record)

Fig. 4-8 Example of Sonic Prospecting Record

Fig.4-9 ISOBATHIC MAP OF G-GROUP

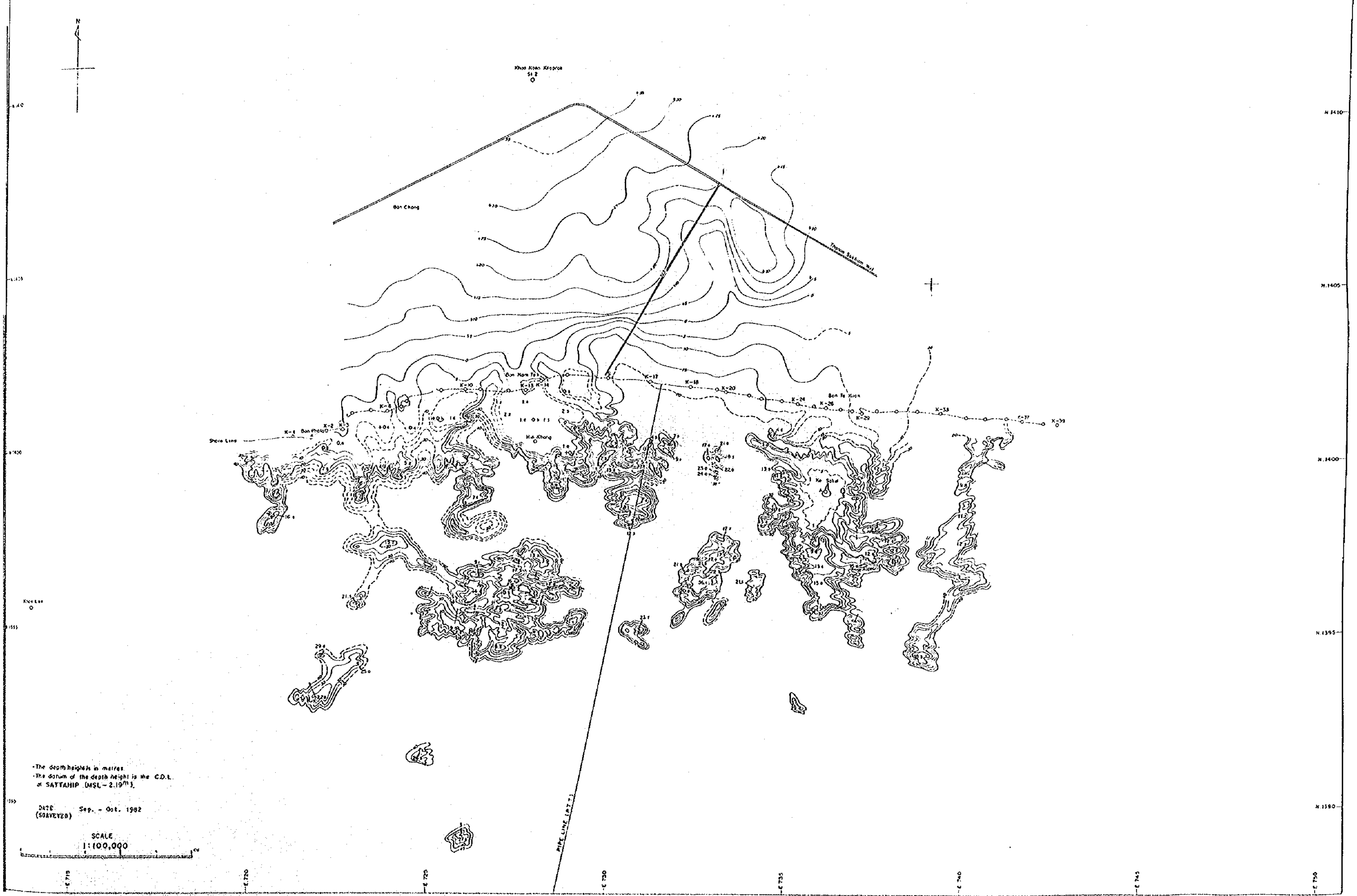


Fig.4-10 ISOBATHIC MAP OF D-GROUP

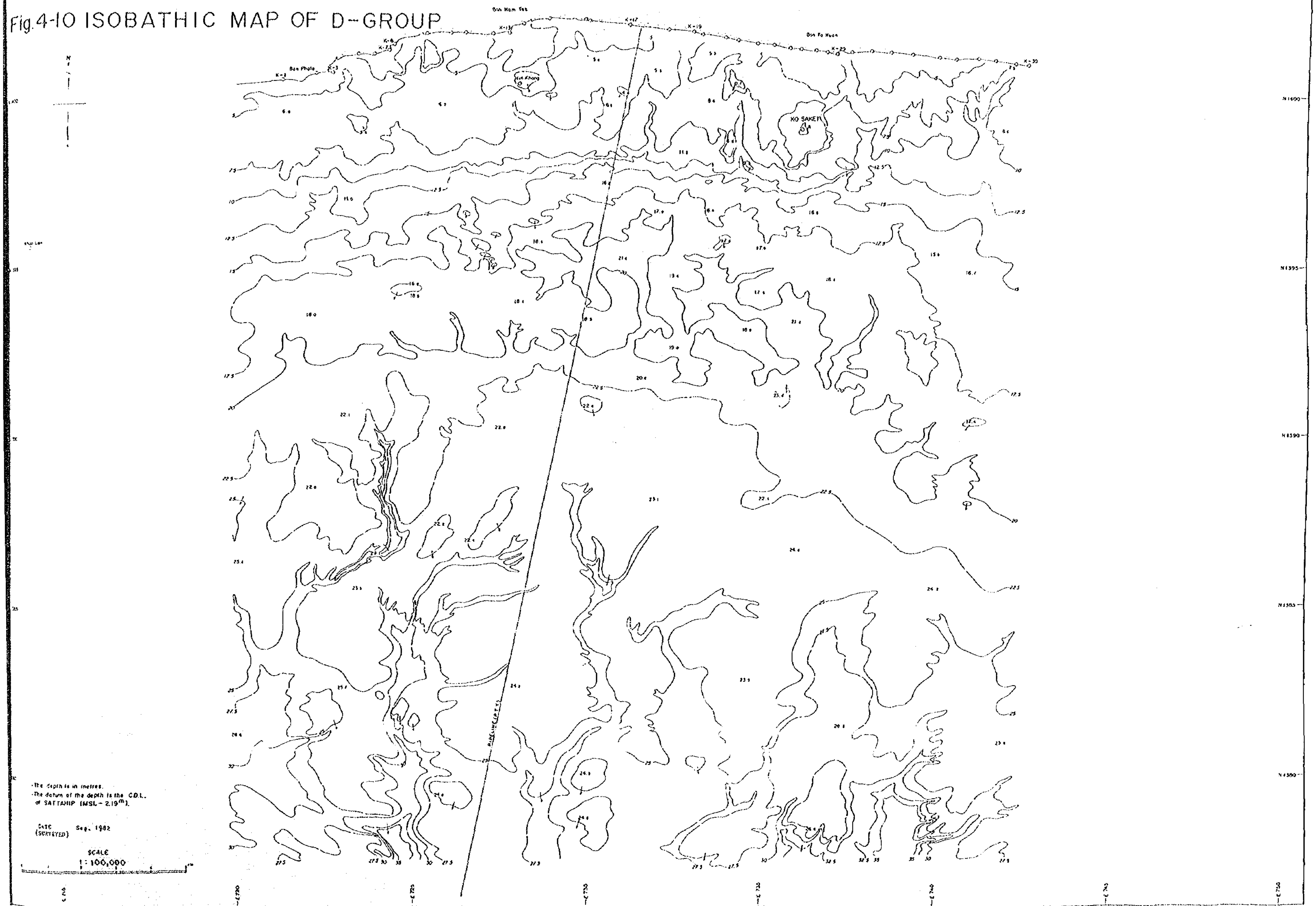
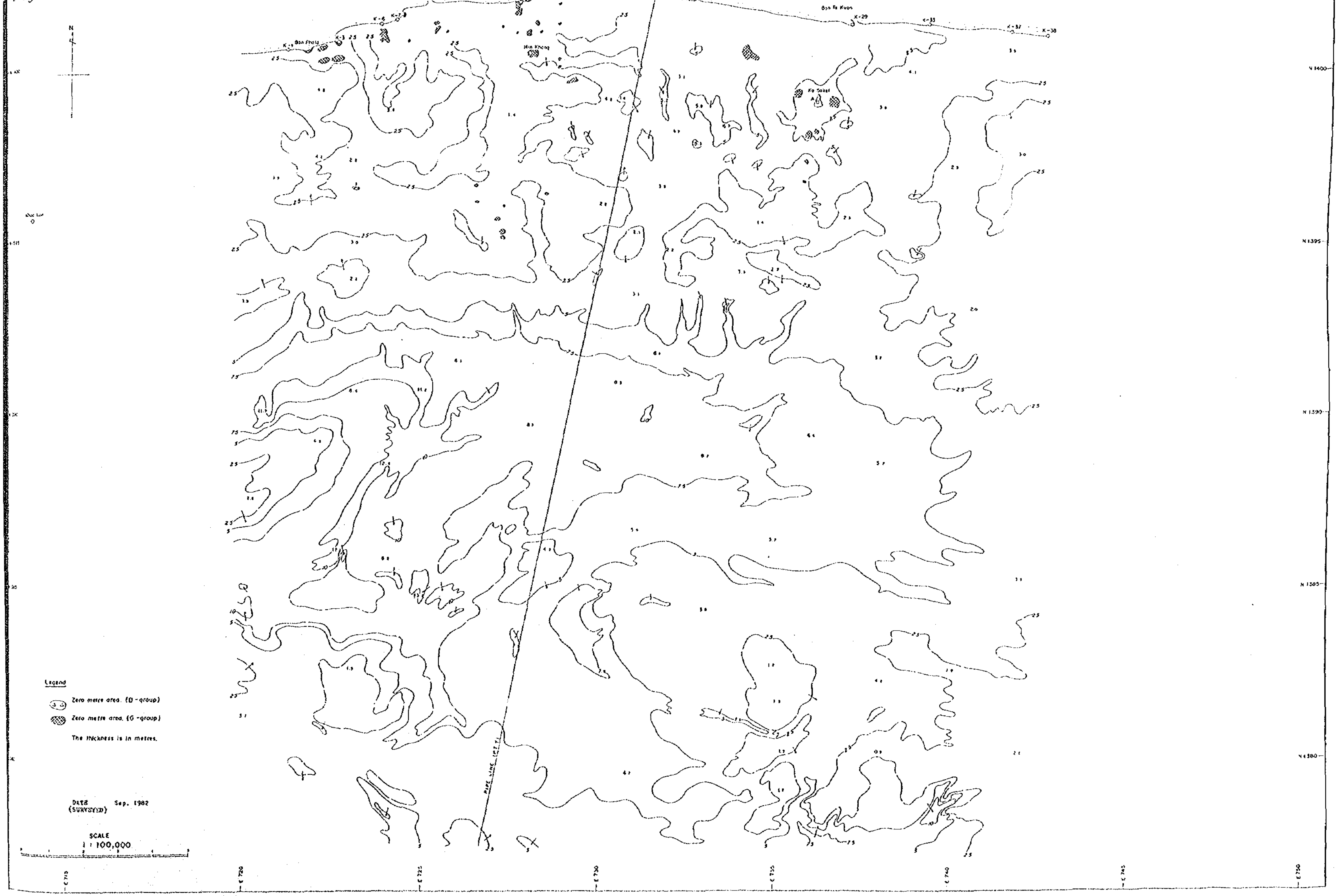


Fig.4-11 ISOPACH MAP OF A-MEMBER



The geological feature of the D-group's surface on offshore area is shown in Fig. 4-10 scaled down from a large original which is shown in the attached map at the end of this report.

(A-Member)

The A-member is recorded with the light and simple coloured pattern under the sea bed which is recorded with blackly coloured line as shown in Fig. 4-8 (2).

This member can be correlated with "Recent Deposits" which are mainly composed of the very loose medium and coarse sands less than 10 in N-value. On offshore area deeper than about 14 meters water depth, this member includes clay and shells.

The thickness of the A-member on offshore area is shown in Fig. 4-11 scaled down from a large original which is shown in the attached map at the end of this report.

(5) Sea-Bottom Materials

The results of the sea-bottom materials are shown in Table 4-3 and Figure 4-12. Table 4-3 shows the results of grain size distribution with 50% (D_{50}), 25% (D_{25}) and 75%(D_{75}) of the grain size distribution curves which are shown in separated appendix "Survey Data".

Seeing the results, the materials on the shoreline are composed of coarse sands with 0.53 to 1.0 millimeters in D_{50} except the sampling points K-2 and K-14 composed of fine sands, K-33 of medium sands and K-6 of gravely sands. On offshore area more than 14 meters water depth, the bottom materials include clay and shells. On the other hand, gravels are observed on the west side of the pipeline and offshore area.

Table 4-3 Results of Sea-Bottom Materials

Sampling No.	D 50	D 25	D 75	Materials	Sampling No.	D 50	D 25	D 75	Materials
K-1-2	0.85	0.65	1.3	cS	B 5	0.80	0.65	1.0	
K-2	0.13	0.10	0.21	fS	B 7	0.73	0.60	1.0	
K-6	1.1	0.26	2.5	SG	B 8	1.2	0.85	1.8	
K-10	0.78	0.52	1.2	cS	D	4.4	3.0	8.7	sh
K-14	0.18	0.12	0.35	fS	19	1.3	0.70	2.3	sh
S	0.53	0.30	0.82	cS	20	0.75	0.15	1.6	sh
Pipe Line	0.53	0.28	0.93	cS	21	0.95	0.63	1.3	
K-20	0.85	0.80	1.1	cS	23	0.90	0.40	3.0	sh
K-24	0.65	0.38	1.0	cS	24	0.78	0.25	1.3	
K-26	0.56	0.29	1.0	cS	25	0.55	0.40	0.80	sh
K-29	0.75	0.50	0.95	cS	26	1.4	0.095	4.0	
K-33	0.41	0.22	0.70	mS	27	(0.05)	—	9.0	sh
K-37	1.0	0.95	1.2	cS	29	3.0	1.9	7.0	
Y-0	1.4	0.90	2.2		30	1.1	0.22	3.5	sh
R-0	0.64	0.36	0.95		31	1.1	0.80	1.1	
G-0	0.42	0.20	0.80						

(Note) D 50 : 50% of grain size distribution
D 25 : 25% of grain size distribution
D 75 : 75% of grain size distribution
cS : coarse sand
mS : medium sand
fS : fine sand
G : gravel
sh : shell

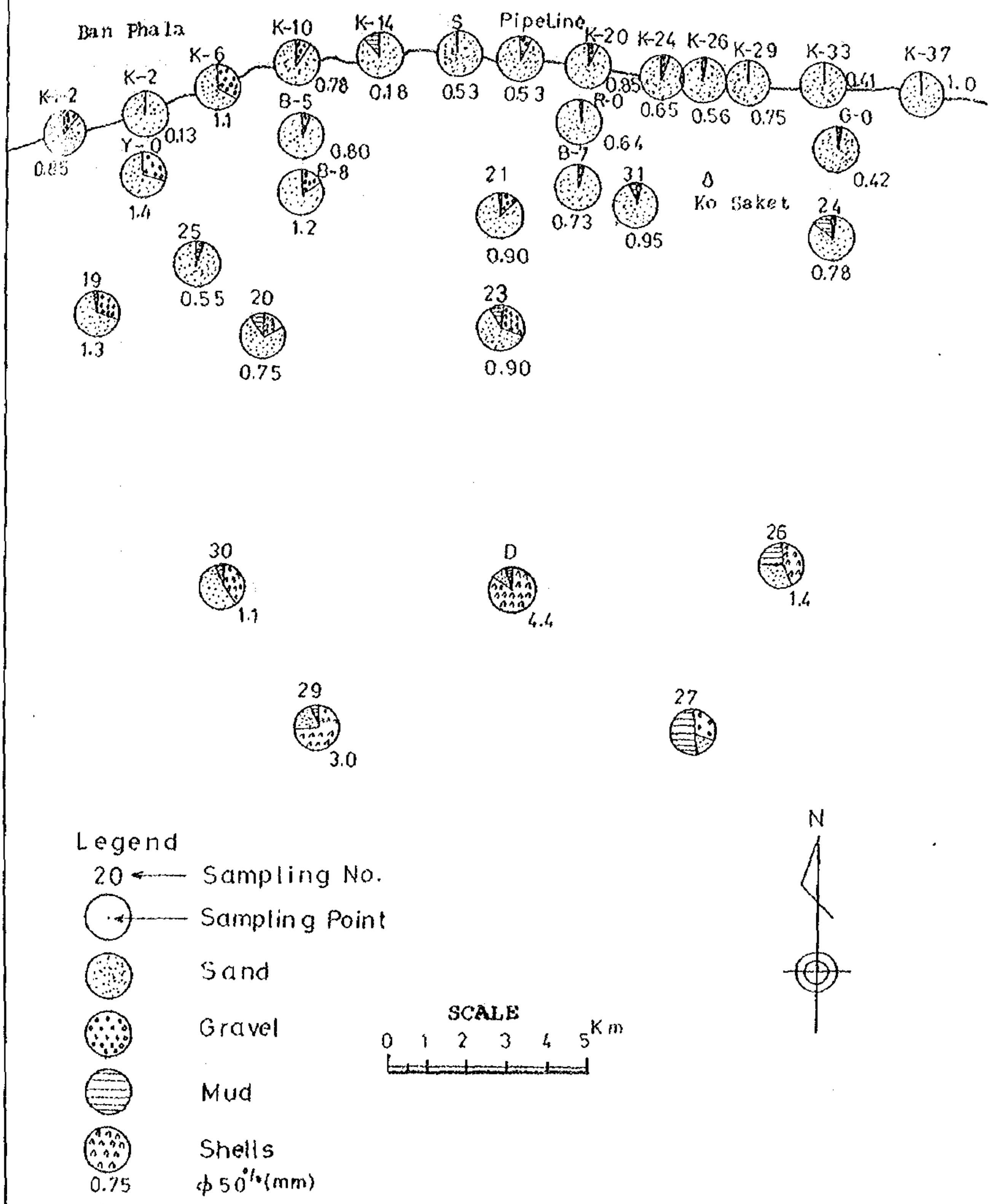


Fig. 4-12 Distribution of Sea-Bottom Materials

4-2-3 Civil Engineering Study

(1) Rock Excability

It is well know that the seismic velocity have a good correlation with the excability which means difficulty in excavating. This empirical correlation is shown in Figure 4-13 with a working efficiency of a bull-dozer and a ripper-dozer for 20 minutes.

The stratigraphic classification on the investigated area is shown in Table 4-2 described before. The soil and rock classification at the right column in Table 4-2 corresponds with the classification of Figure 4-13. Namely, we divided the classification into Soil I, Soil II, Soft Rock I, Soft Rock II, Hard Rock I, Hard Rock II and Hard Rock III. Soil I, Soil II and Soft Rock I, Soft Rock II and Hard Rock I, Hard Rock II and Hard Rock III, Hard Rock III are correlated with recent deposits, terrace deposits, highly weathered granite, weathered granite, and fresh granite respectively.

Soil I·II and Soft Rock I·II may be excavated without the task of blasting. Hard Rock I·II may be excavated with ripper-dozer. Boulder blasting, however, may be required occasionally depending on the weathering degree of granite.

Hard Rock III may be exclusively excavated by blasting. The excavation by blasting is considerably decreased in efficiency comparing with other methods. The dynamite consuming ratio for excavating the velocity layers of 2.4 to 2.6 km/sec and more than 4.4 km/sec may amout 300 to 400 g/m^3 and more than $1{,}000 g/m^3$ respectively.

It is concluded by saying that the efficiency of excavation is set a limit to the highly weathered granite with the velocity classification of 1.1 to 1.4 km/sec.

On the other hand, the criteria of the dredging on offshore area are shown in Table 4-4.

The dredging of A-member, D_1-formation and the upper part of D_2-formation may be possible by a suction dredger and or a grab dredger. The lower part of D_2-formation may be possibility of a rock-cut and a blasting is required to G-group.

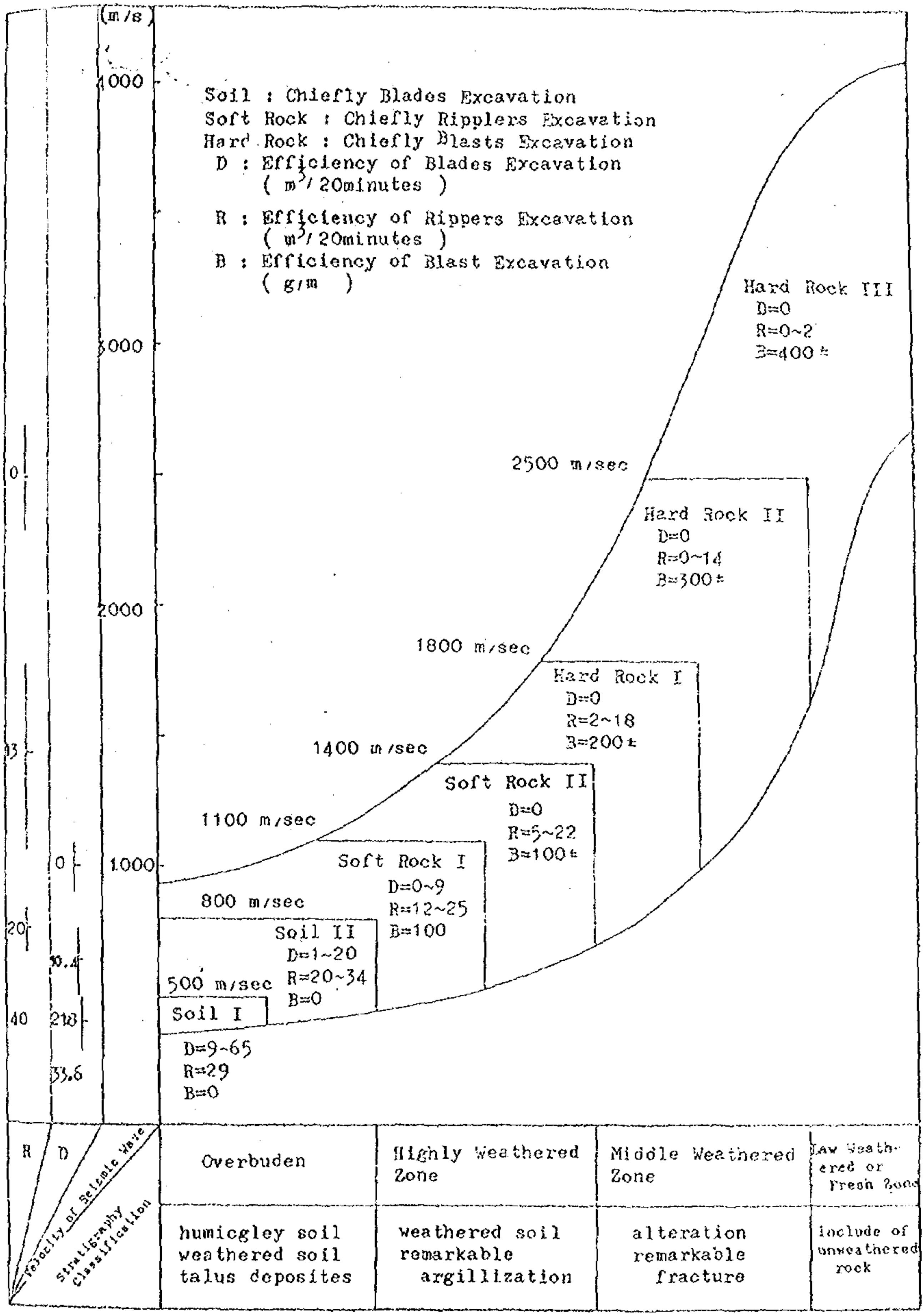


Fig. 4-13 Stratigraphic Classification and Efficiency in Excavating

Table 4-4 Adapting Ship for Dredging

Soil: Division		Soil: Condition	Adaptation of Ship	Summary	
Soil	I	Soft	Dr, B, Gs, Ps, Pr	N Value ≑ 10 below	A-member
Soil	I	Midde	Dr, B, Gs, Ps, Pr	N- Value ≑ 10~20	D_1-formation
Soil	II	Hard	B, Gs, Ps, Pr	N - Value ≑ 20 30	D_1-formation
Soil	II	Most Hard	B, Gr, D, Ps, Pr, Rs	N - Value ≑ 30 above	D_1-formation
Gravel and Soil mixed	I	Soft	B, Gs, Pr	N - Value ≑ appr.30 below	D_2-formation
Gravel and Soil mixed	II	Hard	B, Gr, D, Pr, Rc	N- Value = appr.30 below	D_2-formation
Soft Rock		Soft	B, Gr, D, Pr, Rc, Br		D_2-formation
Hard Rock		Hard	Rc, Br		G-group

B : Bucket dredger
Dr : Drag suction
Gs : Grab dredger(small)
Gl : Grab dredger(big)
D : Dipper dredger
Pl : Suction dredger(appr.5,000ps above)
Ps : Suction dredger(appr.5,000ps below)
Rc : Rock-cutter
Br : Blasting

(2) Bearing Layer

Recent deposits are mainly composed of loose sands and clayey sands less than 10 in N-value, therfore it is obvious that this layer is inadequate for a bearing layer.

Terrace deposits vary from silts to gravels on their compositions. Because of this unstable composition, it is recommended to avoid this layer for a bearing layer though N-value is around 50 in some places.

Highly weathered granites are approximately 20 to 50 in N-value, therefore this layer is also inadequate for a bearing layer because of the low N-value.

In conclusion, the most reliable stratigraphy for a bearing layer is weathered granites which are classified as G-group by the sonic prospecting and the fourth layer around 2.5 km/sec by the velocity classification.

(3) Quarry

There are two proposed sites for a quarry to exploit rock materials.

One site is the granitic mountain located at the northern part of the investigated area. In spite of the advantage in the locality, this site is considered to be not adequate entirely for a quarry because of the weathering and the unsteady distribution of granites.

The other site is located at the highland close to Sattahip, where some lime-stone mines and quarries for rock materials are at work. This rocks are composed of Tanaosi sedimentary rocks and metamorphic rocks. This site is comsidered to be adequate for a quarry.

4-3 Tides

The hourly tidal levels obtained from the tide observation at Ko Saket for the period of about 1.5 months are shown in the separated appendix "Survey Data". Maximum and minimum tide levels observed during the period at Ko Saket are as follows.

Maximum Tide Level : +0.76m (18:00, Sep. 15)
Minimum Tide Level : -1.57m (11:00, Aug. 20)

Where, the datum of tide level is the Mean Sea Level at Koh Lak (hereafter called MSL).

4-3-1 Tidal Harmonic Analysis

The results of the tidal harmonic anolysis by T.I. method are shown in Table 4-5. In Table 4-5, the left column shows the result using the data during one month from Aug. 19 to Sep. 18 (Epock Sep. 3 means the central day of this period), and the right column shows the result during one month from Sep. 3 to Oct. 3 (Epock Sep. 18). Comparing these results, the values are nearly the same. Therefore, the result from Sep. 3 to Oct. 3, namely the value of the right column, is used hereafter.

Diurnal tide constituents K_1 and O_1 prevail in the investigated area, followed by P_1 and semi-diurnal constituents M_2 and S_2. The tide type is given by $(K_1 + O_1) / (M_2 + S_2)$ in general. In this area,

$$\frac{K_1 + O_1}{M_2 + S_2} = \frac{0.601 + 0.357}{0.191 + 0.087} = 3.45 > 1.50$$

This means that the tide type in this area is a diurnal tide which has the high water and low water once per day.

4-3-2 Tidal Diagram

The short period of observation at Ko Saket does not allow to prepare a comprehensive tidal diagram in the investigated area. A final tidal diagram was decided upon by using the existing data from Sattahip Commercial Port and so on as reference as shown in Figure 4-14. In this diagram, the tide level is shown with the Mean Tide Level : MTL (Local Mean Sea Level at

Ko Saket) and MSL (Koh Lak Standard). Criteria for determining each tide level are given below.

HIGHEST HIGH WATER (HHW)

: Highest tide level at Sattahip Port (1970)

MEAN HIGHER HIGH WATER (MHHW)

: Maximum value using the following equation for Tropic Tide :

$$H_m \cdot \cos(29t - K_m) + (H' + H_o) \cdot \cos\left(15t - \frac{K' + K_o}{2}\right)$$

where, H_m, K_m : amplitude and phase lag of M_2 constituent

H', K' : amplitude and phase lag of K_1 constituent

H_o, K_o : amplitude and plase lag of O_1 constituent

namely, $H_m = 0.191m$, $K_m = 91.7°$

$H' = 0.601m$, $K' = 149.3°$

$H_o = 0.357m$, $K_o = 112.0°$

MEAN SEA LEVEL (MSL)

: Mean Sea Level at Koh Lak (Datum of Elevation in Thailand)

MEAN TIDE LEVEL (MTL)

: Local Mean Sea Level at Ko Saket

MEAN LOWER LOW WATER (MLLW)

: Minimum Value using the equation for Tropic Tide

LOWEST LOW WATER (LLW)

: Lowest tide level during observation

CHART DATUM LEVEL (CDL)

: Lowest tide level at Sattahip Port (1951)

Table 4-5 RESULT OF THE TIDAL HARMONIC ANALYSIS

STATION ** KO·SAKET TIME KEPT ** -7 H
LAT. 12-39- 0 N, LONG. 101-10- 0 E UNIT OF HEIGHT ** M

** HARMONIC CONSTANT **

DURATION / EPOCK	ONE MONTH 1982/ 9/ 3 00-00			ONE MONTH 1982/ 9/18 00-00		
CONSTI-TUENT	HEIGHT IN METER	KAPPA	G	HEIGHT IN METER	KAPPA	G
S0	1.3622	0.0	0.0	1.3969	0.00	0.00
(LONG PERIOD TIDE)						
MM	0.0961	30.93	34.74	0.0661	42.50	46.31
MSF	0.0569	239.28	246.39	0.0619	268.28	275.39
Q1	0.0762	90.09	82.71	0.0556	93.41	86.04
O1	0.3675	112.66	109.09	0.3574	111.96	108.39
M1	0.0388	233.36	233.64	0.0209	182.76	183.04
K1	0.5963	147.42	151.54	0.6007	149.31	153.43
J1	0.0256	300.56	308.49	0.0090	258.81	266.74
OO1	0.0242	149.56	161.37	0.0573	176.65	188.46
P1	0.1974	144.82	148.36	0.1988	146.51	150.05
(SEMI-DIURNAL TIDE)						
MU2	0.0206	331.34	324.79	0.0265	317.68	311.12
N2	0.0531	83.20	79.95	0.0436	62.95	59.70
M2	0.1866	88.27	88.82	0.1905	91.68	92.24
L2	0.0324	92.10	96.47	0.0317	108.53	112.89
S2	0.0871	146.36	154.03	0.0865	142.16	149.82
2SM2	0.0097	84.22	99.00	0.0145	92.53	107.31
K2	0.0237	151.06	159.30	0.0235	146.24	154.48
NU2	0.0103	83.88	81.14	0.0085	66.80	64.06
T2	0.0051	144.03	151.41	0.0051	140.14	147.52
(THIRD-DIURNAL TIDE)						
MO3	0.0088	118.36	115.35	0.0094	131.52	128.51
M3	0.0043	263.17	264.00	0.0031	240.49	241.32
MK3	0.0065	168.62	173.30	0.0081	230.80	235.48
(QUARTER-DIURNAL TIDE)						
MN4	0.0032	286.98	284.28	0.0036	250.68	247.99
M4	0.0134	275.05	276.16	0.0124	261.12	262.23
SN4	0.0058	314.89	319.30	0.0019	289.83	294.24
MS4	0.0120	355.69	3.91	0.0108	341.25	349.47
(SIXTH-DIURNAL TIDE)						
2MN6	0.0032	125.18	123.04	0.0040	76.40	74.25
M6	0.0021	115.77	117.43	0.0033	162.86	164.52
MSN6	0.0029	75.57	80.54	0.0026	57.04	62.01
2MS6	0.0015	23.26	32.04	0.0011	271.40	280.17
2SM6	0.0035	68.37	84.26	0.0033	103.86	119.75

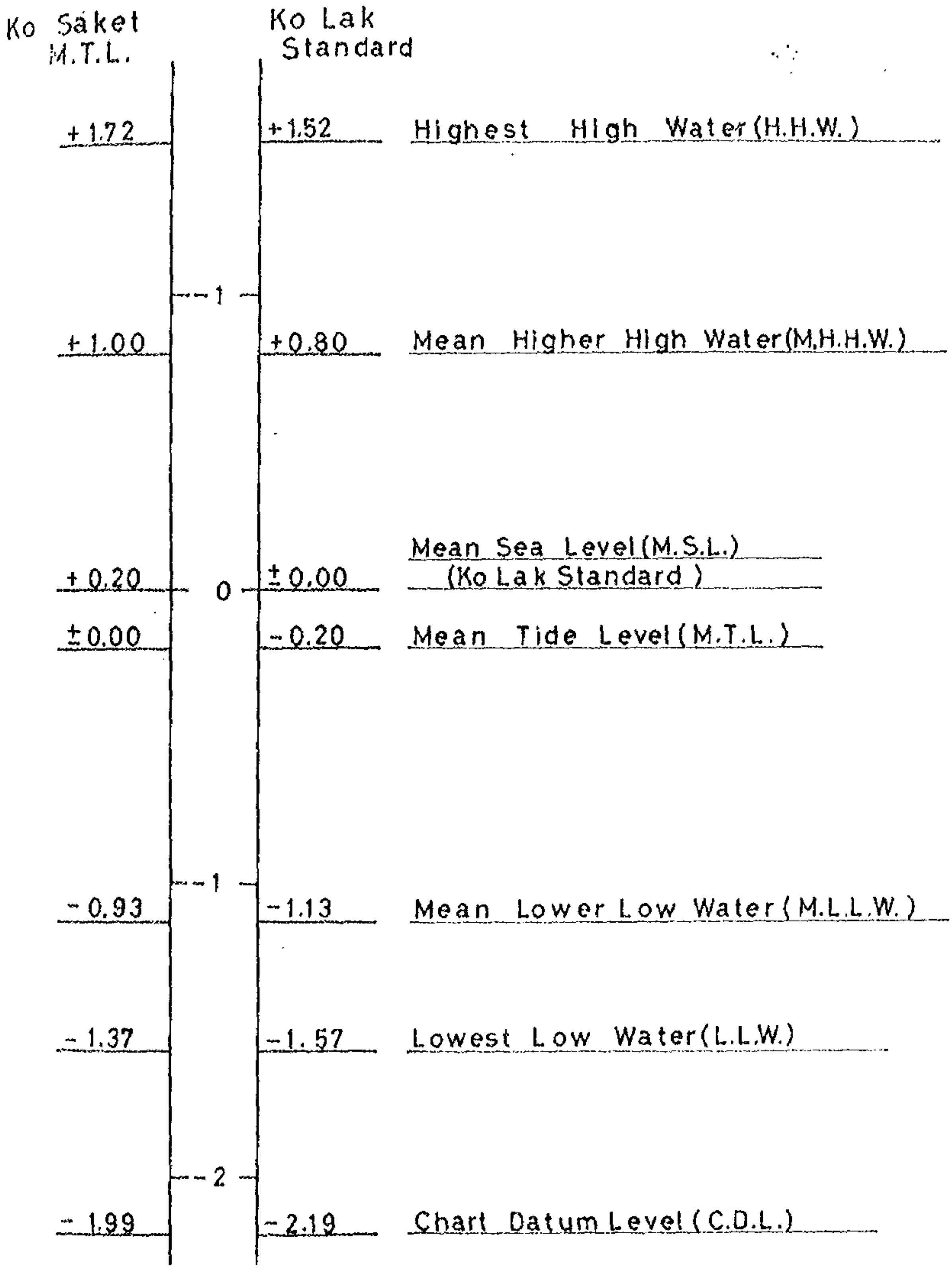


Fig. 4-14 Tidal Diagram at Ko Saket

Regarding the Local Mean Sea Level at Ko Saket (MTL), the annual MTL was obtained by the correction of the following procedure.

(Datum: MSL)

MTL for the period of Sep. 3 to Oct. 3 at Ko Saket	:	-0.293m
MTL for the same period at Sattahip	:	-0.166m
MTL for the long period at Sattahip (see Fig. 4-15)	:	-0.070m
Difference between the short period MTL and the long period MTL at Sattahip	:	-0.096m
MTL for the long period at Ko Saket	:	-0.197m
		(about -0.20m)

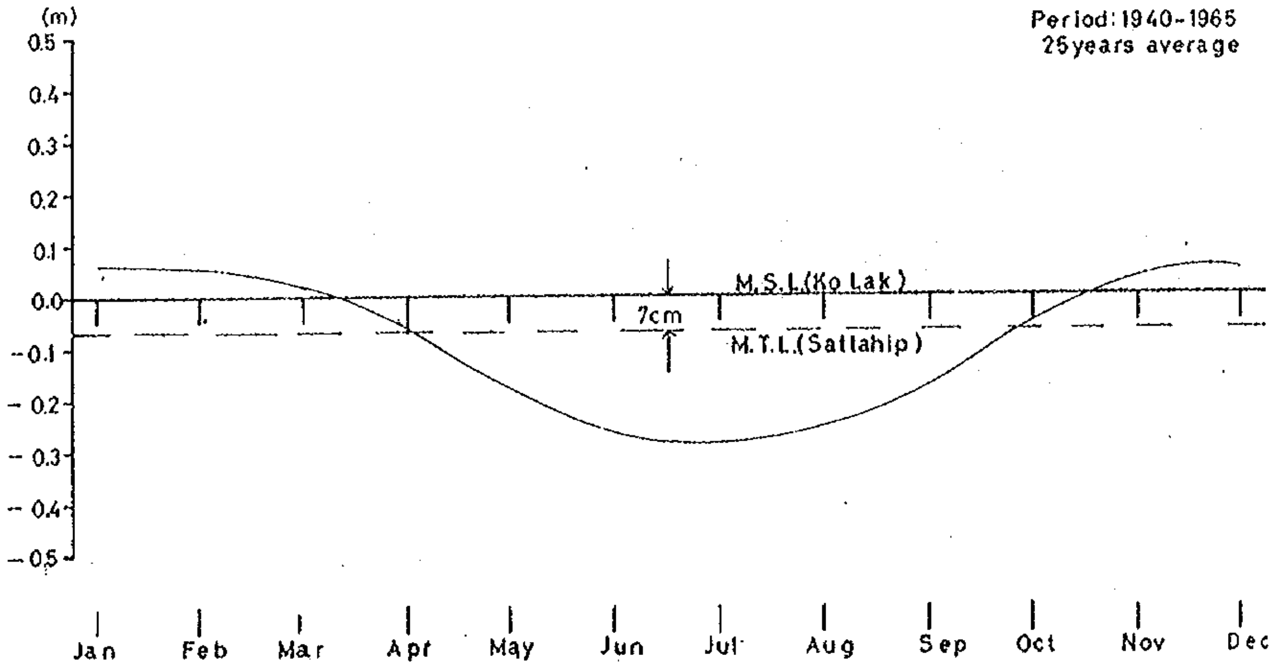


Fig. 4-15 Monthly Mean Tide Level at Sattahip

4-3-3 Comparison between Ko Saket and Sattahip

The existing harmonic constants of tides in Sattahip are shown in Table 4-6.

The harmonic constants at Ko Saket are generally small as compared with that at Sattahip. The tendency, however, is nearly the same in height and phase lag for principal constituents. Seeing in details, the characteristic indices are as follows;

Table 4-7 Characteristic Index of Tides

Characteristic Index		Ko Saket	Sattahip
Sum of Principal Four Constituents (K_1, O_1, M_2, S_2)		115.69cm	119.66cm
Sum of Principal Ten Constituents (K_1, O_1, M_2, S_2, P_1, K_2, Q_1, N_2, M_1, OO_1)		163.48cm	176.78cm
Order of Height:	First (K_1)	60.07cm	59.44cm
	Second (O_1)	35.74cm	42.04cm
	Third	(P_1) 19.88cm	(M_2) 25.68cm
	Fourth	(M_2) 19.05cm	(P_1) 18.20cm
	Fifth (S_2)	8.65cm	12.24cm
Tide Type ($K_1 + O_1 / M_2 + S_2$)		3.45	2.67

Table 4-6 Tidal Harmonic Constants of Sattahip

Zone : -7h

CONSTI-TUENT	HEIGHT IN METER	g IN DEGREE	CONSTI-TUENT	HEIGHT IN METER	g IN DEGREE
LONG PERIOD TIDE			SEMI-DIURNAL TIDE		
Sa	0.2070	297.9	2	0.0044	249.1
Ssa	o.o162	5.0	N2	0.0376	88.9
Mm	0.0064	36.9	M2	0.2568	121.4
Msf	0.0230	136.2	L2	0.0188	153.2
Mf	0.0298	69.8	S2	0.1224	190.9
DIURNAL TIDE			K2	0.0296	189.3
Q1	0.0704	91.3	2	0.0060	116.6
O1	0.4204	112.1	T2	0.0046	66.8
M1	0.0270	144.2	2N2	0.0148	106.2
K1	0.5944	160.6	THIRD-DIURNAL TIDE		
J1	0.0308	203.7	MO3	0.0028	207.5
OO1	0.0272	207.5	MK3	0.0024	301.0
P1	0.1820	161.2	QUARTER-DIURNAL TIDE		
1	0.0060	119.1	M4	o.oo34	331.9
S1	0.0048	176.4	MS4	0.0058	67.8
2Q1	0.0048	55.3	SIXTH-DIURNAL TIDE		
			M6	0.0002	26.6
			2MS6	0.0006	121.0

(Zo = 2.1936 m)

Table 4-7 shows that the tide type at Sattahip is also diurnal tides, and that the sum of constituents at Sattahip is larger than Ko Saket by about 5 centimeters in case of principal four constituents and by about 10 centimeters in case of principal ten constituents in height.

On the other hand, Figure 4-16 shows the tidal curve at Ko Saket and Sattahip from Aug. 19 to Aug. 21, 1982 as an example. The occurence time of the high water and low water is nearly the same at both station. The height, however, is different between Ko Saket and Sattahip. Namely, the height at Ko Soket has a tendency lower than that at Sattahip by about twenty centimeters on this period.

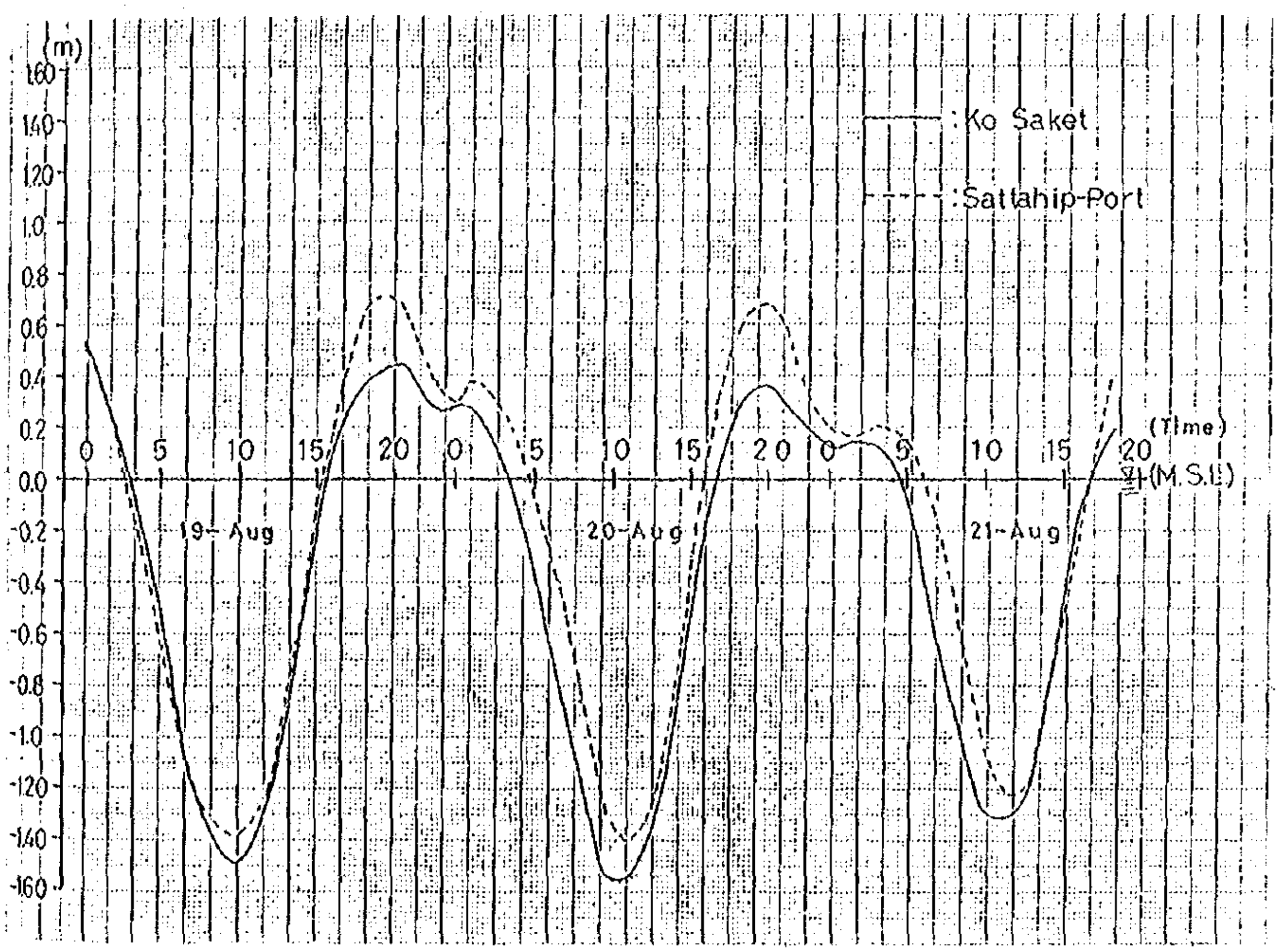


Fig. 4-16 Tidal Curve of Ko Saket and Sattahip

4-4 Tidal Currents

4-4-1. Frequency of Tidal Currents

The average velocity and direction of every 20 minutes obtained from the tidal current observation are shown in the separated appendix "Survey Data".

Figure 4-17 and Table 4-8 show the frequency of direction and velocity. According to the frequencies, southward to westward currents prevail in flood causing by the topography and east northeastward currents prevail in ebb at St. A off Ban Phala. At St. B lacated between the pipeline and Ko Saket, south to westward currents prevail in flood and east to southward currents prevail in ebb, and at St. C located to the direction of east southeast, west to west northwestward currents prevail in flood and northeast to east northeastward currents prevail in ebb. At St. D in offshore area, westward currents prevail in flood and east to east northeastward currents prevail in ebb.

The maximum current velocities during the observation period at each station are as follows;

St. A	(2m below sea surface)	:	34cm/sec (dir. 320°)
St. B	(〃)	:	48cm/sec (dir. 293°)
St. C	(〃)	:	39cm/sec (dir. 218°)
St. D	(〃)	:	48cm/sec (dir. 103°)
St. D	(2m above sea bottom)	:	31cm/sec (dir. 247~282°)

On the other hand, Figure 4-18 shows the tidal current curve at St. D for north-south component and east-west component as an example. The periodicity of tidal currents is clearly recognized as a whole. When the moon's declination is small, the type of tidal currents becomes semi-diurnal currents and when the moon's declination islarge, the type of tidal currents becomes diurnal currents. For example, the moon's declination was on the equator on September 6, and the maximum south declination on August 30 and the maximum north declination on September 12.

Tidal current curves are shown in attached figures at the end of this report in the gross.

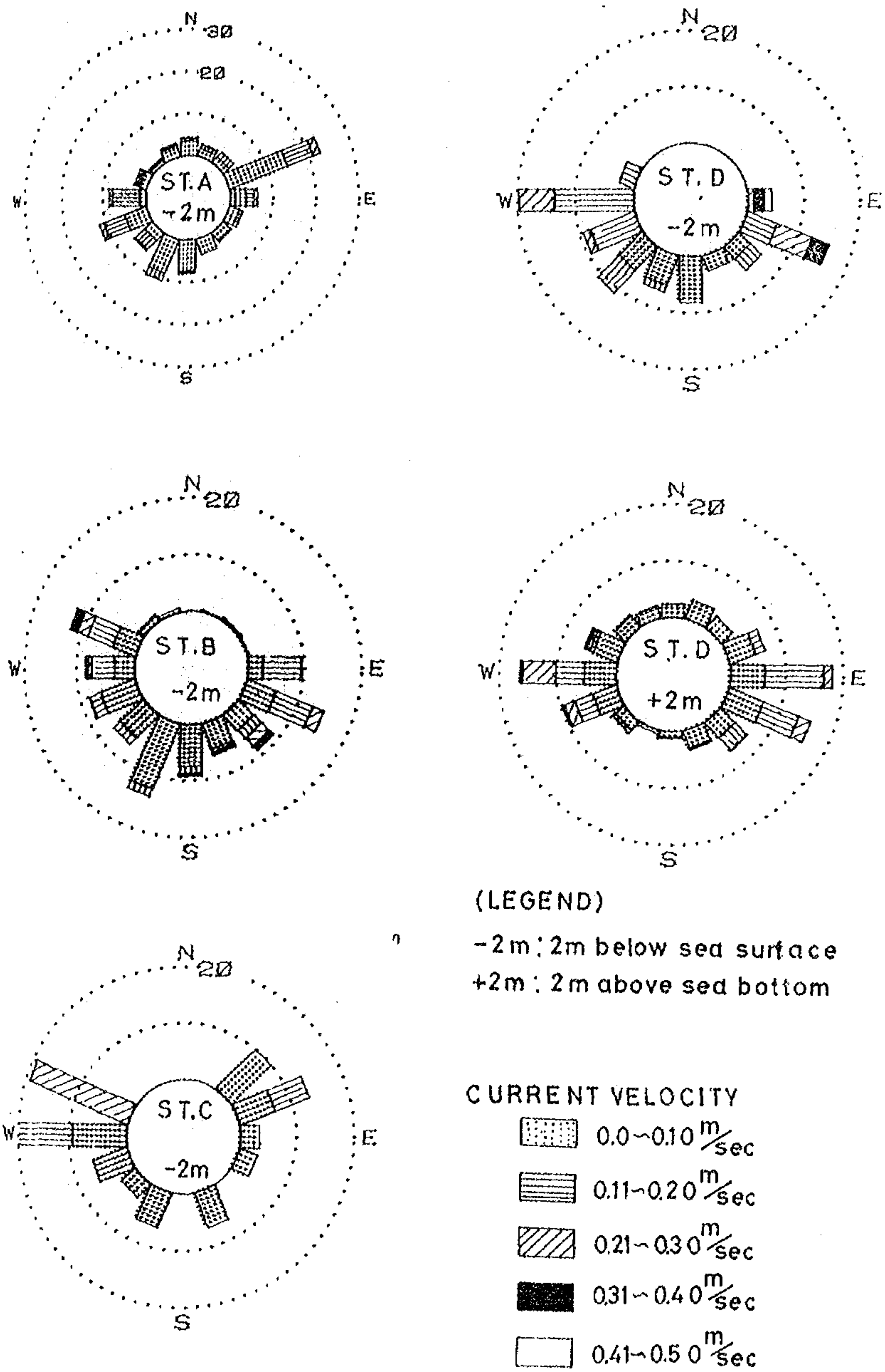


Fig. 4-17 PERCENTAGE FREQUENCY OF TIDAL CURRENT DIRECTION AND VELOCITY

Table 4-8 Frequency of Tidal Current Direction and Velocity

S.T. A (2m below sea surface) 19-Sep～3-Oct

DIR. / VEL.(m/sec)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	CALM	Total
0.0 ～ 0.1	30	16	15	129	33	21	21	34	66	75	21	46	12	15	7	25	0	566
	3.4	1.8	1.7	14.5	3.7	2.4	2.4	3.8	7.4	8.5	2.4	5.2	1.4	1.7	0.8	2.8	0.0	63.8
0.1 ～ 0.2	5	8	13	57	16	7	3	0	4	18	26	46	56	5	0	0	0	264
	0.6	0.9	1.5	6.4	1.8	0.8	0.3	0.0	0.5	2.0	2.9	5.2	6.3	0.6	0.0	0.0	0.0	29.8
0.2 ～ 0.3	2	2	0	15	7	0	0	0	0	0	3	10	6	5	1	0	0	51
	0.2	0.2	0.0	1.7	0.8	0.0	0.0	0.0	0.0	0.0	0.3	1.1	0.7	0.6	0.1	0.0	0.0	5.7
0.3 ～ 0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	0	6
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.7
Total	37	26	28	201	56	28	24	34	70	93	50	102	74	25	11	28	0	887
	4.2	2.9	3.2	22.7	6.3	3.2	2.7	3.8	7.9	10.5	5.6	11.5	8.3	2.8	1.2	3.2	0.0	100.0

S.T. B (2m below sea surface) 3-Sep～4-Oct

DIR. / VEL.(m/sec)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	CALM	Total
0.0 ～ 0.1	0	1	3	2	27	58	40	52	80	132	59	69	37	44	10	6	0	620
	0.0	0.1	0.3	0.2	2.5	5.4	3.7	4.8	7.4	12.3	5.5	6.4	3.4	4.1	0.9	0.6	0.0	57.7
0.1 ～ 0.2	0	0	0	0	73	75	21	6	13	16	17	23	45	53	3	0	0	345
	0.0	0.0	0.0	0.0	6.8	7.0	2.0	0.6	1.2	1.5	1.6	2.1	4.2	4.9	0.3	0.0	0.0	32.1
0.2 ～ 0.3	0	0	0	0	1	22	23	5	4	0	0	2	8	21	0	0	0	86
	0.0	0.0	0.0	0.0	0.1	2.0	2.1	0.5	0.4	0.0	0.0	0.2	0.7	2.0	0.0	0.0	0.0	8.0
0.3 ～ 0.4	0	0	0	0	0	0	6	0	1	0	0	0	1	12	0	0	0	20
	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.1	0.0	0.0	0.0	0.1	1.1	0.0	0.0	0.0	1.9
0.4 ～ 0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	4
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.4
Total	0	1	3	2	101	155	90	63	98	148	76	94	91	134	13	6	0	1075
	0.0	0.1	0.3	0.2	9.4	14.4	8.4	5.9	9.1	13.8	7.1	8.7	8.5	12.5	1.2	0.6	0.0	100.0

ST. C (2m below sea surface) 22-Sep～4-Oct

DIR. / VEL.(m/sec)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	CALM	Total
0.0 ～ 0.1	9	11	8	9	22	17	32	9	8	24	24	29	26	28	18	8	0	282
	1.3	1.5	1.1	1.3	3.1	2.4	4.5	1.3	1.1	3.3	3.3	4.0	3.6	3.9	2.5	1.1	0.0	39.3
0.1 ～ 0.2	7	7	10	46	34	28	23	5	5	5	19	50	56	4	0	1	0	300
	1.0	1.0	1.4	6.4	4.7	3.9	3.2	0.7	0.7	0.7	2.6	7.0	7.8	0.6	0.0	0.1	0.0	41.8
0.2 ～ 0.3	0	0	1	1	8	12	1	0	0	1	5	29	31	7	2	9	0	107
	0.0	0.0	0.1	0.1	1.1	1.7	0.1	0.0	0.0	0.1	0.7	4.0	4.3	1.0	0.3	1.3	0.0	14.9
0.3 ～ 0.4	0	0	0	0	0	0	0	0	0	0	8	7	9	0	0	5	0	29
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	1.0	1.3	0.0	0.0	0.7	0.0	4.0
Total	16	18	19	56	64	57	56	14	13	30	56	115	122	39	20	23	0	718
	2.2	2.5	2.6	7.8	8.9	7.9	7.8	1.9	1.8	4.2	7.8	16.0	17.0	5.4	2.8	3.2	0.0	100.0

ST. D (2m below sea surface) 19-Sep～3-Oct

DIR. / VEL.(m/sec)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	CALM	Total
0.0 ～ 0.1	11	9	5	4	8	21	18	15	14	12	8	13	16	27	33	28	0	242
	0.8	0.6	0.3	0.3	0.6	1.5	1.2	1.0	1.0	0.8	0.6	0.9	1.1	1.9	2.3	1.9	0.0	16.8
0.1 ～ 0.2	9	14	21	34	100	147	15	0	1	1	6	11	46	97	93	19	0	614
	0.6	1.0	1.5	2.4	6.9	10.2	1.0	0.0	0.1	0.1	0.4	0.8	3.2	6.7	6.4	1.3	0.0	42.5
0.2 ～ 0.3	0	0	2	8	95	139	0	0	0	0	0	1	21	92	55	1	0	414
	0.0	0.0	0.1	0.6	6.6	9.6	0.0	0.0	0.0	0.0	0.0	0.1	1.5	6.4	3.8	0.1	0.0	28.7
0.3 ～ 0.4	0	0	0	0	37	28	0	0	0	0	0	0	6	51	32	0	0	154
	0.0	0.0	0.0	0.0	2.6	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.4	3.5	2.2	0.0	0.0	10.7
0.4 ～ 0.5	0	0	0	0	6	3	0	0	0	0	0	0	0	5	6	0	0	20
	0.0	0.0	0.0	0.0	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4	0.0	0.0	1.4
Total	20	23	28	46	246	338	33	15	15	13	14	25	89	272	219	48	0	1444
	1.4	1.6	1.9	3.2	17.0	23.4	2.3	1.0	1.0	0.9	1.0	1.7	6.2	18.8	15.2	3.3	0.0	100.0

ST. D (2m above sea bottom) 26-Aug～15-Sep

DIR. / VEL.(m/sec)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	CALM	Total
0.0 ～ 0.1	25	37	28	51	65	70	38	34	13	7	21	46	59	48	27	23	0	592
	2.3	3.5	2.6	4.8	6.1	6.5	3.6	3.2	1.2	0.7	2.0	4.3	5.5	4.5	2.5	2.1	0.0	55.3
0.1 ～ 0.2	1	0	0	19	108	72	32	3	0	0	6	35	53	6	3	1	0	339
	0.1	0.0	0.0	1.8	10.1	6.7	3.0	0.3	0.0	0.0	0.6	3.3	5.0	0.6	0.3	0.1	0.0	31.7
0.2 ～ 0.3	0	0	0	0	17	24	1	0	1	0	1	21	62	6	0	0	0	133
	0.0	0.0	0.0	0.0	1.6	2.2	0.1	0.0	0.1	0.0	0.1	2.0	5.8	0.6	0.0	0.0	0.0	12.4
0.3 ～ 0.4	0	0	0	0	0	0	0	0	0	0	0	1	3	2	0	0	0	6
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.2	0.0	0.0	0.0	0.6
Total	26	37	28	70	190	166	71	37	14	7	28	103	177	62	30	24	0	1070
	2.4	3.5	2.6	6.5	17.8	15.5	6.6	3.5	1.3	0.7	2.6	9.6	16.5	5.8	2.8	2.2	0.0	100.0

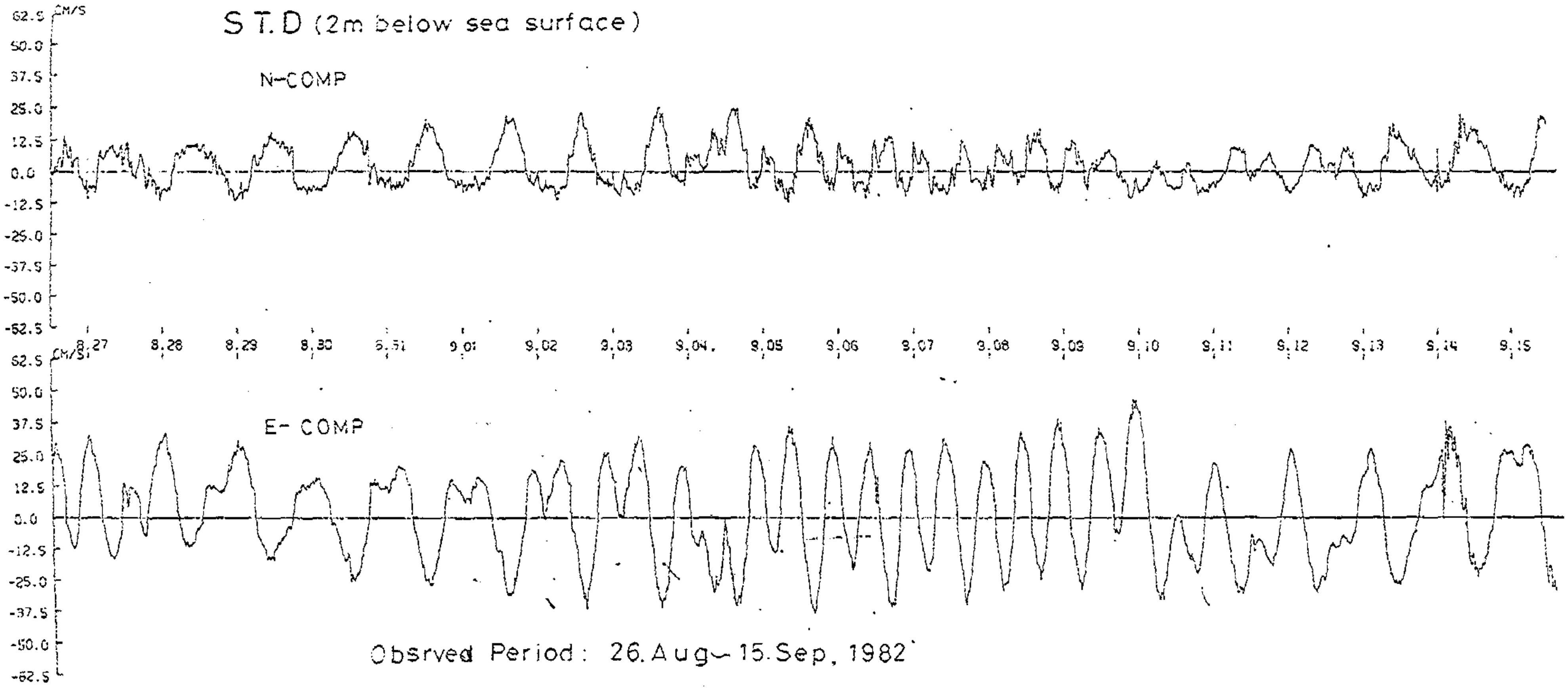


Fig. 4-18 TIDAL CURRENT CURVE

4-4-2 Harmonic Analysis of Tidal Currents

The results of the harmonic analysis are shown in Table 4-9 for each station. Figure 4-19 shows the tidal current ellipses at St. D as an example and all tidal current ellipses are shown in attached figures at the end of this report. According to the analysis, four constituents of K_1, O_1, M_2 and S_2 are prevalent in the investigated area, of which K_1 and M_2 make up a relatively large share.

The constant current is very small, namely less than 4 cm/sec.

Additionally, the principal direction of tidal currents is east southeast (approximately 100°) - west northeast (approximately 280°) as shown in tidal current ellipses.

The tidal current chart predicted using the harmonic constants is shown in the attached map at the end of this report. This chart shows the hourly variation of tidal currents in the investigated area with lunar time. In this chart, the high water means the time of the high water at Sattahip Port.

4-4-3 Drogue Survey

The results of the drogue survey are shown in Figure 4-20 with the mean velocities among the positioning points.

The direction of the coastal currents is along the shoreline as a whole and is west northwestward on the west side of the pipeline. On the east side of the pipeline, the direction is west northwest ward on September 17 and northeast to east ward on September 27. That means that the direction varies day by day depending on the meteorological and oceanographical condition on the east side of the pipeline to say the least.

The average velocity of drogues was approximately 10 cm/sec to 50 cm/sec.

Table 4-9 (1)

List of Harmonic Constants of Tidal Currents

AREA ** RA YO NG STATION ** NO. A
POSITION ** 261 DEGREE, 13.80KM FROM KO SA KE I
GEODETIC CO-ORDINATE ** LAT. 12 - 37.67 N. LONG. 101 - 3.38 E
DEPTH ** 2.0 M BELOW SEA SURFACE

	NORTH		EAST		MAJOR			MINOR			GENERAL	
	VEL.	KAPPA	VEL.	KAPPA	DIR	VEL.	KAPPA	DIR	VEL.	KAPPA	VEL.	KAPPA
V0	-0.028	***	-0.004	***	187	0.028	***	**	***	***	0.004	***
K1	0.029	54.8	0.049	225.6	120	0.057	228.0	210	0.004	318.1	0.055	227.0
P1	0.010	42.5	0.016	220.6	120	0.019	221.1	210	0.000	311.1	0.016	220.9
O1	0.012	251.3	0.026	158.7	91	0.026	158.1	181	0.012	68.1	0.025	151.5
Q1	0.002	170.2	0.005	125.6	70	0.005	131.1	160	0.001	41.1	0.004	120.0
M2	0.025	359.7	0.090	163.2	104	0.093	164.3	194	0.007	254.3	0.093	165.4
N2	0.005	4.4	0.017	140.3	101	0.018	142.5	191	0.003	232.5	0.018	143.3
S2	0.018	351.0	0.062	205.9	103	0.063	203.7	193	0.010	113.7	0.063	203.3
K2	0.005	350.2	0.017	209.4	103	0.017	202.0	193	0.003	112.0	0.017	204.5
M4	0.005	13.2	0.002	197.4	152	0.004	194.1	242	0.000	104.1	0.003	195.9
MS4	0.003	211.2	0.003	132.6	136	0.005	134.3	226	0.001	24.3	0.005	124.8

GENERAL DIRECTION ** 106 (POSITIVE) 286 (NEGATIVE)

AREA ** RA YO NG STATION ** NO. B
POSITION ** 261 DEGREE, 5.20KM FROM KO SA KE I
GEODETIC CO-ORDINATE ** LAT. 12 - 38.37 N. LONG. 101 - 7.67 E
DEPTH ** 2.0 M BELOW SEA SURFACE

	NORTH		EAST		MAJOR			MINOR			GENERAL	
	VEL.	KAPPA	VEL.	KAPPA	DIR	VEL.	KAPPA	DIR	VEL.	KAPPA	VEL.	KAPPA
V0	-0.002	***	0.001	***	166	0.002	***	**	***	***	0.001	***
K1	-0.020	87.6	0.037	309.7	113	0.060	301.1	203	0.016	211.1	0.039	303.4
P1	0.007	35.3	0.012	297.7	114	0.013	289.5	204	0.004	199.5	0.013	291.9
O1	-0.010	345.8	0.031	149.8	107	0.033	151.3	197	0.003	241.3	0.033	151.2
Q1	0.002	292.3	0.006	70.5	283	0.006	252.7	13	0.001	342.7	0.006	74.4
M2	-0.009	199.7	0.026	217.2	82	0.026	216.9	172	0.001	306.9	0.024	218.0
N2	-0.001	135.9	0.005	216.0	88	0.005	215.8	178	0.001	305.8	0.005	218.5
S2	-0.009	319.3	0.015	219.4	100	0.015	213.0	190	0.009	123.0	0.015	207.0
K2	0.002	329.4	0.004	219.6	107	0.004	209.4	197	0.002	119.4	0.004	207.9
M4	0.007	42.3	0.005	293.1	147	0.007	258.9	237	0.005	158.9	0.006	276.8
MS4	0.007	138.0	0.006	327.1	323	0.009	141.3	53	0.001	51.3	0.008	324.5

GENERAL DIRECTION ** 107 (POSITIVE) 287 (NEGATIVE)

AREA ** RA YO NG STATION ** NO. C
POSITION ** 115 DEGREE, 3.80KM FROM KO SA KE I
GEODETIC CO-ORDINATE ** LAT. 12 - 37.87 N. LONG. 101 - 12.35 E
DEPTH ** 2.0 M BELOW SEA SURFACE

	NORTH		EAST		MAJOR			MINOR			GENERAL	
	VEL.	KAPPA	VEL.	KAPPA	DIR	VEL.	KAPPA	DIR	VEL.	KAPPA	VEL.	KAPPA
V0	-0.014	***	-0.037	***	249	0.039	***	**	***	***	-0.036	***
K1	0.040	1.9	0.073	211.2	117	0.082	204.8	207	0.018	114.8	0.075	210.4
P1	0.013	9.0	0.024	207.3	118	0.027	203.1	208	0.004	113.1	0.025	206.7
O1	0.036	104.4	0.068	157.2	62	0.073	149.0	152	0.027	239.0	0.067	158.5
Q1	0.007	155.5	0.013	130.4	63	0.015	135.6	153	0.003	45.6	0.013	129.7
M2	0.008	75.4	0.081	166.5	90	0.083	166.5	180	0.008	256.5	0.081	166.8
N2	0.002	11.2	0.016	173.0	95	0.016	173.2	185	0.001	263.2	0.016	173.1
S2	0.009	195.0	0.045	154.4	81	0.045	155.5	171	0.006	65.5	0.045	154.0
K2	0.002	204.7	0.012	153.4	82	0.012	154.5	172	0.002	64.5	0.012	153.0
M4	0.006	311.2	0.016	95.2	108	0.017	99.1	198	0.003	189.1	0.016	95.9
MS4	0.012	77.3	0.016	191.6	116	0.017	208.2	206	0.010	298.2	0.016	193.6

GENERAL DIRECTION ** 93 (POSITIVE) 273 (NEGATIVE)

Table 4-9 (2)

List of Harmonic Constants of Tidal Currents

AREA ** RA YO NG STATION ** NO. D
POSITION ** 206 DEGREE, 11.90KM FROM KO.SA.KE I.
GEODETIC CO-ORDINATE ** LAT. 12 - 33.01 N. LONG. 101 - 7.87 E
DEPTH ** 2.0 M BELOW SEA SURFACE

	NORTH		EAST		MAJOR			MINOR			GENERAL	
	VEL.	KAPPA	VEL.	KAPPA	DIR	VEL.	KAPPA	DIR	VEL.	KAPPA	VEL.	KAPPA
Y0	0.025	***	0.015	***	31	0.029	***	**	***	***	0.005	***
K1	0.031	42.5	0.134	210.5	121	0.156	213.7	211	0.013	303.7	0.154	212.8
P1	0.027	38.1	0.044	208.4	121	0.052	211.2	211	0.004	301.7	0.051	210.3
O1	0.044	351.3	0.097	132.1	114	0.106	180.2	204	0.008	90.2	0.106	180.4
Q1	0.009	325.8	0.019	167.9	113	0.020	164.3	203	0.003	74.3	0.020	164.7
M2	0.044	333.1	0.157	162.1	105	0.163	161.5	195	0.007	71.5	0.162	161.3
N2	0.008	305.1	0.030	128.2	105	0.032	124.0	195	0.000	38.0	0.031	127.9
S2	0.028	25.4	0.103	225.4	104	0.106	224.1	194	0.009	134.1	0.105	223.5
K2	0.008	29.6	0.028	230.5	104	0.029	229.2	194	0.003	139.2	0.029	228.6
M4	0.000	82.7	0.005	101.3	85	0.005	101.2	175	0.000	191.2	0.005	101.9
MS4	0.002	298.4	0.006	181.7	95	0.006	180.3	185	0.002	90.3	0.006	175.8

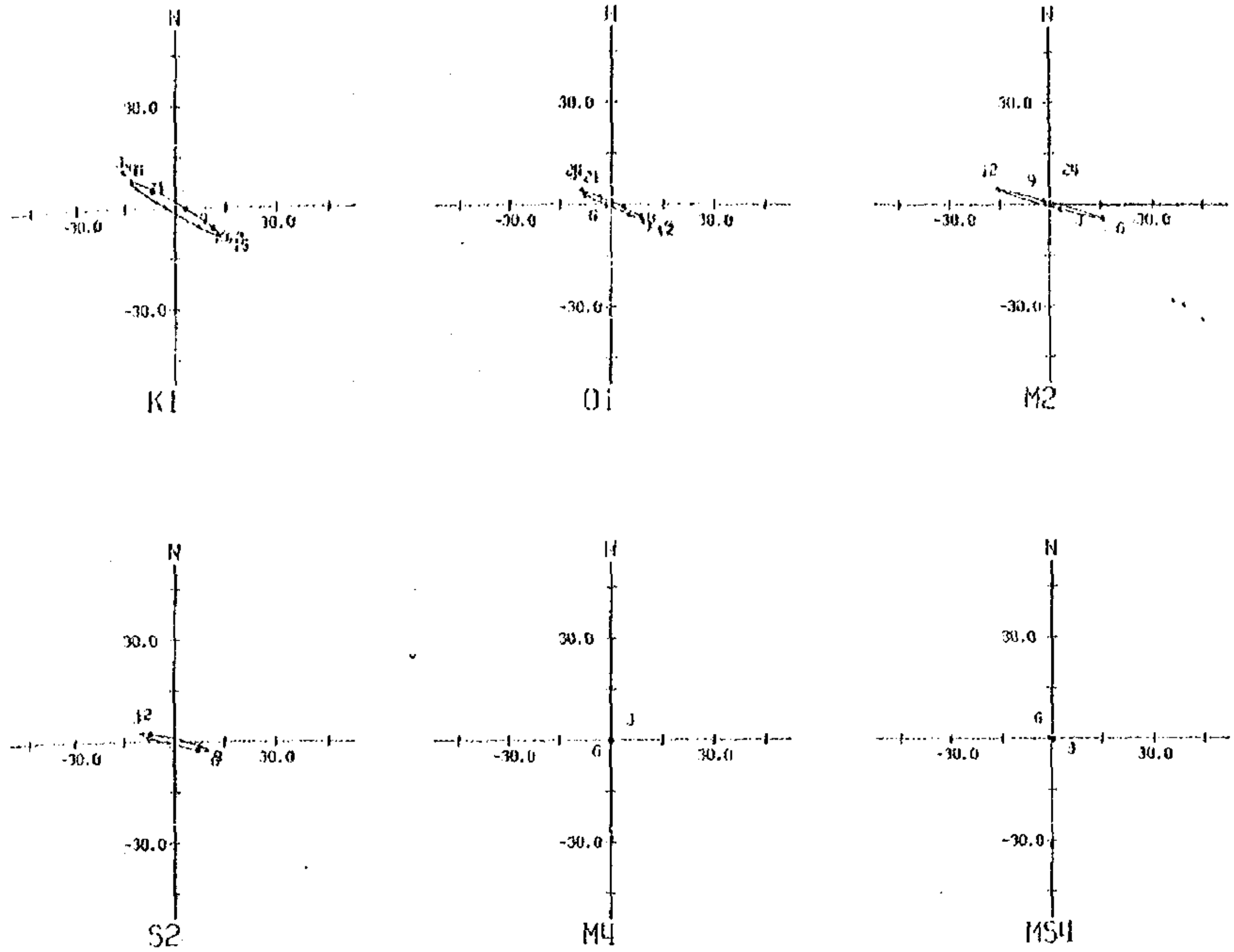
GENERAL DIRECTION ** 111 (POSITIVE) 291 (NEGATIVE)

AREA ** RA YO NG STATION ** NO. D
POSITION ** 206 DEGREE, 11.90KM FROM KO.SA.KE I.
GEODETIC CO-ORDINATE ** LAT. 12 - 33.01 N. LONG. 101 - 7.87 E
DEPTH ** 2.0 M ABOVE SEA BOTTOM

	NORTH		EAST		MAJOR			MINOR			GENERAL	
	VEL.	KAPPA	VEL.	KAPPA	DIR	VEL.	KAPPA	DIR	VEL.	KAPPA	VEL.	KAPPA
Y0	0.012	***	0.005	***	162	0.013	***	**	***	***	0.005	***
K1	0.005	213.4	0.097	226.3	86	0.097	226.3	176	0.001	316.3	0.097	226.3
P1	0.002	226.7	0.032	223.1	86	0.032	223.1	176	0.000	133.1	0.032	223.1
O1	0.015	3.2	0.070	182.2	102	0.072	182.9	192	0.001	272.9	0.070	182.7
Q1	0.003	80.3	0.014	161.1	87	0.015	160.7	177	0.003	250.7	0.014	160.9
M2	0.012	259.6	0.105	177.8	88	0.105	178.0	178	0.012	88.0	0.105	177.9
N2	0.002	201.7	0.020	145.1	87	0.020	145.5	177	0.002	55.5	0.020	145.2
S2	0.005	342.0	0.058	240.5	90	0.058	240.7	180	0.005	150.7	0.057	240.6
K2	0.001	349.1	0.016	245.9	91	0.016	245.8	181	0.001	155.8	0.016	245.9
M4	0.002	251.2	0.002	227.4	6	0.005	260.5	96	0.002	350.5	0.002	225.5
MS4	0.004	255.9	0.006	113.9	118	0.006	130.5	208	0.004	220.5	0.006	113.2

GENERAL DIRECTION ** 89 (POSITIVE) 269 (NEGATIVE)

ST.D(2m below sea surface)　　unit: cm/sec



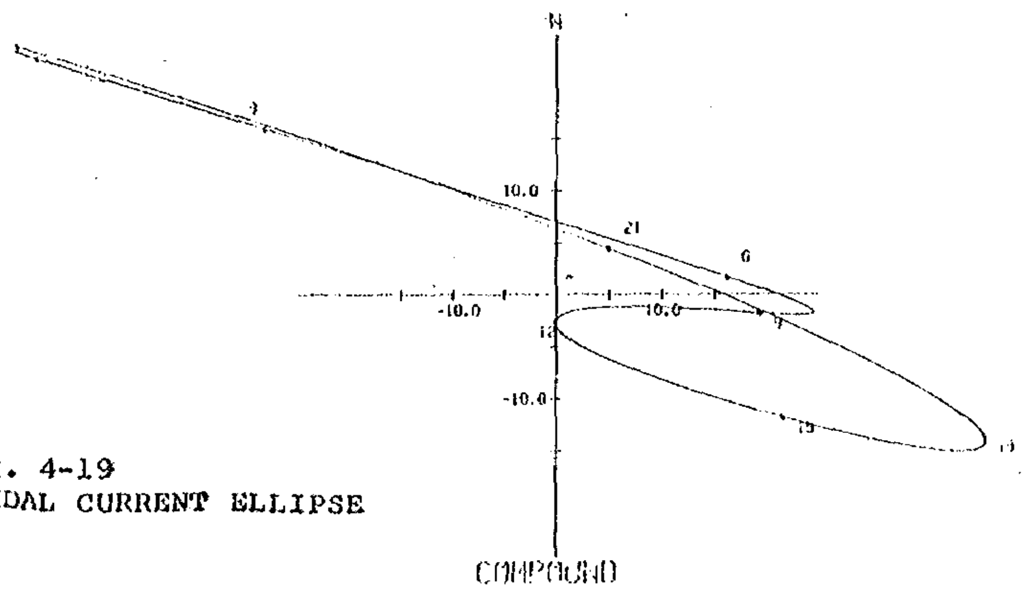
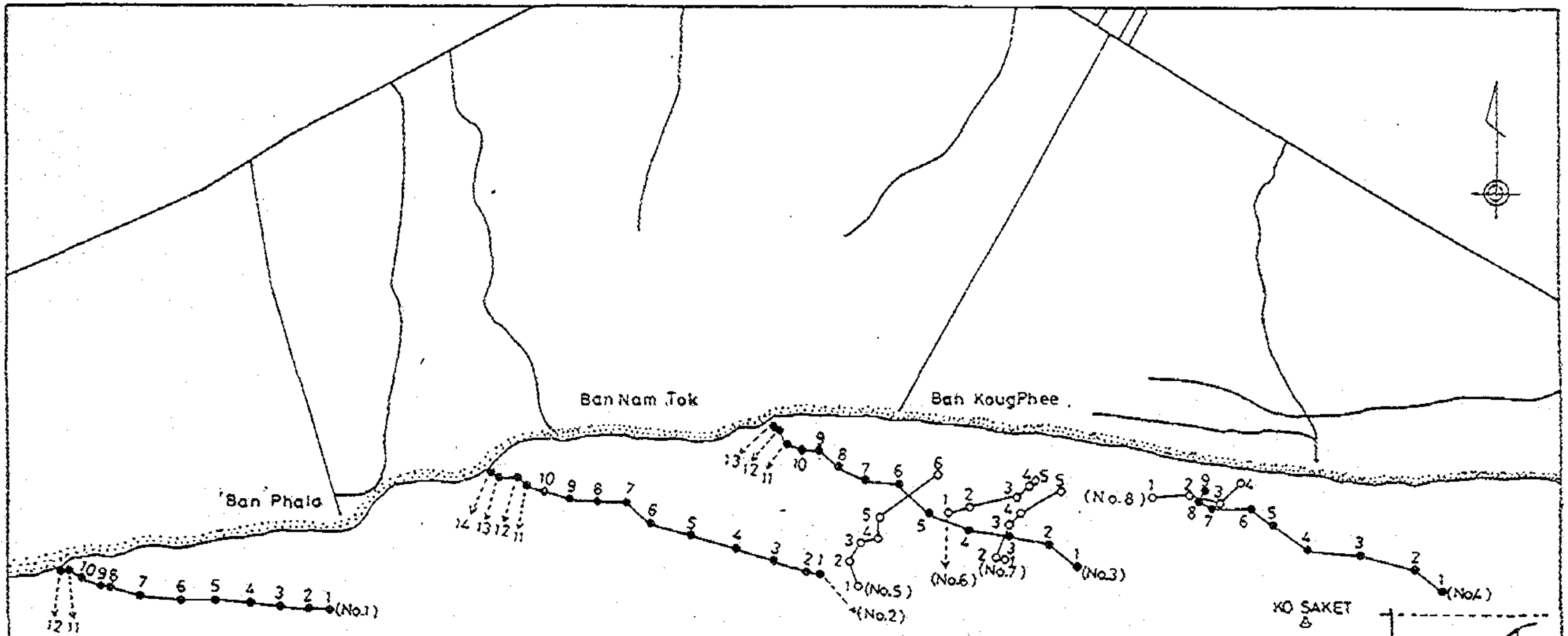


Fig. 4-19
TIDAL CURRENT ELLIPSE



No.1 Sep.17	Time	VEL. (m/s)	No.2 Sep.17	Time	VEL. (m/s)	No.3 Sep.17	Time	VEL. (m/s)	No.4 Sep.17	Time	VEL. (m/s)	No.5 Sep.27	Time	VEL. (m/s)	No.6 Sep.27	Time	VEL. (m/s)	No.7 Sep.27	Time	VEL. (m/s)	No.8 Sep.27	Time	VEL. (m/s)
1	9:31		1	9:43		1	10:02		1	11:00		1	9:12		1	13:45		1	9:21		1	13:24	
2	10:00	0.17	2	10:00	0.19	2	10:30	0.30	2	12:00	0.36	2	9:32	0.22	2	14:15	0.14	2	9:45	0.07	2	14:31	0.11
3	10:30	0.23	3	10:30	0.28	3	11:00	0.31	3	12:30	0.49	3	10:24	0.10	3	15:00	0.18	3	10:39	0.12	3	14:45	0.33
4	11:00	0.26	4	11:00	0.32	4	11:30	0.33	4	13:00	0.47	4	10:54	0.08	4	15:15	0.04	4	11:36	0.06	4	15:30	0.11
5	11:30	0.27	5	11:30	0.38	5	12:00	0.35	5	13:30	0.41	5	11:25	0.11	5	15:52	0.05	5	13:12	0.09			
6	12:00	0.29	6	12:00	0.33	6	12:30	0.41	6	14:00	0.32	6	13:38	0.11									
7	12:30	0.30	7	12:30	0.24	7	13:00	0.36	7	14:30	0.39												
8	13:00	0.27	8	13:00	0.24	8	13:30	0.33	8	15:00	0.26												
9	13:30	0.09	9	13:30	0.21	9	14:00	0.30	9	15:30	0.24												
10	14:05	0.18	10	14:00	0.22	10	14:30	0.26															
11	14:30	0.10	11	14:30	0.16	11	15:00	0.25															
12	15:00	0.10	12	15:00	0.14	12	15:30	0.25															
			13	15:30	0.11	13	16:00	0.21															
			14	16:00	0.11																		

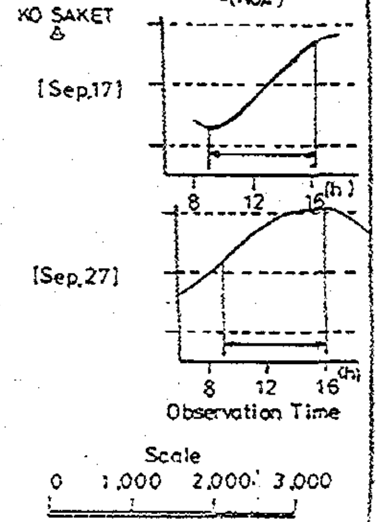


Fig. 4-20 Results of Drogue Survey

4-5 Waves

4-5-1 Frequency of Waves

The frequencies of wave height and wave period observed on this study are shown in Table 4-10 and Figure 4-21 for each month.

According to the frequencies of occurrences, the wave height less than one meter is prominent through all the period of the observation in the investigated area and the wave height more than two meters is seldom observed. The maximum wave height was 3.20 meters on August 11, followed by 3.03 meters on August 16.

The wave height shows a steady decrease day by day from August to October corresponding to the decrease of wind velocity as described later. Especially, the wave height more than 0.5m could not be observed on October.

With respect to the wave period, the period between 3.0 seconds to 6.0 seconds is prominent in the investigated area.

4-5-2 Statistical Analysis of Waves

Table 4-11 shows the daily maximum wave (Hmax. Tmax), 1/10 maximum wave ($H_{1/10}$, $T_{1/10}$), significant wave ($H_{1/3}$, $T_{1/3}$) and mean wave (Hmean, Tmean). Here, the values of $H_{1/10}$, $H_{1/3}$ and Hmean are the mean value of those of every two hours, namely the mean value of twelve values per day.

On August when the sea condition was most rough, $H_{1/10}$ is 0.44 meters to 1.80 meters, $H_{1/3}$ is 0.33 meters to 1.41 meters and Hmean is 0.20 meters to 0.90 meters.

The relation among wave heights and wave periods was investigated using the $H_{1/3}$, $H_{1/10}$, Hman, $T_{1/3}$, $T_{1/10}$ and so on. As a result, the following relations for wave heights are obtained by the least squares method as shown in Figure 4-22. Between wave height and wave period, and between wave period and period, however, significant relations could not be obtained.

$$H_{max} = 1.519\ H_{1/3} + 0.145 \qquad (r = 0.959)$$

$$H_{1/10} = 1.253\ H_{1/3} + 0.044 \qquad (r = 0.996)$$

$$H_{1/3} = 1.558\ H_{mean} + 0.034 \qquad (r = 0.996)$$

$$H_{max} = 1.222\ H_{1/10} + 0.084 \qquad (r = 0.971)$$

$$H_{1/10} = 1.945\ H_{mean} + 0.089 \qquad (r = 0.989)$$

$$H_{max} = 2.356\ H_{mean} + 0.201 \qquad (r = 0.951)$$

Where, r is a coefficient of correlation.

Table 4-10 Frequency of Wave Height and Period

Aug. 1982

Height (m) / Period (sec)	0.0 0.50	0.51 1.00	1.01 1.50	1.51 2.00	2.01 2.50	2.51 3.00	3.01 3.50	Total
0.0~1.0	6	0	0	0	0	0	0	6
1.1~2.0	1	0	0	0	0	0	0	0
2.1~3.0	522	0	0	0	0	0	0	0
3.1~4.0	655	491	122	43	6	1	0	0
4.1~5.0	6417	4619	1296	261	56	17	2	0
5.1~6.0	1770	1314	477	126	16	1	0	0
6.1~7.0	1670	757	263	52	2	2	0	0
7.1~8.0	1312	219	40	5	0	1	0	0
8.1~9.0	212	26	0	0	0	0	0	0
9.1~10.0	258	11	3	0	0	0	0	0
10.1~11.0	44	0	0	0	0	0	0	0
11.1~12.0	57	0	0	0	0	0	0	0
12.1 ~	73	0	0	0	0	0	0	0
Total	12996	7437	2201	483	79	22	0	0

Sep. 1982

Height (m) / Period (sec)	0.0 0.50	0.51 1.00	1.01 1.50	1.51 2.00	2.01 2.50	2.51 3.00	3.01 3.50	Total
0.0~1.0	1	0	0	0	0	0	0	1
1.1~2.0	1	0	0	0	0	0	0	1
2.1~3.0	202	0	0	0	0	0	0	202
3.1~4.0	971	182	21	5	0	0	0	1171
4.1~5.0	7004	1078	192	28	1	0	0	8303
5.1~6.0	2678	569	89	12	1	0	0	3299
6.1~7.0	1683	191	29	1	0	0	0	1904
7.1~8.0	1675	71	3	0	0	0	0	1749
8.1~9.0	346	3	0	0	0	0	0	349
9.1~10.0	612	1	0	0	0	0	0	613
10.1~11.0	143	0	0	0	0	0	0	143
11.1~12.0	277	0	0	0	0	0	0	277
12.1 ~	532	0	0	0	0	0	0	532
Total	16075	2094	334	46	2	0	0	18551

Oct. 1982

Height (m) / Period (sec)	0.0 0.50	0.51 1.00	1.01 1.50	1.51 2.00	2.01 2.50	2.51 3.00	3.01 3.50	Total
0.0~1.0	0	0	0	0	0	0	0	0
1.1~2.0	0	0	0	0	0	0	0	0
2.1~3.0	2	0	0	0	0	0	0	2
3.1~4.0	7	0	0	0	0	0	0	7
4.1~5.0	30	0	0	0	0	0	0	30
5.1~6.0	45	0	0	0	0	0	0	45
6.1~7.0	54	0	0	0	0	0	0	54
7.1~8.0	92	0	0	0	0	0	0	92
8.1~9.0	44	0	0	0	0	0	0	44
9.1~10.0	62	0	0	0	0	0	0	52
10.1~11.0	29	0	0	0	0	0	0	29
11.1~12.0	20	0	0	0	0	0	0	20
12.1 ~	121	0	0	0	0	0	0	121
Total	496	0	0	0	0	0	0	496

TOTAL (Aug.~Oct.)

Height (m) / Period (sec)	0.0 0.50	0.51 1.00	1.01 1.50	1.51 2.00	2.01 2.50	2.51 3.00	3.01 3.50	Total
0.0~1.0	7 (0.0)	0	0	0	0	0	0	7 (0.0)
1.1~2.0	2 (0.0)	0	0	0	0	0	0	2 (0.0)
2.1~3.0	726 (2.0)	0	0	0	0	0	0	726 (1.7)
3.1~4.0	1633 (4.0)	672 (2.0)	143 (0.3)	48 (0.1)	6 (0.0)	1 (0.0)	0	2503 (6.5)
4.1~5.0	13451 (32.0)	5697 (13.0)	1488 (4.0)	289 (0.7)	56 (0.1)	17 (0.0)	2 (0.0)	21000 (49.7)
5.1~6.0	4443 (11.0)	1883 (4.0)	566 (1.0)	138 (0.3)	17 (0.0)	1 (0.0)	0	7048 (16.3)
6.1~7.0	3407 (8.0)	948 (2.0)	292 (0.7)	53 (0.1)	2 (0.0)	2 (0.0)	0	4704 (11.1)
7.1~8.0	3079 (7.0)	290 (0.7)	43 (0.1)	5 (0.0)	0	1 (0.0)	0	3418 (7.8)
8.1~9.0	601 (1.4)	29 (0.0)	0	0	0	0	0	630 (1.4)
9.1~10.0	922 (2.1)	12 (0.0)	3 (0.0)	0	0	0	0	937 (2.2)
10.1~11.0	216 (0.5)	0	0	0	0	0	0	216 (0.5)
11.1~12.0	354 (0.8)	0	0	0	0	0	0	354 (0.8)
12.1 ~	726 (2.0)	0	0	0	0	0	0	726 (2.0)
Total	29567 (69.9)	9531 (22.5)	2535 (6.0)	533 (1.3)	81 (0.2)	22 (0.1)	2 (0.0)	42771 (100.0)

( ): %

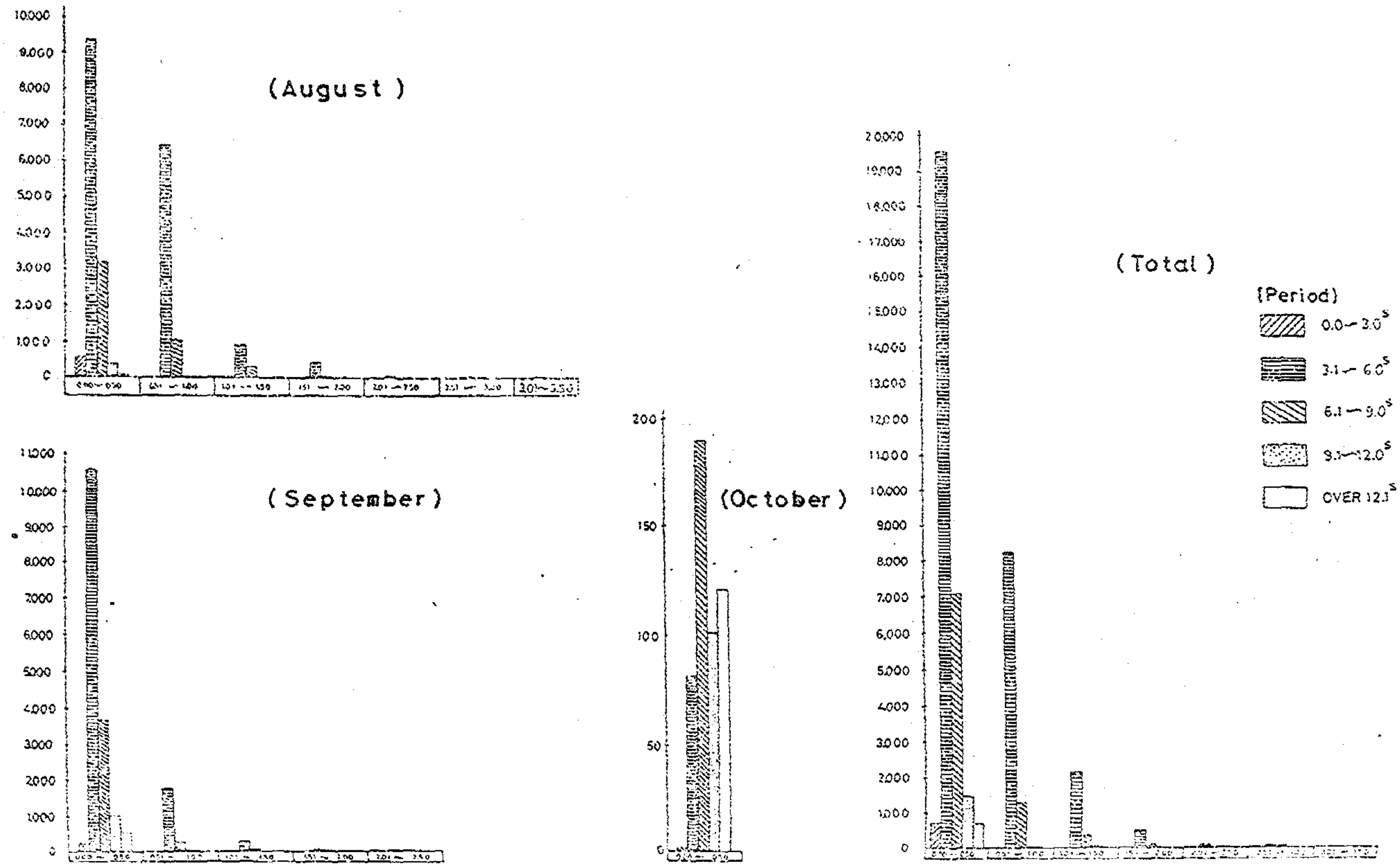


Fig. 4-21 Frequency of Wave Height and Period

Table 4-11 (1) Daily Wave Data

Aug.1982

DATE	HEIGHT (m)				PERIOD (sec)			
	H max	H 1/10	H 1/3	H mean	T max	T 1/10	T 1/3	T mean
1	1.80	1.21	0.92	0.55	4.9	4.9	5.0	5.7
2	1.18	0.76	0.56	0.30	4.4	4.7	4.9	5.7
3	1.05	0.50	0.36	0.22	3.6	4.3	4.6	5.1
4	1.28	0.44	0.33	0.20	3.6	4.0	4.4	4.9
5	2.15	1.35	1.00	0.58	4.7	4.6	4.7	4.9
6	2.33	1.45	1.14	0.71	4.7	4.8	4.9	5.2
7	2.44	1.31	1.01	0.62	4.6	4.8	4.9	5.3
8	1.81	0.92	0.66	0.39	3.3	4.4	4.5	5.0
9	2.63	1.41	1.07	0.65	4.7	4.7	4.8	5.3
10	2.77	1.77	1.36	0.85	4.6	4.9	5.1	5.6
11	3.22	1.80	1.41	0.90	4.7	5.5	5.7	6.0
12	2.57	1.59	1.20	0.72	3.3	4.6	4.8	5.3
13	2.12	0.99	0.74	0.45	3.3	4.6	4.6	5.1
14	1.90	0.79	0.56	0.33	3.6	4.0	4.3	4.7
15	2.51	1.23	0.88	0.52	4.8	5.0	4.9	5.0
16	3.03	1.51	1.04	0.59	4.8	5.0	5.0	5.0
17	2.87	1.71	1.30	0.79	4.6	5.4	5.5	5.6
18	1.75	0.91	0.67	0.40	3.6	4.4	4.6	5.1
19	1.31	0.91	0.65	0.38	3.6	4.3	4.5	5.5
20								
21								
22								
23								
24	NO DATA							
25								
26								
27								
28								
29								
30								
31								

Table 4-11 (2) Daily Wave Data

Sep.1982

DATE	HEIGHT (m)				PERIOD (sec)			
	H max	H 1/10	H 1/3	H mean	T max	T 1/10	T 1/3	T mean
1								
2								
3	1.74	0.87	0.62	0.30	5.1	5.0	5.1	5.7
4	1.68	0.82	0.52	0.22	3.6	4.7	4.7	5.5
5	1.63	1.08	0.79	0.38	4.9	4.9	5.1	5.7
6	1.44	0.75	0.48	0.22	5.2	5.3	5.3	6.1
7	1.43	0.80	0.51	0.24	5.0	5.0	5.2	5.8
8	2.14	1.29	0.95	0.53	5.2	5.3	5.5	6.1
9	2.30	1.24	0.85	0.47	4.9	4.7	4.9	6.0
10	1.15	0.55	0.38	0.20	3.6	5.1	5.4	6.8
11	0.72	0.28	0.19	0.09	3.4	4.7	5.3	7.9
12	2.57	1.59	1.20	0.72	3.3	4.6	4.8	5.3
13	0.77	0.52	0.36	0.19	3.5	4.4	4.6	6.1
14	1.23	0.53	0.34	0.15	4.1	4.2	4.4	5.9
15	1.53	0.69	0.46	0.22	3.6	4.5	4.6	5.4
16	1.63	0.71	0.46	0.22	3.7	4.5	4.6	5.7
17	1.01	0.57	0.36	0.16	3.4	3.9	4.3	5.8
18								
19								
20		CALM						
21								
22	0.20	0.13	0.08	0.04	3.2	4.5	4.6	5.3
23	1.11	0.42	0.24	0.11	4.8	4.9	4.7	5.6
24	0.51	0.20	0.13	0.07	4.6	4.0	4.4	5.3
25	0.24	0.17	0.11	0.05	3.6	3.6	4.3	5.1
26								
27	0.29	0.20	0.11	0.05	3.3	3.2	3.6	4.1
28	0.20	0.16	0.08	0.04	2.3	3.0	3.4	4.0
29								
30								
31								

Table 4-11 (3) Daily Wave Data

Oct.1982

DATE	HEIGHT (m)				PERIOD (sec)			
	H max	H 1/10	H 1/3	H mean	T max	T 1/10	T 1/3	T mean
1								
2								
3								
4								
5		CALM						
6								
7								
8								
9								
10								
11	0.14	0.08	0.04	0.02	8.3	7.5	7.4	8.8
12	0.18	0.08	0.04	0.02	5.1	5.1	6.6	9.7
13								
14								
15								
16								
17		CALM						
18								
19								
20								
21								
22	0.20	0.10	0.05	0.03	2.9	3.5	4.4	7.2
23								
24								
25								
26								
27								
28								
29								
30								
31								

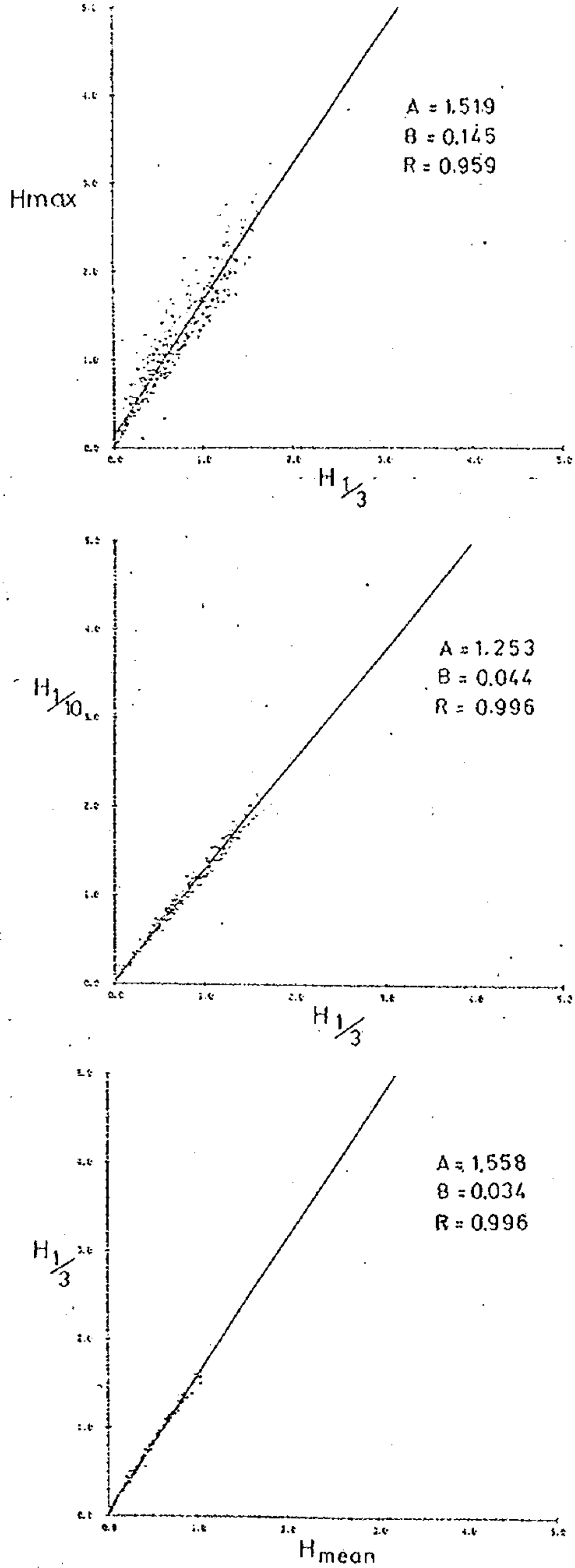


Fig. 4-22 (1) Relation among Wave Heights

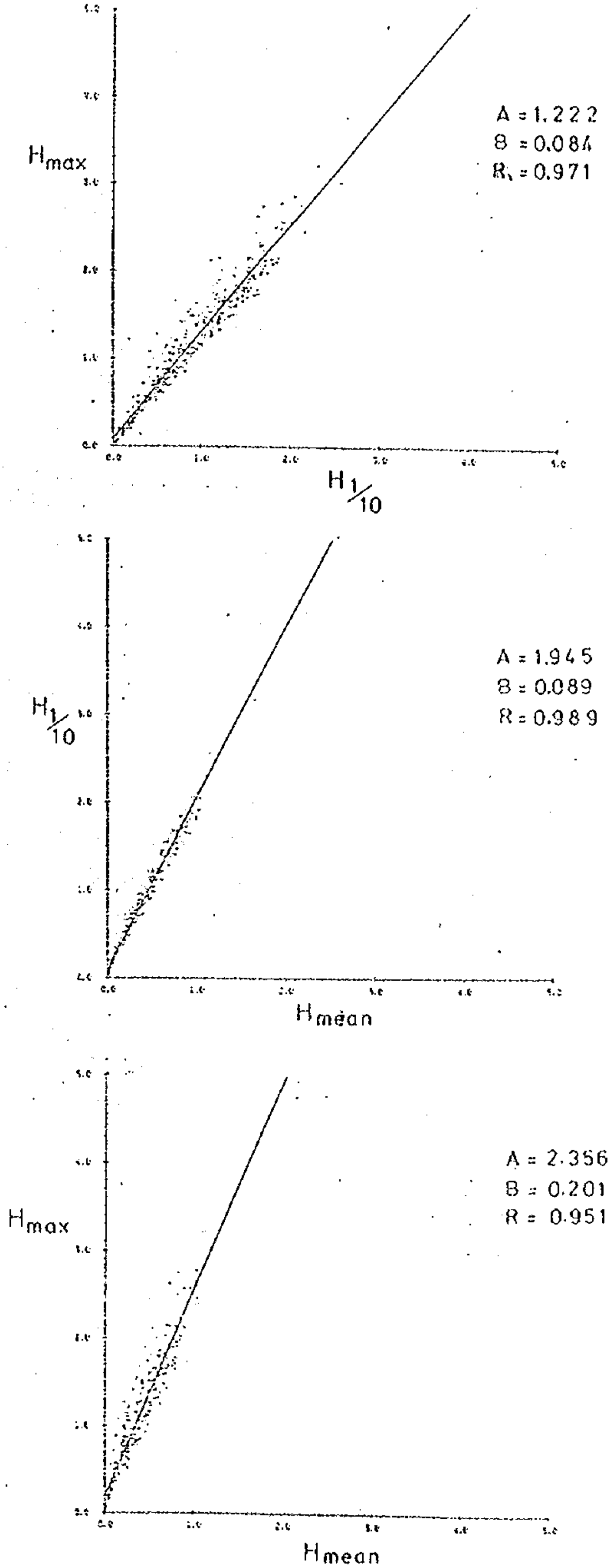


Fig. 4-22 (2) Relation among Wave Heights

4-6 Wind

The results of the wind observation at Ko Saket are shown in the separated appendix "Survey Data" in which the direction, average velocity and instantaneous velocity are shown every ten minutes. The wind data and other meteorological data every three hours during the survey period at U-Tapao Airfield are shown in the separated appendix, too.

Table 4-12, Figure 4-23 and Table 4-13, Figure 4-24 show the frequencies of the wind velocity and direction for average velocity and instantaneous velocity, respectively.

According to the frequencies of occurrences, the wind velocity shows a decrease from August to October. The prominent average velocity on August, September and October was 4.0 ~ 7.0m/sec, 3.0 ~ 6.0m sec/and 1.0 ~ 4.0m/sec, respectively. The prominent instantaneous velocity was 5.0 ~ 8.0m/sec on August, 4.0 ~ 7.0m/sec on Septmeber and 2.0 ~ 5.0m/sec on October.

The maximum velocity observed during the survey period at Ko Saket was 12.1m/sec on August 20 for the average velocity and 20.0m/sec on September 6 for the instantaneous velocity.

With regard to the wind direction, the prominent direction was southeast to south southeast on August and September, north northwest on October. In Thailand, winds are characterized by the northeast and southwest monsoon. The northeast monsoon season is from middle of October to middle of February, and the southwest monsoon season is from middle of May to middle of October. Corresponding to the monsoon season, the southeast to south southeast winds prevail on August and the north northwest wind prevail on Oatober in the investigated area.

Table 4-14 shows the daily wind data at Ko Saket during the observed period from August 17 to October 21, 1983. The items are as follows;

Average Vel. : Daily average velocity of Averagd Velocity of every 10 minutes.

Prominent Dir. : Daily highest frequent direction. Direction in bracket is the second frequency.

Maximum Vel. : Daily maximum velocity of Average Velocity.

Maximum Dir. : Direction of Maximum Velocity.

Maximum Instantaneous Vel.

: Daily maximumvelocity of Instantaneous Velocity.

Table 4-12 Frequency of Wind Velocity and Direction (Average Velocity)

Aug. 1982

WIND DIRECTION	C	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	TOTAL
CALM	89	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	89
0.3- 0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	1	0	4
1.0- 1.9	0	0	13	2	3	0	0	0	6	5	7	10	20	2	4	2	10	84
2.0- 2.9	0	0	6	2	1	2	3	0	3	24	12	18	26	14	12	8	7	138
3.0- 3.9	0	0	0	0	0	1	4	0	5	40	33	27	12	11	4	0	7	144
4.0- 4.9	0	0	0	0	0	0	5	3	16	75	193	68	7	10	0	0	0	377
5.0- 5.9	0	0	0	0	0	0	0	0	8	137	335	53	7	0	0	0	0	540
6.0- 6.9	0	0	0	0	0	0	0	0	1	126	310	19	0	0	0	0	0	456
7.0- 7.9	0	0	0	0	0	0	0	0	0	92	92	4	0	1	0	0	0	189
8.0- 8.9	0	0	0	0	0	0	0	0	0	27	29	2	0	0	0	0	0	58
9.0- 9.9	0	0	0	0	0	0	0	0	0	9	2	2	0	0	0	0	0	13
10.0-10.9	0	0	0	0	0	0	0	0	0	5	3	2	0	0	0	0	0	10
11.0-11.9	0	0	0	0	0	0	0	0	0	7	1	1	0	0	0	0	0	9
12.0-12.9	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	3
13.0-13.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14.0-14.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	89	0	19	4	4	3	12	3	39	491	1019	207	72	41	20	11	24	2064
PERCENT	4.31	0.00	0.92	0.19	0.19	0.15	0.58	0.15	1.89	24.08	49.37	10.03	3.49	1.99	0.97	0.53	1.16	100.00

Sep. 1982

WIND DIRECTION	C	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	TOTAL
CALM	214	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	214
0.3- 0.9	0	11	23	0	1	6	4	1	1	2	3	2	8	1	1	1	3	66
1.0- 1.9	0	66	46	13	9	12	8	8	3	3	2	4	10	3	1	1	16	207
2.0- 2.9	0	131	43	46	35	36	46	35	45	23	34	29	23	16	9	6	48	603
3.0- 3.9	0	46	9	19	32	32	61	15	68	80	80	9	28	23	1	2	12	517
4.0- 4.9	0	36	6	19	30	22	43	27	128	258	211	38	54	46	0	9	16	943
5.0- 5.9	0	11	2	0	3	0	1	8	47	196	276	55	49	21	0	4	11	686
6.0- 6.9	0	6	0	0	1	0	0	3	63	202	402	108	18	2	0	0	4	809
7.0- 7.9	0	4	0	0	0	0	0	0	5	61	102	28	0	1	0	0	4	205
8.0- 8.9	0	1	0	0	0	0	0	0	0	2	45	8	1	0	0	0	1	58
9.0- 9.9	0	0	0	0	2	0	0	0	0	0	4	0	0	0	0	0	0	6
10.0-10.9	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	3
11.0-11.9	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
12.0-12.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13.0-13.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14.0-14.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	214	318	129	97	116	102	163	95	360	829	1159	281	192	113	12	23	117	4320
PERCENT	4.95	7.36	2.99	2.25	2.69	2.36	3.77	2.20	8.33	19.19	26.83	6.50	4.44	2.62	0.28	0.53	2.71	100.00

Oct. 1982

WIND DIRECTION	C	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	TOTAL
CALM	346	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	346
0.3- 0.9	0	63	29	18	12	5	0	1	3	4	5	1	1	1	0	3	15	161
1.0- 1.9	0	177	79	37	52	16	5	11	20	14	9	10	21	1	1	14	37	475
2.0- 2.9	0	311	82	45	35	26	43	61	78	36	13	5	9	3	3	37	21	942
3.0- 3.9	0	286	59	30	40	20	62	59	64	10	11	8	3	2	5	20	15	694
4.0- 4.9	0	71	17	4	10	11	42	43	33	6	13	1	2	3	2	6	7	229
5.0- 5.9	0	32	8	0	1	6	15	25	39	1	3	0	0	2	2	0	0	134
6.0- 6.9	0	0	0	0	0	1	2	0	2	0	0	0	0	0	0	0	0	5
7.0- 7.9	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	2
8.0- 8.9	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	3
9.0- 9.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	342	960	274	134	150	116	171	200	238	71	54	25	26	12	13	75	90	2957
PERCENT	11.77	32.47	9.27	4.53	5.07	3.92	5.78	6.76	8.05	2.40	1.83	0.85	0.88	0.41	0.44	2.54	3.04	100.00

Total (Aug~Oct.)

WIND DIRECTION	C	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	TOTAL
CALM	651	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	651
0.3- 0.9	0	80	52	18	13	5	4	2	4	6	8	3	9	5	1	5	18	233
1.0- 1.9	0	243	138	32	54	28	13	19	29	22	18	24	41	6	6	13	60	775
2.0- 2.9	0	447	131	93	80	94	92	94	126	83	59	52	58	33	24	46	76	1563
3.0- 3.9	0	332	68	49	72	53	127	74	137	130	124	44	43	36	10	22	34	1355
4.0- 4.9	0	127	23	23	40	33	90	73	175	339	417	107	63	59	2	15	23	1609
5.0- 5.9	0	43	10	0	4	6	16	33	94	336	614	108	56	23	2	4	11	1360
6.0- 6.9	0	6	0	0	1	1	2	3	66	328	712	127	18	2	0	0	4	1270
7.0- 7.9	0	4	0	0	0	1	0	0	6	103	194	32	0	2	0	0	4	346
8.0- 8.9	0	1	0	0	1	0	2	0	0	29	74	10	1	0	0	0	1	119
9.0- 9.9	0	0	0	0	2	0	0	0	0	9	6	2	0	0	0	0	0	19
10.0-10.9	0	0	0	0	2	0	0	0	0	5	3	2	1	0	0	0	0	13
11.0-11.9	0	0	0	0	1	0	0	0	0	7	1	1	0	0	0	0	0	10
12.0-12.9	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	3
13.0-13.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14.0-14.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	224	318	129	97	116	102	163	95	360	829	1159	281	192	113	12	23	117	4320
PERCENT	4.95	7.36	2.99	2.25	2.69	2.36	3.77	2.20	8.33	19.19	26.83	6.50	4.44	2.62	0.28	0.53	2.71	100.00

Table 4-13 Frequency of Wind Velocity and Direction (Instantaneous Vel.)

Aug. 1982

WIND DIRECTION	C	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	TOTAL
CALM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.3- 0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.0- 1.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.0- 2.9	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	0	0	4
3.0- 3.9	1	0	0	0	0	0	0	0	0	4	1	0	0	0	0	0	0	6
4.0- 4.9	0	0	0	0	0	0	0	0	0	6	6	0	0	0	0	0	0	12
5.0- 5.9	0	0	0	0	0	0	0	1	0	39	7	1	0	0	0	0	0	48
6.0- 6.9	0	0	0	0	0	0	0	0	5	53	4	3	0	0	0	0	0	65
7.0- 7.9	0	0	0	0	0	0	0	0	0	51	5	5	0	0	0	0	0	61
8.0- 8.9	0	0	0	0	0	0	0	0	0	28	1	2	0	0	0	0	0	31
9.0- 9.9	0	0	0	0	0	0	0	0	0	27	2	0	0	0	0	0	0	29
10.0-10.9	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	3
11.0-11.9	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
12.0-12.9	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
13.0-13.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14.0-14.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15.0-15.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16.0-16.9	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
17.0-17.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.0-18.9	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
19.0-19.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1	0	0	0	0	0	0	1	11	195	30	11	0	0	0	0	0	249
PERCENT	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.40	4.42	78.31	12.05	4.42	0.00	0.00	0.00	0.00	0.00	100.00

Sep. 1982

WIND DIRECTION	C	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	TOTAL
CALM	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
0.3- 0.9	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
1.0- 1.9	30	4	5	5	3	3	2	0	0	0	0	0	2	0	0	0	2	52
2.0- 2.9	5	55	42	25	6	11	16	0	5	2	4	10	13	6	3	4	24	241
3.0- 3.9	0	48	7	34	31	36	61	5	60	40	53	14	7	22	4	5	21	323
4.0- 4.9	1	46	7	24	41	33	40	22	15	145	124	16	12	34	2	2	11	577
5.0- 5.9	1	17	3	2	3	5	12	7	57	205	151	34	46	23	0	5	2	617
6.0- 6.9	0	10	3	0	0	0	3	7	49	132	245	55	32	16	1	3	2	563
7.0- 7.9	0	2	1	0	0	0	0	0	35	92	173	57	21	1	0	2	3	421
8.0- 8.9	0	1	2	0	0	0	1	0	4	34	123	46	4	2	0	0	3	224
9.0- 9.9	0	1	0	0	2	0	1	0	0	12	44	17	0	1	0	0	2	80
10.0-10.9	0	2	0	0	0	0	0	0	0	3	28	1	1	0	0	0	1	44
11.0-11.9	0	3	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	6
12.0-12.9	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	3
13.0-13.9	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	2
14.0-14.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15.0-15.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16.0-16.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17.0-17.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.0-18.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19.0-19.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20.0-20.9	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
21.0-21.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22.0-22.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23.0-23.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24.0-24.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	41	199	72	90	102	88	118	41	296	666	1007	264	171	104	8	17	89	3371
PERCENT	1.22	5.90	2.14	2.67	3.03	2.61	3.50	1.22	8.77	19.76	29.87	7.83	5.07	3.09	0.24	0.50	2.64	100.00

Oct. 1982

WIND DIRECTION	C	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	TOTAL
CALM	273	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	273
0.3- 0.9	0	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	6
1.0- 1.9	11	35	8	2	0	4	0	0	0	1	0	0	0	0	0	1	3	65
2.0- 2.9	25	283	91	50	54	46	20	23	55	36	13	14	17	1	1	17	44	779
3.0- 3.9	0	305	75	56	30	21	35	34	62	14	12	9	4	4	3	38	22	724
4.0- 4.9	0	223	62	19	31	21	34	55	33	9	13	3	4	3	3	19	12	544
5.0- 5.9	0	78	23	3	4	10	38	39	64	3	1	2	0	2	1	0	3	262
6.0- 6.9	0	32	10	2	1	4	13	19	17	0	3	0	1	2	0	0	0	103
7.0- 7.9	0	10	3	0	0	1	2	2	3	0	0	0	0	0	0	0	0	21
8.0- 8.9	0	0	0	0	2	1	1	0	1	0	0	0	0	0	0	0	0	5
9.0- 9.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.0-10.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11.0-11.9	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	2
12.0-12.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13.0-13.9	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2
14.0-14.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	308	374	102	134	142	116	166	192	236	63	50	25	26	12	13	75	90	2870
PERCENT	10.73	13.03	3.55	4.67	4.95	4.04	5.78	6.69	8.22	2.20	1.74	0.87	0.91	0.42	0.45	2.61	3.14	100.00

Total (Aug~Oct)

WIND DIRECTION	C	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	TOTAL
CALM	276	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	276
0.3- 0.9	1	2	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	8
1.0- 1.9	41	39	13	7	3	7	2	0	0	1	0	0	2	0	0	1	10	127
2.0- 2.9	29	321	133	75	60	57	36	23	60	41	23	24	30	7	4	21	77	1022
3.0- 3.9	1	353	84	90	61	64	76	39	122	53	54	23	11	22	9	41	43	1202
4.0- 4.9	1	269	68	43	71	54	79	77	137	180	155	11	16	32	3	21	21	1273
5.0- 5.9	1	95	26	5	12	15	50	67	167	347	133	37	46	27	4	5	14	933
6.0- 6.9	0	42	13	2	1	4	20	26	71	145	247	57	33	18	1	1	3	731
7.0- 7.9	0	12	4	0	0	1	2	2	37	123	203	72	21	1	0	2	3	482
8.0- 8.9	0	1	1	0	0	1	2	0	5	62	127	48	4	2	0	0	3	258
9.0- 9.9	0	1	0	0	2	0	1	0	0	39	46	17	0	1	0	0	2	109
10.0-10.9	0	2	0	0	0	0	0	0	0	7	28	1	1	0	0	0	1	47
11.0-11.9	0	3	0	0	1	1	1	0	0	1	2	0	0	0	0	0	0	9
12.0-12.9	0	0	0	0	2	0	0	0	0	0	1	0	1	0	0	0	0	4
13.0-13.9	0	0	0	0	3	0	0	0	0	0	0	0	1	0	0	0	0	4
14.0-14.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20.0-20.9	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
TOTAL	350	1147	346	224	244	204	284	234	541	924	1087	300	197	116	21	92	179	6490
PERCENT	5.39	17.67	5.33	3.45	3.76	3.14	4.38	3.61	8.34	14.24	16.75	4.62	3.04	1.79	0.32	1.42	2.76	100.00

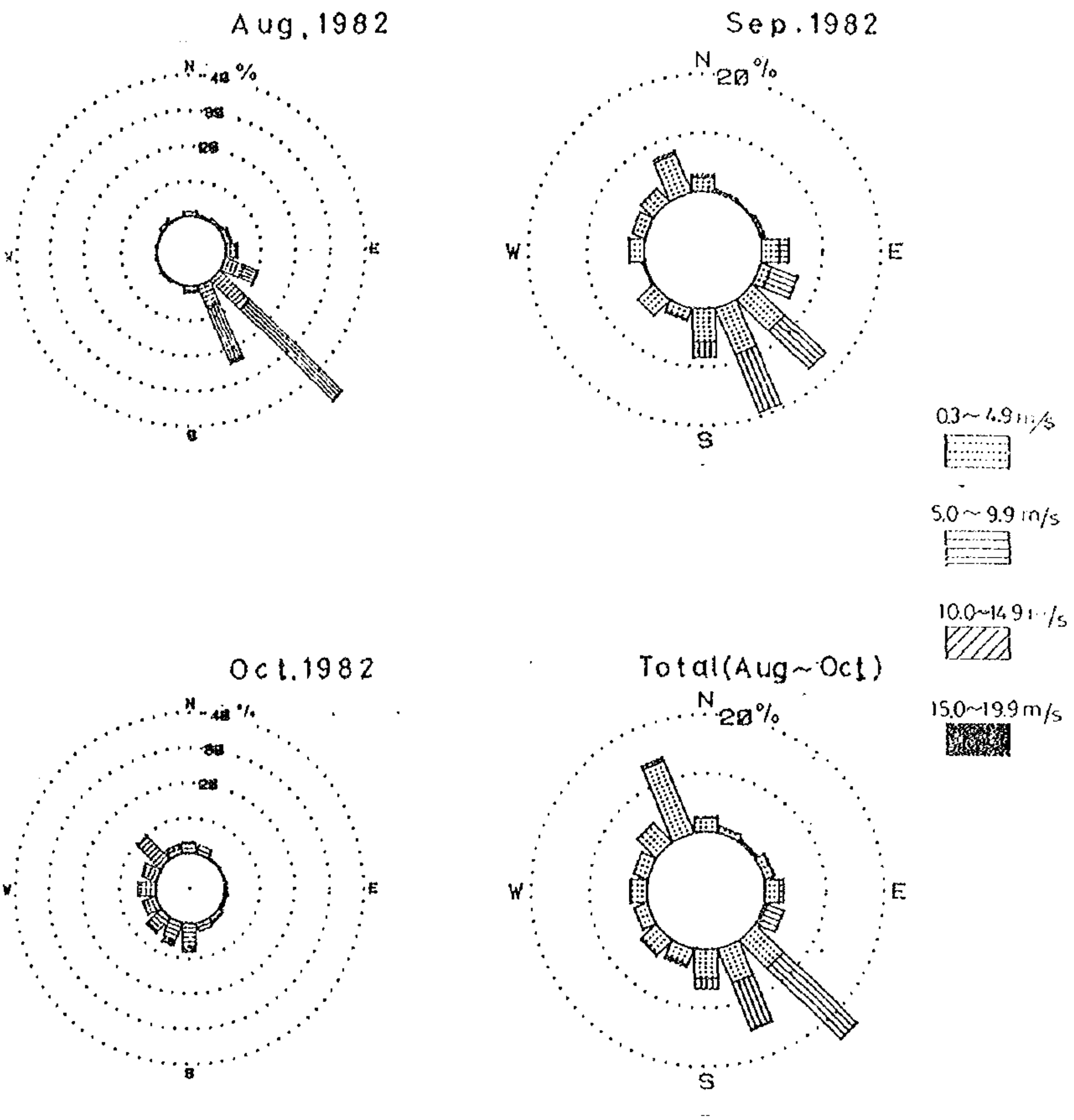


Fig. 4-23 Frequency of Wind Velocity and Direction (Average Velocity)

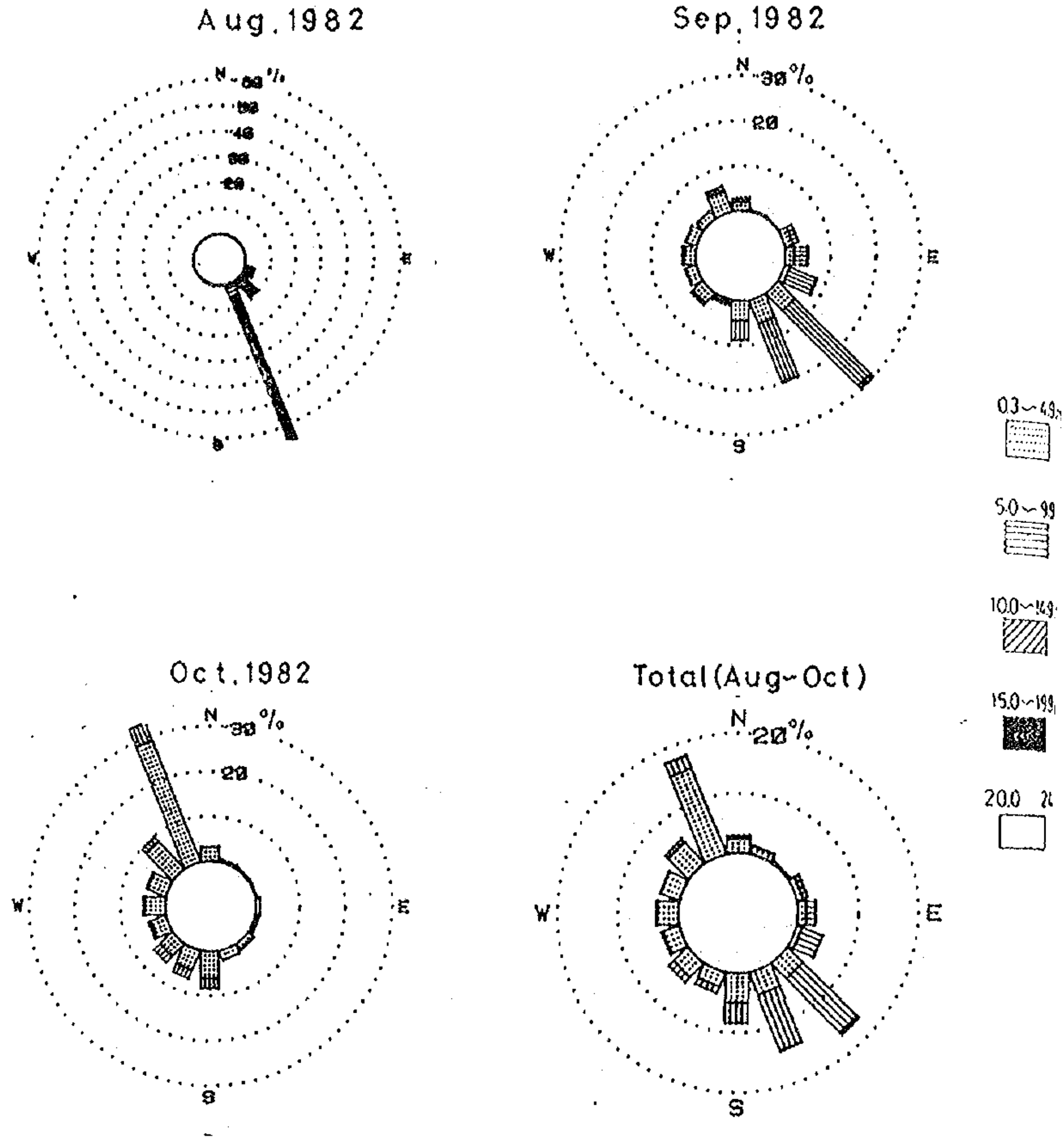


Fig. 4-24 Frequency of Wind Velocity and Direction (Instantaneous Velocity)

Table 4-14 Daily Wind Data at Ko Saket (1)

August, 1982

Date	Average	Prominent	Maximum		Maximum Instantaneous
	VEL(m/sec)	DIR (2nd)	VEL (m/sec)	DIR	VEL(m / sec)
17	5.2	SSW	7.0	SW	8.9
18	4.7	SSW	12.0	SW	18.2
19	6.6	SSW	10.8	SW	16.8
20	6.5	SW	12.1	WSW	
21	5.9	SW	8.5	SW	
22	4.5	SW	7.7	SW	
23	5.1	SW	7.0	SW	
24	2.8	WSW	7.0	SW	
25	4.3	SSW	11.9	SSW	
26	5.7	SW	8.0	SW	
27	5.9	SW	10.2	SW	
28	5.3	SW	7.0	SW	
29	5.1	SW	7.8	SW	
30	3.0	WSW	11.0	WSW	
31	4.0	SSW	6.0	SSW	7.6
Total	5.0	SW	12.1	WSW	18.2

Table 4-14 Daily Wind Data at Ko Saket (2)

Setenber, 1982

Date	Average VEL (m/sec)	Prominent DIR (2nd)	Maximum VEL (m/sec)	Maximum DIR	Maximum Instantaneous VEL (m / sec)
1	4.1	S	6.8	S	7.1
2	5.8	SW	7.9	SW	8.0
3	5.7	SW	7.7	SW	8.8
4	6.1	SW	8.3	SW	10.3
5	6.3	WSW	8.2	WSW	10.9
6	4.1	W	10.1	W	20.0
7	4.5	WNW	6.1	W	9.1
8	6.6	WSW	8.3	SW	11.5
9	4.8	SW	7.8	SW	10.2
10	1.8	N	5.0	NNW	6.0
11	2.3	NNE	7.9	N	10.1
12	2.5	ESE	5.8	NNW	7.2
13	4.4	SSW	6.5	SSW	6.5
14	5.6	SSW	7.4	SSW	7.9
15	5.2	SW	8.0	SW	9.3
16	4.3	SW	6.0	SW	6.2
17	3.2	E	5.1	E	7.6
18	1.9	S	4.0	SE	4.5
19	2.8	NNE	6.0	NNE	6.7
20	3.0	NNE	6.0	SSE	6.5
21	3.8	SW	6.3	SW	7.7
22	4.8	SW	7.0	SW	8.7
23	5.8	SW	9.1	SW	11.0
24	5.6	SSW	7.2	SSW	9.1
25	4.7	SSW	8.1	SW	10.8
26	4.3	SW	5.9	SW	7.0
27	5.4	SSW	7.6	SSW	9.0
28	3.0	SSW	5.0	S	7.9
29	2.5	C(NE)	11.0	E	13.8
30	2.1	C(N)	8.0	N	9.3
Total	4.2	SW	11.0	E	20.0

Table 4-14 Daily Wind Data at Ko Saket (3)

October, 1982

Date	Average VEL(m sec)	Prominent DIR (2nd)	Maximum VEL (m sec)	Maximum DIR	Maximum Instantaneous VEL(m sec)
1	3.4	SSE	5.9	SE	7.0
2	1.7	C(ESE)	4.5	NNE	6.5
3	2.7	SW	5.6	NE	6.7
4	1.7	N	4.3	SSW	4.6
5	1.7	NNW	5.3	WNW	6.2
6	1.1	C(N)	4.8	N	6.1
7	2.3	NNE	4.0	ENE	5.1
8	2.1	S	3.9	S	5.2
9	2.4	NNE	8.5	E	13.7
10	1.7	NNE	4.0	SE	5.1
11	2.4	NNE	6.0	SE	6.5
12	2.8	NNE	5.3	NE	7.1
13	2.3	NNE	4.5	ENE	6.1
14	3.5	NNE	5.8	NNE	7.3
15	2.5	NNE	3.9	NNE	5.8
16	3.4	NNE	5.6	NNE	7.1
17	1.9	NNE	4.4	NE	6.0
18	2.0	SSE	3.8	SE	5.2
19	3.1	SE	4.6	ESE	6.3
20	4.3	S	5.9	S	7.0
21	2.3	NNE	7.1	S	8.0
Total	2.4	NNE	8.5	E	13.7

4-7 Littoral Drift

The results of the sand tracer (fluorescent sand) is shown in Figure 4-25 as a distribution of sand tracers in every sampling times. The results of the sand traps are also shown in Figure 4-26 on sand tube and in Figure 4-27 on sand box with the weight of trapped sands.

From the results of the fluorescent sand tracers, the trend of littoral drifts was discovered to the direction of west and southwest off Ban Phala, to the direction of northwest and northeast between the pipeline and Ko Saket, and to the direction of northwest and southeast on the east side of Ko Saket in general.

The results of sand traps show that the materials trapped by the sand tube were fine silt and clay, and were small in volume. The sands trapped by sand box were medium sands and the largest quantities came from the south. The next largest quantities were from the west.

Judging from the data on littoral drifts together with the results of tidal currents and waves conducted during the same period, the followings may be concluded as mechanism of littoral drifts in the investigated area.

During the southwest monsoon season at the least, waves from the direction of southwest which prevailed during the survey period vary perpendicularly to the shoreline on the coastal area by the affection of sub-marine topography. After that, the coastal currents partly flow westward, namely to the direction of Ban Phala, and partly flow eastward, namely to the direction of Ko Saket, near the shoreline. As the bottom sediments are believed to move along with the coastal currents, the mechanism of littoral sand may be illustrated as Figure 4-28.

Quantites of littoral drifts, however, may be considered to be not so heavy at the offshore area at the least because of the next reasons. By checking the sub-marine route of the existing pipeline by divers, the depression couls be observed along the pipeline at the survey time when it had been passed about one year after setting the pipeline. Sea-bottom materials are composed of coarse sands which are hard to move. Wave heights in the investigated area are not so high.

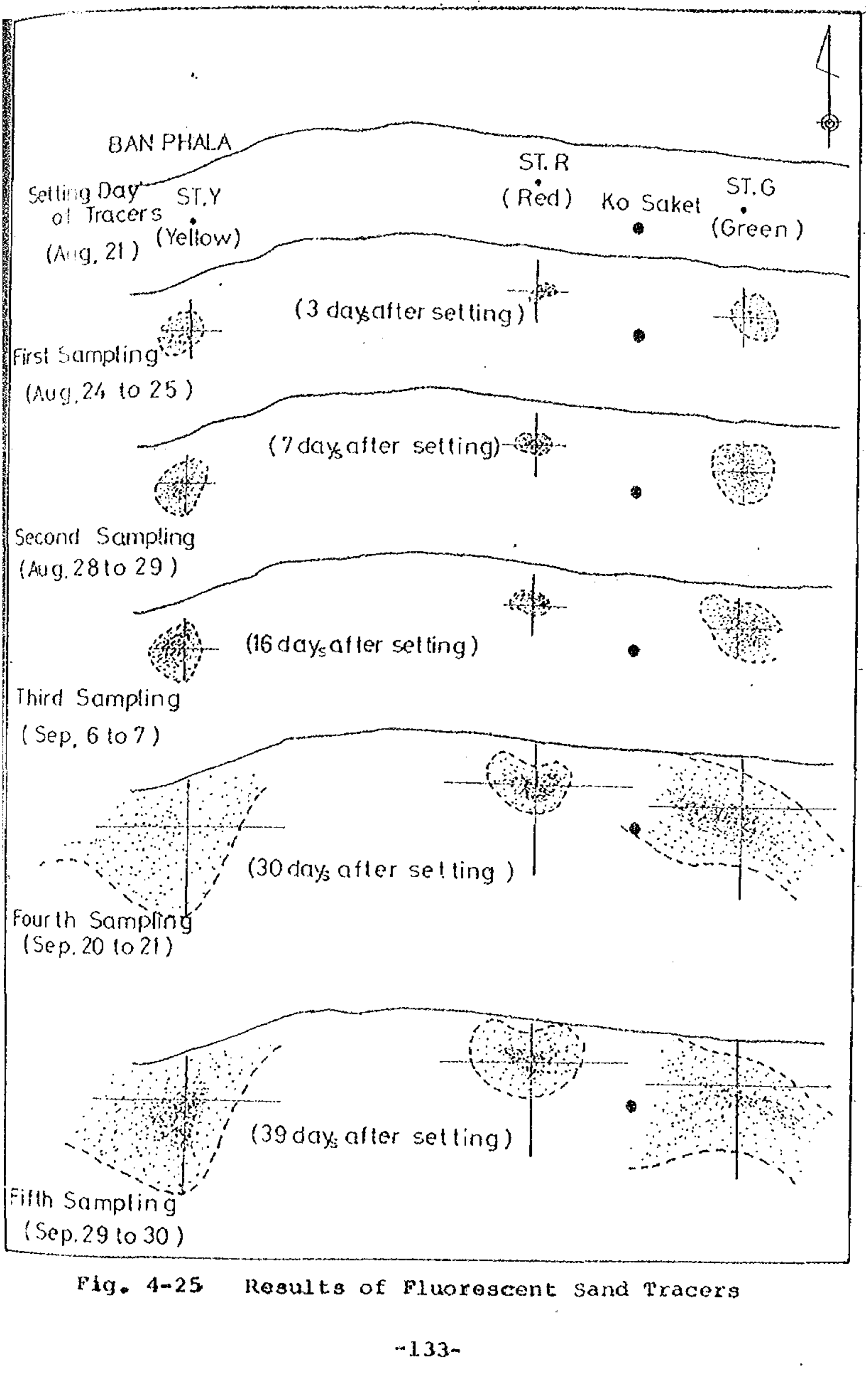
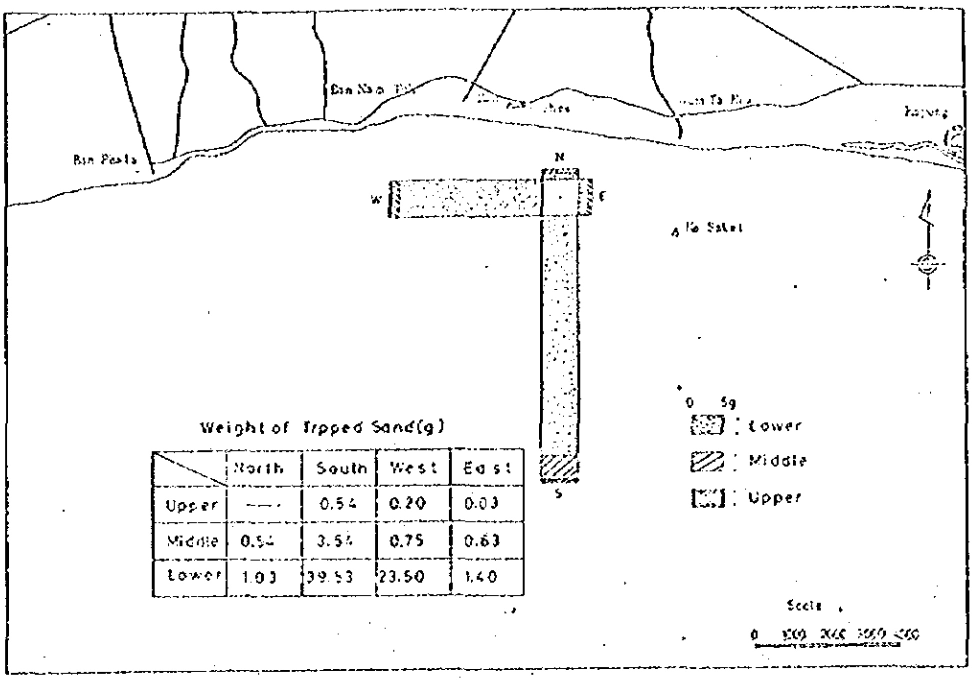


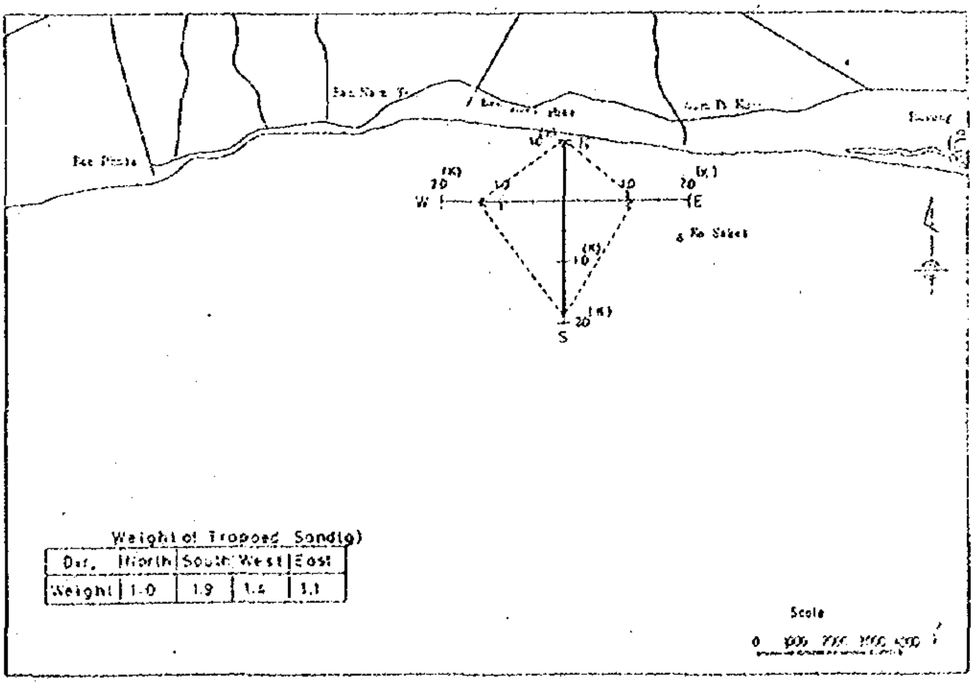
Fig. 4-25 Results of Fluorescent Sand Tracers



Weight of Trapped Sand(g)

	North	South	West	East
Upper	----	0.54	0.20	0.03
Middle	0.54	3.54	0.75	0.63
Lower	1.03	39.53	23.50	1.40

Fig. 4-26 Results of Sand Trap (Tube)



Weight of Trapped Sand(g)

Dir.	North	South	West	East
Weight	1.0	1.9	1.4	1.1

Fig. 4-27 Results of Sand Trap (Box)

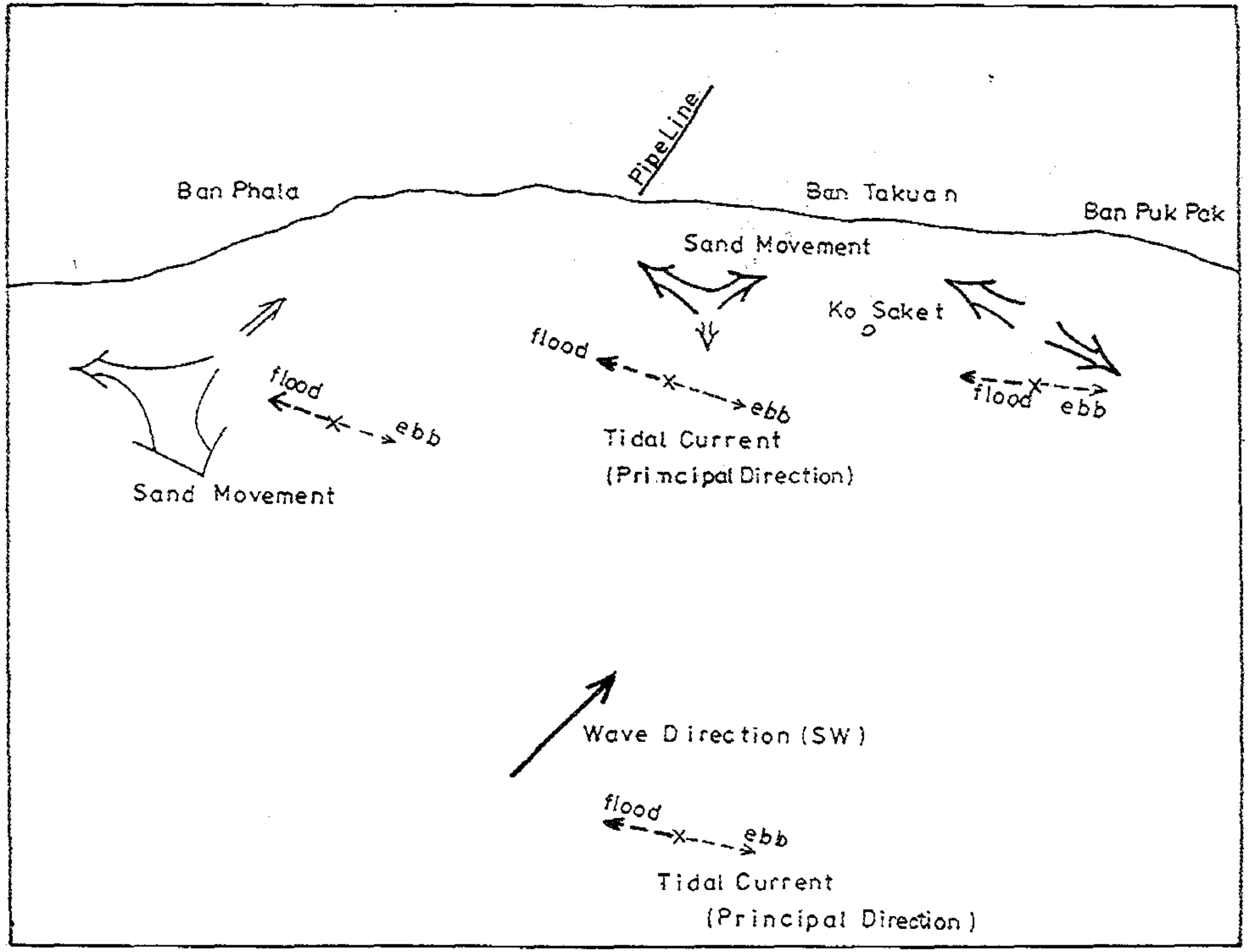


Fig. 4-28 Illustration of Littoral Drift

5. SUMMARY

This natural condition survey was conducted to find out the natural conditions such as topography, geology, soil conditons, bottom materials, tides, tidal currents, waves, wind and so forth in the project area as proposed sites for the development of the industrial port on the eastern seaboard in the Kingdom of Thailand in order to obtain basic informations for preparing a master plan for the industrial port. It is considered that the natural conditions of the investigated area have been considerably grasped through this survey.

The conclusions are summarized as follows ;

1) Topographical Map

The topographical maps at scale of 1:10,000 were drawn with five meters contour in principal by the method of the aerial triangulation using existing aerial photographs of 1:40,000 scale.

The topography of sea bed was drawn with one meter contour by sounding as isobath maps at scale of 1:10,000.

2) Geological and Soil Characteristics

The stratigraphy in the investigated area consists of granitic rocks, terrace deposits and recent deposits.

The granite is characterized by weathering and classified into "Highly Weathered Granite", "Weathered Granite" and "Fresh Granite".

The thickness of highly weathered granite is approximately 13 meters to 17 meters on the shore area and 31 meters or more on the inland area with the N-value of between 20 and 50, and with the seismic velocity of 1.1 km/sec to 1.4 km/sec.

The thickness of weathered granite is 15 meters to 20 meters with the N-value over 50 and with the velocity more than about 2.5 km/sec. This layer was classified as G-group by the sonic prospecting and reliable for a bearing layer. The geological feature of the G-group's surface is shown as a isobathic map of G-group.

The fresh granite has the seismic velocity more than 4.4 km/sec and could not be found out by the soil investigation. The out crops of unweathered granite are observed at Ko Saket, in the coastal area from Ban Nam Tok to Ban Phala, and at Khao Khrok located in the north part of the investigated area.

3) Oceanographical Characteristics

(a) Tides

Diurnal tide constituents K_1 and O_1 prevail in the investigated area, followed by P_1 and semi-diurnal constituents M_2 and S_2. The maximum and minimum tide levels during the observation period at Ko Saket are as follows;

Maximum Tide Level	:	MSL + 0.76m
Minimum Tide Level	:	MSL - 1.57m

(b) Tidal Currents

The prominent direction of tidal currents on offshore area is westward in flood and east to east northeastward in ebb. The maximum current velocity during the observation period is 48 cm/sec.

(c) Waves

The wave height less than one meter is prominent through all the observation period. The wave height shows a steady decrease from August to October corresponding to the decrease of wind velocity. The maximum wave height was 3.20 meters, followed by 3.03 meters.

The prominent wave period was between 3.0 seconds to 6.0 seconds.

(d) Littoral Drift

The principal direction of littoral drifts near the shoreline is westward off Ban Phala located at the west side of the pipeline, and eastward off Ban Takuan located between the pipeline and Ko Saket.

The quantities of littoral drifts, however, may be considered to be not so heavy.

4) Meteorological Characteristics

The wind velocity shows a decrease from August to October. The maximum velocity during the observation period at Ko Saket was 12.1 m/sec for average velocity and 20.0 m/sec for instantaneous velocity.

The prominent wind direction was southeast to south southeast on August and September, north northwest on October.

Lastly, the tide, wave and wind observations are recommended to be continued for a long term to grasp the monthly variation on the investigated area.

ATTACHED SHEETS AND MAPS

ATTACHED SHEETS

1. Summary of Soil Test
2. Geological profiles
3. Tidal Current Curves
4. Tidal Current Ellipses
5. Tidal Chart

ATTACHED MAPS

1. Topographical Map (Scale 1:30,000)
2. Isopach Map of A-Member (Scale 1:50,000)
3. Isobathic Map of D-Group (Scale 1:50,000)
4. Isobathic Map of C-Group (Scale 1:50,000)

1. Summary of Soil Test

SUMMARY OF SOIL TEST

Project: The Natural Conditions Survey on the Development Project of the Industrial Port Standard: ______

Borehole No:		No. 1								
Sample No.		SS-1	SS-2	SS-3	SS-4	SS-5	SS-6	SS-7	SS-8	SS-9
Sample depth		1.00 m ~ 1.45 m	2.00 m ~ 2.45 m	3.00 m ~ 3.45 m	4.00 m ~ 4.45 m	5.00 m ~ 5.45 m	6.00 m ~ 6.45 m	7.00 m ~ 7.45 m	8.00 m ~ 8.45 m	9.00 m ~ 9.45 m
Condition of sample		Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~
Natural water content, %		6.7	8.9	15.4	20.5	20.6	24.2	24.8	22.5	26.4
Specific gravity		2.577	—	2.626	2.441	2.644	2.638	2.641	2.645	2.6[illegible]
Wet density, g/cm³										
Dry density, g/cm³										
Natural void ratio										
Degree of saturation, %										
Atterberg limits	Liquid limit, %									
	Plastic limit, %									
	Plasticity index									
Grain size analysis	Gravel, %	34.3	41.1	22.2	7.1	10.9	8.3	13.2	10.2	12.7
	Sand, %	44.7	6.8	5.1	32.8	39.9	39.1	30.0	40.6	42.0
	Silt, %	5.2	5.1	4.8	8.9	12.1	18.0	24.5	36.6	12.3
	Clay & colloid, %	15.8	46.5	67.9	51.2	37.1	34.6	31.5	12.6	25.0
	Max.diameter, mm	4.76	4.76	4.76	4.76	4.76	4.76	4.76	4.76	4.76
	Diam. at 60 %	1.50	2.00	—	0.09	0.44	0.20	0.25	1.35	0.30
	Diam. at 10 %									
Visual soil description		SM	SC-SC	SC-SM	CL	CL	CL	CL	CL-SC	SC-CL
Unified soil classification										
Unconfined compression test	Undisturbed sample, Kg/cm²									
	Remoulded sample Kg/cm²									
	Sensitivity ratio									
	Strain at failure, %									
Triaxial compression test	Angle of internal friction									
	Cohesion, Kg/cm²									
	Condition of drainage									
Consolidation test	Preconsolidation pressure, Kg/cm²									
	Compression index									

Remarks:

SUMMARY OF SOIL TEST

Project: The Natural Conditions Survey on the Development Project of the Industrial Port Standard: ______

Borehole No.		No. 1								
Sample No.		SS-10	SS-11	SS-12	SS-13	SS-14	SS-15	SS-16	SS-17	SS-18
Sample depth		10.00 m ~ 10.45 m	11.00 m ~ 11.45 m	12.00 m ~ 12.45 m	13.00 m ~ 13.45 m	14.00 m ~ 14.45 m	15.00 m ~ 15.45 m	16.00 m ~ 16.45 m	17.00 m ~ 17.45 m	18.0[illegible] ~ 18.45
Condition of sample		Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~
Natural water content, %		17.2	24.6	12.1	12.8	13.6	16.5	14.6	12.6	9.1
Specific gravity		2.621	2.610	2.612	2.627	2.601	2.629	2.619	2.642	2.61[illegible]
Wet density, g/cm³										
Dry density, g/cm³										
Natural void ratio										
Degree of saturation, %										
Atterberg limits	Liquid limit, %									
	Plastic limit, %									
	Plasticity index									
Grain size analysis	Gravel, %	6.6	10.3	16.1	10.6	11.6	20.0	18.8	19.5	22.4
	Sand, %	57.1	41.4	46.3	59.7	59.7	53.3	54.2	53.2	56.4
	Silt, %	22.8	28.7	37.6 (silt and clay bracketed together)	14.3	15.3	14.3	14.0	11.4	12.[illegible]
	Clay & colloid, %	13.5	19.6		15.4	13.4	12.4	13.0	15.9	8.3
	Max. diameter, mm	4.76	4.76	4.76	4.76	4.76	4.76	4.76	4.76	4.7[illegible]
	Diam. at 60 %	0.40	0.25	0.60	0.60	0.67	1.00	1.00	1.00	1.1[illegible]
	Diam. at 10 %									
Visual soil description		SC-SM	SC-SM	SM	SM	SM	SM	SM	SM	SM
Unified soil classification										
Unconfined compression test	Undisturbed sample, Kg/cm²									
	Remoulded sample, Kg/cm²									
	Sensitivity ratio									
	Strain at failure, %									
Triaxial compression test	Angle of internal friction									
	Cohesion, Kg/cm²									
	Condition of drainage									
Consolidation test	Preconsolidation pressure, Kg/cm²									
	Compression index									

Remarks:

SUMMARY OF SOIL TEST

Project: The Natural Conditions Survey on the Dovolopmont Project of the Industrial Port

Standard: ______________

Borehole No.	No. 1								
Sample No.	SS-19	SS-20	DB-21						
Sample depth	19.00 m – 19.45 m	20.00 m – 20.13 m	26.50 m – 27.00 m	m – m	m – m	m – m	m – m	m – m	m – m
Condition of sample	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~
Natural water content, %	13.3	12.5	—						
Specific gravity	2.636	2.639	—						
Wet density, g/cm³									
Dry density, g/cm³									
Natural void ratio									
Degree of saturation, %									
Atterberg limits: Liquid limit, %									
Atterberg limits: Plastic limit, %									
Atterberg limits: Plasticity index									
Grain size analysis: Gravel, %	23.3	30.2							
Grain size analysis: Sand, %	59.2	57.1							
Grain size analysis: Silt, %	} 17.5	} 12.7							
Grain size analysis: Clay & colloid, %									
Grain size analysis: Max. diameter, mm	4.76	4.76							
Grain size analysis: Diam. at 60 %	1.20	1.50							
Grain size analysis: Diam. at 10 %									
Visual soil description	SH	SH							
Unified soil classification									
Unconfined compression test: Undisturbed sample, Kg/cm²									
Unconfined compression test: Remoulded sample, Kg/cm²									
Unconfined compression test: Sensitivity ratio									
Unconfined compression test: Strain at failure, %									
Triaxial compression test: Angle of internal friction									
Triaxial compression test: Cohesion, Kg/cm²									
Triaxial compression test: Condition of drainage									
Consolidation test: Preconsolidation pressure, Kg/cm²									
Consolidation test: Compression index									

Remarks:

SUMMARY OF SOIL TEST

Project: The Natural Conditions Survey on the Development Project of the Industrial Port Standard:

Borehole No.	No. 2								
Sample No.	SS-1	SS-2	SS-3	SS-4	SS-5	SS-6	SS-7	SS-8	SS-9
Sample depth	1.00 m ~ 1.45 m	2.00 m ~ 2.45 m	3.00 m ~ 3.45 m	4.00 m ~ 4.45 m	5.00 m ~ 5.45 m	6.00 m ~ 6.45 m	7.00 m ~ 7.45 m	8.00 m ~ 8.45 m	9.00 ~ 9.45
Condition of sample	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Dist... ~~Undist...~~
Natural water content, %	—	19.7	11.2	16.5	17.8	14.3	7.2	12.1	13.1
Specific gravity	2.630	2.632	2.631	2.625	2.646	2.648	2.639	2.629	2.6
Wet density, g/cm³									
Dry density, g/cm³									
Natural void ratio									
Degree of saturation, %									
Atterberg limits: Liquid limit, %									
Atterberg limits: Plastic limit, %									
Atterberg limits: Plasticity index									
Grain size analysis: Gravel, %	0.9	1.0	20.1	3.6	3.5	1.3	8.7	12.2	8.0
Grain size analysis: Sand, %	88.9	96.1	67.0	79.6	85.4	87.5	66.2	63.8	73.8
Grain size analysis: Silt, %	} 10.2	} 2.9	4.4	6.5	8.5	7.7	12.6	7.4	5.2
Grain size analysis: Clay & colloid, %			8.5	10.3	2.6	3.5	12.5	16.6	13.0
Grain size analysis: Max. diameter, mm	2.00	2.00	4.76	4.76	2.00	4.76	2.00	4.76	4.76
Grain size analysis: Diam. at 60 %	0.52	0.55	1.00	0.28	0.30	0.45	0.55	0.76	0.65
Grain size analysis: Diam. at 10 %									
Visual soil description	SM	SM	SM	SM	SM	SM	SC	SC	SC
Unified soil classification									
Unconfined compression test: Undisturbed sample, Kg/cm²									
Unconfined compression test: Remoulded sample, Kg/cm²									
Unconfined compression test: Sensitivity ratio									
Unconfined compression test: Strain at failure, %									
Triaxial compression test: Angle of internal friction									
Triaxial compression test: Cohesion, Kg/cm²									
Triaxial compression test: Condition of drainage									
Consolidation test: Preconsolidation pressure, Kg/cm²									
Consolidation test: Compression index									

Remarks:

SUMMARY OF SOIL TEST

Project: The Natural Conditions Survey on the Development Project of the Industrial Ports Standard: ______________

Borehole No.		No. 2								
Sampl. No.		SS-10	SS-11	SS-12	SS-13	SS-14	SS-15	SS-16	SS-17	SS-18
Sample depth		10.00 m – 10.45 m	11.00 m – 11.45 m	12.00 m – 12.45 m	13.00 m – 13.45 m	14.00 m – 14.45 m	15.00 m – 15.45 m	16.00 m – 16.45 m	17.00 m – 17.45 m	18.00 m – 18.45 m
Condition of sample		Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~
Natural water content, %		14.2	11.7	11.2	10.5	13.4	15.6	15.7	14.7	14.8
Specific gravity		2.643	2.639	2.634	2.618	2.627	2.607	2.616	2.614	2.610
Wet density, g/cm³										
Dry density, g/cm³										
Natural void ratio										
Degree of saturation, %										
Atterberg limits	Liquid limit, %									
	Plastic limit, %									
	Plasticity index									
Grain size analysis	Gravel, %	15.2	13.0	22.9	27.1	19.8	6.4	4.3	12.4	10.0
	Sand, %	51.9	52.0	50.6	50.0	34.4	39.5	43.7	11.2	41.2
	Silt, %	5.5	6.9	4.3	3.0	6.0	9.4	7.5	9.7	} 48.8
	Clay & colloid, %	27.4	28.1	22.2	19.9	39.8	44.7	44.5	66.7	
	Max. diameter, mm	4.76	4.76	4.76	4.76	4.76	4.76	4.76	4.76	4.76
	Diam. at 60 %	0.75	0.60	1.10	1.40	0.65	0.30	0.34	--	0.60
	Diam. at 10 %									
Visual soil description		SC	SC	SC	SC	SC-CL	SC-CL	SC-CL	L	SC-CL
Unified soil classification										
Unconfined compression test	Undisturbed sample, Kg/cm²									
	Remoulded sample Kg/cm²									
	Sensitivity ratio									
	Strain at failure, %									
Triaxial compression test	Angle of internal friction									
	Cohesion, Kg/cm²									
	Condition of drainage									
Consolidation test	Preconsolidation pressure, Kg/cm²									
	Compression index									

Remarks :

SUMMARY OF SOIL TEST

Project: The Natural Conditions Survey on the Development Project of the Industrial Port Standard: ______

Borehole No.		No. 2								
Sample No.		SS-19	SS-20	SS-21	SS-22	SS-23	SS-24	SS-25	SS-26	SS-27
Sample depth		19.00 m ~ 19.45 m	20.00 m ~ 20.45 m	21.00 m ~ 21.45 m	22.00 m ~ 22.45 m	23.00 m ~ 23.45 m	24.00 m ~ 24.45 m	25.00 m ~ 25.45 m	25.45 m ~ 28.00 m	28.00 m ~ 29.00 m
Condition of sample		Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~
Natural water content, %		11.2	13.9	11.7	16.5	13.7	13.9	10.8	—	—
Specific gravity		2.621	2.623	2.627	2.641	2.628	2.627	2.612	—	—
Wet density, g/cm³										
Dry density, g/cm³										
Natural void ratio										
Degree of saturation, %										
Atterberg limits	Liquid limit, %									
	Plastic limit, %									
	Plasticity index									
Grain size analysis	Gravel, %	33.1	34.3	12.2	11.1	20.2	26.9	41.0	—	—
	Sand, %	30.0	31.7	44.5	35.2	44.9	47.8	43.2	—	—
	Silt, %	3.2	2.2	4.9	27.0	13.0	13.5	7.2	—	—
	Clay & colloid, %	33.7	31.8	38.4	26.7	21.9	11.8	8.6	—	—
	Max. diameter, mm	4.76	9.52	4.76	4.76	4.76	4.76	9.52	—	—
	Diam. at 60%	1.60	1.60	0.80	0.15	0.70	1.20	1.90	—	—
	Diam. at 10%									
Visual soil description		SC	SC-CL	SC-CL	SC-CL	SC	SC	SM	—	—
Unified soil classification										
Unconfined compression test	Undisturbed sample, Kg/cm²									
	Remoulded sample Kg/cm²									
	Sensitivity ratio									
	Strain at failure, %									
Triaxial compression test	Angle of internal friction									
	Cohesion, Kg/cm²									
	Condition of drainage									
Consolidation test	Preconsolidation pressure, Kg/cm²									
	Compression index									

Remarks:

SUMMARY OF SOIL TEST

Project: The Natural Conditions Survey on the Development Project of the Industrial Port. Standard: ______

Borehole No.	No. 2									
Sample No.	SS-28	SS-29	SS-30							
Sample depth	30.40 m – 30.85 m	36.00 m – 36.03 m	37.00 m – 37.01 m	m – m	m – m	m – m	m – m	m – m	m – m	m – m
Condition of sample	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~
Natural water content, %	11.00	—	—							
Specific gravity	2.626	—	—							
Wet density, g/cm³										
Dry density, g/cm³										
Natural void ratio										
Degree of saturation, %										
Atterberg limits: Liquid limit, %										
Atterberg limits: Plastic limit, %										
Atterberg limits: Plasticity index										
Grain size analysis: Gravel, %	21.3									
Grain size analysis: Sand, %	52.7									
Grain size analysis: Silt, %	26.0 (Silt + Clay & colloid)									
Grain size analysis: Clay & colloid, %										
Grain size analysis: Max. diameter, mm	4.26									
Grain size analysis: Diam. at 60 %	0.78									
Grain size analysis: Diam. at 10 %										
Visual soil description	SM									
Unified soil classification										
Unconfined compression test: Undisturbed sample, Kg/cm²										
Unconfined compression test: Remoulded sample, Kg/cm²										
Unconfined compression test: Sensitivity ratio										
Unconfined compression test: Strain at failure, %										
Triaxial compression test: Angle of internal friction										
Triaxial compression test: Cohesion, Kg/cm²										
Triaxial compression test: Condition of drainage										
Consolidation test: Preconsolidation pressure, Kg/cm²										
Consolidation test: Compression index										

Remarks:

SUMMARY OF SOIL TEST

Project: The Natural Conditions Survey on the Development Project of the Industrial Port Standard: ____________

Borehole No.		No. 3								
Sample No.		SS-1	SS-2	SS-3	SS-4	SS-5	SS-6	SS-7	SS-8	SS-9
Sample depth		1.00 m – 1.45 m	2.00 m – 2.45 m	3.00 m – 3.45 m	4.00 m – 4.45 m	5.00 m – 5.45 m	6.00 m – 6.45 m	7.00 m – 7.45 m	8.00 m – 8.45 m	9.00 – 9.45
Condition of sample		Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~
Natural water content, %		9.1	7.8	8.2	14.7	10.7	20.0	22.1	18.3	16.9
Specific gravity		2.615	2.617	2.629	2.617	2.643	2.629	2.624	2.626	2.6[illegible]
Wet density, g/cm³										
Dry density, g/cm³										
Natural void ratio										
Degree of saturation, %										
Atterberg limits	Liquid limit, %									
	Plastic limit, %									
	Plasticity index									
Grain size analysis	Gravel, %	10.3	20.0	25.8	36.3	32.4	16.0	20.0	24.2	21.1
	Sand, %	87.2	62.7	53.5	37.9	37.5	33.5	27.0	30.2	37.1
	Silt, %	} 2.5	3.9	2.6	2.9	3.1	16.4	24.8	19.2	21.[illegible]
	Clay & colloid, %		13.4	18.1	22.9	27.0	34.1	28.2	26.4	19.[illegible]
	Max. diameter, mm	4.76	4.76	9.52	9.52	4.76	4.76	4.76	4.76	4.76
	Diam. at 60 %	2.82	0.87	1.30	1.65	1.40	0.41	0.34	0.52	0.1[illegible]
	Diam. at 10 %									
Visual soil description		SC	SC	SC	SC	SC	SC	SC	SC	SC
Unified soil classification										
Unconfined compression test	Undisturbed sample, Kg/cm²									
	Remoulded sample, Kg/cm²									
	Sensitivity ratio									
	Strain at failure, %									
Triaxial compression test	Angle of internal friction									
	Cohesion, Kg/cm²									
	Condition of drainage									
Consolidation test	Preconsolidation pressure, Kg/cm²									
	Compression index									

Remarks:

SUMMARY OF SOIL TEST

Project: The Natural Conditions Survey on the Development Project of the Industrial Port. Standard: ____________

Borehole No.		No. 3								
Sample No.		SS-10	SS-11	SS-12	SS-13	SS-14	SS-15	SS-16	SS-17	SS-18
Sample depth		10.00 m – 10.45 m	11.00 m – 11.45 m	12.00 m – 12.22 m	13.00 m – 13.25 m	14.00 m – 14.25 m	15.00 m – 15.27 m	16.00 m – 16.30 m	17.00 m – 17.45 m	18.00 m – 18.29 m
Condition of sample		Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~
Natural water content, %		15.1	15.5	—	12.8	11.7	11.9	17.0	14.0	8.2
Specific gravity		2.622	2.633	—	2.637	2.625	2.626	2.638	2.639	2.634
Wet density, g cm										
Dry density, g cm										
Natural void ratio										
Degree of saturation, %										
Atterberg limits	Liquid limit, %									
	Plastic limit, %									
	Plasticity index									
Grain size analysis	Gravel, %	25.3	23.0	—	12.9	30.1	29.2	21.4	33.1	37.9
	Sand, %	37.7	39.1	—	59.6	46.0	51.2	52.2	32.7	40.4
	Silt, %	21.0	21.9	—	10.5	12.9	12.6	15.4	19.2	10.7
	Clay & colloid, %	16.0	16.0	—	17.0	11.0	7.0	11.0	15.0	11.0
	Max. diameter, mm	4.76	4.76	—	4.76	4.76	4.76	4.76	9.52	9.52
	Diam. at 60%	0.78	0.80	—	0.80	1.40	1.40	1.00	1.50	1.20
	Diam. at 10%									
Visual soil description		SC	SC	—	SH	SH	SH	SH	SH	SH
Unified soil classification										
Unconfined compression test	Undisturbed sample, Kg/cm									
	Remoulded sample Kg/cm									
	Sensitivity ratio									
	Strain at failure, %									
Triaxial compression test	Angle of internal friction									
	Cohesion, Kg/cm									
	Condition of drainage									
Consolidation test	Preconsolidation pressure, Kg/cm									
	Compression index									

Remarks:

SUMMARY OF SOIL TEST

Project: The Natural Conditions Survey on the Development Project of the Industrial Port　Standard: ______

Borehole No.		No. 3								
Sample No.		SS – 19	SS – 20	SS – 21						
Sample depth		19.00 m – 19.12 m	20.00 m – 20.10 m	21.00 m – 21.11 m	m – m	m – m	m – m	m – m	m – m	m – m
Condition of sample		Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~
Natural water content, %		9.1	6.6	11.4						
Specific gravity		2.628	2.639	2.603						
Wet density, g cm³										
Dry density, g cm³										
Natural void ratio										
Degree of saturation, %										
Atterberg limits	Liquid limit, %									
	Plastic limit, %									
	Plasticity index									
Grain size analysis	Gravel, %	44.1	30.8	35.2						
	Sand, %	37.8	46.0	42.6						
	Silt, %	8.1	} 23.2	} 22.2						
	Clay & colloid, %	10.0								
	Max. diameter, mm	9.52	4.76	9.52						
	Diam. at 60 %	2.18	1.28	1.58						
	Diam. at 10 %									
Visual soil description		SH	SH	SH						
Unified soil classification										
Unconfined compression test	Undisturbed sample, Kg/cm²									
	Remoulded sample Kg/cm²									
	Sensitivity ratio									
	Strain at failure, %									
Triaxial compression test	Angle of internal friction									
	Cohesion, Kg cm²									
	Condition of drainage									
Consolidation test	Preconsolidation pressure, Kg cm²									
	Compression index									

Remarks:

SUMMARY OF SOIL TEST

Project: The Natural Conditions Survey on the Development Project of the Industrial Port Standard: ____________

Borehole No.		No. 4								
Sample No.		SS-1	SS-2	SS-3	SS-4	SS-5	SS-6	SS-7	SS-8	SS-9
Sample depth		1.00 m ~ 1.45 m	2.00 m ~ 2.45 m	3.00 m ~ 3.45 m	4.00 m ~ 4.45 m	5.00 m ~ 5.45 m	6.00 m ~ 6.45 m	7.00 m ~ 7.45 m	8.00 m ~ 8.45 m	9.00 m ~ 9.45 m
Condition of sample		Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~
Natural water content, %		15.0	16.2	18.4	20.3	22.2	21.2	22.2	26.7	22.1
Specific gravity		2.641	2.627	2.602	2.630	2.634	2.605	2.617	2.636	2.640
Wet density, g/cm³										
Dry density, g/cm³										
Natural void ratio										
Degree of saturation, %										
Atterberg limits	Liquid limit, %									
	Plastic limit, %									
	Plasticity index									
Grain size analysis	Gravel, %	24.3	25.5	19.7	12.0	9.9	13.5	10.7	13.7	6.2
	Sand, %	35.3	27.9	27.7	36.5	34.1	34.9	31.2	34.6	37.6
	Silt, %	7.3	9.8	8.6	8.4	6.5	9.2	11.5	12.6	13.8
	Clay & colloid, %	33.1	36.8	44.0	43.1	49.5	42.4	46.6	39.1	42.4
	Max. diameter, mm	4.76	9.52	9.52	4.76	4.76	4.76	4.76	4.76	4.76
	Diam. at 60 %	0.25	0.60	0.18	0.27	0.21	0.37	0.34	0.46	0.17
	Diam. at 10 %									
Visual soil description		SC	CL	CL	CL	CL	CL	SC	CL	CL
Unified soil classification										
Unconfined compression test	Undisturbed sample, Kg/cm²									
	Remoulded sample, Kg/cm²									
	Sensitivity ratio									
	Strain at failure, %									
Triaxial compression test	Angle of internal friction									
	Cohesion, Kg/cm²									
	Condition of drainage									
Consolidation test	Preconsolidation pressure, Kg/cm²									
	Compression index									

Remarks:

SUMMARY OF SOIL TEST

Project: The Natural Conditions Survey on the Development Project of the Industrial Port. Standard: ______________

Borehole No.		No. 4								
Sample No.		SS-10	SS-11	SS-12	SS-13	SS-14	SS-15	SS-16	SS-17	SS-[illegible]
Sample depth		10.00 m ~ 10.45 m	11.00 m ~ 11.45 m	12.00 m ~ 12.45 m	13.00 m ~ 13.45 m	14.00 m ~ 14.45 m	15.00 m ~ 15.45 m	16.00 m ~ 16.45 m	17.00 m ~ 17.45 m	18.0[illegible] ~ 18.4[illegible]
Condition of sample		Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Distu[illegible] ~~Undist[illegible]~~
Natural water content, %		20.9	25.0	25.0	21.3	22.5	25.3	24.3	28.4	[illegible]
Specific gravity		2.622	2.626	2.641	2.605	2.580	2.646	2.602	2.625	2.6[illegible]
Wet density, g/cm³										
Dry density, g/cm³										
Natural void ratio										
Degree of saturation, %										
Atterberg limits	Liquid limit, %									
	Plastic limit, %									
	Plasticity index									
Grain size analysis	Gravel, %	12.1	13.4	8.9	16.7	11.9	6.3	13.7	5.6	[illegible]
	Sand, %	36.1	36.6	36.0	34.4	32.1	46.1	44.3	40.8	34.[illegible]
	Silt, %	14.2	50.0 (silt & clay)	11.7	17.4	35.5	14.8	16.0	17.3	[illegible]
	Clay & colloid, %	37.6		43.4	31.5	20.8	32.8	27.0	36.3	[illegible]
	Max. diameter, mm	4.76	4.76	4.76	4.76	4.76	4.76	4.76	4.76	9.[illegible]
	Diam. at 60 %	0.42	0.47	0.30	0.57	0.38	0.68	0.80	0.40	0.[illegible]
	Diam. at 10 %									
Visual soil description		SC	SC	SC	SC	SC	SC	SC	SC	SC
Unified soil classification										
Unconfined compression test	Undisturbed sample, Kg/cm²									
	Remoulded sample Kg/cm²									
	Sensitivity ratio									
	Strain at failure, %									
Triaxial compression test	Angle of internal friction									
	Cohesion, Kg/cm²									
	Condition of drainage									
Consolidation test	Preconsolidation pressure, Kg/cm²									
	Compression index									

Remarks:

SUMMARY OF SOIL TEST

Project: The Natural Conditions Survey on the Development Project of the Industrial Port   Standard: ____________

Borehole No.	No. 4								
Sample No.	SS-19	SS-20	SS-21	SS-22	SS-23	SS-24	SS-25	SS-26	SS-27
Sample depth	19.00 m – 19.45 m	20.00 m – 20.45 m	21.00 m – 21.45 m	22.00 m – 22.45 m	23.00 m – 23.45 m	24.00 m – 24.45 m	25.00 m – 25.45 m	26.00 m – 26.45 m	27.00 m – 27.45 m
Condition of sample	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~
Natural water content, %	20.0	18.2	22.5	13.9	14.4	20.8	10.8	12.2	12.9
Specific gravity	2.633	2.634	2.646	2.636	2.642	2.646	2.625	2.627	2.607
Wet density, g/cm³									
Dry density, g/cm³									
Natural void ratio									
Degree of saturation, %									
Atterberg limits: Liquid limit, %									
Atterberg limits: Plastic limit, %									
Atterberg limits: Plasticity index									
Grain size analysis: Gravel, %	20.4	18.4	18.3	19.6	18.7	11.9	17.3	18.2	21.8
Grain size analysis: Sand, %	40.5	37.4	39.2	41.2	44.5	47.3	49.3	46.5	45.3
Grain size analysis: Silt, %	19.0	21.5	23.0	23.2	21.8	18.5	33.4 (silt + clay)	14.3	14.2
Grain size analysis: Clay & colloid, %	20.1	22.7	19.5	16.0	15.0	22.3		21.0	18.7
Grain size analysis: Max. diameter, mm	4.76	4.76	4.76	4.76	4.76	4.76	4.76	4.76	4.75
Grain size analysis: Diam. at 60 %	0.80	0.65	0.60	0.66	0.60	0.42	0.73	0.73	0.85
Grain size analysis: Diam. at 10 %									
Visual soil description	SH	SH	SH	SH	SH	SH	SH	SH	SH
Unified soil classification									
Unconfined compression test: Undisturbed sample, Kg/cm²									
Unconfined compression test: Remoulded sample, Kg/cm²									
Unconfined compression test: Sensitivity ratio									
Unconfined compression test: Strain at failure, %									
Triaxial compression test: Angle of internal friction									
Triaxial compression test: Cohesion, Kg/cm²									
Triaxial compression test: Condition of drainage									
Consolidation test: Preconsolidation pressure, Kg/cm²									
Consolidation test: Compression index									

Remarks :

SUMMARY OF SOIL TEST

Project: The Natural Conditions Survey on the Development Project of the Industrial Port   Standard:

Borehole No.	No. 4								
Sample No.	SS-28	SS-29	SS-30	SS-31	SS-32	SS-33	SS-34		
Sample depth	28.00 m – 28.40 m	29.00 m – 29.33 m	30.00 m – 30.28 m	32.00 m – 32.28 m	34.00 m – 34.45 m	36.00 m – 36.10 m	38.00 m – 38.05 m	m – m	
Condition of sample	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed Undisturbed	Disturbed Undisturbed
Natural water content, %	10.1	13.5	12.4	10.4	15.5	8.1	—		
Specific gravity	2.610	2.616	2.650	2.605	2.629	2.640	—		
Wet density, g/cm³									
Dry density, g/cm³									
Natural void ratio									
Degree of saturation, %									
Atterberg limits: Liquid limit, %									
Atterberg limits: Plastic limit, %									
Atterberg limits: Plasticity index									
Grain size analysis: Gravel, %	18.2	31.5	21.8	21.6	15.8	24.2			
Grain size analysis: Sand, %	47.7	52.0	59.4	51.3	53.2	52.1			
Grain size analysis: Silt, %	15.9	} 16.5	} 18.8	14.6	17.0	13.8			
Grain size analysis: Clay & colloid, %	18.2			12.5	14.0	9.9			
Grain size analysis: Max. diameter, mm	4.76	9.52	4.76	4.76	4.76	4.76			
Grain size analysis: Diam. at 60 %	0.70	1.50	1.00	1.10	0.80	1.20			
Grain size analysis: Diam. at 10 %									
Visual soil description	SM	SM	SM	SM	SM	SM			
Unified soil classification									
Unconfined compression test: Undisturbed sample, Kg/cm²									
Unconfined compression test: Remoulded sample, Kg/cm²									
Unconfined compression test: Sensitivity ratio									
Unconfined compression test: Strain at failure, %									
Triaxial compression test: Angle of internal friction									
Triaxial compression test: Cohesion, Kg/cm²									
Triaxial compression test: Condition of drainage									
Consolidation test: Preconsolidation pressure, Kg/cm²									
Consolidation test: Compression index									

Remarks:

SUMMARY OF SOIL TEST

Project: The Natural Conditions Survey on the Development Project of the Industrial Port Standard: ____________

Borehole No.	No. 5								
Sample No.	SS-1	SS-2	SS-3	SS-4	SS-5	SS-6	SS-7	SS-8	SS-9
Sample depth	0.15 m - 0.45 m	1.15 m - 1.45 m	2.15 m - 2.45 m	3.15 m - 3.45 m	4.15 m - 4.45 m	5.15 m - 5.45 m	6.15 m - 6.45 m	7.15 m - 7.45 m	8.15 m - 8.45 m
Condition of sample	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~
Natural water content, %	13.0	8.2	13.2	12.6	14.7	10.6	9.9	11.1	14.0
Specific gravity	2.633	2.625	2.577	2.670	2.607	2.602	2.650	2.608	2.630
Wet density, g/cm³									
Dry density, g/cm³									
Natural void ratio									
Degree of saturation, %									
Atterberg limits: Liquid limit, %									
Atterberg limits: Plastic limit, %									
Atterberg limits: Plasticity index									
Grain size analysis: Gravel, %	—	27.9	5.5	8.7	18.2	—	13.0	24.4	5.6
Grain size analysis: Sand, %	—	48.9	53.2	54.1	47.8	—	61.1	52.6	70.5
Grain size analysis: Silt, %	—	7.9	20.7	11.5	7.2	—	1.6	4.3	7.5
Grain size analysis: Clay & colloid, %	—	15.3	20.6	25.7	26.8	—	24.3	16.6	16.4
Grain size analysis: Max. diameter, mm	—	4.76	4.76	2.00	4.76	—	0.80	1.20	0.24
Grain size analysis: Diam. at 60 %	—	1.40	0.30	0.65	0.90	—	0.80	1.20	0.24
Grain size analysis: Diam. at 10 %									
Visual soil description		SM	SC-CL	SC-CL	SC-CL		SC	SC	SC
Unified soil classification									
Unconfined compression test: Undisturbed sample, kg/cm²									
Unconfined compression test: Remoulded sample, kg/cm²									
Unconfined compression test: Sensitivity ratio									
Unconfined compression test: Strain at failure, %									
Triaxial compression test: Angle of internal friction									
Triaxial compression test: Cohesion, kg/cm²									
Triaxial compression test: Condition of drainage									
Consolidation test: Preconsolidation pressure, kg/cm²									
Consolidation test: Compression index									

Remarks:

SUMMARY OF SOIL TEST

Project: The Natural Conditions Survey on the Development Project of the Industrial Port. Standard: ____________

Borehole No.		No. 5								
Sample No.		SS-10	SS-11	SS-12	SS-13	SS-14	SS-15	SS-16	SS-17	SS-1[illegible]
Sample depth		9.15 m – 9.45 m	10.15 m – 10.45 m	11.15 m – 11.45 m	12.15 m – 12.45 m	13.15 m – 13.45 m	14.15 m – 14.38 m	15.15 m – 15.36 m	16.15 m – 16.33 m	16.70 – 17.15
Condition of sample		Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~
Natural water content, %		11.9	12.2	10.6	12.2	—	8.5	16.8	9.0	8.6
Specific gravity		2.600	2.616	2.600	2.606	—	2.634	2.604	2.632	2.6[illegible]
Wet density, g/cm³										
Dry density, g/cm³										
Natural void ratio										
Degree of saturation, %										
Atterberg limits	Liquid limit, %									
	Plastic limit, %									
	Plasticity index									
Grain size analysis	Gravel, %	14.3	38.6	4.2	35.9	—	26.3	26.4	28.6	3[illegible]
	Sand, %	65.1	21.5	59.4	42.4	—	53.7	48.1	54.1	48.[illegible]
	Silt, %	20.6 (silt & clay)	3.0	7.0	3.4	—	7.8	8.2	17.2 (silt & clay)	17.[illegible] (silt & clay)
	Clay & colloid, %		36.9	28.6	18.3	—	12.2	17.3		
	Max. diameter, mm	4.76	4.76	4.76	4.76	—	4.76	4.76	4.76	4.7[illegible]
	Diam. at 60%	1.00	0.20	1.80	1.80	—	1.20	1.05	1.18	1.[illegible]
	Diam. at 10%									
Visual soil description		SC	GC	CL	GC		SM	SM	SM	SM
Unified soil classification										
Unconfined compression test	Undisturbed sample, Kg/cm²									
	Remoulded sample Kg/cm²									
	Sensitivity ratio									
	Strain at failure, %									
Triaxial compression test	Angle of internal friction									
	Cohesion, Kg/cm²									
	Condition of drainage									
Consolidation test	Preconsolidation pressure, Kg/cm²									
	Compression index									

Remarks:

SUMMARY OF SOIL TEST

Project: The Natural Conditions Survey on the Development Project of the Industrial Port Standard: ______

Borehole No.		No 6								
Sample No.		SS-1	SS-2	SS-3	SS-4	SS-5	SS-6	SS-7	SS-8	SS-9
Sample depth		1.05 m – 1.35 m	2.05 m – 2.35 m	3.05 m – 3.35 m	4.05 m – 4.35 m	5.05 m – 5.35 m	6.05 m – 6.35 m	7.05 m – 7.35 m	8.05 m – 8.35 m	9.05 m – 9.35 m
Condition of sample		Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~
Natural water content, %		—	17.3	14.1	13.5	13.7	11.2	14.6	13.6	11.7
Specific gravity		—	2.620	2.623	2.622	2.615	2.582	2.616	2.574	2.555
Wet density, g/cm³										
Dry density, g/cm³										
Natural void ratio										
Degree of saturation, %										
Atterberg limits	Liquid limit, %									
	Plastic limit, %									
	Plasticity index									
Grain size analysis	Gravel, %	—	12.6	22.0	4.7	7.0	4.7	6.5	24.9	31.9
	Sand, %	—	54.8	53.6	59.0	46.8	59.3	47.8	45.6	21.0
	Silt, %	—	5.8	3.8	6.5	18.6	9.7	8.8	3.2	47.1 (silt + clay)
	Clay & colloid, %	—	26.8	20.6	29.8	27.6	26.3	36.9	26.3	
	Max. diameter, mm	—	2.00	4.76	2.00	2.00	2.00	2.00	4.76	4.70
	Diam. at 60 %	—	0.60	1.00	0.34	0.42	0.34	0.42	0.70	1.20
	Diam. at 10 %									
Visual soil description			SC	SC	SC-CL	SC-CL	SC-CL	SC-CL	GC	GC
Unified soil classification										
Unconfined compression test	Undisturbed sample, Kg/cm²									
	Remoulded sample, Kg/cm²									
	Sensitivity ratio									
	Strain at failure, %									
Triaxial compression test	Angle of internal friction									
	Cohesion, Kg/cm²									
	Condition of drainage									
Consolidation test	Preconsolidation pressure, Kg/cm²									
	Compression index									

Remarks :

SUMMARY OF SOIL TEST

Project: The Natural Conditions Survey on the Development Project of the Industrial Port. Standard: ____________

Borehole No.	No. 6								
Sample No.	SS-10	SS-11	SS-12	SS-13	SS-14	SS-15	SS-16	SS-17	SS-1
Sample depth	10.05 m ~ 10.35 m	11.05 m ~ 11.35 m	12.05 m ~ 12.35 m	13.05 m ~ 13.35 m	14.05 m ~ 14.35 m	15.05 m ~ 15.35 m	16.05 m ~ 16.35 m	17.05 m ~ 17.35 m	18.05 ~ 18.35
Condition of sample	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Dist ~~Undi~~
Natural water content, %	13.7	16.1	21.1	22.4	18.2	12.9	20.7	—	16.
Specific gravity	2.585	2.637	2.560	2.598	2.573	2.636	2.527	—	2.5
Wet density, g/cm³									
Dry density, g/cm³									
Natural void ratio									
Degree of saturation, %									
Atterberg limits — Liquid limit, %									
Atterberg limits — Plastic limit, %									
Atterberg limits — Plasticity index									
Grain size analysis — Gravel, %	26.5	25.9	4.5	11.2	1.9	10.0	23.9	—	2.1
Grain size analysis — Sand, %	24.0	27.7	30.9	41.0	52.4	42.5	34.5	—	67.
Grain size analysis — Silt, %	} 49.5	3.4	} 64.6	16.1	12.9	} 47.5	} 41.6	—	} 30.
Grain size analysis — Clay & colloid, %		42.5		31.7	32.5			—	
Grain size analysis — Max. diameter, mm	4.76	4.76	4.76	4.76	4.76	4.76	4.76	—	4.7
Grain size analysis — Diam. at 60 %	0.95	1.19	—	1.09	0.28	0.31	0.83	—	0.5
Grain size analysis — Diam. at 10 %									
Visual soil description	GC	GC	SC	SC	SC	SC	SM		SM
Unified soil classification									
Unconfined compression test — Undisturbed sample, Kg/cm²									
Unconfined compression test — Remoulded sample, Kg/cm²									
Unconfined compression test — Sensitivity ratio									
Unconfined compression test — Strain at failure, %									
Triaxial compression test — Angle of internal friction									
Triaxial compression test — Cohesion, Kg/cm²									
Triaxial compression test — Condition of drainage									
Consolidation test — Preconsolidation pressure, Kg/cm²									
Consolidation test — Compression index									

Remarks:

SUMMARY OF SOIL TEST

Project: The Natural Conditions Survey on the Development Project of the Industrial Port. Standard:

Borehole No.	No. 6									
Sample No.	SS-19	SS-20	SS-21							
Sample depth	19.05 m – 19.35 m	20.05 m – 20.33 m	21.05 m – 21.23 m	m – m	m – m	m – m	m – m	m – m	m – m	m – m
Condition of sample	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~
Natural water content, %	19.7	17.2	11.5							
Specific gravity	2.610	2.588	2.607							
Wet density, g/cm³										
Dry density, g/cm³										
Natural void ratio										
Degree of saturation, %										
Atterberg limits: Liquid limit, %										
Atterberg limits: Plastic limit, %										
Atterberg limits: Plasticity index										
Grain size analysis: Gravel, %	0.4	9.6	25.2							
Grain size analysis: Sand, %	67.6	56.8	49.6							
Grain size analysis: Silt, %	17.0	16.1	9.2							
Grain size analysis: Clay & colloid, %	15.0	17.5	16.0							
Grain size analysis: Max. diameter, mm	2.00	4.76	9.52							
Grain size analysis: Diam. at 60 %	0.34	0.36	1.10							
Grain size analysis: Diam. at 10 %										
Visual soil description	SM	SM	SM							
Unified soil classification										
Unconfined compression test: Undisturbed sample, Kg/cm²										
Unconfined compression test: Remoulded sample, Kg/cm²										
Unconfined compression test: Sensitivity ratio										
Unconfined compression test: Strain at failure, %										
Triaxial compression test: Angle of internal friction										
Triaxial compression test: Cohesion, Kg/cm²										
Triaxial compression test: Condition of drainage										
Consolidation test: Preconsolidation pressure, Kg/cm²										
Consolidation test: Compression index										

Remarks:

SUMMARY OF SOIL TEST

Project: The Natural Conditions Survey on the Dovolopment Project of the Industrial Port. Standard: ______

Borehole No.		No. 7								
Sample No.		SS-1	SS-2	SS-3	SS-4	SS-5	SS-6	SS-7	SS-8	SS-9
Sample depth		1.00 m – 1.30 m	2.00 m – 2.30 m	3.00 m – 3.30 m	4.00 m – 4.30 m	5.00 m – 5.30 m	6.00 m – 6.30 m	7.00 m – 7.30 m	8.00 m – 8.30 m	9.00 – 9.30
Condition of sample		Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~
Natural water content, %		21.9	—	12.8	12.8	19.1	19.5	11.7	13.7	10.1
Specific gravity		2.630	—	2.609	2.649	2.621	2.622	2.631	2.602	2.6
Wet density, g/cm³										
Dry density, g/cm³										
Natural void ratio										
Degree of saturation, %										
Atterberg limits	Liquid limit, %									
	Plastic limit, %									
	Plasticity index									
Grain size analysis	Gravel, %	2.2	—	18.7	19.8	7.7	8.0	2.3	6.1	8.1
	Sand, %	90.4	—	80.8	71.8	90.2	89.6	57.1	69.3	65.
	Silt, %	} 7.4	—	} 0.5	} 9.0	} 2.1	} 2.4	2.8	3.9	8.1
	Clay & colloid, %		—					37.8	25.7	16.
	Max. diameter, mm	2.00	—	4.76	4.76	4.76	2.00	2.00	2.00	2.
	Diam. at 60 %	0.75	—	1.30	1.20	1.30	1.7	0.70	0.36	0.
	Diam. at 10 %									
Visual soil description		SP		SP	SP	SP	SP	SC	SC	SC
Unified soil classification										
Unconfined compression test	Undisturbed sample, Kg/cm²									
	Remoulded sample Kg/cm²									
	Sensitivity ratio									
	Strain at failure, %									
Triaxial compression test	Angle of internal friction									
	Cohesion, Kg/cm²									
	Condition of drainage									
Consolidation test	Preconsolidation pressure, Kg/cm²									
	Compression index									

Remarks:

SUMMARY OF SOIL TEST

Project: The Natural Conditions Survey on the Development Project of the Industrial Port. Standard: ____________

Borehole No.	No 7								
Sample No.	SS-10	SS-11	SS-12	SS-13	SS-14	SS-15	SS-16	SS-17	SS-18
Sample depth	10.00 m – 10.30 m	11.00 m – 11.30 m	12.00 m – 12.30 m	13.00 m – 13.30 m	14.00 m – 14.30 m	15.00 m – 15.30 m	16.00 m – 16.30 m	17.00 m – 17.30 m	18.00 m – 18.30 m
Condition of sample	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~
Natural water content, %	9.5	10.8	—	11.9	15.9	11.5	10.6	10.0	—
Specific gravity	2.615	2.593	—	2.631	2.634	2.630	2.637	2.634	—
Wet density, g/cm³									
Dry density, g/cm³									
Natural void ratio									
Degree of saturation, %									
Atterberg limits: Liquid limit, %									
Atterberg limits: Plastic limit, %									
Atterberg limits: Plasticity index									
Grain size analysis: Gravel, %	11.0	29.6	—	15.7	14.9	13.3	25.8	22.0	—
Grain size analysis: Sand, %	68.7	40.9	—	52.1	45.8	63.0	44.7	49.4	—
Grain size analysis: Silt, %	4.7	5.7	—	3.7	5.8	4.6	29.5 (silt + clay)	3.5	—
Grain size analysis: Clay & colloid, %	15.6	23.8	—	28.5	33.5	19.1		25.1	—
Grain size analysis: Max. diameter, mm	4.76	4.76	—	4.76	4.76	4.76	4.76	4.76	—
Grain size analysis: Diam. at 60 %	1.30	1.40	—	0.65	0.625	1.00	1.30	1.20	—
Grain size analysis: Diam. at 10 %									
Visual soil description	SC	GC		SC-CL	SC-CL	SC-CL	SC-CL	SC-CL	
Unified soil classification									
Unconfined compression test: Undisturbed sample, Kg/cm²									
Unconfined compression test: Remoulded sample, Kg/cm²									
Unconfined compression test: Sensitivity ratio									
Unconfined compression test: Strain at failure, %									
Triaxial compression test: Angle of internal friction									
Triaxial compression test: Cohesion, Kg/cm²									
Triaxial compression test: Condition of drainage									
Consolidation test: Preconsolidation pressure, Kg/cm²									
Consolidation test: Compression index									

Remarks:

SUMMARY OF SOIL TEST

Project: The Natural Conditions Survey on the Development Project of the Industrial Port. Standard:

		No. 7								
Borehole No.		No. 7								
Sample No.		SS-19	SS-20	SS-21	SS-22	SS-23	SS-24	SS-25	SS-26	
Sample depth		19.00 m – 19.30 m	20.00 m – 20.30 m	21.00 m – 21.30 m	22.00 m – 22.30 m	23.00 m – 23.30 m	24.00 m – 24.30 m	24.85 m – 24.95 m	25.40 m – 25.44 m	
Condition of sample		Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Dist[illegible] ~~Undi[illegible]~~
Natural water content, %		13.8	10.4	17.4	11.1	8.4	—	6.1	—	
Specific gravity		2.627	2.603	2.571	2.611	2.635	2.636	2.633	—	
Wet density, g/cm³										
Dry density, g/cm³										
Natural void ratio										
Degree of saturation, %										
Atterberg limits	Liquid limit, %			30.0						
	Plastic limit, %			17.1						
	Plasticity index			13.9						
Grain size analysis	Gravel, %	26.6	11.0	0.9	13.5	16.2	21.2	25.6	—	
	Sand, %	52.0	73.9	36.7	65.3	69.7	54.0	59.0	—	
	Silt, %	6.9	3.5	39.2	} 21.2	7.4	} 24.8	} 15.4	—	
	Clay & colloid, %	14.5	11.6	23.2		6.7			—	
	Max. diameter, mm	4.76	4.76	4.76	2.00	4.76	4.76	4.76	—	
	Diam. at 60 %	1.10	0.95	0.07	0.90	1.20	1.50	1.20	—	
	Diam. at 10 %									
Visual soil description		SC	SC	CL	SC	SC	SC	SM		
Unified soil classification										
Unconfined compression test	Undisturbed sample, Kg/cm²									
	Remoulded sample Kg/cm²									
	Sensitivity ratio									
	Strain at failure, %									
Triaxial compression test	Angle of internal friction									
	Cohesion, Kg/cm²									
	Condition of drainage									
Consolidation test	Preconsolidation pressure, Kg/cm²									
	Compression index									

Remarks:

SUMMARY OF SOIL TEST

Project: The Natural Conditions Survey on the Development Project of the Industrial Port. Standard: ____________

Borehole No.	No. 8								
Sample No.	SS-1	SS-2	SS-3	SS-4	SS-5	SS-6	SS-7	SS-8	SS-9
Sample depth	0.75 m – 1.05 m	1.75 m – 2.05 m	2.75 m – 3.05 m	3.75 m – 4.05 m	4.75 m – 5.05 m	5.75 m – 6.05 m	6.75 m – 7.05 m	7.75 m – 8.05 m	8.75 m – 8.90 m
Condition of sample	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~
Natural water content, %	22.3	—	19.0	19.6	17.2	14.1	14.2	13.7	10.1
Specific gravity	2.603	—	2.646	2.623	2.647	2.534	2.602	2.606	2.[illegible]
Wet density, g/cm³									
Dry density, g/cm³									
Natural void ratio									
Degree of saturation, %									
Atterberg limits: Liquid limit, %				46.0					
Atterberg limits: Plastic limit, %				26.1					
Atterberg limits: Plasticity index				19.9					
Grain size analysis: Gravel, %	8.8	—	25.5	7.1	9.1	27.3	14.4	—	—
Grain size analysis: Sand, %	85.5	—	71.6	23.1	33.0	32.1	36.1	—	—
Grain size analysis: Silt, %	5.7 (silt + clay)	—	2.9 (silt + clay)	8.8	4.4	3.5	3.1	—	—
Grain size analysis: Clay & colloid, %		—		61.0	53.5	37.1	46.4	—	—
Grain size analysis: Max. diameter, mm	4.76	—	4.76	4.76	2.00	4.76	2.00	—	—
Grain size analysis: Diam. at 60 %	1.0	—	1.60	—	0.20	1.30	0.55	—	—
Grain size analysis: Diam. at 10 %									
Visual soil description	SP		SP	CL	CL-SC	GC	GC		
Unified soil classification									
Unconfined compression test: Undisturbed sample, Kg/cm²									
Unconfined compression test: Remoulded sample Kg/cm²									
Unconfined compression test: Sensitivity ratio									
Unconfined compression test: Strain at failure, %									
Triaxial compression test: Angle of internal friction									
Triaxial compression test: Cohesion, Kg/cm²									
Triaxial compression test: Condition of drainage									
Consolidation test: Preconsolidation pressure, Kg/cm²									
Consolidation test: Compression index									

Remarks:

SUMMARY OF SOIL TEST

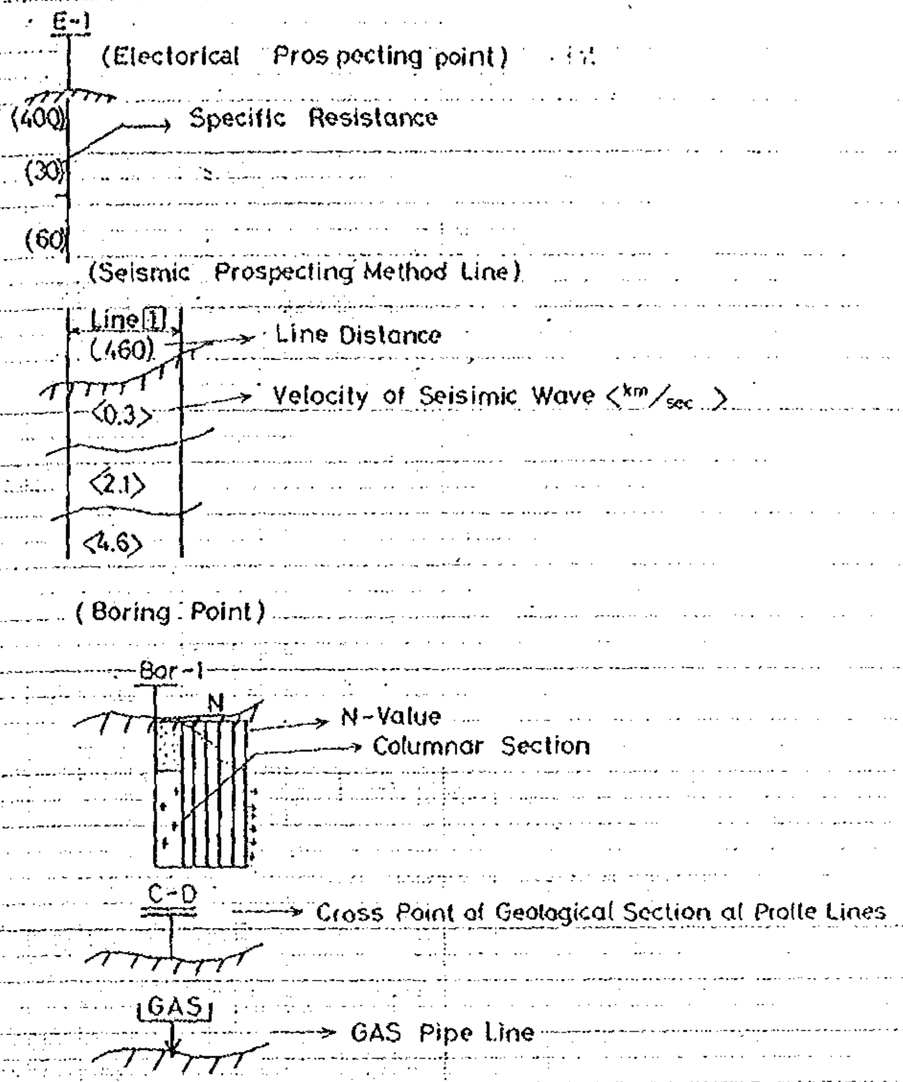
Project: The Natural Conditions Survey on the Development Project of the Industrial Port. Standard:

Borehole No.		No. 8								
Sample No.		SS-10	SS-11	SS-12	SS-13	SS-14	SS-15	SS-16		
Sample depth		9.75 m ~ 10.05 m	10.75 m ~ 11.05 m	11.75 m ~ 12.05 m	12.75 m ~ 13.05 m	13.75 m ~ 14.05 m	15.60 m ~ 15.71 m	15.90 m ~ 15.94 m	m ~ m	
Condition of sample		Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed ~~Undisturbed~~	Disturbed Undisturbed	Disturbed Undisturbed	Disturbed Undisturbed
Natural water content, %		13.1	15.2	20.1	13.6	17.8	15.9	—		
Specific gravity		2.609	2.620	2.607	2.625	2.574	2.606	—		
Wet density, g/cm³										
Dry density, g/cm³										
Natural void ratio										
Degree of saturation, %										
Atterberg limits	Liquid limit, %									
	Plastic limit, %									
	Plasticity index									
Grain size analysis	Gravel, %	32.4	—	26.1	24.7	21.5	20.5	—		
	Sand, %	28.8	—	28.2	36.5	54.1	33.5	—		
	Silt, %	4.1	—	10.6	6.7	11.4	46.0 (silt & clay)	—		
	Clay & colloid, %	34.7	—	35.1	32.1	13.0		—		
	Max. diameter, mm	4.76	—	4.76	4.76	4.76	4.76	—		
	Diam. at 60 %	1.40	—	0.80	0.95	0.75	1.20	—		
	Diam. at 10 %									
Visual soil description		GC		SC	SC	SC	SM			
Unified soil classification										
Unconfined compression test	Undisturbed sample, Kg/cm²									
	Remoulded sample, Kg/cm²									
	Sensitivity ratio									
	Strain at failure, %									
Triaxial compression test	Angle of internal friction									
	Cohesion, Kg/cm²									
	Condition of drainage									
Consolidation test	Preconsolidation pressure, Kg/cm²									
	Compression index									

Remarks:

2. Geological Profiles

LEGEND

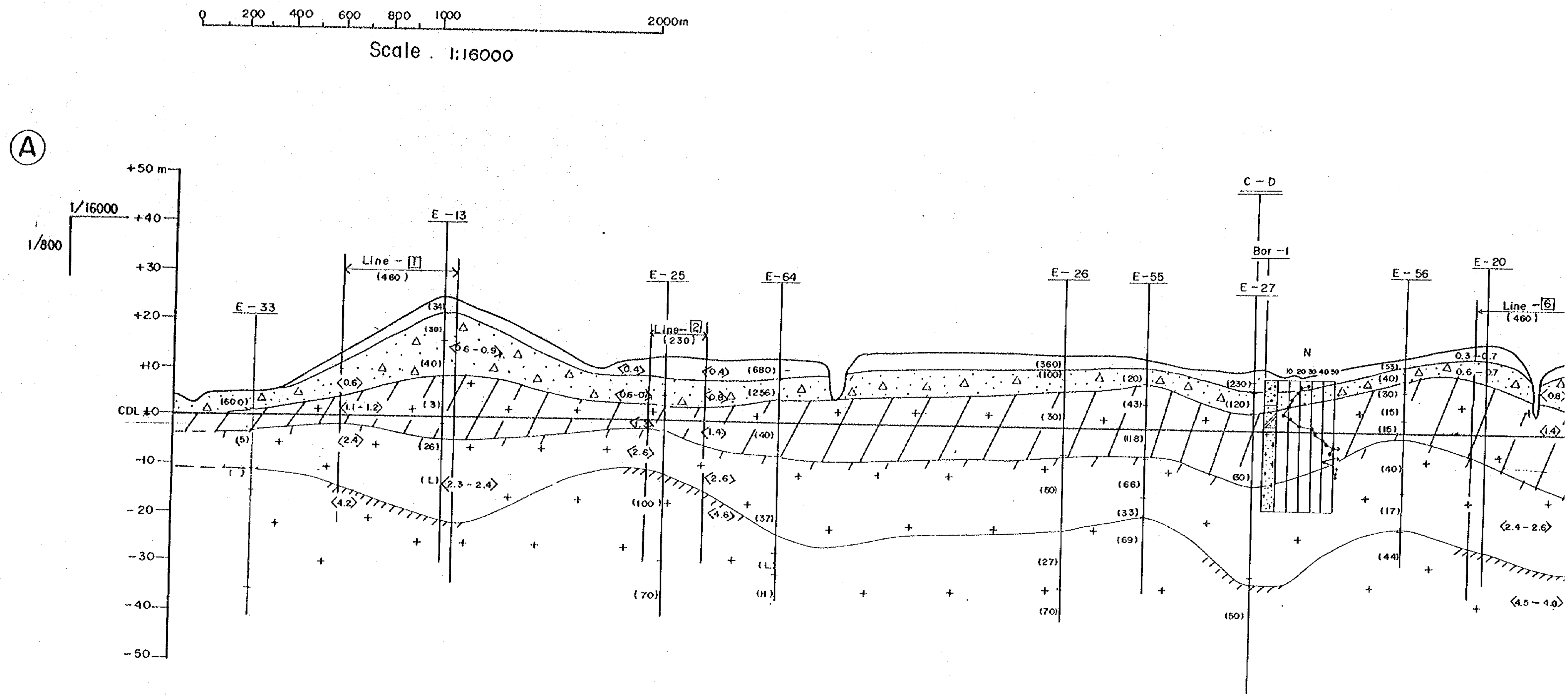


(Land Area)

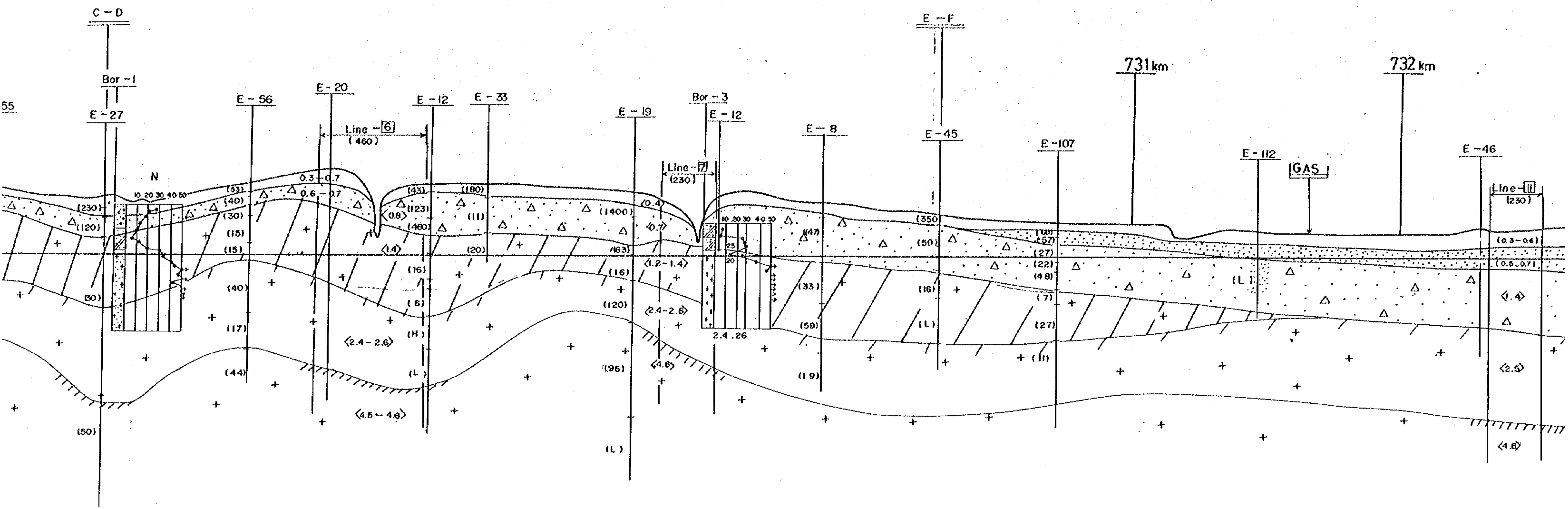
- Surface Soil
- Sand, Sand·Gravel·Silt·Clay — Terrace Deposits
- Highly Weathered, Weathered, Fresh — Granitic Rocks

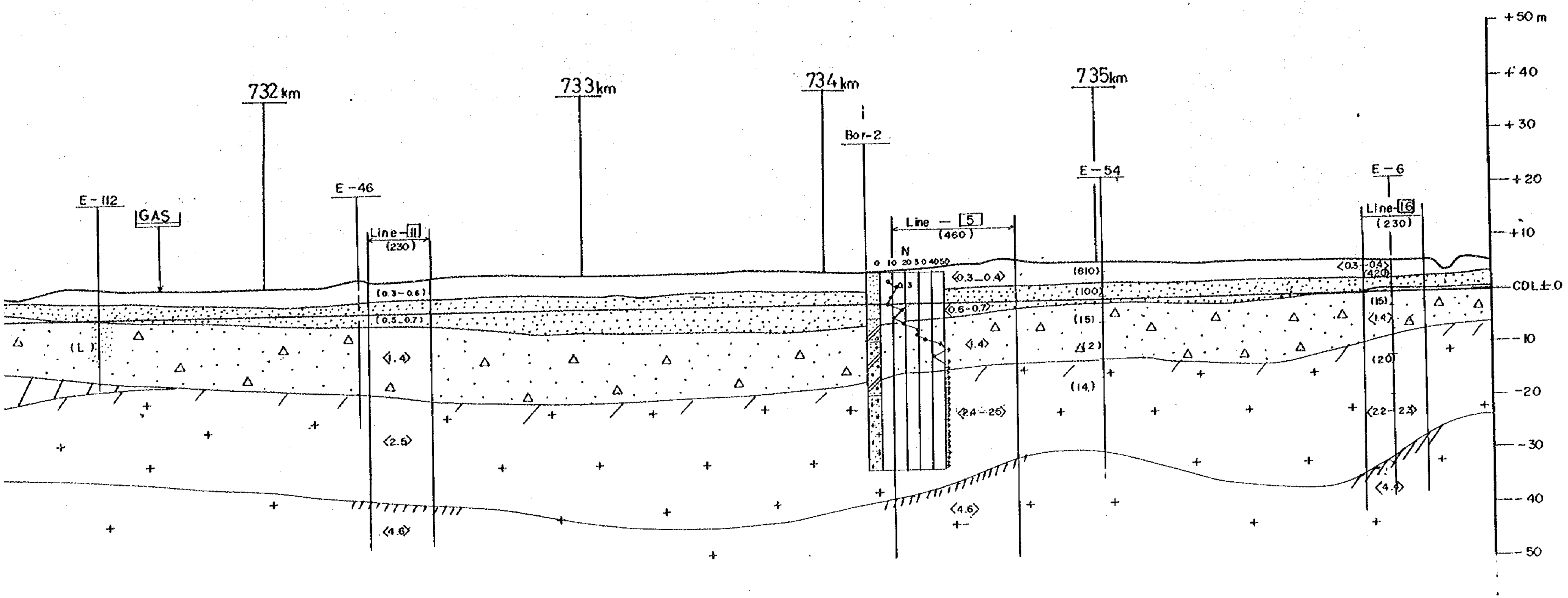
(Sea Area)

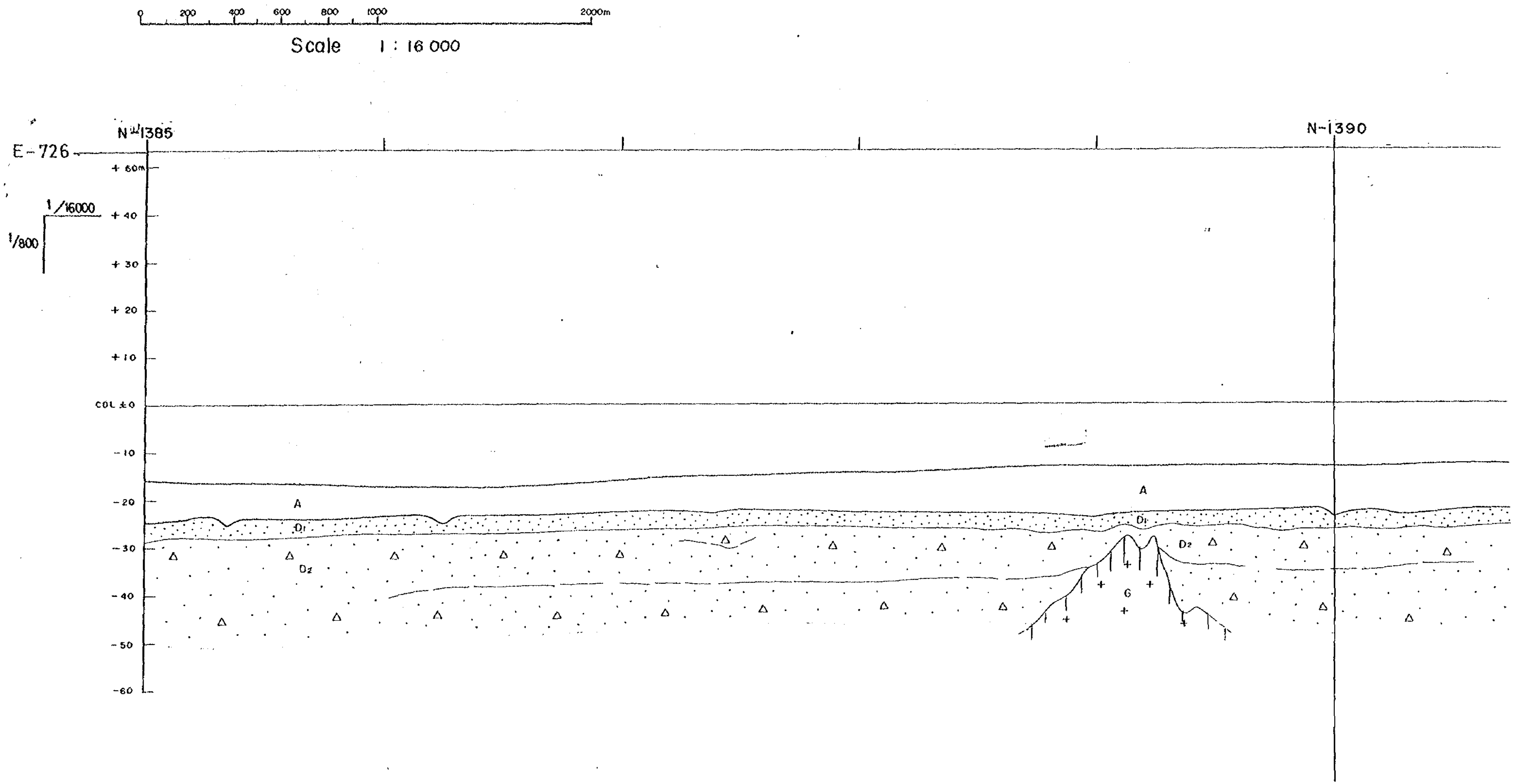
- A — Recent Deposits
- D — Late Pleistocene Deposits
- D, — Terrace Deposits & Highly Weathered Granitic Rocks
- G — Granitic Rocks (Weathered or Fresh)

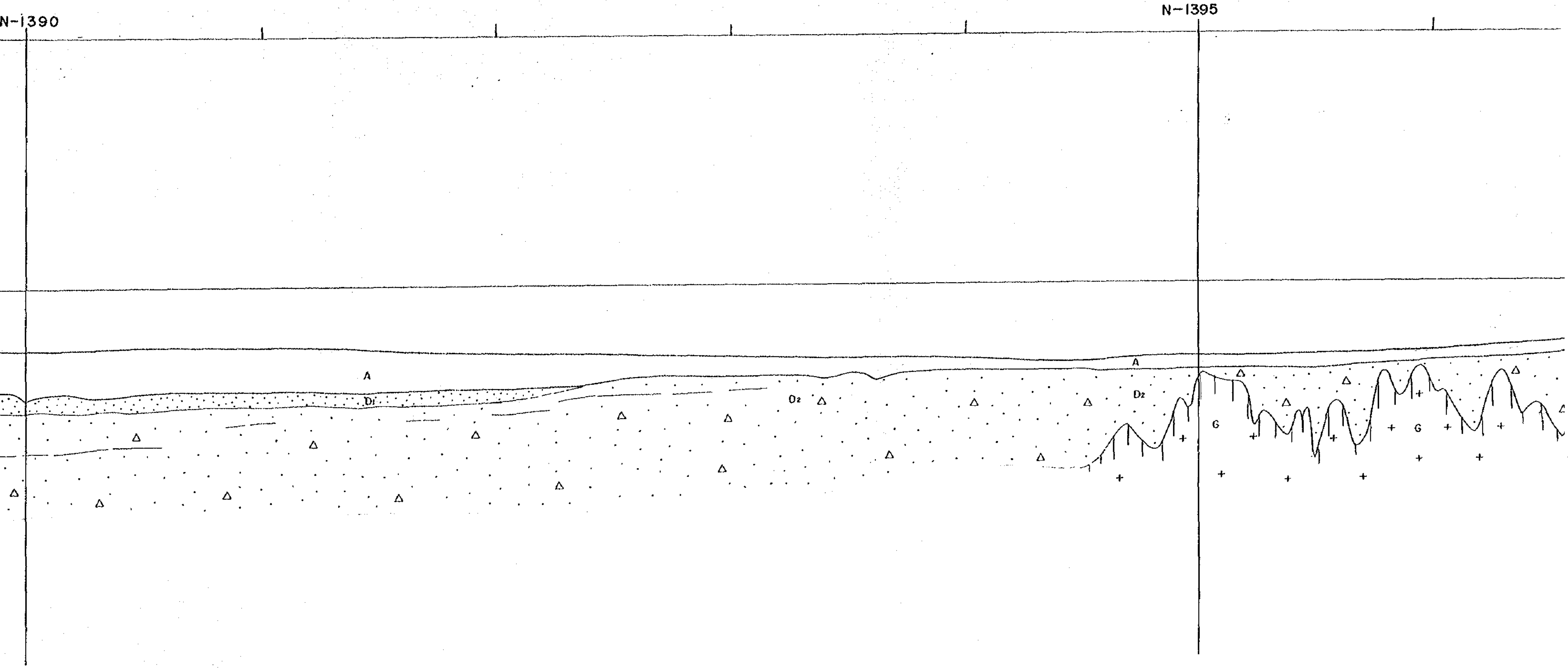


0 200 400 600 800 1000 2000m
Scale . 1:16000
A
1/16000
1/800
+50 m
+40
+30
+20
+10
CDL ±0
-10
-20
-30
-40
-50
E-33
E-13
Line - 1
(460)
E-25
Line - 2
(230)
E-64
E-26
E-55
C - D
Bor - 1
E-27
E-56
E-20
Line - 6
(460)
N

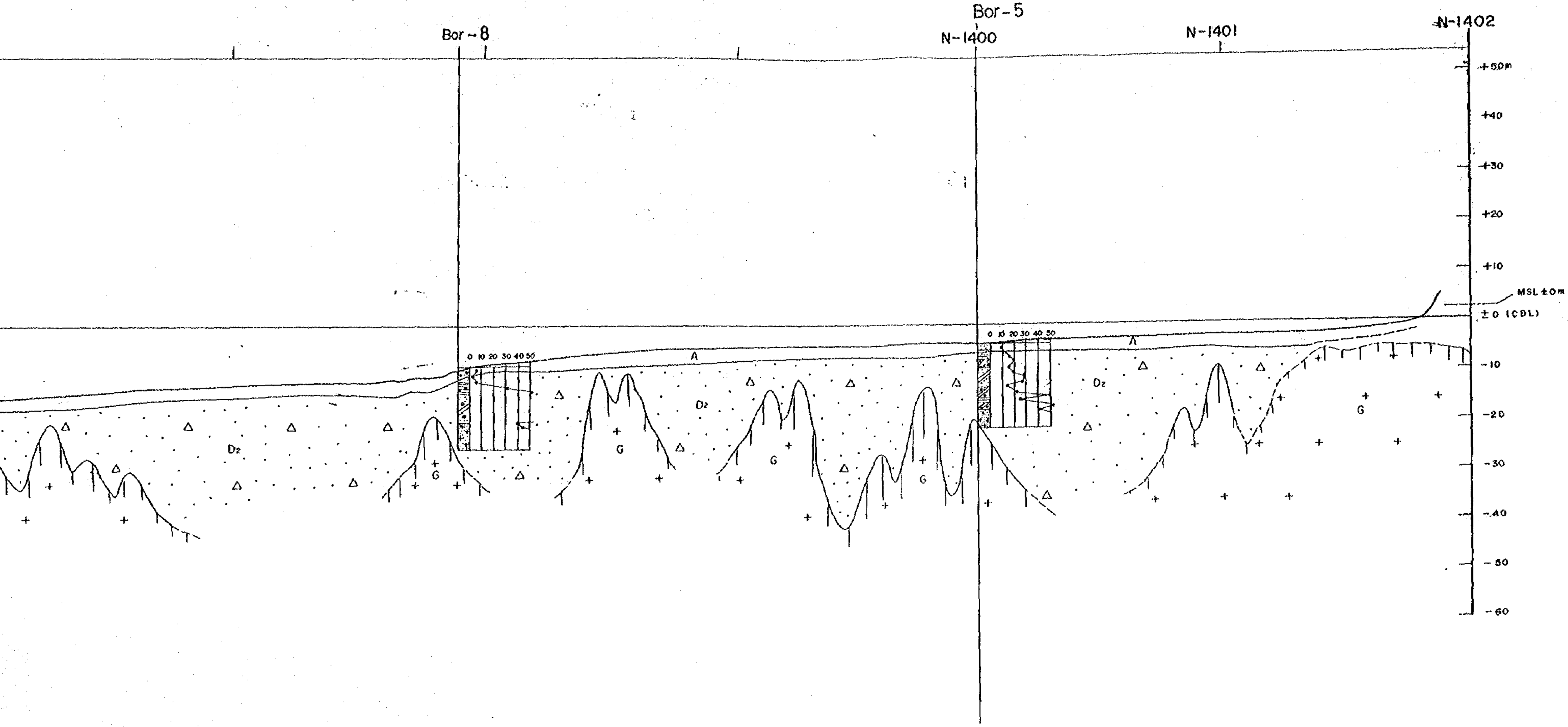

C - D
Bor - 1
E - 27
E - 56
E - 20
Line - 6
(460)
E - 12
E - 33
E - 19
Line - 7
(230)
Bor - 3
E - 12
E - 8
E - F
E - 45
E - 107
731 km
E - 112
GAS
732 km
E - 46
Line - 11
(230)
N
2.4 . 26


B
732 km
733 km
734 km
735 km
E-112
GAS
E-46
Line-11
(230)
Bor-2
Line-5
(460)
E-54
E-6
Line-16
(230)
+50 m
+40
+30
+20
+10
CDL±0
-10
-20
-30
-40
-50
(L)
(0.3-0.6)
(0.3-0.7)
(610)
(100)
(15)
(14)
(20)
(2.5)
(4.6)

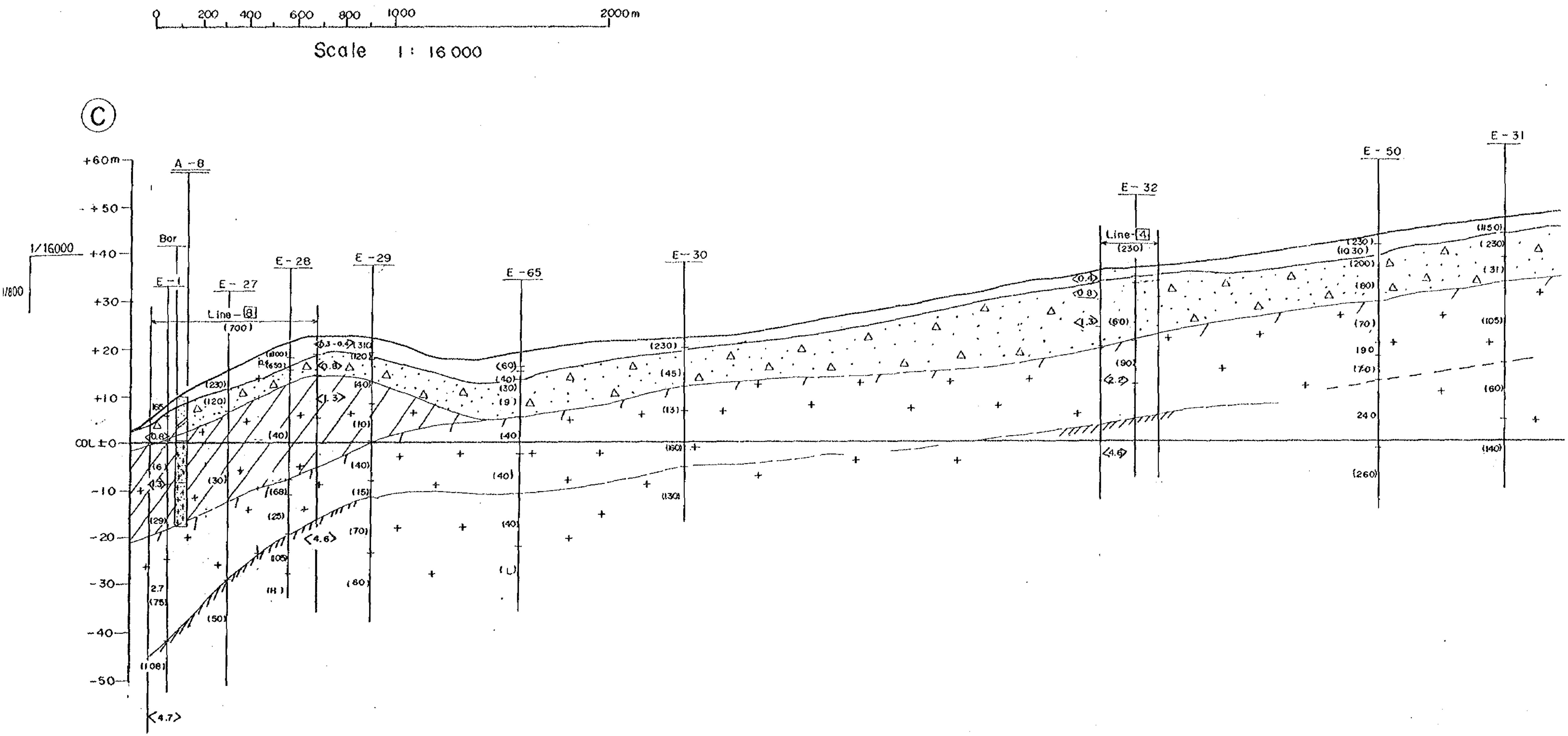

0
200
400
600
800
1000
2000m
Scale 1 : 16 000
N° 1385
N-1390
E-726
1/16000
1/800
+ 60m
+ 40
+ 30
+ 20
+ 10
COL ± 0
- 10
- 20
- 30
- 40
- 50
- 60
A
D1
D2
G



N-1390
N-1395
A
D1
D2
A
D2
G
G

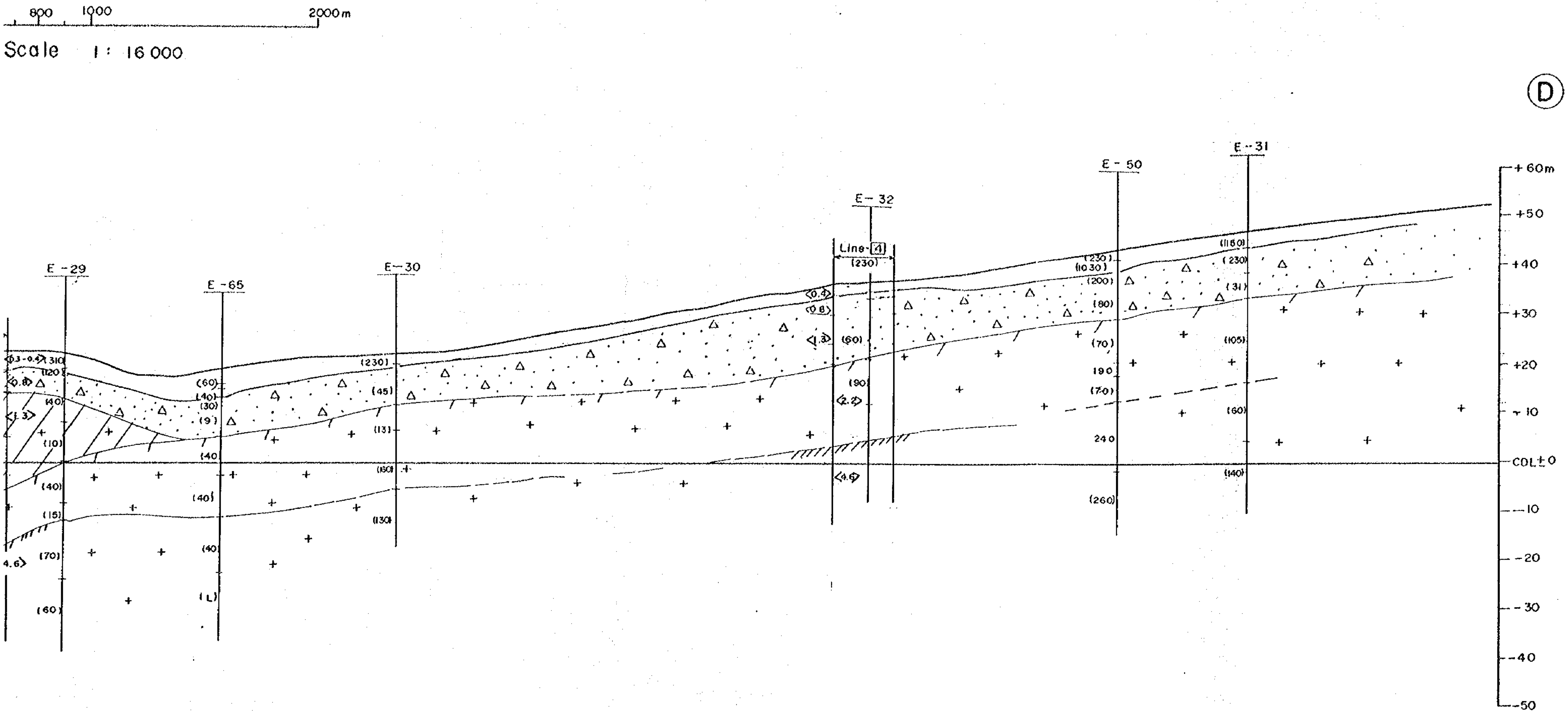


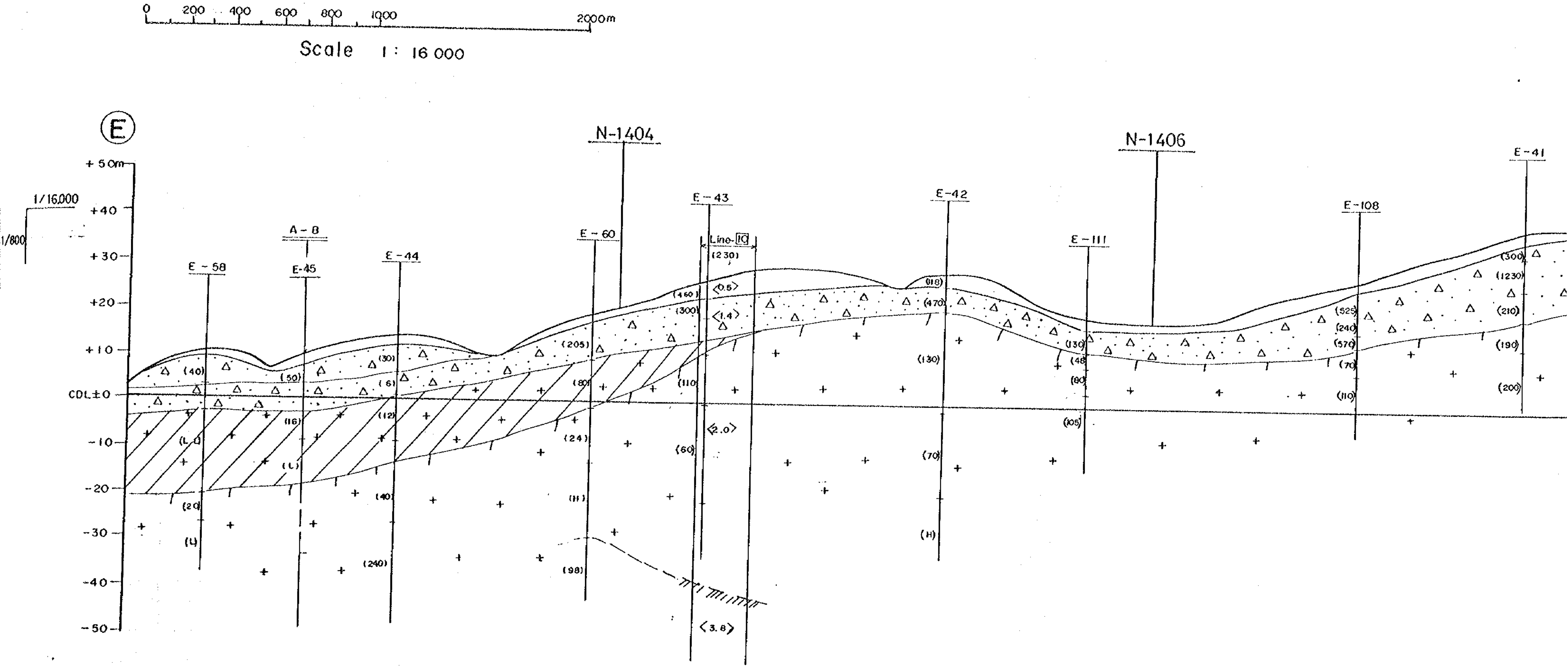
Bor-8
Bor-5
N-1400
N-1401
N-1402
+50m
+40
+30
+20
+10
MSL ±0m
±0 (CDL)
-10
-20
-30
-40
-50
-60
0 10 20 30 40 50
A
D2
G



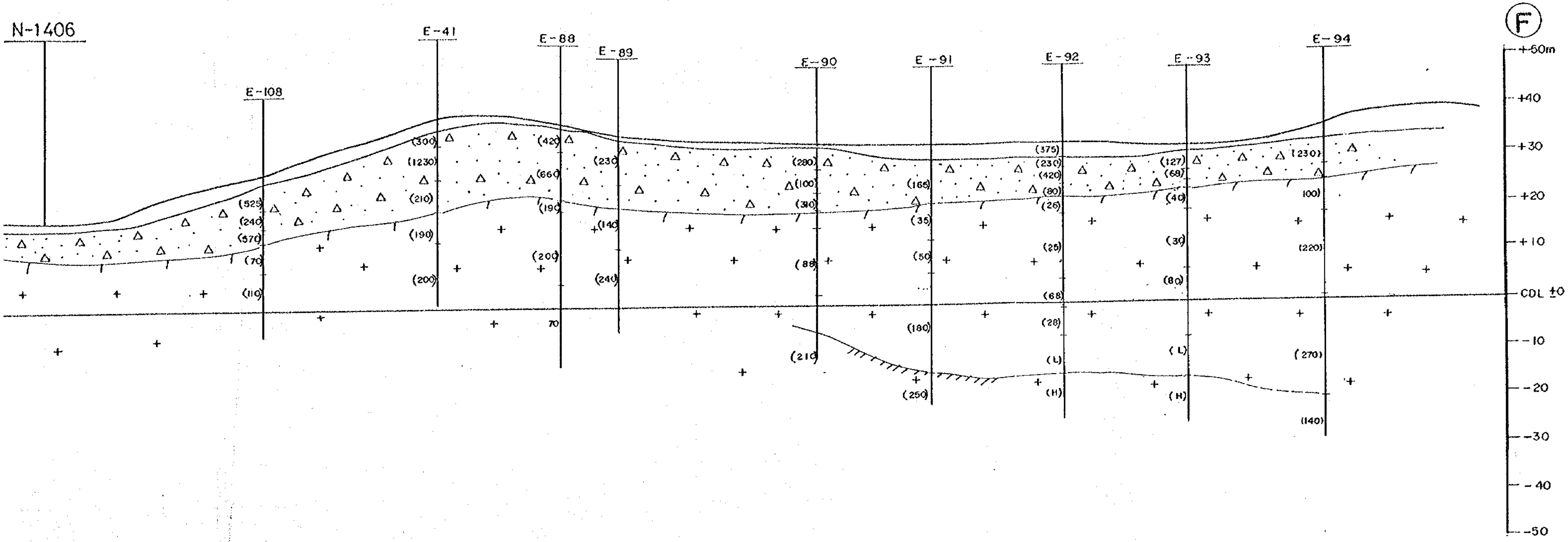
0 200 400 600 800 1000 2000m
Scale 1 : 16 000
C
+60m
+50
+40
+30
+20
+10
CDL ±0
-10
-20
-30
-40
-50
1/16000
1/800
A-8
Bor
E-1
E-27
E-28
E-29
E-65
E-30
E-32
E-50
E-31
Line-8
(700)
Line-4
(230)

Scale 1 : 16 000

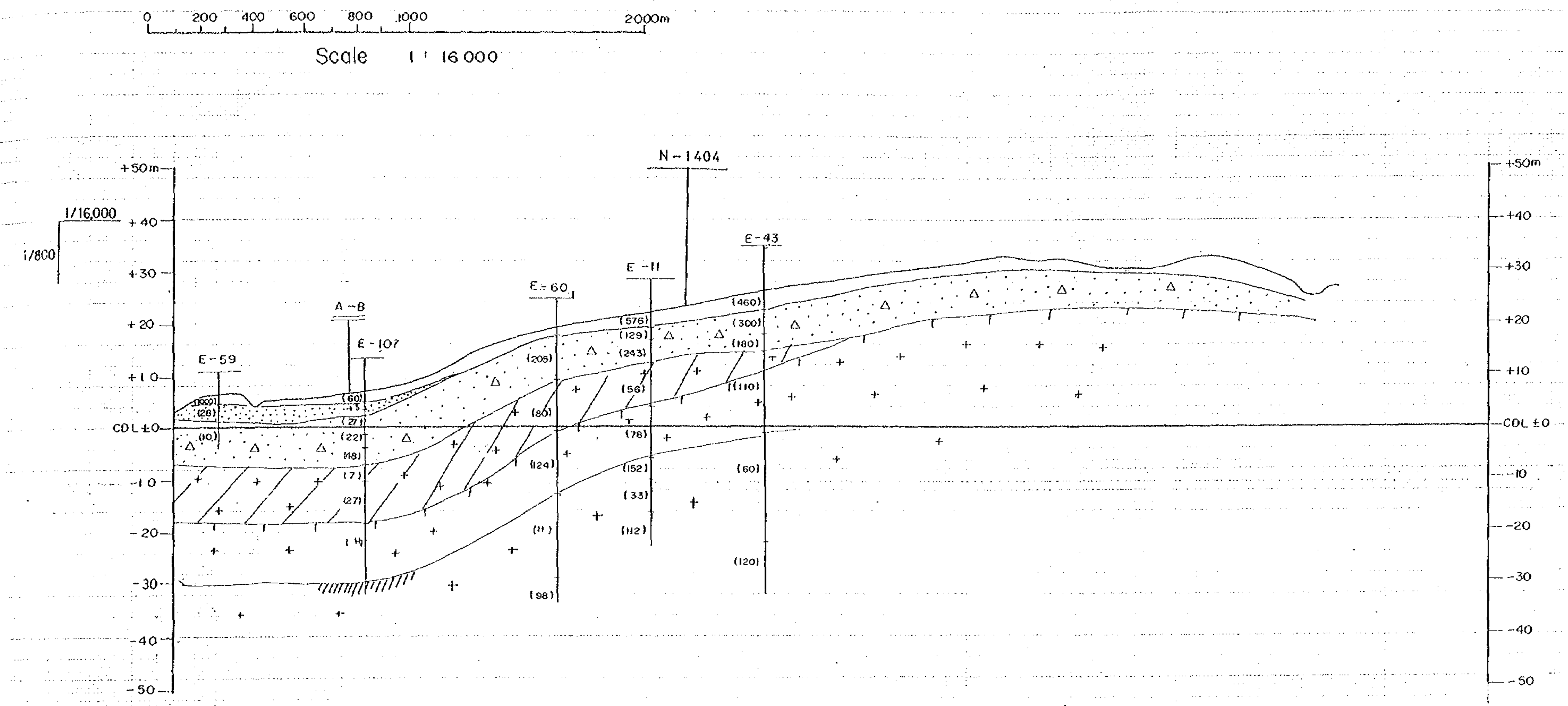


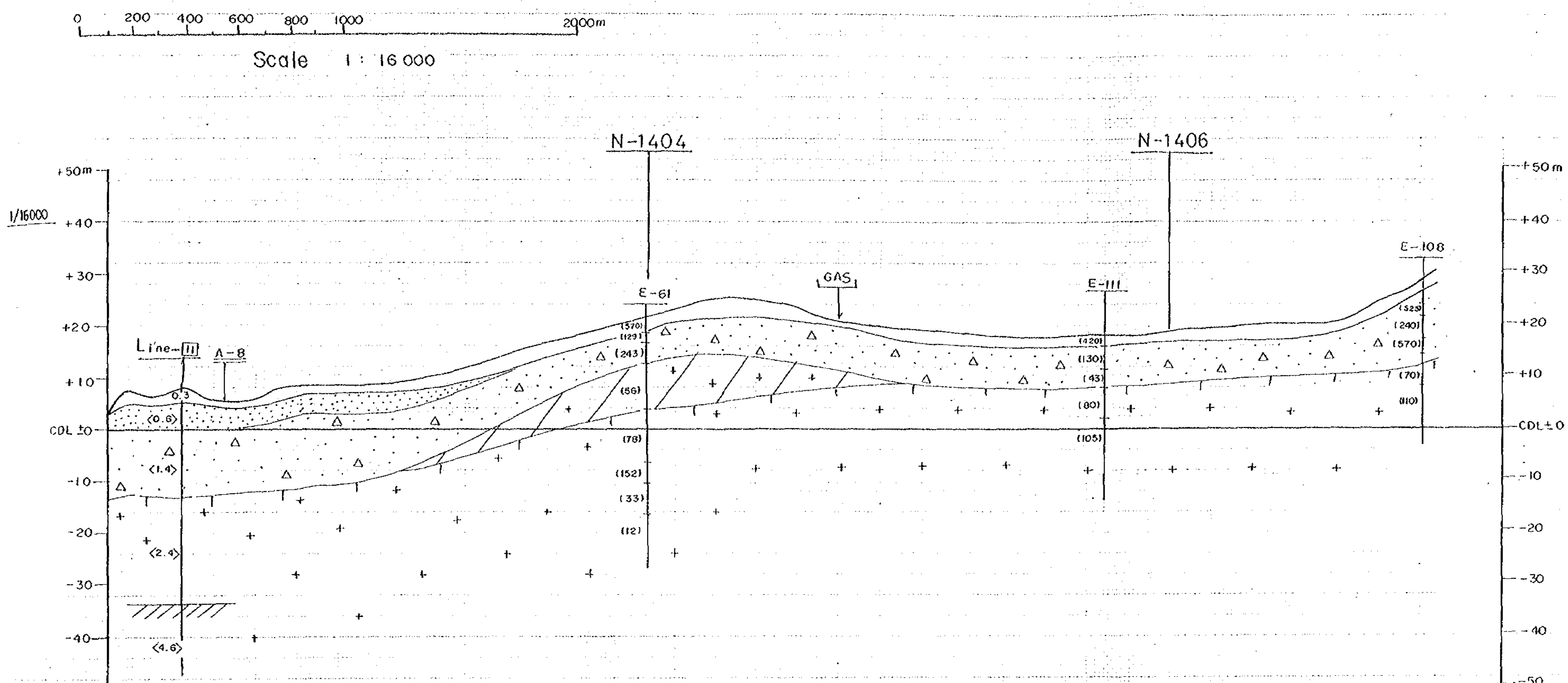


0 200 400 600 800 1000 2000m
Scale 1 : 16 000
E
1/16,000
1/800
+50m
+40
+30
+20
+10
CDL±0
-10
-20
-30
-40
-50
N-1404
N-1406
E-58
A-8
E-45
E-44
E-60
E-43
Line-10
E-42
E-111
E-108
E-41

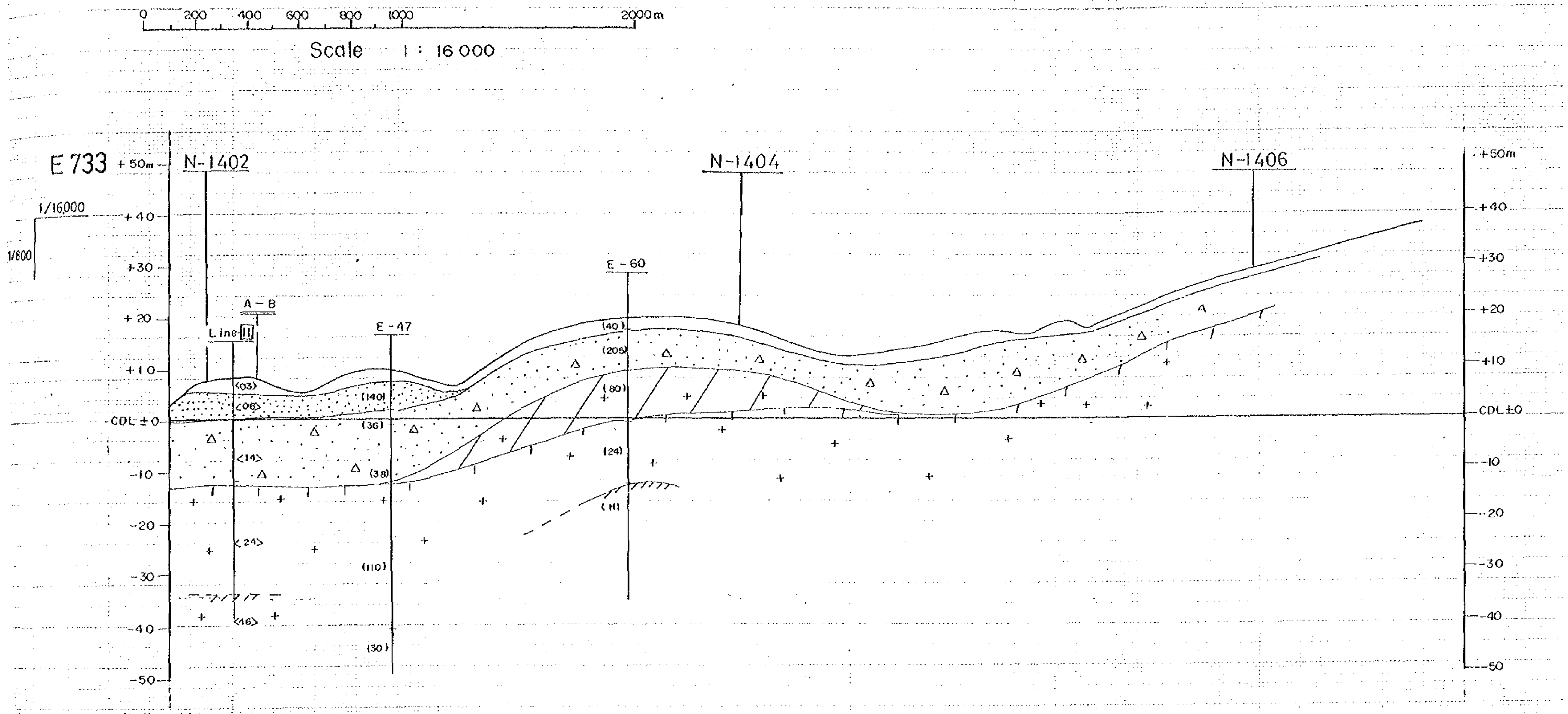


N-1406
E-108
E-41
E-88
E-89
E-90
E-91
E-92
E-93
E-94
F
+50m
+40
+30
+20
+10
CDL ±0
-10
-20
-30
-40
-50

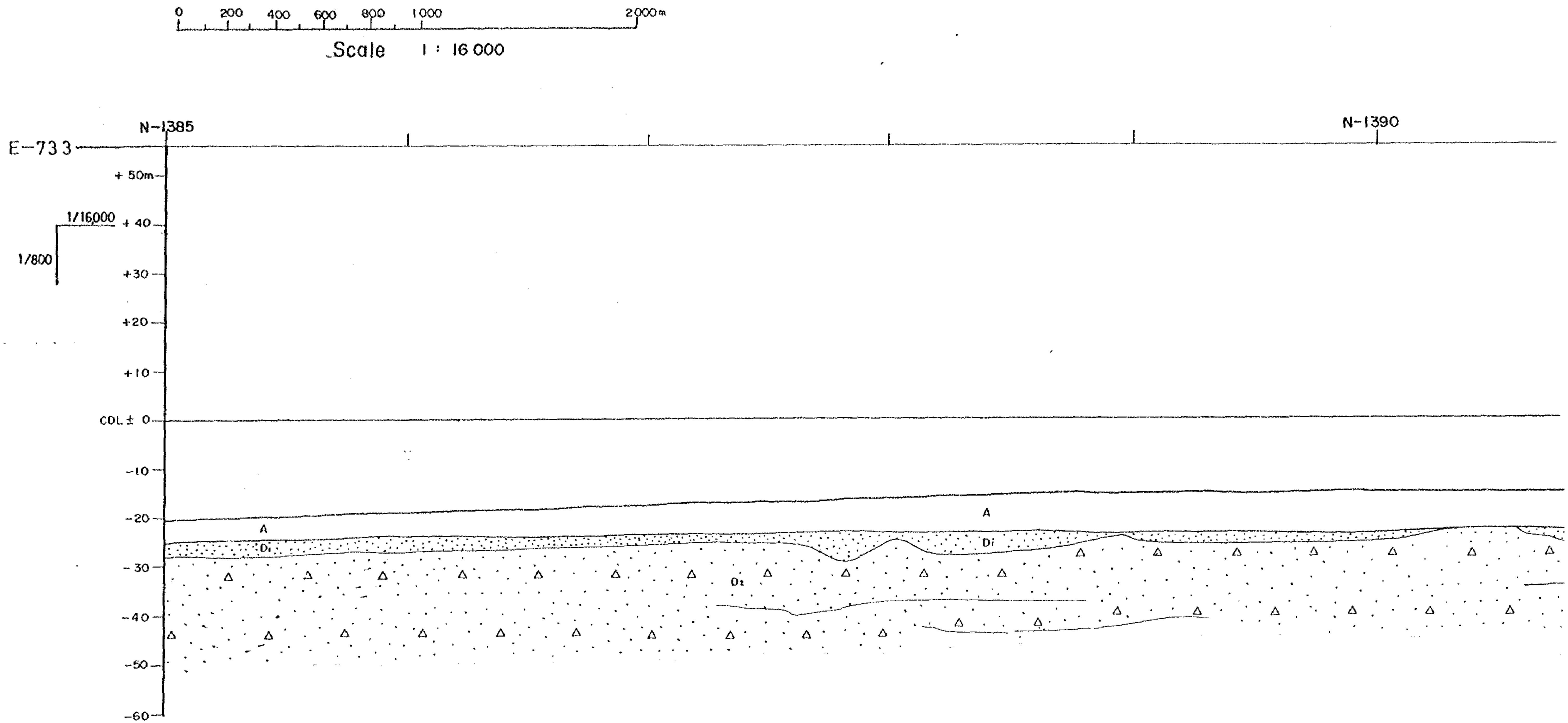

0 200 400 600 800 1000 2000m
Scale 1 : 16 000
1/16,000
1/800
+50m
+40
+30
+20
+10
CDL ±0
-10
-20
-30
-40
-50
E-59
A-B
E-107
E-60
E-11
N-1404
E-43
(1000)
(28)
(10)
(60)
(21)
(22)
(48)
(7)
(27)
(206)
(80)
(124)
(11)
(98)
(576)
(129)
(243)
(56)
(78)
(152)
(33)
(112)
(460)
(300)
(180)
(110)
(60)
(120)



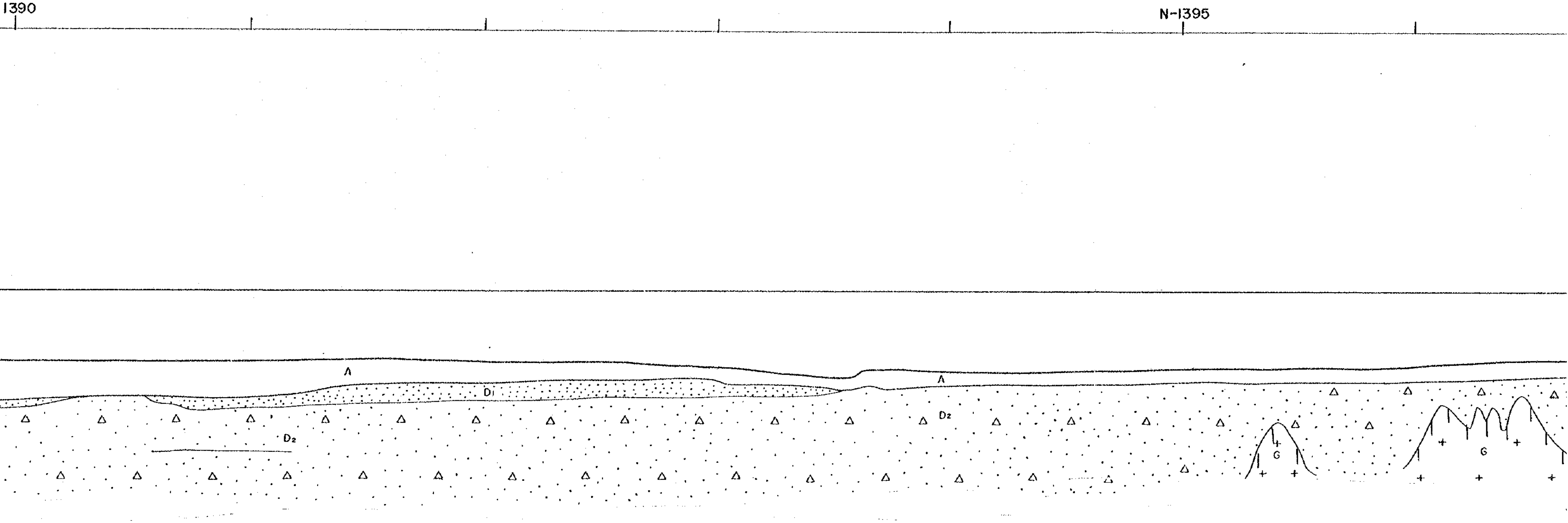
0 200 400 600 800 1000 2000m
Scale 1 : 16 000
N-1404
N-1406
1/16000
+50m
+40
+30
+20
+10
CDL ±0
-10
-20
-30
-40
-50
E-61
GAS
E-111
E-108
Line-III
A-8
CDL±0



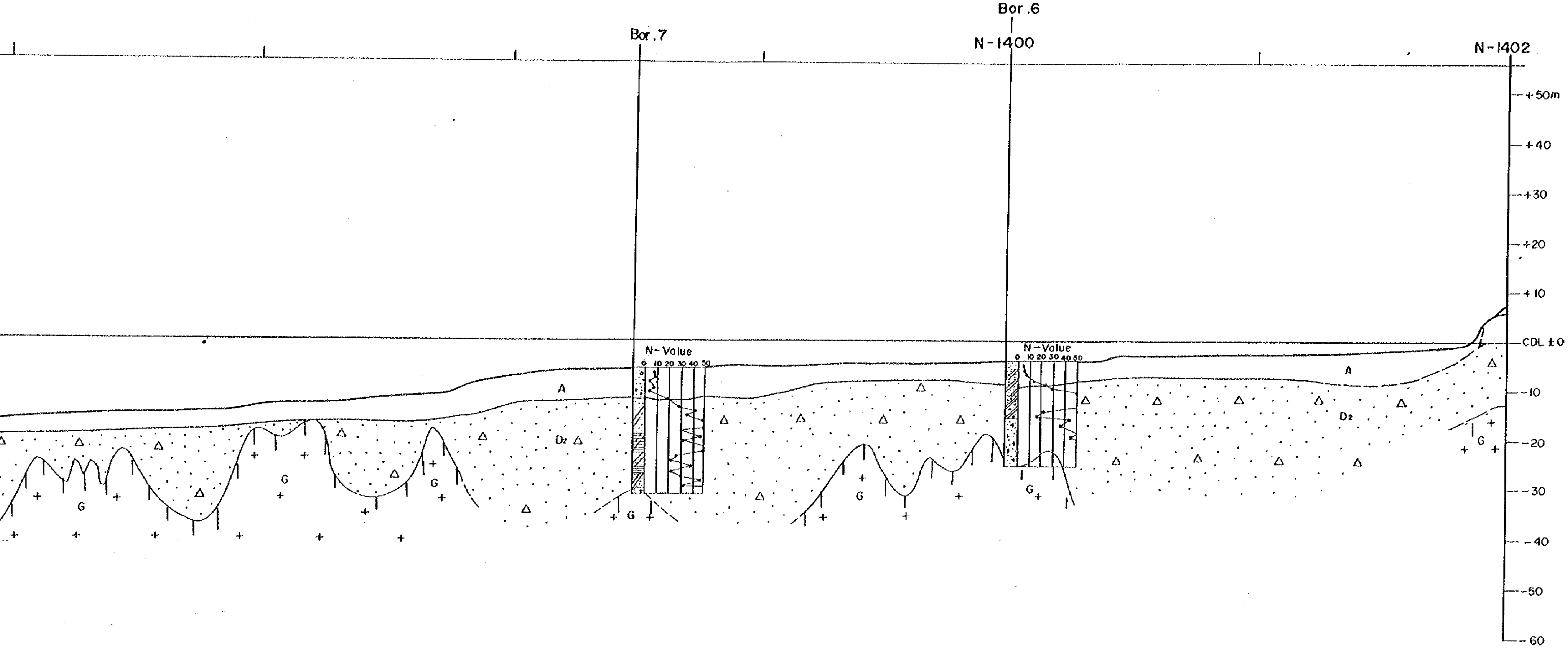
0 200 400 600 800 1000 2000m
Scale 1 : 16 000
E 733
1/16,000
1/800
+50m
+40
+30
+20
+10
CDL±0
-10
-20
-30
-40
-50
N-1402
A - B
Line III
E - 47
E - 60
N-1404
N-1406
(03)
(06)
(140)
(36)
(14)
(38)
(24)
(46)
(110)
(30)
(40)
(205)
(80)
(24)
(H)

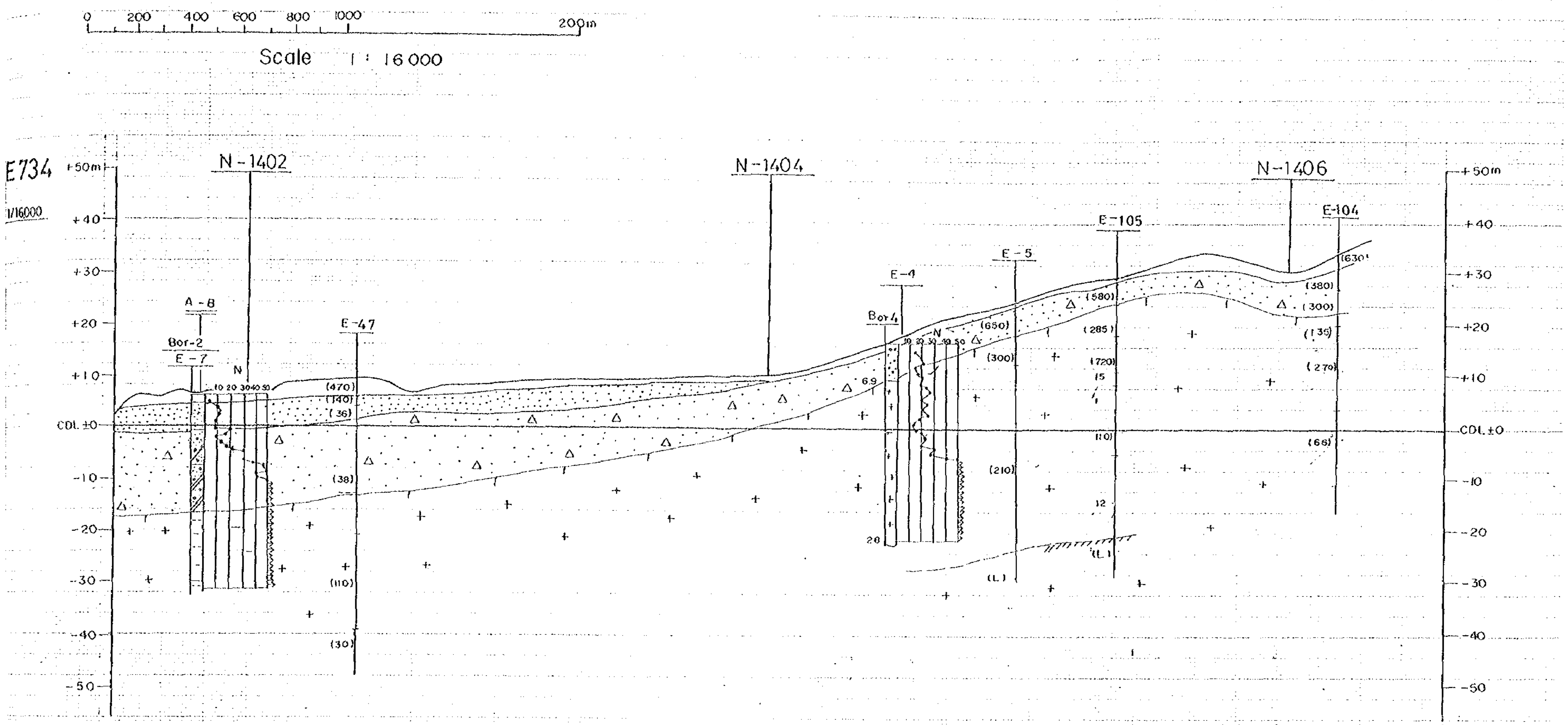


0
200
400
600
800
1000
2000m
Scale 1 : 16 000
N-1385
N-1390
E-733
+ 50m
1/16000
1/800
+ 40
+30
+20
+10
CDL ± 0
-10
-20
-30
-40
-50
-60
A
Di
Dt

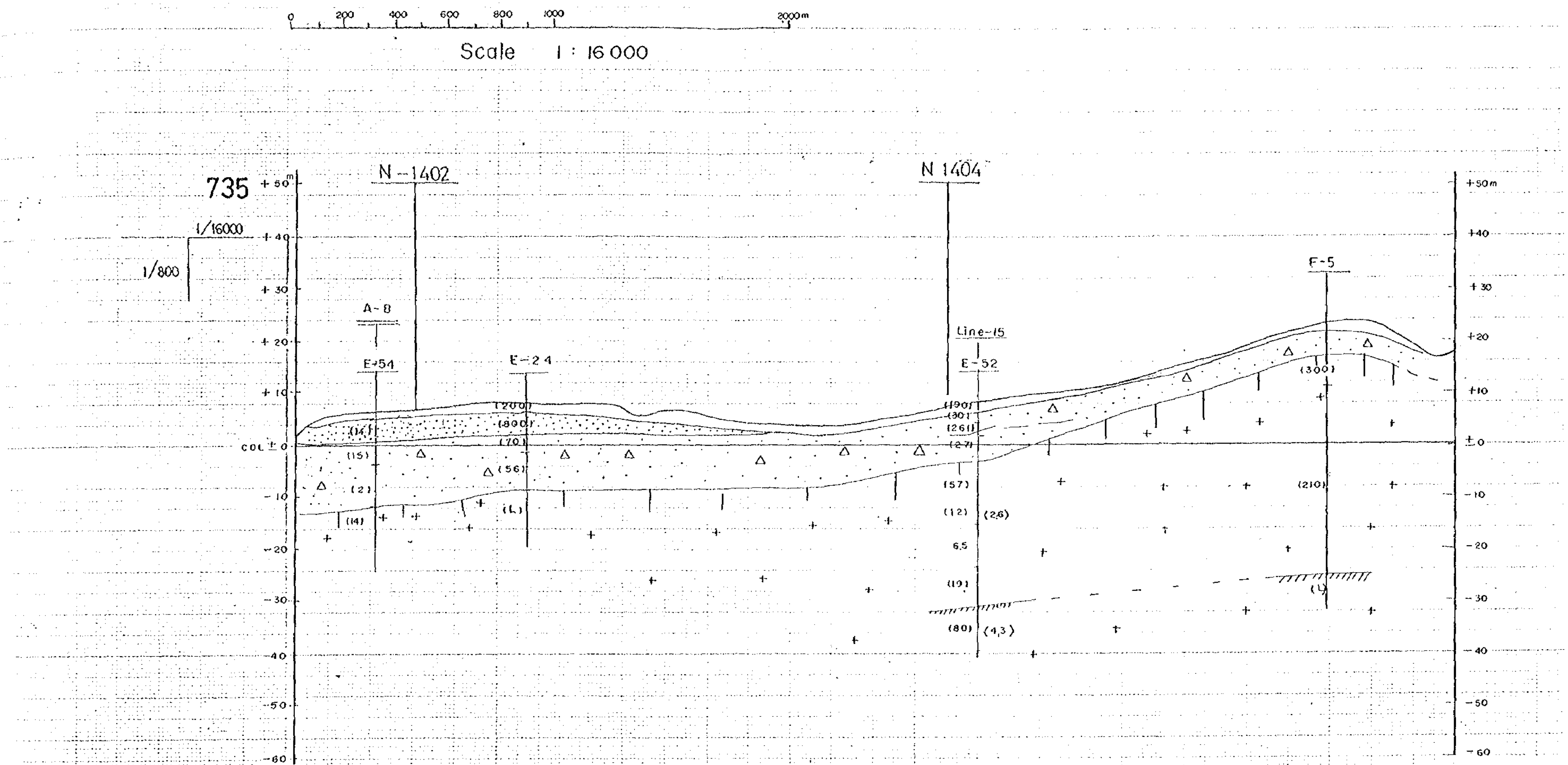


1390
N-1395
A
A
D1
D2
D2
G
G

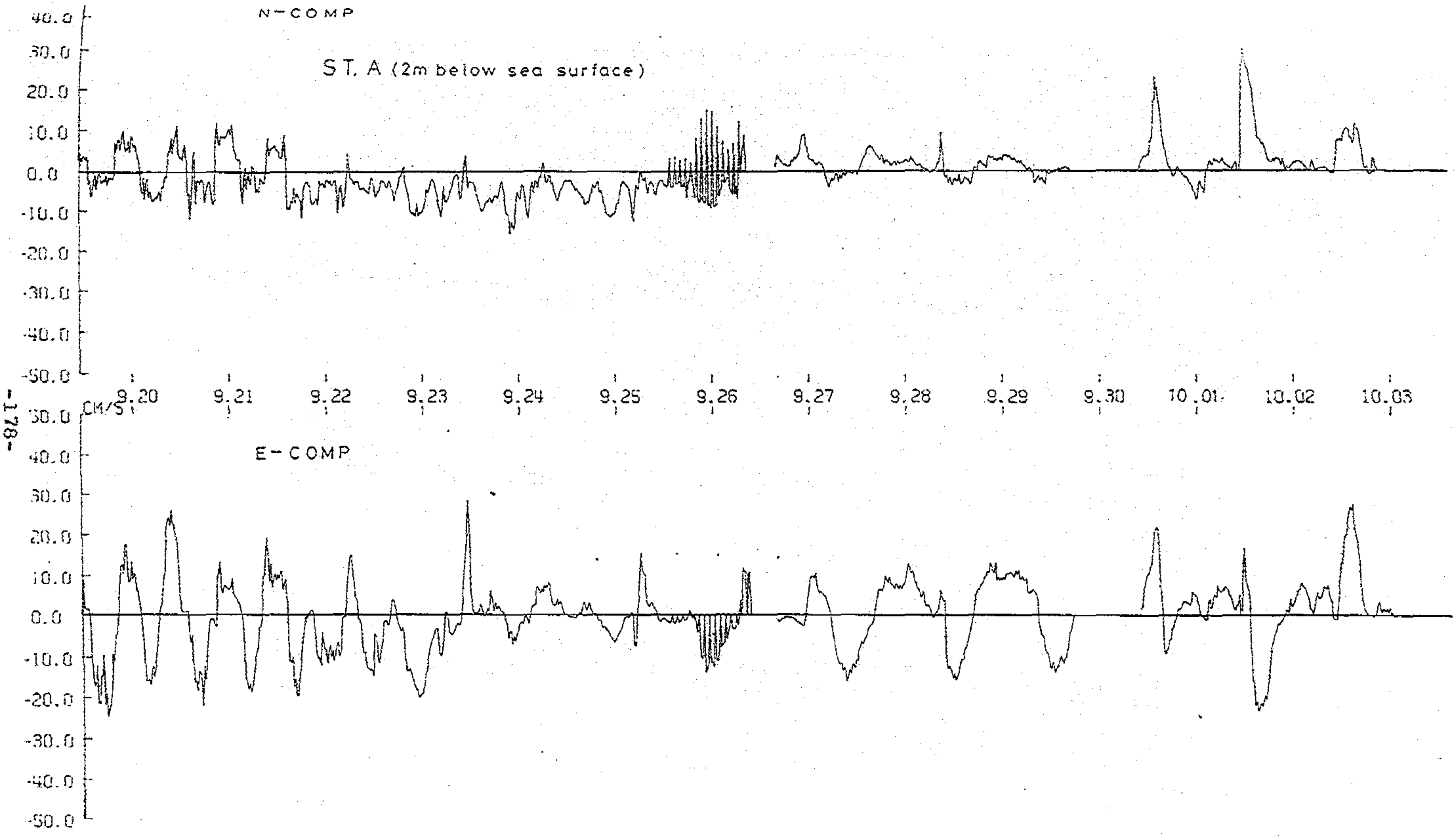

Bor.7
Bor.6
N-1400
N-1402
N-Value
0 10 20 30 40 50
A
D2
G
+50m
+40
+30
+20
+10
CDL ±0
-10
-20
-30
-40
-50
-60



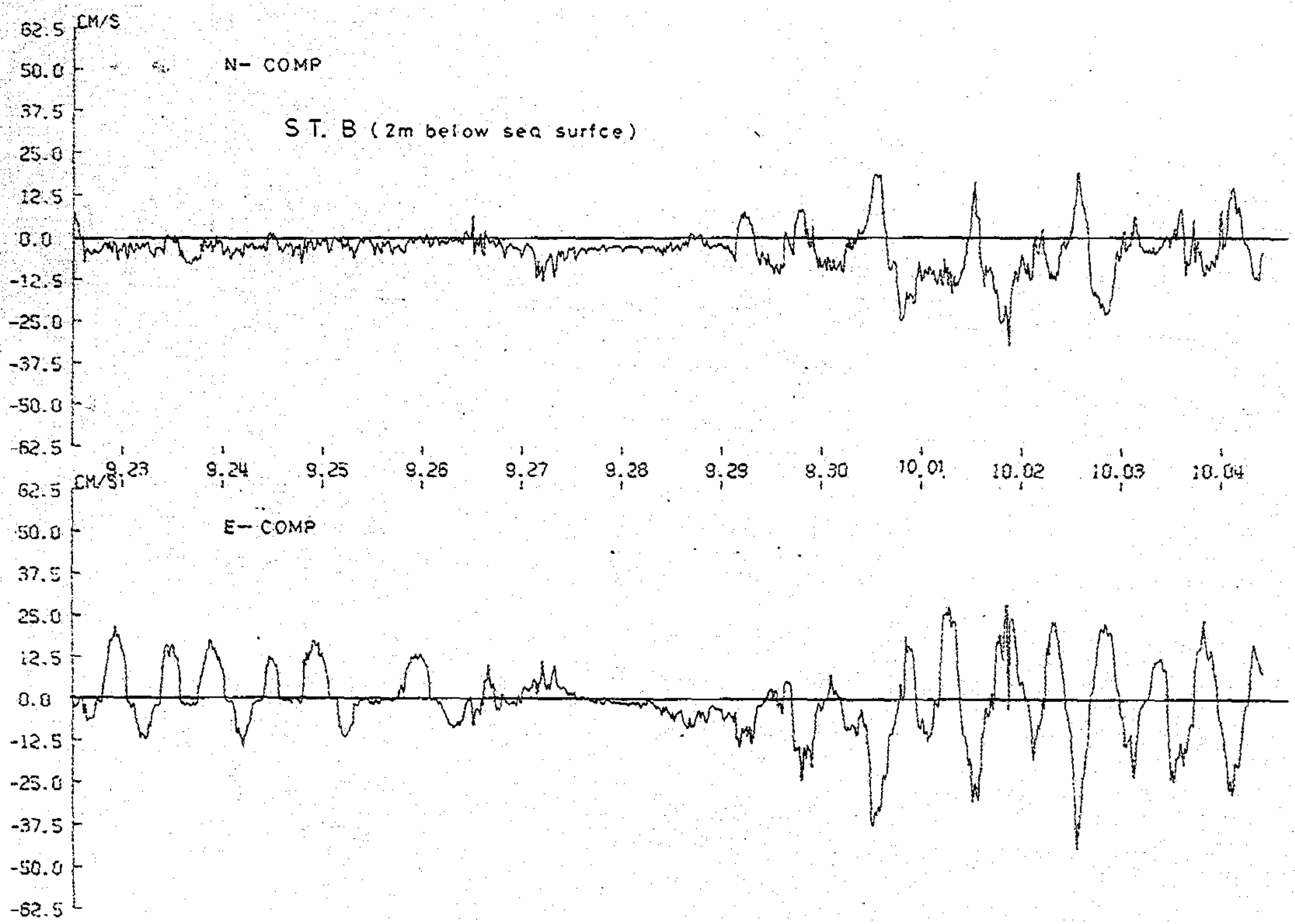
0 200 400 600 800 1000 200m
Scale 1 : 16000
E734
1/16000
N-1402
N-1404
N-1406
A-8
Bor-2
E-7
E-47
E-4
Bor 4
E-5
E-105
E-104
CDL ±0
+50m
+40
+30
+20
+10
-10
-20
-30
-40
-50
(470)
(140)
(36)
(38)
(110)
(30)
(650)
(300)
(210)
(580)
(285)
(720)
(630)
(380)
(300)
(135)
(270)
(66)
(L)


0 200 400 600 800 1000 2000m
Scale 1 : 16 000
735
1/16000
1/800
N-1402
N 1404
A-8
E-54
E-24
Line-15
E-52
E-5
+50m
+40
+30
+20
+10
±0
-10
-20
-30
-40
-50
-60
COL

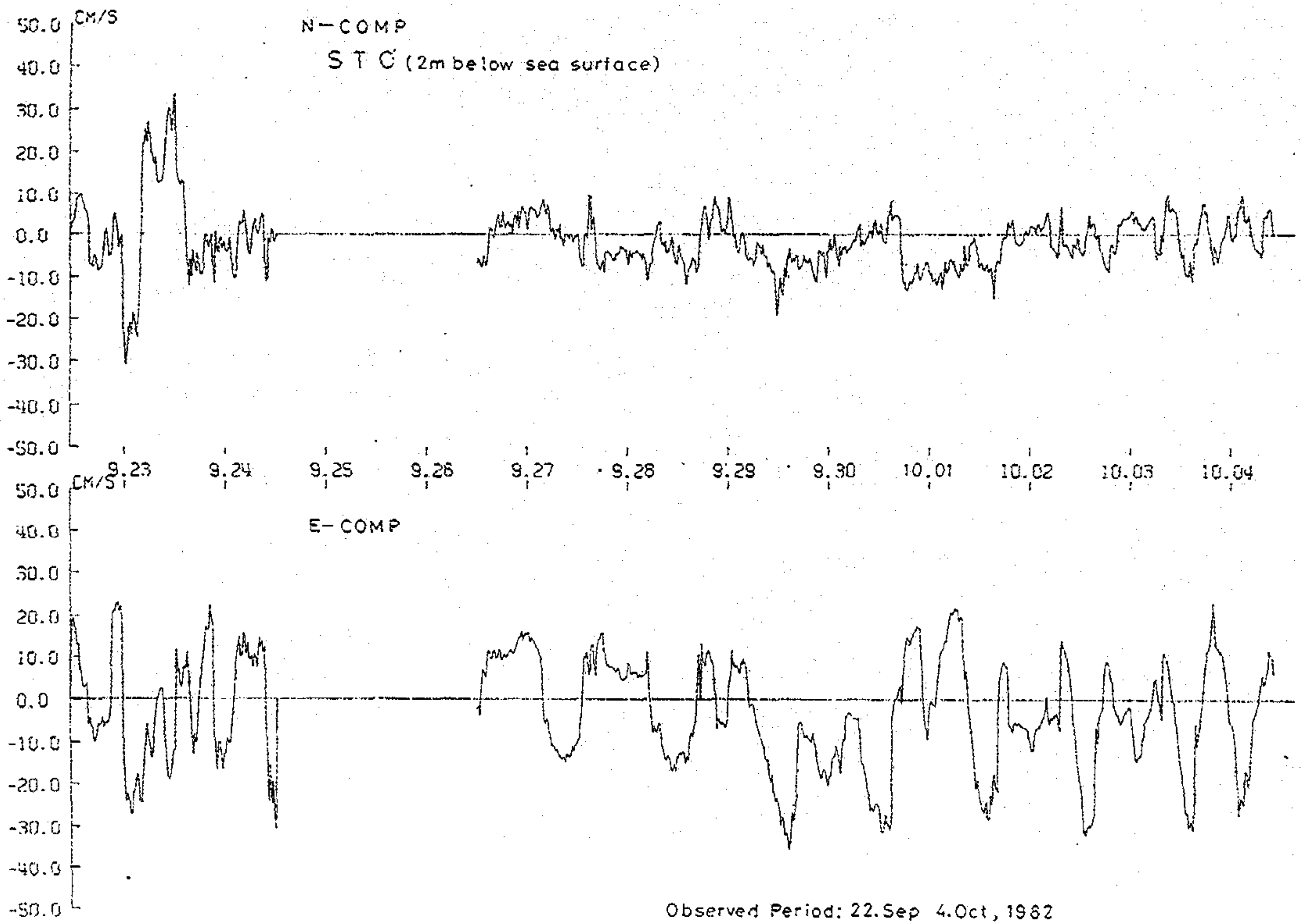
3. Tidal Current Curves

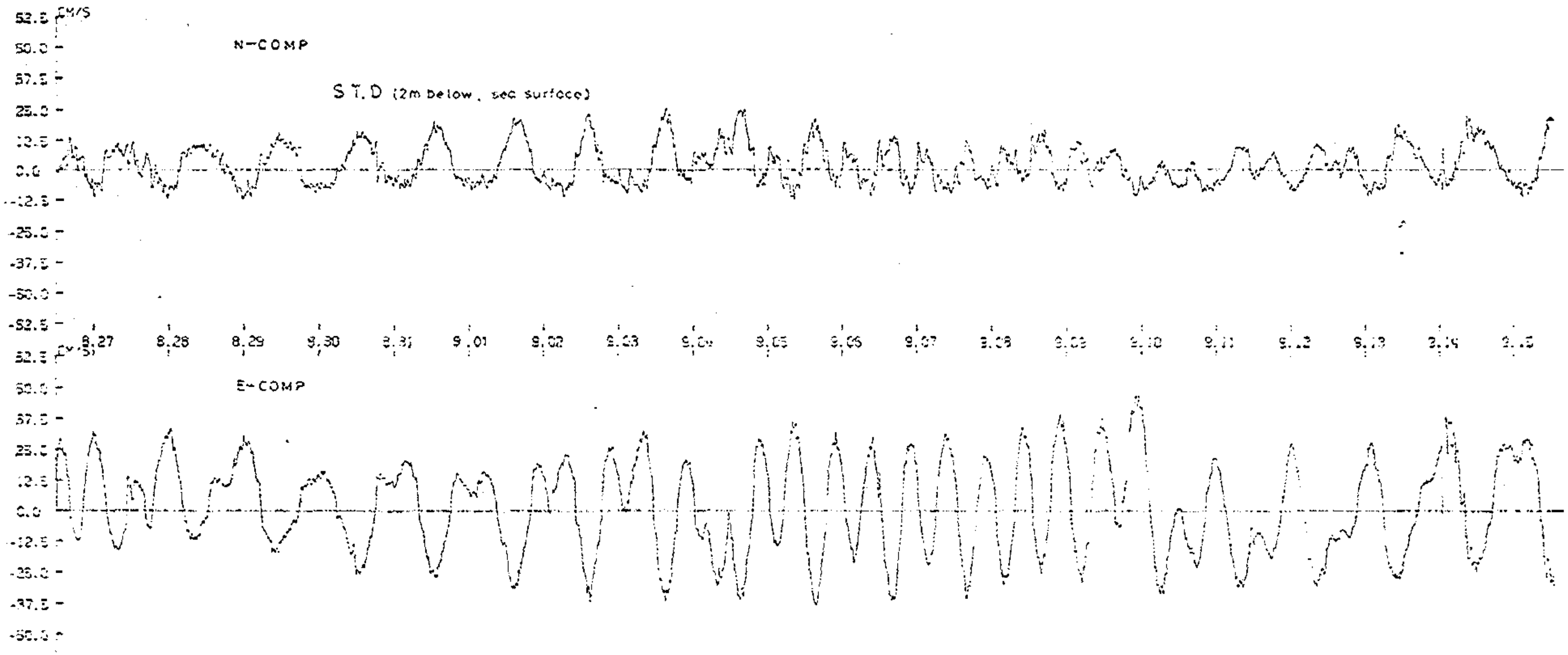


Observed Period: 19.Sep 3.Oct, 1982

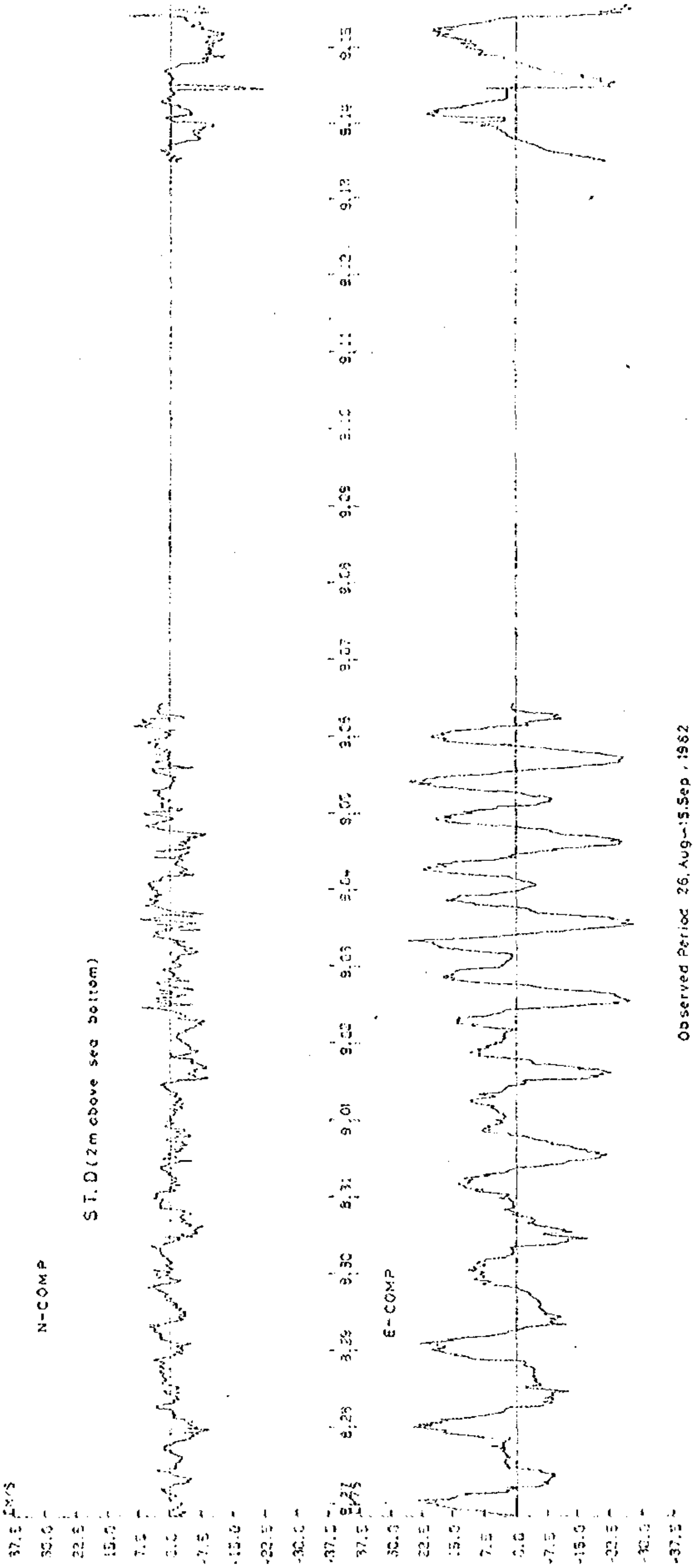


Observed Period: 22.Sep 4.Oct,1982

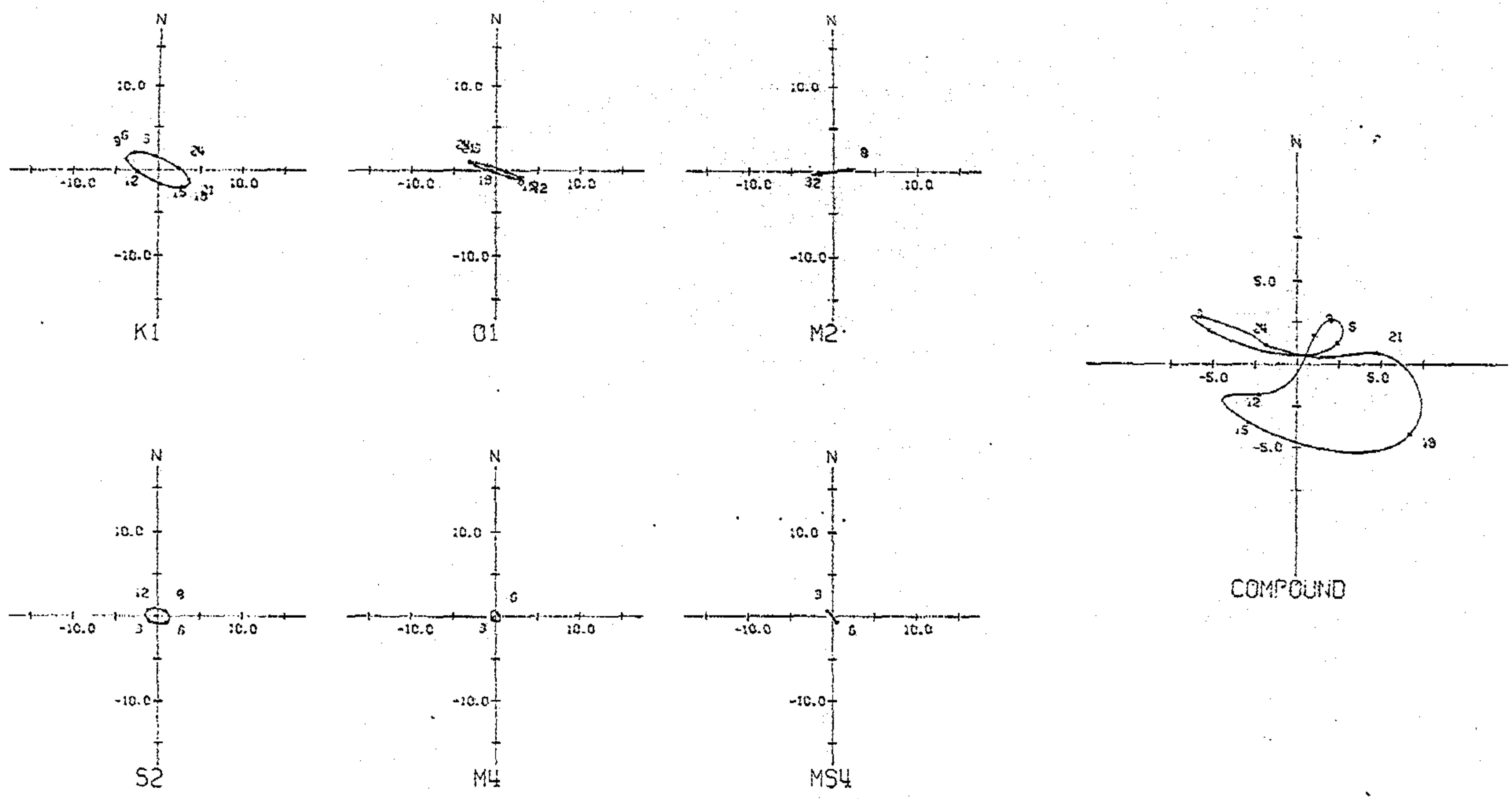

N—COMP
S T C (2m below sea surface)
CM/S
50.0
40.0
30.0
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-50.0
9.23
9.24
9.25
9.26
9.27
9.28
9.29
9.30
10.01
10.02
10.03
10.04
E- COMP
Observed Period: 22.Sep 4.Oct, 1982



Observed Period: 26.Aug~ 15.Sep, 1982

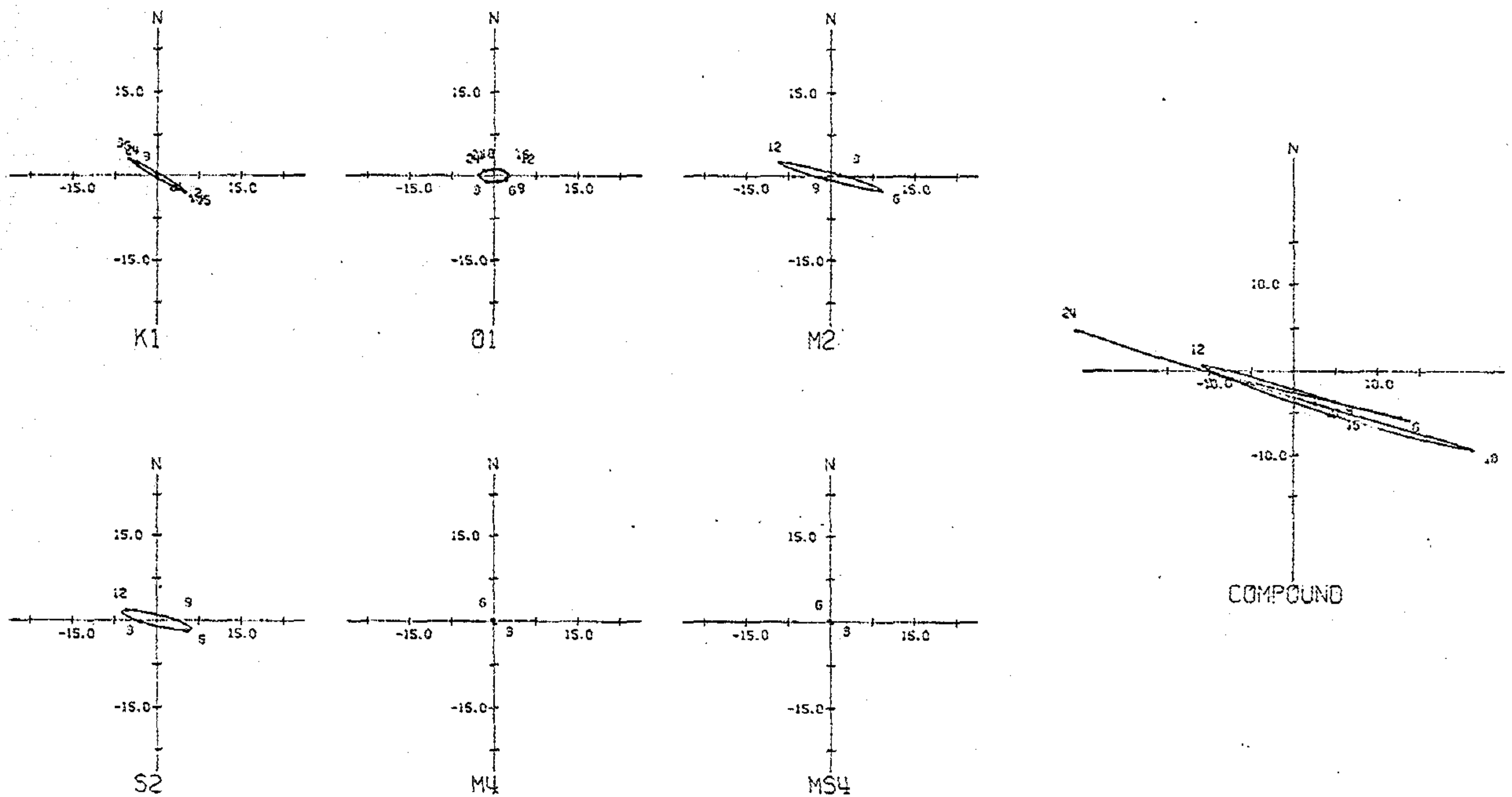

N-COMP
E-COMP
S.T.D (2m above sea bottom)
Observed Period 26.Aug-15.Sep, 1962
cm/s

4. Tidal Current Ellipses



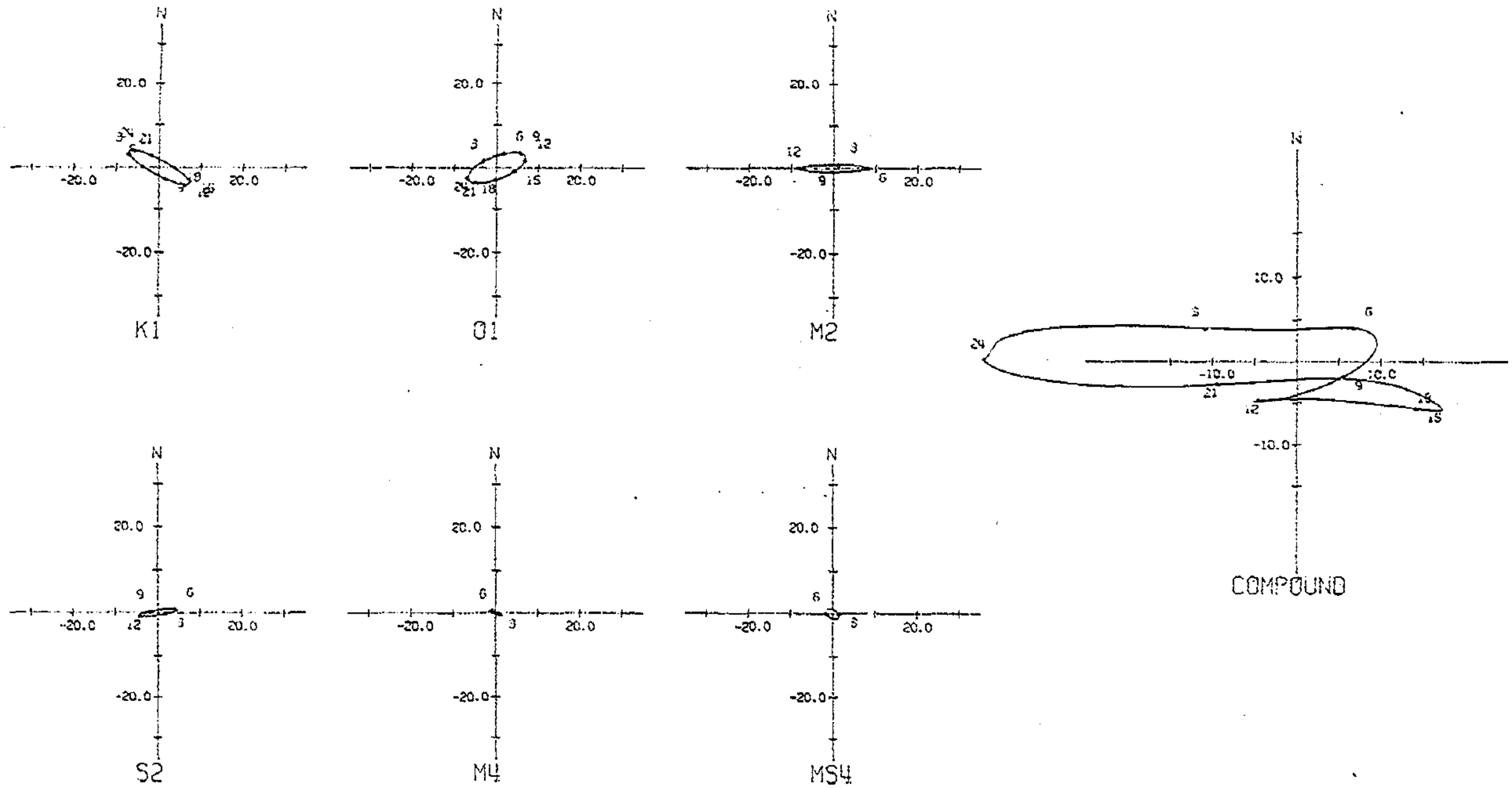
S T. A (2m below sea surface)

Observed Period: 19. Sep ~ 3. Oct , 1982



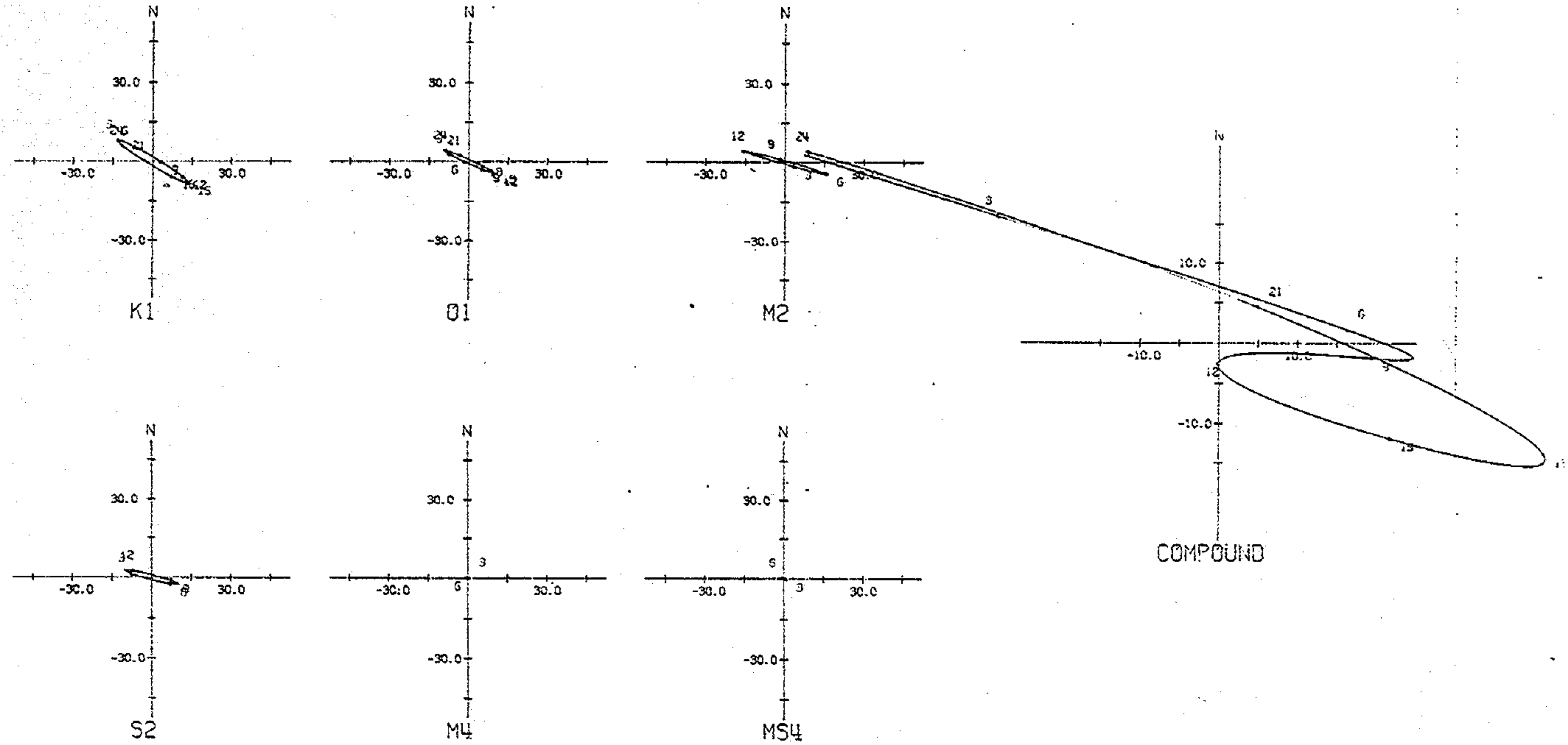
S T B (2m below sea surfce)

Observed Period: 22.Sep~4.Oct,1982



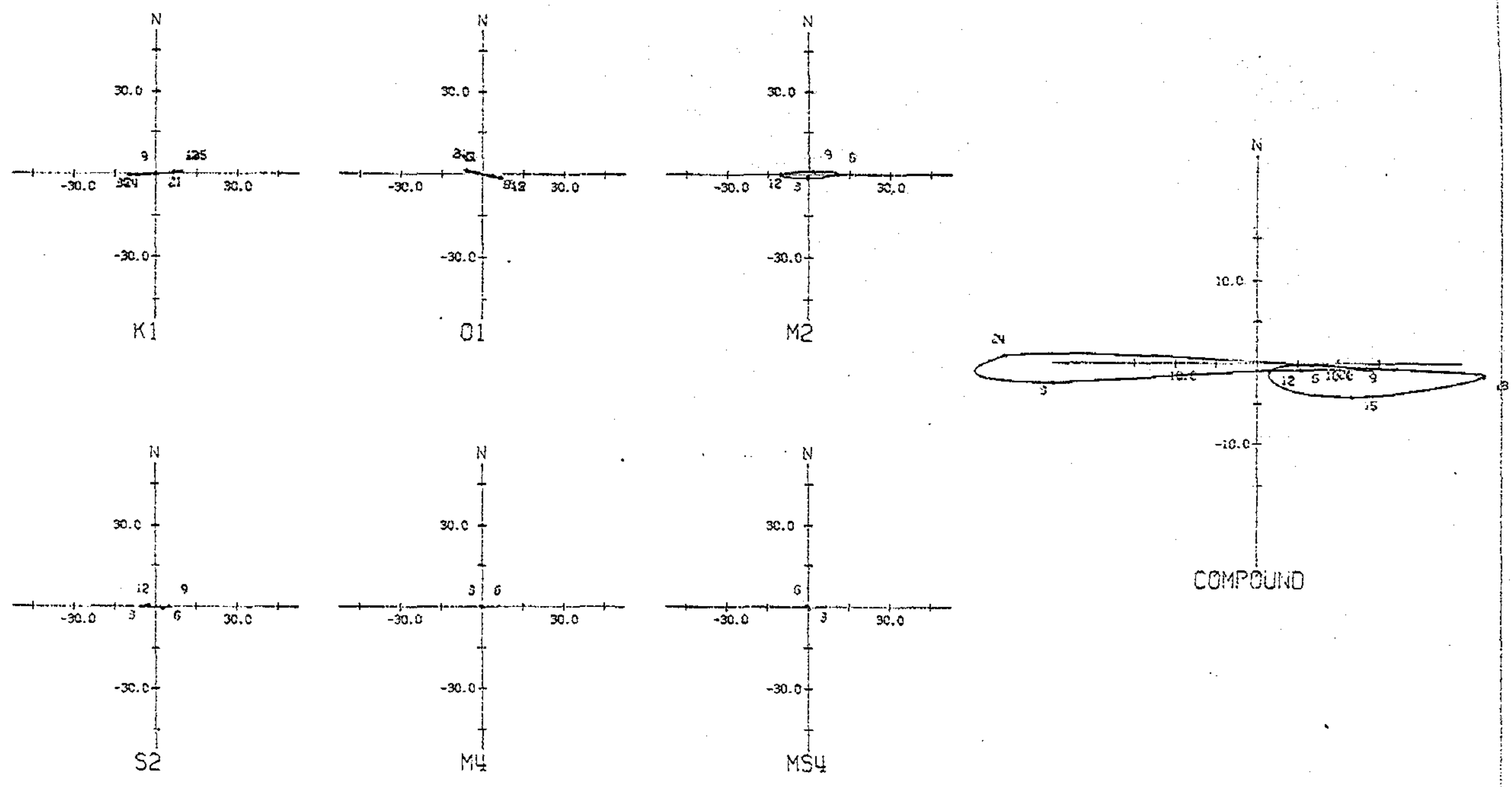
S T. C (2m below sea surface)

Observed Period 22.Sep~ 4.Oct, 1982



S T. D (2m below sea surface)

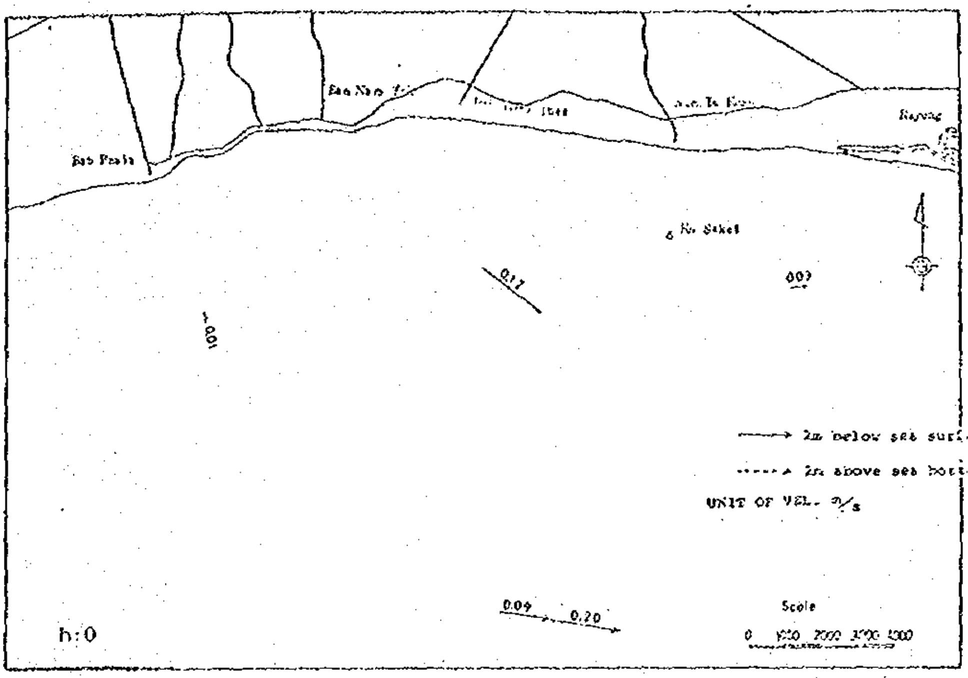
Observed Period: 26.Aug ~ 15.Sep,1982

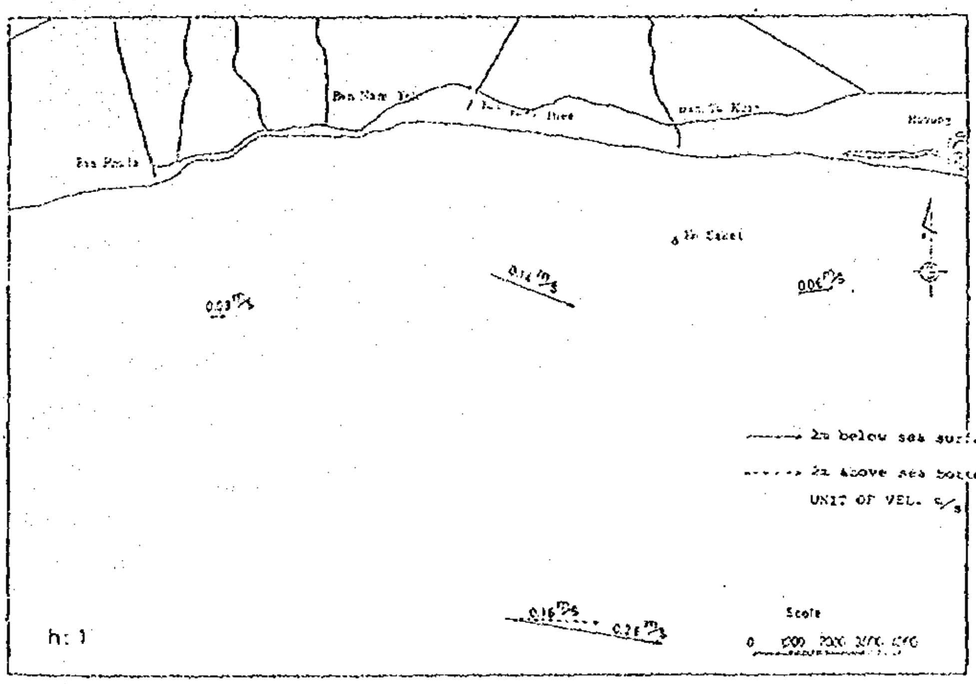


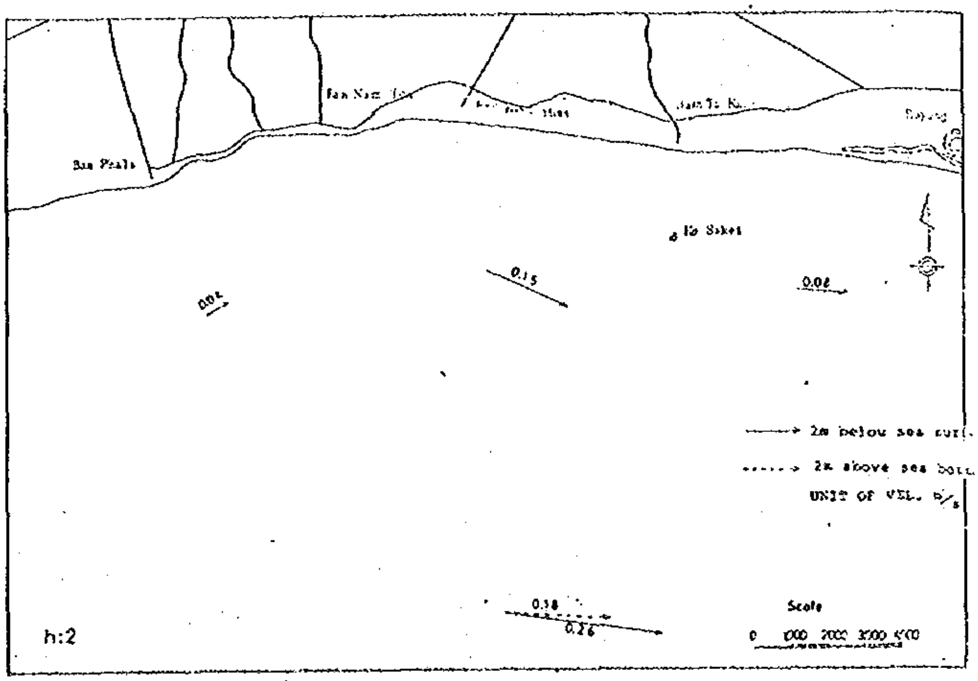
S T D (2m above sea bottom)

Observed Period : 26.Aug～15.Sep , 1982

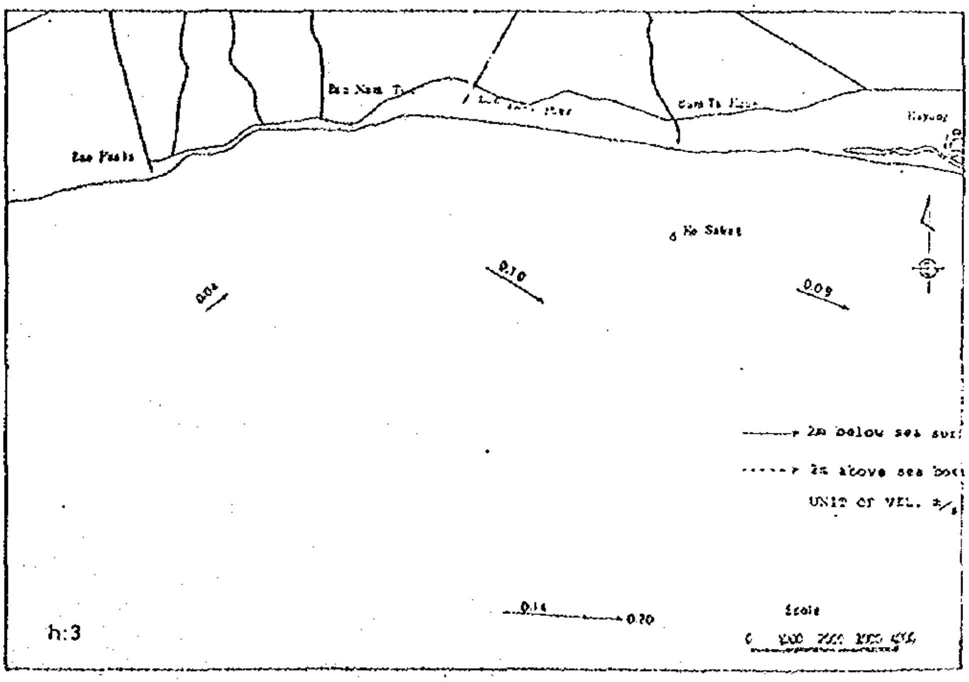
5. Tidal Chart


0.17
0.01
2m below sea surf
2m above sea bott
UNIT OF VEL. m/s
0.09
0.20
Scale
0 1000 2000 3000 4000
h:0

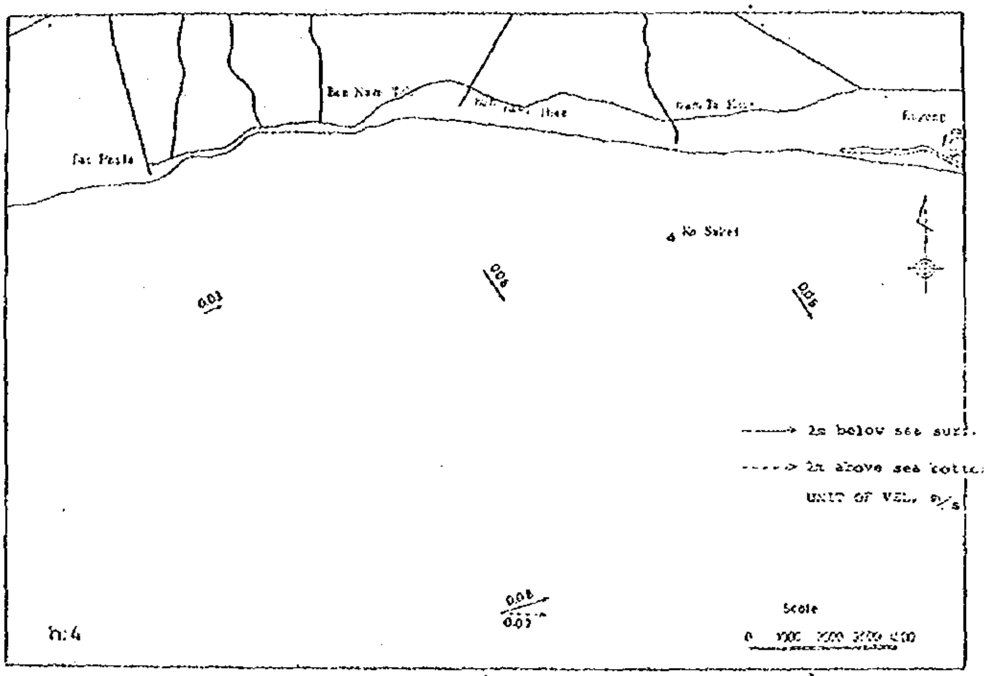

0.14 m/s
0.03 m/s
2m below sea surfa
2m above sea botto
UNIT OF VEL. m/s
Scale
0 1000 2000 3000 4000
h: 1

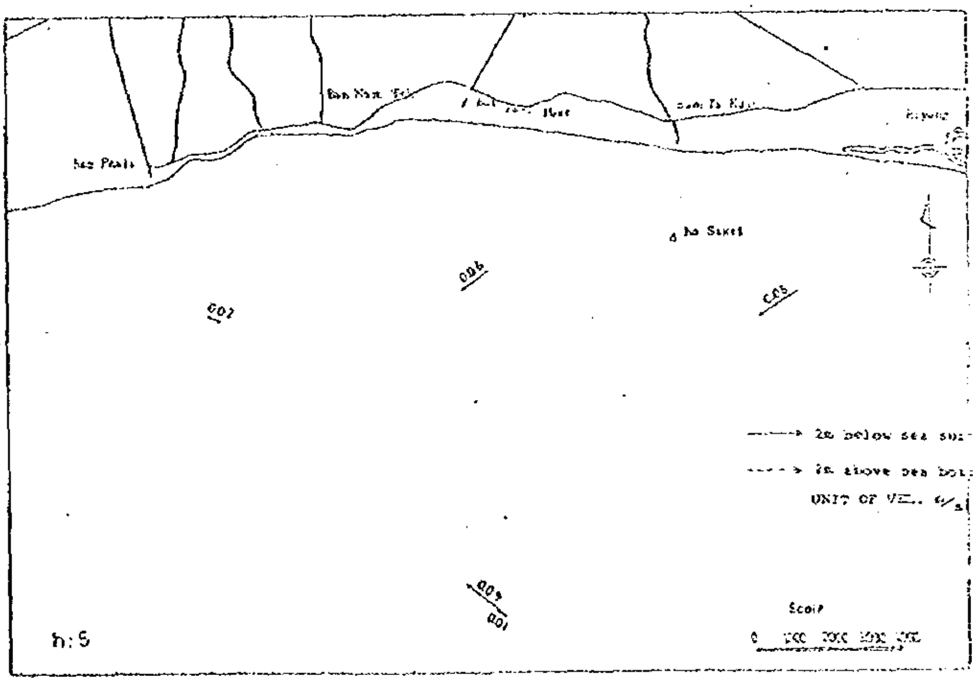


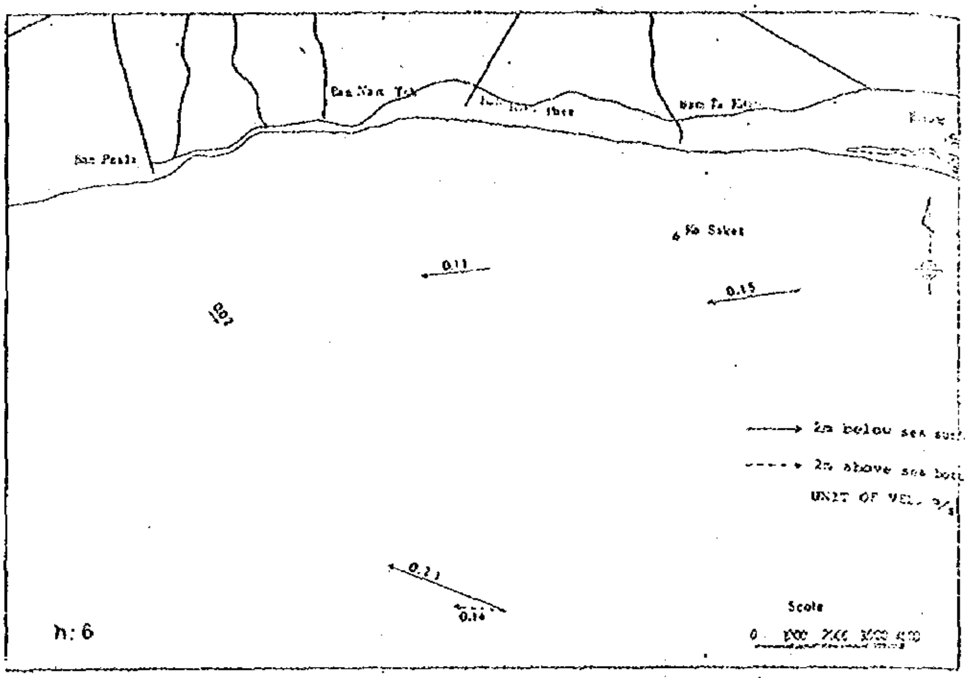
Ko Saket
0.15
0.08
2m below sea surf.
2m above sea bott.
UNIT OF VEL. m/s
0.18
0.26
Scale
0 1000 2000 3000 5000
h:2



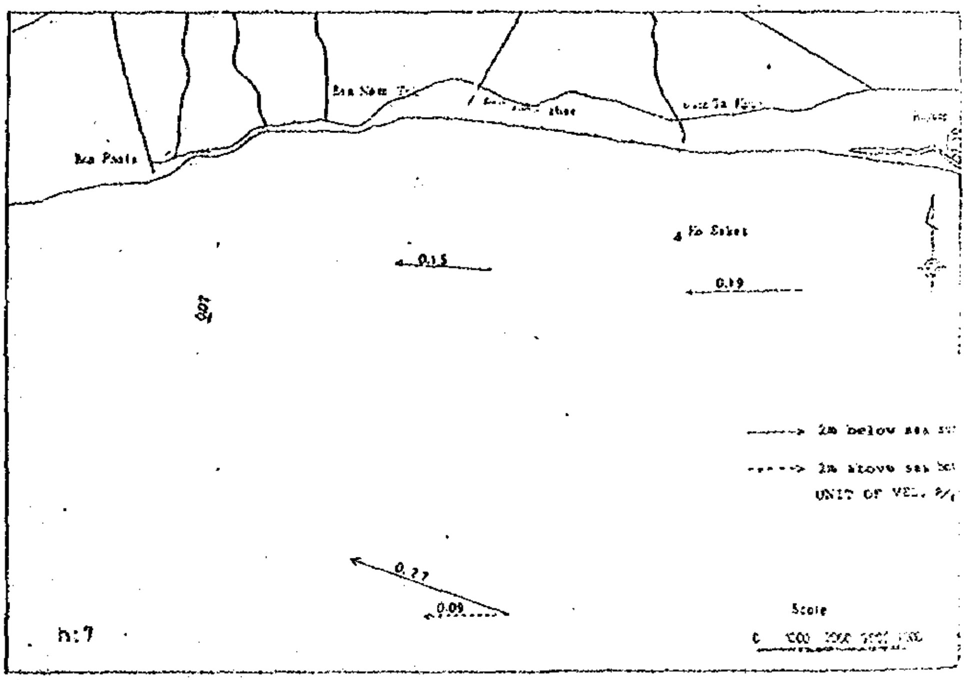
Ko Saket
0.10
0.09
2m below sea surf
2m above sea bott
UNIT OF VEL. m/s
0.14
0.20
Scale
h:3


h:4

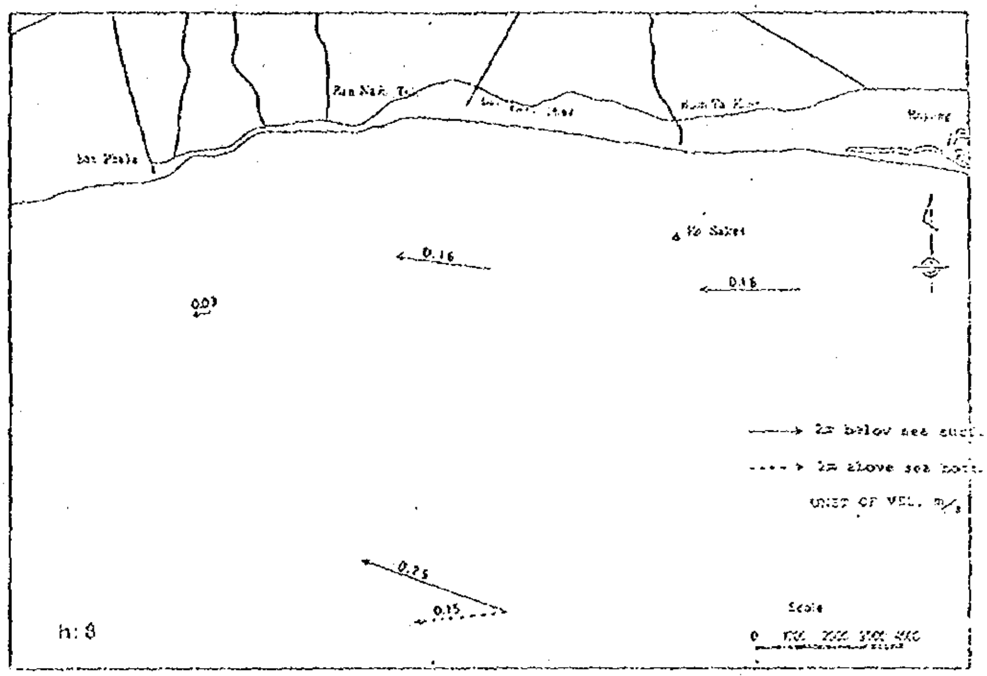

h:5

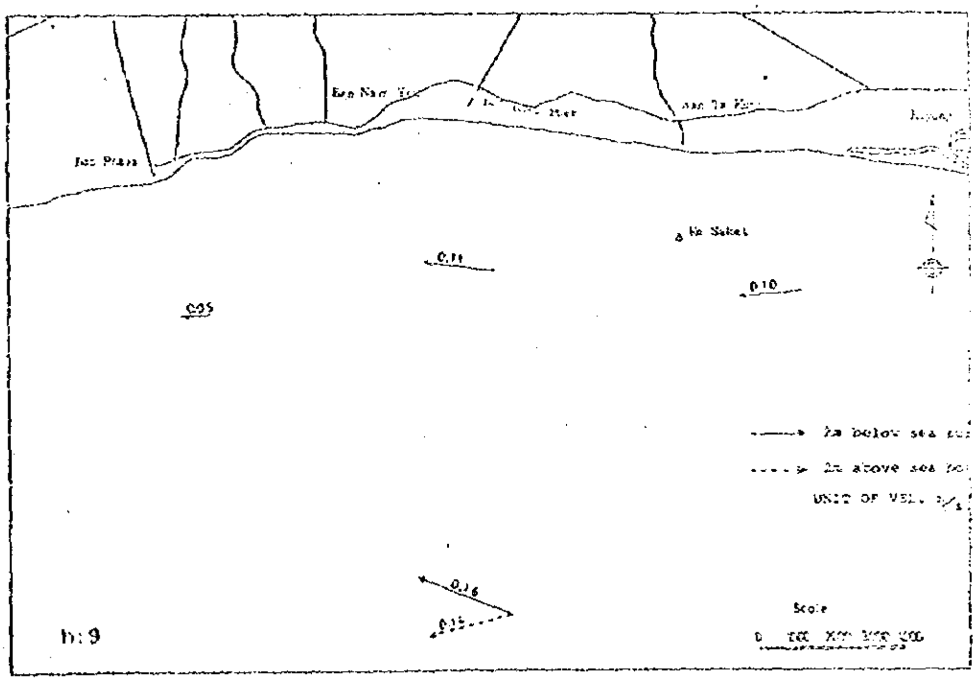


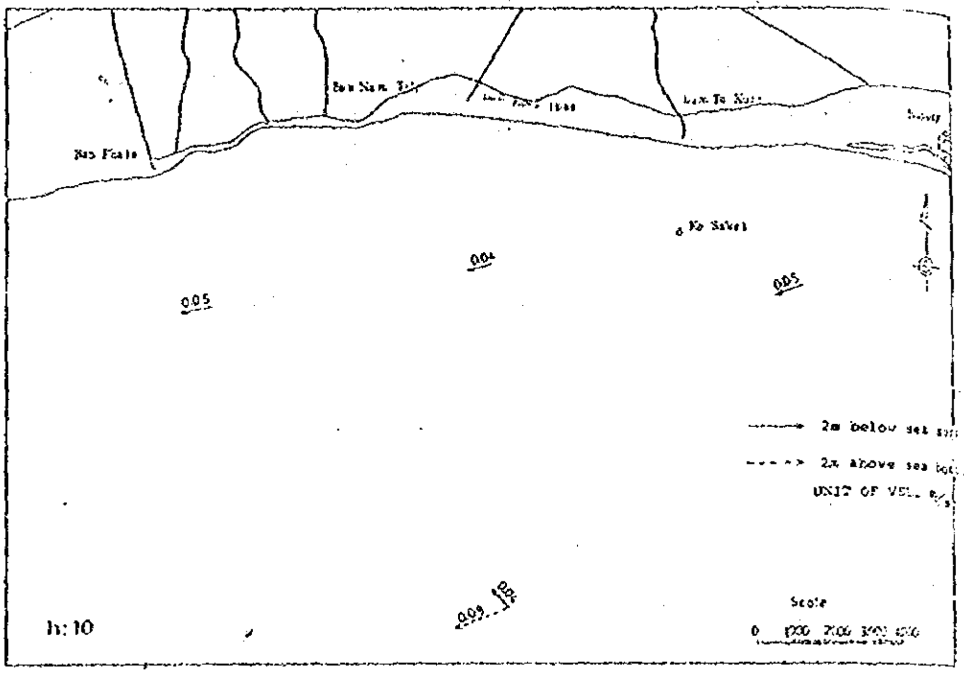
Ko Saket
0.11
0.15
0.21
0.14
2m below sea
2m above sea
UNIT OF VEL.
Scale
h: 6

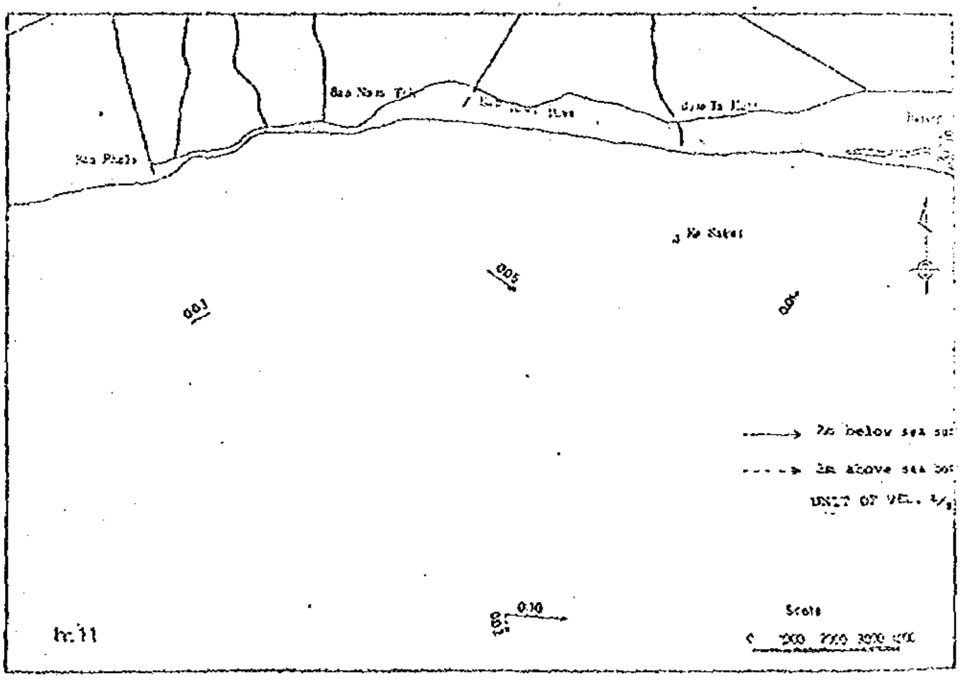


Ko Saket
0.15
0.19
0.27
0.09
2m below sea
2m above sea
UNIT OF VEL.
Scale
h:7


Ban Phala
Ko Saket
0.16
0.16
0.03
0.25
0.15
UNIT OF VEL. m/s
Scale
h: 8


Ko Saket
0.11
0.10
0.05
0.16
0.15
UNIT OF VEL. m/s
Scale
h: 9

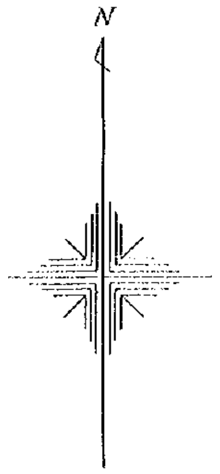

0.04
0.05
0.05
2m below sea
UNIT OF VEL.
Scale
h: 10


0.05
0.03
0.10
below sea
above sea
UNIT OF VEL.
Scale
h: 11

ATTACHED MAPS

1. Topographical Map (Scale 1:30,000)
2. Isopach Map of A-Member (Scale 1:50,000)
3. Isobathic Map of D-Group (Scale 1:50,000)
4. Isobathic Map of G-Group (Scale 1:50,000)

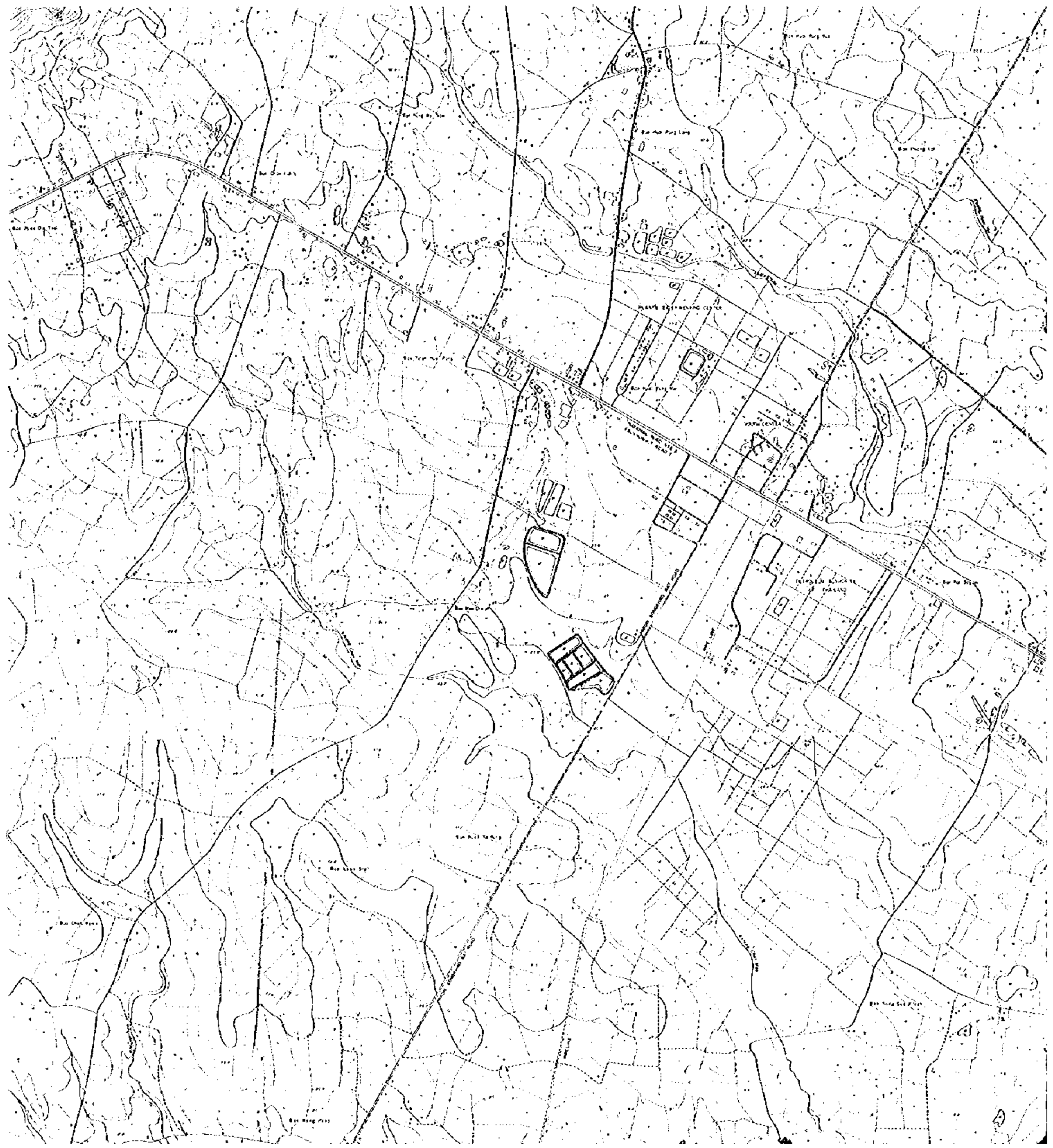
E 720 E 720 E 730 E 735

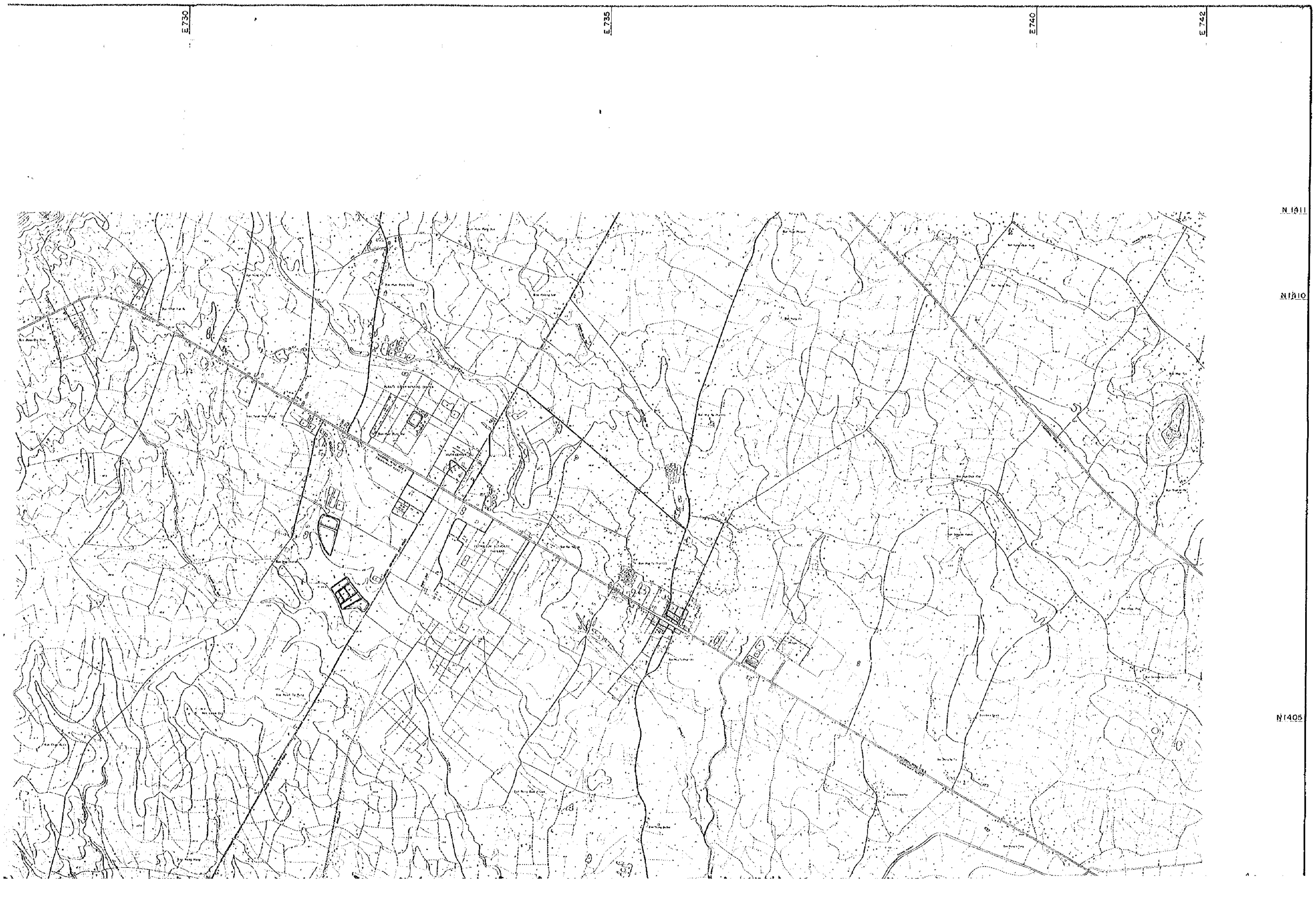


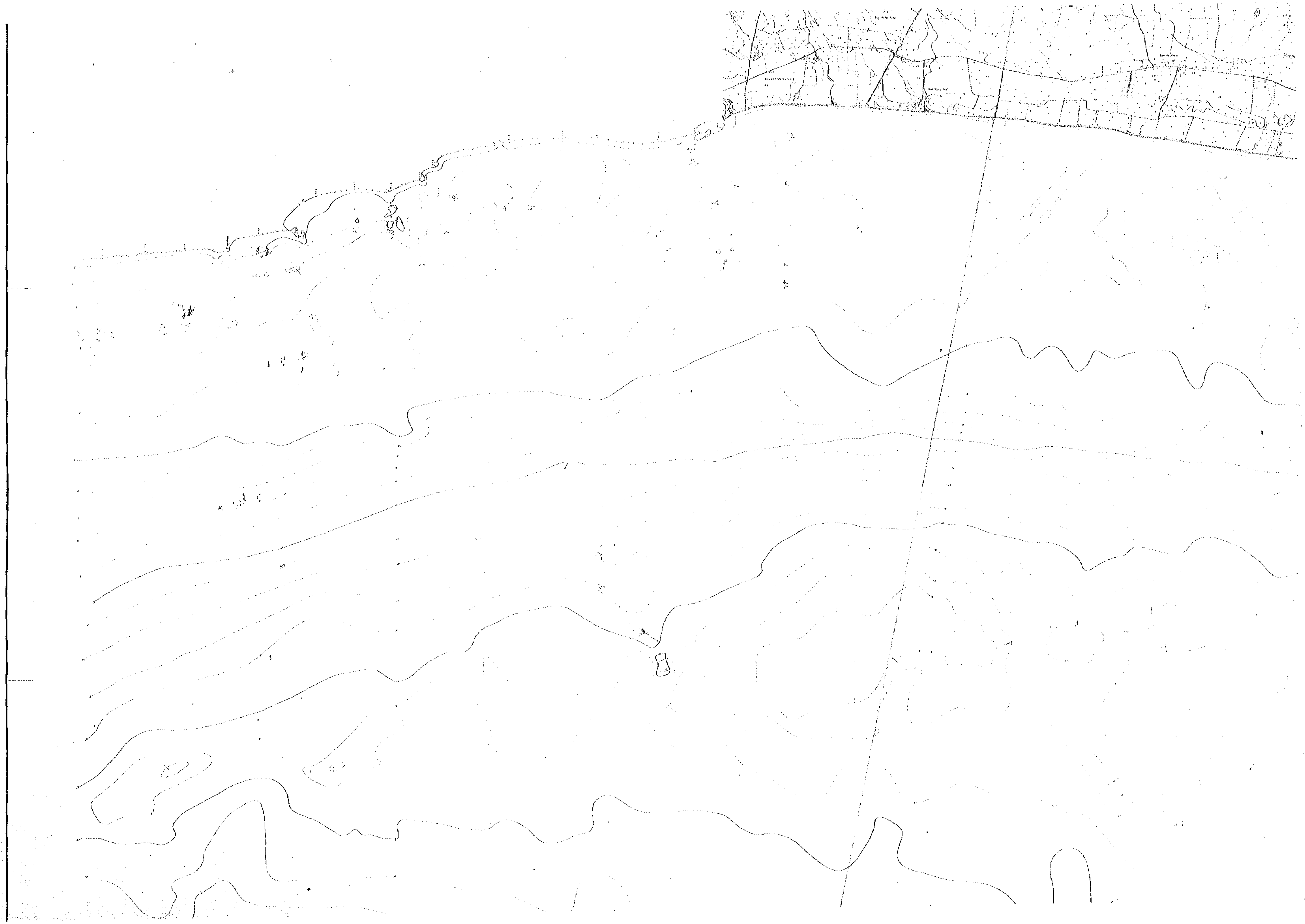
Legehd.

Topographic contour line.

- The depth (Sea area) or tlre height (Land area) is in metres.
- The datum of the depth is the C.D.L at SATTAHIP. (Sea area)
- The datum of the height is the M.S.L at KOH LAK. (Land area)
- C.D.L = M.S.L − 2.19m



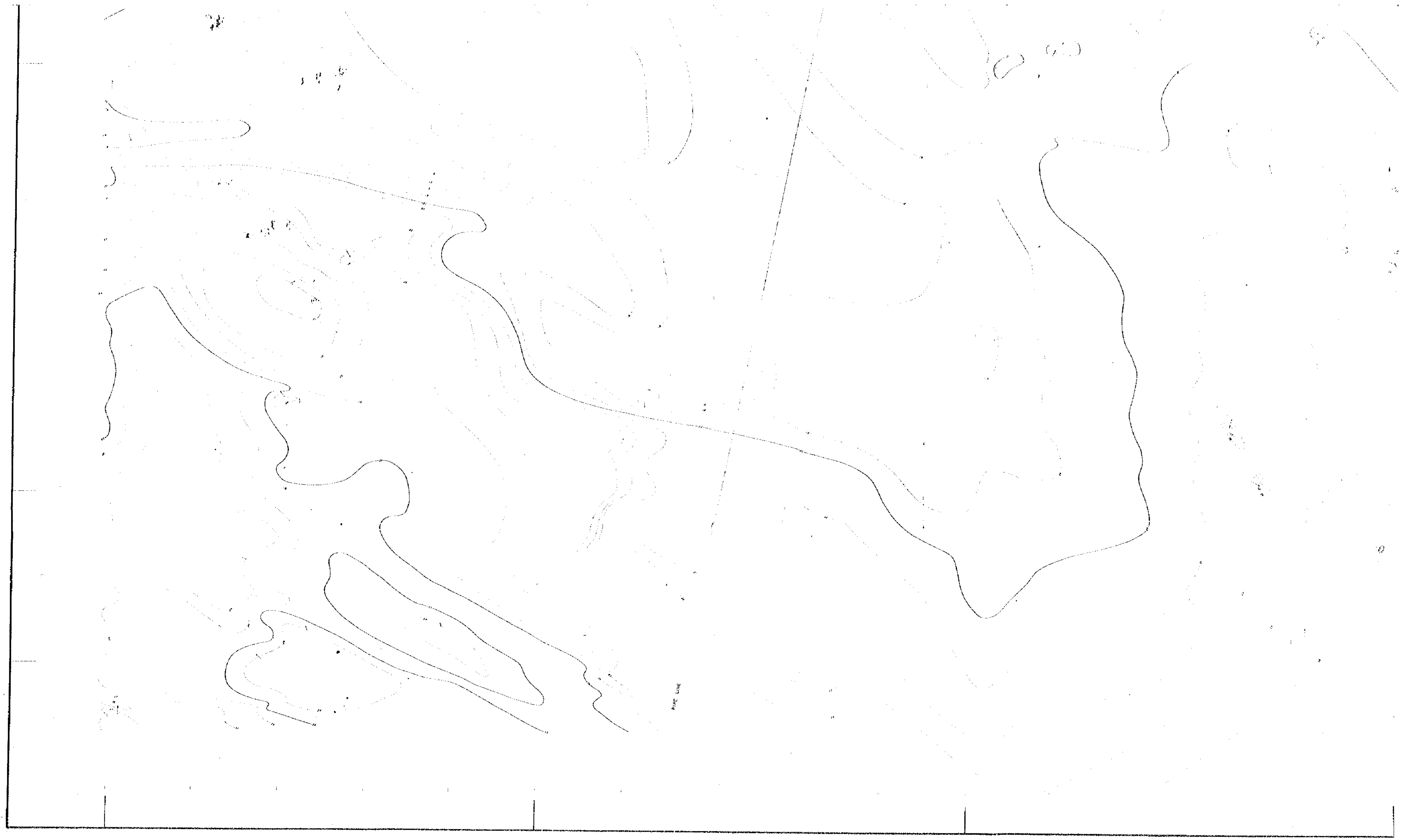

E 730
E 735
E 740
E 742
N 1411
N 1410
N 1405




N 1400
N 1395

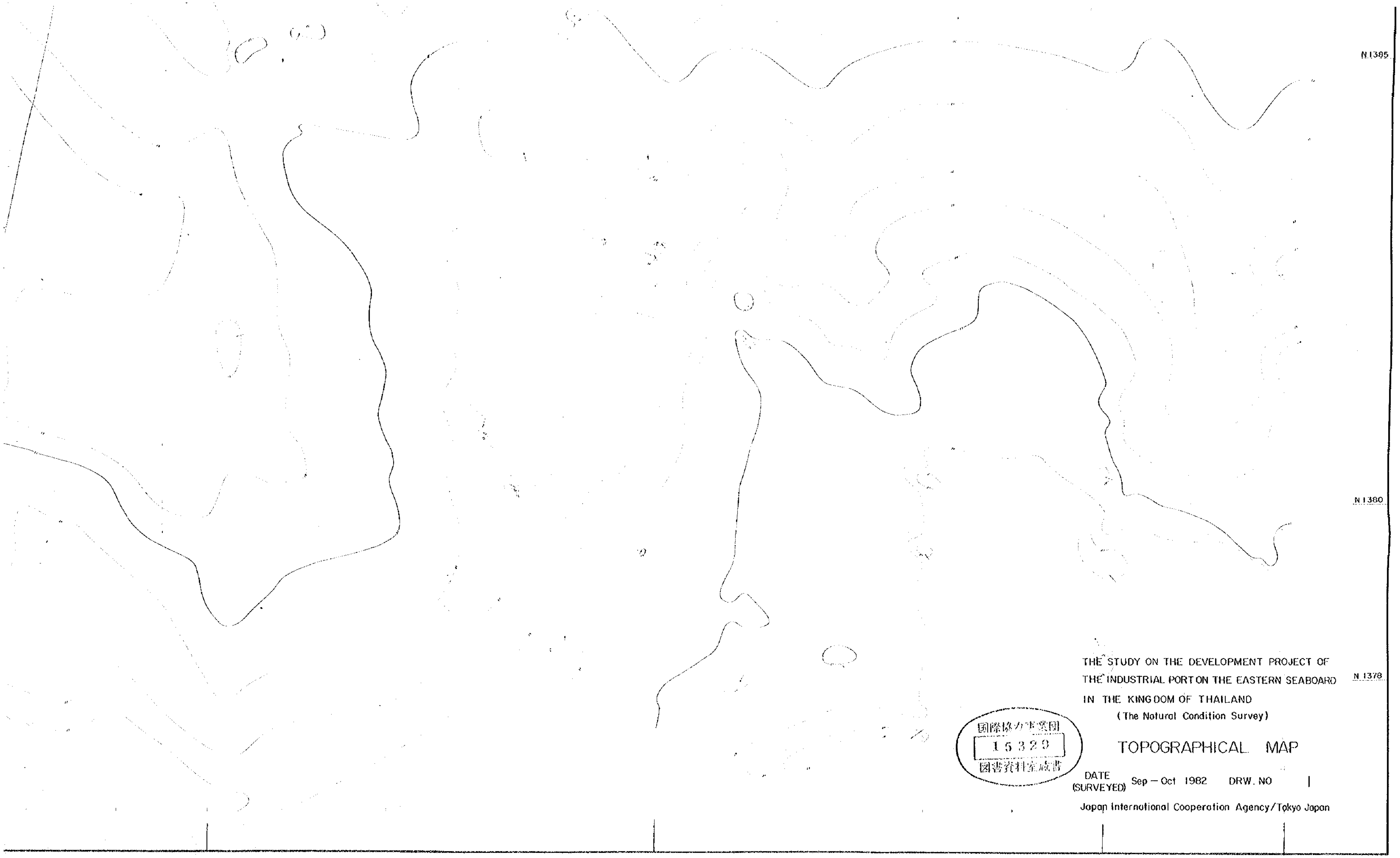

PIPE LINE


PIPE LINE
N 1390
N 1385



SCALE 1 : 30000

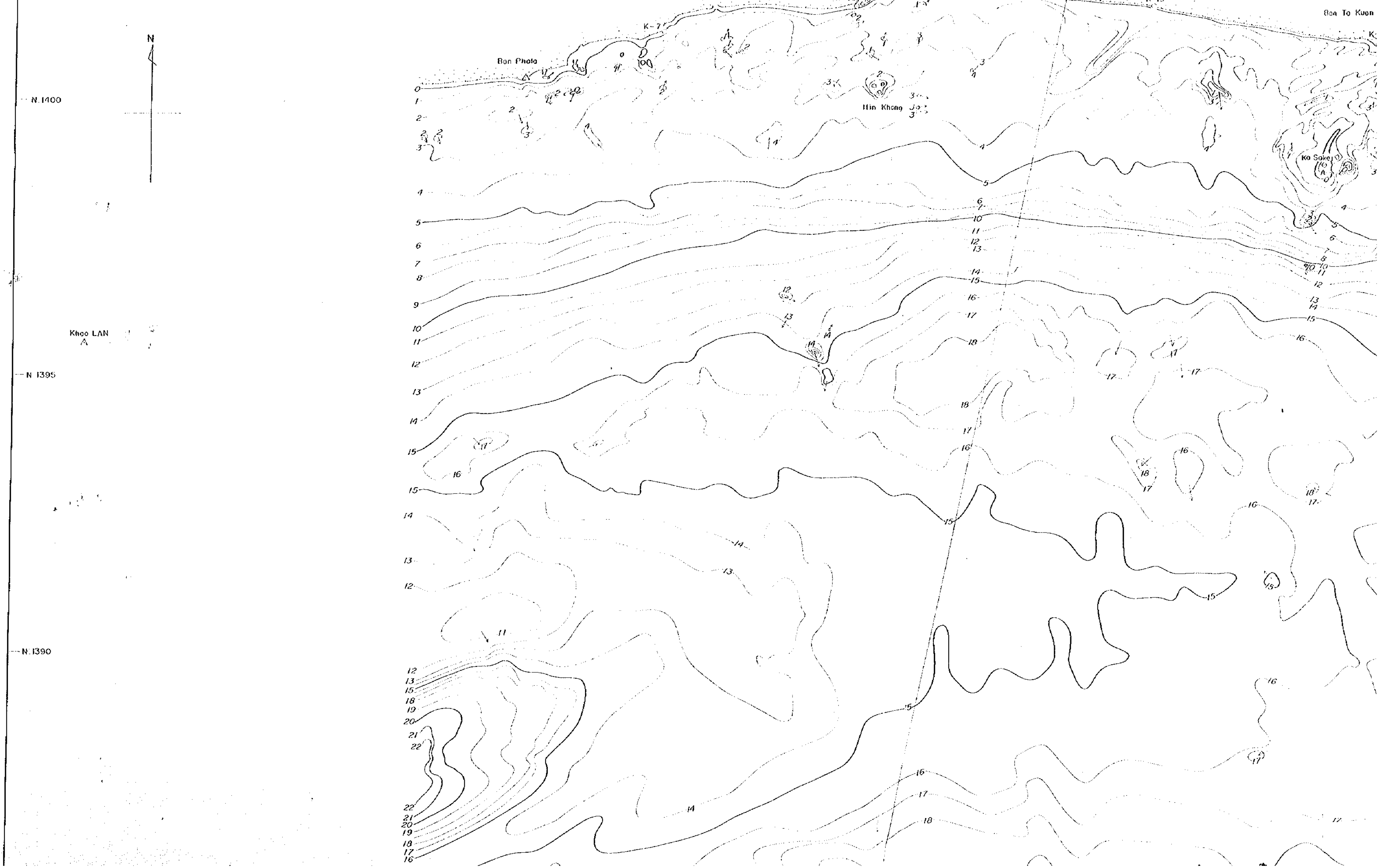
0 0.5 1 2 3KM



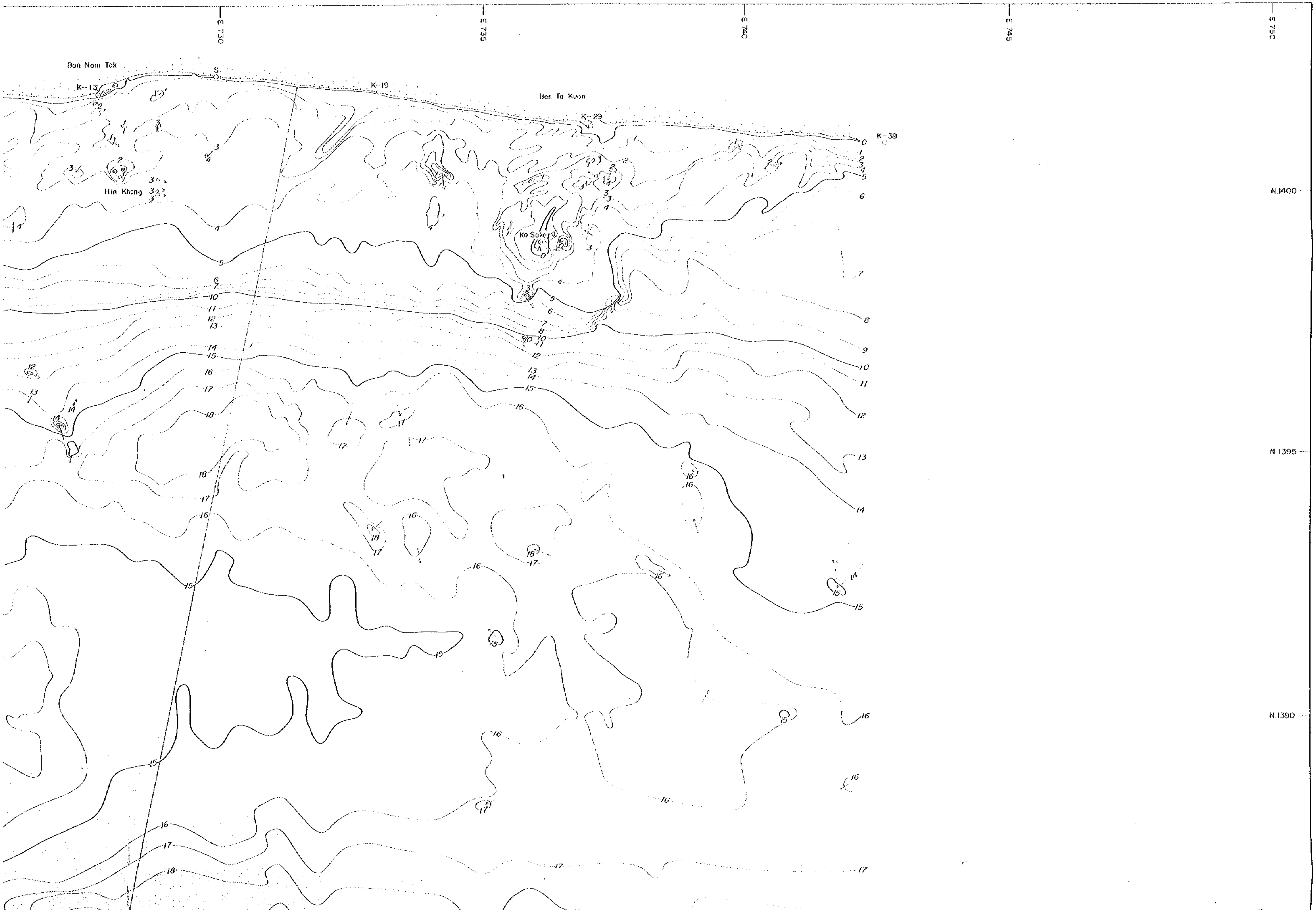
SCALE 1 : 30000

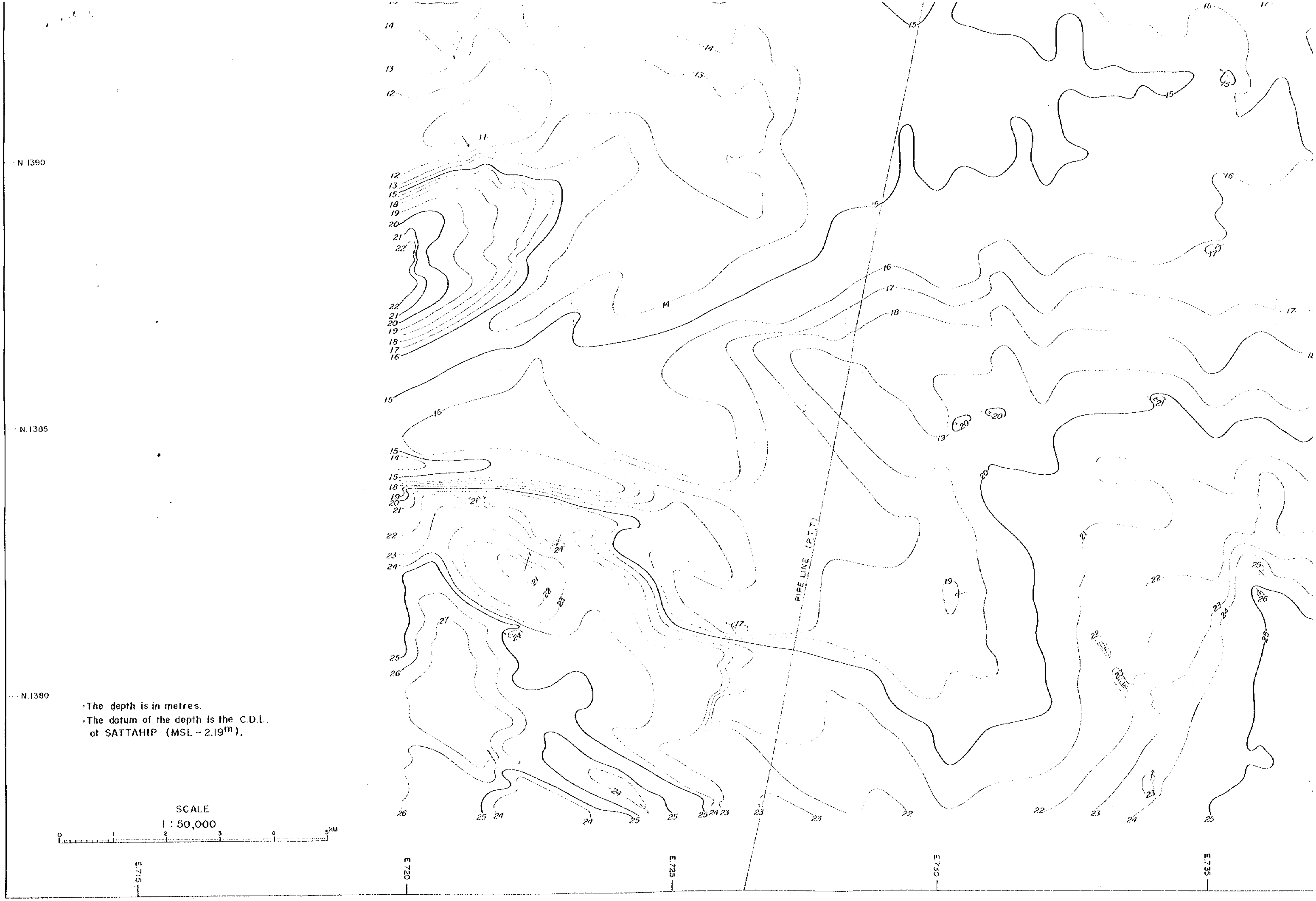
0 0.5 1 2 3 KM

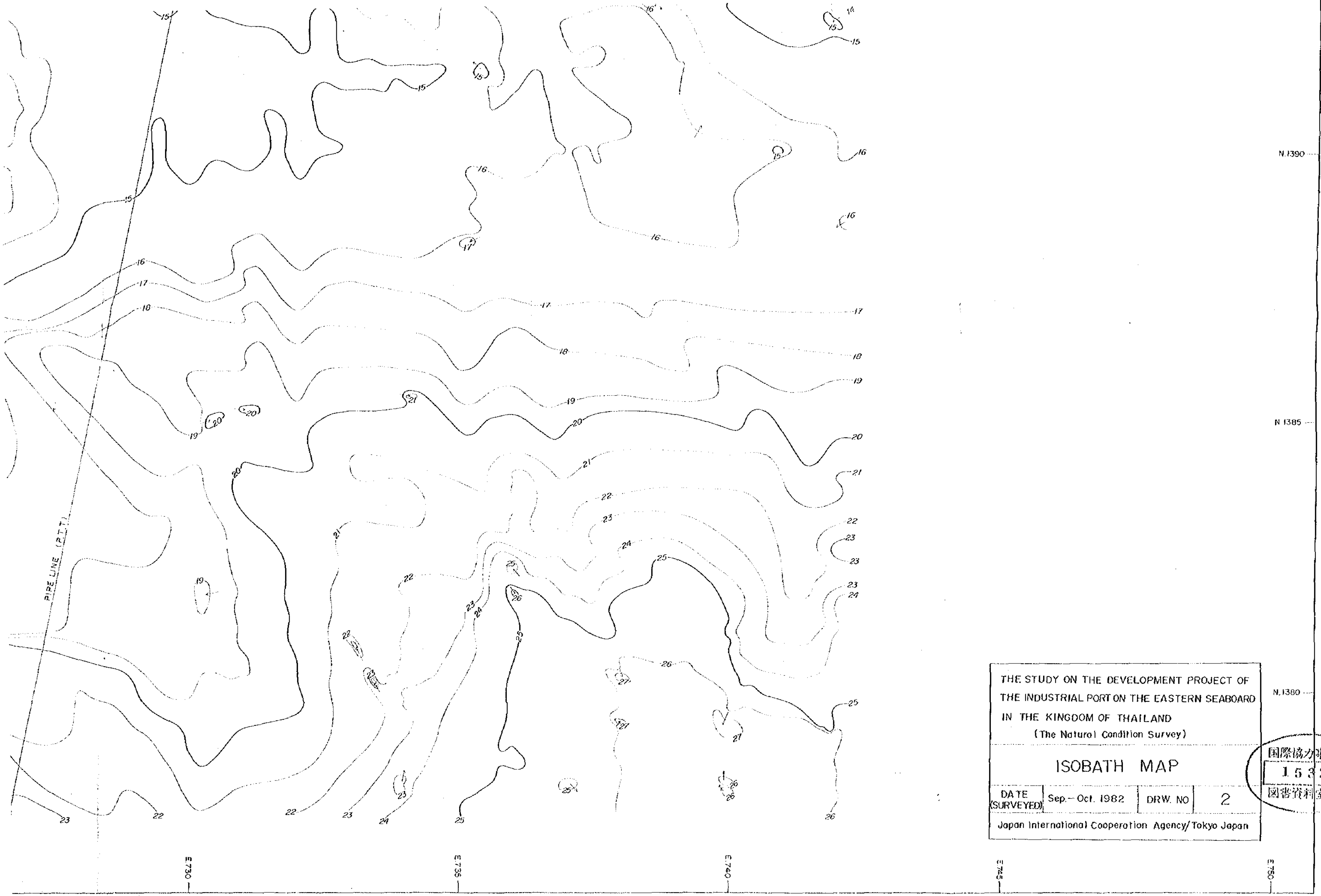
ISOBATH MAP



E.715
E.720
E.725
E.730
E.735
N
N.1400
N.1395
N.1390
Ban Nom Tok
K-13
K-19
Ban To Kuan
K-7
Ban Phola
Hin Khong
Ko Sakei
Khao LAN


E 730
E 735
E 740
E 745
E 750
Ban Nam Tok
K-13
S
K-19
Ban Ta Kuan
K-29
K-39
Hin Khong
N 1400
N 1395
N 1390


N.1390
N.1385
N.1380
E.715
E.720
E.725
E.730
E.735
PIPE LINE (P.T.T.)
•The depth is in metres.
•The datum of the depth is the C.D.L. at SATTAHIP (MSL – 2.19m).
SCALE
1 : 50,000
0 1 2 3 4 5KM



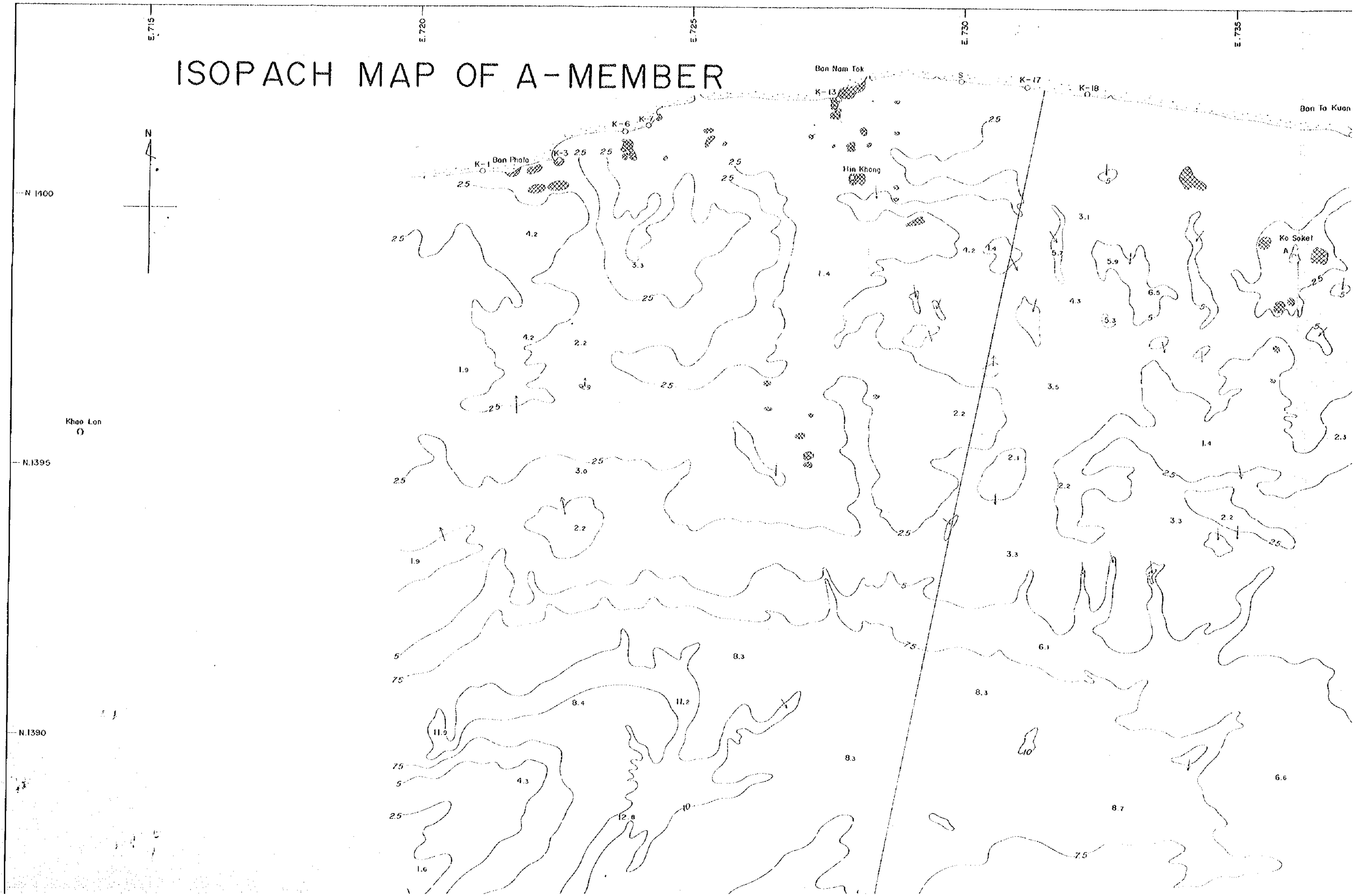
THE STUDY ON THE DEVELOPMENT PROJECT OF THE INDUSTRIAL PORT ON THE EASTERN SEABOARD IN THE KINGDOM OF THAILAND
(The Natural Condition Survey)

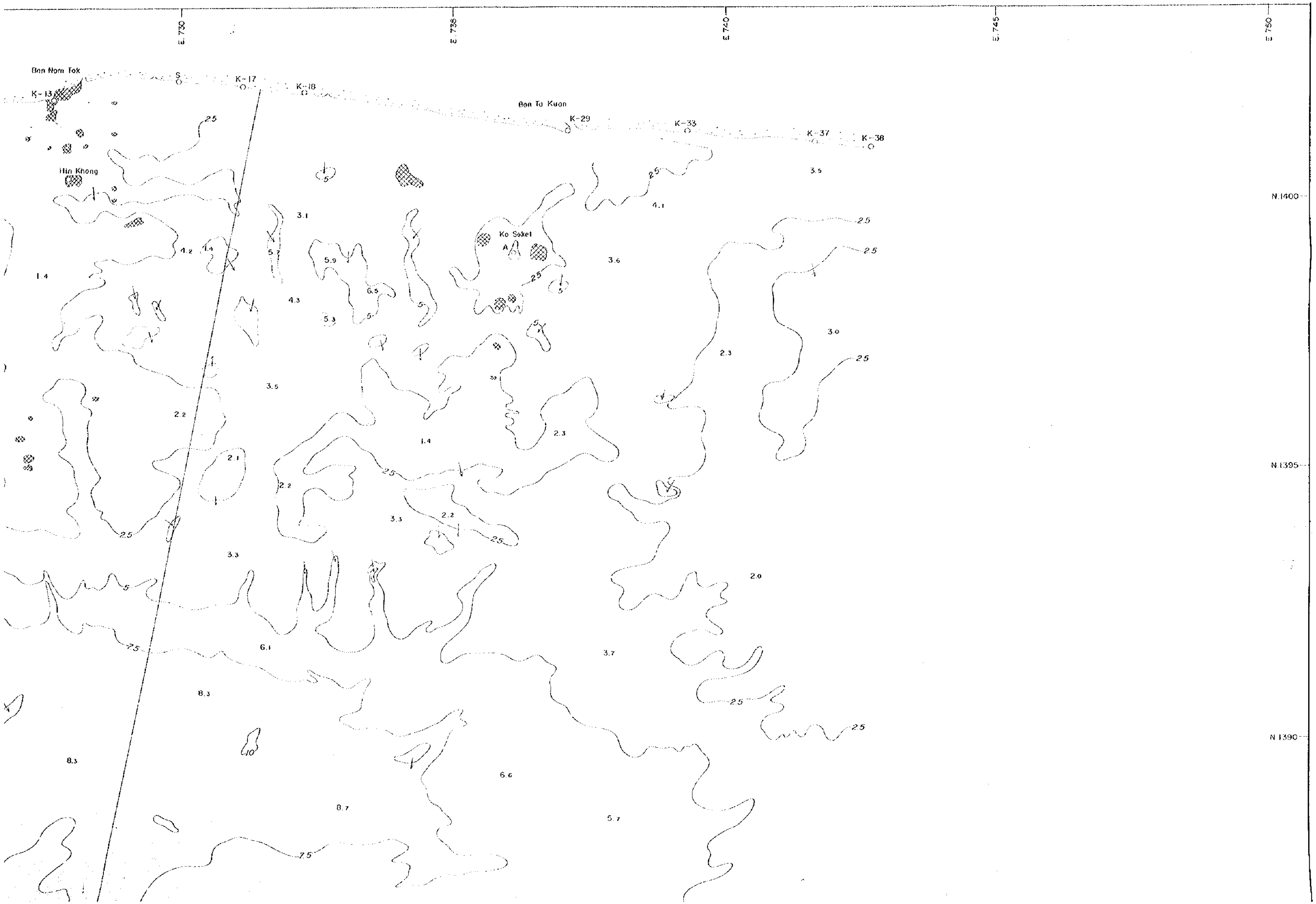
ISOBATH MAP

DATE (SURVEYED)	Sep.– Oct. 1982	DRW. NO	2

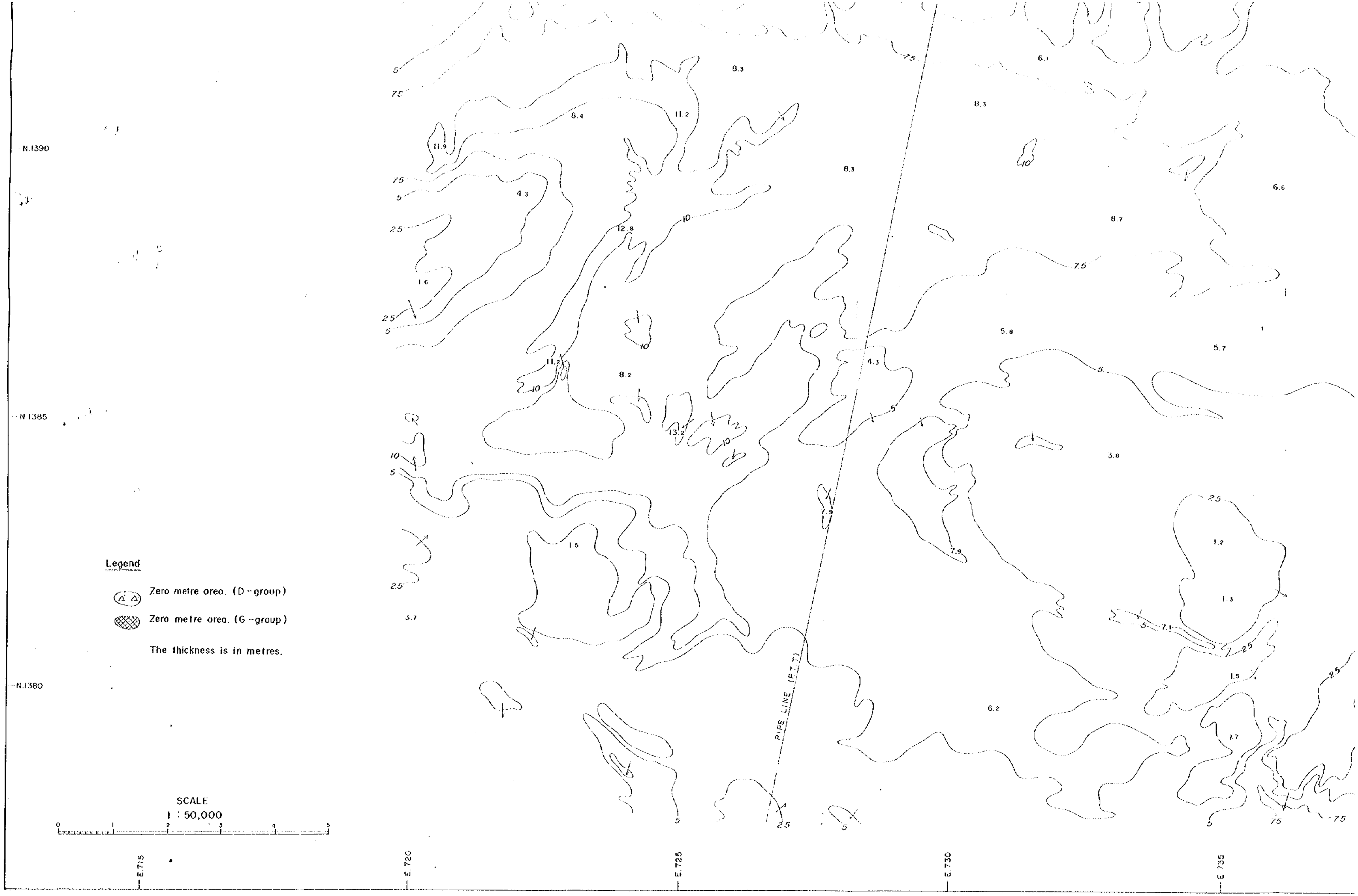
Japan International Cooperation Agency/ Tokyo Japan

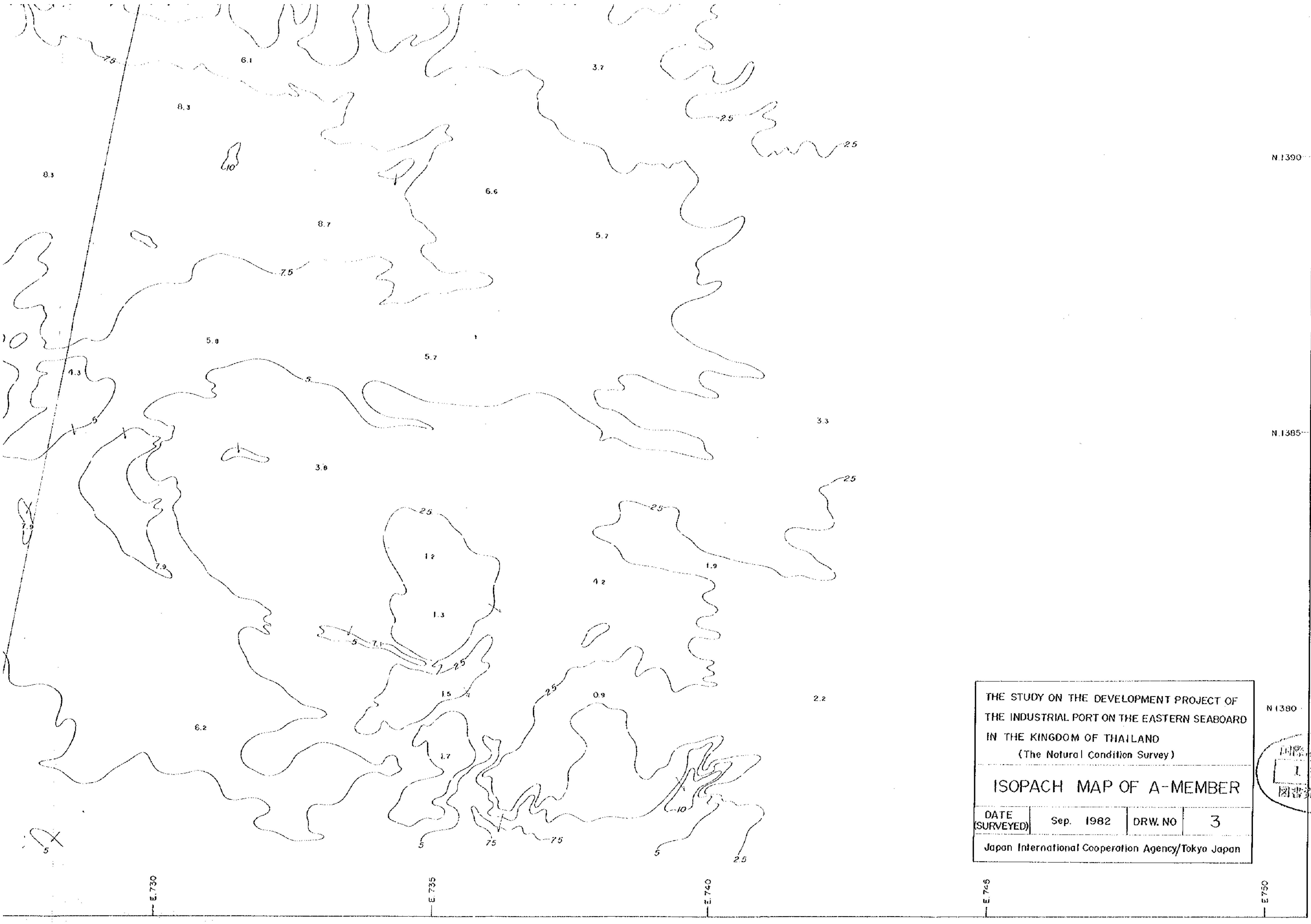
ISOPACH MAP OF A-MEMBER





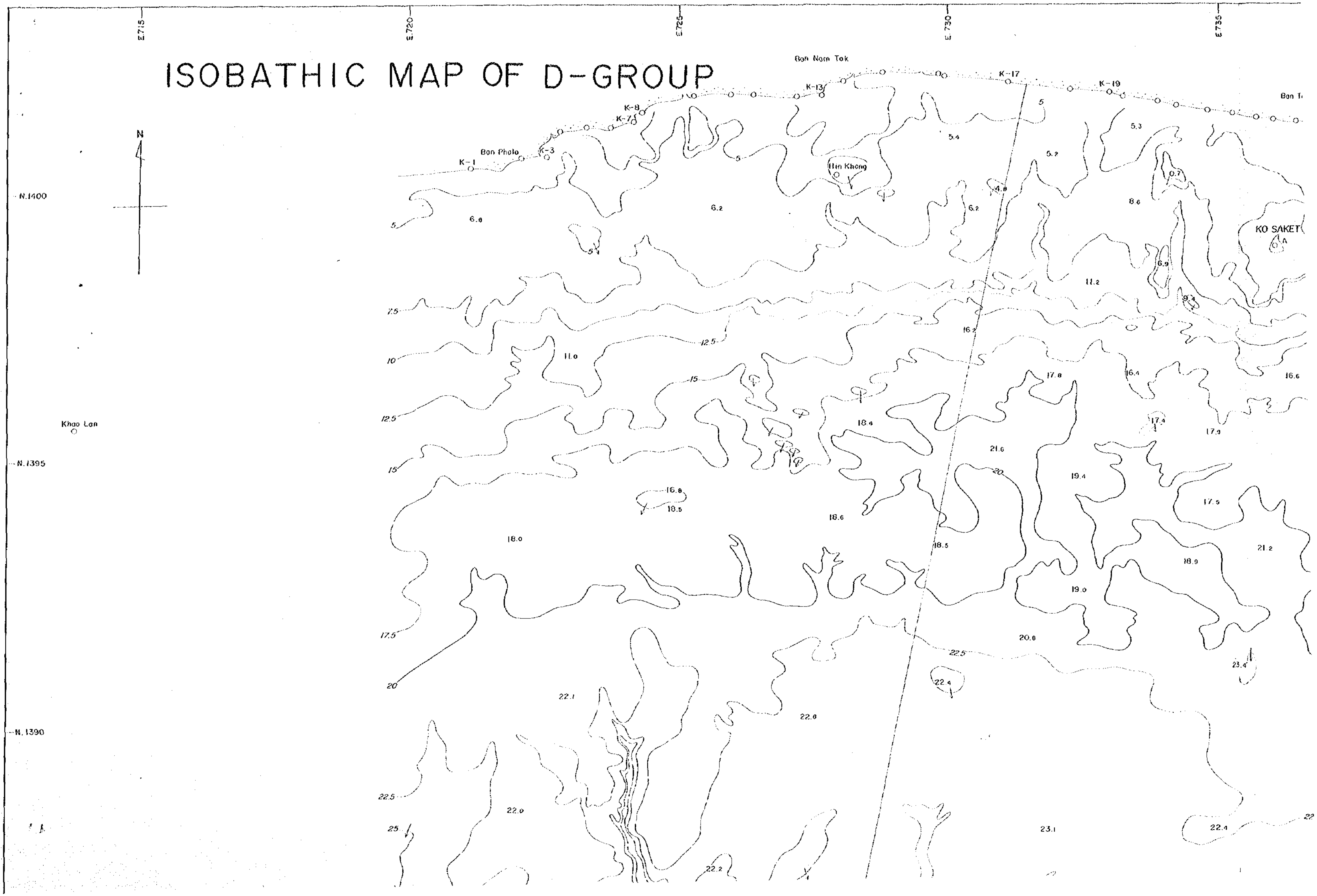
E.730
E.735
E.740
E.745
E.750
N.1400
N.1395
N.1390
Ban Nam Tok
K-13
K-17
K-18
Ban Ta Kuan
K-29
K-33
K-37
K-38
Hin Khong
Ko Soket

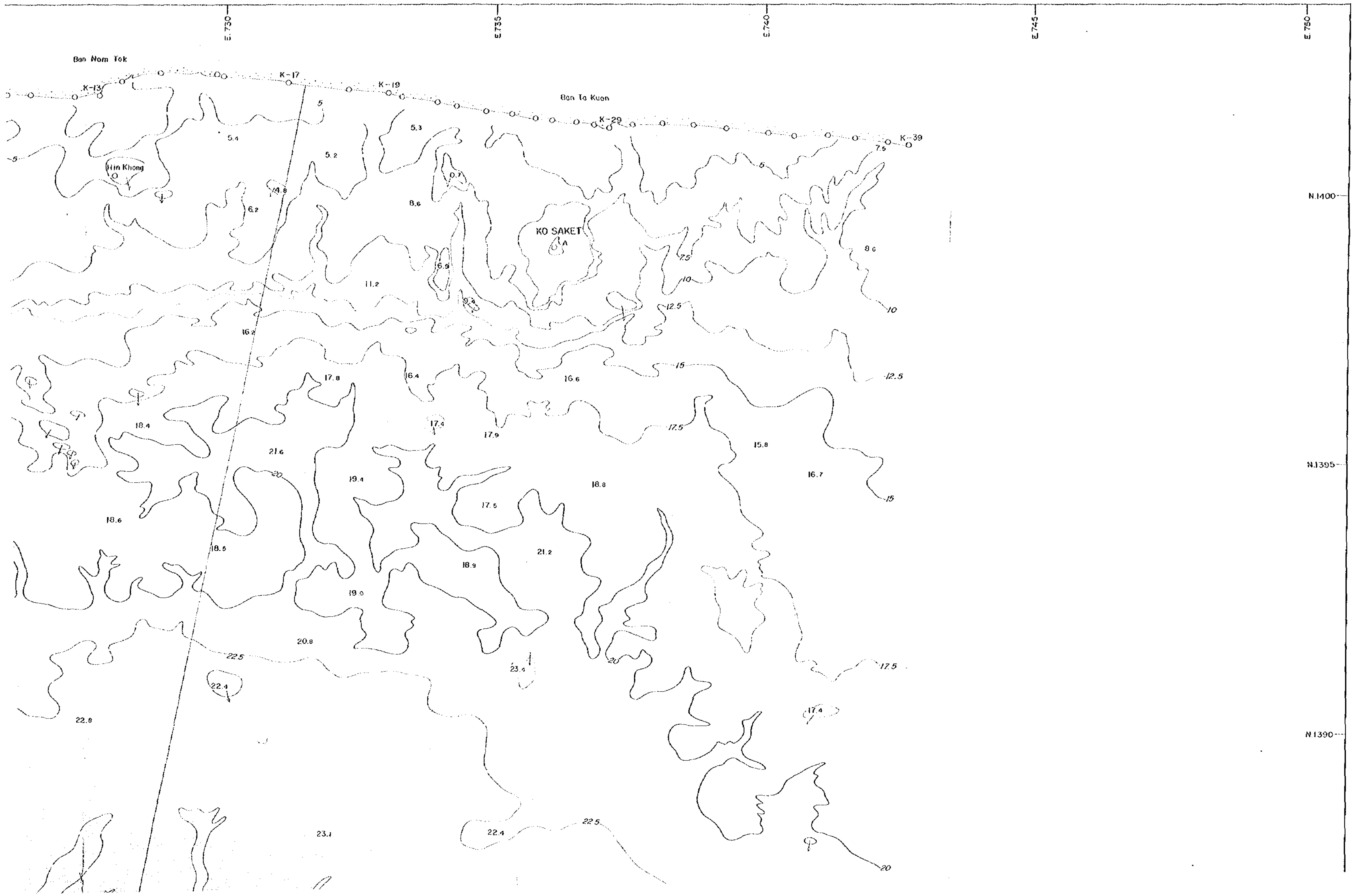

Legend
Zero metre area. (D-group)
Zero metre area. (G-group)
The thickness is in metres.
SCALE
1 : 50,000
0
1
2
3
4
5
N.1390
N.1385
N.1380
E.715
E.720
E.725
E.730
E.735
PIPE LINE (P.T.T.)



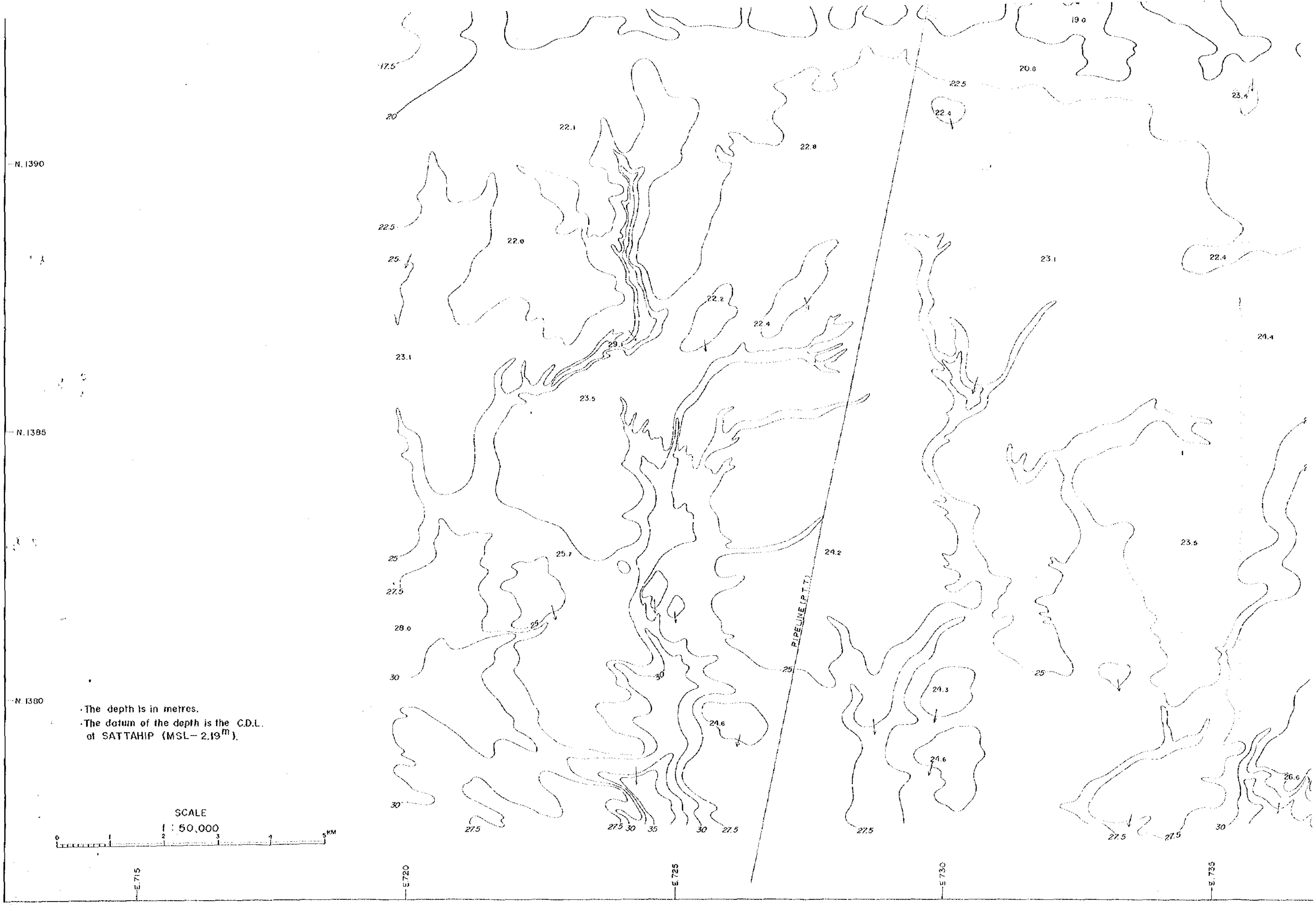
THE STUDY ON THE DEVELOPMENT PROJECT OF THE INDUSTRIAL PORT ON THE EASTERN SEABOARD IN THE KINGDOM OF THAILAND (The Natural Condition Survey)			
ISOPACH MAP OF A-MEMBER			
DATE (SURVEYED)	Sep. 1982	DRW. NO	3
Japan International Cooperation Agency/Tokyo Japan			

ISOBATHIC MAP OF D-GROUP

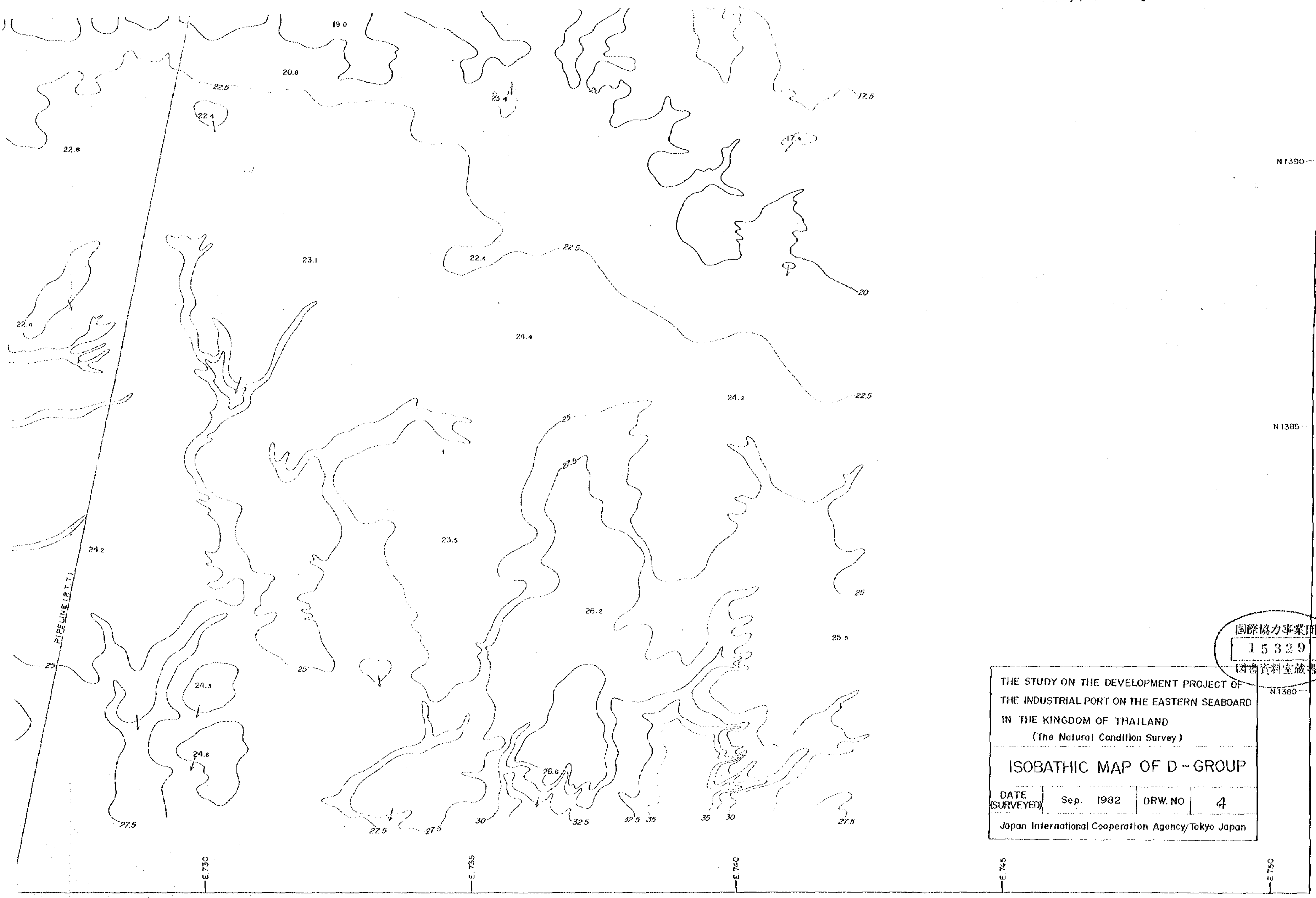




E.730
E.735
E.740
E.745
E.750
Ban Nom Tok
K-13
K-17
K-19
Ban Ta Kuan
K-29
K-39
Hin Khong
KO SAKET
N.1400
N.1395
N.1390
5
7.5
10
12.5
15
17.5
20
22.5
5.4
5.2
5.3
6.2
8.6
11.2
16.2
16.4
16.6
17.8
17.9
18.4
21.6
19.4
17.5
18.8
15.8
16.7
18.6
18.5
18.9
21.2
19.0
20.8
23.4
22.4
22.8
17.4
23.1



N.1390
N.1385
N.1380
17.5
20
22.5
22.0
22.1
22.8
19.0
20.8
22.5
22.4
23.4
25
22.2
22.4
29.1
23.1
24.4
23.5
25.7
27.5
28.0
30
24.2
PIPELINE (P.T.T.)
23.5
24.3
24.6
26.6
35
·The depth is in metres.
·The datum of the depth is the C.D.L. at SATTAHIP (MSL–2.19m).
SCALE
1 : 50,000
0 1 2 3 4 5KM
E.715
E.720
E.725
E.730
E.735



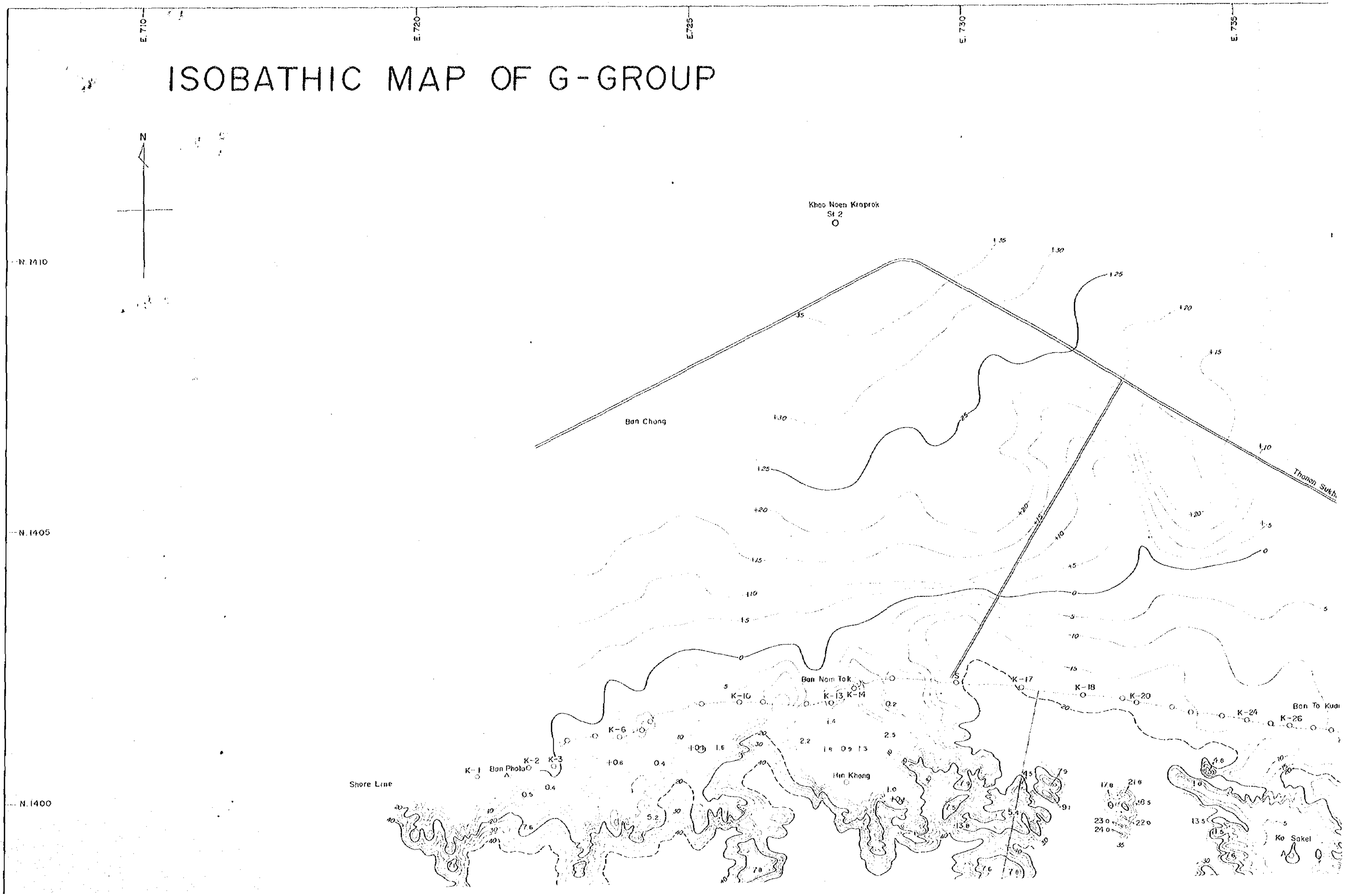
THE STUDY ON THE DEVELOPMENT PROJECT OF
THE INDUSTRIAL PORT ON THE EASTERN SEABOARD
IN THE KINGDOM OF THAILAND
(The Natural Condition Survey)

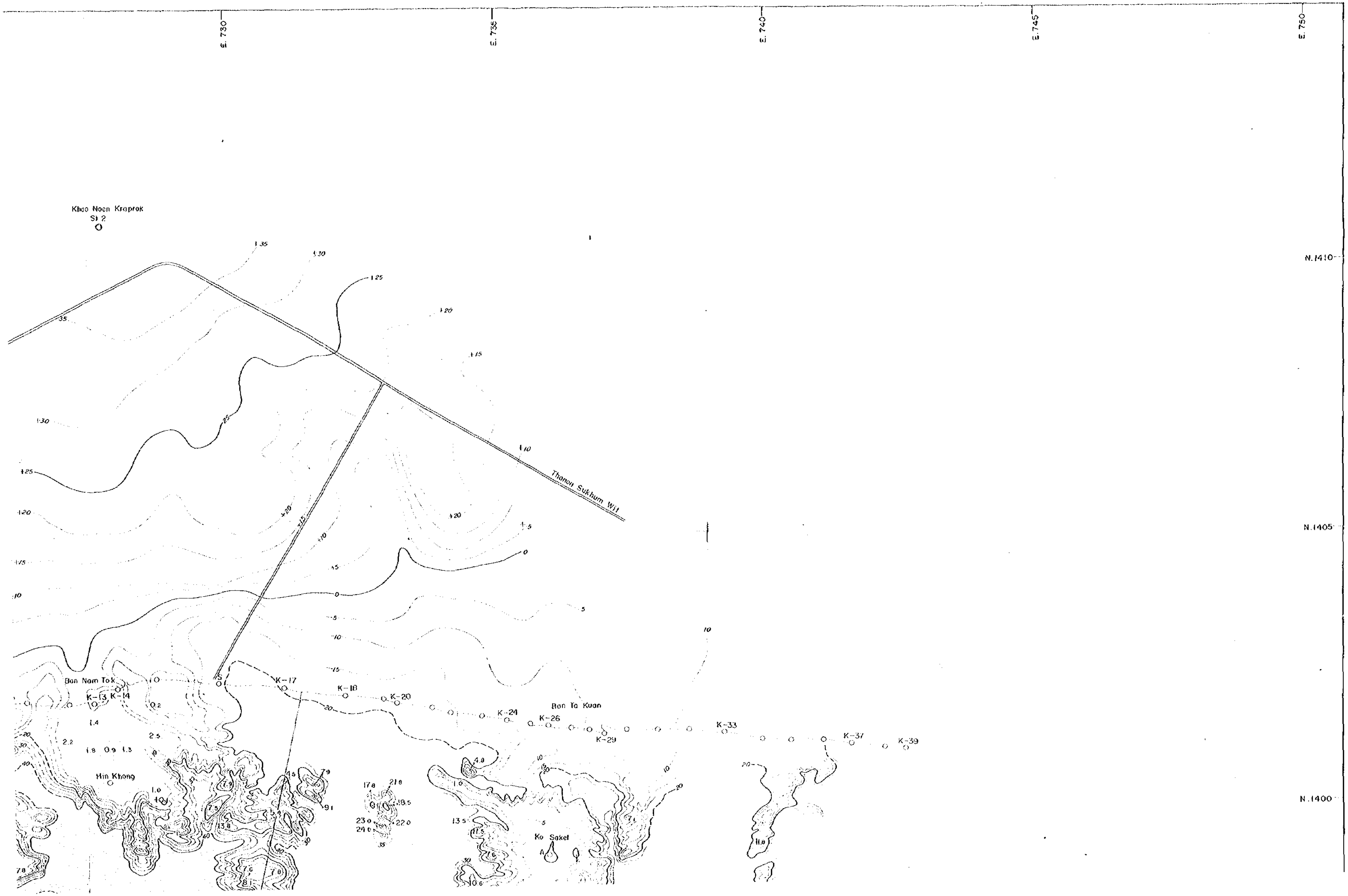
ISOBATHIC MAP OF D-GROUP

DATE (SURVEYED)	Sep. 1982	DRW. NO	4

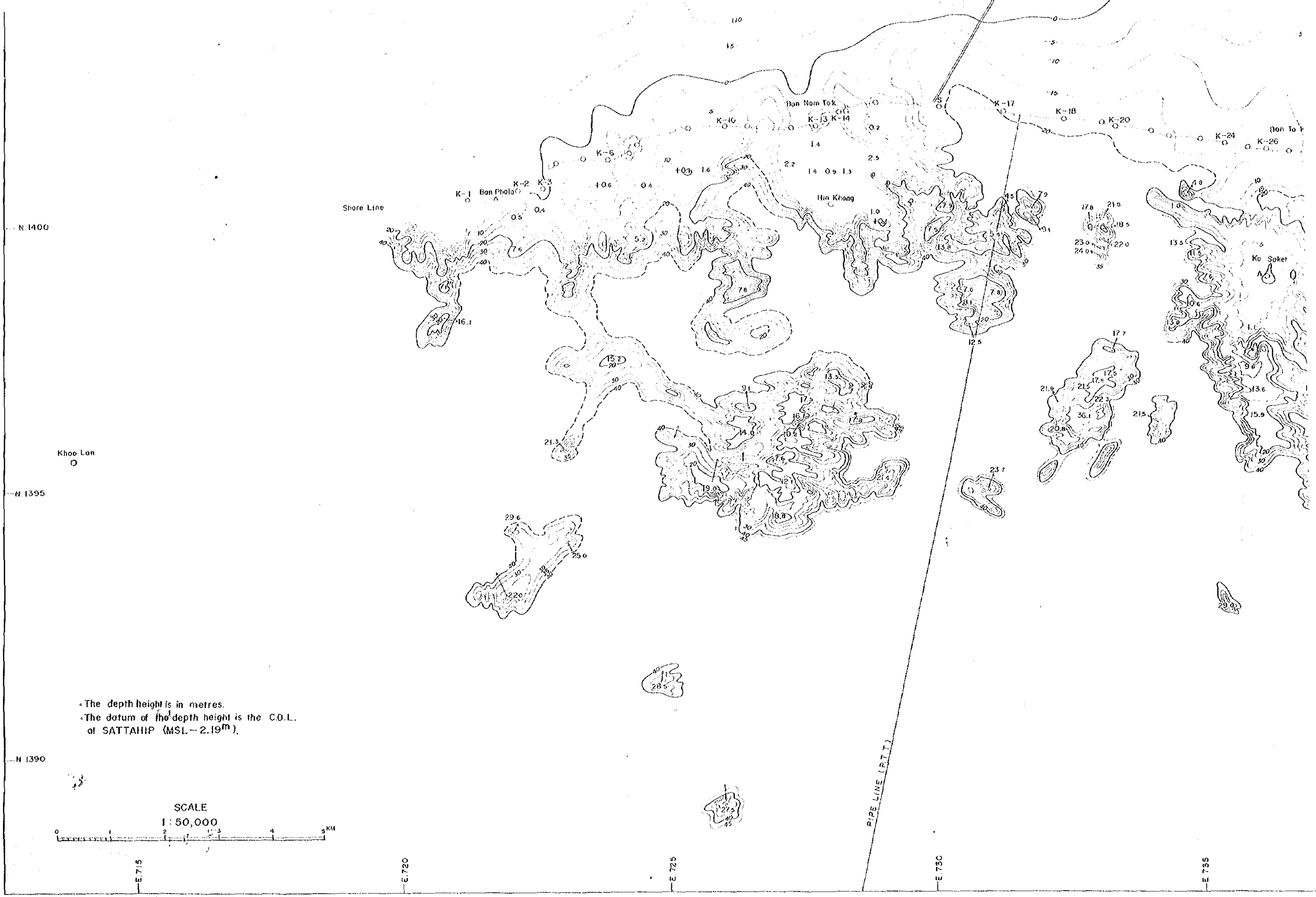
Japan International Cooperation Agency/Tokyo Japan

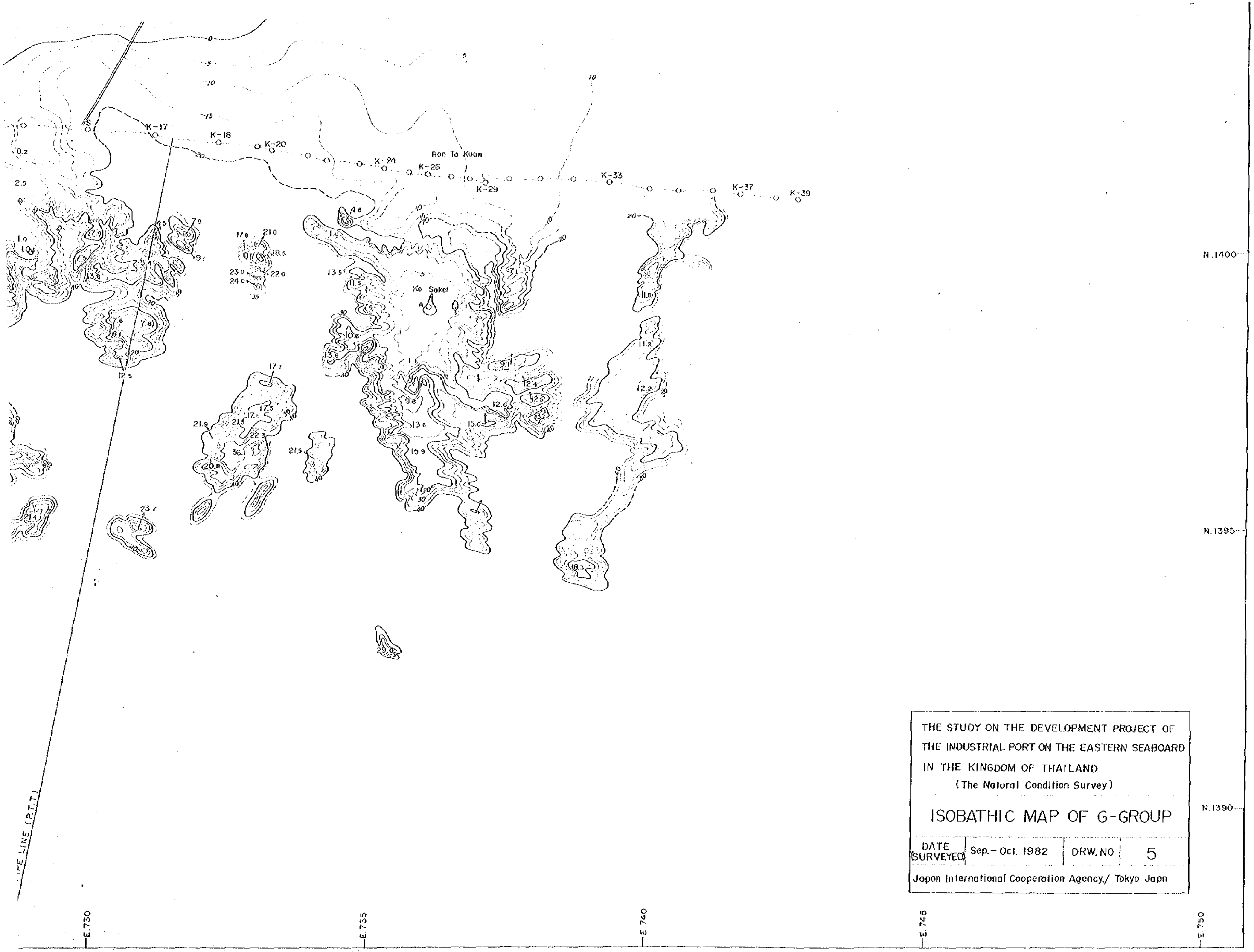
ISOBATHIC MAP OF G-GROUP





E. 730
E. 735
E. 740
E. 745
E. 750
N.1410
N.1405
N.1400
Khao Noen Kraprok
Thanon Sukhum Wit
Ban Nam Tok
K-13
K-14
K-17
K-18
K-20
K-24
K-26
K-29
K-33
K-37
K-39
Ban Ta Kuan
Hin Khong
Ko Saket


Shore Line
Ban Phola
Ban Nam Tok
Hin Khong
Ban To
Ko Soket
Khao Lon
K-1
K-2
K-3
K-6
K-10
K-13
K-14
K-17
K-18
K-20
K-24
K-26
N 1400
N 1395
N 1390
E 715
E 720
E 725
E 730
E 735
PIPE LINE (P.T.T.)
◦The depth height is in metres.
◦The datum of the depth height is the C.O.L. at SATTAHIP (MSL−2.19m).
SCALE
1 : 50,000
0
1
2
3
4
5 KM



THE STUDY ON THE DEVELOPMENT PROJECT OF THE INDUSTRIAL PORT ON THE EASTERN SEABOARD IN THE KINGDOM OF THAILAND

(The Natural Condition Survey)

ISOBATHIC MAP OF G-GROUP

DATE (SURVEYED)	Sep.– Oct. 1982	DRW. NO	5

Japan International Cooperation Agency./ Tokyo Japn